Edited by

Richard D. Beilfuss
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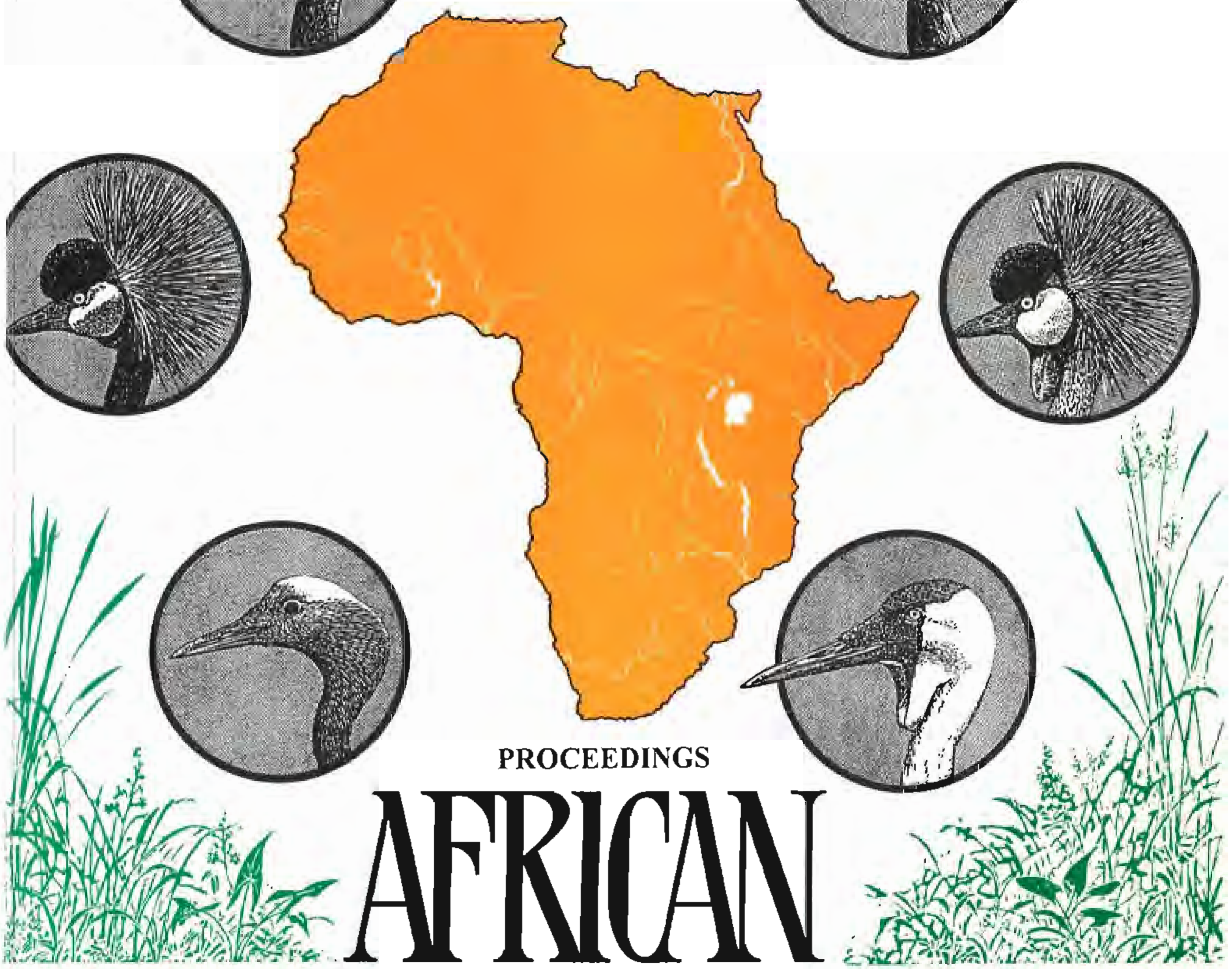

PROCEEDINGS

AFRICAN Crane & Wetland TRAINING WORKSHOP

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1993
AFRICAN CRANE AND WETLAND TRAINING WORKSHOP

8-15 AUGUST 1993
WILDLIFE TRAINING INSTITUTE
MAUN, BOTSWANA

Edited by

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1996

DEDICATION

Africa's wetlands and grasslands support the greatest abundance and diversity of wildlife in the world. They also provide sustenance for countless thousands of indigenous people. Over the millennia, people have been an integral part of Africa's wetland and grassland communities, living alongside the wildlife and drawing resources from these ecosystems in a sustainable manner.

Today, wars, agricultural drainage schemes, large dams, overgrazing, desertification, and agrochemicals threaten many of Africa's wetlands and grasslands, and the livelihoods of all who depend on them. If steps are not taken, these ecosystems will be destroyed at an ever-increasing rate. Such steps require local understanding and global support.

This volume is dedicated to our African colleagues - scientists, conservationists, policy makers, chiefs, wardens, educators, development workers - for their dedication to creating a secure home for people and wildlife in Africa. We wish them every success in finding uniquely African solutions to the conservation challenges facing this immense and remarkable continent.

CONTENTS

OPENING ADDRESS

"The Spirit of Maun"

Welcome to Botswana and the African Crane and Wetland Training Workshop. This meeting in Maun is historic. It marks the first gathering of crane specialists from South Africa with colleagues from a diversity of other African nations. Botswana was chosen because of the political facility for all Africans to visit the nation, and because it maintains one of the world's most important wetlands, the Okavango Delta. The excellent facilities at the Wildlife Training Institute, wildlife viewing at the adjoining game park, and the availability of small fixed wing aircraft for field trips over the Okavango, make Maun an ideal spot for this meeting of more than 100 crane and wetland experts from 19 African nations.

The African Crane and Wetland Training Workshop is an offspring of the African Working Group on Cranes, an ad hoc group established at the first major International Crane Workshop that took place in India in 1983. Members of the AWGC received both the quarterly publication of the International Crane Foundation, **The ICF Bugle**, and a semi-annual newsletter including crane research and conservation news from Africa**, The Crowned Crane**. AWGC members met in conjunction with the various meetings of the Pan African Ornithological Congress and the International Ornithological Congress. Subsequently, two new groups, the East African Working Group on Cranes and the Black Crowned Crane Working Group, formed and convened regional meetings. About the same time, several working groups where formed in South Africa including the Southern African Crane Foundation in Natal, the Highland Crane Working Group in eastern Transvaal, and the Overberg Crane Working Group in Cape Province.

The workshop agenda calls for daily concurrent sessions of training lectures and papers over four of the next five days, kicking off with lessons in crane and wetland conservation from our colleagues in Uganda, Kenya, and Zambia. Every day we have set aside large blocks of time for working groups to meet and discuss regional conservation issues, and for national delegations to draft National Crane and Wetland Action Plans. For example, this meeting provides the first opportunity for the various working groups from South Africa to meet and discuss relationships between groups and means of consolidating a strong national conservation front for cranes, wetlands, and grasslands.

Let us strive to make this meeting in Maun a cornerstone in promoting the welfare of cranes and their wetland and grassland habitats throughout Africa. Reaching that goal depends on the work of each of the participants. The International Crane Foundation, the Department of National Parks and Wildlife of Botswana, and the various financial supporters of this meeting have brought us together in this remarkable spot where people and nature exist in harmony. Let us hope this spirit will be carried back to all nations represented here this week and that we can all join forces to brighten the future for African cranes and wetlands.

August 1993

George Archibald
International Crane Foundation
Baraboo, Wisconsin USA

INTRODUCTION

As our plane soared over the Okavango Delta, the remarkable abundance and diversity of wildlife scattered across this magnificent wetland home awed us. Elephant, hippo, zebra, buffalo, impala, and giraffe paraded across the mosaic landscape. Lone Saddlebilled Storks dotted isolated, shallow wetlands. And, just before dusk, a flock of more than 50 Wattled Cranes flew gracefully alongside us into their roosting grounds near the Boro River.

Before long we reached our destination: the dusty town of Maun, Botswana, gateway to the Okavango. A procession of four-wheel drive vehicles promptly arrived to whisk us the short distance to the Wildlife Training Institute, our home for the next week. Soon, more than 100 delegates from nineteen African nations, Saudi Arabia, Japan, Europe, and North America would join us for the first African Crane and Wetland Training Workshop.

We came to Botswana and the Wildlife Training Institute with six goals in mind:

- to teach each other how to study and protect Africa's cranes and wetlands;
- to write a Crane and Wetland Action Plan for every country represented at the workshop;
- to strengthen Africa's regional working groups on cranes and wetlands;
- to create new working groups and alliances in northern and southern Africa;
- to help develop funding strategies for African research and conservation projects involving cranes and wetlands;
- to build bonds of trust and friendship that would strengthen the drive to conserve nature throughout Africa.

Together, we hoped to explore how cranes could serve as focal points for broad-based conservation programs that benefit the people and wildlife of Africa's wetlands and grasslands. Throughout the world, cranes serve as important symbols for conservation. They are large and conspicuous "umbrella species" under which entire ecosystems may be protected. When people become concerned about the fate of cranes, concrete steps can be taken towards conserving the communities that serve, in part, as crane habitat.

The wetland and grassland communities of Africa support six of the world's fifteen species of cranes. The Black Crowned Crane (*Balearica pavonina*), national bird of Nigeria, is resident in western and central Africa. The Grey Crowned Crane (*B. regulorum*), national bird of Uganda, spans eastern and southern Africa. The Wattled Crane (*Bugeranus carunculatus*), largest and rarest of Africa's cranes, ranges from Ethiopia to South Africa. The Blue Crane (*Anthropoides paradiseus*), national bird of South Africa, is endemic to the grasslands of South Africa and Namibia. The Demoiselle Crane (*A. virgo*) and Eurasian Crane (*Grus grus*) are winter visitors to northern Africa.

Cranes occur in thirty-two African nations, from Senegal to Ethiopia, Tunisia to South Africa. Wetlands that provide a home for cranes include the floodplains of the great river systems of Africa, such as the Kafue Flats and Zambezi Delta of the Zambezi River system, the Okavango River Delta, the Sudd of the Upper Nile River, the Bangweulu Basin and Zaire swamps of the Zaire River system, the Senegal River Delta, the Inner Niger River Delta, and the wetlands of Lake Chad and Lake Victoria and their tributaries. Small, isolated wetlands known as dambos or vleis provide vital breeding habitat.

Although people and wildlife have lived in harmony in Africa's wetlands through the ages, modern threats are disrupting this fragile balance. Large dams, wars, agricultural drainage schemes, overgrazing, desertification, and agrochemicals threaten many of Africa's wetlands and grasslands, and the livelihoods of all who depend on them. How could our gathering of dedicated conservationists begin to tackle such significant problems?

Co-sponsored by the International Crane Foundation and the Government of Botswana Department of National Parks and Wildlife, the African Crane and Wetland Training Workshop convened on 8 August 1993. The workshop began with two days of intensive training sessions by colleagues from Uganda, Zambia, and Kenya. Paul Mafabi described Uganda's national policy for the conservation and management of wetland resources, providing us with a model for wetland policy formulation in other African nations. Delegates from the WWF-Zambia Wetlands Project then described case studies of community-based wetland management at Kafue Flats and Bangweulu Basin. We compared and contrasted the approaches taken in Zambia, in which villagers contribute to management decisions and receive a portion of license fees collected from sport hunters, with those of the CAMPFIRE program in Zimbabwe and other efforts to make local people partners in wetland conservation. Then delegates from Kenya, headed by Nathan and Cecilia Gichuki, concluded the opening symposia with a session on understanding cranes and their environments. The group discussed a wide range of tools for conserving cranes, including biological studies of cranes and wetlands, environmental education programs, and crane/waterbird counts. Delegates also described how initial efforts to protect the breeding grounds of the Grey Crowned Crane at Saiwa National Park in northern Kenya have blossomed into a community-wide catchment conservation program that includes biointensive agriculture, soil conservation, fish pond creation, environmental education, reforestation of native trees, bee keeping, and other activities.

On the third day of the workshop we laid down our notepads and set off to explore the great Okavango Delta on the back of three flatbed trucks. Local experts described the natural processes that formed and maintain the flora and fauna of the Delta. At the end of the day, delegates hiked through several kilometers of shallow marsh to observe the evening fly-in of Wattled Cranes to a roosting area in the delta. A local villager hunting impala off in the distance illustrated but one of the many ways that Africa's wetlands are shared by people and wildlife.

The final three days of the workshop provided a feast of papers, posters, videos, demonstrations, flights over the Okavango Delta, and small group discussions. More than 70 papers and posters were presented on topics such as "wetlands, cranes, and sustainable development," "wetland monitoring and evaluation," "reintroduction and captive management of cranes," and "wetland values and environmental education," and covered the ecology and conservation of each of the six species of African cranes. A demonstration of Global Positioning System (GPS) technology offered delegates a new tool for mapping and censusing cranes and their habitats. Each delegate was given a thirty-minute flight over the delta in a Cessna 12-seat aircraft to gain a different perspective on this magnificent wetland and its wildlife.

The East Africa Crane and Wetland Working Group and Black Crowned Crane Working Group convened to strategize new crane and wetland conservation initiatives. The North African Working Group was established among delegates from Morocco, Tunisia, Egypt, Sudan, Ethiopia, and Saudi Arabia. The Southern African Crane Foundation, Highlands Crane Group, Overberg Crane Group, and Wakkerstroom Natural Heritage Association of South Africa met together to explore new avenues for cooperation on behalf of the cranes of South Africa.

Throughout the workshop, delegates from each country were busy drafting preliminary National Crane and Wetland Action Plans. Training sessions provided delegates with skills to produce the action plans, prioritize national and regional conservation initiatives, and secure funding for implementing key projects. At-large international delegates from England, the Netherlands, Japan, and the United States advised and assisted with the action plans. These working plans provide guidance for citizens, scientists, resource managers, agency officials, and political leaders concerned about cranes and their wetland and grassland homes.

Over the seven days of the workshop, and during time spent sharing meals, campsites, and discussions, a spirit of comraderie and common purpose unfolded. New and renewed working groups for crane and wetland conservation took shape. Unique regional collaborations among delegates and nations emerged. Unprecedented exchanges of information between South African delegates and other workshop participants occurred. With the upcoming peaceful, multi-party elections in South Africa and Mozambique, and a cease-fire foreseen in Angola, the opportunities for regional cooperation had never been greater. In the future, efforts to help rebuild conservation programs in war-torn countries like Rwanda and Sudan will similarly depend on international outreach and exchange.

On the last evening of the workshop, the delegates gathered and discussed resolutions pertaining to Sudan, Mozambique, Nigeria, Zimbabwe, and South Africa. They gave special recognition to the efforts of Maurice Wanjala of Kenya and Elna Kotze of South Africa for their terrific work in creating citizen groups to work on local conservation issues. Maurice sang a song, and Peter Micheni read a poem he had written about the workshop. Then Nathan Gichuki asked everyone to join hands in "the spirit of Maun" and the workshop adjourned. By morning, most delegates were on their way back home to spread the spirit throughout Africa.

This volume represents the first comprehensive compilation of reports on crane research and conservation projects in Africa. Until the 1993 workshop, much of this information was unavailable. The papers presented here involve crane and wetland research in 29 African nations (Figure 1).

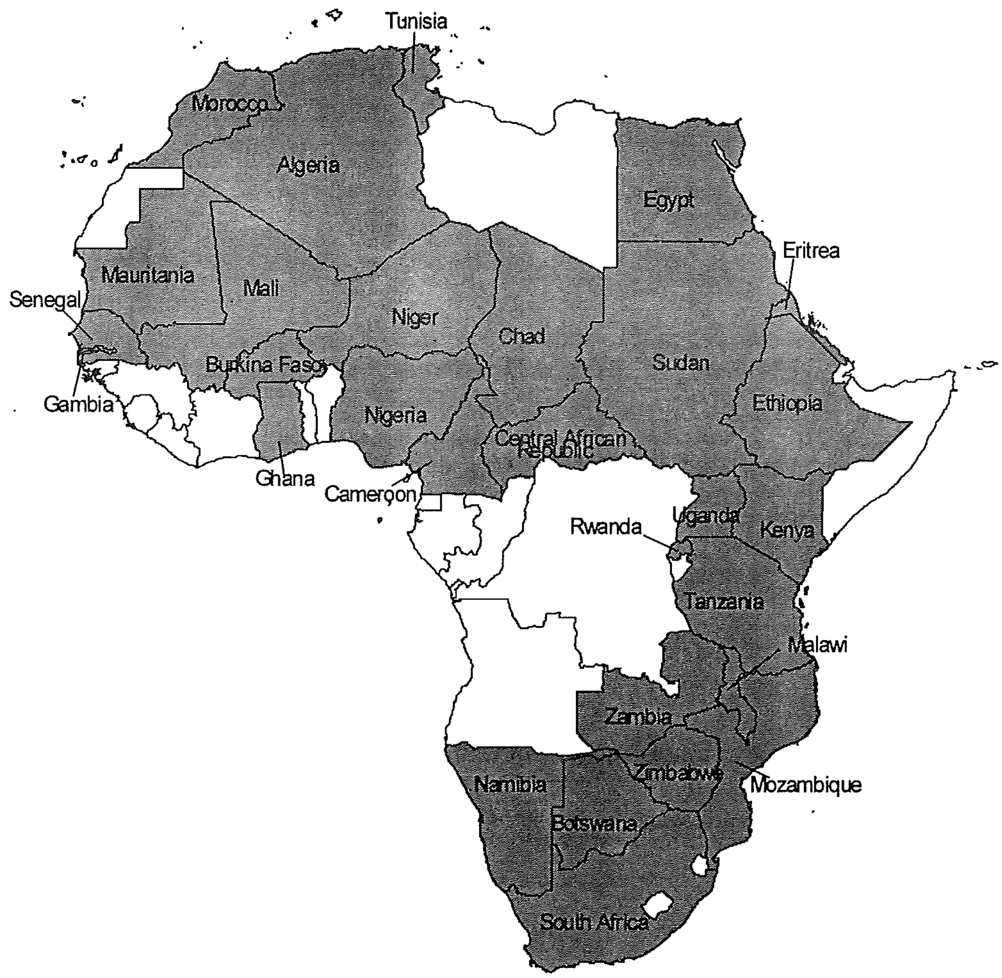

Figure 1. Map of Africa with countries covered by papers in these proceedings shaded.

Of the 97 papers in this proceedings, 71 were presented as papers, posters, handouts, or training sessions at the 1993 African Crane and Wetland Training Workshop. Fourteen papers are crane and wetland action plans that were drafted during the workshop. Addenda to the proceedings include:

- three papers expanding on work presented by David Allan at the workshop, adapted from his recent thesis work on the Blue Crane in South Africa;
- two papers from authors who were registered and sponsored to the workshop, but who were unable to attend;
- three papers from the **Conference on the Black Crowned Crane and its Wetland Habitats in West And Central Africa**, which convened in Kano, Nigeria, in 1992. Papers from that conference provided important information on the status of Black Crowned Cranes across their range from Senegal to Ethiopia, and have not been published elsewhere;
- four papers that provide recent information from geographic areas not covered by the workshop (Niger, Western Chad, and Northern Cameroon) and recent survey results that supplement information presented at the workshop (Okavango and Zambezi Deltas).

Section 1, **Overview**, provides a review of the biology and status of cranes in Africa. The remaining papers are organized in sections by broad geographic region. Section 2, **Crane and Wetland Conservation in Northern Africa**, covers the area from Morocco to Egypt, Ethiopia, and the Middle East, where wintering Demoiselle and Eurasian Cranes occur. Section 3, **Crane and Wetland Conservation in Western and Central Africa**, includes papers covering the range of the Black Crowned Crane, from Senegal to Sudan. Section 4, **Crane and Wetland Conservation in Eastern Africa**, includes papers from Kenya, Rwanda, Tanzania, and Uganda, covering roughly the northern half of the range of Grey Crowned Cranes. Section 5, **Crane and Wetland Conservation in Southern Africa**, covers nations south of Zaire and includes papers on the southern half of the Grey Crowned Crane range, as well as the entire range of Blue and Wattled Cranes. Section 6, **International Perspectives on Crane and Wetland Conservation**, includes selected papers on wetland monitoring and evaluation, and the captive management and reintroduction of cranes. Section 7, **National Crane and Wetland Action Plans**, includes thirteen action plans from countries represented at the workshop and a regional action plan for North and Northeast Africa. Some of the action plans appear as they were drafted at the workshop, others were later revised with input from colleagues who were unable to attend the workshop. The action plans have been formatted according to an outline presented by Dr. Emil Urban at the workshop. All papers have been standardized to American English for consistency.

ACKNOWLEDGMENTS

The 1993 African Crane and Wetland Training Workshop would not have been possible without the generous support of a great number of dedicated individuals and organizations. Air travel and workshop costs for workshop delegates were provided by: Birdlife International of the UK; the Government of Botswana Department of National Parks and Wildlife; the British Council - Kenya; the Department of State of the United States; the East African Wildlife Society of Kenya; the Endangered Wildlife Trust of South Africa; the Mava Foundation of Switzerland; the World Conservation Union (IUCN); Lufthansa Airlines; the John D. and Catherine T. MacArthur Foundation; the Southern African Nature Foundation of South Africa; Dr. and Mrs. Samuel Taylor; Mr. Russell Train; the World Wildlife Fund - U.S.; the Worldwide Fund for Nature - East Africa; and contributions from members of the International Crane Foundation. Dan Martin, Nonie Coulthard, Henri Nsanjama, Curtis Bohlen, Ian MacDonald, Douglas McNeal, and Mark Stanley Price were invaluable in securing this assistance. Publication and distribution costs of these proceedings were met by workshop registration fees.

The workshop was a product of discussions by the African Working Group on Cranes, and organized by George Archibald, Emil Urban, Nathan Gichuki, Nolly Zaloumis, and Richard Beilfuss. Joan Wolhuter and Lindy Rodwell provided invaluable logistical assistance throughout the workshop. Ann Burke helped organize the workshop session on reintroduction and captive management of cranes. Rose Blada and Teresa Searock of the International Crane Foundation helped with workshop mailings and registration. Eric Scott arranged air travel for many of the delegates. Cecilia Gichuki organized travel logistics for ten delegates from East Africa, and made last minute substitutions enabling other delegates to attend. Stephen Newton catalyzed the newly formed North Africa Crane and Wetland Working Group. Thanks are also due to each of the session chairs for their assistance.

In Botswana, grateful thanks are due to Nigel Hunter of the Department of National Parks and Wildlife, Julius Mangabuli and Frederick Mokgwa of the Wildlife Training Institute, Mr. Moraka and Mr. Maakwe of B.P. Botswana for the use of their trucks for the field trip, Pelonomi Venson and other members of the Kalahari Conservation Society, Mr. G. P. Hopcraft, Peter Smith and Fred Ellery for their helpful guidance on the field trips, Tim Longden and Mark Muller for the use of their planes for aerial field trips over the delta, Tim Liversidge, Paul Sheller and his committee of TOCT, Florence Viruly of the Okavango Observer, Jeff Burm, Mr. Wooff-Chief Tsetse Officer, Pony Transport, and Riley's Hotel. We thank also the dedicated staff of the Wildlife Training Institute for allowing us to use the center, for cooking delicious food, and for maintaining comfortable and friendly accommodations throughout the workshop.

Finally, special thanks are due to co-editors Dr. Warwick Tarboton and Dr. Nathan Gichuki for assistance with reviewing and editing the papers from southern Africa and eastern Africa, respectively. Joanne Brown did preliminary copyediting and formatting of many of the papers. Rose Blada helped type several of the manuscripts. Loreli Moore and Steve Bouffard scanned many of the typed papers into computer files. Elena Smirenski carefully edited the final galley proofs. Curt Meine and Jim Harris provided valuable editing advice. Erik Sandin produced the map of Africa showing the countries covered in this volume. Victor Bakhtin designed and illustrated the cover of these proceedings.

1 May 1996

Richard Beilfuss
International Crane Foundation
Baraboo, Wisconsin USA

RESOLUTION ON THE MARROMEU COMPLEX OF THE ZAMBEZI DELTA, MOZAMBIQUE

WHEREAS the Marromeu Complex of the Zambezi Delta, located in Sofala Province in central Mozambique and covering an area of approximately 360 km^2, supports a diversity of important habitats including deciduous miombo woodland, mesic forests, dambos, palm savanna, acacia savanna, seasonally inundated grassland, swamp forest, papyrus swamp, floodplain lakes, mangrove swamps, and coastal dunes and beach;

WHEREAS the Marromeu Complex has an international reputation for its diverse and extensive wildlife populations, in particular vast herds of buffalo and waterbuck on the floodplains, and rare species such as Liechtenstein's hartebeest and sable in the woodlands; and

WHEREAS the Marromeu complex is a major breeding area a significant percentage of the world's population of endangered Wattled Cranes and White Pelicans, and supports abundant populations of waterfowl species;

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana, August 8-15, 1993, urge the nomination and ratification of the Marromeu Complex as a Wetland of International Importance under the Ramsar Convention and as a World Heritage Site under the United Nations.

RESOLUTION ON KAFIN ZAKI DAM IN NIGERIA

WHEREAS the construction of the Kafin Zaki Dam in Northern Nigeria will likely have catastrophic impact on downstream communities in Yobe and Borno States;

WHEREAS independent studies, recently carried out, clearly demonstrate that the natural floodplain agricultural production in the area downstream of the proposed Kafin Zaki Dam greatly exceeds the potential production of the area capable of being irrigated by the Dam;

WHEREAS the natural flood plays an important role in the replenishment of the water table;

WHEREAS the lowering of this will have a major effect on the numerous small villages that are dependent on the aquifer for domestic use and agricultural activities;

WHEREAS up to two million people throughout the north of the two states are likely to be affected in one way or another if the Dam goes ahead;

WHEREAS the loss of essential dry season grazing areas for upwards of half a million head of cattle will put tremendous pressure on resources further south as the grazers are forced to search for suitable pasture further afield; and

WHEREAS Julius Berger Nigeria PLC of Germany is constructing the Kafin Zaki Dam;

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana , August 8-15, 1993, do hereby:

> APPEAL to the National Government of Nigeria to carry out a full environmental impact study on the proposed Kafin Zaki Dam before embarking on a course of action that could have far reaching environmental consequences; and
>
> APPEAL to the Government of Germany to request the Nigerian Government to carry out a full environmental impact study on the proposed Dam before embarking on a course of action that could have far reaching environmental consequences.

RESOLUTION ON RESTORED FLOODING IN THE ZAMBEZI DELTA

WHEREAS the Zambezi Delta in general, and Marromeu Complex in particular, is recognized for its biodiversity and its habitat for large numbers of endangered Wattled Cranes;

WHEREAS the delta requires a natural flooding regime in both timing and volume in order to maintain its ecological processes and integrity;

WHEREAS problems have been identified in the Zambezi Delta due to changes in the flood regime as result of major perturbations in the Zambezi catchment area including the Kariba and Cahora Bassa dams;

WHEREAS these dams primary function is the production of hydro-electricity; and

WHEREAS there is concern with the possibility that further dams might be built;

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana , August 8-15, 1993, call upon the SADCC states within the Zambezi catchment (Angola, Botswana, Mozambique, Namibia, Zambia, and Zimbabwe) to initiate comprehensive Environmental Impact Assessments at the beginning of the planning process, prior to any decisions being made for further water resource development in the Zambezi catchment area; and furthermore

WHEREAS Mozambique is committed to the conservation of its natural resources;

WHEREAS ESKOM is the major client purchasing electricity from the Cahora Bassa scheme; and

WHEREAS South Africa has scientific expertise available;

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana , August 8-15, 1993, call upon the Government Of Mozambique to:

> ENSURE THAT adequate releases of water from the Cahora Bassa Dam be made to simulate natural flooding;
>
> ENSURE THAT such releases are timed to emulate the natural flood hydrography; and
>
> ESTABLISH AND IMPLEMENT a monitoring program to ENSURE THAT the releases take place at the recommended times and volumes; ENSURE THAT the effects of such releases are in fact beneficial to the delta; and ENSURE THAT the releases be fine tuned on the recommendations of the monitoring team to the improved benefit of the ecosystem; and

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana , August 8-15, 1993, call upon the ESKOM to:

> ENSURE THAT it is willing to meet its obligations in the conservation of the environment by making it a condition of purchase of electricity from the Mozambique government that the aforementioned water release and monitoring program be implemented; and

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana , August 8-15, 1993, call upon the Government of South African to:

> MEET its obligations in assisting its neighbors make wise use of their natural resources;
>
> ENCOURAGE the Government of Mozambique to implement the aforementioned water release and monitoring program; and
>
> MAKE expertise available to assist the Mozambique government in establishing this monitoring program.

RESOLUTION ON THE WETLANDS OF SUDAN

WHEREAS the wetlands of the Republic of Sudan are some of the most important and extensive wetlands in Africa, covering more than 700,00 km^2 , providing habitat for thousands of waterfowl and rare and endemic fauna (e.g., Shoebill Stork, sitatunga, and Nile lechwe), and providing important staging areas for thousands of migratory Palearctic birds;

WHEREAS most of the wetlands in the Sudan, and the Sudd in particular, have met and satisfied the criteria of the Ramsar Convention for designation as a Wetland of International Importance;

WHEREAS the Government of Sudan is not a contracting party to the Ramsar convention;

WHEREAS a number of swamps in Sudan are transnational, such as Lotagipi (505,000 ha. in Kenya and 215,000 ha. in Sudan) and Machov (500,000 ha. in Ethiopia and 400,000 ha. in Sudan);

WHEREAS long-term efforts to protect and guarantee the continuation of the wetlands require more attention paid to the conservation and management of catchment areas that feed the wetlands; and

WHEREAS some of these catchment areas occur outside the country where the wetlands occur;

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana , August 8-15, 1993, do hereby

> URGE the Government of Sudan to become a contracting party to the Ramsar Convention and nominate Sudan's wetlands that are of international importance;
>
> URGE the international co-operation of riparian countries to develop joint programs for the management and conservation of transnational wetland areas.

RESOLUTION ON WORLD HERITAGE SITES

WHEREAS World Heritage Sites are proposed and proclaimed all over the world for important conservation areas; and

WHEREAS many World Heritage Sites are proclaimed in countries which cannot afford to maintain them;

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana , August 8-15, 1993, urge the United Nations to recognize the importance of their proclaimed World Heritage Sites, provide specific information about the terms and conditions of World Heritage status, and give substantial financial support for the maintenance of World Heritage Sites.

RESOLUTION ON BLUE CRANES IN SOUTH AFRICA

WHEREAS at the first Southern African Crane Conference held in December 1989, attention was focused on the plight of the Blue Crane, the southern African endemic national bird of the Republic of South Africa; and

WHEREAS Dr. Archibald, Director of the International Crane Foundation, at that time described the Blue Crane as the least studied of the world's fifteen crane species;

NOW THEREFORE BE IT RESOLVED that we, the delegates of the African Crane and Wetland Training Workshop held in Maun, Botswana , August 8-15, 1993, strongly encourage the President of South Africa and Department of Environmental Affairs to support research into various aspects of the biology of the Blue Crane and especially into its migratory movements.

SECTION 1

OVERVIEW

A REVIEW OF THE BIOLOGY AND CONSERVATION STATUS OF CRANES[1]

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ABSTRACT

There is no recent and detailed review of the cranes (Gruidae). This contribution provides such a review, concentrating on the phylogeny, general biology, and conservation of the group. Concerning their general biology, particular attention is paid to the morphology, distribution, foraging habitat, diet, roosts, movements, flocking, territoriality, longevity, and, especially, the breeding habits of these birds. The review is slightly biased towards the relevance of current knowledge to the three southern African crane species, in particular the Blue Crane (*Anthropoides paradiseus*).

The taxonomic incorporation of the cranes in the order Gruiformes has been confirmed by DNA-DNA hybridization studies, which have also confirmed their close relationship with the bustards (Otidides). The closest relative of the Blue Crane is the Demoiselle Crane (*Anthropoides virgo*), and both species differ from other cranes in their emancipation from wetland habitats. Most species have distinctively colored and patterned heads but the Blue Crane is the plainest of the group in this regard. The elongated and convoluted trachea of cranes allows their characteristically far-carrying vocalizations. Cranes do not show obvious sexual dimorphism. Juvenile (first year) cranes resemble adults, but can be recognized from other age classes by subtle cues. Cranes are found on all continents, except South America and Antarctica, with Asia boasting the greatest diversity of species. Africa supports four breeding species and an additional two species which occur as non breeding migrants. Three species occur in southern Africa, all as breeding species.

Most cranes characteristically feed in wetlands but the Blue and Demoiselle Cranes are major exceptions and typically forage in dry habitats throughout the year. Most other species, however, also will forage in drylands, including crop fields, especially out of the breeding season. Cranes are omnivorous but most species are largely vegetarian, especially in the non-breeding period, and their carnivorous habits appear to have been over-estimated by many authorities. All cranes, including the Blue and Demoiselle Cranes, show a strong preference for roosting overnight in shallow waterbodies.

Most cranes of temperate regions are highly migratory but those of more tropical regions show wide variation in the extent of their movements, from being totally sedentary, to evidencing nomadism, and regular or partial migration, including altitudinal migration. There are intraspecific differences in the extent of movements shown by many species. Breeding pairs of cranes defend territories, at least during the breeding period. Flocking is characteristic of cranes which are not breeding and the large proportion of non-breeding, but apparently adult, individuals in crane populations ensures that flocks occur throughout the year. Cranes show prolonged longevity and wild individuals of at least 20 years of age are known.

Cranes are monogamous and pair bonds, once firmly established, probably are life-long, with mated pairs remaining in close proximity to one another throughout the year, even when they join flocks. Age of first breeding is delayed and successful breeding probably is rare before about 3-5 years of age and can occur as late as 5-8 years of age. The large proportion of non-breeding, but apparently adult, birds in crane populations, pronounced longevity, and delayed breeding are all associated and characteristic life history strategies of crane species.

Cranes are reliant on wetlands for breeding, except for the Blue and Demoiselle Cranes which, in addition to being independent of wetlands for foraging, also typically nest in dry habitats. The clutch size in most cranes is remarkably consistent and comprises two eggs. Repeat clutches after initial failure are common in cranes, contrary to statements by some authors. The traditional view that cranes only rear a single young, due to desertion of the second egg and sibling aggression, is incorrect for many, indeed probably most, species and the rearing of two young together, probably by means of 'brood-splitting', is a regular occurrence. The post-

[1] Addendum to the Proceedings. Adapted from Allan, G. 1993. Aspects of the biology and conservation status of the Blue Crane *Anthropoides paradiseus*, and the Ludwig's *Neotis ludwigii* and Stanley's *N. denhami stanleyi* Bustards in Southern Africa. M.S. Thesis. University of Cape Town, South Africa.

fledging dependence period is protracted and juveniles remain with their parents throughout most of the first year of their lives. Family cohesion is maintained even when families join flocks.

The gathering and synthesis of information on breeding success in cranes is hampered by several practical difficulties and methodological differences between reported studies. The proportion of mated pairs that attempt to breed every year appears relatively low. Hatching success has been viewed as high in cranes but recent studies suggest that traditional methods (intermittent nest visits) have over-estimated this measure of breeding success. The mobility of young makes assessment of brood success difficult and even less information is available on post-fledging survival. Assessments of the proportion of breeding pairs with fledged young in the post-breeding period is confounded by the flocking habits of cranes. Counts of the proportion of post-fledging juveniles in crane populations has been used widely in assessing productivity and population health. Such data, however, are open to gross misinterpretation and this largely has been ignored in reports and discussions of crane age ratios.

This review of the general biology of the family highlights its evolutionarily highly conservative nature and there is little diversity in the life history strategies of the various species.

The conservation status of cranes is poor and seven of the fifteen extant species are threatened. One of these species, the Wattled Crane (*Bugeranus carunculatus*), occurs in South Africa. Recent assessments of the conservation status of the other two species occurring in this country, the Grey Crowned (*Balearica regulorum*) and Blue Cranes, the latter of which is virtually endemic, suggest that their populations in South Africa also are decreasing alarmingly. The major threats are habitat destruction and poisoning, the latter largely stemming from the selection by cranes of agricultural habitats. Cranes, however, can show remarkable adaptability to anthropogenic changes to the environment.

INTRODUCTION

Walkinshaw (1973) and Johnsgard (1983) have produced monographs on the characteristic biology of cranes. Their syntheses, however, are somewhat superficial and are now outdated in many instances by information from more recently published studies. These monographs form the basis for the discussion below but have been extensively supplemented and updated here, drawing from additional and more recent sources. The latter monograph provides distribution maps of the breeding and non-breeding ranges of all crane species. The most intensively studied species is the Sandhill Crane (*Grus canadensis*) (Archibald and Pasquier 1987) and much of the current knowledge of crane biology is based on research on this species. A concise summary of the complex patterns of distribution and movements shown by the six sub-species of Sandhill Crane (Lesser *G. c. canadensis*, Greater *G. c. tabida*, Canadian *G. c. rowani*, Florida *G. c. pratensis*, Mississippi *G. c. pulla*, and Cuban *G. c. nesiotes*), along with details of the basic biology and conservation status of this species, is provided by Drewien and Lewis (1987). These authors also provide details on the various sub-populations of the Greater Sandhill Crane.

PHYLOGENY OF CRANES

The phylogeny of cranes relative to other birds

The earliest fossils of crane-like birds appear in Eocene 37-53 million years old) deposits (Johnsgard 1983). Traditionally, cranes have been placed in the family Gruidae, within the order Gruiformes. This classification has been confirmed by the DNA-DNA hybridization studies of Sibley and Ahlquist (1990), whose phylogenetic arrangement has been followed here. The scientific name (*Anthropoides paradisea*) used by Sibley and Ahlquist (1990), and many others, for the Blue Crane, however, has been corrected here, and elsewhere in this review, to *A. paradiseus*, following Clancey *et al.* (1991).

Two unusual taxa, the Limpkin (*Aramus guarauna*) and the sungrebes or finfoots (*Podica senegalensis*, *Heliopais personata*, and *Heliornis fulica*), appear to be the closest living relatives to the cranes. Sibley and Ahlquist (1990) place them in the same superfamily (Gruoidea) as the cranes. The three extant species of trumpeters (*Psophia*), superfamily Psophioidea, share the same parvorder (Gruida) as the cranes, Limpkin and sungrebes. The next most closely related taxa are the seriemas (*Chunga*) and the Kagu (*Rhynochetus jubata*), placed in the parvorder Cariamida. All the above mentioned taxa share the infraorder Gruides. The two other infraorders within the suborder Grui are the Eurypygides, represented by one extant species, the Sunbittern (*Eurypyga helias*), and the Otidides or bustards. Finally, the two other suborders within the Gruiformes are the Ralli, a highly speciose taxon, which includes the crakes, rails, flufftails, moorhens, gallinules, and coots, and the Mesitornithi of Madagascar.

Sibley and Ahlquist (1990) stress that DNA-DNA hybridization studies have not yet been done to confirm the position of *Podica*, *Heliopais*, and the Mesitornithi. Their work, however, does confirm the hotly debated and previously obscured close relationship between the cranes and the bustards.

The relatively ancient order Gruiformes, among which the Rallidae are most speciose, are characterized by several distinctive life history traits, which are shared by most, but not all, members of this taxon. These include a reliance on wetland habitats, a largely vegetarian diet, a tendency towards non-territoriality, and even sociality, out of the breeding season, and monogamous and non-colonial breeding systems. Nests are usually well concealed and placed at, or close to, water-level. Exposed or elevated sites, such as on bare ground, in trees or on cliffs, are rarely used. Some of these traits are in marked contrast to the majority of members of the other major order containing wading birds, the Ciconiiformes, specifically the shorebirds in the infraorder Charadriides (snipes, sandpipers, jacanas, thick-knees or dikkops, oystercatchers, avocets, stilts, plovers, coursers, etc.) and the parvorder Ciconiida (herons, flamingoes, ibises, spoonbills, pelicans, storks, etc.). Members of this latter order are largely carnivorous and often breed colonially, usually in exposed or elevated positions.

Phylogenetic relationships within the cranes

Krajewski (1989) has revised taxonomic relationships within the extant cranes, using DNA-DNA hybridization. He also provides a brief review of the previous taxonomic arrangements within the group. He includes a discussion of Archibald's (1975, 1976) classification, which was based on a study of an important aspect of crane reproductive behavior, their stereotyped intra-pair mating vocalizations (unison calls).

Fifteen extant species are recognized by Krajewski (1989), in two distinct subfamilies. The Balearicinae, or crowned cranes, comprises two species, the Black (*Balearica pavonina*) and Grey (*B. regulorum*) Crowned Cranes, and represent the older lineage. There has been some controversy as to whether these two taxa represent separate species or are merely subspecies of the same form. For example, White (1965), Snow (1978), and Johnsgard (1983) treat them as conspecific, while Walkinshaw (1964, 1973) and Archibald (1975, 1976) consider them to be separate species. The latter opinion appears to have gained ascendancy recently, e.g., Sibley and Monroe (1990), based on morphological (Walkinshaw 1964, 1973), behavioral (Archibald 1975, 1976), electrophoretic (Wood 1979; Ingold *et al.* 1987), and DNA-DNA hybridization (Ingold *et al.* 1989) studies.

The second subfamily, the Gruinae, or gruine cranes, contains 13 species in five species groups (Krajewski 1989). The group 'Grus' contains five species: the Eurasian (*Grus grus*), Hooded (*G. monachus*), Whooping (*G. americana*), Black-necked (*G. nigricollis*), and Redcrowned (*G. japonensis*) Cranes. The group 'Antigone' includes three species: the Sarus (*G. antigone*), Brolga *G. rubicunda*), and Whitenaped (*G. vipio*) Cranes. The 'Anthropoides' group also contains three species: the Demoiselle (*Anthropoides virgo*), Blue (*A. paradiseus*), and Wattled (*Bugeranus carunculatus*) Cranes. The last two groups, 'Leucogeranus' and 'Canadensis', each have only a single representative, the Siberian (*G. leucogeranus*) and Sandhill (*G. canadensis*) Cranes respectively. The crowned and gruine cranes appear to have separated in the Miocene, between 10.0 and 6.2 million years ago (Ingold *et al.* 1989).

Krajewski (1989) suggests that the genera *Anthropoides* and *Bugeranus* should be merged with the genus *Grus*, due to the extremely close genetic similarity between all the gruine cranes, as measured by DNA-DNA hybridization. This suggestion is supported by Ingold *et al.* (1989), who cite Sibley and Ahlquist's (1982) statement that birds have been 'oversplit' at taxonomic levels higher than species. Sibley and Monroe (1990), in their recent checklist of the world's birds, have implemented this proposal. It has not been followed here, however, as the link between the Blue and Demoiselle Cranes, and their distinction from the rest of the gruine species, is considered useful, at least from an ecological viewpoint. Both species differ from all other cranes in being largely independent of wetland habitats when breeding and foraging (Johnsgard 1983). This approach dictates the recognition of *Bugeranus*, which apparently is linked phylogenetically with *Anthropoides* and is relatively distinct from the other gruine cranes (Krajewski 1989).

Hybridization between Wattled and Blue Cranes

Reports of hybridization between Wattled and Blue Cranes in the wild are of particular interest, seen in the light of the close genetic relationship of these two species. Four incidents of hybridization are known from South Africa (Lawson 1968; Johnson 1985; Vernon and Boshoff 1986; W. Tarboton *pers. comm.*). Apparently viable offspring were reared in at least three of these incidents. Wattled Crane populations in South Africa have been severely reduced and fragmented in recent times (Brooke 1984; Geldenhuys 1984; Tarboton 1984; Collar and Stuart 1985; Vernon and Boshoff 1986; Tarboton *et al.* 1987; Brooke and Vernon 1988) and these cases of hybridization have occurred in the smallest and most isolated populations. Indeed, the Wattled Cranes involved in at least two of the incidents apparently were offspring of nearby single Wattled Crane pairs that, by then, were isolated from other conspecifics by distances of more than 100 km. This was brought about by habitat destruction in the intervening areas. The extent to which these incidents are 'natural' therefore is questionable, and they may reflect the anthropogenically induced isolation of these offspring from conspecifics.

Hybridization in the wild, with the production of viable offspring, has also been reported in other cranes, for example, between Hooded and Eurasian Cranes (Nishida 1981) and between Sarus and Brolgas (Archibald 1981b). Brolga/Sarus Crane hybrids appear to be fertile and apparently have mated in the wild with Sarus Cranes to produce viable offspring.

BIOLOGY OF CRANES

Morphology

Cranes are amongst the tallest of flying birds and the Sarus Crane holds the avian record in this regard (Archibald *et al.* 1981). It follows that they are characterized by their long necks and legs. Most species have distinctively colored head and facial features. These usually involve the combination of areas of red plumage, or exposed patches of red skin, surrounded by black, gray, and white plumage, occasionally accompanied by pronounced wattles and ornate crests. The Blue Crane is an exception and has the least patterned head relative to other cranes. The feathering at the rear of the head in adults of this species, however, is elongated, resulting in a distinctive bulbous appearance (Johnsgard 1983). Crane bills are long and straight, and are used for pecking at, or digging for, food. Another typical feature of cranes, although not the crowned cranes, is their elongated and convoluted trachea. This allows them to produce resonant and bugle-like vocalizations. Cranes are not characterized by obvious sexual dimorphism; males and females are similar in size and plumage. Juvenile (first year) cranes resemble adults but in most, if not all, species they can be recognized by relatively subtle differences (e.g., Lewis 1979 for the Sandhill Crane). These can involve the color, pattern, and even length of at least elements of their plumage, their size, the coloration of their bare parts, and their vocalizations.

Distribution

Cranes are found on all the world's continents, except for South America and Antarctica. Asia boasts the highest diversity, with eight breeding species. Two of these, the Demoiselle and Eurasian Cranes, also extend into Europe (western Palearctic) as breeding species. There also is a small, isolated breeding population of the former species in north-eastern Africa (Cramp and Simmons 1980; Urban 1988). Australia has two breeding species, one of which, the Sarus Crane, is shared with Asia. North America is inhabited by two breeding species, the Whooping and Sandhill Cranes. The breeding range of the latter extends into northeastern Siberia (Cramp and Simmons 1980) and therefore it could be considered as a ninth Asian breeding species. Sub-Saharan Africa supports four breeding species, the Black Crowned, Grey Crowned, Blue, and Wattled Cranes. In addition, a further two species, the Demoiselle and Eurasian Cranes, are non-breeding migrants to northeastern sub-Saharan Africa.

Foraging habitat

Most cranes characteristically feed in wetlands. Blue and Demoiselle Cranes are the major exceptions. These two species typically occur in dry habitats. All species, except for the Siberian Crane (Archibald *et al.* 1981), however, will forage in drylands, including crop fields, occasionally or even regularly, especially out of the breeding season (Johnsgard 1983).

The exploitation of man-made crop fields as foraging habitats has been subject to intensive research in the Sandhill Crane (e.g., Lovvorn and Kirkpatrick 1982a; Krapu *et al.* 1984; Iverson *et al.* 1985; Littlefield 1986; Reinecke and Krapu 1986; Iverson *et al.* 1987; Sugden *et al.* 1988) and, to a lesser extent, the Eurasian and Demoiselle Cranes (Alonso, Alonso, and Veiga 1984; Alonso, Alonso, and Veiga 1987; Alonso, Veiga, and Alonso 1987; Khachar *et al.* 1991).

The motivation for these investigations has been driven largely by three factors. Firstly, the perceived or actual economic damage caused to farmers through crop depredations by cranes. Numerous studies mention this problem, e.g., for the Grey Crowned, Eurasian, Hooded, Whitenaped, Blue, and Sandhill Cranes (Pomeroy 1980; Archibald *et al.* 1981; Nishida 1981; van Ee 1981; Walkinshaw 1981a; Geldenhuys 1984; Tarboton 1984, 1992; Johnson and Barnes 1986; Morris 1987; Filmer and Holshausen 1992; Johnson 1992; Stretton 1992; Vernon *et al.* 1992; Youhui 1991). Secondly, the potential relevance of the use of crop fields to the threatened conservation status of at least some populations of these species. Thirdly, in the case of the Sandhill Crane, the significance of these habitats to the management of this species as a legally hunted gamebird. The decision to reinstate the Sandhill Crane as a gamebird was based chiefly on crop damage caused by these birds (Stephen *et al.* 1966; Miller *et al.* 1972).

Diet

Cranes are omnivorous, eating both vegetable and animal (mainly invertebrate) matter. They are largely vegetarian, however, and their carnivorous habits appear to have been over-estimated, or at least over-stressed, by some observers. In fact, an examination of the species accounts in Johnsgard (1983) confirms that vegetable matter predominates in at least 13 species. Only two species, the Whooping and Redcrowned Cranes, reportedly favor invertebrates, although both also take plant material. In the former species, diet has been studied only on the non-breeding grounds (Hunt and Slack 1989), while the diet of the latter is poorly known and requires further study to confirm the alleged preference for animal food. Cranes chicks of all species, however, appear to be fed largely on small invertebrates.

All species, except for the Siberian Crane, occasionally or regularly, indeed during some periods virtually exclusively, feed on crops, e.g., wheat, corn, rice, sorghum, barley, oats, rye, sunflowers, peanuts, soya beans, beans, peas, cabbages, spinach, lucerne, etc. (Pomeroy 1980; Johnsgard 1983; Reinecke and Krapu 1986; Alonso and Alonso 1991; Fulin 1991; Youhui 1991). Cereal crops are particularly favored and the birds usually glean fallen seeds in harvested fields.

The Eurasian Crane seems unusual in regularly feeding on crops which grow below ground and must be probed for and unearthed, i.e., potatoes, sweet potatoes, carrots, beets, and radishes (Swanberg 1987; Fulin 1991; Lan 1991; Youhui 1991). An experimental study (Sugden and Clark 1988) showed that Sandhill Cranes prefer some cereal crops to others. Sometimes this habit brings them into conflict with man and renders them vulnerable to intentional or inadvertent poisoning. Crop damage is not just restricted to feeding on these plants, but also results from trampling, especially during display dancing, and uprooting while searching for invertebrate prey. Exploitation of these unnatural foods is most common during the non-breeding period in most wetland dependent species. The habit has obvious economic, conservation, and management implications.

Detailed dietary analyses exist only for the Sandhill Crane. One study (Mullins and Bizeau 1978) of the diet of this species on its breeding grounds, drawn from gizzard contents, found that natural plant material comprised 73% by volume and the remaining 27% consisted of invertebrate matter. Another study of diet during the non-breeding season (Reinecke and Krapu 1986), based on gut contents, found that plant material comprised 97% by dry weight, exclusively cultivated corn, the remainder being invertebrates. This latter study found that the birds foraged for prolonged periods in natural grasslands and lucerne fields to obtain the relatively small proportion of invertebrates consumed, which they suggest are essential to compensate for the protein and calcium deficiencies in corn. In addition, the birds ate small amounts of lucerne shoots, which also are rich in protein. Mixed farming of crops (cultivated corn) and livestock (natural and lucerne grazing lands) therefore was important for providing suitable foraging habitat for this species. The shortage of natural grasslands limits Sandhill Crane numbers on the non-breeding grounds.

A further study on the non-breeding diet from another locality (Hunt and Slack 1989), based on an analysis of fecal samples, found vegetable matter to comprise 98% by volume and invertebrate matter 2%. Although the plant material consumed consisted almost entirely of natural plants (acorns *Quercus virginiana* and wolfberry *Lycium virginiana*), cultivated grains were the major diet in the region and the samples analyzed, which came from a protected wetland reserve, were from birds which temporarily visited the site to feed on natural vegetation rich in nutrients (ascorbic acid, iron, calcium, and amino acids) that are absent from corn, the main dietary component. These studies suggest that the heavy reliance of cranes on cultivated crops, which are poor in certain nutrients, could have significant physiological consequences for these birds.

Roosts

All cranes, including Blue and Demoiselle Cranes, show a strong preference for roosting communally at night in shallow waterbodies. The crowned cranes are unique in regularly roosting in trees (Walkinshaw 1964; Pomeroy 1980; Frame 1982; Urban *et al.* 1986; Urban 1987) and even on wooden or steel overhead transmission structures (*pers. obs.* in the Eastern Transvaal and Eastern Cape, South Africa).

Detailed investigations have been carried out on the characteristics and use of roosts by Sandhill (e.g., Lovvorn and Kirkpatrick 1981; Melvin and Temple 1983; Krapu *et al.* 1984; Iverson *et al.* 1985; Littlefield 1986; Iverson *et al.* 1987; Sugden et al 1988; Folk and Tacha 1990; Pogson and Lindstedt 1991), Eurasian (Alonso, Alonso, and Veiga 1984; Alonso *et al.* 1985; Alonso, Alonso, and Veiga 1987; Alonso, Veiga, and Alonso 1987), and Hooded (Kawamura 1981) Cranes. These studies have been spurred by the demonstrated importance of roosts in dictating the habits of cranes. These include their patterns of large-scale distribution, abundance, local dispersion, and use of foraging habitats. The spatial concentration of large numbers of cranes inherent to their use of communal roosts has obvious significance, relevant to crop damage, conservation, and management. Cranes show flexibility in their use of roosts and can adapt to using artificial or human regulated waterbodies and to anthropogenic changes in roost availability (Lovvorn and Kirkpatrick 1981; Pogson and Lindstedt 1991). Archibald *et al.* (1981) and Kawamura (1991) stress the importance of secure roosting sites in the conservation of cranes.

Movements

Most cranes inhabiting temperate regions are strongly migratory, with widely disjunct breeding and wintering ranges. Cranes typically concentrate at traditional localities prior to, and during, migration, and the term 'staging areas' has been coined for these sites (Krapu 1987). Tropical species are more sedentary but can show marked local movements and some nomadism, although the extent of these can differ between populations of the same species. Some of the movements shown by tropical cranes are between large wetland systems, others apparently are seasonal altitudinal movements, and some are related to drought conditions. For example, a low level of vagrancy has been reported for the Grey Crowned Crane in South Africa (Geldenhuys 1984; Tarboton 1992). Many of the Wattled Cranes breeding in the vast Kafue Flats of southern Zambia frequently visit the Makgadikgadi wetlands in northern Botswana but the extent of this movement varies between years (Konrad 1981). By contrast, the Transvaal population in South Africa is wholly sedentary (Tarboton 1984). Altitudinal movements have been reported for the Blue Crane in Natal, South Africa (Walkinshaw 1963, 1973). Movements related to drought conditions occur in the Brolga (Blackman 1978 *in* Johnsgard 1983).

Extreme variation in the extent of migration can occur even in temperate species. For example, the Sandhill Crane has some populations which annually migrate over thousands of kilometers between their breeding grounds in the Arctic tundra and the southern United States, while the southernmost breeding populations are entirely sedentary (Drewien and Lewis 1987). Cranes also show adaptability in their patterns of movements in response to man-made influences. These responses include alterations to migratory routes, stopovers and timing (Littlefield 1986; Fulin 1991; Pogson and Lindstedt 1991; Genard and Lanusse 1992). Eurasian Cranes which used to winter largely in northwestern Africa now spend most of the winter in Spain due to habitat destruction in the former area and increased cereal farming in the latter region (Alonso, Veiga, and Alonso 1987).

Gruine cranes employ a combination of soaring, downward gliding and flapping flight when migrating and undertaking other, short-distance movements (Pennycuick *et al.* 1979; Johnsgard 1983; Kuyt 1987; Williams *et al.* 1991). Blue Cranes soar regularly (Maclean 1985; Urban *et al.* 1986; *pers. obs.*). Pennycuick *et al.* (1979) state that it is unclear whether the crowned cranes soar. During the period 1982-1992, details of 178 observations of Grey Crowned Cranes were recorded in the Transvaal and Transkei, South Africa, including 21 observations of birds in flight (*pers. obs.*). In no instance was soaring flight observed.

Migratory flights, and even flights between foraging areas and roosts, in at least some cranes, occur occasionally and even regularly at night (Pennycuick *et al.* 1979; Lovvorn and Kirkpatrick 1981; Nesbitt and Hintermister 1984; Alonso *et al.* 1985; Urban *et al.* 1986; Kovshar 1987; Deppe 1991; Williams *et al.* 1991).

Flocking

Most cranes are gregarious in the non-breeding season. Flocking is characteristic, particularly in migratory species, and can involve hundreds or even thousands of individuals. The foraging and predator detection advantages of flocking in the Eurasian Crane are discussed by Alonso and Alonso (1991). The term 'floaters' has been coined for flocks of unmated cranes, i.e. immatures and unmated adults (Tarboton 1984; Tarboton *et al.* 1987). Flocks of non-breeding cranes can be found at all times of year, including during the breeding season, and can comprise a substantial proportion of the total population (Table 1). For most species the proportion of non-breeders is based on counts of cranes not isolated in pairs during the breeding season. Non-breeders comprise 50% or more of the population in most species. The data presented for the Grey Crowned Crane in East Africa and the Wattled Crane are confounded by the protracted breeding seasons of these species (Irwin 1981; Konrad 1981; Pomeroy 1987; Tarboton *et al.* 1987), i.e., many pairs that bred at times other than when some of the counts were made could have been in apparent flocks of non-breeders when counted. This problem is likely to affect the assessment of the proportion of non-breeders in other species as well, but probably to a lesser extent.

The significance of high numbers of non-breeders to the conservation status of cranes has been discussed by Tarboton *et al.* (1987). On the one hand, it may represent a healthy surplus of individuals precluded from breeding by saturation of the breeding habitat by established pairs. On the other hand, it may represent large numbers of breeding birds temporarily or permanently displaced from their breeding sites by droughts or wetland destruction.

Many studies show that flocks of cranes are unstable social units, with flocks regularly splitting up or merging with other groups (e.g., Pennycuick *et al.* 1979; Tacha 1988). For example, observed flock sizes tend to vary with time of day (Miller and Stephen 1966; Alonso, Veiga, and Alonso 1987). Mated pairs and family groups, however, are highly stable and the individuals comprising such groups remain in close proximity to one another, even when within large flocks (Miller and Stephen 1966; Lovvorn and Kirkpatrick 1982b; Layne 1983; Tacha 1988; Tacha and Vohs 1984).

Territoriality

The extent of territoriality while breeding is poorly known for most species. Nests, however, usually are well spaced (Johnsgard 1983) but occasionally are sited close together (e.g., Masterson 1986). Mated pairs of non-migratory Sandhill Cranes defend territories, while unmated adults do not establish territories (Nesbitt and Williams 1990). Some mated pairs remain on their territories throughout the year, while others vacate their territories during the post-breeding period. During the period after breeding, these cranes regularly feed in dryland habitats. Pairs having dryland habitats within their territories remain resident, while those without such habitat in their territories vacate them to flock with other cranes in dryland areas. Territoriality by family groups on the non-breeding grounds has been found in the Whooping (Allen 1952; Blankinship 1976), Hooded (Kawamura 1987), and Siberian (Sauey 1987) Cranes. In the Hooded Crane (Eguchi *et al.* 1991) the protection of a food supply for the juveniles has been suggested as the reason for territoriality in the wintering quarters.

Longevity

Wild cranes probably are long-lived, a feature suggested by their low breeding productivity and age of first breeding (see under 'Breeding' below). Sufficient data from studies employing individually marked birds to confirm longevity exist only for the Sandhill Crane, and, even for this species, the relevant information is meager. Ringing data suggest an annual mortality rate of about 22% and a population turnover rate of about 15 years (Johnsgard 1983). These ringing data, however, probably are not representative of wild crane populations, as many recoveries came from hunted birds. Johnsgard's analysis is aimed at stressing the potential over-harvesting of this species, rather than at examining natural survival rates and longevity of wild crane populations per se. He does, however, identify two further biases inherent to such ringing studies of long-lived species, i.e., ringed birds surviving beyond the analysis period and ring loss, which would inflate mortality estimates. In one study using marked Sandhill Cranes (Tacha *et al.* 1989) five individuals survived for at least nine years, and in another (Nesbitt 1992) some individuals that were at least 19 years old were still breeding successfully.

A color-ringing study of Hooded and Whitenaped Cranes (Ozaki 1991) showed that 70% and 78%, respectively, of cranes color-ringed on the wintering grounds returned the following year. A higher proportion of adults (78% and 82%, respectively) were seen the following year, compared to juveniles (60% and 70%, respectively).

A model of survivorship in the Whooping Crane (Binkley and Miller 1980), based on counts of adults and juveniles on the wintering grounds, suggested that mortality is high in the first year (almost 40%), drops off dramatically in the second year, then rises slowly (to about 10%) in the 15th year, when it accelerates dramatically to reach about 50% in the 22nd year. They suggest a maximum longevity of 22-24 years. A recent study suggests that mortality in this species appears to be highest during migration (Lewis 1991).

Captive cranes typically live for long periods. Johnsgard (1983) shows that survival in captivity beyond 20 years is regular. A Siberian Crane, which lived for 82 years in captivity, evidenced the longest known life-span of any bird (Matthews and McWhirter 1992). These records demonstrate the potential for extended longevity in wild cranes.

Breeding

Mating system and age of first breeding

Cranes are monogamous, probably with life-long pair bonds (Nesbitt and Wenner 1987; Tacha 1988). Mated pairs remain together throughout the year. 'Divorce', however, has been recorded in the Sandhill Crane (Littlefield 1981b).

Most cranes probably do not breed until they are two to five years old (Cramp and Simmons 1980), but age of first breeding in the wild has only been intensively investigated for the Sandhill Crane. Pair bonds in this species are initiated within flocks of non-breeders (Nesbitt and Wenner 1987, Nesbitt 1989, 1992). Initial pairings occur at the end of a crane's second year, and are followed by breeding attempts early in the third year. These, however, are usually ephemeral and the typical sub-adult pairs five times with different individuals before breeding successfully. The earliest and mean age of successful breeding is three and five years, respectively, in both migratory (Greater Sandhill Cranes) and sedentary (Florida Sandhill Cranes) populations. The modal age of first successful breeding, however, was five years in sedentary populations and four years in migratory populations. The duration of pair bonds was related to breeding success. Pairs that did not breed successfully in their initial breeding attempts frequently separated, while those that were successful tended to remain together, even if they failed in subsequent breeding attempts.

Another study (Tacha *et al.* 1984) also found that pair bonds were formed in flocks of non-breeders. Tacha *et al.* (1989) studied age of first breeding in a different population of migratory Sandhill Cranes (Lesser Sandhill Cranes). They found the earliest age of pairing to be three years old, 20% of individuals were paired by four years old, most formed pair bonds during their fifth or sixth years, and virtually all were paired by age eight. The earliest age of first successful reproduction was five years but most individuals did not breed successfully until they were seven or eight years old.

First, but unsuccessful, breeding (egglaying) by two pairs of three year old birds has been found in wild Whooping Cranes (Kuyt 1981).

Nest sites

Most cranes nest in wetlands, sometimes man-made (e.g., White 1987 for the Brolga), constructing a nest mound of wetland vegetation to raise the eggs above water level. The Blue and Demoiselle Cranes are exceptions. These two species, in addition to being independent of wetlands for foraging, also nest in dryland habitats. Eggs are laid directly on the ground, with little or no nesting material involved (Walkinshaw 1963; Xueming and Junchang 1991). Both species occasionally line the nest scrape with small stones (Walkinshaw 1963; Johnsgard 1983; Schoff 1991). Demoiselle Cranes breed in agricultural fields in some parts of their range (Kovshar 1987; Winter 1991). The Sandhill Crane, the nests of which are usually restricted to wetland sites, occasionally nests in dry situations (Layne 1982; Toland 1991). About 50% of Mississippi Sandhill Crane nests are on dry ground but always adjacent to wetland habitats (Valentine 1981). Cuban Sandhill Cranes characteristically nest, and even forage, virtually entirely in dry situations (Walkinshaw 1953). Grey Crowned Cranes, remarkably, have been recorded nesting occasionally in trees, and in at least two of three southern African records the abandoned stick nests of other large birds were used (Steyn and Ellman-Brown 1974; Lees 1977).

Eggs

The eggs of gruine cranes are richly colored and patterned, but those of the crowned cranes are plain white.

<u>Clutch sizes</u>

Studies of captive birds show that cranes are indeterminate layers and that individual females can be induced to lay 8-9 eggs by removing eggs as they are laid. Up to 17 eggs have been elicited from a single female during the course of one breeding season using this method (Derrickson and Carpenter 1987).

The typical clutch size of most wild gruine cranes is remarkably consistent between species and usually comprises two eggs, sometimes one, and very rarely three (Table 2). The data on clutch sizes presented in Johnsgard (1983) have been included in Table 2.

How many of the observed single egg clutches represent incomplete clutches is unclear in most studies. Crane eggs within clutches are laid two to four days apart (Cramp and Simmons 1980) and therefore many observations of single eggs may be of incomplete clutches (Thompson 1970). Indeed, as the incubation period in most cranes is approximately 30 days (Johnsgard 1983) and eggs usually are laid two days apart, about 7% of clutches examined could be expected to be incomplete. The problem of accurately determining clutch sizes is highlighted by examples of Sandhill Crane nests from which one of the two eggs disappeared during incubation (Thompson 1970). Another instance of a three egg clutch in the Sandhill Crane was attributed to two females laying in the same nest (Littlefield 1981a).

The clutch sizes of Wattled and crowned cranes are exceptions to the typical two-egg clutch of cranes. The former regularly lays a single egg, and the crowned cranes regularly lay three, and occasionally even four, eggs per clutch (Table 2). The eggs in single-egg clutches of Wattled Cranes are significantly heavier than the eggs in two-egg clutches (Johnson and Barnes 1991).

Replacement clutches

Johnsgard (1983) states that the laying of repeat clutches to replace earlier eggs or broods lost is unusual in cranes. This may be incorrect. In the sedentary Florida Sandhill Crane, 77% of pairs that failed after egglaying during their first breeding attempt laid a second clutch, and 80% that failed during their second attempt laid a third clutch (Nesbitt 1988). One pair even laid a fourth clutch. Repeat clutches were laid within 18-20 days of the loss of the previous clutch. Later clutches were more successful than earlier ones and re-nesting did not affect clutch size or fertility. In a different population of this subspecies, 70% of pairs that failed during their first attempt laid a second clutch, and that 29-40% that failed during their second attempt laid a third clutch (Bennett and Bennett 1990). Repeat clutches were laid within 7-25 days. There was no significant difference in clutch size or hatching success between earlier and later clutches, but brood success was significantly higher for later broods. In a third population of this subspecies, an estimated 21% of breeding attempts were repeat attempts (Dwyer and Tanner 1992).

Second and third clutches also have been found in the Eurasian Crane (Cramp and Simmons 1980; Neumann 1987). Repeat clutches have been recorded for the Wattled Crane in the Transvaal (Tarboton 1984) and Natal (Johnson and Barnes 1991). In the latter area, a third clutch after two successive failures in the same breeding season was observed and repeat nesting after failure was found to be usual and occurred soon after the earlier failure. The success of repeat clutches was similar to that of first clutches in Natal. There was some evidence that repeat clutches were larger than initial clutches, i.e., more likely to comprise two eggs. Repeat clutches have been reported for at least the Grey Crowned (Pomeroy 1980; Mafabi 1991), Whitenaped (Liying *et al.* 1991), Redcrowned (Jie *et al.* 1991), and Blue (Tarboton 1976) Cranes. No difference in fertility, or weights, between the eggs in first and subsequent clutches has been reported in the Redcrowned Crane during artificial manipulation (Jie *et al.* 1991). Whooping Cranes, however, apparently rarely replace lost clutches (Kuyt 1981).

Information from captive cranes provided by Dr. George Archibald (*in lit.*) is illuminating with reference to replacement clutches. Captive Florida Sandhill Cranes can be induced to lay several clutches over about a six-month period. This species is sedentary in the wild. Captive Greater Sandhill Cranes, which are migratory, by contrast can produce eggs only for a few weeks or months per annum. Similarly, captive Brolga and Sarus Cranes, and crowned cranes can produce eggs over a longer period than can other strongly migratory species.

Young

Crane chicks are precocial and nidifugous and can leave their nest sites and accompany their parents within at least two days of hatching (Cramp and Simmons 1980).

Brood sizes

Data on brood sizes in cranes are presented in Table 3. The Whooping, Wattled, and Siberian Cranes have been excluded from Table 3, as these three species usually rear only a single young per breeding attempt (Novakowski 1966; Flint and Kistchinski 1981; Konrad 1981; Tarboton *et al.* 1987). Whooping Cranes, however, have been subject to the removal of single eggs from two-egg clutches during management and prior to this 14.5% of pairs on the wintering grounds were accompanied by two young (Walkinshaw 1973). Wattled Crane pairs with broods of two chicks have been seen twice in Malawi (Collar and Stuart 1985), and two pairs out of 117 pairs with fledged young had two chicks in Zambia (Benson and Pitman 1964). On only two occasions have Siberian Crane pairs on the wintering grounds been accompanied by two young (Zhigang *et al.* 1991). 'Adopted' juveniles (Masatomi 1972) could be the explanation for families of more than three members.

Miller (1973) discusses brood size in the Whooping and Sandhill Cranes. In the Whooping Crane, citing Novakowski

(1966), he attributes the loss of the second hatched chick under natural conditions to its being abandoned by the parents. The Wattled Crane appears similar to the Whooping Crane in this regard. Only a single young is reared per breeding attempt, despite two eggs regularly being laid (Konrad 1981). In this species, the second egg is abandoned as soon as the first hatches (Tarboton *et al.* 1987; Johnson and Barnes 1991). In captivity, strong inter-chick aggression has been noted in this species (Abrey 1992). Sibling aggression in the Whooping Crane may be implicated in the loss of the second chick (Erickson and Derrickson 1981). Siberian Cranes also rarely raise more than a single chick per brood, and this has been attributed to sibling aggression (Flint and Kistchinski 1981; Bin and Zuoyi 1991). Putnam and Archibald (1987) state that chicks of this species show the most intense and prolonged inter-chick aggression, relative to other cranes.

In the Sandhill Crane, Miller (1973) attributes the loss of the second chick to sibling aggression. He states that the raising of two young is 'not common'. The evidence he provides to support this is his observation that of 623 wintering families of Lesser Sandhill Cranes, only one pair had two young and an 'adopted' young was possibly involved in that instance. He cites the observations by Hyde (1957) and Walkinshaw (1965a) of sibling aggression in the wild and several unpublished reports for captive birds. Walkinshaw (1981a) and Miller *et al.* (1972) repeat that there is strong inter-sibling aggression in wild Sandhill Crane chicks, occasionally resulting in the death of the second chick. Aggression between crane chicks in all species is well known in captivity (Larue 1981; Derrickson and Carpenter 1987). Walkinshaw (1965a, 1981a), however, points out that the successful rearing of two young together does occur and is brought about by the parents dividing the brood between them ('brood splitting').

Sibling aggression, sometimes resulting in the death of the smaller chick, also has been recorded in the Eurasian Crane (Cramp and Simmons 1980). Brood splitting is believed to be the key to the survival of both young in this species (Cramp and Simmons 1980). Masatomi (1981) reports sibling aggression in the Redcrowned Crane and suggests it may lead to mortality in broods of two young. All the evidence presented above contradicts the statement by Maclean (1991) that there "is no siblicide in any species of crane, as far as is known". Dehao *et al.* (1991) note that siblicide has been alleged as regular in the Blacknecked Crane. Their observations, however, of a brood of two young in this species lead them to conclude that, although some sibling aggression was noted, it was unlikely to result in mortality. Aggression only occurred on the day the second chick hatched and the relationship between the two chicks was harmonious after they left the nest the following day. In the Demoiselle Crane, parents have been observed to split the brood but no fighting was observed between young at any stage in the wild (Winter 1991). Sibling aggression has been seen in wild Blue Crane chicks (Walkinshaw 1963) and was characteristic and intense in young reared in captivity at a bird park ('World of Birds') in Cape Town (W. Mangold *pers. comm.*).

If brood splitting is necessary for two young to be reared simultaneously, due to sibling aggression, then this aggression militates against a clutch size of more than two eggs and indeed may be the key factor determining clutch size in these birds.

Miller (1973), however, has significantly under-estimated the proportion of two-chick broods in some cranes, including subspecies of the Sandhill Crane other than the Lesser Sandhill Crane, and therefore the frequency with which a fatal outcome to sibling aggression is avoided. Both young produced by the typical two-egg clutch of most of the gruine cranes regularly are reared together successfully (Table 3). Between 12% and 67% of fledged broods consisted of two young in the seven gruine species examined. In Greater and Florida Sandhill Cranes, 12-44% of fledged broods had two young. Bin and Zuoyi (1991) found that fledged brood sizes of most families of Whitenaped Cranes on their wintering grounds consisted of two young, but do not report full details. Dwyer and Tanner (1992) in their study of Florida Sandhill Cranes, reported that "both members of a brood seldom survived", but do not provide supporting details. In some cases, however, where a brood of two young is observed with a pair that are out of their breeding territory, it is possible that one of the young could have been 'adopted' after wandering away from its own parents (G. Archibald *in lit.*).

In the Eurasian Crane, fledged brood sizes were similar between years and localities, despite relatively large differences in the proportion of successful breeding pairs between years and localities (Prange and Mewes 1991). Nilsson (1982) and Alonso *et al.* (1987), however, found that brood sizes were positively correlated with the relative proportion of successful breeding pairs in this species.

Broods of three young have been recorded regularly for Grey Crowned Cranes, at least in East Africa (Pomeroy 1980; Frame 1982; Mafabi 1991). At least two of these instances involved recently fledged young, and the role of sibling aggression and brood-splitting requires investigation in this species.

Post-fledging dependence period

Young cranes typically remain with their parents for several months, up to a year, after fledging (e.g., Tacha 1988; Alonso, Veiga, and Alonso 1987). Even when family units join up with flocks, the young remain in close proximity to their parents, including during migration (Miller and Stephen 1966; Lovvorn and Kirkpatrick 1982b; Layne 1983; Tacha and Vohs 1984). In one study of the Sandhill Crane, 90% of juveniles remained with their parents throughout the sojourn on the wintering grounds and parent-offspring units only disintegrated halfway through the return migration to the breeding grounds (Tacha 1988). Young Whooping Cranes also only leave their parents during the return migration to the breeding grounds (Lingle *et al.* 1991). In the Eurasian Crane, family cohesion gradually decreases on the wintering grounds and juveniles depart for the breeding grounds after adults (Alonso, Veiga, and Alonso 1984). Siberian Crane juveniles are reliant on their parents for food virtually throughout the period on the wintering grounds and only learn to find food for themselves during the final weeks before the return migration (Zhiyong and Bin 1991).

Breeding productivity

There are few studies of productivity based on monitoring the success of individual breeding pairs. Bennett and Bennett (1990), Dwyer and Tanner (1992), and Nesbitt (1988, 1992) provide useful reviews of such studies for the Sandhill Crane. It is difficult to compare directly the results of many studies of breeding productivity in cranes, due to differences in methodology, analysis and presentation between them. For example, some of these studies exclude data from nests that failed due to human disturbance (e.g., Walkinshaw 1949), while others include data from such nests (e.g., Bennett and Bennett 1990).

The monitoring of breeding productivity is hampered by several practical difficulties. One problem lies in the interpretation of the status of the individuals occurring in non-breeding flocks during the breeding season. This segment of the population can be relatively large, and can exceed the number of breeding birds (see under 'Flocking' above and Table 4). Some of these birds doubtless are below the age when pairing and breeding usually occur (see under 'Mating system and age of first breeding' above). Some, perhaps many, however, probably are old enough to breed but either have not yet paired, or have paired but have not yet established a breeding territory (Nesbitt 1987). They may have previously bred but have lost breeding status due to loss of their mates, or are mated pairs that have bred previously but are not breeding in that particular breeding season (Konrad 1981). For example, in the Sandhill Crane, breeding females that lost their mates rejoined flocks of non-breeders, and, in some instances, it was several years before they re-paired and bred again (Nesbitt 1989). In the Eurasian Crane, most non-breeders in flocks are believed to be adults, including some established pairs that are not breeding in any particular year (Prange and Mewes 1991).

The flocking habits of cranes and the problem that, in most species, only two age classes can be distinguished (first-year birds from those in their second year and older) militate against the identification of these different classes of individuals, without a long-term, extensive marking program.

A further difficulty involves the initial breeding attempts made by cranes. For example, Nesbitt and Wenner (1987) found that in the Sandhill Crane, initial pairings, accompanied by the establishment of a territory, were usually ephemeral, and that nest building and the successful production of eggs and young was uncommon during these liaisons (see under 'Mating system and age of first breeding' above). Similar behavior has been reported in 'young' pairs of Eurasian Cranes (Bylin 1980). Nesbitt and Wenner (1987) report that pair bonds in Sandhill Cranes only become permanent after successful breeding. The extent to which breeding attempts by novice pairs should be included when assessing breeding productivity is debatable. It is likely that such breeding attempts frequently are overlooked. For example, the low nesting success found by Nesbitt (1988) for the Sandhill Crane, relative to other studies of this species, has been attributed to the intensity of his study, which resulted in the location and inclusion of breeding attempts by novice pairs, which would have been overlooked in other studies (Dwyer and Tanner 1992). Assessment of productivity is perhaps best restricted to established breeding pairs, with a history of at least one successful breeding attempt.

The occurrence of repeat breeding attempts (see under 'Repeat clutches' above) after initial failure in the same season further confounds measures of annual breeding productivity (e.g., Dwyer and Tanner 1992), unless the birds monitored are individually marked. Repeat attempts can result in the under-estimation of annual breeding productivity. For example, it is not possible to calculate the mean number of young reared/pair/annum from the data presented by Bennett and Bennett (1990), due to the high proportion of repeat attempts.

The mobility of the young can make it difficult to determine whether the eggs in a nest hatched or not. An empty nest may have failed at the egg stage or the young may have left the nest. This mobility of chicks during the fledgling period also can make it problematic to monitor their survival during this time. The characteristic measure of breeding success, number of chicks 'fledged', has little meaning in cranes, which are ground-dwelling and have offspring dependence periods that extend far beyond the age of first flying in the young (see under 'Post-fledging dependence period' above). Measurement of chick survival to independence requires the monitoring of young until virtually the end of their first year.

Despite the problems outlined above, many studies provide information about breeding productivity based on some measure of breeding success, as discussed below. The relevance of age of first breeding, clutch and brood sizes, and repeat clutches to breeding productivity will not be discussed in detail, as these have already been mentioned. The data on the Grey Crowned Crane in East Africa and the Wattled Crane presented in several of the sections below are biased by the protracted breeding seasons of these species (Irwin 1981; Konrad 1981; Pomeroy 1987; Tarboton *et al.* 1987). Some pairs would have bred outside the periods when many of the assessments of breeding status and success were made.

Proportion of pairs attempting to breed each year

This is one of the most poorly-known aspects of breeding ecology, largely due to non-breeding pairs frequently joining flocks and therefore being overlooked (Konrad 1981, Prange and Mewes 1991). As most cranes are dependent on wetlands for breeding and the extent of these habitats frequently fluctuates according to local rainfall conditions, it can be expected that some pairs will be precluded from breeding at sites previously used by them, and that these birds will join flocks when drought conditions prevail (e.g., Kuyt 1981, Tarboton *et al.* 1987). Wetland habitats are subject to anthropogenic disturbance (e.g., Archibald *et al.* 1981) and some pairs may be forced to abandon their territories and join flocks when their breeding sites are destroyed (Tarboton *et al.* 1987).

The proportion of pairs in several crane species that do not attempt to breed every year is presented in Table 4. The information presented for the Wattled Crane comes from the Kafue Flats in Zambia, where the proportion of pairs attempting to breed annually fluctuates widely, depending on the flooding of the wetland system (Douthwaite 1974). In normal years, a maximum of 40% of pairs attempts to breed, falling to only 3% in years of unfavorable flooding. Concerning the data for the Florida Sandhill Crane, Layne (1983) ignored any pairs that were in flocks, which results in an under-estimation of the proportion of pairs not attempting to breed. He also cautioned that he was unable to identify the proportion of novice pairs in his sample.

Hatching success

Hatching success can be presented either as the success of each individual egg in each clutch monitored (e.g., Kuyt 1981), or can be defined as a nest in which at least one egg hatched (e.g., Dwyer and Tanner 1992). The latter is more easily and reliably determined. Johnsgard (1983) provides a brief review of hatching success in cranes. More recent studies providing and reviewing hatching success data on Sandhill Cranes include Nesbitt (1988), Bennett and Bennett (1990), and Dwyer and Tanner (1992). Table 5 summarizes data from all the studies cited by these authors and additional information not mentioned by them. The data reproduced in Johnsgard's (1983) review contains some omissions and mistakes, when compared with the original publications cited, and these have been amended in Table 5.

Hatching success would appear relatively high in cranes (Table 5). Recent studies (Nesbitt 1988; Dwyer and Tanner 1992), however, suggest that traditional methods of determining hatching success in cranes (intermittent nest visits) may significantly over-estimate this measure of breeding success. Nesbitt (1988) found hatching success rates of only 39% and 48%, for eggs and nests respectively, in the Florida Sandhill Crane, and attributed this to the intensity of his study, which located and included novice pairs that frequently abandoned clutches soon after laying them. Dwyer and Tanner (1992) were the first to employ the Mayfield method (Mayfield 1961, 1975) in assessing breeding success in cranes. They found a hatching success rate (per nest) of 59% in Florida Sandhill Cranes, whereas use of the traditional method would have given a figure of 68%. The Mayfield method is preferable, as it compensates for nests which failed soon after initiation and before being discovered.

Brood success

Brood success (Table 6), similar to hatching success, can be expressed either as the proportion of individual young fledged relative to the number of eggs hatched (e.g., Masatomi 1981), or as the proportion of broods in which at least one young fledged (e.g., Bennett and Bennett 1990). Relevant to the data on the Whooping Crane (Table 6), which almost exclusively rears a single chick per breeding attempt (see under 'Brood sizes' above), the proportion of young fledged equals the proportion of broods that were successful.

Layne (1983) showed that there was a decrease in mean brood size in Florida Sandhill Cranes, due to the attrition of individual young, during the course of the fledgling period, with a mean of 1.71 young/brood (n=17 broods) during the first month, 1.62 young/brood (n=26 broods) 2-3 months of age, and 1.44 young/brood (n=142 broods) after three months. Florida Sandhill Cranes fledge at about three months old. This decrease in mean brood size does not accurately measure brood success, however, as loss of entire broods is overlooked.

Even less information is available on survival during the post-fledging to independence period. About 25% of Whooping Crane chicks survive from hatching to arrival on the wintering grounds in Texas (Erickson and Derrickson 1981), with 35% dying during the fledgling period and 40% perishing between fledging and completing the southward migration. In the Lesser Sandhill Crane, about 80% of young survive between fledging and arrival on the wintering grounds (Tacha *et al.* 1989). Nesbitt (1992) reports that 82% of young Florida Sandhill Cranes survive from fledging to independence (248-321 days old). The probability of surviving from hatching to independence was 57% in his study. In the Eurasian (Alonso, Veiga, and Alonso 1987) and Siberian (Zhigang *et al.* 1991) Cranes, age ratio data (see under 'Percentage of juveniles in other cranes' below) suggest that 6.7% and 22.2%, respectively, of juveniles die during the winter period. These estimates, however, are based on the assumption that adult mortality during this period is zero, which probably is unrealistic.

Proportion of pairs with fledged young

Another measure of breeding success is the proportion of pairs with and without fledged young in the post-breeding period. This information is relatively easily obtained. Its accuracy, however, again is compromised by the problem of some pairs without young joining flocks, especially as pairs with young avoid flocks (Miller and Hatfield 1974; Tacha and Vohs 1984; Alonso, Veiga, and Alonso 1987; Bishop 1988). This would result in a tendency to over-estimate the success of breeding pairs. In addition, it can be difficult to identify the members of different pairs and their offspring in flocks (Layne 1983; *pers. obs.*), which presents the practical problem of assessing brood size, i.e., one pair with two chicks or two pairs with one chick?

Several studies present data on the proportion of pairs with fledged young, relative to the total number of pairs (Table 7).

Number of young reared/pair/annum

The number of young reared per pair per annum (Table 8) probably is the most widely used measure of breeding success in avian studies. It can be expressed relative to either the total number of mated pairs or the number of breeding pairs which lay eggs. The former approach is preferable for assessing overall population breeding productivity. Data on the proportion of pairs with young in the post-breeding period, coupled with knowledge of mean brood size (Table 7), have been translated into a measure of young/pair/annum in Table 8 in some cases. The information on the Whooping Crane is based on that presented in Johnsgard (1983), and assumes that repeat nesting attempts are rare and that only one young is reared per successful attempt (Novakowski 1966; Kuyt 1981). In the Florida Sandhill Crane, the data presented from Nesbitt (1992) is based on his finding that mean individual breeding productivity was 0.35 young/adult/ annum for all adults in the population (n=133 adults during 574 crane breeding years). The same calculation restricted to adults that had bred successfully at least once gives a figure of 0.51 young/adult/annum.

Percentage of juveniles in the total population

The proportion of juvenile cranes in the population, as assessed during the post-breeding period, has been widely used to assess the productivity of several crane populations. Information on this measure of recruitment to the total population is relatively easily collected and need not be negatively affected by the flocking habits of cranes. It is extremely valuable in conservation and management assessments, especially as it provides extensive sample sizes of population-wide productivity and measures survival of young well beyond the fledgling period. Healthy populations of cranes should have about 10-15% juveniles in the post-breeding period (Archibald *et al.* 1981).

Extensive information in this regard has been collected for many crane species, especially the Sandhill Crane (Tables 9 and 10). In compiling Tables 9 and 10, data from different years have been treated separately in the calculations.

Percentage of juveniles in Sandhill Cranes

Recruitment rates of 13-14% characterized increasing populations of Rocky Mountain Greater Sandhill Cranes (Drewien 1973 *in* Bennett and Bennett 1990), while rates of 8-10% characterized stable populations of Central Valley Greater Sandhill Cranes (Littlefield and Ryder 1968 *in* Bennett and Bennett 1990) . The apparent decrease in the proportion of juveniles (from 19.4% in 1952-58 to 7.7% in 1984-86) in eastern Greater Sandhill Cranes during 1952-1986, has been attributed to the stabilization of the increase in this taxon's numbers during this time (Lovvorn and Kirkpatrick 1982b). Working on this taxon after the stabilization of the increase, Urbanek *et al.* (1991) found that a juvenile percentage of 4.8% characterized a year of poor breeding success, while a percentage of 9.9% characterized a year of high breeding success. A stable population of Florida Sandhill Cranes had 11.1% juveniles (Nesbitt 1992). During the period when most of these data were collected, the Eastern and Rocky Mountain populations of the Greater Sandhill Crane, and the Lesser and Canadian Sandhill Cranes were believed to be increasing, and the Central Valley population of the Greater Sandhill Crane and the Florida Sandhill Crane were believed to be stable (Drewien and Lewis 1987). The difference in annual recruitment between the Lesser and Greater/Canadian Sandhill Cranes may be due to the latter breeding at an earlier age than the former (Tacha and Vohs 1984; Tacha *et al.* 1984, 1986, 1989). Differences in mean brood size, however, between the Lesser Sandhill Crane and other sub-species (Table 3), also could be involved.

Percentage of juveniles in other crane species

Several of the species, or populations of species, in Table 10 have characteristics worth mentioning, relevant to the interpretation of age ratio data.

The relatively low percentages of juvenile Eurasian Cranes counted in Sweden by Swanberg (1981) may be due to age related differences in migration patterns in some years. Prange and Mewes (1991) suggest that the figures of 14-16% juveniles in Central Europe represents an increasing population, 12.3% in Scandinavia a stable population, and 9.0% in Finland a decreasing population. The Scandinavian population, however, also may have been increasing during this period (Bylin 1987).

The data for the Hooded Crane in Izumi, Japan are anomalous. During the period 1968-72, the percentage of juveniles decreased in the following manner: 1968-20.0%, 1969-15.0%, 1970-11.7%, 1971-11.0%, 1972-2.0%. The author provides no explanation for this dramatic and monotonic decrease. The data presented for this species in Yashiro, Japan are based on a remnant wintering population.

The information on the Whooping Crane cannot be regarded as representative of the natural situation in cranes, as it covers a period during which the population recovered from virtual extirpation (22 individuals) to 72 individuals. It is of interest to note that the percentage of juveniles decreased during this period of population increase, possibly associated with saturation of the available breeding habitat (Johnsgard 1983). The data for the Redcrowned Crane in Japan also are from a rapidly increasing population. In this population the percentage of juveniles remained relatively high (12.7%) and constant during the period of increase, although there was an apparent reduction in the percentage of juveniles (from about 13-14% to about 12%) during the latter stages of the increase, due to saturation of the breeding habitat (Archibald 1987). The data on the Siberian Crane from India is for the remnant, and still decreasing, western population. The percentage of juveniles remained relatively high (14.3%) and constant during this period of steep population decrease (Sauey 1987).

The data from White (1987) on the Brolga are not directly comparable with those for the other species. He states that his figure of 10% juveniles in the population refers to a combination of both first- and second-year birds. Both age classes can be differentiated from adults in this species. The same may also apply to the data from Blackman (1971) for this species, and might explain the relatively high proportion of 'juveniles' recorded by him. Similarly, the surprisingly high percentages of juveniles recorded for the other two members of the 'Antigone' group of gruine cranes (see under 'Phylogenetic relationships within the cranes' above), the Sarus and Whitenaped Cranes, may also be due to both first- and second-year young being counted. The relatively high proportion of young birds counted by Kemin and Zhongqin (1991) for the Redcrowned Crane may also include some birds older than first-years, as they use the term 'sub-adults' when reporting their results. Second-year Siberian Cranes, and even third-year immatures, are distinguishable from adults (Flint and Kistchinski 1981) and therefore some of the results presented for this species in Table 10 also may be biased.

Differences between the numbers of juveniles counted during the autumn and spring migrations have been found in the Eurasian (Alonso, Veiga, and Alonso 1987) and Redcrowned (Zhigang *et al.* 1991) Cranes. In the former there was a decrease of 6.7% in the number of juveniles between these two periods, and in the latter a decrease of 22.2%.

Four age classes are recognizable in the Siberian Crane, and Flint and Kistchinski (1981) provide one of the few analyses of age structures in crane populations. On the breeding grounds, they found that 7.3% comprised first-year birds, 17.0% second-years, 34.1% third-years, and 41.6% fourth-year and older birds in this species (n=41 birds aged). The explanation offered for the obvious discrepancy in these figures is that some young birds do not return to the breeding grounds until they are mature. They also suggest that, as birds of three years old can breed, the total proportion of sexually immature cranes in the population is about 25%, but that this figure also is subject to the same bias. Dr. George Archibald (in lit.), however, states that these age data are unreliable and that Siberian Cranes of over one year of age are indistinguishable from adults. Siberian Cranes place mud on their plumage when breeding and the supposed 'age classes' were based on the amount of brown mud observed on plumage of adult birds. Zhigang *et al.* (1991), however, based on observations at a migratory stopover site, suggest that 24% comprised first-year birds, 16% sub-adults, and 60% paired adults in this species (n=100 birds aged).

Based on observations of migrating cranes, Williams *et al.* (1991) recorded 84.2% adults, 15.5% juveniles and 0.3% sub-adults in Eurasian Cranes (n=871 birds aged), and 76.7% adults, 21.8% juveniles and 1.5% sub-adults in Redcrowned Cranes (n=206 birds aged).

Problems with percentages of juveniles data

The collection of data on the proportion of juveniles in biological populations and its interpretation when assessing productivity must be made with care (Caughley 1974), as the results are influenced by several confounding variables. Relevant to cranes, these include differential habitat use (Buller 1979; Lovvorn and Kirkpatrick 1982b; Alonso, Veiga, and Alonso 1987), timing of roosting and choice of roosts (Lovvorn and Kirkpatrick 1982b), distance of the birds from roosts (Alonso, Veiga, and Alonso 1987), migration routes (Swanberg 1981), and the timing of migration by family units (Miller and Hatfield 1974; Swanberg 1981; Carlisle and Tacha 1983; Tacha and Vohs 1984; Tacha, Jorgenson, and Taylor 1985) compared to the balance of the population, and avoidance of large flocks by family groups (Miller and Hatfield 1974; Tacha and Vohs 1984; Alonso, Veiga, and Alonso 1987; Bishop 1988). Age ratios also can differ between locations in the non-breeding range of migratory populations of Eurasian (Alonso, Veiga, and Alonso 1987) and Sandhill (Tacha and Vohs 1984) Cranes. In the former, fewer juveniles were found at staging areas and irregularly used wintering sites compared to typical wintering sites. The data presented in Tables 9 and 10 show variation between percentages of juveniles counted in breeding areas, during migration at stopover and staging areas, and on the wintering grounds for several species. Counts of juveniles also differ between autumn and spring at stopover sites (Alonso, Veiga, and Alonso 1987; Zhigang *et al.* 1991). The inclusion of immatures older than one year in counts of 'juveniles', in those species where more than two age classes can be discerned, is an additional problem (see under 'Percentage of juveniles in other cranes' above).

Estimates of proportions of juveniles in Sandhill Cranes reported by Layne (1983) are exaggerated, as the latter only counted family groups and not unsuccessful breeders and non-breeders (Bennett and Bennett 1990). The data from Layne's study therefore are not directly comparable with most other studies of productivity based on counts of adult:juvenile ratios, and are excluded here. Estimates of annual recruitment based on age ratios of migrating Sandhill Cranes at one staging area in the Central Flyway were unreliable, due to extensive overall and age-related variation in migration phenology, both within and between years (Carlisle and Tacha 1983). The data from Miller and Hatfield (1974) in Table 9 probably are unreliable. They based their counts on cranes seen in flight and Tacha and Vohs (1984) show that accurate aging is not possible for flying Sandhill Cranes. In addition, their study site was a staging area in the Central Flyway and therefore probably subject to the same migration phenology problems found by Carlisle and Tacha (1983). Indeed, Miller and Hatfield (1974) report differences in age ratios related to time periods and suggest that their counts in one year were prior to the arrival of most of the population. They suggest that a figure of 6.5% found in another year, when the population had peaked, probably was more accurate.

Counts of the proportion of juveniles are affected by the proportion of non-breeders in the population (Lovvorn and Kirkpatrick 1982b). Therefore the proportion of juveniles may change, not only in response to breeding success, but also due to changes in the numbers of non-breeders present. For example, an increase in the proportion of juveniles may be due to mortality of, or emigration by, non-breeders, while a decrease may be due to relatively large numbers of non-breeders, brought about by immigration or high productivity in previous breeding seasons (Lovvorn and Kirkpatrick 1982b).

CONSERVATION STATUS

International Red Data Book status of cranes

Cranes are among the most threatened avian taxa. Seven of the world's fifteen species are listed in the International Council for Bird Preservation's (ICBP, now Birdlife International) Checklist of Threatened Birds (Collar and Andrew 1988). These are the Hooded, Whooping, Blacknecked, Redcrowned, Whitenaped, Wattled, and Siberian cranes. The conservation saga of the Whooping Crane is renowned (see Erickson and Derrickson 1981 for a useful review) and has become a symbol of conservation efforts to preserve threatened species (Binkley and Miller 1980).

Conservation status of African cranes

The Wattled Crane is the only African crane listed in the ICBP Checklist. The African Red Data Book of the ICBP/IUCN (International Union for the Conservation of Nature and Natural Resources) lists this species as `Of Special Concern' (Collar and Stuart 1985). The South African Red Data Book (Brooke 1984) categorizes the Wattled Crane as 'Endangered'; one of only five bird species in the region that are considered in imminent danger of local extinction. The status of this species in South Africa is discussed in detail by Geldenhuys (1984), Tarboton (1984), Vernon and Boshoff (1986), Tarboton *et al.* (1987), Brooke and Vernon (1988), and Johnson and Barnes (1991).

The other three breeding cranes found in sub-Saharan Africa, the Black and Grey Crowned Cranes and the Blue Crane, were not considered as threatened by any of these Red Data Books. Recently, however, concern has been expressed as to the conservation status of the Black Crowned Crane, especially in West Africa (Urban 1987). The Grey Crowned Crane cannot, as yet, be considered as globally threatened and has a total population of at least 100 000 individuals (Urban 1988). The South Africa breeding population, however, probably does not exceed 1,000 pairs (Geldenhuys 1984; Johnson and Barnes 1986; Johnson 1992; Tarboton 1992; Vernon 1992). These latter authors all claim that the species is decreasing locally, due to wetland degradation and poisoning. It should therefore be considered as a candidate for inclusion as a Red Data Book species in South Africa.

Threats to cranes

The major threats to cranes world-wide are habitat destruction and persecution (Archibald *et al.* 1981). Habitat destruction usually comes in the form of degradation of wetlands and surrounding areas, and can include the impact of commercial afforestation. Afforestation has been implicated as a threat to the Mississippi Sandhill Crane, a critically endangered subspecies of this crane (Valentine 1987), to the Wattled Crane in Zimbabwe, Malawi, and the Transvaal (West 1977 *in* Konrad 1981; Tarboton 1984), and to the Blue Crane (Johnson 1992). Persecution is usually motivated by crop damage and can be of particular concern when poisons are used to kill large numbers of cranes. The Brolga, for example, has suffered major mortalities due to poisoning to protect crops (White 1987). Mortality due to poisoning by farmers also has been reported for the Grey Crowned, Eurasian, Blacknecked, Demoiselle, Blue, and Wattled Cranes (van Ee 1981; Ledger 1985, 1988; Bennett 1986; Johnson and Barnes 1986; Fuzhang and Wenning 1987; Tyson 1987; Vernon 1987; Khachar *et al.* 1991; Urquhart 1991; Youhui 1991; Filmer and Holtshausen 1992; Johnson 1992; Stretton 1992; Tarboton 1992; Vernon *et al.* 1992).

Collisions with overhead transmission lines also are proving to be a significant cause of direct mortality in many species. In the Redcrowned Crane in Japan, 71% (n=245) of known mortalities were due to such collisions before markers were placed on the relevant lines rendering them more visible to flying cranes (Akiyama 1981). This was calculated as 2.1% of all mortalities in adults and 13.1% in juveniles (Archibald 1987). This source of unnatural mortality has been identified as the key factor that retarded the recovery of this species in Japan, until ameliorative measures were implemented (Masatomi 1991). A similar problem exists in

Korea (Kyu and Oesting 1981). This source of mortality also has been recorded and considered as potentially serious in the Brolga (White 1987; Goldstraw and Du Guesclin 1991), and Whooping (Erickson and Derrickson 1981; Kuyt 1987) and Sandhill (Walkinshaw 1956; Tacha *et al.* 1979 *in* Johnsgard 1983; Windingstad 1988) Cranes. One study of the Eurasian Crane found that eight of 17 adults found dead were killed by colliding with overhead lines (Neumann 1987). In South Africa, at least three Wattled Cranes have died in this way (Berruti 1990; Johnson 1991). Fences also can present hazards to cranes, and mortalities caused by these structures have been recorded in at least Brolgas and Whooping, Blue, and Sandhill Cranes (White 1987; Allen 1990; Filmer and Holtshausen 1992).

Simulation models devised for the management of Sandhill Cranes (Miller *et al.* 1972; Miller and Bodkin 1974) have highlighted the vulnerability of populations of this species to unnatural mortality of adult birds. This vulnerability is due to the species' low reproductive potential. The purpose of their studies was to examine the potential impact of hunting on this crane, but can be extrapolated to other forms of unnatural mortality, such as poisoning and collisions with overhead lines, and to other species of cranes, all of which have similarly low reproductive potentials. A similar model has been produced for the Eurasian Crane, which identifies the potential importance of density-dependent factors, i.e., increased reproductive success at reduced densities, in mitigating the effects of increased unnatural mortality of adult cranes (Alonso *et al.* 1991). Unfortunately no data are available on density-dependent population parameters in cranes.

Archibald (1987), working on the Redcrowned Crane, highlights the importance of monitoring breeding success and recruitment in addition to population size. Pairs of long-lived cranes may inhabit areas long after their breeding habitat has been destroyed and therefore a population decrease may become apparent only several years later.

Adaptability of cranes to anthropogenic change

The discussion presented in this review repeatedly illustrates the adaptability of cranes to man-modified conditions. This includes their ubiquitous use of agricultural foods and foraging habitats, and their ability to adjust their patterns of movements, migrations, and roosting in response to man-made alterations of natural environments. Even when breeding, many species show surprising tolerance in nesting close to human activities, e.g., Sandhill (Dwyer and Tanner 1992) and Redcrowned (Archibald 1987) Cranes. Demoiselle Cranes will even nest in agricultural fields (Kovshar 1987). Other examples include the Eurasian Crane in Sweden and Poland, which has undergone a dramatic increase recently, due to its adapting to breeding near to human activity (Bylin 1987; Dobrowolski and Halba 1987). The Sarus Crane in India (Archibald *et al.* 1981), and the Grey Crowned Crane in Transkei, South Africa (Quickelberge 1989) and in East Africa (Pomeroy 1987) both benefit from coexistence with tolerant local peoples and despite the density of the human populations in these areas. It has been shown (Masatomi 1991) that even the problem of collisions with overhead lines can be solved by rendering these more visible to flying cranes using markers.

Captive breeding of cranes

The contribution of captive breeding to the conservation of cranes has received much attention, largely through the efforts of the International Crane Foundation, and large numbers of most species breed regularly in captivity (Mirande 1991). A list of the numbers of Grey crowned, Blue, and Wattled Cranes held in captivity in southern Africa has been compiled (Allan 1985).

An integrated approach to crane conservation research

A useful outline of the integrated research program needed to compile a strategy for the efficient and successful management and conservation of cranes has been produced, using the Sandhill Crane as a model (Tacha *et al.* 1987). It includes a brief summary of the relevant biological data that need to be gathered. These include details of population size, age and sex distributions, reproductive strategies, recruitment, mortality, migration routes, seasonal distribution patterns, habitat use and feeding ecology, a behavioral repertoire and time budgets, energetics, diseases and parasites, and social organization. They stress that all these aspects must be covered to ensure that any potentially problematic areas are identified. They also insist that these aspects must be studied throughout the annual cycle and simultaneously, rather than piecemeal at different times or locations.

The difficulties in successfully achieving this goal are admitted by these authors, who confess that scientists "have studied mid-continent Sandhill Cranes for years, but still cannot identify population trends". They recommend that "determining with precision the status and trends of populations for all species of cranes should be a research priority".

Archibald *et al.* (1981) provide a discussion of practical methods that can be employed in crane conservation. These include the reinforcement of traditional, and cultivation of new, human values, protective legislation and its enforcement, winter feeding (Koga 1981; Ohsako 1987; Swanberg 1987), habitat protection and enhancement, and re-stocking programs.

Potentially significant threats that have as yet received little attention are the long-term effects of very small population sizes, and population and habitat fragmentation. Another poorly-researched field is the impact of predators on crane populations. It is likely that the natural relationship between cranes and their predators has been modified by anthropogenic changes. The intensive control of mammalian predators in small stock farming regions may be to the benefit of cranes, especially during the breeding cycle.

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REFERENCES CITED

Abrey, A.N.S. 1992. The Wattled Crane: hatching and raising in captivity. Pages 86-90 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Akiyama, M. 1981. Countermeasures for the preservation of Red-crowned Cranes at present and in the future. Page 102 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Aldrich, J. W. 1972. A new subspecies of Sandhill crane from Mississippi. Proceedings of the Biological Society of Washington 85: 63-70.

Allan, D. G. 1985. Southern African cranes in captivity. Bokmakierie 37: 81-83.

Allen, G. T. 1990. A review of bird deaths on barbed-wire fences. The Wilson Bulletin 102: 553-558.

Allen, R. P. 1952. The Whooping Crane. National Audubon Society Research Report 3: 1-246.

Alonso, J. A., J. C. Alonso, and F. J. Cantos. 1986. On the size of the Common Crane *Grus grus* population migrating through western Europe. Ornis Fennica 63: 58-59.

Alonso, J. A., J. C. Alonso, J. S. Martinez-Vincente, and L. M. Bautista. 1991. Simulations on a Common Crane population model. Pages 277-283 *in* J. Harris,, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Alonso, J. A., J. C. Alonso, and J. Veiga. 1984. Winter feeding of the Crane in cereal farmland at Gallocanta, Spain. Waterfowl 35: 119-131.

Alonso, J. A., J. C. Alonso, and J. Veiga. 1985. The influence of moonlight on the timing of roosting flights in the Common Crane *Grus grus*. Ornis Scandinavica 16: 314-318.

Alonso, J. C. and J. A. Alonso. 1991. Costs and benefits of flocking in wintering Common Cranes. Pages 271-276 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Alonso, J. C., J. A. Alonso, and J. P. Veiga. 1987. Flocking in wintering Common Cranes *Grus grus*: influence of population size, food abundance and habitat patchiness. Ornis Scandinavica 18: 53-60.

Alonso, J. C., J. P. Veiga, and J. A. Alonso. 1984. Familienauflosung und Abzug aus dem Winterquartier beim Kranich *Grus grus*. Journal fur Ornithologie 125: 69-74.

Alonso, J. C., J. P. Veiga, and J. A. Alonso. 1987. Possible effects of recent agricultural development on the wintering and migratory pattern of Common Crane in Iberia: a study of winter ecology in a suitable habitat. Pages 277-299 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Archibald, G. W. 1975. The unison call of cranes as a useful taxonomic tool. Ph.D. Thesis. Cornell University, Ithaca, New York, USA.

Archibald, G. W. 1976. Crane taxonomy as revealed by the unison call. Pages 225-251 *in* J. C. Lewis, ed., Proceedings of the International Crane Workshop. Oklahoma State University Publishing and Printing Department, Stillwater, Oklahoma, USA.

Archibald, G. W. 1981a. Cranes wintering in the Republic of Korea. Crane research around the world: Pages 66-69 *in* J. C. Lewis and H. Masatomi, eds., Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Archibald, G. W. 1981b. Introducing the Sarolga. Pages 213-215 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Archibald, G. W., Y. Shigeta, K. Matsumoto, and K. Momose. 1981. Endangered cranes. Crane research around the world: Pages 1-12 *in* J. C. Lewis and H. Masatomi, eds., Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Archibald, G. W. and R. F. Pasquier. 1987. Editors' introduction: North American cranes. Page 363 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Archibald, K. 1987. The conservation status of the breeding ground of the Red-crowned Crane in Hokkaido, Japan. Pages 63-86 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Bankovics, A. 1987. The migration of the Common Crane in Hungary during 1982. Pages 247-250 *in* G. W. Archibald and R. F. Pasquier,, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Bennett, A. J. 1978. Ecology and status of Greater Sandhill Cranes in southeastern Wisconsin. M.A. Thesis. University of Wisconsin, Stevens Point, Wisconsin, USA.

Bennett, A. J. 1989a. Population size and distribution of Florida Sandhill Cranes in the Okefenokee Swamp, Georgia. Journal of Field Ornithology 60: 60-67.

Bennett, A. J. 1989b. Movements and home ranges of Florida Sandhill cranes. Journal of Wildlife Management 53: 830-836.

Bennett, A. J. and L. A. Bennett. 1990. Productivity of Florida Sandhill Cranes in the Okefenokee Swamp, Georgia. Journal of Field Ornithology 61: 224-231.

Bennett, G. 1986. Cranes poisoned! Bokmakierie 38: 66.

Benson, C. W., and C.R.S. Pitman. 1964. Further breeding records from Northern Rhodesia (No. 4). Bulletin of the British Ornithologists' Club 84: 54-60.

Berruti, A. 1990. Wattled Crane mortalities. The Crane 1(3) 3-4.

Bin, C. and W. Zuoyi. 1991. Observations on wintering ecology of cranes at Poyang Lake. Pages 105-107 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Binkley, C. S. and R. S Miller. 1980. Survivorship of the Whooping Crane *Grus americana.* Ecology 61: 434-437.

Bishop, M. A. 1988. Factors affecting productivity and habitat use of Florida Sandhill Cranes: an evaluation of three areas in central Florida for a non-migratory population of Whooping Cranes. Ph.D. Thesis. University of Florida, Gainsville, Florida, USA.

Blackman, J. G. 1971. Sex determination of Australian Cranes (Gruidae). Queensland Journal of Agriculture and Animal Science 28: 281-286.

Blackman, J. G. 1978. The swamp. Pages 147-183 *in* H. J. Lavery, ed., Expedition north. Richmond Hill Press, Victoria, Australia.

Blankinship, D. R. 1976. Studies of Whooping Cranes on the wintering grounds. Pages 197-206 *in* J. C. Lewis, ed., Proceedings International Crane Workshop. Oklahoma State University Publishing and Printing Department, Stillwater, Oklahoma, USA.

Boise, C. M. 1976. Breeding biology of the Lesser Sandhill Crane - a preliminary report. Pages 126-129 *in* J. C. Lewis, ed., Proceedings International Crane Workshop. Oklahoma State University Publishing and Printing Department, Stillwater, Oklahoma, USA.

Boise, C. M. 1977. Breeding biology of the Lesser Sandhill Cranes on the Yukon-Kuskokwim Delta, Alaska. M.A. Thesis. University of Alaska, Fairbanks, Alaska, USA.

Brooke, R. K. 1984. South African Red Data Book-Birds. South African National Scientific Programmes Report 97: 1-213.

Brooke, R. K., and C. J. Vernon. 1988. Historical records of the Wattled Crane *Bugeranus carunculatus* (Gmelin) in the Cape Province and the Orange Free State, South Africa. Annals of the Cape Provincial Museums (Natural History) 16: 363-371.

Brown, C. J. 1992. The status of cranes in Namibia. Pages 73-78 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Brown, L. H., and D. E. Pomeroy. 1984. The age structure of populations of wild birds in tropical Africa, as demonstrated by plumage characters and marking techniques.

Pages 97-119 *in* J. Ledger, ed., Proceedings of the Fifth Pan-African Ornithological Congress. Southern African Ornithological Society, Johannesburg, South Africa.

Buller, R. J. 1976. Recent studies of age ratios of Sandhill Cranes in the Central Flyway. Pages 78-85 *in* J. C. Lewis, ed., Proceedings International Crane Workshop. Oklahoma State University Publishing and Printing Department, Stillwater, Oklahoma, USA.

Buller, R. J. 1979. Lesser and Canadian Sandhill crane populations, age structure and harvest. U. S. Fish and Wildlife Service, Special Scientific Report 221: 1-10.

Bylin, K. 1980. Tranans *Grus grus* upptradande under hackningstiden. Var Fagelvarld 39: 15-19.

Bylin, K. 1987. The Common Crane in Sweden-distribution, numerical status, habitats, breeding success and need of protection. Pages 215-223 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation. Baraboo, Wisconsin, USA.

Carlisle, M. J. and T. C. Tacha. 1983. Fall migration of Sandhill cranes in west central North Dakota. Journal of Wildlife Management 47: 818-821.

Caughley, G. 1974. Interpretation of age ratios. Journal of Wildlife Management 38: 557-562.

Chishan, W. and H. Xiaolun. 1987. Status and ecology of wintering Hooded Cranes in the lower reaches of the Yangtze (Changjiang) River of China. Pages 105-106 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Clancey, P. A., R. K. Brooke, T. M. Crowe, and J. M. Mendelsohn. 1991. S. A. O. S. checklist of southern African birds. Second updating report 1991. Southern African Ornithological Society, Johannesburg, South Africa.

Collar, N. J. and P. Andrew. 1988. Birds to watch: the ICBP World Checklist of Threatened Birds. International Council for Bird Preservation Technical Publication No. 8: 1-303.

Collar, N. J. and S. N. Stuart. 1985. Threatened birds of Africa and related islands: the ICBP/IUCN Red Data Book, Part 1. ICBP/IUCN, Cambridge, UK.

Cramp, S. and K.E.L. Simmons, eds. 1980. The birds of the Western Palearctic. Vol. 2. Oxford University Press, Oxford, UK.

Crete, R. A. 1980. Biology of Greater Sandhill Cranes in Burnett County, Wisconsin. M. A. Thesis. St. Cloud State College, St. Cloud, Minnesota, USA.

Crete, R. A. and A. H. Grewe. 1982. Greater Sandhill Cranes of Burnett County, Wisconsin. Pages 281-287 *in* Proceedings of the 1981 Crane Workshop. National Audubon Society, Tavernier, Florida, USA.

Dehao, L. 1987. The distribution and status of the Black-necked Crane on the Tibetan Plateau. Pages 45-49 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Dehao, L., Z. Zhijun, W. Zhikang, L. Zhumei, and W. Youhui. 1991. On the structure and behavior of the breeding population of Black-necked Cranes in Songpan Meadow in Sichuan Province. Pages 83-87 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Deppe, H. -J. 1991. Fruhjahrszug des Kranichs (*Grus grus*) in Mecklenburg und Wettereinflub. Die Vogelwarte 36: 62-67.

Derrickson, S. R. and J. W. Carpenter. 1987. Behavioural management of captive cranes-factors influencing propagation and reintroduction. Pages 493-511 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Dobrowolski, K. A., and R. Halba. 1987. The Common Crane in Poland. Pages 231-238 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Douthwaite, R. J. 1974. An endangered population of Wattled Cranes (*Grus carunculatus*). Biological Conservation 6: 134-142.

Drewien, R. C. 1973. Ecology of Rocky Mountain Greater Sandhill Cranes. Ph.D. Thesis. University of Idaho, Moscow, Idaho.

Drewien, R. C. and E. G. Bizeau. 1974. Status and distribution of greater sandhill cranes in the Rocky Mountains. Journal of Wildlife Management 38: 720-742.

Drewien, R. C. and J. C. Lewis. 1987. Status and distribution of cranes in North America. Pages 469-477 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the

1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Dwyer, N. C. and G. W. Tanner. 1992. Nesting success in Florida Sandhill Cranes. The Wilson Bulletin 104: 22-31.

Eguchi, K., H. Nagata, M. Takeish, Y. Hemil, and M. Takatsuka. 1991. Foraging and time budget of the Hooded Cranes in a wintering area at Yashiro, Japan. Pages 305-310 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Erickson, R. C. and S. R. Derrickson. 1981. The Whooping Crane. Pages 104-118 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Fernandez-Cruz, M., ed. 1981. La migracion e invernada de la grulla Comun (*Grus grus*) en Espana. Resultados del proyecto Grus (Crane Project). Ardeola 26-27: 1-164.

Filmer, R. J. and G. R. Holtshausen. 1992. The southern African crane census, 1985/1986. Pages 132-153 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban.

Flint, V. E. and A. A. Kistchinski. 1981. The Siberian Crane in Yakutia. Pages 136-145 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Flint, V. E. and A. G. Sorokin. 1981. The biology of the Siberian Crane (Sterkh) in Yakutia. Pages 146-149 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Folk, M. J. and T. C. Tacha. 1990. Sandhill crane roost site characteristics in the North Platte River valley. Journal of Wildlife Management 54: 480-486.

Frame, G. W. 1982. East African Crowned Crane *Balearica regulorum gibbericeps* ecology and behaviour in northern Tanzania. Scopus 6: 60-69.

Fulin, W. 1991. Distribution of cranes in Shanxi and their relationship to the ecological environment. Pages 91-94 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Fuzhang, Z. and D. Wenning. 1987. Siberian Cranes wintering in the lower Yangtze in China. Pages 171-172 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Geldenhuys, J. N. 1984. The status of cranes (Aves: Gruidae) in the Orange Free State. South African Journal of Wildlife Research 14: 15-18.

Genard, M. and D. Lanusse. 1992. Use of marshlands by Common Cranes in winter in south-western France. Ornis Fennica 69: 19-28.

Gichuki, N. N. and C. M. Gichuki. 1991. Relationships between habitat selection and flock characteristics in foraging Grey Crowned Cranes *Balearica regulorum* in Kenya. Pages 357-361 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Glutz von Blotzheim, U. N. 1973. Handbuch der Vogel Mitteleuropas. Volume 5. Akademische Verlagsgellschaft, Weisbaden, Germany.

Goldstraw, P. W. and P. B. du Guesclin. 1991. Bird casualties from collisions with a 500 KV transmission line in southwestern Victoria, Australia. Pages 219-224 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Golf, P. 1987. Observing the Sarus. Pages 107-114 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Grewe, A. H. 1977. The current status of Eastern Greater Sandhill cranes in Minnesota. Pages 12-17 *in* R. D. Feldt ed., Papers of the Symposium on the Eastern Population of the Greater Sandhill Crane. The Indiana Chapter of The Wildlife Society, Indiana Conservation Council, and the Indiana Division of Fish and Wildlife, Indiana, USA.

Herter, D. R. 1982. Staging of Sandhill Cranes on the eastern Copper River delta, Alaska. Pages 273-280 *in* J. C. Lewis, ed., Proceedings of the 1981 Crane Workshop. National Audubon Society, Tavernier, Florida, USA.

Hoffman, R. H. 1979. Thickness and variability of eggshells of southern Michigan cranes. Pages 181-188 *in* J. C. Lewis, ed., Proceedings of the 1978 Crane Workshop. Colorado State University Printing Service, Fort Collins, Colorado, USA.

Howard, G. W. 1989. Recent counts of Wattled Cranes *Bugeranus carunculatus* on the Kafue Flats, Zambia-November 1987. Scopus 12: 69-72.

Howard, G. W. and D. R. Aspinwall. 1984. Aerial censuses of Shoebills, Saddlebilled Storks and Wattled Cranes at the Bangweulu Swamps and Kafue Flats, Zambia. Ostrich 55: 207-212.

Hunt, H. E. and R. D. Slack. 1989. Winter diets of whooping and sandhill cranes in south Texas. Journal of Wildlife Management 53: 1150-1154.

Hyde, P. O. 1957. My Greater Sandhill Cranes. Audubon Magazine 59: 265-267.

Ingold, J. L., S. I. Guttman, and D. R. Osborne. 1987. Biochemical systematics of the crowned cranes. Pages 317-322 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Ingold, J. L., J. C. Vaughn, S. I. Guttman, and L. R. Maxson. 1989. Phylogeny of the cranes (Aves: Gruidae) as deduced from DNA-DNA hybridization and albumin micro-complement fixation analyses. Auk 106: 595-602.

Irwin, M.P.S. 1981. The birds of Zimbabwe. Quest, Harare, Zimbabwe.

Iverson, G. C., P. A. Vohs, and T. C. Tacha. 1985. Habitat use by sandhill cranes wintering in western Texas. Journal of Wildlife Management 49: 1074-1083.

Iverson, G. C., P. A. Vohs, and T. C. Tacha. 1987. Habitat use by mid-continent sandhill cranes during spring migration. Journal of Wildlife Management 51: 448-458.

Jantunem, J., J. Kontiokorpi, and K. Tiilikainen. 1985. Syysmuutto Etela-Karjalassa 1984. Ornis Karelica 11: 36-48.

Jie, X., S. Liying, and J. Xingxing. 1991. A way of expediting the recovery of the Red-crowned Crane. Pages 47-50 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Jinlu, L. and F. Kemin. 1991. Overwintering of Red-crowned and Siberian Cranes in China. Page 191 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Johnsgard, P. A. 1983. Cranes of the world. Indiana University Press, Bloomington, Indiana, USA.

Johnson, D. N. 1985. Hybridisation between Wattled and Blue Cranes. Bokmakierie 37: 126.

Johnson, D. N. 1991. The Wattled Crane in Natal: 1990 update. The Crane 2(1): 3-4.

Johnson, D. N. 1992. The status of cranes in Natal in 1989. Pages 20-28 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Johnson, D. N. and P. R. Barnes. 1986. The Natal crane census. Lammergeyer 37: 40-49.

Johnson D. N. and P. R. Barnes. 1991. The breeding biology of the Wattled Crane in Natal. Pages 377-386 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Karlin, A., and S. Raivio. 1987. Crane research in Finland in 1983. Proceedings of the International Crane Foundation Working Group on European Cranes, Hungary 1985. Aquila 93: 39-48.

Kawamura, N. 1981. The Hooded Crane at Yashiro, Yamaguchi Prefecture, Japan. Pages 244-249 *in* J. C. Lewis and H. Masatomi eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Kawamura, N. 1987. Territorial and flocking behaviour of the Hooded Crane at Yashiro, Yamaguchi Prefecture, Japan. Pages 99-103 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Kawamura, N. 1991. Conservation of the Hooded Crane at Yashiro, Japan. Pages 301-303 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Kemin, F. and Z. Zhongqin. 1991. The importance of wetlands in protecting birds. Pages 35-36 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Keskpaik, J. and J. Rinne. 1986. Suomalais-neuvostoliittolainen kurkityo. Lintumies 21: 217-220.

Khachar, S., H. R. Patankar, A. Gaekwad, T. Mundkur, R. ravez, and R. M. Naik. 1991. Wintering cranes in Gujarat State, India. Pages 327-333 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Koga, T. 1981. Wild and captive cranes in Japan. Pages 50-56 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Konrad, P. M. 1981. Status and ecology of Wattled Cranes in Africa. Pages 220-237 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Kovshar, A. V. 1987. The Demoiselle Crane in Kazakhstan and Central Asia. Pages 23-31 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Krajewski, C. 1989. Phylogenetic relationships among cranes (Gruiformes: Gruidae) based on DNA hybridization. Auk 106: 603-618.

Krapu, G. L. 1987. Use of staging areas by Sandhill Cranes in the midcontinent region of North America. Pages 451-462 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Krapu, G. L., D. E. Facey, E. K. Fritzell, and D. H. Johnson. 1984. Habitat use by migrant sandhill cranes in Nebraska. Journal of Wildlife Management 48: 407-417.

Kuyt, E. 1981. Clutch size, hatching success, and survival of Whooping Crane chicks, Wood Buffalo National Park, Canada. Pages 126-129 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Kuyt, E. 1987. Whooping Crane migration studies 1981-82. Pages 371-379 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Kyu, K. H. and M. R. Oesting. 1981. Cranes in Korea. Pages 57-60 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Lan, Y. 1991. Distribution and habitats of the cranes in Yunnan Province. Pages 127-129 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Larue, C. 1981. Techniques for breeding cranes in captivity. Pages 15-18 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Lawson, W. J. 1968. Mating of Blue and Wattled Cranes. Natal Bird Club Newsletter 156: 2.

Layne, J. N. 1982. Dry ground nests of Florida Sandhill Cranes. Florida Field Naturalist 10: 55-56.

Layne, J. N. 1983. Productivity of sandhill cranes in south central Florida. Journal of Wildlife Management 47: 178-185.

Ledger, J. 1985. The poison people. African Wildlife 39: 6-8.

Ledger, J. 1988. Cranes for the king. Quagga 20/21: 23-24.

Lees, S. G. 1977. Crowned Crane nesting in a tree. Honeyguide 92: 49.

Lewis, J. C. 1979. Field identification of juvenile sandhill cranes. Journal of Wildlife Management 43: 211-214

Lewis, J. C. 1991. International cooperation in the recovery of Whooping Crane: a model for other nations. Pages 389-394 *in* J. Harris, ed., Proceedings 1987 International

Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Libbert, W. 1969. Ueber das Verhalten der Kraniche auf Rastund Sammelplatzen. Beitrage Vogelkunde 14: 388-405.

Lingle, G. R., G. A. Wingfield, and J. W. Ziewitz. 1991. The migration ecology of Whooping Cranes in Nebraska, U. S. A. Pages 395-402 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Littlefield, C. D. 1976. Production of Greater Sandhill Cranes on Malheur National Wildlife Refuge, Oregon. Pages 86-92 *in* J. C. Lewis, ed., Proceedings of the International Crane Workshop. Oklahoma State University Publishing and Printing Department, Stillwater, Oklahoma, USA.

Littlefield, C. D. 1981a. A probable record of intraspecific egg dumping for Sandhill Cranes. Auk 98: 631.

Littlefield, C. D. 1981b. Mate-swapping of Sandhill Cranes. Journal of Field Ornithology 52: 244-245.

Littlefield, C. D. 1986. Autumn Sandhill Crane habitat use in southeast Oregon. The Wilson Bulletin 98: 131-137.

Littlefield, C. D. and R. A. Ryder. 1968. Breeding biology of the greater sandhill crane on Malheur National Wildlife Refuge, Oregon. Transactions of the North American Wildlife and Natural Resources Conference 33: 444-454.

Liying, S., X. Jie, and Z. Desheng. 1991. Breeding habitats of White-naped Cranes at Zhalong Nature Reserve, China. Pages 51-58 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Lovvorn, J. R. and C. M. Kirkpatrick. 1981. Roosting behaviour and habitat of migrant greater sandhill cranes. Journal of Wildlife Management 45: 842-857.

Lovvorn, J. R. and C. M. Kirkpatrick. 1982a. Field use by staging eastern greater sandhill cranes. Journal of Wildlife Management 46: 99-108.

Lovvorn, J. R. and C. M. Kirkpatrick. 1982b. Recruitment and socially specific flocking tendencies of Eastern Sandhill Cranes. The Wilson Bulletin 94: 313-321.

Ma, G. -E. 1981. Breeding habits of Red-crowned Cranes. Pages 89-93 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Maclean, G. L. 1985. Roberts' birds of southern Africa. Trustees of the John Voelcker Bird Book Fund, Cape Town, South Africa.

Maclean, G. L. 1991. Crane conservation in southern Africa. Birding in Southern Africa 43: 122-123.

Mafabi, P. G. 1991. The ecology and conservation status of the Grey Crowned Crane in Uganda. Pages 363-367 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Masatomi, H. 1972. Communal wintering of a Sandhill Crane with Japanese Cranes in Hokkaido, Japan. The Wilson Bulletin 84: 250-260.

Masatomi, H. 1981. Population of Red-crowned Cranes in Hokkaido. Pages 86-88 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Masatomi, H. 1991. Population dynamics of Red-crowned Cranes in Hokkaido since the 1950s. Pages 297-299 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Masterson, A. 1986. Wattled Cranes-hot seating? Honeyguide 32: 154-155.

Matthews, P. and N. D. Mcwhirter. 1992. The Guinness Book of Records. 1993. Guiness Books, Enfield, Middelsex, UK.

Mayfield, H. 1961. Nesting success calculated from exposure. The Wilson Bulletin 73: 255-261.

Mayfield, H. 1975. Suggestions for calculating nest success. The Wilson Bulletin 84: 456-466.

Melvin, S. M., and S. A. Temple. 1983. Fall migration and mortality of Interlake, Manitoba sandhill cranes in North Dakota. Journal of Wildlife Management 47: 805-817.

Melvin, S. M., W.J.D. Stephen, and S. A. Temple. 1990. Population estimates, nesting biology, and habitat preferences of Interlake, Manitoba, Sandhill Cranes, *Grus canadensis*. Canadian Field Naturalist 104: 354-361.

Miller, L., L. Yongtong, C. Wenbin, Z. Yufeng, W. Liantie, D. Wei, and J. Ying. 1991. A breeding group of Red-crowned Cranes in Ziaoning Province. Pages 75-78 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Miller, R. S. 1973. The brood size of cranes. The Wilson Bulletin 85: 436-441.

Miller, R. S. and D. B. Bodkin. 1974. Endangered species: models and predictions. American Scientist 62: 172-181.

Miller, R. S. and J. P. Hatfield. 1974. Age ratios of sandhill cranes. Journal of Wildlife Management 38: 234-242.

Miller, R. S., G. S. Hochbaum, and D. B. Botkin. 1972. A simulation model for the management of Sandhill Cranes. Yale University School of Forestry and Environmental Studies Bulletin No. 80: 1-49.

Miller, R. S. and W.J.D. Stephen. 1966. Spatial relationships in flocks of Sandhill Cranes (*Grus canadensis*). Ecology 47: 323-327.

Mirande, C. M. 1991. The role of captive breeding in the conservation of cranes. Pages 425-432 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Morris, A. 1987. The status of cranes in Zimbabwe. Pages 345-348 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Mullins, W. H. and E. G. Bizeau. 1978. Summer foods of Sandhill Cranes in Idaho. Auk 95: 175-178.

Mundy, P. J., A. Morris, and P. Hougaard. 1984. Aerial survey for Wattled Cranes, 1983. Honeyguide 30: 98-104.

Nesbitt, S. A. 1988. Nesting, renesting and manipulative nesting of Florida sandhill cranes. Journal of Wildlife Management 52: 758-763.

Nesbitt, S. A. 1989. The significance of mate loss in Florida Sandhill Cranes. The Wilson Bulletin 101: 648-651.

Nesbitt, S. A. 1992. First reproductive success and individual productivity in sandhill cranes. Journal of Wildlife Management 56: 573-577.

Nesbitt, S. A. and J. H. Hinterminster. 1984. Night migration of Sandhill Cranes. Florida Field Naturalist 12: 20.

Nesbitt, S. A. and A. S. Wenner. 1987. Pair formation and mate fidelity in Sandhill Cranes. Pages 117-122 *in* J. C. Lewis, ed., Proceedings of the 1985 Crane Workshop. Platte River Whooping Crane Trust, Grand Island, Nebraska, USA.

Nesbitt, S. A. and K. S. Williams. 1990. Home range and habitat use of Florida sandhill cranes. Journal of Wildlife Management 54: 92-96.

Neumann, T. 1987. Breeding status of the Common Crane in the Federal Republic of Germany. Pages 243-245 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Nilsson, S. G. 1982. Differences in the breeding success of the Common Crane *Grus grus* between South and Central Sweden. Journal fur Ornithologie 123: 93-95.

Nishida, S. 1981. Wintering life of cranes in Kagoshima and Yamaguchi Prefectures, Japan. Pages 52-56 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Novakowski, N. S. 1966. Whooping crane population dynamics on the nesting grounds, Wood Buffalo National Park, Northwest Territories. Canadian Wildlife Service Report Series 1: 1-20.

Ohzako, Y. 1987. Effects of artificial feeding on cranes wintering in Izumi and akune, Kyushu, Japan. Pages 89-98 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Ozaki, K. 1991. Returns and recoveries of Hooded and White-naped Cranes banded in winter at Izumi, Japan. Pages 311-314 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Pennycuick, C. J., T. Alerstam, and B. Larsson. 1979. Soaring migration of the Common Crane *Grus grus* observed by radar and from an aircraft. Ornis Scandinavica 10: 241-251.

Pogson, T. H. and S. G. Lindstedt. 1991. Distribution and abundance of large Sandhill Cranes, *Grus canadensis*, wintering in California's Central Valley. The Condor 93: 66-278.

Pomeroy, D. E. 1980. Aspects of the ecology of Crowned Cranes *Balearica regulorum* in Uganda. Scopus 4: 29-35.

Pomeroy, D. E. 1987. The ecology and status of Crowned Cranes in East Africa. Pages 323-330 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Prance, H. and W. Mewes. 1991. The Common Crane in the German Democratic Republic. Pages 263-269 *in* J. Harris, ed., Proceedings 1987. International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Putman, M. S. and G. W Archibald. 1987. The Siberian Crane: its history and biology in captivity. Pages 173-195 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Quickelberge, C. D. 1989. Birds of Transkei. Durban Natural History Museum, Durban, South Africa.

Reinecke, K. J. and G. L. Krapu. 1986. Feeding ecology of sandhill cranes during spring migration in Nebraska. Journal of Wildlife Management 50: 71-79.

Rinne, J. 1987. Crane (*Grus grus*) migration in Finland. Proceedings of the International Crane Foundation Working Group on European Cranes, Hungary 1985. Aquila 93: 149-151.

Rinne, J. 1991. Cranes in Finland. Pages 257-258 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Sauey, R. T. 1987. Disturbance factors affecting Siberian Cranes at Keoladeo National Park, India. Pages 151-170 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Schoff, G. H. 1991. Reflections: the story of cranes, International Crane Foundation, Baraboo, Wisconsin, USA.

Scholorff, R. W., G. Herron, G. Kaiser, C. Kebbe, G. W. Kramer, and C. D. Littlefield. 1983. Pacific flyway management plan for the Central Valley population of greater sandhill cranes. U. S. Fish and Wildlife Service, Portland, Oregon, USA. 28 pp.

Sibley C. G. and J. E. Ahlquist. 1982. The relationships of the Yellow-breasted Chat (*Icteria virens*) and the alleged slowdown in the rate of molecular evolution in birds. Postilla 187: 1-19.

Sibley, C. G. and J. E. Ahlquist. 1990. Phylogeny and classification of birds: a study in molecular evolution. Yale University Press, New Haven, Connecticut, USA.

Sibley, C. G. and B. L. Monroe. 1990. Distribution and taxonomy of birds of the world. Yale University Press, New Haven, Connecticut, USA.

Snow, D. W. 1978. An atlas of speciation in African non-passerine birds, British Museum of Natural History, London, UK.

Stephen, W. J. D., R. S. Miller, and J. P. Hatfield. 1966. Demographic factors affecting management of sandhill cranes. Journal of Wildlife Management 30: 581-588.

Sterbetz, I. 1987. Juvenile ratio of Common Crane (*Grus grus* L., 1758) at staging sites in Se-Hungary. Proceedings of the International Crane Foundation Working Group on European Cranes, Hungary 1985. Aquila 93: 197-202.

Steyn, P. and Ellmann-Brown, P. 1974. Crowned Crane nesting on a tree. Ostrich 45: 40-42.

Stretton, W. S. 1992. Some thoughts on the decline of the Blue Crane and the role of the farmer in its conservation. Pages 111-114 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Sugden, L. G. and R. G. Clark. 1988. Small grain selection by captive sandhill cranes. Journal of Wildlife Management 52: 263-265.

Sugden, L. G., R. G. Clark, E. J. Woodsworth, and H. Greenwood. 1988. Use of cereal fields by foraging sandhill cranes in Saskatchewan. Journal of Applied Ecology 25: 111-124.

Swanberg, O. 1981. Notes on the population of Common Crane in Scandinavia and Finland: a preliminary survey. Pages 184-185 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Swanberg, O. 1987. Migrating Common Crane in Sweden: experiments in farming for cranes and vegetation control in wetlands. Pages 225-229 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Tacha, T. C. 1988. Social organization of sandhill cranes from midcontinental North America. Wildlife Monographs 99: 1-37.

Tacha, T. C., D. E. Haley, and R. R. George. 1986. Population and harvest characteristics of sandhill cranes in southern Texas. Journal of Wildlife Management 50: 80-83.

Tacha, T. C., D. E. Haley, and P. A. Vohs. 1989. Age of sexual maturity of sandhill cranes from mid-continental North America. Journal of Wildlife Management 53: 43-46.

Tacha, T. C., C. Jorgenson, and P. S. Taylor. 1985. Harvest, migration, and condition of sandhill cranes in Saskatchewan. Journal of Wildlife Management 49: 476-480.

Tacha, T. C., D. C. Martin, and C. G. Endicott. 1979. Mortality of Sandhill Cranes associated with utility highlines in Texas. Pages 175-176 *in* J. C. Lewis, ed., Proceedings of the 1978 Crane Workshop. Colorado State University Printing Service, Fort Collins, Colorado, USA.

Tacha, T. C. and P. A. Vohs. 1984. Some population parameters of sandhill cranes from mid-continental North America. Journal of Wildlife Management 48: 89-98.

Tacha, T. C., P. A. Vohs, and G. C. Iverson. 1984. Migration routes of sandhill cranes from mid-continental North America. Journal of Wildlife Management 48: 1028-1033.

Tacha, T. C., P. A. Vohs, and G. C. Iverson. 1987. An integrated approach to crane research-lessons from Sandhill Cranes of mid-continental North America. Pages 463-468 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Tacha, T. C., P. A. Vohs, and W. D Warde. 1985. Morphometric variation of sandhill cranes from mid-continental North America. Journal of Wildlife Management 49: 246-250.

Tarboton, W. 1976. Growth and fledging period of Blue Crane chicks. Wits Bird Club Newsheet 93: 14-15.

Tarboton, W. R. 1984. The status and conservation of the Wattled Crane in the Transvaal. Pages 665-678 *in* J. Ledger, ed., Proceedings of the Fifth Pan-African Ornithological Congress. Southern African Ornithological Society, Johannesburg, South Africa.

Tarboton, W. R. 1992. The population status of the Crowned Crane in the Transvaal. Pages 10-19 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Tarboton, W. R., P. R. Barnes, and D. N. Johnson. 1987. The Wattled Crane in South Africa during 1978-1982. Pages 353-361 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Thompson, R. L. 1970. Florida Sandhill Crane nesting on the Loxahatchee National Wildlife Refuge. Auk 87: 492-502.

Toland, B. 1991. An unusual nest site of the Florida Sandhill Crane in southeastern Florida. Florida Field Naturalist 19: 10-12.

Tyson, N. 1987. 29 Blue Cranes poisoned in the Cape. African Wildlife 41: 266.

Urban, E. K. 1987. The cranes of Africa - an overview. Pages 307-315 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Urban, E. K. 1988. Status of cranes in Africa. Pages 315-329 *in* G. C. Backhurst, ed., Proceedings of the Sixth Pan-African Ornithological Congress. 5th PAOC Organizing Committee, Nairobi, Kenya.

Urban, E. K., C. H. Fry, and S. Keith. 1986. The birds of Africa. Vol. 2. Academic Press, London, UK.

Urbanek, R. P., J. L. McMillen, and T. A. Bookhout. 1991. Rocket-netting Greater Sandhill Cranes on their breeding grounds at Seney National Wildlife Refuge. Pages 241-245 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Urquhart, C. 1991. Editorial. The Bee-eater 41: 50.

Valentine, J. M. 1981. The Mississippi Sandhill Crane, 1980. Pages 167-174 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Valentine, J. M. 1987 Management of the Mississippi Sandhill Crane. Pages 387-397 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Van Ee, C. A. 1981. Status of the Blue Crane in South and Southwest Africa. Page 259 *in* J. C. Lewis and H. Masatomi, eds., Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Vernon, C. J. 1987. Blue Cranes - Latest victims in the Cape Province. African Wildlife 41: 337.

Vernon, C. J. and A. F. Boshoff. 1986. The status and conservation of the wattled crane, *Grus carunculatus*, in the Cape Province and Transkei. Bontebok 5: 37-41.

Vernon, C. J., A. F. Boshoff, and W. S. Stretton. 1992. The status and conservation of cranes in the Eastern Cape Province. Pages 47-72 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Viniter, S. V. 1981. Nesting of the Red-crowned Crane in the central Amur region. Pages 74-80 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Walkinshaw, L. H. 1949. The Sandhill Cranes. Cranbrook Institute of Science Bulletin 29: 1-22.

Walkinshaw, L. H. 1953. Nesting and abundance of the Cuban Sandhill Crane on the Isle of Pines, Cuba. Auk 70: 1-10.

Walkinshaw, L. H. 1955. The Sandhill Crane on the Phyllis Haehnle Sanctuary area. Jack Pine Warbler 33: 77-82.

Walkinshaw, L. H. 1956. Sandhill Cranes killed by flying into power line. The Wilson Bulletin 68: 325-326.

Walkinshaw, L. H. 1963. Some life history studies of the Stanley Crane. Proceedings of the International Ornithological Congress 13: 344-353.

Walkinshaw, L. H. 1964. The African Crowned Cranes. The Wilson Bulletin 76: 355-377.

Walkinshaw, L. H. 1965a. One hundred thirty-three Michigan Sandhill Crane nests. Jack-Pine Warbler 43: 137-142.

Walkinshaw, L. H. 1965b. Why the decrease in young cranes? Jack Pine Warbler 43: 148.

Walkinshaw, L. H. 1973. Cranes of the world. Winchester Press, New York, USA.

Walkinshaw, L. H. 1976. Sandhill Crane on and near the Kissimmee Pairie, Florida. Pages 1-18 *in* J. C. Lewis, ed., Proceedings of the International Crane Workshop. Oklahoma State University Publishing and Printing Department, Stillwater, Oklahoma, USA.

Walkinshaw, L. H. 1981a. The Sandhill Cranes. Pages 151-162 *in* J. C. Lewis and H. Masatomi, eds., Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Tavernier, Florida, USA.

Walkinshaw, L. H. 1981b. West African Crowned Crane observations. Pages 255-257 *in* J. C. Lewis and H. Masatomi, eds., Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Tavernier, Florida, USA.

Walkinshaw, L. H. 1982. Nesting of the Florida Sandhill Crane in central Florida. Pages 53-62 *in* J. C. Lewis, ed., Proceedings of the 1981 Crane Workshop. National Audubon Society, Tavernier, Florida, USA.

Walkinshaw, L. H., W. P. Cottrille, and B. D. Cottrille. 1960. Southern Michigan Sandhill Crane survey, 1952-1958. Jack Pine Warbler 38: 25-28.

Walkinshaw, L. H. and R. H. Hoffman. 1974. Southern Michigan Sandhill Crane survey, 1971-1973. Jack Pine Warbler 52: 102-114.

Walkinshaw, L. H. and H. F. Wing. 1955. Censusing Southern Michigan Sandhill Cranes. Auk 72: 374-384

West, O. 1963. Notes on the Wattled Crane *Bugeranus carunculatus* (Gmelin). Ostrich 34: 63-77.

West, O. 1977. The wattled crane, an endangered species. Endangered Wildlife 1: unpaginated.

White, C. M. N. 1965. A revised checklist of African non-passerine birds. Government Printer, Lusaka, Zambia.

White, D. M. 1987. The status and distribution of the Brolga in Victoria, Australia. Pages 115-131 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Williams, M. D., D. N. Bakewell, G. J. Carey, H. Weishu, and J. Longrong. 1991. Migration of cranes at Beidaihe Beach, Hebei Province, China. Pages 139-147 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Windingstad, R. M. 1988. Non-hunting mortality in sandhill cranes. Journal of Wildlife Management 52: 260-263.

Winter, S. W. 1991. The Demoiselle Crane in the agricultural landscape of the Ukrainian steppe zone. Pages 285-294 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Wood, D. S. 1979. Phenetic relationships within the Family Gruidae. The Wilson Bulletin 91: 384-399.

Xiaojie, G. 1991. Cranes wintering at East Dongting Lake. Pages 113-114 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Xueming, Y. and T. Junchang. 1991. Preliminary studies on the breeding habits and domestication of the Demoiselle Crane. Pages 79-81 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Yiching, M. and J. Longrong. 1987. Distribution of the Red-crowned Crane in northeast China. Pages 57-60 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Youhui, W. 1991. A preliminary study of the wintering ecology of Common Cranes in Caohai. Pages 119-122 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Zhigang, W., H. Xiaodong, and W. Li. 1991. Observations of the migratory Siberian Cranes at Momoge Nature Reserve. Pages 135-137 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Zhiyong, L. and C. Bin. 1991. The wintering ecology of the Siberian Crane. Pages 109-112 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Table 1. The proportion of cranes that are non-breeders relative to the total population.

Species	Percentage non-breeders	Source
Black Crowned Crane	63%	Walkinshaw (1981b)
Grey Crowned Crane	17% (Serengeti)	Frame (1982)
	82% (Ngorongoro)	Frame (1982)
	50% (East Africa)	Pomeroy (1987)
	48% (Uganda)	Mafabi (1991)
	41% (Zimbabwe/Zambia/Natal)	Walkinshaw (1964)
	60% (Transvaal)	Tarboton (1992)
Eurasian Crane	51%	Prange and Mewes (1991)
Whooping Crane	50%	Kuyt (1981)
Blacknecked Crane	52%	Dehao *et al.* (1991)
Redcrowned Crane	66%	Mingyu *et al.* (1991)
Sarus Crane	31%	Gole (1987)
Blue Crane	72%	Geldenhuys (1984)
Wattled Crane	59% (Kafue)	Douthwaite (1974)
	58% (Kafue)	Howard (1989)
	81% (Zambia)	Howard and Aspinwall (1984)
	47% (Zimbabwe)	Mundy *et al.* (1984)
	31% (Zambia and Botswana)	Konrad (1981)
	10% (Transvaal)	Tarboton *et al.* (1987)
	25% (Natal)	Johnson and Barnes (1991)
Siberian Crane	62% (Siberia)	Flint and Kistchinski (1981)
	40% (China)	Zhigang *et al.* (1991)
Lesser Sandhill Crane	48%	Tacha *et al.* 1989
Greater Sandhill Crane	40% (Michigan)	Walkinshaw (1955)
	53% (Minnesota)	Grewe (1977 *in* Walkinshaw 1981a)
	79% (Manitoba)	Melvin *et al.* (1990)
Florida Sandhill Crane	26%	Bennett (1989a)

Table 2. Clutch size in cranes.

Species	1 egg	2 eggs	3 eggs	4 eggs	Mean clutch size	n=	Source
Black Crowned Crane	-	3	14	-	2.47	17	Walkinshaw (1973)
	-	1	4	-	2.80	5	Walkinshaw (1981b)
Grey Crowned Crane							
Kenya/Uganda	-	-	-	-	2.56	41	Pomeroy (1980)
Zimbabwe/Zambia/Malawi	-	-	-	-	2.33	28	Urban *et al.* (1986)
Zimbabwe/Zambia	4	3	10	-	2.35	17	Walkinshaw (1964)
Southern Africa	-	-	-	-	2.44	34	Urban *et al.* (1986)
Southern Africa	-	-	-	-	2.6	51	Maclean (1985)
South Africa	3	10	16	5	2.67	34	Walkinshaw (1973)
Transvaal	7	15	21	3	2.87	39	Tarboton (1992)
Natal	-	-	-	-	2.93	16	Urban *et al.* (1986)
Eastern Cape	-	19	15	1	2.49	35	Vernon *et al.* (1992)
Eurasian Crane	1	15	1	-	2.00	17	Glutz (1973 *in* Johnsgard 1983)
	2	17	-	-	1.89	19	Glutz (1973 *in* Johnsgard 1983)
	-	-	-	-	1.97	263	Prange and Mewes (1991)
Whooping Crane	17	220	3	-	1.94	240	Kuyt (1981)
Blacknecked Crane	3	7	-	-	1.70	10	Dehao (1987)
	1	3	-	-	1.75	4	Dehao *et al.* (1991)
Redcrowned Crane	-	-	-	-	1.83	52	Masatomi (1981)
	1	4	-	-	1.80	5	Viniter (1981)
	4	13	1	-	1.83	18	Ma (1981)
Sarus Crane	4	126	2	-	1.99	132	Walkinshaw (1973)
Brolga	6	20	1	-	1.82	27	Walkinshaw (1973)
	10	21	-	-	1.68*	31	White (1987)
Whitenaped Crane	1	22	-	-	1.96	23	Liying *et al.* (1991)
Demoiselle Crane	1	7	-	-	1.88	8	Glutz (1973 *in* Johnsgard 1983)
	-	7	-	-	2.00	7	Xueming and Junchang (1991)
	1	28	-	-	1.97*	29	Winter (1991)
Blue Crane	7	53	1	-	1.90	61	Walkinshaw (1973)
	-	-	-	-	1.8	150	Maclean (1985)
	-	8	-	-	2.0	8	Brown (1992)
	-	17	-	-	2.0	17	Vernon *et al.* (1992)

Table 2. Continued.

Wattled Crane							
Southern Africa	38	57	-	-	1.60	95	Konrad (1981)
Zambia	12	16	-	-	1.57	28	Benson and Pitman (1964)
Zimbabwe	-	5	-	-	2.00	5	West (1963)
Zimbabwe	4	2	-	-	1.33	6	Mundy *et al.* (1984)
Zimbabwe	10	11	-	-	1.52	21	Urban *et al.* (1986)
Transvaal	31	7	-	-	1.18	38	Tarboton *et al.* (1987)
Natal	43	27	-	-	1.39	70	Tarboton *et al.* (1987)
Siberian Crane	-	-	-	-	1.75	12	Flint and Sorokin (1981)
Lesser Sandhill Crane	17	54	-	-	1.76	71	Boise (1976 *in* Walkinshaw 1981a)
	11	76	-	-	1.87	87	Walkinshaw (1981a)
Canadian Sandhill Crane	5	48	-	-	1.91	53	Walkinshaw (1981a)
Greater Sandhill Crane	9	99	-	-	1.92	108	Littlefield and Ryder (1968 *in* Johnsgard 1983)
	24	310	3	-	1.94	337	Drewien (1973 *in* Johnsgard 1983)
	-	-	-	-	1.91	-	Bennett (1978 *in* Nesbitt 1988)
	17	275	1	-	1.95	293	Walkinshaw (1981a)
	7	37	2	-	1.89	46	Melvin *et al.* (1990)
Florida Sandhill Crane	10	54	-	-	1.84	64	Thompson (1970)
	13	181	-	-	1.94	194	Walkinshaw (1973, 1982 *in* Johnsgard 1983)
	28	71	-	-	1.72	99	Nesbitt (1988)
	22	165	-	-	1.88	187	Bennett and Bennett (1990)
	18	75	-	-	1.81	93	Dwyer and Tanner (1992)
Mississippi Sandhill Crane	7	28	1	-	1.83	36	Walkinshaw (1981a)
	-	-	-	-	1.86	79	Valentine (1982 *in* Johnsgard 1983)
Cuban Sandhill Crane	-	10	-	-	2.00	10	Walkinshaw (1973)

* All complete clutches

Table 3. Brood sizes in cranes (excluding the Whooping, Wattled, and Siberian Cranes).

Species	Mean brood size	% broods two young	n= broods	Source
Grey Crowned Crane				
East Africa	2.1*		35	Pomeroy (1987) (pre-fledging)
East Africa	1.7+	70%	39	Pomeroy (1987) (at fledging)
East Africa	1.5+	50%	32	Pomeroy (1987) (post-fledging)
East Africa	1.6*	60%	9	Frame (1982)
East Africa	2.1*		12	Mafabi (1991)
East Africa	2.3+		3	Mafabi (1991)
South Africa	1.7*	50%	13	Filmer and Holtshausen (1992)
South Africa	1.55*	55%	29	Tarboton (1992)
Eurasian Crane	1.18+	18%	887	Fernandez-Cruz (1981)
	1.25+	25%	-	Swanberg (1981)
	1.34+	34%	41	Nilsson (1982)
	1.33+	33%	424	Alonso, Veiga, and Alonso (1987)
	1.24+	24%	33	Bylin (1987)
	1.89*	89%	*ca* 90	Prange and Mewes (1991)
	1.37+	37%	173	Prange and Mewes (1991)
	1.42+	42%	1,164	Prange and Mewes (1991)
Hooded Crane	1.48+	48%	-	Nishida (1981)
	1.29+	29%	34	Chishan and Xiaolun (1987)
Sarus Crane	1.25*	25%	4	Gole (1987)
Brolga	1.23*	23%	43	White (1987)
Whitenaped Crane	1.27+	27%	-	Nishida (1981)
Demoiselle Crane	1.50*+	50%	14	Kovshar (1987)
	1.50*	50%	14	Winter (1991)
	1.67+	67%	9	Winter (1991)
Blue Crane	1.58*+	58%	12	Brown (1992)
	1.50*	50%	92	Filmer and Holtshausen (1992)

Table 3. Continued.

Lesser	1.00[+]	0%	623	Miller (1973)
Sandhill Crane	1.00[+]	0%	-	Tacha *et al.* (1989)
Greater	1.31[+]	31%	324	Walkinshaw (1973)
Sandhill Crane	1.35[+]	35%	372	Drewien (1973 *in* Johnsgard 1983)
	1.24[+]	24%	282	Drewien and Bizeau (1974 *in* Johnsgard 1983)
	1.20[+]	20%	134	Littlefield (1976 *in* Johnsgard 1983)
	1.36[+]	36%	-	Bennett (1978 *in* Bennett and Bennett 1990)
	1.19[+]	19%	-	Lovvorn and Kirkpatrick (1982b)
Florida	1.11	11%	27	Walkinshaw (1976 *in* Johnsgard 1983)
Sandhill Crane	1.65[•]	65%	43	Layne (1983)
	1.44[+]	44%	142	Layne (1983)
	1.25[+]	25%	-	Bishop (1988 *in* Bennett and Bennett 1990)
	1.12[+]	12%	34	Bennett and Bennett (1990)

[•] Fledgling stage
[+] At or post-fledgling stage

Table 4. The proportion of pairs in various crane populations that do not attempt to breed every year.

Species	% pairs not breeding	Source
Wattled Crane		
Kafue	60-97%	Douthwaite (1974)
Zimbabwe	59%	Mundy *et al.*(1984)
Natal	41%	Johnson and Barnes (1991)
Siberian Crane	40%	Flint and Sorokin (1981)
Florida Sandhill Crane	44%	Layne (1983)
Eurasian Crane	14%	Neumann (1987)
Blacknecked Crane	46%	Dehao *et al.* (1991)
Sarus Crane	50%	Gole (1987)

Table 5. Hatching success in cranes, presented as the percentage of individual eggs hatched (% eggs hatched) and as the percentage of nests in which at least one egg hatched (% nests hatched).

Species	% eggs hatched	% nests hatched	Source
Grey Crowned Crane	56%	-	Pomeroy (1980)
Eurasian Crane	-	73%	Glutz (1973 *in* Johnsgard 1983)
	74%	-	Glutz (1973 *in* Johnsgard 1983)
	-	63%	Glutz (1973 *in* Johnsgard 1983)
	-	70.7%	Prange and Mewes (1991)
Whooping Crane	79%	-	Kuyt (1981)
Redcrowned Crane	79%	74%	Masatomi (1981)
	93%	-	Ma (1981)
Demoiselle Crane	73%	82%	Winter (1991)
Blue Crane	89%	93%	Walkinshaw (1963)
Wattled Crane	-	55%	Johnson and Barnes (1991)
Lesser Sandhill Crane	64%	67%	Boise (1976 *in* Johnsgard 1983)
Greater Sandhill Crane	67%	75%	Walkinshaw (1949)
	-	78%	Drewien (1973 *in* Johnsgard 1983)
	-	44%	Littlefield (1976 *in* Johnsgard 1983)
	-	84%	Bennett (1978 *in* Bennett and Bennett 1990)
	73%	77%	Hoffman (1979 *in* Johnsgard 1983)
	77%	82%	Walkinshaw (1981a)
Florida Sandhill Crane	70%	88%	Thompson (1970)
	77%	74%	Walkinshaw (1981a)
	39%	48%	Nesbitt (1988)
	-	57%	Bennett and Bennett (1990)
	-	59%	Dwyer and Tanner (1992)
Mississippi Sandhill Crane	-	64%	Valentine (1982)

Table 6. Brood success of cranes, presented as the percentage of individual young fledged from eggs hatched (% young fledged), and as the percentage of nests in which least one young fledged (% nests fledged) for nests in which eggs hatched.

Species	% young fledged	% nests fledged	Source
Grey Crowned Crane	60%	-	Pomeroy (1980)
	28%	-	Mafabi (1991)
Eurasian Crane	73%	-	Prange and Mewes (1991)
Redcrowned Crane	56%	-	Masatomi (1981)
	60-70%	-	Viniter (1981)
Whooping Crane	65%	-	Novakowski (1966); Kuyt (1981) (both in Johnsgard 1983)
	-	-	
Demoiselle Crane	63%	64%	Winter (1991)
Wattled Crane	-	50%	West (1963)
	-	47%	Tarboton *et al.* (1987)
Lesser Sandhill Crane	-	60%	Boise (1977 *in* Tacha *et al.* 1989)
Greater Sandhill Crane	97%	98%	Walkinshaw (1981a)
Florida Sandhill Crane	99%	-	Walkinshaw (1982 *in* Johnsgard 1983)
	-	46%	Bennett and Bennett (1990)
	65%	-	Nesbitt (1992)

Table 7. **Proportion of breeding pairs of cranes with fledged young in the post-breeding period.**

Species	% pairs with young	Mean brood size	n= pairs	Source
Eurasian Crane	48%	1.18	1,847	Fernandez-Cruz (1981)
	55%	1.34	75	Nilsson (1982)
	41%	1.24	81	Bylin (1987)
	77%	1.42	1,517	Prange and Mewes (1991)
Hooded Crane	81%	1.29	42	Chishan and Xiaolun (1987)
Wattled Crane				
Zambia/Botswana	13%	1.00	254	Konrad (1981)
Kafue	20%#	1.00	64	Howard and Aspinwall (1984)
Kafue	12%	1.00	76	Howard (1989)
Bangweulu	34%	1.00	32	Howard and Aspinwall (1984)
Lesser Sandhill Crane	60%*	1.00		Boise (1977 *in* Tacha *et al.* 1989)
	48%+	1.00		Tacha *et al.* (1989)
Greater Sandhill Crane	53%	1.28	225	Walkinshaw (1955, 1965b)
Florida Sandhill Crane	39%	1.44	365	Layne (1983)

* On Alaskan breeding grounds
\+ Post-migration in Texas and Nebraska
\# Incomplete as count too early in the breeding season

Table 8. Breeding productivity in cranes, expressed as the number of young reared per pair per annum, where Young/pair/year = mean number of young reared per pair per annum; Young/breeding/ pair/year = mean number of young reared per pair that attempted to breed (laid eggs) per annum.

Species	Young/pair/ year	Young/breeding pair/year	n= pairs	Source
Grey Crowned Crane	-	1.00	12	Pomeroy (1980)
	-	0.58	12	Mafabi (1991)
Eurasian Crane	0.57	-	1,847	Fernandez-Cruz (1981)
	0.74	-	75	Nilsson (1982)
	0.51	-	81	Bylin (1987)
	0.87	1.01	146	Neumann (1987)
	-	1.09	1,517	Prange and Mewes (1991)
Hooded Crane	1.05	-	42	Chishan and Xiaolun (1987)
Whooping Crane	*ca* 0.52	-	248	Novakowski (1966), Kuyt (1981) (both *in* Johnsgard 1983)
Demoiselle Crane	-	0.88	17	Winter (1991)
Wattled Crane				
Zambia/Botswana	0.13	-	254	Konrad (1981)
Kafue	0.20#	-	64	Howard and Aspinwall (1984)
Kafue	0.12	-	76	Howard (1989)
Bangweulu	0.34	-	32	Howard and Aspinwall (1984)
Zimbabwe	0.60	-	5	West (1963)
Transvaal	0.41	-	94	Tarboton *et al.* (1987)
Natal	-	0.23	-	Tarboton *et al.* (1987)
Lesser Sandhill Crane	0.60*	-	-	Boise (1977 *in* Tacha *et al.* 1989)
	0.48+	-	-	Tacha *et al.* (1989)
Greater Sandhill Crane	0.68	-	225	Walkinshaw (1955, 1965b)
	0.74	-	67	Grewe (1977 *in* Walkinshaw 1981)
	-	1.39	204	Walkinshaw (1981a)
Florida Sandhill Crane	0.56	-	365	Layne (1983)
	0.70	-	287	Nesbitt (1992)

* On Alaskan breeding grounds
\+ Post-migration in Texas and Nebraska
\# Incomplete as count too early in breeding season

Table 9. Percentages of juveniles in various Sandhill Crane populations, where Locality type: B = on breeding grounds; M = during autumn migration, at staging, and stopover sites; W = on wintering grounds.

Population	Locality	Locality type	% juvs	n= individuals	Range	Source
Lesser	Alaska	M	7.2%	2,108	-	Herter (1982 *in* Johnsgard 1983)
	W. Texas	W	10.9%	-	9.2-13.7%	Tacha and Vohs (1984)
	W. North Dakota	M	10.6%	-	-	Tacha and Vohs (1984)
Canadian	Central Flyway	M	17%	-	-	Buller (1976 *in* Walkinshaw 1981a)
	-	-	18%	-	-	Aldrich (1979 *in* Walkinshaw 1981a)
	E. North Dakota	M	21.0%	-	-	Tacha and Vohs (1984)
	Oklahoma	M	14.0%	-	10.8-17.1%	Tacha and Vohs (1984)
	S. Texas	W	18.2%#	583 (flocks)		Tacha *et al.* (1986)
Lesser and Canadian	Saskatchewan	M	4.8%	32,837	3.5-5.9%	Miller and Hatfield (1974)
	Central Flyway	M	11.6%	-	8.8-19.9%	Buller (1979 in Melvin and Temple 1983)
	North Dakota	M	-	-	10.9-15.9%	Melvin and Temple (1983)
Eastern Greater	Michigan (1952-58)	B	19.4%	-	-	Walkinshaw *et al.* (1960 *in* Lovvorn and Kirkpatrick 1982b)
	Michigan (1971-73)	B	14.0%	-	-	Walkinshaw and Hoffman (1974 *in* Lovvorn and Kirkpatrick 1982b)
	Minnesota (1977)	B	15.0%	333	-	Grewe (1977 *in* Walkinshaw 1981a)
	Indiana (1977)	M	11.3%	9,894	-	Bennett (1978 *in* Lovvorn and Kirkpatrick 1982b)
	Indiana (1976)	M	13%	525	-	Crete (1980 *in* Lovvorn and Kirkpatrick 1982b)
	Indiana (1977)	M	10.3%	4,861	-	Crete (1980 *in* Lovvorn and Kirkpatrick 1982b)
	Wisconsin/Indiana	M	11.5%	14,442	-	Crete and Grewe (1982 *in* Johnsgard 1983)
	Indiana (1979-80)	M	12.7%	21,530	11.9*-13.4+%	Lovvorn and Kirkpatrick (1982b)
	Michigan (1984-86)	B	7.7%	-	4.8-9.9%	Urbanek *et al.* (1991)
Rocky Mountain Greater	Idaho	M	-	-	13.0-14.0%	Drewien (1973 *in* Bennett and Bennett 1990)
	New Mexico	W	11.5%	2,658	-	Drewien (1973 *in* Bennett and Bennett 1990)
Central Valley	Oregon	B	-	-	8-10%	Littlefield and Ryder (1968 *in* Bennett and Bennett 1990)
Greater	Oregon	B	6.6%	-	-	Scholorff *et al.*. (1983 *in* Bennett and Bennett 1990)
Florida	Florida	B	15.6%	192	-	Walkinshaw (1976 *in* Johnsgard 1983)
	Florida	B	10.1%	-	8.0-16.5%	Bishop (1988 *in* Nesbitt 1992)
	Georgia	B	8.8%	-	7.4-10.7%	Bennett and Bennett (1990)
	Florida	B	5%	100+	-	Dwyer and Tanner (1992)
	Florida	B	11.1%	-	7.8-13.6%	Nesbitt (1992)

* S.D. = 0.2
\+ S.D. = 0.3
\# S.E. = 0.6

Table 10. Percentages of juveniles in various crane populations, where Loc. type: B = on breeding grounds; MA = during autumn migration, at staging, and stopover sites; MS = during spring migration, at staging, and stopover sites; W = on wintering grounds.

Species	Locality	Locality type	% juvs	n= individuals	Range	Source
Grey Crowned	Uganda	B	11.7%	534	-	Brown and Pomeroy (1984)
Crane	Transkei, South Africa	B	11.1%	72	-	D. Allan (*pers. obs)*
Eurasian	-	-	12.0%	5,808	-	Libbert (1969 *in* Johnsgard 1983)
Crane	Sweden (1967-68, 1973)	MA	5.6%	-	5-6.7%	Swanberg (1981)
	Scandinavia	MA	12.3%[1]	22,740		Prange and Mewes (1991)
	Central Europe	MA	-	-	14-16%	Prange and Mewes (1991)
	Spain (1979)	W	11.4%	17,240	-	Fernandez-Cruz (1981)
	Spain (1979-86)	W	13.5%	121,826	11.7-19.0%	Alonso *et al.* (1991)
	Finland	MA	8.1%	-	-	Jantunen *et al.* (1985 *in* Rinne 1991)
	Finland (1983-85)	MA	8.5%	3,809	-	Rinne (1991)
	Finland (1983-85)	MA	9.0%[2]	6,137		Karlin and Raivio (1987), Rinne (1991) (both *in* Prange and Mewes 1991)
	Estonia	MA	13.9%	8,680	12.4-15.4%	Keskpaik and Rinne (1986)
	Hungary	MA	-	22 (flocks)	10-25%	Bankovics (1987)
	Hungary	MA	11.4%[3]	71,497		Sterbetz (1987 *in* Prange and Mewes 1991)
	India (1986)	W	15.4%	1,043	-	Khachar *et al.* (1991)
	China (1986)	W	15,5%	871	-	Williams *et al.* (1991)
	China (1987)	W	12.7%	71	-	Xiaojie (1991)
Hooded	Izumi, Japan (1968-72)	W	11.9%	2,984	2.0-20.0%	Nishida (1981)
Crane	Yashiro, Japan (1983-85)	W	21.2%	188	14.5-25.8%	Eguchi *et al.* (1991)
	China (1986)	MA	16.8%	309	-	Williams *et al.* (1991)
	China (1985-87)	W	17.4%	236	9.2-23.7%	Xiaojie (1991)
Whooping	Aransas, Texas (1938-52)	W	17.3%	-	-	Johnsgard (1983)
Crane	Aransas, Texas (1953-66)	W	15.1%	-	-	Johnsgard (1983)
	Aransas, Texas (1967-80)	W	10.6%	-	-	Johnsgard (1983)
Redcrowned Crane	Japan (1962-82)	B	12.7%	*ca* 4,200	6.8-20.9%	Masatomi (1979, 1981 *in* Johnsgard 1983), Archibald (1987)
	China (1980)	B	12.7%	173	-	Yiching and Longrong (1987)
	China (1981, 1984)	B	16.7%[4]	362	13.3-20.1%	Kemin and Zhongqin (1991)
	China (1986)	MA	21.8%	206	-	Williams *et al.* (1991)
Sarus Crane	Australia	B	16.7%	137	-	Blackman (1971 *in* Johnsgard 1983)
Brolga	Australia (1968-70)	B	17%	-	-	Blackman (1971 *in* Johnsgard 1983)
	Australia (1980)	B	10%[5]	*ca* 433	-	White (1987)
Whitenaped	Japan (1968-72)	W	15.4%	1,826	11.2-21.6%	Nishida (1981)
Crane	Korea	W	15%	*ca* 2,000	-	Archibald (1981a)
	China (1986)	MA	16.0%	25	-	Williams *et al.* (1991)
	China (1985)	W	24.7%	1241	-	Bin and Zuoyi (1991)
	China (1986)	W	7.6%	157	-	Xiaojie (1991)
Demoiselle Crane	India (1986)	W	8.7%	576	-	Khachar *et al.* (1991)
Wattled	Kafue	B	5.4%	147	3.6-7.5%	Douthewaite (1974)
Crane	Zambia/Botswana	B	4.2%	784	0.0-9.5%	Konrad (1981)
	Transvaal	B	6.3%	711	0.0-14.0%	Tarboton *et al.* (1987)

Table 10. Continued.

Siberian Crane	India (1969)	W	8.5%	65	-	Walkinshaw (1973)
	India (1967-82)	W	14.3%	568	9.1-26.1%	Sauey (1987)
	Yakutia, Siberia (1970's)	B	7.3%	41	-	Flint and Kistchinski (1981 *in* Johnsgard 1983)
	Poyang, China (1981-82)	W	9.1%	321	8.3-9.9%	Fuzhang and Wenning (1987)
	Poyang, China (1979-84)	W	14.5%	737	-	Jinlu and Kemin (1991)
	Poyang, China (1981-86)	W	12.6%	3,519	10.9-14.8%	Bin and Zuoyi (1991)
	Dongting, China (1985-87)	W	23.1%	26	-	Xiaojie (1991)
	Momoge, China (1985-86)	MA	22.5%	234	20.9%-24.0%	Zhigang *et al.* (1991)
	Momoge, China (1985-86)	MS	17.5%	126	-	Zhigang *et al.* (1991)
	Hebei, China (1986)	MA	21.9%	155	-	Williams *et al.* (1991)

[1] ±1.1%

[2] ±4.4%

[3] ±4.1%

[4] Sub-adults

[5] Immatures and juveniles, 1-22 months old

STATUS OF CRANES IN AFRICA, 1994

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INTRODUCTION

During the last five to ten years considerable interest has been generated in the conservation and research of cranes in Africa. This interest has resulted in the appearance of newsletters like the Working Group on African Crane's *The Crowned Crane* (published by the International Crane Foundation) and *The Crane* (published by the Southern African Crane Foundation). Workshops have been held, such as the 4th International Crane Workshop in Qiqihar, China, in May 1987 and the African Crane and Wetlands Training Workshop in Maun, Botswana, in August 1993. Papers in these newsletters, presentations given along with national action plans prepared at these workshops and published in their proceedings, and unpublished data given to the author of this paper suggest that the status of some cranes in Africa has changed from that estimated in 1985 (Urban 1988). This paper updates these changes through October 1994.

Eurasian Crane (*Grus grus*)

The number of Eurasian Cranes seems not to have changed in the past ten years in Africa (Table 1), except that a total of about 30,000 (North and Northeast Africa Crane and Wetland Action Plan *this proceedings*) rather than 30,000-50,000 seems to be a more reasonable estimate. Major concentrations of some 12,000-15,000 have been reported in northeast Tunisia (Gaultier and Essetti 1989). Since 1985 the Eurasian Crane has been reported twice in Djibouti; one of these records was a flock of 26 (G. Welch *pers. comm.*). Counts of this Palearctic winter visitor are needed particularly from Algeria and Libya where little is known about its status, especially in recent years.

Wattled Crane (*Bugeranus carunculatus*)

Although the total number of Wattled Cranes in 1994 has remained at the 1985 estimate of about 13,000-15,000, its status in at least two nations has changed in recent years (Table 2). In Mozambique the number has increased considerably due to the discovery of some 2,500 in the early 1990s (Goodman 1992). In Zambia, however, there appears to have been a reduction in numbers from 11,000 in 1985 to 7,000-8,000 in 1994 (T. Dodman *pers. comm.*).

Demoiselle Crane (*Anthropoides virgo*)

The number of Demoiselle Cranes from the Palearctic wintering in Africa does not appear to have changed much in the last 10 years (Table 3). However, the endangered resident population in Morocco has dropped from 20-30 individuals in 1985 to 5-6 pairs in 1994 (B. Haddane *this proceedings*). There is a special need to determine the status of the Demoiselle in Algeria where it recently has been reported (B. Haddane *this proceedings*). Since 1985, 9 Demoiselle Cranes were once reported on NE Kenya coast (Grumbley 1986) and a flock of 30 in Djibouti on 8 February 1988 (G. Welch *pers. comm.*). An especially interesting hypothesis published recently (Newton and Symens 1993) poses the possibility that most Demoiselle Cranes in Sudan migrate over the Red Sea and then east and northeast through Saudi Arabia. Hundreds to possibly a few thousand individuals may be involved.

Blue Crane (*Anthropoides paradiseus*)

There has been a major decline of the Blue Crane in eastern South Africa, especially in Natal. Tarboton (1992), for example, reported over 1,000 Blue Cranes in Natal in the early 1980s but only 100 breeding pairs in 1989. Recent estimates suggest there are presently about 500 birds in Natal (Porter 1993). The Blue Crane also has undergone a reduction in Namibia from some 700 in 1985 to 80 in 1993 (Brown 1992). In contrast, this crane is thriving in southwestern South Africa with some 10,000-21,000 noted there in recent years (Table 4) (Scott and Scott *this proceedings*; Allan 1992, *this proceedings*; South Africa Crane and Habitat Action Plan *this proceedings*). The current population may total 21,000, but there is much concern that its numbers may have declined as much as 90% in parts of its range (South Africa Crane and Habitat Action Plan *this proceedings*).

Black Crowned Crane (*Balearica pavonina*)

Based on recent reports (October 1994) of 3,500 at Waza Logone floodplain in Cameroon and the same number at Lac Fitri in Chad (P. Scholte *pers. comm.*), the Black Crowned Crane may be more numerous than estimated in some parts of West Africa. Overall, however, this crane appears to have declined in most parts of its range in West Africa (Nigeria Crane and Wetland Action Plan *this proceedings*) (Table 5). Estimates in western Africa have gone from 15,000-20,000 in 1985 to 11,500-17,500 in 1994. Numbers of this crane in the eastern part of its range, however, seem to have remained fairly stable with some 50,000 or so still reported there. There is a need for additional information on the status of the Black Crowned Crane in all nations where it occurs, most especially from western nations such as Burkina Faso, Central African Republic, and Mali where little is known of its status.

Grey Crowned Crane (*Balearica regulorum*)

The estimates of 100,000+ in 1985 compared with 85,000-95,000 in 1994 (Table 6) suggest that the Grey Crowned Crane has undergone some reduction in numbers in recent years. Support for this possible decline is based on several counts. In Natal (Johnson 1992), 941 individuals were counted in 1982 and 422 in 1989. In Uganda (P. Mafabi *pers. comm.*), this crane has apparently declined from 35,000 in 1985 to possibly less than 30,000 in 1994. Also the Kenya Crane and Wetland Action Plan (*this proceedings*) suggests that numbers of this crane are less in 1994 than they were in the mid-80s.

SUMMARY

The status of cranes as presented in 1985 is updated through July 1994. Estimates indicate that the numbers of Eurasian and Demoiselle Cranes have remained approximately the same, although the endangered resident population of the Demoiselle Crane has undergone further reduction to only about 5-6 pairs. The total number of Wattled Cranes has not changed much in the last 10 years, probably because reductions in parts of its range have been balanced by the discovery of previously unrecorded populations such as the 2,500 in Mozambique. There is, however, major concern for this species in countries such as Zambia where its numbers in the last 10 years have dropped from 11,000 to possibly as few as 7,000. The Blue Crane has undergone major reductions in Namibia and eastern South Africa but is thriving in southwestern South Africa. The major decline of the Black Crowned Crane, which began in West Africa in the 1970s, appears to have continued. This species, however, may be more common than thought in some areas of West Africa where recent counts of 3,500 have been reported from both Cameroon and Chad. The Grey Crowned Crane appears also to have undergone reduction in numbers in the last 10 years from 100,000 to some 85,000.

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REFERENCES CITED

Allan, D. G. 1992. Distribution, relative abundance and habitat of the Blue Crane in the Karoo and the south-western Cape. Pages 29-46 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Allan, D. In press. Cape Bird Blue Crane and Stanley's Bustard counts. Promerops.

Brown, C. J. 1992. The status of cranes in Namibia. Pages 75-78 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban. South Africa.

Gaultier, T. and I. Essetti. 1989. "Mission d'etude des Grues cendrees (*Grus grus*) hiverant en Tunisie." Association "Les Amis des Oiseaux," Tunis, Tunisia.

Goodman, P. S. 1992. Wattled Cranes in the Marromeu flood plain. Pages 155-156 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Grumbley, T. 1986. Demoiselle Cranes in Kenya. Bull. East Africa Nat. Hist. Soc. 16(2):16.

Johnson, D. N. 1992. The status of cranes in Natal in 1989. Pages 20-28 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Newton, S. F. and P. Symens. 1993. A survey of African Demoiselle Cranes *Anthropoides virgo* migrating through Saudi Arabia in spring 1992. Pages 595-596 *in* R. T. Wilson, ed., Proceedings of the Eighth Pan-African Ornithological Congress. Annales Musee Royal de l'Afrique Centrale (Zoologie) 268.

Porter, D. 1993. Crane numbers. The Crane 4(3):2.

Tarboton, W. R. 1992. Extent and reasons for population declines in South Africa's three crane species. Pages 117-118 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Urban, E. K. 1988. Status of cranes in Africa. Pages 315-329 *in* G. C. Backhurst, ed., Proceedings of the Sixth Pan-African Ornithological Congress. Nairobi, Kenya.

Table 1. Estimate by country of Eurasian Crane (*Grus grus*) wintering in Africa, 1985 and 1994.

Country	Number of Individuals	
	1985	1994
Algeria	low 1,000s	low 1,000s ?
Djibouti	-	vagrant
Egypt	many 1,000s	1,000s passage migrant < 100 wintering
Eritrea	50-100 ?	50-100 ?
Ethiopia	3,000	3,000-3,500
Libya	few 100s	?
Morocco	low 1,000s	2,000-3,000
Niger	vagrant	-
Nigeria	-	vagrant
Sudan	several 1,000s	several 1,000s
Tunisia	several 1,000s	12,000-15,000
Total	30,000-50,000	30,000 +

Table 2. Estimate by country of Wattled Crane (*Bugeranus carunculatus*) in Africa, 1985 and 1994.

Country	Number of Individuals 1985	1994
Angola	500	500 ?
Botswana	200*	1,400-3,500
Ethiopia	several 100s	100s
Malawi	100	50
Mozambique	250	2,500-2,800
Namibia	150	200-300
South Africa	300	250-300
Tanzania	several 100s	100s
Zaïre	several 100s	100s
Zambia	11,000	7,000-8,000
Zimbabwe	few 100s	250
Total	13,000 - 15,000	13,000-15,000

* The old reports of 2,000 birds at Makgadikgadi Pan and 2,500 - 3,000 at Okavango Delta are not included

Table 3. Estimate by country of Demoiselle Crane (*Anthropoides virgo*) in Africa, 1985 and 1994.

Country	Number of Individuals			
	Palearctic Visitors		Resident Population	
	1985	1994	1985	1994
Algeria	-	-	0?	0?
Chad	several 100	100s	-	-
Djibouti	-	vagrant	-	-
Ethiopia	?	?	-	-
Kenya	-	vagrant	-	-
Morocco	-	-	20-30	10-12
Nigeria	900	< 50	-	-
Sudan	several 1,000s	10,000-20,000	-	-
Tunisia	-	-	0 ?	-
Total	10,000-20,000	10,500-20,500	20-30	10-12

Table 4. Estimate by country of Blue Crane (*Anthropoides paradiseus*) in Africa, 1985 and 1994.

Country	Number of Individuals	
	1985	1994
Botswana	vagrant	vagrant
Namibia	700	80
South Africa	10,000-20,000	10,000-21,000
Zimbabwe	vagrant ?	vagrant
Total	10,000-20,000	10,000-21,000

Table 5. Estimate by country of Black Crowned Crane (*Balearica pavonina*) in Africa, 1985 and 1994.

Country	Number of Individuals 1985	1994
Benin	50 ?	50 ?
Burkina Faso	100 ?	100 ?
Cameroon	2,000	2,000-3,500
Central African Republic	several 100s to several 1,000s	several 100s
Chad	few 1,000s	3,500-5,000
Congo	600-700	0 ?
Egypt	-	vagrant ?
Ethiopia	few 1,000s	few 1,000s
Gambia	?	100
Ghana	50	50
Guinea-Bisseau	0 ?	?
Ivory Coast	-	vagrant
Kenya	few 100s	100s
Mali	7,000-8,000	3,000-5,000
Mauritania	200	200
Niger	several 100s	< 1,000
Nigeria	few 100s	< 100
Senegal	1,000	1,000-2,000
Sudan	50,000	50,000
Togo	50	50
Uganda	500	500
Total		
Western part of range	15,000-20,000	11,500-17,500
Eastern part of range	50,000-70,000	55,000-60,000

Table 6. Estimate by country of Grey Crowned Crane (*Balearica regulorum*) in Africa, 1985 and 1994.

Country	Number of Individuals 1985	1994
Angola	100	100
Botswana	100	100
Burundi	400-600	100s
Kenya	35,000	35,000
Malawi	100s	50-100
Mozambique	100s to low 1,000s	100s to low 1,000s
Namibia	100	40
Rwanda	500-1,000	100s ?
South Africa	low 1,000s	< 4,000
Tanzania	several 1,000s	several 1,000s
Uganda	35,000	< 30,000
Zaïre	5,000	5,000
Zambia	several 1,000s	5,000-6,000
Zimbabwe	several 1,000s	3,000-5,000
Total	100,000+	85,000-95,000

SECTION 2

CRANE AND WETLAND CONSERVATION IN NORTHERN AFRICA

WETLANDS AND CRANES IN NORTH AFRICA

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INTRODUCTION

Strategically situated on the northwest coast of Africa between the Sahara and Atlantic Coast, the North African countries of Morocco, Algeria, and Tunisia provide critical wintering grounds for hundreds of thousands of wintering waterbirds. The wetlands of North Africa also provide wintering habitat for two species of cranes: the Demoiselle (*Anthropoides virgo*) and the Common or Eurasian Crane (*Grus grus*).

Although many of these wetlands are protected in "Reserves Permanente" or "Parcs National," they are used for a variety of human activities, including grazing, fishing, vegetation harvest, and tourism. The surrounding areas are densely settled and cultivated, and water from the wetlands is used for hydroelectric power, irrigation, and domestic use.

This paper presents survey results on the status of cranes and other wintering waterbirds in Morocco and Algeria, and examines the socioeconomic constraints to the management and conservation of waterbirds and wetlands in North Africa.

METHODS AND MATERIALS

Data for the inventory of the wetlands and the annual census of waterbirds were compiled from published and unpublished articles, personal communication with colleagues, and field observations.

Cranes and waterbirds were censused in the most important wetlands of the Mediterranean and central regions of Algeria, and of the northeast, Atlantic, and mountainous regions of Morocco. The censuses were undertaken by National Park staff between October and March, 1983-present.

RESULTS

Of the 80 wetlands that were regularly inventoried in Algeria, 33 sites received a large number of wintering birds species. The three most important areas for wintering waterbirds in Algeria were the northeastern (56% of the mean annual waterbird total), the mid-north (16%), and the western regions (15%) (Bouzid 1991 and Table 1). The most important areas for Eurasian Cranes were the mid-north, west, and central regions. Demoiselle Cranes were not encountered during the census, but were reported to be present in the mid-north and west regions.

Of the 62 wetlands visited annually in Morocco between 1983 and 1993, 58% received large flocks of resident or migrating waterbirds. The most important region was the northwest (75% of the mean annual waterbird total) (Table 2). Other important regions included the northeast (4%); the middle and high Atlas Mountains (3%), the central Atlantic (10%), and the south Atlantic Coast (8%). Eurasian Cranes occurred in the northwest, northeast, south, and Atlantic regions. Small numbers of Demoiselle Cranes were occasionally found in the northeast and Atlas mountain regions.

DISCUSSION

Despite the arid to semi-arid nature of these Mediterranean countries, North Africa is rich in coastal and inland wetlands which are of great variety and ecological importance. With its 32 dams and 62 natural lakes, streams, and rivers, Morocco offers strategic feeding and staging sites for waterbirds migrating from Europe to Africa through the Gibraltar strait. The wetlands in Algeria receive a large number and diversity of wintering bird species. Tunisia provides habitat for more than 420,000 wintering waterfowl, which represents approximately 60% of the North Africa visiting waterfowl. Lake Ichkeul on the Mediterranean coast of Tunisia represents the most important wetland for waterbirds in North Africa. In general, waterfowl numbers in North Africa are controlled by the hydrology of the wetlands which is related to the annual rainfall on the country.

The Eurasian Crane is a frequent visitor to North Africa during the winter. The number of wintering Eurasian Cranes depends on the climate in a given year. The Demoiselle Crane is a scarce visitor to the region. This species has wintered in the mountainous areas between Morocco and Algeria for many decades, with a nesting flock in the Atlas Mountains of Morocco. A flock of Demoiselle Cranes spend the winter and spring at a breeding site in Timehdit district, Morocco. After hatching and fledging the cranes leave the site for 6 months, reappearing the following year.

Although both Eurasian and Demoiselle Cranes are protected by legislation that prohibits hunting and trade, the cranes are acutely affected by the loss of wetlands and increase in human activity in wetlands. During the last decade, such human activities as grazing, mining, timber and tourism have increased in the Atlas Mountains. Although the Demoiselle Crane still visits and winters in the region, the resident flock has grown smaller in number and may no longer be breeding.

Threats to wetland and waterbird conservation

The future of the wetlands in North Africa is related to socioeconomic development and the control of human activities around wetland areas. The completion of hydroelectric dams before and after national independence, the shortage of suitable land for the rapidly growing human population, and the need to drain wetlands to satisfy the demand for agricultural development have created serious challenges for the management and conservation of wetlands in North Africa.

Runoff from winter rainfall is currently sufficient to support wetland vegetation, but upstream dams in the catchments of important wetlands threaten their future water supply. In the next century, the human population of Morocco, Algeria, and Tunisia will probably reach 100 million (Table 3). Sixty percent of this population make their living from rural resources, and in 1990, more than 50% of the human population lived within 50 km of the coastal areas. This high population growth will make it increasingly difficult for decision makers to meet the demands of the citizenry.

Urbanization is a threat to these fragile ecosystems because of sewage outflow and the tourism industry. In Tunisia, at least 27% of lakes and marshes and 21% of rivers are polluted (Faouzi 1991). Mountain erosion, causing the transport and deposition of sediments in plains outside the riverbed has already occurred in most deltas. The appearance of eutrophication in some lagoons has reduced the vital capacity of wetlands to support a vulnerable wildlife population, particularly birds and fish.

Socio-economic value of wetlands

Wetlands have important cultural and historic value in North Africa. In addition, although there are insufficient data to produce a reliable figure for the economic value of these wetlands, permanent wetlands are usually used by local people for grazing, fishing, and collecting vegetation. Seasonal wetlands are frequently used for planting crops. To maintain these activities and the fertility of the land, the wetlands should be flooded regularly. Other direct economic income comes from the development of aquaculture including fish, eels, bivalves, and snails, although this industry will be directly affected by wide and uncontrolled use of pesticides and fertilizers.

CONCLUSION

North African countries have an important role to play in the protection of the regional environment on the south side of the Mediterranean sea and north of the Sahara desert, particularly the conservation of the variety of fragile ecosystems and their natural resources that occur there. In this region of the world where 84% of the territory is facing desertification and 7.5% of the wetlands are threatened because of desiccation, the loss of such ecosystems will dramatically affect not only the wildlife in the region but also the surrounding communities.

Government departments are very aware of the importance of wetlands and despite limited funds and scarce resources, they have attempted to conserve and to protect many wetland sites. If northern Africa's migratory routes for thousands of waterfowl are to be maintained until the next century, the conservation efforts launched by local governments must be continued and endorsed.

The establishment of a Mediterranean Wetland Organization (MWO) financed by all participating countries and supported by various international organizations (e.g., the International Union for the Conservation of Nature, World Wildlife Fund, and the European Economic Community) would be a positive step toward promoting the conservation and management of wetlands around the Mediterranean Sea.

Any program of conservation should not only maintain bird habitats but should also include the wise use and the sustainable utilization of a rich ecosystem vital for global socioeconomic development. The questions of who should benefit from wetlands and why have become central issues in the wildlife conservation strategy for North Africa. Without the participation of the local authorities and the inhabitants in the management of wetlands and wildlife for direct benefits, the tendency towards overexploitation will likely persist and resources such as wildlife will suffer as a consequence.

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REFERENCES CITED

Ashiq, Ahmed. 1991. The future of cranes in Pakistan with special reference to the northwest. Pages 335-339 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Bouzid, Chalabi. 1991. The status of wetlands and waterbirds in Algeria. Pages 79-82 *in* Managing Mediterranean wetlands and their birds: Proceedings of a Symposium in

Grado, Italy. International Waterfowl and Wetland Bureau, Slimbridge, UK.

Direction des Eaux et Forets. 1990. Ecologie et gestion des zones humides marocaines. Rapport de perfectionnement Janvier 1990.

Faouzi, Maamouri and Jocelyne Hughes. 1991. Prospects for wetlands and waterfowl in Tunisia. Pages 47-52 *in* Managing Mediterranean wetlands and their birds: Proceedings of a Symposium in Grado, Italy. International Waterfowl and Wetland Bureau, Slimbridge, UK.

GOMAC. 1992. Chronique ornithologie du GOMAC. Porphyrio 4(1/2): 95.

Recensement hivernal d'oiseaux d'eau au Maroc: 1986-1987, 1988. Institut Scientifique no. 11.

Schoff, G. H. 1991. Reflections: the story of cranes. International Crane Foundation, Baraboo, Wisconsin, USA.

Winter, S. W. 1991. The Demoiselle Crane in the agricultural landscape of the Ukrainian steppe zone. Pages 285-294 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Table 1. Census of waterbirds, Eurasian Cranes, and Demoiselle Cranes by region in Algeria, 1983-1991. The percentage by region of the national census of birds for Algeria is shown in parentheses (Bouzid 1991).

Species	Northeast	Mid-North	West	Central	South
Waterbirds	78,200 (56%)	21,350 (16%)	20,800 (15%)	6,800 (5%)	9,860 (8%)
Eurasian Crane	730 (4%)	254 (1%)	11 (0.1%)	-	-
Demoiselle Crane	-	-	reported	reported	-

Table 2. Census of waterbirds, Eurasian Cranes, and Demoiselle Cranes by region in Morocco, 1983-92.

Year	Species	Northwest Mnts	Northeast center	Atlas center	Atlantic	South	Total
1983	Waterbirds	70,579	1,522	9,761	646	10,858	93,366
	Eurasian	250	?*	-	-	47	297
	Demoiselle	-	-	8	-	-	8
1984	Waterbirds	51,654	3,419	6,447	7,579	6,753	75,852
	Eurasian	47	3	-	1	108	159
	Demoiselle	-	-	2	-	-	2
1985	Waterbirds	35,438	1,224	4,210	7,110	8,287	56,269
	Eurasian	-	250	-	148	78	556
	Demoiselle	-	-	-	-	-	-
1986	Waterbirds	66,317	10	1,849	865	8,420	77,461
	Eurasian	-	-	-	-	63	63
	Demoiselle	-	-	-	-	-	-
1987	Waterbirds	75,053	990	11,664	9,202	4,451	101,360
	Eurasian	601	-	-	370	56	1,027
	Demoiselle	-	-	-	-	-	-
1988	Waterbirds	103,209	6	3,266	8,262	15,440	130,183
	Eurasian	63	16	1	650	35	765
	Demoiselle	-	-	-	-	-	-
1989	Waterbirds	38,148	3,258	8,193	6,498	4,831	60,928
	Eurasian	16	106	-	-	40	162
	Demoiselle	-	-	-	-	-	-
1990	Waterbirds	77,092	2,226	2,820	4,801	6,046	92,985
	Eurasian	95	93+	-	48	94	237
	Demoiselle	-	-	2	-	-	2
1991	Waterbirds	85,119	800	7,387	13,587	7,651	114,544
	Eurasian	77	-	-	32	80	189
	Demoiselle	-	-	-	-	-	-
1992	Waterbirds	65,144	4,023	5,982	14,064	2,513	91,726
	Eurasian	975	480	-	-	39	1,494
	Demoiselle	-	-	4	-	-	4

* Observed, but not counted
+ Birds observed flying, not included in total

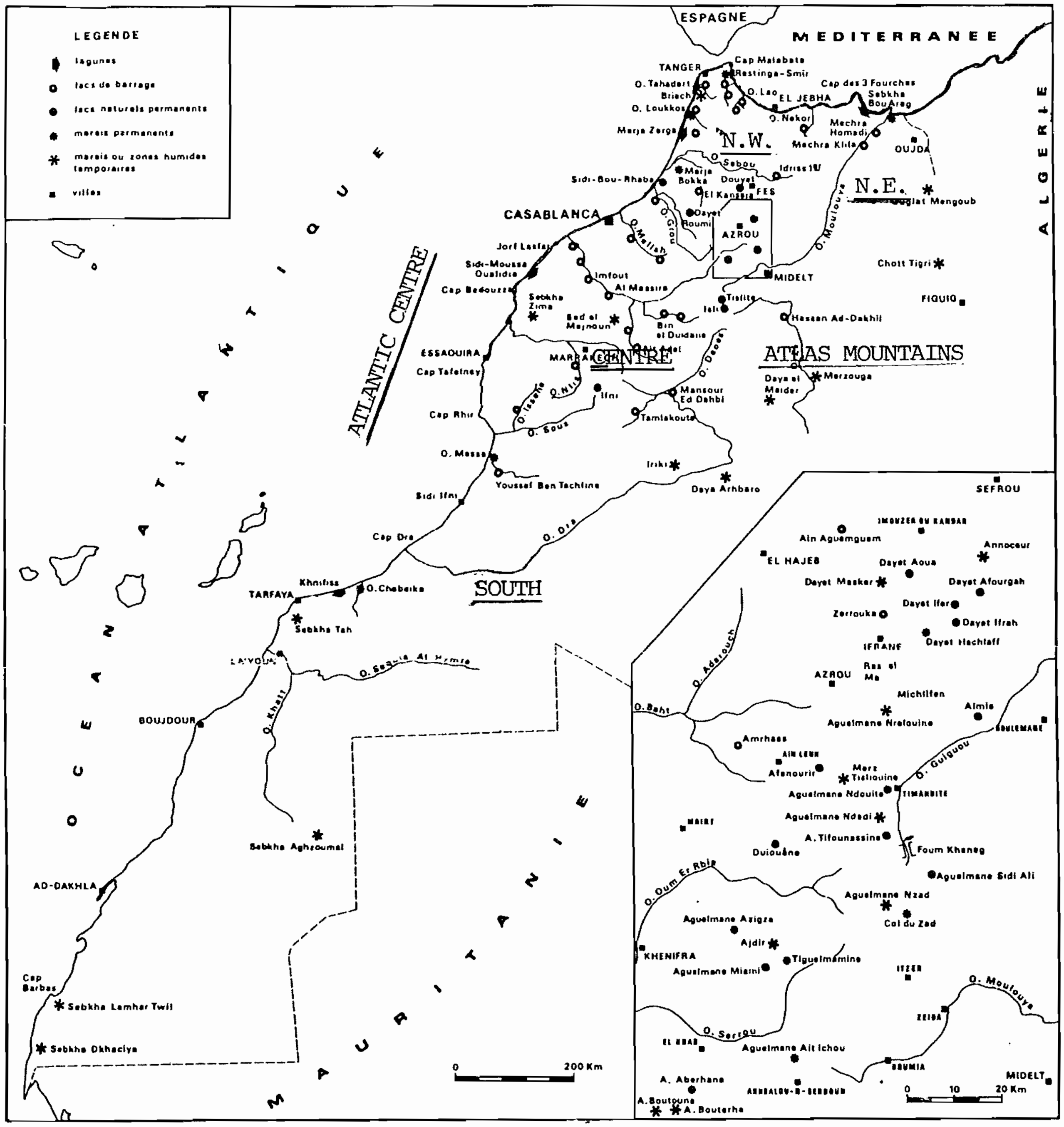

Figure 1. Important waterfowl areas of Morocco.

Table 3. Current and projected population (in thousands) and population density (persons/km^2) of Algeria, Morocco, and Tunisia.

Year		Morocco	Algeria	Tunisia
1990	Population	25,278	25,344	8,235
	Density	55.1	10.6	50.2
2000	Population	33,248	34,064	10,593
	Density	72.5	14.3	64.5

WETLANDS AND EURASIAN CRANES IN TUNISIA

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INTRODUCTION

Tunisia is the smallest country in North Africa, covering 164,150 km^2 area with a population of approximately 8 million. It is bounded by Algeria to the west and Libya to the southeast, and has 1,200 km of coastline along the Mediterranean Sea.

Average annual rainfall is greater than 1,000 mm in the extreme north and less than 100 mm in the south. Surface water resources are exploited by 20 dams and 14 large reservoirs, located mostly in northern Tunisia. Shallow groundwater resources and non-renewable deep water aquifers are also heavily exploited.

WETLANDS IN TUNISIA

Because of its relief in the north and in the center, Tunisia has many important wetlands for breeding and wintering waterfowl. IUCN has designated three Category A wetlands and five category B wetlands in Tunisia. Other significant wetlands in addition to these also occur.

Wetlands of Category A

Ichkeul Lake

Ichkeul Lake (37°13'N/9°30'E, 10,000 ha. maximum area in winter) is the most important wetland in North Africa. It provides fresh water in winter and salty water in summer. It is classified as a Wetland of International Importance under the Ramsar Convention because of its tremendous waterbird populations. Up to 300,000 waterbirds use Ichkeul Lake during particularly cold winters in Europe. The White-headed Duck (*Oxyura leucocephala*) is often observed there. Ichkeul Lake is designated a National Park in Tunisia, with full protection since 1980. It is classified by UNESCO as a World Heritage Site and a Biosphere Reserve.

The building of dams across three of the six oueds that feed the lake currently threatens the balance of this unique ecosystem. However, the Tunisian Ministry of the Environment is carrying out an international study to determine the quantity of fresh water (which would be released from Sejnane dam) needed to preserve the lake ecosystem.

Sebkhet Kelbia

The 13,000 ha. Sebkhet Kelbia (35°50'N/10°25'E) hosts a great number of wintering waterfowl (several ten thousands) among which are Eurasian Widgeon (*Anas penelope*), Pintail (*A. acuta*), and Shoveler (*A. clypeata*). Kelbia is the most important roosting area for Eurasian Cranes (*Grus grus*) in North Africa.

Bhiret El Bribane

Located in southeast Tunisia near the Libyan border (35°17'N/11°14'E), this great salty sea hosts a large number of salt-water birds including Greater Flamingo (*Phoenicopterus ruber*). During some years it is used as a roosting area for Eurasian Cranes.

Wetlands of Category B

Tunis Lake

Until 1985, the northern part of Tunis Lake (31°10'N/9°51'E, 4,500 ha.) receives all the wastewater from Tunis. More recently, treatment plants have been purifying the water and the lake has been dredged. The clean northern part of the lake, however, currently hosts many fewer birds than the polluted southern part (which receives industrial wastes). Thousands of waterbirds, including Whiteheaded Ducks, use the southern part of the lake. Tunis lake is fully protected as a National Reserve.

Kerkennak Island and Kneiss complex

Kerkennak Island (34°45'N/11°15'E) has the only Mediterranean wetland with a high amplitude tide, providing muddy beaches and lagoons. It is of international importance for migratory and wintering waders, herons, gulls, and terns. Ten to twelve thousand Whitebreasted Cormorants (*Phalacrocorax carbo*) and 150 to 200 Eurasian Cranes winter on Kerkennak Island. Breeding species include Little Egret *(Egretta garzetta)*, Redshank (*Tringa totanus)*, Slenderbilled Gull *(Larus genei)*, Common Tern (*Sterna hirundo),* and Little Tern (*S. albifrons)*. All these islands are fully protected.

Sebkhet Ennoual and Sebkhet Sidi Mausour

Sebkhet Ennoual (34°23'N/9°45'E, 11,000 ha.) and Sebkhet Sidi Mausour (34°15'N/09°30'E, 3,000 ha.) are salty lakes in a semi-arid region (less than 150 mm rainfall per year). The water level depends on autumn and winter rains, so the lakes may be totally dry during some years. They are of great importance for Greater Flamingo and wintering Common Shelduck *(Tadorna tadorna)*, Shoveler, and

Whiteheaded Duck. The lakes can be used as roosting areas for Eurasian Cranes.

Chott El Jerid

A great salty lake in an arid and barren zone, Chott El Jerid (33°40'N/8°10'E) is fed primarily by rain water. It is an important nesting site for Greater Flamingo in zones which are inaccessible for humans; observation can be carried out only by plane.

Jerba Island and neighboring regions

These wetlands (33°35'N/10°50'E) are important for waders, gulls, and terns. In winter, Jerba Island hosts several hundred cranes.

Other Wetlands

Several other wetlands not included on the IUCN list are also of international importance. These include:

Sebkhet Sidi El Hani

Sebkhet Sidi El Hani (35°35'N/10°25'E, 25,000 ha.) is a wetland of international importance as a regular roosting area for cranes and breeding area for Greater Flamingo during wet years.

Sejoumi Lake

Located in southwest Tunis city (36°45'N/10°10'E), this lake is of great importance for migrating and wintering waterfowl, especially Pintail, Shovelers, European Widgeon, and Common Shelduck (which breed there). Several thousand Greater Flamingo feed there during winter and spring. The site is fully protected.

There are other wetlands of international importance for waterfowl and waders in Tunisia, though perhaps to a lesser degree than the ten wetlands described above. The reservoir dams of northern and central Tunisia should also be considered among the important wetlands. A very rich flora has developed on the borders of these dams and host a great number of wintering ducks. The White-headed Duck is among the species breeding in the reservoir dams.

THE EURASIAN CRANE IN TUNISIA

Observations carried out by the association "Les Amis des Oiseaux" (Friends of the Birds) and foreign ornithologists, M. Ullman (1982-84), C. Iapichino (1985, 1989), and Rinne *et al.* (1991-92), show that the Eurasian Crane population wintering in Tunisia is over 12,000 individuals.

Periods, migration routes, and origin

Eurasian Cranes begin arriving in Tunisia from mid-October to the end of November. Departures begin in early March and peak in mid-March; observations of passages in April are rare. The most important migrating population is observed over the Cap Bon (in autumn and spring), following the median Mediterranean route which runs past Sicily Strait. Observations of passages over the Kerkennak Islands in autumn, however, show that the Eurasian Crane is able to fly across the whole Mediterranean Sea.

It is well known that the western population of Eurasian Cranes nest north of the 50th parallel from Scandinavia to Oural, mainly in Norway, Sweden, Finland, and the former Soviet Union. Not long ago, we had little information about the origin of Eurasian Cranes wintering in Tunisia. During the last few years, however, the installation of simple emitting stations and emitters detectable by satellite by the Finnish team lead by Professor Rinne has shown that a great number of Eurasian Cranes breed in Finland and winter in Tunisia, migrating past Estonia, Hungary, and Sicily (*pers. comm.*). These cranes winter in central Tunisia in the Kairorian Plain. It is highly probable that the cranes which winter in the Kerkennak islands and Jerba, however, breed further east of Finland and migrate across the entire width of the Mediterranean Sea.

Roosting and feeding places

Eurasian Cranes always roost in wetlands, particularly lakes, sebkhets, and marine lagoons which are shallow and safe from predators such as jackals and foxes. It is the availability and extent of surface water that governs the selection of these areas. In 1992-93, for example, Kelbia Lake was used as a roosting area only from the end of December, after heavy rains over the region. During the day, the cranes spread over newly plowed and sown wheat and barley fields. Eurasian Cranes are especially fond of bean fields; they also dig up the roots of plants such as *Herodium hirtum* and *Arisarum vulgare*.

Diet

Blanchet (1957) examined the stomach contents of Eurasian Cranes killed in the Sousse region. He noted the presence of wheat and barley grains as well as a great number of olive stones (250 stones in the stomach per individual, on average).

Protection

Tunisia has 20,000 hunters among its 8 million inhabitants. Legislation specifies the game species (less than thirty) and asserts that all the other species are protected, including the Eurasian Crane. Tunisian hunters especially target hares, Barbary Partridges (*Alectoris barbara)*, and thrushes (*Turdus* sp.), while hunting by tourists is permitted only for wild boars (*Sus sorofa*), thrushes, and European Starlings *(Sturnus vulgaris*). As a result, waterfowl and especially cranes are relatively safe in Tunisia.

REFERENCE CITED

Blanchet, R. 1957. Oiseaux de Tunisie, Mém. Soc. Sci. Nat. Tunisie 1(2): 186-188.

STATUS OF CRANES IN EGYPT

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Three species of cranes are recorded among the migratory birds of Egypt: the Eurasian Crane (*Grus grus*), the Demoiselle Crane (*Anthropoides virgo*), and the Black Crowned Crane (*Balearica pavonina*).

The Eurasian Crane is the most common passage visitor in the seasons of autumn and spring. The autumn migration is more visible in the eastern side of the country and lasts from late September to early December, peaking between mid-October and mid-November. The spring migration is more visible in the western desert during the period from early March to late April and reaches its peak in mid-March to April. The number of migrants is estimated to be several thousand and range widely across Egypt, especially in Sinai, the Suez Canal area, and the Nile Valley during the autumn migration season, and across the western desert, especially Wadi El-Natrun, the Oasis of Kharga, Dakhla, and Siwa during the spring migration.

Occasionally, the migrating cranes may land for a short time for rest and refueling. Wadi El-Natrun is a good resting area for the migrating cranes in the spring. A few cranes may winter in the Nile Valley, especially in the south including Lake Nasser. However, the accurate number of passage migrant or wintering cranes is not known because there is no regular count.

The Demoiselle Crane is recorded at present as a rare passage and winter visitor to Egypt. There is no recent sighting of the bird. The latest records are one bird on 22 December 1953, south of Alexandria and one bird in January 1978 in south Sinai (Hobel 1987 *in* Goodman and Meininger 1989). Older records show that the bird was seen by the thousands in the Nile Valley during the spring migration, indicating that this species was a common migrant in Egypt until the beginning of this century (Shelley 1872 *in* Goodman and Meininger 1989).

The Black Crowned Crane is considered an accidental visitor to Egypt. Von Besserer observed 30 birds in the Nile in 1908, and there have been unconfirmed records of this species near Gebel Elba, where three or four were shot in 1971 or 1972 (Goodman and Meininger 1989).

Human disturbance and shooting are probably the main problems facing cranes at their resting sites in Egypt. Few birds are thought to be shot annually, however, because their short length of stay limits the chance of shooting. In 1967 all crane species became protected by law against hunting.

Generally, cranes as well as other birds of Egypt have not received adequate study. Therefore, it is recommended that a regular count of migratory cranes be conducted and investigations of crane ecology be considered for future study.

REFERENCE CITED

Goodman, S. M. and P. L. Meininger, eds. 1989. The birds of Egypt. Oxford University Press, Oxford, UK.

STATUS OF CRANES AND WETLANDS IN ETHIOPIA

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INTRODUCTION

Ethiopia, including the vicinity that is now the nation of Eritrea, is the tenth largest African country, and covers approximately 1.24 million km² (Wolde-Mariam 1969). Located within the tropics, the country has many different land forms and significant variations in altitude, ranging from 4,620 m above sea level at Mount Ras Dejene (Gondar region) to the Dallol depression in Afar region, 120 m below sea level. The Great Rift Valley, passing through Ethiopia, separates the western highlands from the southeastern highlands of the country.

The altitudinal variation within Ethiopia results in a range of climatic variation. Vegetation diversity is high (Figure 1). The country is relatively well-endowed with different land forms that include high and rugged mountains, flattop plateaus, deep gorges, and river valleys. Approximately 51% of the total area is arable (Habte-Michael 1970).

Ethiopia has numerous wetland areas including more than 10 major catchment basins and more than 75 lakes, swamps, dams, and reservoirs (Gemetchu 1977; Hillman 1991). The rivers form a complex drainage system.

The country, has complex landscape with extremes of altitude, climate, and vegetation. Ethiopia has 861 different bird species, of which 28 are endemic. There are 204 wetland bird species, including four crane species. Out of the 204 wetland species, 3 are endemic: Blue Winged Goose *(Cyanochen cyanoptera)*, Rouget's Rail *(Rallus rougetii)*, and Wattled Ibis *(Bostrychia carunculata)*; 93 are resident; 82 are western Palearctic migrants; 8 are western Palaearctic migrants with resident races; and 6 are intra-African migrants. Although the diversity of Ethiopian birds is high, the exact populations of these different species is poorly known. The country's statistics on wildlife show birds to comprise 3.3% of the total number of wildlife species (EWCO 1989).

This paper reviews the distribution and occurrence of cranes, the range and status of wetlands, and the threats to and conservation needs of the cranes and of the wetlands that harbor the cranes.

CRANES OF ETHIOPIA

There are four crane species reported from Ethiopia. These are the Black Crowned Crane *(Balearica pavonina)*, the Wattled Crane (*Bugeranus carunculatus)*, the Eurasian Crane (*Grus grus)*, and the Demoiselle Crane (*Anthropoides virgo)*. Of these 4 crane species, the Crowned Cranes and the Wattled Cranes are residents while the other two are Palaearctic migrants (Urban and Brown 1971).

The Crowned Crane is resident in the western highlands, the western parts of the country and in the Rift Valley lakes and rivers. It breeds in August and September.

The Wattled Crane occasionally makes movements of a short distance within its distribution range in Ethiopia. It is resident in the montane habitats, the highland grasslands, streams, and marshes of the western and southeastern highlands, and the Rift Valley system (Figure 2). It feeds in the broadleaf tall grass savanna habitats and breeds in June and October.

The Eurasian Crane and the Demoiselle Crane are the two Palaearctic migrants, residing in Ethiopia from October to March. The Eurasian Crane, although mainly found in the western highlands and frequently in the Rift Valley, is seen throughout the country. It usually inhabits the aquatic ecosystems of the larger freshwater lakes and rivers, highland streams, and marshes, and feeds in grasslands including the highland grasslands acacia, short grassland savanna, and semi-desert savanna.

The exact status of the Demoiselle Crane is not clear. Its main wintering ground is in the Sudan, but it is locally common in western Ethiopia and the Rift Valley (Urban and Brown 1971).

According to Urban (1983) and Syvertsen (1993) there are about 3,000 Eurasian Cranes, a few thousand Crowned Cranes, and several hundred Wattled Cranes in Ethiopia.

The Wattled Crane, is known to occur in at least nine provinces of Ethiopia, including Gondar, Gojam, Shoa, Wellega, Keffa, Arssi, Bale, Sidamo, and Gamo Gofa (Urban and Walkinshaw 1967; Collar and Stuart 1985). There are no well-defined and organized data showing the exact population numbers and status of these cranes.

WETLANDS OF ETHIOPIA

The great geographical diversity of Ethiopia has endowed the country with a number of wetlands. The Great Rift Valley system, that passes through Ethiopia, ranges from 40 km to 60 km in width. Its floor contains a number of lakes like Zway, Langano, Abijata, Shala, Awassa, Abaya, and Chamo. In addition, volcanic crater lakes, small- to medium-sized alpine lakes of the volcanic plateaus, and a number of springs and creeks originate in the mountains of Ethiopia. There are also some artificial lakes (e.g., Akaki and Koka) which were constructed for potable water supply to cities.

A number of small and large earth dams are also found in the country. These have been constructed to partially mitigate the recurring drought problems that the country faces. Ethiopia is also known to possess large rivers, like the Blue Nile, the huge meandering river, that transverses the Sahara Desert to join the Mediterranean Sea. Twelve major rivers systems occur in Ethiopia.

CRANE AND WETLAND CONSERVATION IN ETHIOPIA: THREATS AND CONSERVATION MEASURES

In Ethiopia birds are protected through religious customs and by law. Most people are usually indifferent to birds, unless they are affected by them.

The main factors adversely affecting cranes are the loss, disturbance, and destruction of habitat, nests, and young. These are attributed to the burning of breeding sites, overgrazing, drought, deforestation, agricultural intensification, road building, wetland drainage, wetland damming, and so on.

The Ethiopian Wildlife Conservation Organization (EWCO), which is within the Ministry of Natural Resources Management and Environmental Protection, is the major governmental body responsible for conserving the wildlife of the country. Under the jurisdiction of the organization are national parks, wildlife sanctuaries and reserves, and controlled hunting areas.

Although the organization has achieved many things during the last 20 or more years, it doesn't seem to be competent enough to undertake all the necessary management activities which are among its responsibilities. This may be accounted for in part by its limited resources and certain other factors.

Cranes are known to occur in the five of the eight national parks. Wattled Cranes inhabit Abijatta-Shala Lakes National Park and Bale Mountain National Park. Crowned Cranes inhabit the Abijatta-Shala Lakes National Park, Gambella National Park, and the Mago National Park.

Unfortunately, it is rather disheartening to visualize the extent to which many of these protected areas suffer from human encroachment. For example, the Abijatta-Shala Lakes National Park is a protected area but is one of the most densely populated parts of Ethiopia. A considerable number of livestock and intensive farming practices cover almost the entire area of this park. Fuelwood collection, charcoal making, human use of the hot spring for medical purposes, and fishing in Lake Abijatta (especially during fasting periods from February to April) are some of the activities practiced by the settlers around the park (Hillman 1991).

Moreover, Lake Abijatta is the major site from which commercial industrial soda-ash extraction takes place. Rivers that drain to this lake and to Lake Shala are under intensive use for agriculture. This not only decreases the total amount of water that flows into the lakes but also results in heavy silt loads. Periodic fluctuation in the volume of lake water results in changes in algal composition and fish and cormorant populations, and may lead to the death and emigration of several bird species. It is only good rain that restores the original situation by raising the water level again.

The Abijatta-Shala Lakes National Park, which is located in the southern part of Shoa, was primarily established because of the abundance of such water birds as the White Pelican (*Pelecanus onocrotalus)* and Lesser Flamingos *(Phoenicopterus minor).* Of the 299 bird species in the park, 6 are endemic. The park was also founded to protect the bird breeding islands in Lake Shala. It is however, not yet gazetted.

Neither are the other national parks free from problems. Both Awash National Park (one of the two gazetted national parks in the country), and Bale Mountain National Park have considerable problems with respect to interference and settlement. For example, 2,500 people have settled around Bale Mountain National Park with their 8,300 cattle and 1,800 sheep and goats. Mago National Park, in the southern Omo region, one of the parks that harbor the crowned crane, has no permanent settlement because of the prevalence of tsetse fly. Nevertheless, nomadic pastoralists occupy a limited area of the park, and use it seasonally for their livestock (Hillman 1991).

Although the country continues with the general practice of conservation, the natural resource conservation in a given protected area, free from human interference (except tourism and management practices), seems unrealized. The term "Wetland Reserves" appears in the policy of the Ethiopian Wildlife Conservation Organization, but no such reserved area are exist However, the organization has developed a research plan on the Wattled Cranes of the Bale Mountains National Park (Hillman and Hillman 1992).

MAJOR PROBLEMS OF CONSERVATION

Conservation of natural resources, in Ethiopia, seems to have too little importance to keep pace with the changes that are occurring in the environment, changes that arise from the increasing human population in the country. The population of the country was estimated to be 53 million by mid-1992, with an approximate 3% growth rate. This gives an estimated 67.1 million Ethiopians by the year 2000, a size that leaves the country too poor to consciously undertake strong conservation measures (Wakbulcho 1992).

Environmental problems in Ethiopia can be attributed to a number of factors that include man-made and natural disasters, economic exploitation, traditional agricultural practices, human misuse of resources, and ignorance. At present, however, the country's major environmental problems must be linked with poverty and lack of development. In this country, there are millions of people living without the basic human requirements of enough food, adequate shelter, clothing, and health care. Still again, a number of people lack the opportunity to have even elementary education or a regular job. This situation, which is unbearable for a human being, results in the degradation of the environment, the only available natural resource from which people satisfy their needs.

In Ethiopia, where 88% of the people live in rural areas, people use traditional agricultural practices. The majority of these people are not literate and to survive have no alternative other than exploiting their environment. It is generally the improvement of the kind and quality of the life of the poor people that can pave the way to deal with environmental problems.

The environmental problems that are linked with the poor socioeconomic conditions of the rural and urban areas in Ethiopia have been provoked by additional problems that arise from the country's developmental moves. For example, damming wetlands to provide water and drainage to provide grazing or farming lands can completely change the natural structure of the and its natural resources. The use of pesticides, herbicides, and chemicals to control mosquitoes poses a threat to the wetlands of Ethiopia. Moreover, mineral extraction, agricultural intensification, and road construction activities threaten the wetland and the natural resources that the wetlands hold. Economic and social development must consider ways to fulfill the basic needs of the poorest human strata, to eradicate poverty and ignorance.

A more serious problem is that the value of the wetlands and the factors that contribute to the existence of the wetland were largely unknown or ignored until recently. Thus, the organizations and government bodies that regulate land use, while being aware of the concept of forest conservation, unlikely to achieve the wise use of wetlands. This has made them unable to practice wetland conservation strongly.

ACTIONS NEEDED FOR CRANE AND WETLAND CONSERVATION

Ethiopian wetlands are complex and numerous, and are characterized by high densities of individuals and/or high densities of species and productivity. Wetlands of the river systems have important hydrological values. They supply water during the dry season. Wetlands store nutrients, provide natural filters, minimize erosion, and in some cases recharge ground water supply (Gemetchu 1977).

Large wetlands host highly diversified life forms, i.e., diverse plant life, invertebrates, fishes, reptiles, birds, and mammals. These wetlands produce large amounts of fish and are able to provide food for large human populations. They provide extensive habitats for a great variety of bird life. The birds use the wetlands for feeding, roosting, migrating, wintering, nesting, and molting. Domestic animals (livestock) also use the wetland borders as a grazing area. The small wetlands also provide an important portion of the total habitat available for different life forms. The assessment of the importance of wetland values in this short review is never likely to be satisfactory. Wetlands have a wide range of products and services that can be harnessed to the benefit of human beings.

In short wetlands, taken as a constitute part of the natural ecosystem of Ethiopia:

- are of major importance in the maintenance of basic ecological processes on which man and all life depend;
- are part of Ethiopia's natural resources and national heritage that contribute to the genetic reservoir of the future;
- contribute directly to the national economy;
- and themselves and the life that they support have the right to exist.

The Ethiopian government seems to be aware of the need for soil conservation and has a department responsible for water and soil conservation in the country. This department is primarily responsible for motivating people in afforestation and soil conservation activities, but does not deal with the conservation of other resources. Thus there is an obvious need for a new approach to conserving wetland ecosystems of Ethiopia.

Wetland conservation programs should have as their objective ensuring that the wetland resources remain intact in perpetuity. The great diversity of wetlands may result in problems in integrated management, for the wetlands can only be managed through an interdisciplinary approach and the unreserved cooperation of different departments and authorities. In addition, since the country has such a variety of wetlands, conservation and management strategies for each wetland must be established according to the features of that wetland's ecosystem.

People need and use wetlands for a range of products. but do not yet recognize the real importance of these areas. This is especially true of the majority who have little or no opportunity for education. Such conditions don't enable the mass to be aware of the importance of these natural resources.

If people are taught about the values of the wetlands and if they are advised and encouraged to use the resources wisely, then they would be able to recognize the value and the essence of conserving the resources for future use. Recognizing the idea of conserving the resources for future use is difficult for a poor hungry population. It is poverty that drives the people to unwisely use and degrade their own environment. A new approach of resource management which involves and directly benefits the people who live within and around the location of the natural resources is required.

Actions like sharing the revenues brought by tourism, game cropping, and other activities of the conservation areas can change the people's life and encourage them to protect their environment. The local people should be encouraged to produce and sell some cultural objects or crafts to visitor in the area. The management approach to a project can also be used to associate social and economic development with wetland management. For instance, construction of clinics, elementary schools, a clean water supply, an electric power supply, and so on, from the income of the management area, can help the people to have a somewhat better life. Thereafter, people will care more about managing the environment.

Rural parents produce and support large number of children. This is either because they don't know the importance of family planning or, even if they do know, they don't have the means, or their cultural and religious customs may not allow them to practice it. Thus the human population that the environment supports is increasing at a fast rate. Education and the supply of the necessary means to develop family planning is necessary to avoid resultant manmade disasters.

Those who seek socioeconomic benefits (development) from the wetlands have to know the values of the wetlands and the factors that contribute to the existence of these areas. They also need to recognize the importance of conserving the wetlands and the natural resources.

The government and other responsible bodies should give close attention to the management of wetlands. Government policies that are kept in black and white only must be practiced implemented for the benefit of conservation.

In some cases, the governmental policies do not recognize the interdisciplinary nature of wetland management and are based on general and vague statements. When looking at such policies, it seems that it is the central government that requires more education and training than the rural settings.

The government and other responsible bodies have to develop an integrated approach towards conservation and sustainable utilization of wetland and wetland resources. They need to:

- undertake national inventories of wetlands and their biota (studies like wetland size, hydrological characteristics, species occurrence, and importance should be made before making any decision or before developing legislation);
- develop national wetland management policies including a review of current legislation relevant to wetlands management;
- develop wetland tourism, and establish adequate facilities;
- develop a means by which the local people benefit from such activities;
- assess the potential of wetland food resources and the population that they harbor;
- establish important areas for wetland conservation maintenance of biodiversity, education activities and recreation.

If the government undertook such activities, the sustainable use of the environment would be practiced. To protect the cranes, breeding sites need to be protected, burning of vegetation should be avoided or carefully planned, and great control should be practiced over the use of toxic agricultural chemicals and insecticides.

It is also important to raise people's awareness of wetland values through education. At the local level, village, community, and religious leaders and (especially) children are the key elements of education. Their understanding of conservation issues and their direct (active) participation in environmental activities assure not only the present but also the future conditions of wetland system. At national levels, training or enlightening the decision-makers, policy developers, investors, economists, as well as the active involvement of the media, school, wildlife clubs, and NGOs, among others, would be helpful in raising the awareness of the people.

The country has to be a party to the Ramsar Convention and manage Ramsar sites as required by the convention. The government should encourage the people to make wise use of the wetlands in order to ensure sustainable development.

CONCLUSION

An integrated approach to managing environments for sustainable utilization of the wetlands and wetland resources needs to be appreciated and practiced by the government and people soon. Crane and wetland conservation in Ethiopia will be realized by increasing the awareness of all the people of the values wetlands and by improving the poor living standards of the people. Poverty is a big threat to the environment and biological resources.

REFERENCES CITED

Brown, L. 1973. Conservation for survival: Ethiopia's choice. Haile Selassie I University, Addis Ababa, Ethiopia.

Collar, N. J. and S. N. Stuart. 1985. Wattled Crane. Pages 202-219 *in* Threatened birds of Africa and related islands, 3rd ed. International Council for Bird Preservation Cambridge, UK; IUCN, Gland, Switzerland.

EWCO. 1989. Agro-ecological zonation study of Ethiopia. Ethiopian Wildlife Conservation Organization (EWCO), Addis Ababa, Ethiopia. Mimeographed report.

EWCO. 1991. Information on the various crane species found in Ethiopia: crane record sheet. Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia.

Gemetchu, D. 1977. Aspects of climate and water budget in Ethiopia. Addis Ababa University Press, Addis Ababa, Ethiopia.

Habte-Michael, P. 1971. Ethiopia: fondements socio-economiques et reconstruction. IMF Report, Geneva, Switzerland, pp. 9-11.

Hillman, C. and S. Hillman. 1992. Records of cranes in Ethiopia. Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia. Mimeographed report.

Hillman, J. C. 1991. Ethiopia: a compendium of wildlife conservation information, Vol. 1 and 2. Ethiopian Wildlife Conservation Organization, Addis Ababa, Ethiopia.

Hundessa, T. 1991. Wetlands and waterbirds in eastern Africa. Pages 17-19 *in* C. M. Finlayson and D. E. Pomeroy, eds., Proceedings of an IWRB workshop in Uganda, 3-12 March, 1991. International Waterfowl and Wetlands Research Bureau, Slimbridge, Gloucester, UK.

Pichi-Sermolli, R.E.G. 1957. Una cartageobotanica dell'Africa orientale: Eritrea, Ethiopia, Somalia. Webbia, 13: 83-119

Syvertsen, P. O. 1993. Waterbird survey in Ethiopia in January 1993. University of Oslo, Norway.

Urban E. K. and L. H. Brown 1971. A checklist of birds of Ethiopia. Haile Sellasie I University Press, Addis Ababa, Ethiopia.

Urban E. K. and L. H. Walkinshaw, 1967. The Wattled Crane in Ethiopia. Auk 84(2): 263-264.

Wolde-Mariam, M. 1969. Atlas of Ethiopia. Haile Selassie I University Press, Addis Ababa, Ethiopia.

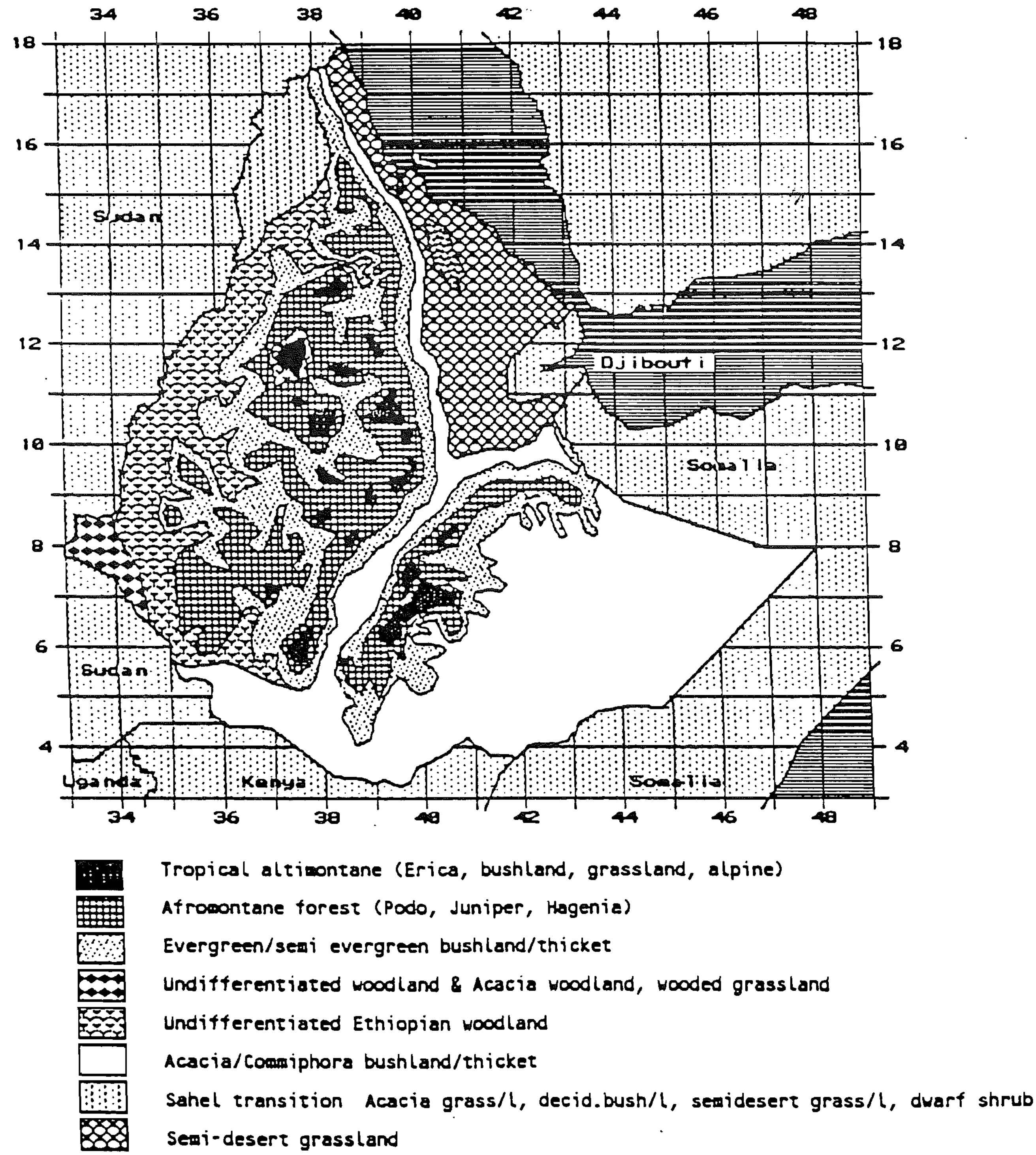

Figure 1. Vegetation map of Ethiopia (from Hillman 1991).

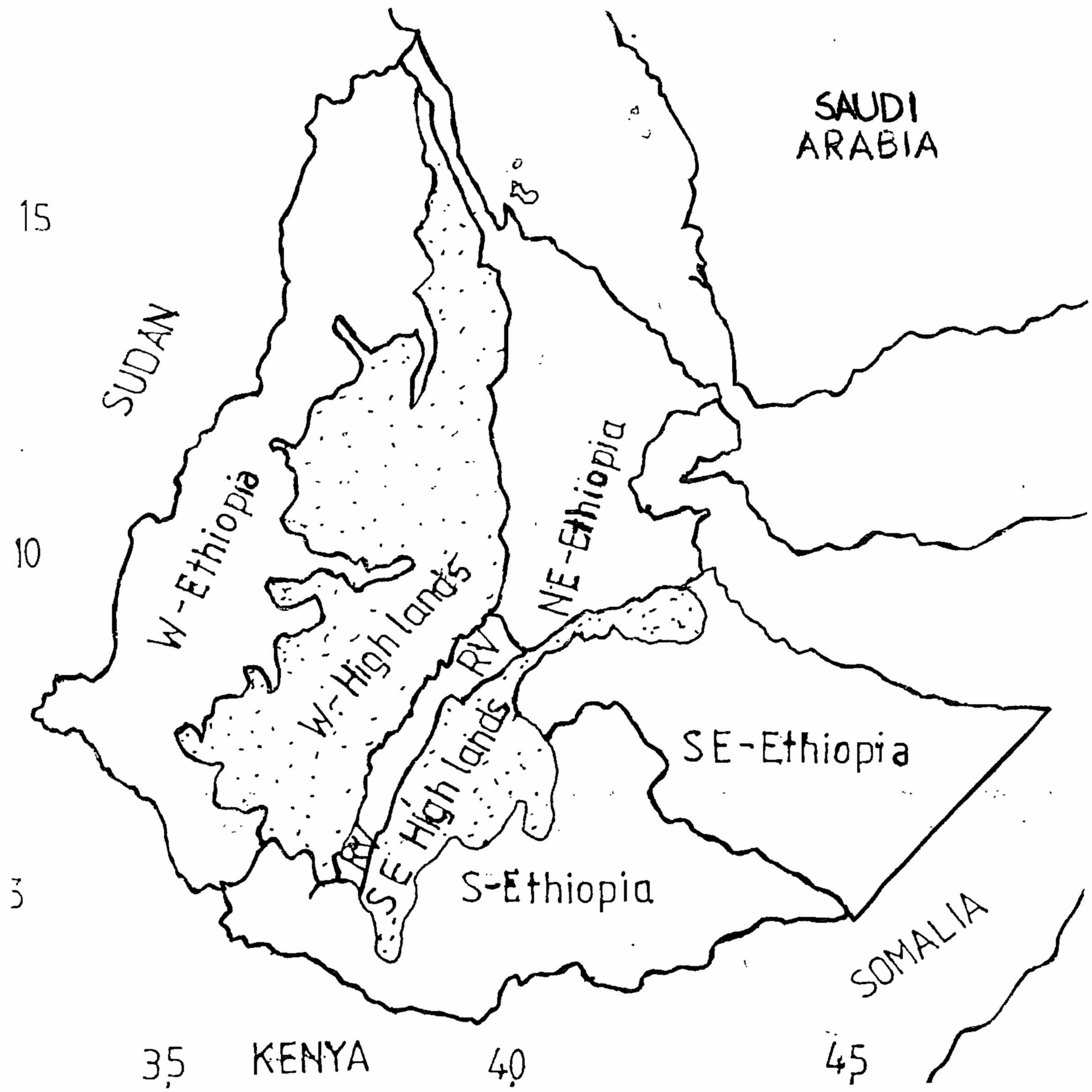

Figure 2. Geographical regions of Ethiopia (from Urban and Brown 1971).

ESTABLISHING A MONITORING PROGRAM FOR THE AFRICAN WINTERING POPULATION OF DEMOISELLE CRANES DURING THEIR SPRING MIGRATION THROUGH SAUDI ARABIA

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ABSTRACT

The regular migration of African-wintering Demoiselle Cranes (*Anthropoides virgo*) over the city of Jeddah on the Saudi Arabian Red Sea coast in spring and autumn is a well known phenomenon. Elsewhere in the Arabian peninsula, the species has vagrant status, though the sighting of a few flocks in north central Saudi in 1986 put a second point on the migratory flyway of the species. Prior to 1992, however, there had been no systematic attempt to enumerate the cranes involved or to determine precisely the route taken by this population. The principal reason for the involvement of the National Commission for Wildlife Conservation and Development (NCWCD) was to determine if any staging posts were used in the Kingdom which would need incorporation into the protected area network. Small teams of observers have been present in the Ha'il region (27°30'N/41°45'E) in spring 1992 and 1993. Totals of 4,500 and 6,000 Demoiselle Cranes were recorded in 1992 and 1993, respectively. Although the majority passed north on a fairly narrow front, the flyway is probably in excess of 100 km wide and flocks will occur in different areas depending on prevailing wind directions. Timing of passage was similar in both years with the majority occurring during the last week of March. Some flocks of cranes landed to roost in both desert habitats and on ephemeral flood pools. However, no regular or predictable staging areas were located and the cranes were largely uninterested in the abundant pivot-irrigation wheat fields as a food source. As we have been unable to cover the full width of the flyway simultaneously, we are not sure how many cranes are missed. Even if recorded numbers are doubled, then our totals are still a long way short of the 30,000 estimated by Russian researchers on the breeding grounds between the Caspian and Black Seas. Consequently another migratory flyway is presumed to exist, possibly via Cyprus as this is the only other non-African location where large numbers of Demoiselle Cranes have been seen in the recent past.

INTRODUCTION

Two species of crane occur regularly in the Middle East and northeast Africa: the Eurasian Crane (*Grus grus*) and the Demoiselle Crane (*Anthropoides virgo*). The Eurasian Crane is the better known of the two and is a reasonably common resident or partial migrant in the wetlands of central Turkey (maximum 12,690 in winter 1982, Martins 1989) and a common passage migrant over Egypt (Goodman and Meininger 1989) and Cyprus (Flint and Stewart 1992). The traditional wintering range has centered on the Gezira, between the Blue and White Niles in Sudan (Hogg *et al.* 1984; Khule 1988). During the mid 1970s large numbers of cranes have begun wintering in Israel and currently numbers are 6,000-7,000 (Levy and Yom-Tov 1991). On the Arabian Peninsula, Meinertzhagen (1954) reported that "many winter around Port Sudan but they have not yet been recorded from the Arabian coast of the Red Sea." Here too, however, the situation is changing and smaller numbers of Eurasian Cranes are wintering on several wetland areas and farms. Most notably, a wintering flock of up to 200 has become established at Wadi Jizan Dam in the extreme southwest of Saudi Arabia since they were first reported in 1988 (Symens 1990). Smaller groups are also wintering at other sites on the Red Sea coastal plain of Saudi Arabia (Rahmani *et al.* 1994) and in southern Oman (Eriksen 1992).

Conversely, the Demoiselle Crane is much more poorly known in the western part of its range. The species is a very scarce breeder and irregularly recorded migrant in Turkey (Kasparek 1988; Eames 1989). It is a regular migrant over Cyprus, especially in autumn (Flint and Stewart 1992) and, although there is considerable confusion with Eurasian Cranes, it is feared that numbers are declining. It has very seldom been recorded in Egypt in the twentieth century (Goodman and Meininger 1989) and despite considerable bird watching activity in Israel, Paz (1987) only gives seven records totaling 12 individuals for the period 1963-1984, although there is a recent record of a flock of 126 heading north along the west shore of the Dead Sea on 21 March 1988. The main wintering range in Sudan apparently overlaps with the Eurasian Crane, although smaller numbers also winter in the Lake Chad basin and the extreme northeast corner of Nigeria (Urban *et al.* 1986). Although large numbers of these cranes have regularly been recorded migrating over Jeddah on the Saudi Red Sea coast since

1937 (Trott 1941, 1947) and Port Sudan (Nikolaus *in* Urban *et al.* 1986), the numbers involved and their migratory flyway have not been investigated further despite their listing as a world Red Data species (Collar and Andrew 1988). Following observations of 1,200 Demoiselle Cranes in the Ha'il area of northcentral Saudi Arabia in spring 1986, ornithologists from the National Commission for Wildlife Conservation and Development have attempted to improve our knowledge of this threatened population of cranes (Newton and Symens 1993) and to devise an annual monitoring scheme.

This paper gives details of the crane migration monitoring in spring 1993 in northcentral Saudi Arabia and makes comparisons with observations from the same area in 1992.

METHODS

Nine observation points were selected to the north of Ha'il City near the edge of the Nafud Desert, which commanded good views to the south. The stations were mostly spaced 10-20 km apart, more or less in sight of one another, given good visibility. The east-west distance spanned by these stations was about 90 km, but lack of manpower reduced the effective sections of the flyway monitored to just over 50 km, between observation stations H and F (Figure 1). The outlying stations were visited infrequently on the ground but were covered during most aerial surveys.

There were four main methods of recording cranes. First, watch periods of between two and five hours were established during both early morning and late afternoon, with up to four sites being covered simultaneously. During watches, the horizon was scanned at frequent intervals through telescopes and binoculars to pick up birds over a wide area. Species, numbers, direction of travel, altitude, and time were recorded onto prepared forms. During all timed watches, the following meteorological variables were monitored: wind speed, wind direction, cloud cover, and horizontal visibility. Second, any casual observations while driving between observation stations or while between watches were recorded. Additionally, other people not directly involved in the survey supplied us with many incidental, casual observations. Third, in 1993 a group of volunteers arrived in Ha'il at the beginning of Eid holiday and helped to watch out for cranes. Finally, interviews with local people (garage attendants, shop keepers, and farmers) provided more records, although not all people were able to count/estimate the numbers of birds they had seen. Nevertheless, such observations still indicated timing and location of crane passage.

Six reconnaissance flights of 2.5-4 hours each were made, using single-engine Maule M6 aircraft, at times when ground observers were recording peak numbers of cranes. Usually north-south transects were flown over a wider area than was covered on the ground. Transects were usually spaced 10' latitude apart (c. 20 km), extending from the vicinity of Hufair in the west to Baq'a in the east, between 28°10'N and 27°15'N. Flight altitude was usually in the range 1,000-1,500 feet (300-500 m), approximately that at which most cranes were recorded.

RESULTS

Four NCWCD personnel were present in the Ha'il region for 17 days (from 18 March to 3 April) and were assisted by volunteers, particularly during the Eid holiday (23 to 27 March). Systematic crane migration watches were made at up to four stations simultaneously for a 13-day period (20 March to 1 April). On each day between two and five hours of observations were made in both the morning and afternoon, totaling 185.5 hours over the 13 days. A total of 19.5 hours aerial survey, entailing six missions, was made over 4 days of peak crane migration.

Number of flocks and individuals

We made, or received, a total of 44 observations of Demoiselle Crane flocks comprising a minimum total of 5,972 individuals. Three observations were of single birds, of which two presumably were of disoriented individuals that had temporarily "lost" their flocks, while the third was a dead bird reported below power lines. This perhaps indicated that a flock had passed through that locality during night-time. A group of three birds was recorded on the ground at midnight on 28 March in Al Aziziah Farm. Two apparently flew off; presumably the third bird was one released from captivity the previous day. Additionally, two flocks were reported to us, but in each case the observer was unable to give us an indication of their size. Consequently, the remaining 38 reports were of groups of five or more and these had a mean group size of 157 (range 6-550). It seems most probable that in excess of 6,000 Demoiselle Cranes passed through our study area.

Timing and pattern of sightings

The first cranes reported in the study area were seen on 16 March, the day before the arrival of the first NCWCD personnel. At least another two flocks passed the following day, but subsequently none were recorded until 22 March. Thereafter, flocks were seen daily until 2 April, with the exception of 30 March. Staff at Al Aziziah Farm reported no further observations in the period 3 to 14 April (Table 1). Two days of peak passage were 23 and 27 March, when nine and eight flocks were recorded, totaling 1,386 and 2,242 cranes, respectively (Figure 2). Most birds were detected when the prevailing wind direction was in the easterly sector (SE-NE) in the period 23 to 31 March (Table 1). Wind directions prior to and following this period were predominantly westerly.

Source of sighting data

The majority of the 5,972 cranes recorded were casual sightings (61%), 29% were attributable to systematic surveys, and 10% resulted from interviews. Only one individual was located during aerial surveys; the remainder were picked up from the ground.

Location of sightings

A map of the study area showing locations where cranes were observed is given (Figure 1) and these data have been grouped into five "sectors" (Table 2). Most of the cranes apparently passed through the western and central sectors of the study area, although it must be borne in mind that this was the area with the greatest observer coverage. The majority, 20 flocks and nearly 2,800 cranes, were detected in the central sector encompassing stations G, G', and Al Aziziah Farm. Of interest are the more westerly and easterly observations as these may help define the width of the Demoiselle Crane migratory flyway. A total of seven flocks (1,160 individuals) was recorded in the southern and western parts of Jabal Aja'. Three flocks were detected well to the east of our study area (Sector 5, Table 2): two were in the vicinity of Jabal Salma and one was recorded by volunteers returning to Riyadh, just northwest of Buraydah at 26°25'N/43°15'E.

Flight direction, altitude, and time of day

Most flocks were reported as heading "north", although observers frequently experienced difficulty in being precise due to the cranes' tendency to alternate periods of directional movement with swirling behavior as they gained altitude on thermals. However, directions recorded of flocks detected in the southern and western parts of Jabal Aja' frequently included a more easterly component. This tendency is consistent with cranes migrating approximately north-easterly from the Jeddah area (where most are thought to cross the Red Sea) until they reach the edge of the Nafud Desert in the Ha'il area where they then turn to follow a more northerly course. Some exceptions to this rule were noted, for example on 31 March, when two flocks headed east-north-east near Al Aziziah Farm towards a large flood pool where they eventually landed to roost.

The assessment of altitude frequently posed problems, because landmarks of known height (e.g., mountains) were often not visible. However, the range of altitudes recorded was similar to that observed in 1992: 100-300 m was typical, with the highest flocks (500-1,000 m) seen around the middle of the day. Table 3 shows the number of flocks recorded in five time periods through the day (local sunrise was about 06:00 and sunset 18:30 and darkness around 19:00). Most flocks were recorded in the late afternoon; early afternoon was the quietest period and the two morning periods showed intermediate activity. These data tend to support the hypothesis that cranes are most detectable early and late in the day when thermals are most poorly developed and during the middle of the day some may be higher than the human eye or ear may be able to detect. The "flock" recorded at midnight was apparently roosting.

Crane behavior

Nearly all flocks recorded by the survey were recorded as "flying/migrating." Two of the earliest observations obtained from interviews, both in the vicinity of Jabal Salma, were reported as "cranes seen throughout the day feeding and resting at a flood pool, but gone by the next day" and "feeding on fields, calling at night." The former flock comprised only about 20 individuals and no numbers were given in the second instance. These records seem to be exceptional as a considerable ground area was covered during daytime surveys but no flocks were recorded either feeding or resting in all habitats overflown (cereal fields, desert, flood pools/lakes). Given that cranes contrast very strongly against the bright green background of cereal fields, it was felt that if field feeding was a frequent occurrence, then we should have picked it up from aerial surveys.

Several observations of cranes were made at nightfall. One flock of 160 was detected flying north over Al Aziziah Farm at 18:45 on 23 March. They were followed using binoculars for 10 minutes (until total darkness) and were still flying strongly over the Nafud Desert. On 27 March, a large flock of 420 was seen high over the northeastern part of Jabal Aja' at 18:50. These cranes were initially at an altitude of 600 m above the plain level (100 m above the top of the mountains) but on clearing the northern limit of the massif, they began to descend rapidly, by circling, to 100 m. They presumably landed on the desert floor at about 19:00, to roost overnight.

In the late afternoon (16:27 and 17:00) of 31 March, two flocks were seen flying quite low towards the east-northeast along Al Khottah valley. The prevailing weather was very windy (force 5-6 SE) with rain, and overcast with low cloud. The earlier, smaller flock of 40 landed on a small shallow flood pool (estimated 50 x 30 m) within a cereal field, and most cranes began to drink. Half an hour later the larger flock joined them and most individuals rested, wing stretched and occasionally preened or pecked and drank. The birds were still present at nightfall (18:50) and most birds were roosting. At 07:10 the following morning no cranes were present on the pool. It seems that these flocks were flying contrary to their true migration flight line to find a satisfactory roost before embarking on the crossing of the Nafud.

DISCUSSION

The survey can be considered a success in terms of more cranes counted than in spring 1992, but the increase in numbers was not proportional to the considerably greater amount of time spent in the field by the main survey team, let alone the number of volunteers moving about the area. In 1992, 70% of all cranes recorded (4,542) were seen by a single team based at observation station B, during a total of 75 hours of watching (primarily at this site and observation station A). In 1993 approximately 72 hours (out of 205) were spent at these stations but only 510 cranes (8.5%) were seen. Clearly the migration pattern in 1993 was somewhat different: 29% of birds seen during watches (cf. 70% in 1992), 61% seen during casual observations or by farm staff (12% in 1992) and 10% accounted for by interviewing local residents (18% in 1992).

However, there were some similarities. The overall totals counted were of the same order of magnitude, in excess of 4,500 in 1992 and in excess 6,000 in 1993. These totals are still felt to be underestimates, as undoubtedly flocks passed through at watch stations when no observers were present, or during the night, or over parts of the flyway not covered by our teams. A "guesstimate" may put the population currently using the "Ha'il flyway" at 10,000 to 12,000 individuals. This is a long way short of the breeding population estimates of 30,000 for Demoiselles breeding in Russia between the Black and Caspian Seas (V. Flint *pers. comm.*) where the Saudi birds are thought to be heading. Several hypotheses may account for these differences.

1. The flyway through Saudi Arabia may be much wider than we assumed in our survey.

2. The majority of the population uses another flyway (perhaps through Cyprus?).

3. Counts from Russia are overestimates or the population has declined substantially since they were made.

We have some evidence from both years that the north central Saudi Arabian flyway extends east at least as far as Jabal Salma and may even extend towards Buraydah. If the former is the regular flyway, it extends approximately 100 km (E-W) but if flocks are regular in the latter, than it could be as much as 300 km.

Despite further literature research and the increase in bird watching activity across the Kingdom since the creation of NCWCD, the Jeddah and Ha'il areas remain the only two locations where Demoiselle Cranes are regularly observed. It thus would appear that most cranes cross the Red Sea at its narrowest point (between Port Sudan and Jeddah), fly northeasterly to the Ha'il area where they readjust direction and head more northerly on a bearing that would bring them to their Russian breeding grounds without further sea crossings (Figure 3). The flyway across the Kingdom would appear to be relatively narrow (the 100 km option) and the flock seen in Buraydah may prove to be an exception rather than the norm.

In both years, the majority of cranes was observed when easterly winds prevailed. If the flyway extends from the west side of Jabal Aja' to the east side of Jabal Salma and, given most of our observation stations were in the west (where Jabal Aja', Ha'il, and Al Aziziah Farm lie), then this pattern has a logical explanation. Perhaps placing observers in the Baq'a or Jabal Salma areas may be fruitful when westerly winds prevail during periods of peak migration.

Another similarity between the two years of observation was the timing of the main passage periods (Figure 2). In 1992 most cranes were seen on 27 March and 31 March (approximately 4 days apart); in 1993 flocks were seen over a more extensive period but there were still two peaks, on 23 March and 27 March (again four days apart, but four days earlier). We are now fairly certain that most cranes will predictably turn up in the last week to 10 days of March, despite considerable differences in weather between the two years. Overall, conditions for watching were poorer in 1993 with mist, low clouds, and precipitation of much more frequent occurrence.

Having questioned whether the Russian researchers' estimates are accurate, we ought to review our own methodologies. There is no doubt that cranes are difficult to count. Flock sizes are often large and their tendency for apparently stable v-shaped formations to fold into a swirling mass of soaring birds does not help. We have one interesting example that may indicate that our counts, especially those from inexperienced ornithologists or volunteers, may be underestimates. On 28 March two observers counted the same flock: one gave a count of 110 and took a photograph; the other estimated 120-150 cranes. Subsequent analysis of the photograph revealed 232 individuals. Only about 2,800 cranes of our total of nearly 6,000 (under 50%) were counted by experienced ornithologists; if the remainder were underestimated by 100% then our final count may have approached 9,000. If volunteers assist in future, there is probably little we can do to improve their counting technique, although provision of a leaflet comprising the "counting waterbirds" section of Perennou (1991) might help. On most of the occasions when both experienced personnel and inexperienced volunteers were together at a station, cranes failed to make an appearance. It is probably better to spread people more widely and accept that counts may not be perfect--the knowledge that a flock has passed at a site not otherwise covered, and the time, location, and order of magnitude will often suffice.

During all our time watching for cranes, we saw little evidence that the birds were facing any immediate threats from human activity in the Ha'il area. No hunting was observed and the only dead bird resulted from collision with power lines. Also, we have no direct evidence to suggest that cranes exploit and cause damage to the agricultural fields in the Ha'il area. Our only observation of cranes in a field was of birds using a flood pool (an area already "spoiled" by high rainfall or excessive irrigation) and the cranes were more interested in resting and drinking than in feeding.

Our results to date should now be considered from a wider, international perspective. If Russian estimates of population size are correct, and if most of these birds winter in Africa, then it would appear that a significant sub-population may be using another flyway. Cyprus is the only other location where migrating Demoiselle Cranes are seen regularly (Flint and Stewart 1992). Here, there is considerable confusion between Demoiselle and Eurasian Cranes, especially in spring when the migration timing overlaps, but in autumn the two periods are well separated with the bulk of Demoiselles passing mid-August to mid-September. No thorough counts have been made for over 20 years and although those undertaken in 1971 and 1972 were not complete, the minimum number involved was 3,000. In spring 1980, however, exceptional numbers of unidentified cranes were recorded (8,800). Presumably, many of these could have been Demoiselles, and this perhaps indicates that this western flyway may support as large numbers as the Saudi Arabian flyway does. Unfortunately, such large numbers are not picked up to the north and south of Cyprus, i.e., eastern Turkey (Kasparek 1988; Martins 1989) or Egypt (Goodman and Meininger 1989). The latter authors consider they may pass unnoticed at night or at high altitude, but our experience from Ha'il shows that they do not totally overfly the area at high altitude and are also detected frequently by local people. One possible explanation may be that Cyprus birds, often seen heading south-southwest out to sea from Akrotiri, the southernmost part of the island, may pass over the Egyptian Western Desert (see old records in Goodman *et al.* 1986) bound for more western parts of the wintering range (Elgood 1981). Flaxman (1987) reports some more recent evidence that partly supports a passage through Wadi Natrun on the edge of the Western Desert. His hunting acquaintances claimed that Demoiselle Cranes (misidentified as female Eurasian Cranes) passed through the area in April, but in lesser numbers than the Eurasian Cranes, which presumably pass through slightly earlier. The link between the Saudi flyway and the Sudanese/Nile wintering stronghold is far less speculative (Figure 3).

CONCLUSIONS AND RECOMMENDATIONS

Internationally important numbers of Demoiselle Cranes pass through the Ha'il area each spring. NCWCD should continue to monitor their population size, but no particular action is needed to safeguard sites via the protected area network.

Aerial surveys did not improve our ability to detect migrating flocks of cranes. However, in wet years, such as spring 1993, it does enable ephemeral wetlands to be located and visited quickly to check for roosting waterbirds.

A third migration watch in the Ha'il area is planned for spring 1995. In this and future years, the peak migration period will fall outside public holidays and we are unlikely to get the help of Saudi volunteer naturalists. Consequently, we may focus our attention on school teachers and children throughout the Ha'il region. Crane observation forms and instructions could be distributed to all schools and public offices in the area. Not only would this increase the public involvement in conservation, but it may be the only feasible way to fill the gaps in our information about the cranes' migration. Efforts should also be made to monitor the autumn migration of the species, either in Ha'il or Jeddah.

To help complete our understanding of the African wintering population of Demoiselle Cranes, more observations are urgently needed from the wintering areas, especially Sudan and the Lake Chad Basin, and these could be supplemented with an organized crane migration watch in Cyprus.

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REFERENCES CITED

Collar, N. J. and P. Andrew. 1988. Birds to watch: the ICBP world check-list of threatened birds. ICBP, Cambridge, UK.

Cramp, S. 1980. Handbook of the birds of Europe, the Middle East and North Africa. Vol. II: The birds of the western Palearctic. Oxford University Press, Oxford, UK.

Eames, J. 1989. Selected bird observations from Turkey: spring and summer 1987. OSME Bull. 23: 6-13.

Elgood, J. H. 1981. The Birds of Nigeria: an annotated check-list. British Ornithological Union Check-list No. 4, London, UK.

Eriksen, T. 1992. Asian waterfowl census in 1992. Oman Bird News 12: 3.

Flaxman, T. 1987. Cranes in Egypt. OSME Bull. 19: 16-17.

Flint, P. R. and P. F. Stewart. 1992. The birds of Cyprus: an annotated check-list. British Ornithological Union, Tring, UK.

Goodman, S. M. and P. L. Meininger. 1989. The birds of Egypt. Oxford University Press, Oxford, UK.

Goodman, S. M., P. L. Meininger, and W. C. Mullie. 1986. The birds of the Egyptian Western Desert. Miscellaneous publications no. 172, Museum of Zoology. University of Michigan, Ann Arbor, Michigan, USA.

Hogg, P., P. J. Dare, and J. V. Rintoul. 1984. Palearctic migrants in the central Sudan. Ibis 126: 307-331.

Kasparek, M. 1988. The Demoiselle Crane, *Anthropoides virgo*, in Turkey: distribution and population of a highly endangered species. Zoology in the Middle East 2: 31-38.

Khule, W. 1988. Wintering cranes from Eurasia. The Crowned Crane 2: 24.

Levy, N. and Y. Yom-Tov. 1991. Activity and status of cranes *Grus grus* wintering in Israel. Sandgrouse 13: 58-72.

Martins, R. P. 1989. Turkey bird report. Sandgrouse 11: 1-41.

Meinertzhagen, R. 1954. Birds of Arabia. Oliver and Boyd, Edinburgh, UK.

Newton, S. F. and P. Symens. 1993. A survey of African Demoiselle Cranes *Anthropoides virgo* migrating through Saudi Arabia in spring 1992. Pages 595-596 *in* R. T. Wilson, ed., Proceedings of the Eighth Pan-African Ornithological Congress. Annales Musee Royal de l'Afrique Centrale (Zoologie) 268.

Paz, U. 1987. The birds of Israel. Christopher Helm, London.

Perennou, C. 1991. African waterfowl census 1991. IWRB, Slimbridge, Gloucester, UK.

Rahmani, A. R., M. Shobrak, and S. F. Newton. 1994. Birds of Tihamah coastal plains of Saudi Arabia. OSME Bull. 32:1-19.

Symens, P. 1990. Notes on the birds of the N.C.W.C.D. protected areas of south west Saudi Arabia. NWRC quarterly report, Spring: 98-116.

Trott, A. C. 1941. Notes on birds seen and collected at Jedda. Ibis (Series 14) 5: 396-402.

Trott, A. C. 1947. Notes on birds seen and collected at Jedda and in Arabia during 1937, 1938, 1939 and 1940. Ibis 89: 77-98.

Urban, E. K., C. H. Fry, and S. Keith. 1986. The birds of Africa. Vol 2. Academic Press, London, UK.

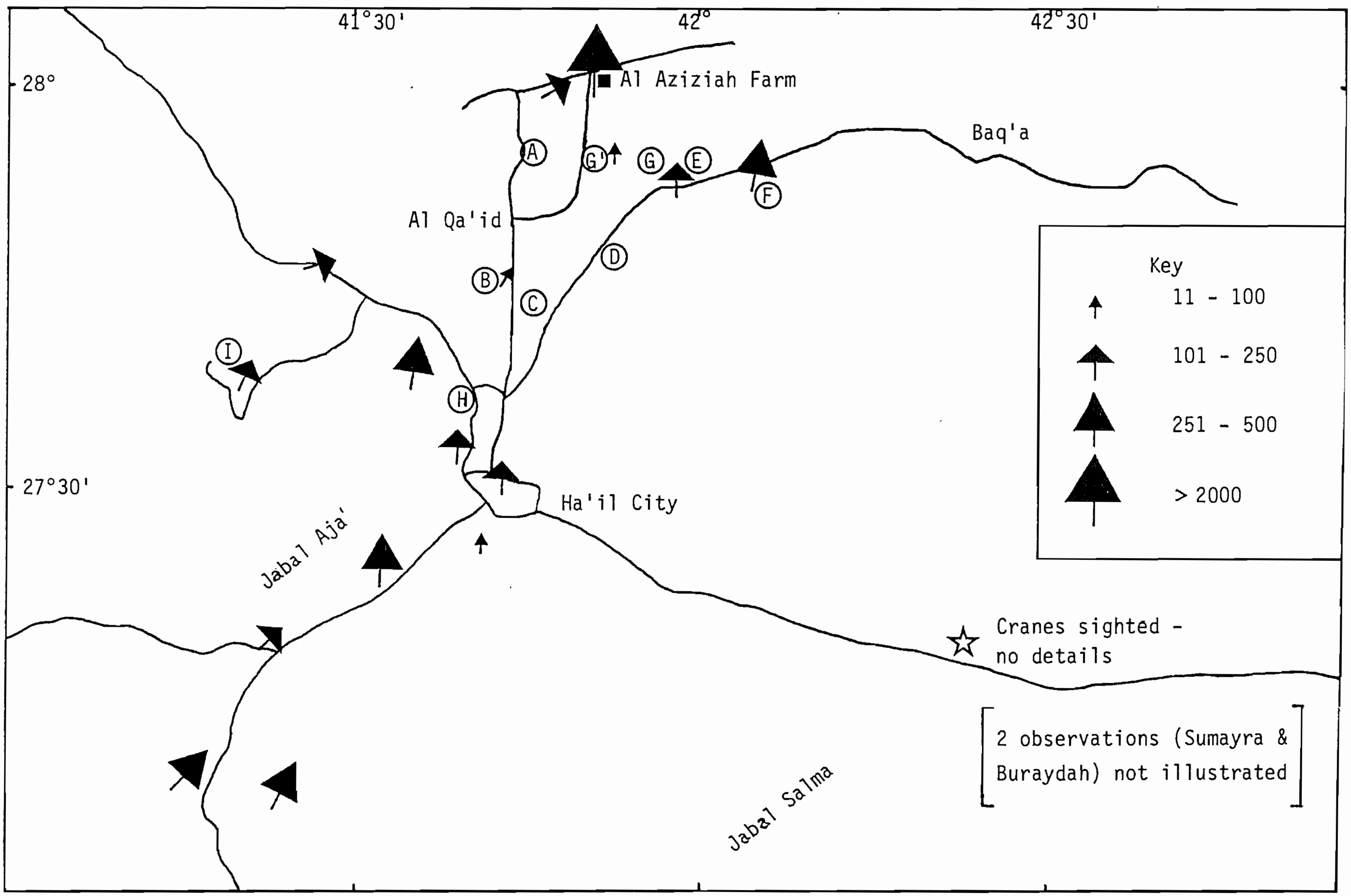

Figure 1. Size and flight direction of Demoiselle Crane flocks in the Ha'il region, spring 1993.

Table 1. Numbers of Demoiselle Cranes recorded on each day, Ha'il region, and predominant wind direction, 16 March - 14 April 1993.

Date	Birds	Flocks	Predominant wind direction morning	Predominant wind direction afternoon
March 16	190	1	-	-
March 17	191	1*	-	-
March 18	0	0	-	-
March 19	0	0	-	-
March 20	0	0	SW	SW/SSW
March 21	0	0	SW/NW	NW
March 22	220	2	W/NW	WNW/NW
March 23	1,386	9*	-	E
March 24	95	2	ESE/SE	ENE
March 25	260	2	SE	ENE
March 26	495	3	NNE	N
March 27	2,242	8	S	ESE/E
March 28	454	5	NE	ENE
March 29	70	1	SE	ESE
March 30	0	0	-	-
March 31	161	3*	SE	SE
April 1	58	1	E	WNW/NW
April 2	150	1	-	-
April 3-14	0	0	-	-

*Single bird "flocks"

Table 2. Numbers of Demoiselle Cranes recorded in different sectors across the flyway, Ha'il region, spring 1993.

No. of:	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Total
Flocks	7	8	20*	3	3	41*
Birds	1,160	1,312	2,844	435+	220+	5,971

*Also 2 "flocks" of 1 bird each (these singles are included in bird, but not flock, totals); 3rd single excluded (found dead beneath power lines)

The sectors are defined as follows:

Sector no.	Name	Coordinates	Observation station and other sites
1	West Aja	41°15'-41°30'	I, Al Uqlah, Al Ula turnoff, Jabal Bizakhah
2	East Aja and Ha'il	41°30'-41°45'	B, H, Al Mughawwat, As Self, Ha'il City and airport
3	Al Aziziah Farm	41°45'-42°00'	Farm, G', G, E
4	East	42°00'-42°15'	F
5	Far east	42°15'-42°45'	Sumayra, Jabal Salma north, northwest Buraydah

Table 3. Number of flocks of Demoiselle Cranes recorded in five time periods through the day.

Time Period	06:00-09:00	09:01-12:00	12:01-15:30	15:31-19:00	19:01-24:00
No. Flocks	9	8	5	17	1

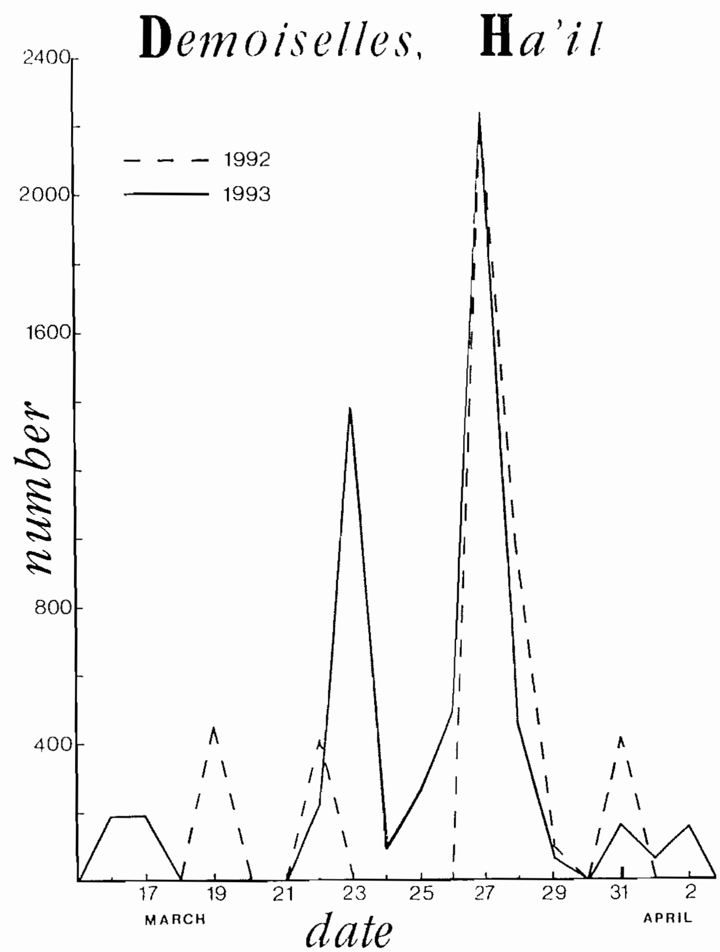

Figure 2. Numbers and timing of passage of Demoiselle Cranes passing through the Ha'il region in spring.

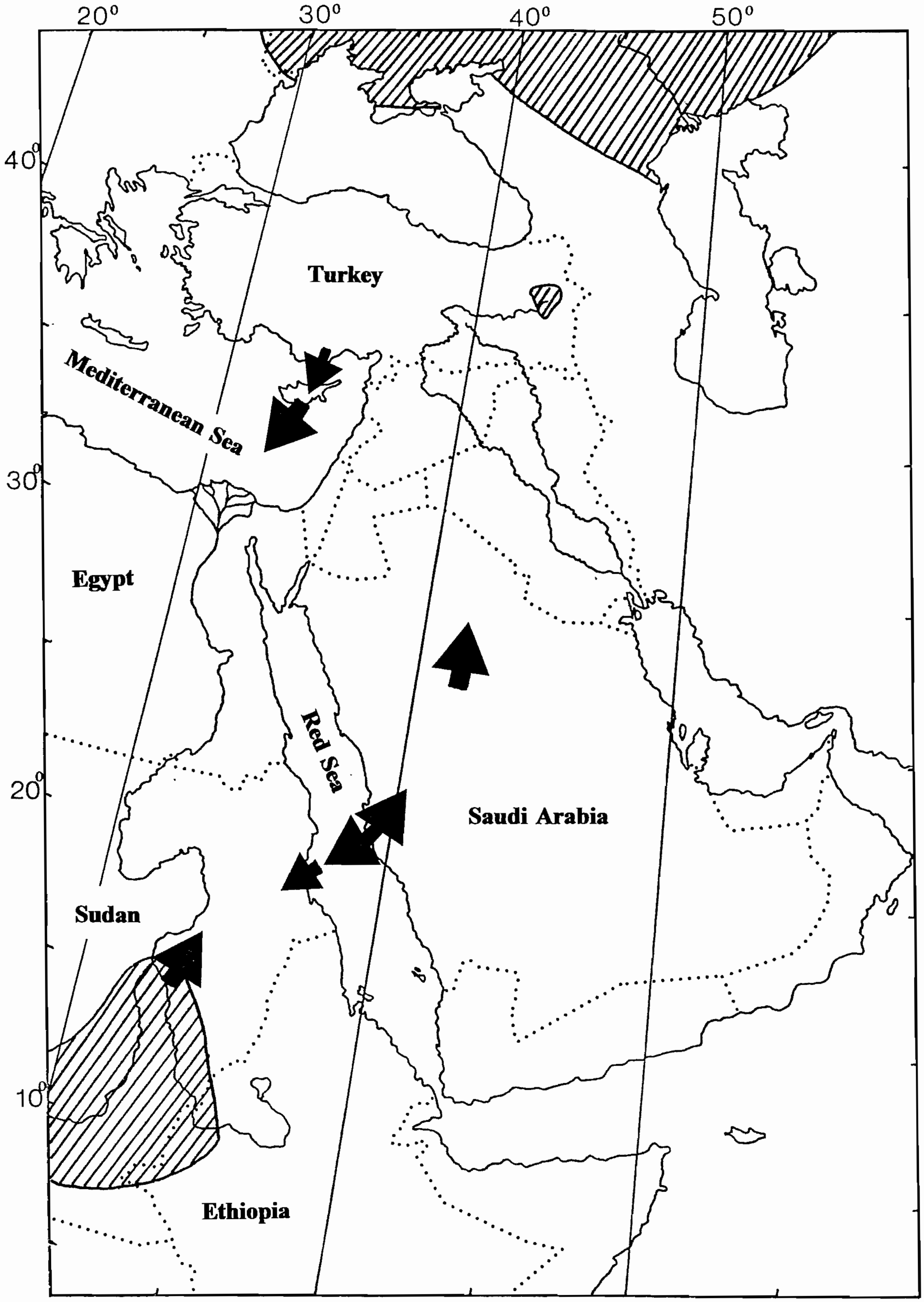

Figure 3. Migratory routes of the western breeding population of Demoiselle Cranes.

SECTION 3

CRANE AND WETLAND CONSERVATION IN WESTERN AND CENTRAL AFRICA

STRATEGIES FOR CONSERVATION OF CRANES AND THEIR HABITATS[1]

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ABSTRACT

The main aim of World Conservation Strategy is to convince everyone of the need to conserve natural resources so that they can regenerate naturally and supply us with our needs indefinitely. Cranes and wetlands are resources which require urgent conservation in West and Central Africa. Recent studies of the Black Crowned Crane in West Africa emphasized a near total neglect in this direction. Efforts however, had been made in some countries to recover declining crane populations successfully. This paper proposes various conservation strategy options for cranes and their habitats in West and Central Africa.

INTRODUCTION

Various strategies for crane conservation and special crane recovery programs have been developed and applied by many researchers and conservation organizations worldwide. In these and other related works, the message is clear that cranes and their habitats are being threatened worldwide. Although some of these conservation strategies have helped in the recovery of certain crane populations around the world (e.g., Whopping Cranes in North America), the Black Crowned Crane population continues to decline in almost all its known range in West Africa.

The authors of this paper believe that because the main causal factors responsible for the loss of cranes and destruction of their habitats are human-induced, any strategies for crane and habitat conservation should address measures aimed at reducing and/or eliminating problems such as deforestation, over-grazing, extensive fadama farming, trapping and shooting of cranes, and the use of herbicides and associated poisons.

We recognize that without the understanding and goodwill of the people who directly depend on wetlands or cranes for their livelihood, conservation cannot succeed. We therefore advocate extensive cooperative conservation education programs to safe-guard the cranes and their habitats.

As an urgent or interim measure, we advocate the establishment of pilot crane sanctuaries together with other crane related projects and activities throughout the sub-region. Emphasis is also placed on strategies like the establishment of captive breeding programs, stricter laws against crane and wetland destruction, and the creation of a National Bird Recovery or Survival Group in Nigeria. Other thought-provoking conservation plans are also advocated.

CONSERVATION STRATEGIES

As man reduces or damages the world's wild areas, the need to monitor and manage them becomes increasingly urgent. Through the basic principles of saving some of today's resources for tomorrow is now. Yet this paper not only seek to reiterate some of these strategies to safeguard the Black Crowned Crane (*Balearica pavonina*) and its habitats.

To save any wild species one must first save its habitat. The series of conservation strategies advocated below recognize this fact and demand cooperative conservation education and the need for alternative and/or better land use options, among others. Below are some of the proposals:

Establishment of crane sanctuaries

It is proposed here that after a joint feasibility study in all known areas harboring large concentration of cranes or large expanse of wetlands, the following types of protected areas should be established:

- crane sanctuaries or refuges (because of the status of the Black Crowned Crane as a national bird in Nigeria, a sanctuary could be called a "National Bird Sanctuary");
- pilot "Transfrontier Crane Parks", peace parks at international frontiers with large expanse of wetlands.

The management of these peace parks should be the responsibility of the countries concerned to be supported financially by national and international conservation

[1]Addendum to the Proceedings. Paper presented at the Conference on the Black Crowned Crane and its Wetland Habitats in West and Central Africa, Kano State, Nigeria, 25 February 1992.

organizations.

We believe that with the establishment of sanctuaries, refuges and parks, basic crane threat factors like extensive disturbances and destruction of wetlands, and trapping and shooting of cranes in and around crane concentration areas will be reduced if not completely eliminated.

Cooperative conservation education

Without the goodwill of the public, especially the rural communities, all conservation strategies embarked upon by well-meaning conservationists will amount to nothing. It is therefore proposed as a vital conservation strategies to lay a solid and lasting foundation for conservation education program aimed at enlightening crane and wetland dependent communities. It is also our view that the public at large should also be our concern.

In the light of the above, the following plans are being proposed towards this goal:

- conservation education on a cooperative basis should involve the Fisheries Department, Agriculture Department, Social Welfare Department, Farmers and Fishermen Cooperative Societies, cattle grazers, conservation organizations, Traditional Rulers, Wildlife and Forestry Department, and schools and colleges;
- target Groups should include crane trappers and dealers, fadama farmers and grazers, law makers, law enforcement agencies, etc.;
- outreach to the target group should be achieved through public lectures, print and electronic media advertisements, distribution of handbills and posters on crane and wetlands conservation, formation of crane and wetlands clubs, launching of appeal funds and Gala nights, introduction of special crane and wetlands commemorative stamps, and sale of crane souvenirs.

The training of personnel and the provision of equipment for this conservation education program should be the responsibility of both the local and international agencies.

Captive breeding program

Many our endangered wildlife species have been saved from total extinction through captive breeding programs. Species such as Arabian oryx, Pere David deer, and Patua land suail have been bred in captivity and released to the wild. Efforts are underway to improve the wild populations of several crane species through captive breeding programs, including globally endangered Whooping Cranes, Siberian Cranes, and Wattled Cranes.

This paper advocates for an extensive cooperative breeding program for the Black Crowned Crane in each of the sub-regional centers with appreciable crane populations. In areas where this option is not feasible for logistic reasons, breeding program could be carried out from a centralized pool and the program distributed to less privileged areas. We have in mind the International Crane Foundation as the major breeder for the sub-region.

It should be emphasized that before this program is put in place almost all proposed crane sanctuaries should have been created. In areas where local captive breeding could be undertaken, the experimental cohort should come from local sources.

The authors recognize the need for foreign assistance in this sphere since captive breeding projects are capital intensive. Technical assistance could be obtained from notable wild species breeding institutions like the Jersey Wildlife Preservation Trust.

Special laws to safeguard the Black Crowned Crane and its habitats

The authors again recognize the fact that man's continuous destruction of wildlife resources and their environments mainly arise from his inherent urge to circumvent loose and ambiguous laws and regulations. There is hardly a rural person who does not know the value of natural resources, especially those resources that he or she depends on. Yet destruction of wildlife and wild places continues on a daily basis because there are hardly any penalties deterring enough to discourage such wanton destruction by people.

It is in the light of this that we propose more purposeful and deterring laws to be specially enacted throughout the sub-region to halt the excesses of crane dependent business. In Nigeria a "National Bird Protection Decree" could be promulgated as a pace-setter for the entire West and Central Africa to follow. We also advocate crane and wetlands protection in Africa as a priority in future OAU deliberations.

Scope of proposed laws

New laws are needed to cover the following activities:

- prohibition of trapping and shooting of cranes;
- total exclusion of human settlements within areas of high crane concentration;
- prohibition of all forms of human activities in proposed) crane sanctuaries;
- control or total prohibition of herbicides and other forms of poison in wetland areas;
- regulating resources use (fish, water, vegetation, birds) in and around all wetlands;
- special law enforcing powers for crane protection guards.

Establishment of crane and wetlands endowment fund

It is proposed that in order to execute some of or most of these conservation strategies, a special endowment fund be created to serve as financial source for all envisaged crane and wetlands projects. It is envisaged that the endowment fund would be initiated at both local and international levels. In Nigeria for instance, we could launch a "National Bird Survival Fund." The establishment of local endowment fund should in no way replace would-be external aid.

Introduction of alternative and/or better land use options

Since the trapping of cranes and over-exploitation of wetland resources are regarded as some people's way of life, this paper suggests a radical change in peoples attitudes toward resource use in wetland areas. It is intended that much as we do not intend to take the bread away from the crane dealer's table, we seek to initiate a more sustainable way of livelihood for such people.

The following measures are therefore proposed.

1. Governments in all areas concerned with crane protection should help secure financial assistance to provide an alternative to crane trapping for crane trappers who may be willing to go into more viable ventures like fish, poultry, rabbit, livestock, or fadama farming.

2. Nomadic fadama farmers should be supported with access to better farming methods, supplies of agricultural in-puts as well as agriculture-related loans, supplies of improved seeds, and better options for storage and marketing. Permanent settlers should be encouraged to serve as an attraction to nomadism. We believe that nomads do not always have a strong obligation to rationally use any given natural resource.

Establishment of crane survival groups

As a prerequisite to permanent and sustained crane protection measures, we advocate the establishment of crane survival or recovery groups for each country within the sub-region where cranes occur. In Nigeria in particular we should endeavor to establish a national bird survival or recovery committee. Similar groups or committees should be established in all countries within the sub-region with crane protection problems.

We again suggest, as an interim measure, the creation of a sub-regional Crane and Wetlands Research and Monitoring Unit. It is envisaged that this unit would be responsible for all major crane related projects within the sub-region. Funding of such projects as has earlier been recommended should be multinational in outlook, but with local support.

This paper is of the opinion that the establishment of crane recovery/survival groups should be the major priority in country even before the formation of crane sanctuaries. We believe that if there is a statutory group responsible for an all embracing crane survival package, there will be little room for uncoordinated efforts which is the bane of most conservation programs in developing countries.

CONCLUSION

The authors of this paper are of the view that if most of the above conservation strategies proposed for the survival the Black Crowned Cranes and their habitats are embarked upon, we in West and Central African sub-region will lay a solid foundation for the survival and sustained use of cranes and wetlands.

In adopting any of our proposals, emphasis should be placed on the rational use of wetlands. For the fact still remains that no wild animal can be properly managed in the wild in the absence of its ideal habitat.

Finally, we should all agree that rural communities do not destroy natural resources if they have sustained means of livelihood. Efforts therefore, should be made to involve the wetland-dependent communities as integral parts of these programs.

WETLAND HABITATS FOR BLACK CROWNED CRANES IN WEST AND CENTRAL AFRICA[1]

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INTRODUCTION

In West Africa, Black Crowned Cranes (*Balearica pavonina pavonina*) are concentrated in two main areas, Senegambia and the Chad Basin, with sparse populations elsewhere. According to Urban *et al.* (1986), the overall population in West Africa has declined since the 1970s. The total population in Senegambia is estimated at 2,500 (Morel and Morel 1990). The Chad basin population is approximately 6,000-9,000 (Urban *this proceedings*). The population in the Inner Niger Delta of Mali is perhaps 3,000-5,000 at most. In Burkina Faso, Ivory Coast, Ghana, Benin, Togo, and Niger the total population of cranes is less than a few thousand, and they are nearly extinct in their former range in Nigeria.

ROOSTING AND FEEDING HABITAT

Black Crowned Cranes inhabit various open areas, including marshes, damp fields, and the margins of lakes and rivers. They are rarely associated with open water. Crowned Cranes roost in trees. Feeding grounds may be several kilometers away from roosting sites, although they are sometimes within walking distance (Urban *et al.* 1986). The cranes feed most often on cultivated fields, river sandbars, and riverbanks (Bannerman 1931).

Food is mainly live prey, according to Bouet (1955). Mackworth-Praed and Grant (1970) noted small reptiles and large insects (locusts and grasshoppers) as part of the diet. Cranes also prefer plant material, rice, and water lily seeds (Bouet 1955). The biggest concentrations of cranes this author observed were on dry, plowed, rice fields.

FACTORS EFFECTING BLACK CROWNED CRANE POPULATIONS

Climatic changes in the Sahelian zone

Climatic changes studied at the Lake Mare d'Oursi in Burkina Faso reflect changes in the prevailing conditions in a great part of the West Africa's Sahelian zone. According to Claude *et al.* (1991), the climatic aridity has increased since the early 1970s under a drought characterized by its unusual length, severity, and large geographical coverage. During the past two decades, the Sahel has witnessed a reduction of the total quantity of rain and a decrease in the number of rainy days. Along with soil defacement, these factors have further increased the severity of aridity in the Sahelian zone.

Human pressure

The continuous increase of the human population in West Africa is leading to what may be an irreversible loss of natural resources. Cultivated areas are expanding, livestock populations are increasing, and pastoral space is becoming saturated (Claude *et al.* 1991). As a result, the open space available for Crowned Cranes is decreasing. Also, trees where cranes usually roost have suffered heavily from drought and human utilization for fuelwood, charcoal, and building material. It has been estimated that for every one hectare of trees planted in the Sahel, 29 hectares are destroyed (Doyen 1988).

Illegal hunting and capture

Legal hunting is not a serious threat for Black Crowned Cranes because hunting legislation in most countries forbids crane shooting. A number of countries have insufficient financial resources to control illegal hunters, however. Poachers have been caught carrying live and dead Crowned Cranes (Fry 1974). Live cranes are sometimes kept in captivity for recreational use. In countries involved in war, soldiers hunt freely in the fields and the toll on wildlife including Black Crowned Cranes may be high.

Locust control

Aerial spraying has expanded during the past decades to control locust swarms in agricultural areas and may be having an impact on the Black Crowned Crane population. Cranes occurring in the sprayed areas may be directly poisoned by eating sprayed locusts, and may also suffer from a decreased food supply because locusts were one of the main food sources for Crowned Cranes. However, new observations of Crowned Cranes during a locust storm in northern Senegal in December 1993 revealed that the cranes were apparently feeding on seeds and not on locusts, despite the abundance of available locusts.

Heavily sprayed areas include Mali, Niger, Chad, and Mauritania. In Senegal, only a small area is sprayed. In Burkina Faso and the Cape Verde Islands there have been

[1]Addendum to the Proceedings. Paper presented at the Conference on the Black Crowned Crane and its Wetland Habitats in West and Central Africa, Kano State, Nigeria, 25 February 1992.

locust swarms, but no extensive spraying has occurred (A. Ndiaye *pers. comm.*).

Other factors

Senegal

Two dams were recently built on the Senegal River. The Manantali Dam in Mali retains floodwaters and permits the irrigation of a huge area for agricultural development. The coastal Diama Dam prevents saltwater from encroaching upstream. Year round water availability now permits the development of numerous rice schemes, often in marshes and other wetlands that provided good crane habitat. Dikes and embankments of rivers and lakes allow more water to be kept for agricultural or city use, but the increased water levels (such as in the Senegal River and Guiers Lake) result in a loss of habitat for numerous species of birds including Crowned Cranes.

The war with Mauritania has lead to the displacement of large human settlements. About sixty thousand people from Mauritania are settling in new cultivable land in northern Senegal. Wetlands are being heavily exploited by most of these refugees to grow irrigated rice.

At the Djoudj National Park, where Black Crowned Cranes breed, there is now a need for water management. Water is available in sufficient quantity because of the downstream dams on the Senegal River, but changes in water quality have been recorded recently. Ponds are becoming over-grown with vegetation, including *Pistia stratoides*, *Typha*, *Phragmites*, *Cyperus articulatus*, and algae.

Mauritania

The creation of the Diawling National Park in Mauritania should provide good wetland conservation for the benefit of Black Crowned Cranes. Although the main resting areas for Crowned Cranes are located on the Senegal side of the river, some cranes cross the river regularly to feed in Mauritania. The war with Senegal has prevented the investigation of the area. There are still Crowned Cranes in the neighboring Keur Macene (once a hunting center), but the army occupation there may have lead to the slaughter of some birds (Stuart *et al.* 1990). Mauritania's wetlands are at risk from drought and increasing human use, including irrigation.

Mali

The severe drought in the Sahelian zone has caused the desiccation of Mali's northern lakes and forced the human population to concentrate in the remaining wetlands, further south. Those lakes that are still flooded annually are usually cultivated with subsistence millet. The Inner Niger Delta would best be managed through a carefully designed multi-use program, with key reserves at a few well chosen localities, such as Lake Debo, Lake Horo, and Lake Seri, where Ramsar Sites have been established (Stuart *et al.* 1990).

Burkina Faso

The only large lake in Burkina Faso, the Mare d'Oursi, is now intensively cultivated and the human population has increased significantly. There are proposals (Stuart *et al.*, 1990) for new ornithological reserves at Beli and Mare d'Oursi. The effects of irrigation projects on wildlife should be monitored, particularly in the north.

Niger

According to Stuart *et al.* (1990), Niger is one of several Sahelian countries that has suffered a very severe degradation of its natural resources as a consequence of droughts and overgrazing by livestock. "W" National Park, however, remains one of the key areas for conservation of savanna in West Africa along with other important wildlife habitat further north along the Niger River. Important wetlands exist in the southeast around Lake Chad, but these are not currently the subject of any conservation initiatives. There are numerous seasonal wetlands or "mares" with ponded water, which are often wooded, across the Sahel zone. These are extremely important for wildlife, particularly birds, and need to be evaluated.

Nigeria

Nigeria has many important wetland sites, particularly in the north, including Lake Chad, the Hadejia-Nguru Wetlands, and others. Current issues which need addressing include the sustainable use of wetland resources by local people and the ecological implications of large irrigation schemes in northern Nigeria (Stuart *et al.* 1990).

Cameroon

Water management schemes in northern Cameroon have disrupted natural flooding regimes, resulting in a reduction of species diversity and loss of floodplain habitats. In Waza National Park, an important area for Black Crowned Cranes, a decrease in some wildlife populations has resulted from reduced flooding in the floodplain after the construction of a dam on the Logone River (Stuart *et al.* 1990).

Chad

The Sahelian drought has forced cattle herds to relocate further south where there is still water and pasture to feed on. This has led to a large increase in the cattle population in areas that provided good habitat for Crowned Cranes. Stuart *et al.* (1990) note that several wetland areas in the country are at risk from the pressures of intensive irrigated agriculture and the increasing use of pasture and fisheries resources. Also, Chad's critical sites have become seriously compromised as a result of disturbances to the protected area network during the civil war.

Central Africa Republic

Floodplains in northern Central African Republic need assessment and implementation of appropriate conservation measures, including anti-poaching efforts in the wet season (Stuart *et al.* 1990).

Ghana

Black Crowned Cranes appear to be declining very rapidly in Ghana (J. Mason *pers. comm.*). Individuals are now only occasionally sited on the Accra plains. Very few appear to remain in the wild, and there is no information about their numbers, distribution, or status in the country.

CONCLUSION AND PROSPECTS

The return of more normal climatic conditions to the Sahel will not be enough to resolve the regional problems faced by Black Crowned Cranes. Many factors have seriously reduced the carrying capacity of the environment for humans and wildlife. The increased concentration of Black Crowned Cranes in certain areas is more likely due to an overall reduction in habitat and decrease in the abundance and availability of food in West Africa, and not a real population increase. In the Djoudj National Park in Senegal, for example, one can see more cranes today than ten or twenty years ago, but this may well be the effect of habitat loss elsewhere in Senegambia and Mauritania.

There is great need for a common strategy to coordinate research on Black Crowned Cranes and their habitats, to census the entire population, and to disseminate the results to colleagues in the different countries involved. Black Crowned Crane conservation efforts must be coordinated with agriculture, fishing, and hunting programs.

REFERENCES CITED

Bannerman, D. A. 1931. The birds of tropical West Africa. Vol. II: the crowned agents for the colonies. Oliver and Boyd, Edinburgh, UK, and London, UK.

Bannerman, D. A. 1953. The birds of West and Equatorial Africa. Vol I. Oliver and Boyd, Edinburgh, UK.

Bouet, G. 1955. Faune de l'Union française (ancienne faune de l'empire français), vol. XVI, Oiseaux de l'Afrique tropicale (premiére partie). Office de la Recherche Scientifique et Technique Outre-Mer. Larose, Paris, France.

Claude, J., M. Grouzis, and P. Milleville, eds. 1991. Un espace sahélien, la mare d'Oursi, Burkina Faso. Éditions de l'ORSTOM, Paris, France.

Doyen, A. 1988. Les problemes forestiers dans les pays du Sahel. Environment African 23(3-4): 97-109.

Fry, C. H. 1976. West African crowned crane status. Pages 251-253 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world. International Crane Foundation, Baraboo, Wisconsin, USA.

Mackworth-Praed, C. W. and C.H.B. Grant. 1970. African handbook of birds. Series 3. Birds of West Central and Western Africa. Vol I. Longman, London, UK.

Morel, G. J. and M. Y. Morel. 1990. Les oiseaux de Sénegambie. Éditions de l'ORSTOM, coll. Didactiques, Paris, France.

Stuart, S. M., R. J. Adams, and M. D. Jenkins. 1990. Biodiversity in sub-saharan Africa and its islands, conservation, management and sustainable use. Occasional paper no. 6 of the IUCN Species Survival Commission. IUCN, Gland, Switzerland.

Urban, E. K., C. H. Fry, and S. Keith. 1986. The birds of Africa. Vol. 2. Academic Press, London, UK.

THE BLACK CROWNED CRANES IN THE SENEGAL DELTA

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INTRODUCTION

The Senegal Delta has always been one of the privileged sites where Black Crowned Cranes (*Balearica pavonina*) live. Yet this environment has undergone very important changes during the last 30 years. The effects of these changes on the population of Black Crowned Cranes are not well known, since the only aerial censuses that have been completed quite regularly in this area were conducted mainly to provide duck counts and a large part of the crane population may not have been counted. Recent hydro-agricultural extensions seem to have induced a gathering in and around the Djoudj National Park, where cranes are easier to watch than in the past. In general, we have no proof of a decrease in the total population in Senegal. Outside the breeding season, important gatherings of up to 300 birds may occur in one place or another along the Senegal River in Senegal or Mauritanian. Teams from the Direction des Parcs Nationaux have now started regular censuses of the cranes they see and a few breeding attempts have been noted in November and January.

THE ENVIRONMENT

A number of factors have affected the environment for the Black Crowned Cranes in Senegal.

1. **Climatic changes.** According to a study by Claude *et al.* (1991), the climatic aridity has increased since the early 1970s under a drought characterized by its unusual length, severity, and large geographical coverage. In the north of Senegal, the annual rainfall has decreased from 350 mm per year to less than 200 mm annually.

2. **Hydro-agricultural changes.** Two dams have been built recently on the Senegal River. The Manantali dam, in Mali, retains floodwaters and permits the irrigation of a huge area for agricultural development. The Diama dam prevents saltwater intrusion upstream from the sea. Year-round water availability now permits the development of numerous rice schemes, often in marshes and other wetlands that were good crane habitats.

3. **Human pressure.** Wetlands are being settled by displaced people from other parts of Senegal and southern Mauritania, especially for producing irrigated rice. Black Crowned Cranes often feed on rice fields during the non-growing season, and the extension of cultivated land may be good for cranes if marshes are still available not too far away for roosting.

4. **Chemical spraying.** The spraying of locusts and pest birds with chemicals may affect the population of Black Crowned Cranes. The poisoning of cranes by direct spraying is probably not occurring, but the disappearance of locusts may reduce the amount of food available for cranes. In Senegal, spraying is nevertheless quite limited in comparison to other Sahelian countries where about 2.5 million ha. are sprayed each year.

CENSUS DATA

Black Crowned Cranes were counted in some years during duck censusing in and around Djoudj National Park. Because of the war with Mauritania, planes have not been used since 1989, so southern Mauritania has not been censused. Figure 1 shows the results of these January censuses. The total number of birds counted seems to be quite stable. Morel and Morel (1990) give a figure of about 2,500 cranes for the whole of Senegambia of which about 1,000 occurred in the Senegal Delta prior to 1980 - much greater than the maximum of 549 Black Crowned Cranes counted recently. However, there may well be more cranes across the entire Senegal Delta, because only the wetlands were flown over during the censuses.

The new Diawling National Park (15,000 ha.) in South Mauritania, adjacent to the Djoudj National Park (16,000 ha.) in Senegal may help cranes find suitable habitat to live and breed. A canal has been dug to fill again the N'Diael Birds Reserve (46,500 ha, Hughes and Hughes 1992). The N'Diael Reserve should be filled up more each year, but the canal is probably not large enough to fill it to capacity. The area south of Guiers Lake has already filled up with water, which now extends more than 60 km southeast of Keur Momar Sarr. These two areas are complementary to the Djoudj National Park and will help compensate for loss of habitat in other parts of the delta. In other areas of Senegal, cranes have been seen regularly but in small parties. In the Niokolo-Koba National Park, no more than 20 have been seen at one time. In Casamance, southern Senegal, 400 were seen together in December 1992.

Figure 2 shows the monthly number of groups encountered and mean group size during the period 1990-91. Black Crowned Cranes wander in small parties during the breeding season (from September to December/January) and gather in larger flocks during the dry season. At that time, rice fields have been harvested and cranes are often seen on these fields especially after they have been plowed (Birane Faye *pers. comm.*).

BREEDING

Evidence of breeding is very difficult to obtain for Black Crowned Cranes, but in Djoudj National Park, young birds have been found in late November and early December in different years. Some nests have also been found: one at the end of 1985 and one in early January 1993. Unfortunately, this last nest failed when the eggs were eaten by some animal.

CONCLUSION

These very few data expose the need for more work to understand this beautiful species in Senegal. Regular crane observations were initiated only recently after the Conference on Black Crowned Cranes and their Wetland Habitats in West and Central Africa, held in Kano, Nigeria in February, 1992. In the future, we hope to determine the exact status of the cranes in Senegal.

REFERENCES CITED

Claude, J., M. Grouzis, and P. Milleville, eds. 1991. Un espace sahélien, la mare d'Oursi, Burkina Faso. Éditions de l'ORSTOM, Paris, France.

Hughes, R. H. and J. S. Hughes. 1992. A Directory of African Wetlands. IUCN, Gland, Switzerland and Cambridge, UK / UNEP, Nairobi, Kenya / WCMC, Cambridge, UK.

Morel, G. J. and M. Y. Morel. 1990. Les oiseaux de Sénegambie. Éditions de l'ORSTOM, coll. Didactiques, Paris.

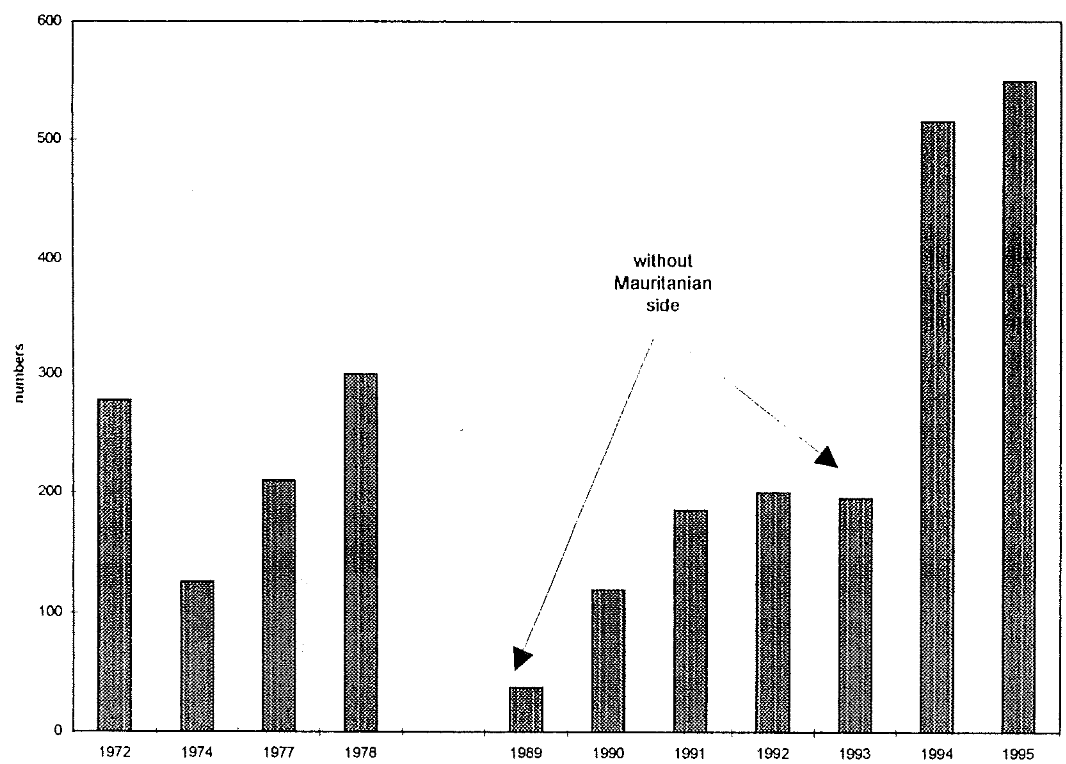

Figure 1. Total number of Black Crowned Cranes observed in the Senegal Delta during January censuses. Cranes were not censused on the Mauritanian side of the Delta during period 1989-93.

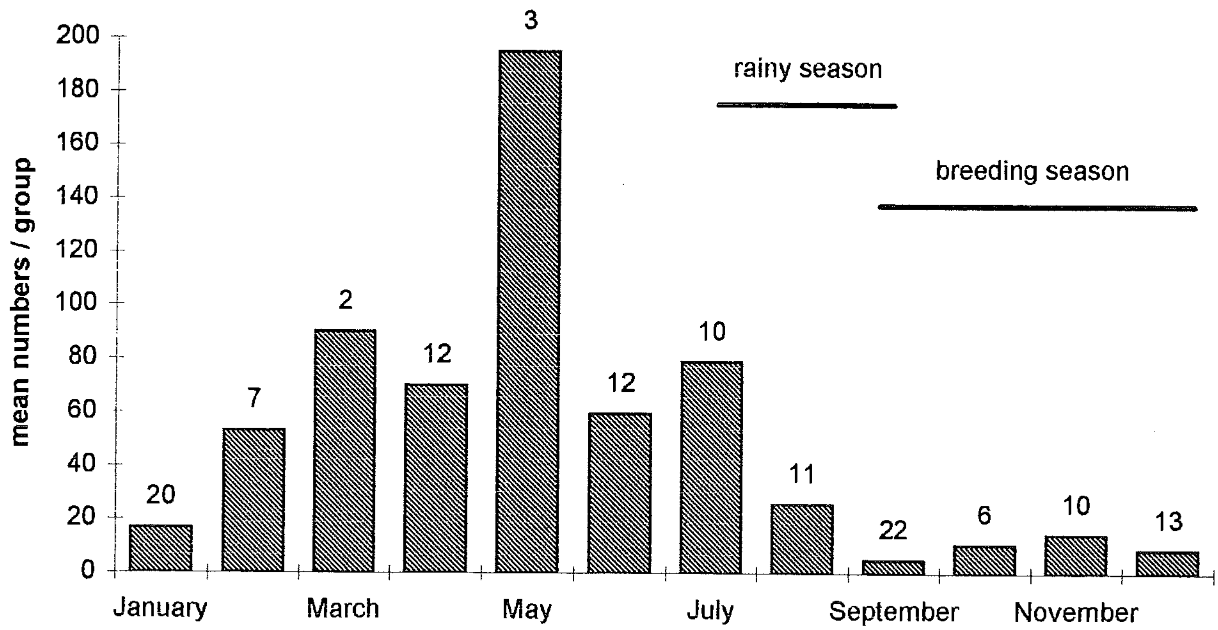

Figure 2. Mean size of groups and number of groups encountered per month during the years 1991 and 1992.

LEGAL AND INSTITUTIONAL CONSTRAINTS ON THE CONSERVATION OF WETLANDS IN BURKINA FASO, AND FRENCH-SPEAKING COUNTRIES OF WEST AFRICA

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ABSTRACT

Wetlands must be recognized by the governments as resources of global value (such as national parks), requiring particular ways of protection. So the institutional and legal basis of the public administrations for wetlands management must change, in order to adapt them to the policy of wise- use in accordance with the international conventions (Ramsar, Bonn, Biodiversity, etc). It is shown that no institution is really responsible for the administration of wetlands in French-speaking countries of West Africa, because although every ministry (agriculture, energy, environment, water, etc.) feels concerned, there is no coordination and no leadership. Everywhere, the solutions of coordination fail because they have only considered economical aspects of wetlands, and not the ecological factors.

For these reasons, this paper recommends that the national authorities and the donors trust the specialized NGOs as the best institutional solutions for wetland utilization and conservation. These NGOs (the Banc d'Arguin Foundation in Mauritania, the NATURAMA Foundation in Burkina Faso, etc.), are flexible and able to ensure the equitable participation of neighboring communities, as well as all the concerned public services.

Taking up the legal aspects, the paper proposes a categorization of wetlands in five parts:

- the large wetlands for which planning must be submitted to studies of impacts for all the previous activities;
- the small dams managed by local communities;
- the natural zones such as protected areas and natural ponds;
- the traditional zones which belong to the villages and must be submitted to the traditional rules, focused on the customary rights;
- the wetlands located on the frontiers, which need a harmonization of the relevant policies and legislation through inter-state conventions.

These analyses are illustrated in the paper by three case studies in Burkina Faso, Niger, and Benin, concerning respectively the natural pond of Satiri (called Mare aux Hippos); the International Park of W, which has a trilateral convention with regard to the comprehensive protection of the park region as a whole; and the inter-villages wetland of Banh (in Burkina Faso), which demonstrates how villagers can be mobilized for the conservation of an area of interest to them.

The author thanks the International Crane Foundation and the Wildlife Training Institute for their commitment to the conservation of biodiversity in Africa, and for the initiative they have taken for this important workshop.

INTRODUCTION

Le Burkina Faso est un pays sahélien qui couvre une superficie de 274,000 km², et est situé au coeur de l'Afrique de l'Ouest, entre les domaines climatiques sahélien et soudanien. Sur le plan biogéographique, il fait partie du vaste domaine afrotropical dont six sous-composantes locales sont représentées. Il s'agit des secteurs: sahélien, sub-sahélien, du plateau central, du Mouhoun, de la Comoé Léraba, et de la Pendjari-Mekrou.

Les zones humides sont inégalement disséminées autour des plans d'eau à travers ces 6 secteurs biogéographiques avec une plus forte présence à l'Ouest et à l'Est du pays. On estime généralement à 0.1% la superficie des plans d'eau en rapport avec le territoire national. La pluviométrie varie entre 300 mm au Nord et 1,500 mm à l'Ouest, avec 9 à 4 mois de saison sèche.

La menace la plus grave qui pèse sur les espèces de flore et de faune au Sahel est certainement la destruction de leurs habitats. L'eau étant le principal facteur limitant, les espèces se concentrent autour des principales zones humides naturelles ou artificielles, déjà fortement convoitées et surexploitoées par l'agriculture et l'élevage.

Il convient de noter que les espèces aquatiques (végétales et animales) dépendent strictement de ces hydrosystèmes. - Plusieurs espèces de poissons couramment rencontrées par les pêcheurs sont devenues très rares, et certains ont probablement disparues des plans d'eau Burkinabè.

Certaines zones humides sont déjà incluses dans des aires protégées: mares aux hippos, mare d'oursi, mare de Pembado, etc. D'autres ne le sont pas. Elles méritent toutes des mesures spéciales pour être durablement gérées.

Dans ce sens, les moyens juridiques et institutionnels devraient jouer un grand rôle dans la gestion de l'eau et des autres ressources naturelles des zones humides. Il reste cependant aussi important de considérer les contextes historiques, socio-économiques, et politiques de leur milieu. La stratégie de gestion et la législation doivent s'appuyer sur ces réalités locales.

Il convient aussi de noter le fait que la propriété exclusive de l'Etat sur les ressources naturelles en géneral (y compris les zones humides) reste fortement affirmée, contrairement aux déclarations officielles qui proclament la responsabilisation des populations. Par ailleurs, les règles du droit positif moderne se sont superposées sur les principes du droit coutumier, ce qui place les gestionnaires dans une situation de perpétuelle recherche de compromis sur le terrain. Cette conciliation est souvent délicate en raison de l'écart entre les stratégies de gestion (qui ont beaucoup évoluées) et l'univers juridique de la protection de la nature (qui est resté relativement figé).

Cette situation complexe engendre une problématique que nous tenterons d'élucider dans la présente étude de cas.

Nous aborderons d'abord le cadre juridique et institutionnel global de la gestion de l'eau et des ressources naturelles des zones humides. Puis, nous examinerons les cas particuliers de 3 sites choisis en fonction de leurs spécificités. Il s'agit de:

- la réserve de la Biosphère de la mare aux hippos (Ouest Burkina);
- le Parc international du W du Niger (Est Burkina);
- la Forêt inter-villageoise de BANH (Nord Burkina).

CADRE JURIDIQUE ET INSTITUTIONNEL

Dans ce chapitre, nous traiterons du régime de l'eau et des autres ressources naturelles des zones humides dans la règlementation Burkinabé, en le mettant en rapport avec le droit coutumier. Nous aborderons ensuite les instruments juridiques internationaux, ainsi que le cadre institutionnel au plan national et régional.

Le régime juridique de l'eau et des autres ressources naturelles des zones humides au Burkina Faso.

Ce régime est déterminé par l'Ordonnance n° An VIII 0039 bis/FP/PRES du 04/6/91 portant Ré-organisation Agraire et Foncière au Burkina Faso, et son décret d'application n° An VIII 0328 TER/FP/Plan-Coop du 04/6/91.

L'Ordonnance institue un Domaine Fancier National (DFN) constitué par toutes les terres situées dans les limites du territoire national, et celles acquises par l'Etat et les collectivités publiques secondaires à l'étranger. Elle édicte également les principes de l'aménagement et de la gestion du DFN. Certains biens immeubles du DFN béneficient de mesures particulières de gestion et de protection au terme de l'Article 12 qui classe dans cette catégorie de terres :

- les cours d'eau et leurs lits, les sources et leurs dépendances, les lacs, les étangs et leurs emprises dans leurs limites légales;
- les ouvrages exécutés dans un but d'utilité publique pour la maîtrise des eaux;
- les parcs nationaux et les autres formations naturelles classées, avec leurs emprises et leurs dépendances dans leurs limites légales.

Ces biens immeubles grévent les fonds de terre riverains de servitudes d'utilité publique dont la nature et l'importance sont déterminées d'après la destination des terrains concernés.

L'Ordonnance définit aussi les différents droits réels immobiliers (au nombre de huit) qui sont: la propriété, le droit de superficie, l'usufruit, le bail de longue durée ou emphytéose, le droit d'usage et d'habitation, les servitudes ou services fonciers, le nantissement immobilier ou antichrèse, les privilèges ou hypothèques.

Le Décret d'application a pour but l'aménagement du territoire, la gestion des terres, la réglementation des droits réels immobiliers, ainsi que le régime des forêts, de la faune, des pêches, des eaux, des substances minérales et des pollutions et nuisances diverses. La première partie du Livre III de ce Décret est consacrée au régime de l'eau. Sur les fonds de terre qui supportent les eaux avec leurs emprises et leurs dépendances, le régime de l'eau emporte celui des autres ressources naturelles qui s'y trouvent, sauf si ces terres sont classées à d'autres fins.

Quelques Traits Saillants du Régime de l'Eau

Constituent des eaux domaniales ou eaux publiques au sens de cette règlementation toutes les ressources en eau ainsi que les constructions et aménagements hydrauliques appartenant aux personnes morales de droit public ou réalisés dans un but d'intérêt général.

Les ressources en eau comprennent les eaux superficielles, souterraines et atmosphériques: fleuves, rivières, lacs, étangs, et mares, et leurs dépendances légales, nappes souterraines, et nuages dans les limites de l'espace national.

Sont soumis au régime de l'eau, les constructions et aménagements suivants sans que la liste soit exhaustive:

- les ouvrages exécutés pour faciliter la retenue de l'eau, la circulation ou l'écoulement sur les cours et étendues d'eau (digues, barrages, écluses, chaussées) dans la limite des terrains occupés et lorsque ces ouvrages appartiennent à des personnes morales de droit public ou sont réalisés dans un but d'intérêt général;
- les périmètres aménagés au nom de l'Etat ou de tout autre personne morale publique ou avec leur accord ou sous leur responsabilité ainsi que les ouvrages d'aménagement des puits, forages, sources et points d'eau mis à la disposi-

tion du public par des personnes morales de droit public;
- les canaux servant à la navigation, à l'irrigation, aux drainages, acqueducs, et transport des eaux usées et leurs accessoires aménagés par une personne morale de droit public;
- les acqueducs, conduites d'eau ou d'égout, l'ensemble des installations de toute nature qui en sont les accessoires ainsi que les chemins dans leurs limites déterminées par leur bord extérieur réservés le long de ces ouvrages pour assurer leur entretien;
- les ouvrages servant à l'utilisation des forces hydrauliques édifiées par une personne morale de droit public.

Les limites des cours et étendues d'eau peuvent être déterminées à partir de l'interpretation des données hydrologiques, hydrogéologiques, botaniques, etc. Elles peuvent être matérialisées par des balises, des arbres ou par tout autre moyen approprié.

Elles sont fixées par un Arrêté conjoint des Ministres chargés respectivement de l'hydraulique, des fordês et des domaines.

L'Arrêté de délimination peut donner lieu à contestation aux fins de modification. Toutefois, en cas de changement des limites naturelles d'un cours d'eau délimité, les riverains intéressés peuvent demander au Ministre chargé de l'hydraulique une nouvelle délimitation.

Si, dans le délai d'un an à compter de la date de la demande, le Ministre n'a pas statué, les requérants pourront saisir le tribunal compétent.

La délimitation des cours et étendues d'eau est déclarée d'utilité publique. Les dommages ou voies de fait qui en résultent sont soumis à la réglementation sur l'expropriation pour cause d'utilité publique lorsque l'occupant lésé est détenteur d'un titre de propriété ou de jouissance régulièrement délivré.

Le cas échéant, l'Administration peut procéder à son recasement ou éventuellement à une compensation.

Suivant leur situation naturelle, les fonds de terre inférieurs reçoivent des fonds de terres plus élevés les eaux qui coulent sans intervention de l'homme. Le titulaire du titre de propriété ou de jouissance sur le fonds supérieur ne doit rien faire qui puisse aggraver la situation du fonds inférieur.

Les fonds de terre riverains des cours d'eau, lacs, et étangs supportent une servitude de passage sur une largeur de cent métres sur chaque rive ou sur tout le pourtour selon le cas.

Toute exploitation ou installation relative à l'utilisation des ressources en eau dans un but d'intérêt général grève les fonds de terre intermédiaires d'une servitude de passage pour les lignes électriques, les chemins d'accès, les conduites souterraines, les canaux d'amenée d'eau aux usines, et les canaux d'irrigation et de drainage.

Tout titulaire d'un droit de superficie a le droit d'user et de disposer des eaux pluviales qui tombent sur son fonds, à seule charge s'il y a accumulation artificielle, de déclarer la capacité et la nature des installations.

Toutes les autres utilisations, ainsi que les prélèvements d'eau par puits, forages, canal, détournement ou dérivation ainsi que les ouvrages qui les accompagnent, sont soumis à déclaration ou à autorisation, sauf s'ils sont destinés à des fins domestiques.

Sont considérés comme affectés à des fins domestiques, les prélèvements d'eau destinés à la satisfaction des besoins individuels ou familiaux dans les limites des quantités nécessaires à l'alimentation humaines, aux soins d'hygiène et aux productions animales ou végétales des individus ou des familles, et ne dépassant pas 2,000 litres par jour.

Analyse du régime juridique des ressources naturelles des zones humides, en relation avec le droit coutumier et les stratégies de développement

La place première de l'Etat dans la gestion des ressources naturelles s'exprime tout d'abord à travers le principe de la domanialité de ces ressources: la terre, les forêts, la faune, appartiennent à l'Etat. L'institution de la propriété privé sur les ressources naturelles a sans doute été favorisée par les principes du droit coutumier selon lesquels l'homme ne peut s'approprier que ce qu'il a créé. Tout ce qui est donné par la nature est la propriété de la communauté toute entière. On peut trés bien comprendre le souci de l'Etat de s'affirmer comme le garant de l'intérêt général.

En s'appropriant les ressources naturelles, l'Etat veut en assurer la maîtrise totale. Cependant, cet objectif noble soulève de nombreux problèmes lorsqu'on le considère sous l'angle de ses conséquences sur le poids de la responsabilité de l'Etat. Seul maître des ressources naturelles, seul garant de leur gestion rationnelle, l'Etat a en toute logique fini par se considérer comme le seul responsable de la protection. La conséquence est la déresponsabilisation des populations qui considèrent que la préservation des ressources est l'affaire de l'administration et des services techniques.

Les résultats d'une telle conception sont bien connus. Du point de vue de l'Etat une telle responsabilité est très vite apparue comme démesurée au vu des moyens dérisoires dont disposaient les services forestiers notamment. Du point de vue des populations l'accent est mis sur la sur-exploitation des ressources naturelles sans aucun souci de leur renouvellement.

Il faut aussi souligner les nombreux problèmes institutionnels tels que l'absence d'une participation des associations intéressées à la gestion des ressources naturelles à certains organes consultatifs ou d'administration, et la très faible efficacité de nombreuses structures associatives concernées.

La politique de gestion des ressources naturelles des Etats sont en pleine mutation. De ce point de vue, il ne faut pas que la législation soit en contradiction avec les objectifs généraux fixés. Elle doit au contraire donner les moyens dune plus grande efficacité à la politique de développement. En particulier la législation devrait tendre aujourd'hui à intéresser les populations à une meilleure gestion des ressources naturelles.

L'affirmation du monopole de l'Etat sur les zones humides est une option de politique législative qu'il ne nous appartient pas de contester. Il faut cependant améliorer le taux de réussite des législations sur le terrain.

La solution véritable à la gestion effective et rationnelle de la terre ne réside pas dans l'accroissement de la responsabilité de l'Etat, déjà très occupé à résoudre de nombreux problèmes économiques et sociaux, et considérablement handicapé par l'absence de moyens matériels et humains.

L'objectif n'est pas non plus d'aboutir à la démission de l'Etat par rapport à sa mission de garant de la préservation du patrimoine naturel commun. Il est de ramener cette mission à sa juste place: celle d'assurer le contrôle de la gestion, de concevoir et d'impulser une politique de gestion des ressources, cohérente avec les objectifs économiques généraux de l'Etat, et d'assurer la conscientisation, la formation, et l'éducation de la population par rapport aux enjeux de l'environnement.

Par ailleurs, les fonds de terre qui supportent les zones humides étant soumis aux législations fonciéres nationales, on ne peut changer fondamentalement les bases juridiques relatives à ces aires sans réformer au préalable le systéme domanial et foncier.

Les considérations actuelles reposent sur la prise de conscience quasi-générale que la terre est une ressource naturelle stratégique pour le développement du pays, et que ce développement est gravement compromis par la dégradation accélérée de cette ressource naturelle. En conséquence la lutte pour l'auto-suffisance alimentaire apparaît donc aussi comme une lutte pour une meilleure occupation et une exploitation plus rationnelle des terres.

Des nouvelles bases législatives devraient reposer la problématique sous l'angle d'une meilleure adhésion des populations. Pour réussir dans la mission de conservation des zones humides l'Etat doit compter avec la participation des populations. Des expériences pratiques de gestion des terroirs villageois riverains des zones humides, de même que l'aménagement de zones tampons à la périphérie de réserves naturelles annoncent lentement mais éloquemment une nouvelle ère d'intégration des populations.

Responsabiliser la population vis à vis de son espace foncier, c'est peut être d'abord lui faire confiance en n'hésitant pas à reconnaître et à garantir les droits fonciers qu'elle exerce depuis toujours. En d'autres termes, il faut renforcer la sécurité fonciére des populations rurales si on veut espérer de leur part une collaboration franche avec les instances chargées de la conservation.

Cependant de nombreuses questions demeurent posées quant à l'efficacité de méthodes de participation des populations utilisées. Un des paramètres sûr de cette efficacité réside dans la confiance que les populations placent dans leurs représentants et sur l'autorité morale de ces derniers.

Dans certains cas, la "gestion populaire" de la terre a eu des conséquences catastrophiques. Cela résulte en particulier des confusions négatives entre les missions politiques et partisanes de certaines structures populaires chargées de la participation, et les missions spécifiques de gestion foncière qui requièrent l'information et la formation des acteurs.

La gestion des zones humides induit de nombreux conflits d'intérêt qu'il faut prendre en considération si on ne veut pas que les populations locales lésées entravent leur bon fonctionnement. La question essentielle concerne les droits d'usage.

Instruments juridiques inter-etats et internationaux

Conventions et accords ratifiés par le Burkina Faso

Le Burkina a adhéré à la plupart des conventions internationales relatives à la conservation des ressources naturelles. On peut citer:

- la Convention de Ramsar relative aux zones humides d'importance internationale, particulièrement comme habitats des oiseaux d'eau;
- la Convention de Bonn relative à la conservation des espèces migratrices;
- la Convention de Washington relative au commerce des espèces de flore et de faune sauvages ménacées d'extinction (CITES);
- la Convention d'Alger relative à la conservation des ressources naturelles en Afrique;
- la Convention du Patrimoine Mondial;
- la Convention de Berne relative à la conservation du milieu naturel en Europe;
- la Convention du Conseil de l'Entente (ou Convention de Yamoussokro) relative à la réglementation de la chasse.

Le Burkina a également conclu un accord inter-Etat avec le Bénin, le Niger pour la lutte contre le braconnage, et des accords sur la transhumance dans le cadre de la Communauté Economique du Bétail et de la Viande (CEBV).

Elements de besoins à couvrir par des nouveaux accords

Sans que cela ne soit exhaustif, nous pouvons dégager les besoins prioritaires suivants:

- la lutte contre les feux de brousse aux frontières avec tous les pays voisins, car des difficultés sérieuses abondent à ce niveau;
- l'extension de l'accord de lutte contre le braconnage à d'autres pays comme le Ghana, la Côte d'Ivoire, le Togo, et le Mali;
- la négociation d'instruments juridiques communs de protection des bassins versants des principaux cours d'eau inter-états.

Contraintes rencontrées dans l'application des Conventions

Elles sont essentiellement de 2 ordres: l'insuffisance de personnel qualifié pour promouvoir ces accords auprès du public et assurer une synergie dans leur application,
et l'insuffisance chronique de moyens d'exécution à la disposition des services gouvernementaux.

Cadre institutionnel

Au niveau national

Les services gouvernementaux essentiellement concernés par la gestion de l'eau et des ressources naturelles des zones humides sont: le Service des Eaux et Forêts, les Services de l'Agriculture et de l'Elevage, les Services de l'Hydraulique, le tourisme et les instituts de recherche scientifique.

La gestion des zones humides est incontestablement un secteur intéressant pour beaucoup d'ONG du Sahel, en raison de son caractère hautement vital. De même, de multiples organisations paysannes ont été créées pour gérer des zones humides précises. Cependant, il faut noter que la motivation principale de ces organisations, c'est l'exploitation de l'eau, plutôt que la gestion globale et durable de toutes les ressources de ces zones humides.

L'Office National des Barrages a récapitulé en 1990 plus de 700 retenues d'eau construits en une décennie, dont un bon nombre ne joue pas sa fonction, en raison de la mauvaise qualité des études préalables, ou des techniques de construction utilisées.

Des contraintes institutionnelles existent notamment dans la complémentarité qui devrait régir les rapports entre le Service des Eaux et Forêts et les Services de l'Hydraulique. Elles concernent leurs domaines d'intervention. De même les agents d'Agriculture et d'Elevage ont souvent tendance à privilégier l'exploitation (méme irrationnelle).

Pour lever ces contraintes, une Commission Nationale d'Aménagement du Territoire a été instituée par le Décret d'Application de la R.A.F., mais son fonctionnement rencontre des lourdeurs, qui risquent de le rendre inefficace.

Au niveau régional

Quelques structures inter-gouvernementales ont été mises en place: Autorité du Liptako Gourma (Burkina-Mali-Niger), Comité Inter-Etats de lutte contre la Sécheresse au Sahel (CILSS), Comité Inter-Etats d'Etudes Hydrauliques (CIEH), et Ecole Inter-Etats des Techniciens de l'Hydraulique et de l'Equipement Rural (ETSHER).

La gestion des ressources naturelles étant par essence une question internationale. La coopération avec les états voisins devrait mieux s'organiser aussi bien en vue d'harmoniser les législations, que de rendre plus efficaces les actions développées dans les régions frontaliéres. En particulier, il serait opportun de négocier avec les états concernés par une zone humide la constitution d'accords inter-états qui renforceront l'efficacité des mesures de conservation.

CAS PARTICULIER DE 3 SITES, DONT 2 SONT INSCRITS SUR LA LISTE DES ZONES HUMIDES D'IMPORTANCE INTERNATIONALE

La Réserve de la Biosphère de la Mare aux Hippos

La Réserve de la Biosphère de la Mare aux Hippos est située dans le secteur biogéographique du Mouhoun, dans l'Ouest-Burkina, caractérisé par un climat de type sudsoudanien, avec une pluviométrie moyenne de 1,000 mm/an et une saison sèche de 6 mois.

Le cas de ce site illustre l'importance de la sécurité foncière dans la gestion des zones humides.

Présentation de la Réserve

La mare est située sur un affluent rive droite du Mouhoun, le Tinamou. Celui-ci trouve son origine au niveau de résurgences diffuses situées 4 km environ au sud de la Mare. L'écoulement est continu sur l'année et assure une alimentation pérenne de la Mare.

On retrouve le Tinamou en aval de la Mare jusqu'à sa confluence avec la Leyessa puis le Mouhoun. Ce tronçon représente environ 2 km.

Ce réseau hydrologique s'inscrit en saison des pluies dans un complexe de plaine d'inondation. Il y a alors un mélange des eaux de ce réseau avec celles du Mouhoun.

<u>Fiche d'identification</u>

Historique:
Forêt classée par l'Arrêté n° 836 SE du 26 Mars 1937
Intégrée au réseau des Réserves de la Biosphère en 1986

Superficie: 19,200 ha.classés.

Situation et paramètres climatiques:
Latitude entre 11°30' et 11°45' N
Longitude entre 04°05' et 04°12' W
à environ 80 km au Nord de Bobo-Dioulasso
Climat sud Soudanien (classification de R. Molard)
Pluviométrie annuelle: 1,100 mm
Température moyenne annuelle: 28°C

Populations riveraines:
22,000 habitants dans les 6 communautés villageoises limitrophes: Badema, Bala, Bossora, Fina, Soukourami Tierako
Populations essentiellement Bobo et Dioula avec des migrants Mossi en importance variable selon les villages

Potentialités du milieu

Ce qui frappe d'abord dans la Réserve, c'est la diversité des milieux présents (cf. étude botanique). On trouve à la fois de grandes savanes herbeuses favorables aux "paisseurs" (cob de buffon notamment), des savanes arborées et des forêts sèches, avec des îlots de végétation sur termitières offrant abris et nourriture, des forêts galeries, milieux plus fermés convenant à certaines antilopes comme le guib harnaché et surtout de nombreux points d'eau permanents; avec le Mouhoun, la mare, et les "sources" (cours d'eau permanent qui alimente la mare), il n'y a pas d'endroit de la Réserve à plus de 7 km d'un point d'eau permanent.

Même la Leyessa, totalement à sec à la fin de la saison sèche, offre encore à cette époque un point d'eau, de part et d'autre du pont de la piste Bossora-Bala.

Tous ces facteurs donnent à penser que la Réserve est potentiellement riche. Cela est confirmé par les récits des anciens, qui parlent de troupeaux importants d'antilopes, avec une grande diversité d'espèces.

a) Les oiseaux de la réserve

Sur l'ensemble de la Réserve, le nombre d'espèces présentes à un moment ou l'autre de l'année est au total de l'ordre de 200. La richesse (nombre d'espèces dans un milieu) est maximale dans l'ensemble "site de la mare + ceintures de végétation". Le milieu linéaire constitué par le Mouhoun et ses sites plus ou moins boisés est également extrêmement riche.

Le site de la Mare aux Hippos lui-même est, de loin, le plus remarquable sur ce plan. Une multitude de groupes taxonomiques y est représentée, chacun présentant plusieurs espèces. On citera ainsi: les hérons et les aigrettes, les cigognes et ibis, les cormorans, les canards et oies, les rapaces diurnes, les limicoles (dont les jacanas, les vanneaux, en plus des chevaliers et becasseaux), les râles, les passereaux liés aux milieux aquatiques (sylvidés, gobemouches, turdidés).

Si on considère le site de la mare dans sa totalité, c'est-à-dire avec sa végétation périphérique, la diversité augmente encore.

Les oiseaux de savane sont pour une large part des espèces inféodées à ce milieu. Vu les superficies occupées par les formations de savane, l'effectif total d'individus est assez important: vanneaux; dicnème du Cap; rollier d'Abyssinie; guépiers; francolins, pintades, et poule de roche; colombidés; et une multitude d'espèces de passereaux à densité faible ou très faible.

b) Populations piscicoles

L'inventaire des espèces de poissons de la Mare a été réalisé avec l'aide des pêcheurs permanents. Vingt-cinq espèces ont été rencontrées à comparer aux 40 mentionnées par Daget (1957): *Brycinus nurse*, *Schilbe mystus*, *Synodontis* sp. (3 espèces), *Parachanna obscura*, *Heterotis niloticus*, *Oreochronis niloticus*, *Sarotherodon galilaeus*, *Tilapia zillii*, *Hemichromis fasciatus*, *Hemichromis bimaculatus*, *Normyrus rume*, *Marcusenius senegalensis*, *Protopterus annectens*, *Clenopoma kingsleyae*, *Clarias anguillaris*, *Clarias gariepinus*, *Hetrobranchus sp.*, *Auchenoglanis occidentalis*, *Labeo senegalensis*, *Polypterus endlicheri*, *Tetraodon lineatus*, and *Gymnarchus niloticus*.

Niveau d'exploitation actuelle des ressources

L'agriculture et l'élevage

La Réserve est perçue par les populations de plusieurs villages riverains comme un ensemble de contraintes pour les agriculteurs qui manquent de terre; c'est le cas, en particulier, des habitants de Sokourani.

La société traditionnelle avait des règles bien établies d'utilisation de l'espace, habitat très dense dans le village, champs de case fumés avec culture de tabac et maïs, culture avec jachère courte sur les terroirs fertiles proches du village, culture avec jachère longue sur la périphérie du territoire villageois.

Actuellement, les autochtones de certains villages (ceux qui ont su limiter l'installation des migrants) cherchent à verouiller l'espace en mettant en culture les "frontières" de leur territoire, y compris celles un peu particulières constituées par la limite de la Réserve, ils sont amenés à construire des campements d'hivernage pour éviter de consacrer trop de temps, en saison des pluies, à des déplacements entre village et parcelles de culture.

La situation est très variable d'un village à l'autre.

A Sokourani, le classement de la forêt a amputé le territoire des 3/4 des terres et a coupé le village des champs de culture. En période d'hivernage, les familles quittent le village, et s'installent provisoirement à l'ouest de la Réserve, au milieu de la zone de culture. Les habitants de Sokourani n'ont jamais voulu créer un nouveau village car ils n'ont pas renoncé à obtenir un déclassement de la Réserve. Ils vivent donc dans des conditions précaires, obligés chaque année, après l'hivernage, de restaurer les maisons du village, mises à mal par les pluies. Conscients de l'étroitesse de leur espace cultivable, ils n'ont pas accepté de migrants; quelques uns cependant se sont installés à l'ouest, en limite de leur territoire. Le village ne possède ni école, ni dispensaire, la culture attelée y est peu développée. Elle est pratiquée par 22 exploitants sur les 419 recensés dans le village.

A Tierako la situation est assez proche de celle de Sokourani. Là aussi, la forêt classée concerne une partie importante du territoire. La zone de culture de Tierako se trouve immédiatement au sud de celle de Sokourani, sans possibilité d'extension vers le sud où la présence d'une cuirasse interdit toute mise en valeur agricole.

Les deux villages sont d'ailleurs très solidaires et ont fait plusieurs démarches officielles pour demander le déclassement de la Réserve.

En ce qui concerne les relations entre les autochtones et les migrants, on peut distinguer trois situations:

- Sokourani et Tierako, dont le territoire traditionnel a été gelé au moment de la création de la forêt classée, comptent très peu de migrants;
- Bala, dont une partie importante du territoire a été laissé en dehors de la forêt classée, mais qui a pris conscience de la nécessité d'une gestion prudente des terroirs, et qui contrôle le peu de migrants installée là depuis relativement longtemps;
- les autres villages, où la terre était plus abondante et qui ont eu une politique plus souple vis à vis de l'installation de migrants. Ceux-ci occupent une place importante, habitent des campements en périphérie des territoires villageois, et sont quelques fois installés dans certains quartiers du village.

Quand une famille de migrants veut s'installer, elle demande conseil au chef de terre (souvent l'aine de la famille fondatrice du village). Celui-ci désigne un agriculteur auquel est reconnu, par le village, des droits sur un espace précis. C'est avec lui que négocie le candidat à l'installation. Celui-ci met en culture les parcelles qui lui sont désignées, il peut transmettre ce droit de culture à ses enfants ais ne peut, de sa propre initiative, cultiver de nouvelles parcelles.

La pêche

Les pêcheurs sont représentés essentiellement par des Bobos, mais on trouve aussi parmi les pêcheurs permanents des Dioulas, des Dafings, un Bozo, et un Koroboro. Les pêcheurs permanents qui habitent au bord de la Mare (campement de Djegada) sont au nombre de 10. Un groupement de pêcheurs a été constitué et regroupe 24 membres: les 10 permanents et des villageois de Bala.

Mais d'autres pêcheurs pratiquent aussi sur la Mare. Le nombre total de pêcheurs monte ainsi à une cinquantaine.

Les feux de brousse

Les feux de brousse constituent un problème difficile à analyser. Qui est à l'origine des feux?

1. Les mécontents qui souhaitent un déclassement de la Réserve et considèrent que celui-ci sera plus facile quand la forêt aura reculé sous l'effet de feux répétés.

2. Les agriculteurs qui se préoccupent peu du devenir d'un feu de mise en culture qui leur échappe le plus souvent.

3. Les chasseurs pour débusquer le gibier ou simplement pour protester contre l'interdiction de chasse dans la Réserve.

4. Les éleveurs pour disposer d'une repousse recherchée par leurs bêtes.

Il y a certainement une parte de responsabilité au niveau de chacun, ce qui complique toute solution à ce problème.

Il est rare de trouver des troupeaux dans la Réserve où le pâturage est interdit. Par contre, des troupeaux traversent (clandestinement) la Réserve pour s'abreuver sur le Mouhoun.

Les bergers, quand ils sont pris sur le fait, sont poursuivis avec des arguments souvent dissuasifs mais ils sont obligés, tant qu'ils n'auront pas d'alternative, d'abreuver tous les jours leurs animaux au Mouhoun!

Questions institutionnelles et juridiques

Gestion administrative

Le Ministère de l'Environnement et du Tourisme gère la Réserve, car celle-ci a conservé son statut de forêt classée. La surveillance est assurée par un agent forestier qui réside à Bala, et qui a une mission générale de surveillance aux feux de brousse, pâturage, mise en culture, et pêche.

Malgré une bonne volonté évidente, ses pouvoirs sont limités car, il doit s'occuper non seulement de la Réserve mais aussi des actions de la compétence du Ministère de l'Environnement dans le département de Satiri où il est le seul représentant du Service Forestier.

D'autres institutions sont indirectement impliquées dans la gestion de la réserve: services de l'Agriculture, de l'Elevage, et de l'Hydraulique. Il arrive que sur des thèmes de vulgarisation donnés des informations et des conseils contradictoires soient donnés aux villageois, ce qui rend difficile la synergie nécessaire à toute oeuvre de conservation du milieu naturel.

Evolution de la réserve en relation avec son statut juridique

La Réserve de la Mare aux Hippopotames et sa zone périphérique constituent un secteur de l'ordre de 60,000 ha.qui a subi, en 20 ans, une profonde mutation avec la mise en culture "explosive" des territoires de la plupart des villages riverains de la Réserve. Cette mutation est liée à 3 éléments: la croissance démographique dans l'ensemble du pays; l'évolution des techniques culturales et notamment le développement de la mécanisation qui permet d'améliorer la productivité du travail donc d'accroitre les surfaces en culture; et l'installation de migrants venant du nord, avec une situation très différente d'un village à l'autre.

L'Etat a fait un choix en créant, dès 1936, une forêt classée dans un secteur qui, à l'époque, était peu peuplé et avait une faune abondante et variée; ce choix a été confirmé récemment par le statut donné à ce même espace de Réserve de la Biosphère. L'Etat doit rester cohérent avec ce choix.

Or, les fonctions d'une Réserve de la Biosphère sont conservation en "système ouvert," à l'opposé de l'idée de sanctuaire et de refuge; recherche et suivi en continu, par des méthodes pertinentes, de l'évolution des ressources en sol, végétation, et eau; éducation et formation; coopération, à travers des actions pluridisciplinaires indispensables à une gestion raisonnée des ressources naturelles.

Rester cohérent avec les choix dejà faits, c'est raisonner la Réserve et sa zone périphérique comme une units exemplaire d'aménagement des terroirs.

De nombreux arguments plaident dans ce sens: *la richesse de la Réserve*, exceptionnelle pour la région, dont la dégradation n'est pas irréversible et qui pourrait retrouver rapidement, à travers une gestion bien conduite, une grande diversité biologique; et une zone périphérique avec *une société dynamique*, ouverte à l'innovation, qui a fait la preuve, dans certains villages, de la conscience aigüe qu'elle a de la nécessité de gérer de façon prudente un espace limité.

Actuellement, il existe une situation conflictuelle. La Réserve est perçue, par de nombreux habitants des villages riverains, comme un espace gelé par une décision ancienne et arbitraire de l'Administration. Son déclassement devrait permettre, à leurs yeux, la libération de terres de cultures dont ils ont besoin.

Pour cela, il faudrait, par un projet gestion de zones périphériques disposant de moyens importants, rendre sans objet l'actuelle revendication sur la Réserve.

C'est dans le cadre d'un dialogue constructif avec des populations convaincues qu'en contre partie d'une limitation d'usage dans la Réserve, elles bénéficient d'une aide dans la zone périphérique, que pourra être aménagée la Réserve et restauré son potentiel floristique et faunistique.

Le Parc du W du Fleuve Niger

Ce cas est traité dans le sens d'illustrer l'intérêt de la coopération inter-étatique dans la gestion des zones humides transfrontières.

Présentation du parc

Le W du Niger est un parc inter-états, réparti entre le Burkina Faso, le Niger, et le Bénin. Il doit son nom à la forme anguleuse du cours du fleuve Niger dans la traversée des contreforts septentrionaux de l'Atakora.

Parc refuge du moyen-Niger en 1926, délimité et classé en réserve totale de faune en 1952 et 1953, le parc national du W du Niger est constitué définitivement en 1954, en même temps que le parc du Niokolo Koba au Sénégal, et que le parc de la Boucle du Baoulé au Mali. Il s'étend sur 220,000 ha.en République du Niger, 350,000 ha.au Burkina Faso, et 502,000 ha.au Mali.

La vaste pénéplaine qui le constitue est traversée par l'extrémité Nord de la chaine de l'Atakora qui se réduit à des barres de quartzites peu élevées Dans la savane boisée, des groupements de baobab marquent le site d'anciens villages. De nombreux rôniers poussent le long des rivières Tapoa, Mékrou, Alibori, réduites à des chapelets de mares en saison sèche.

Les éléphants parcourent les zones humides de la Tapoa et de la Mékrou sur toute l'étendue du parc, on rencontre des buffles, hippopotames, bubales, cobs de Buffon, Cobs Defassa, Guibs harnachés, reduncas, céphalophes à flancs roux, etc. qui ne s'éloignent pas des points d'eau. Les hippopotames se rencontrent sur le fleuve. Les babouins et les phacochères sont communs.

Près de 300 espèces d'oiseaux ont été enrégistrées, parmi lesquels les grues couronnées, ibis, hérons, ombrettes, grandes oies, marabouts, outardes, et serpentaires en bordure des mares.

Examen de l'accord inter-etat de lutte contre le braconnage

Cet accord a été signé le 12 Juillet 1984 entre le Burkina Faso et le Bénin, et est entré en vigueur le 1er Janvier 1985. La République du Niger a adhéré à cet accord en 1986, conformément à l'article 14 qui stipule que "le présent Accord est ouvert à la signature de tout Etat possédant une réserve adjacente aux frontières d'un Etat Partie." (Voir le texte original de cet accord en Appendice)

<u>Contexte historique de l'accord</u>

Le Parc du W est situé dans une région où le colonisateur Français avait opéré de nombreux classements de réserves en raison de la richesse particulière de la biodiversité. En effet, cette région compte 3,000,000 d'ha.de réserves situées de part et d'autre des frontières.

Pour protéger ces réserves, les services forestiers des trois pays rencontraient des difficultés multiformes car les braconniers n'éprouvent aucune contrainte pour passer d'un pays à l'autre. Aussi, il est apparu indispensable d'établir des relations inter-états dans l'exécution des polices cynégétiques. Pour une efficacité dans l'action quotidienne, ces relations supposent l'institution d'un droit de poursuite des délinquants. Au terme du présent accord, les agents des Eaux et Forêts peuvent traverser les frontières en tenue et en armes. Ce qui a permis de changer les données dans la recherche et la répression du braconnage.

<u>Evolution dans l'application de l'accord</u>

En ce qui concerne l'application de cet accord, les difficultés rencontrées jusque là semblent être dues exclusivement aux moyens d'opérations plutôt qu'à l'intreprétation du texte.

En effet, il a été difficile de mettre en place et d'opérationnaliser le Comité Inter-Etat prévu à l'article 5. Néanmoins, quelques opérations conjointes ont été exécutées avec la participation des services forestiers frontaliers. On note également, le fait que cet accord a créé un climat très propice à la collaboration et aux échanges d'information entre les agents de terrain concernés.

Les avantages d'un tel instrument juridique dans la gestion des ressources transfrontières sont ainsi évidents. En principe, si les moyens de suivi de cet accord avaient été conséquents, d'autres pays frontaliers comme le Togo, le Ghana, la Côte d'Ivoire, et le Mali auraient pu être invités à y adhérer pour constituer une chaîne sous-régionale plus étoffée. Les institutions de coopération et d'intégration régionale devraient pouvoir jouer un rôle catalyseur dans ce domaine, en vue de rapprocher les Etats qui semblent avoir la volonté, mais qui sont trop sollicités par les impératifs courants.

Expression de la coopération internationale

A la faveur de ce climat favorable de collaboration, les trois pays ont conçu et soumis à la CCE un projet régional d'aménagement des réserves naturelles contigües et de protection de l'environnement à leurs frontières.

Ce projet devrait couvrir une zone de 3,000,000 d'ha, et promouvoir la conservation de la biodiversité, l'écodéveloppement dans les terroirs riverains, et le développement d'un tourisme sous-régional. D'un coût estimé à 10 billion F CFA, ce projet accuse un retard de démarrage, mais il semble avoir un espoir de le voir finalement démarrer au cours de l'année 1993.

Il faut cependant reconnaître que la conception de ce projet n'a pas été facile. Sa finalisation nous offre tout de même quelques expériences à échanger.

Cet example semble indiqué que la communauté internationale est disposé à appuyer des efforts inter- étatiques de ce genre, mais pour qu'elle s'y engage, il faut au préalable que les pays bénéficiaires y croient et fassent le premier pas.

La Fôret Inter-Villageoise de Banh

Il s'agit d'une zone humide située sur un territoire non classée par l'Etat, mais qui a été conservée par les villageois riverains en raison de la pertinence de son importance pour eux. Elle est située dans le district biogéographique subsahélien.

Présentation de la Forêt de Banh

Située dans la Province du Yatenga, dans une des régions les plus sahélisées du Burkina, cette forêt couvre environ 25,000 ha. Elle offre une situation spectaculaire aux visiteurs. En effet, après avoir traversé des terres dénudées fréquentées par des vents de sable, et alors qu'on s'attend à pire en avançant vers le nord, on se retrouve soudain en face d'une forêt sèche particulièrement boisée, habitée par d'innombrables oiseaux et quelques mammifères terrestres.

Dans cette région, la saison sèche dure 9 à 10 mois. La pluviométrie de la zone varie entre 400 mm et 600 mm. Au cours de la dernière décennie, les hauteurs d'eau n'ont jamais dépassé les 550 mm.

Dans cette province frontalière du Mali, il n'existe pas de vastes zones d'un seul tenant sans manifestation d'activités humaines. Aux villages d'agriculteurs sédentaires éparpillés un peu partout, s'ajoutent des campements provisoires de nomades avec des parcs à bétail autour desquels le piétinement a fait disparaître toutes traces de tapis herbacé.

La végétation y est de type steppe arbustive où interfèrent de nombreuses espèces sahéliennes et soudaniennes. La majeure partie des surfaces à végétation peu modifiées par l'homme sont des savanes arbustives à prédominance d'acacias ainsi qu'une brousse tigrée sur les sols gravillonnaires. Le lit très large des rivières est bordé par des plateaux latéritiques très secs, fortement érodés.

On note la présence de peuplements d'*Euphorbia balsamifera*. Sur les cuirasses latéritiques démantelées, on trouve *Ptérocarpus luceus* (souvent émondé par les nomades pour son feuillage apprécié par le bétail), *Combretum micranthum*, *Grewia bicolor*, *Boscia senegalensis*, *Commiphora africana*, and *Maerva crassifolia.*

Parmi les grands mammifères, seuls la gazelle à front roux, le phacophère, l'ourébi, et le céphalope de Grimm semblent communs, avec rarement des mammifères de grande taille. Un troupeau d'éléphants migrants de part et d'autres de la frontière a été observé quelquefois dans cette zone en saison des pluies.

Durant l'hiver Européen, on y observe de nombreuses espèces d'oiseaux migrateurs: rôllier d'Europe, echasse blanche, coucou gris, cigogne blanche, héron pourpré, etc. Les groupes taxonomiques les plus communes sont les colombidés, les ardéidés, les francolins, et pintades communes.

Sur le plan physique, la forêt est située dans une plaine encaissée, sur sols argilo-sableux, émaillés de bowés. Elle est irriguée par deux rivières qui alimentent en hivernage des mares qui s'assèchent cependant pendant la saison sèche. La nappe souterraine est peu profonde.

La conservation de la forêt par les villageois

En raison de la richesse particulière de cette forêt, quelques paysans des villages voisins ont senti très tôt la nécessité de la protéger contre le pâturage excessif, les défrichements agricoles, le braconnage, et la coupe du bois. Aussi, ils se sont organisés pour la surveillance de la forêt, tout en instituant au plan interne des règles équitables d'exploitation du pâturage.

Cette organisation est même appuyée de pénalités en nature pour les résidents d'une part, et pour les nomades d'autre part. Un système de permanence permet aux villageois riverains de surveiller à tour de rôle la forêt contre les envahisseurs.

En 1990, suite à la demande d'un village lointain, une Ong a voulu construire un barrage en amont sur la principale rivière irriguant la forêt. A l'annonce de la nouvelle, les villageois de Banh ont réalisé que ce barrage pouvait bloquer le ravitaillement de la forêt en eau, et modifier négativement l'écologie du milieu. Aussi, ils ont organisé des démarches auprès de l'administration et ont obtenu l'annulation de ce projet de barrage suite à une délibération de la Commission Provinciale d'aménagement du Territoire.

Pendant longtemps, cette organisation a fonctionné assez bien, et à procurer une satisfaction pour les populations riveraines. Cependant, elles rencontrent de plus en plus de difficultés en raison de l'agressivité de certains éleveurs nomades (en transhumance), qui refusent d'obtempérer aux instructions des surveillants.

Plusieurs bagarres occasionnant des coups et blessures ont été soumises au tribunal de première instance de Ouahigouya dans ce sens. Ces affaires ont alors posé la question d'un statut juridique de cette forêt et la reconnaissance de prérogatives de protection et d'exploitation pour les communautés villageoises concernées.

Il devient de plus en plus certains que si une solution urgente n'est pas trouvée par l'administration, ces villageois seront obligés de baisser les bras.

CONCLUSION GENERALE

Quelle analyse et quelles leçons nous suggèrent cette expérience au plan juridique et institutionnel?

Il est évident qu'au Sahel en particulier les zones humides constituent les plus grands réservoirs de biodiversité, et aussi le maillon le plus fragile de beaucoup d'écosystèmes en raison des convoitises socio-économiques.

Au plan juridique et institutionnel, nous avons examiné - plusieurs examples dans cette étude de cas relative au Burkina Faso. A l'observation, les contraintes décrites ici sont très semblables à celles d'autres pays, et peuvent inspirer des solutions multiformes dans la problématique de gestion des zones humides.

Au plan stratégique, il nous semble pertinent de mettre davantage l'accent sur les questions prioritaires, ayant une grande influence sur le milieu naturel, et susceptibles d'entrainer des effets positifs récurrents. Dans ce sens, il est évident qu'au Sahel (et même dans d'autres écosystèmes), l'aménagement et la gestion des zones humides sont à la fois urgents et prioritaires. Cependant, pour passer à l'action, il faut des cadres compétents, convaincus, et convaincants.

Puisse ce séminaire avoir largement contribué à atteindre cet objectif pour la sauvegarde de notre patrimoine naturel unique.

APPENDICE

TEXTE DE L'ACCORD DE LUTTE CONTRE LE BRACONNAGE ENTRE LA REPUBLIQUE DU BENIN, ET LE BURKINA FASO

Considérant les Parcs Nationaux et Réserves dont disposent les deux Etats et qui sont:

- Pour la République de Haute Volta: le Parc National du W, les Réserves d'Arly, de Kourtiagou, de Pama et de Madjoari;

- Pour la République Populaire du Bénin: Le Parc National et les Zones Cynégétiques de la Pendjari et de l'Atacora;

- Le Parc International du "W" du fleuve Niger à cheval sur la République du Niger, la République de Haute-Volta et la République populaire du Bénin.

Considérant les difficultés constatées et relatives à la gestion des réserves et Parcs dans les deux Etats, difficultés dues d'une part au manque de coordination des activités de contrôle, d'autre part à l'infiltration de braconniers et à leurs pratiques illicites de se réfugier dans l'un ou l'autre Etat une fois leur forfait consommé;

Observant que le fait d'abattre des animaux sans discernement ni mesures est un mépris de la science, de la préservation de la nature et de la morale;

Examinant la situation de plus en plus dégradée des réserves et parcs qui constituent des habitats pour la faune sauvage, une des ressources naturelles renouvelables irremplaçables;

Considérant que de par la pratique des braconniers, les espèces animales de ces réserves naturelles sont menacées de disparition, entraînant ainsi une ruine sur le plan économique, scientifique et écologique et empêchant à l'avenir la reproduction de ces espèces, ce qui représenterait une catastrophe pour l'humanité entière en raison du rôle et des services que peuvent rendre ces espèces frappées de disparition dans l'amélioration des autres souches animales ou de la médecine par example;

Conscient de ce que la conservation des ressources naturelles vivantes relève de la coopération et de la responsabilité internationale, et soucieux d'organiser la gestion et la préservation de leurs parcs et réserves contigus sans porter atteinte au droit souverain des Etats de disposer de leurs propres ressources naturelles;

Le Gouvernement de la République Populaire du Bénin et le Gouvernement de la République de Haute Volta;

Reconnaissant les relations étroites qui lient l'homme aux systèmes naturels renouvelables, et la nécessité d'une exploitation rationnelle des ressources naturelles;

Conscient des perturbations intervenant dans les processus écologiques essentiels et les graves menaces qui pèsent sur le capital faune sauvage en particulier;

Considérant la valeur écologique, scientifique, économique, culturelle, éducative et esthétique de la faune sauvage;

Soucieux de préserver la diversité génétique, les écosystèmes et les paysages au bénéfice du développement socio-économique et culturel des générations présentes et futures;

Convaincus que dans l'intérêt supérieur des peuples, des mesures doivent être prises d'urgence;

Sont convenus de ce qui suit:

TITRE I: DES DEFINITIONS

Article 1er - Aux fins du présent Accord:

a) Les expressions: Parc National, zone cynégétique et Réserve de faune s'entendent "mutatis mutandis" dans l'acceptation de la Convention Africaine pour la Conservation de la Nature et de ces Ressources Naturelles.

b) La politique harmonisée de protection désigne la concertation entre les Etats contractants du présent accord en vue d'organiser la lutte préventive et active contre les facteurs de dégradation de la faune et de son habitat, en particulier le braconnage.

c) Le délinquant est celui qui se livre à des activités en violation des textes en vigueur.

Le braconnier est celui qui se livre à la chasse illégale.

TITRE II: DE LA PROTECTION DE LA FAUNE

Article 2 - Chaque Etat contractant du présent accord prendra des dispositions nécessaires pour l'application effective des textes en vigueur en matière des Parcs Nationaux et réserves de faune situés sur son territoire.

Article 3 - Les réserves et zones cynégétiques contigués feront l'objet d'une politique harmonisée de protection entre les Etats Parties.

Article 4 - Les actions de lutte contre le braconnage sont quotidiennes et permanentes au niveau de chaque Etat. Toutefois des opérations conjointes et périodiques de ratissage systématique des aires suscitées seront organisées par les pays contractants. Les modalités pratiques d'exécution de ces opérations seront laissées à l'initiative des Autorités de chaque pays.

Article 5 - Il sera créé un Comité Inter-Etat de lutte contre le braconnage dans les zones de protection contiguës. Ce comité supervisera les travaux d'harmonisation de la lutte contre le braconnage dans ces zones.

TITRE III: DE LA REPRESSION DES INFRACTIONS

Article 6 - Les Etats parties collaboreront à la repression des infractions.

Article 7 - En cas de flagrant délit, le droit de poursuite des délinquants est reconnu aux Etats contractants. Dans cette circonstance sur le terrain, les agents forestiers peuvent poursuivre les délinquants au-délà des frontières, mais tout en restant à l'intérieur des zones de faune contiguës. Dans ce cas, aussitôt après la poursuite, ils doivent prendre contact avec le responsable du poste forestier le plus proche.

Article 8 - Les délinquants arrêtés sur le territoire d'un pays seront confiés aux Autorités compétentes de ce pays s'ils en sont ressortissants. Ces Autorités se chargeront de reprimer les infractions commises conformément aux textes en vigueur.

Article 9 - Les dépositions des Autorités ayant constaté l'infraction feront foi jusqu'à preuve du contraire.

Article 10 - Il sera remis à l'Etat contractant lésé, les produits et sous-produits de la chasse provenant de l'acte délictueux.

Article 11 - Il sera effectivement infligé aux délinquants les peines prévues par la règlementation en matière de faune dans chaque Etat. Dans tous les cas, la confiscation des armes et matériels ayant servi à commettre l'infraction sera appliquée au profit de l'Etat ayant exercé la poursuite judiciaire.

Article 12 - Un rapport circonstancié sur les peines infligées au délinquant sera adressé à l'Etat lésé par le pays ayant exercé la poursuite judiciaire.

TITRE IV: DES DISPOSITIONS GENERALES

Article 13 - Le présent accord est conclu pour une période indéterminée. Il entre en vigueur au 1er Janvier de l'année suivant celle de sa signature.

Article 14 - Le présent accord est ouvert à la signature de tout Etat possédant une réserve adjacente aux frontières d'un Etat Partie.

Article 15 - Un Etat peut devenir Partie au présent accord par adhésion.

Article 16 - L'adhésion se fera par le dépôt d'un instrument d'adhésion auprès du Gouvernement de la République du Bénin.

Article 17 - Toute Partie contractante pourra par notification écrite au Gouvernement dépositaire, dénoncer l'accord à tout moment à partir de la date de son entrée en vigueur. La dénonciation prendra effet à compter du 1er Janvier de l'année suivant celle où la notification à cet effet aura été reçue.

Article 18 - Le Gouvernement dépositaire du présent accord informera les Etats Parties:

- des dépôts d'instruments d'adhésion;
- des notifications de dénonciation.

Article 19 - Les soussignés dûment mandatés à cet effet ont signé le présent accord et s'engagent unanimement à s'acquitter des tâches administratives et techniques permanentes qu'il impose.

Fait a Ouagadougou, le 12 Juillet 1984

Pour le gouvernement de la Republique Populaire du Benin:

Tiamiou Adjibade
Le Ministere des Affaires Etrangeres et de la Cooperation

Pour le gouvernement de la Republique de Haute-Volta:

Hama Arba Diallo
Le Ministre des Affaires Etrangeres

CONSERVATION STATUS OF CRANES IN NIGER[1]

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WETLANDS OF IMPORTANCE TO CRANES IN NIGER

Several types of wetlands occur in Niger.

1. **Irrigation projects along the Niger river** (plus what is left of natural wetlands in the Niger valley). The river used to be at its highest throughout most of the second half of the dry season (January-April). Because of the construction of more dams in Mali (and Guinée?), and an increase in irrigation from the river in Niger itself, the river now generally peaks in December-January and then drops rapidly, except following years with very high rainfall such as 1994.

2. **Wetlands in the Sahara** (north of about a line formed by the 17th parallel between the Mali border and Agadez, and hence southeast to Nguigmi); there is very little recent information about these wetlands.

3. **Permanent, semi-permanent and temporary wetlands in the Sahelian zone** (roughly around and north of the line Téra-Tillabéri-Tahoua-Zinder). Almost all of these wetlands are natural.

4. **Semi-permanent and temporary wetlands in the Sudanian zone** (extreme SE Niger and border with Nigeria east to about Zinder). Some of these wetlands are artificial.

5. **Lake Chad**. At present temporary in Niger and permanent in other riparian countries, Lake Chad suffers from the excessive extraction of water in its catchment.

6. **The Komadougou-Yobé river wetlands** (on the border with Nigeria west of Lake Chad). Formerly semi-permanent, now temporary, these wetlands also suffer from excessive water extraction in their catchment.

For Black Crowned Cranes (*Balearica pavonina*), natural and artificial wetlands in the Niger valley north of Niamey, and natural wetlands in the area between the Niger river and the borders with Burkina Faso and Mali, appear to be the most important. It remains to be determined how high the Black Crowned Crane numbers are in the contiguous areas of Burkina Faso (generally more developed than the adjoining part of Niger) and Mali. A small number of pairs can also still be found along the border with Nigeria, 50-100 km south-west, as well as several hundred km east, of Zinder (Matameye, Magaria, Goudoumaria). The January-February 1995 waterbird count found 26 Black Crowned Cranes on the wetlands between the Niger river and the Burkina and Mali borders; 17 along the Niger river north of Niamey, 3 along the river south of Niamey, and 2 near Diffa close to Lake Chad (Mullié *et al.* 1995). Lake Chad and the Komadougou-Yobé River wetlands are virtually dry during most of the dry season, because water is extracted for irrigation in Nigeria, Chad, and Cameroon, and possibly because of low rainfall over the past years.

Threats to most, if not all, wetlands in Niger include general degradation and conversion to agricultural land. Both degradation and conversion are related to increases in population pressure and in demand for production of food. Conversion to agricultural land takes place both at the small scale (along many small temporary wetlands) and at the large scale (a number of large irrigation projects occur along the Niger river). One recent large project claimed 3,000-5,000 ha. of floodplain for rice cultivation, and is unlikely to be economical. Degradation processes include water and wind erosion and deposition, soil salinization and alkalinization, and possible application of fertilizer. Application of insecticides in vegetable gardens along ponds and on floodplains is on the increase, but at present not a threat to Black Crowned Cranes. In addition, the increased disturbance of wetlands, because of increases in population, is very likely widespread. What is more, there is pressure to construct a very large dam in the Niger river at Kandadji, NW of Tillabéri. This would greatly affect the important natural wetlands upstream at Ayourou, as well as all the wetlands downstream of the dam site.

[1]Addendum to the Proceedings. Report submitted to the Specialist Group on Cranes 25 May 1994.
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It is unclear what effect possible climatic changes over the next 25-50 years would have on wetlands and Black Crowned Cranes in Niger. Global circulation model predictions are that rainfall in the area where the Niger river originates will decrease, while in the area of the headwaters of the major rivers flowing into Lake Chad rainfall is calculated to increase; predictions for Niger itself are more or less neutral for western Niger, with an increase in rainfall calculated for eastern Niger (cf. Brouwer and Ouattara 1995, after a draft publication of the Intergovernmental Panel on Climate Change).

At the same time, a number of new natural wetlands have appeared in the Sahelian zone of Niger in the past twenty years; at least one of these is as large as 1,800 ha., following good rains (Brouwer and Mullié 1994).

Only one wetland area, along the Niger river in the Parc National du W, is adequately protected. All the other areas are not protected, although hunting and taking of wildlife is illegal everywhere in Niger. Hunting still takes place, however, even if on a small scale. According to Giraudoux *et al.* (1988), the Niger river between Tillabery and the border with Mali, as well as the Komadougou-Yobé region along the eastern part of the border with Nigeria, appear to be the only completely "unthreatened" sites for this species that is otherwise threatened everywhere in west Africa. However, at least into the 1970's many Black Crowned Cranes were caught in the Magaria area south of Zinder, reputedly by people coming from across the border in Nigeria, who attracted the cranes by putting out grain. There are now apparently insufficient Black Crowned Cranes in that area for the practice to continue. (N. Framine *pers. comm.*)

The area between the Niger river and the borders with Burkina Faso and Mali does appear to be the major breeding area for Black Crowned Cranes between the Lake Chad Basin and Senegal River Basin. For Mali, Lamarche (1980) mentions the species as being common, all year round, in the Inner Delta (groups of 100-250 during the dry season), and in general in the vicinity of perennial wetlands, breeding November-January. Urban *et al.* (1986) describe it as sparse between the two main areas of occurrence in West Africa, Senegambia and the Lake Chad Basin, and on the verge of extinction in Nigeria.

Almost all the areas mentioned are very poorly explored ornithologically, with little idea of their relative importance to waterbirds at different times of the year or during wet or dry years. A proper inventory and survey of Niger's wetlands, and their importance to birds, is urgently needed (See Mullié *et al.* 1993). Training government personnel in the various parts of Niger in the identification and survey of waterbirds, and providing them with the means to do so (including binoculars and bird guides) is essential. So is soliciting all the records still only in observers' notebooks.

The national wetland survey should be followed by the development and implementation of a national wetland management plan, which takes account of all the various, and often conflicting, uses of wetland areas. These include wildlife, agriculture, pastoralism, fisheries, and collection of plant products.

STATUS OF CRANES IN NIGER

The Eurasian Crane (*Grus grus*) is a vagrant in Niger. The Black Crowned Crane appears to be doing reasonably well in the northern part of southwest Niger (wetlands to the west of the Niger river, the Niger river valley). It is not clear whether there is any breeding further east (cf. groups seen during dry seasons at Filingué and Abalak). We know of no recent observations from the border region with Nigeria, or east of 6° E, which is worrying.

There is a general lack of information on wetlands and waterbirds in Niger. Few records of a particular species may signify rarity, but may also only reflect a lack of observers in the right places at the right time of year (or a lack of communication of their observation!).

Species accounts

Eurasian crane (Grus grus)

Status: Vagrant. Only one observation, of a young female in very good health and flying well, at Bilma (18°41'N/12°56'E), 14.12.70, digestive tube full of date kernels (Fairon 1971 *in* Giraudoux *et al.* 1988) **Habitat:** No information. **Abundance:** No information. **Conservation Status:** No information. **Threats:** No information. **Needed Information:** Confirmed observations.

Black Crowned Crane (Balearica pavonina)

Status: Breeding along the Niger river valley north of Niamey and between the Niger river and the borders with Burkina Faso and Mali. Likely also further south along the river (Kolo), possibly as far south as the border with Nigeria. Still breeding in small numbers 50-100 km southwest, as well as several hundred km east, of Zinder (Matameye, Magaria; Goudoumaria). Dry season visitor elsewhere in the southern half of the country, very few recent observations in the east (two birds seen near Diffa, 24 January 1995). **Habitat:** Inland and riverine wetlands. Also feeds in dry fields. **Abundance:** Unknown, probably fewer than 1,000. **Conservation status:** Insufficiently known, probably declining; few pairs remaining along the border with Nigeria. The January-February 1995 waterbird survey only turned up 17 individuals along the Niger river north of Niamey. However, during that period there were still large expanses of flooded wetland away from the river, due to the copious rains during the 1994 rainy season. All historic observations of large concentrations of Black Crowned Cranes appear to have been made during drier times.

Threats: Wetland degradation, due to increased usage of the wetlands themselves and their catchments, and possibly related to declining rainfall. Disturbance. Possibly trapping of young and (formerly?) also of adults. It is not known what effect rebel and/or bandit activity have had in the area where Niger, Burkina and Mali meet. **Needed information:** A census of wetlands in south-west Niger and along the border with Nigeria.

REFERENCES CITED

Brouwer, J. and W. C. Mullié. 1994. The importance of small wetlands in the Central Sahel. IUCN Wetlands Programme Newsletter no. 9, June 1994, pp.12-13.

Brouwer, J. and M. Ouattara 1995. Interactions between wetlands and surrounding drylands in the Sahel: a key to sustainable use. Paper presented at the meeting of IUCN's Sahelian Floodplains Taskforce, Dakar, Senegal, 21-24 May 1995.

Cheke, R. A., J. F. Walsh, and J.D.C. Fishpool. 1985. Bird records from the Republic of Niger. Malimbus 7: 73-90.

Giraudoux, P., R. Degauquier, P. J. Jones, J. Weigel, and P. Isenmann. 1988. Avifaune du Niger: état des connaissances en 1986. Malimbus 10: 1-140.

Hamerlynck, O., E. ould Samba, B. ould Messaoud, and C. H. Diagana 1995. Valeurs ornithologiques du Bas-Delta Mauritanien. Présenté au Colloque "Environnement et Littoral Mauritanien", Nouakchott, Mauritania, 12-13 June 1995.

Holyoak, D. T. and M. B. Seddon. 1991. Note sur la répartition des oiseaux du Niger (1er partie). Alauda 59(1): 55-57.

Koster, S. H. and J. F. Grettenberger. 1983. A preliminary survey of birds in Park W, Niger. Malimbus 5: 62-72.

Lamarche, B. 1980. Liste commentée des Oiseaux du Mali (Part 1). Malimbus 2: 121-158.

Mullié, W.C. and J. Brouwer, eds. 1994. [Waterbirds and wetlands in Niger: a threatened resource. Results of 3 years monitoring (1992-1994) in the Republic of Niger. Preliminary report to IUCN-Niger.] (in French). With F. Codjo, P. Dupont, A. Kounou and P. Souvairan. Niamey, Niger. 59 pp. + tables and figures.

Mullié, W. C., F. Codjo, T. Crisler, C. Jameson, A. Kounou, and P. Souvairan. 1995. Results of the January-February 1995 waterbird count in Niger. Unpublished report to the International Waterfowl and Wetlands Research Bureau, Slimbridge, UK.

Newby, J., J. Grettenberger, and J. Watkins. 1987. The birds of the northern Aïr, Niger. Malimbus 9: 4-16.

Perennou, C. 1992. African waterfowl census 1992. International Waterfowl and Wetlands Research Bureau, Slimbridge, UK. 87 pp.

Rose, P. M. and D. A. Scott. 1994. Waterfowl population estimates. Compiled by P. M. Rose and D. A. Scott. International Waterfowl and Wetlands Research Bureau Publication 29. Slimbridge, UK. 102 pp.

Sauvage, A. 1993. Notes complémentaires sur l'avifaune du Niger. Malimbus 14: 44-47.

Shul, B., M. Grettenberger, and J. Newby. 1986. Recent observations of birds in W National Park (Niger). Malimbus 8: 23-24.

Taylor, V. 1993. African waterfowl census 1993. International Waterfowl and Wetlands Research Bureau, Slimbridge, UK. 156 pp.

Taylor, V. and P. Rose. 1994. African waterfowl census 1994. International Waterfowl and Wetlands Research Bureau, Slimbridge, UK. 184 pp.

Triplet, P., P. Yésou, I. Sylla, E. ould Samba, B. Tréca, A. Ndaye, and O. Hamerlynck. *In press*. Oiseaux d'eau dans le delta du Sénégal. Bull. Mens. Off. Natl. Chasse.

Urban, E. K., C. H. Fry and S. Keith. 1986. The birds of Africa. Vol. 2. Academic Press, London, UK. 552 pp.

APPENDIX

Details of observations of Black Crowned Cranes in Niger.

W. C. Mullié *et al.* (1993), W. C. Mullié and J. Brouwer (1994), and W. C. Mullié *et al.* (1995) (waterbird counts in January-February 1992, 1993, 1994 and 1995):

Locality	Date	°N	°E	Number
Tabalak	920129	15.27	6.17	43
N'Dounga	920125	13.21	2.17	33
Tabalak	930100	15.27	6.17	40*
Sibéri	930118	13.48	2.18	5
Namarigoungou	930119	14.20	1.15	1
Parc du W	930121	12.15	2.30	15
Sibéri	940113	13.48	2.18	6
N'Dounga	940113	13.21	2.17	2
Balafoulbe	940121	12.54	1.56	2
Kero	940123	13.48	1.05	10
Kokoro	940201	14.10	0.55	12
Goudel	940205	13.31	2.02	2
Lata	940206	13.44	1.41	19
Balati	940206	13.31	1.49	2
Bac Farie	942301	13.48	1.39	46
Bitoa N'Gor	950124	13.16	12.36	2
Kpennyua	950131	12.49	1.44	5
Sibéri	950205	13.48	2.18	3
Goudel	950207	13.33	2.05	6
Kéro	950207	13.48	1.05	16
Kokoro	950208	14.10	0.55	3
Namari Goungou	950209	14.20	1.15	4
Tillabéri	950209	14.13	1.27	2
Diomana	950210	?14.40	?1.00	2
Ayourou	950210	14.44	0.55	3
Bala Foulbé	950212	12.54	1.56	2

*Black Crowned Cranes were not actually seen at Tabalak in 1993, but local farmers said about 40 roosted at the northern end of the lake, and went out to feed in the surrounding fields during the day; in January 1994 all the trees had been cut at the northern end of the lake, because of a dispute between local farmers and the authorities

W. C. Mullié and J. Brouwer (1990-94) (other than during waterbird counts):

Zone 2 (refer to Figure 1)-

Regularly seen along the Niger river between Kolo (40 km SE of Niamey) and Gotheye (80 km NW of Niamey). One offered for sale by villager from the Niger-Mali Border.

Locality	Date	°N	°E	Number
Dougel Kaina	900510	13.16	2.21	2
Sibéri	900527	13.15	2.22	2
Saga	900804	13.27	2.09	+
Sibéri	900804	13.15	2.2	6
Dougel Kaina	910701	13.16	2.21	3
Dougel Kaina	910919	13.16	2.21	+
Liboré	911207	13.24	2.12	2
N'Dounga	911207	13.21	2.17	13
Rive droite	911208	13.35	2.00	4
Saga	911225	13.27	2.09	2
Liboré	911225	13.24	2.12	14
Saga-Kolo	920321	13.20	2.1	21
Filingué	921122	14.20	3.20	10
Kohan	930412	13.19	2.17	2
Goudel	930522	13.33	2.05	2
Namaro	930523	13.42	1.42	48
Sibéri	930601	13.15	2.22	4
Gongozougou	930601	13.13	2.23	3
Say	930602	13.06	2.21	21
Kirtachi	930602	12.48	2.30	2
Liboré/N'Dounga	930602	13.23	2.15	2
Liboré/N'Dounga	930605	13.23	2.15	4
Wekouré Tondi	930604	12.33	2.32	3
Say	930823	13.06	2.21	2
Dougel Kaina	940215	13.16	2.21	2
Torodi	940314	13.07	1.48	3

R. A. Cheke *et al.* (1985):

Zone 1 (refer to Figure 1)-

Park W: 1 individual (6/84; 9/84)

Zone 2 -

Near Ayourou: 20 roosting in trees (15/5/78), 1 individual (17/7/78), 86 total birds along 120 km stretch of Niger River between Gotheye and Ayourou (21/9/84);

Bosse Bangou: 1 pair (7/84, 9/84);

Torodi: up to 11 birds (9/84).

P. Giraudoux *et al.* (1988):

Zone 1-

Park W: 1 individual (17/4/79).

Zone 2-

near Tillabery: dancing near town in April;

near Ayourou: more than 50 near town (31/3/78), several tens (5/7/78), 130 (11/2/84), present (4/80);

Namarigougouone: one pair on nests (7/11/85);

near Niamey: present (3/79); 2 (4/80).
Zone 3-
Maradi-Tanout region: rare, in small groups during rainy season (1939-41 as reported in Rousselot 1947);
Boboye 110 km E of Niamey and Dogon Doutchi: observed in May and October.
Zone 4 (refer to Figure 1)-
Mainé-Cheri: observed (24/8/75);
Kaadjia: observed (13/8/75);
Ngalaoua: several (29/12/77).
Zone 5 (refer to Figure 1)-
north of Tanout: group observed in December (Rousselot 1947);
40 km N Abalakn: 2 birds observed (7/10/77).

Locality	°N	°E
Abalak	15.27	06.17
Ayourou	14.44	00.55
Boboye	13.00	02.52
Bosse Bangou	13.21	01.18
Dogondoutchi	13.38	04.02
Firgoun	14.48	00.53
Kaadjia	13.54	12.48
Kolo	13.15	02.20
Mainé Cheri	13.26	11.21
Makalondi	12.49	01.44
Maradi	13.38	07.06
Namarigoungou	14.21	01.16
Ngalaoua	13.34	12.54
Niamey	13.31	02.07
Park W	12.15	02.15
Tanout	14.58	08.53
Tillabery	14.13	01.27
Torodi	13.18	01.40
Yatakala	14.45	00.25

M. Framine (*pers. comm.*) (living in Matameye 1993-1995):
Zone 3 (refer to Figure 1)-
Matameye and Magaria (13.15 N, 8.45 E): in 1994 still about 5 breeding pairs;
Goudoumaria (13.45 N/11.15 E): still breeding in low density 1994

D. T. Holyoak and M. B. Seddon (1991):
No observations

S. H. Koster and J. F. Grettenberger (1983) and B. Shul *et al.* (1986):
Zone 1-
Park W: observed from October to April along the Niger and Mekrou rivers; not found nesting.

S. J. Millington *pers. comm.* (living in Niamey 1989-91):
Zone 2-
Kolo: observed regularly in 1989, maximum 31 birds (27/8/89);
Firgoun: 5-6 pairs up river from Firgoun (30/4/89).

J. Newby *et al.* (1987):
No observations

C. Perennou (1992):
West African population estimated at 5,000 birds. During the January 1992 African Waterfowl Census 50 Black Crowned Cranes were counted in Mali (inner Delta), 76 in SW Niger, 200 in western Senegal.

P. M. Rose and D. A. Scott (1994):
Total population of the Black Crowned Crane estimated at 50.000 birds (of which no doubt a clear majority are of the subspecies *ceciliae*, which occurs in eastern Chad, the Sudan and Ethiopia).

A. Sauvage (1993):
No observations

P. Souvairan (*pers. comm.*) (living in Makalondi 1968-present):
Zone 1-
Makalondi: frequent around all [sic] inland depressions, from the first rains until February; two chicks of approx. two weeks old (1/10/71); group of 10 every day in the fields next to the village (1-15/10/78); 5 pairs, each with their own territory, along about a 7 km string of wetland depressions along an ephemeral stream bed, at Koulbou (19/2/84);
Yatakala: observed together with Marabou Storks, forming a large flock on the banks of the wetland (19/5/68);
Niamey: present all year round, along the river, up to the limits of the towns Niamey and Say (1968-85);
Tabalacet Baga: present at the wetlands (8/3/68 and 30/1/73);
Dolbel: arrive in pairs with the first water running down the Goroual (1/6/68).

V. Taylor (1993):
The 1993 African Waterfowl Census reported 1,046 birds in Waza-Logone floodplain, north Cameroon, 233 in Senegal, 21 in Niger, and 2 in Mauritania.

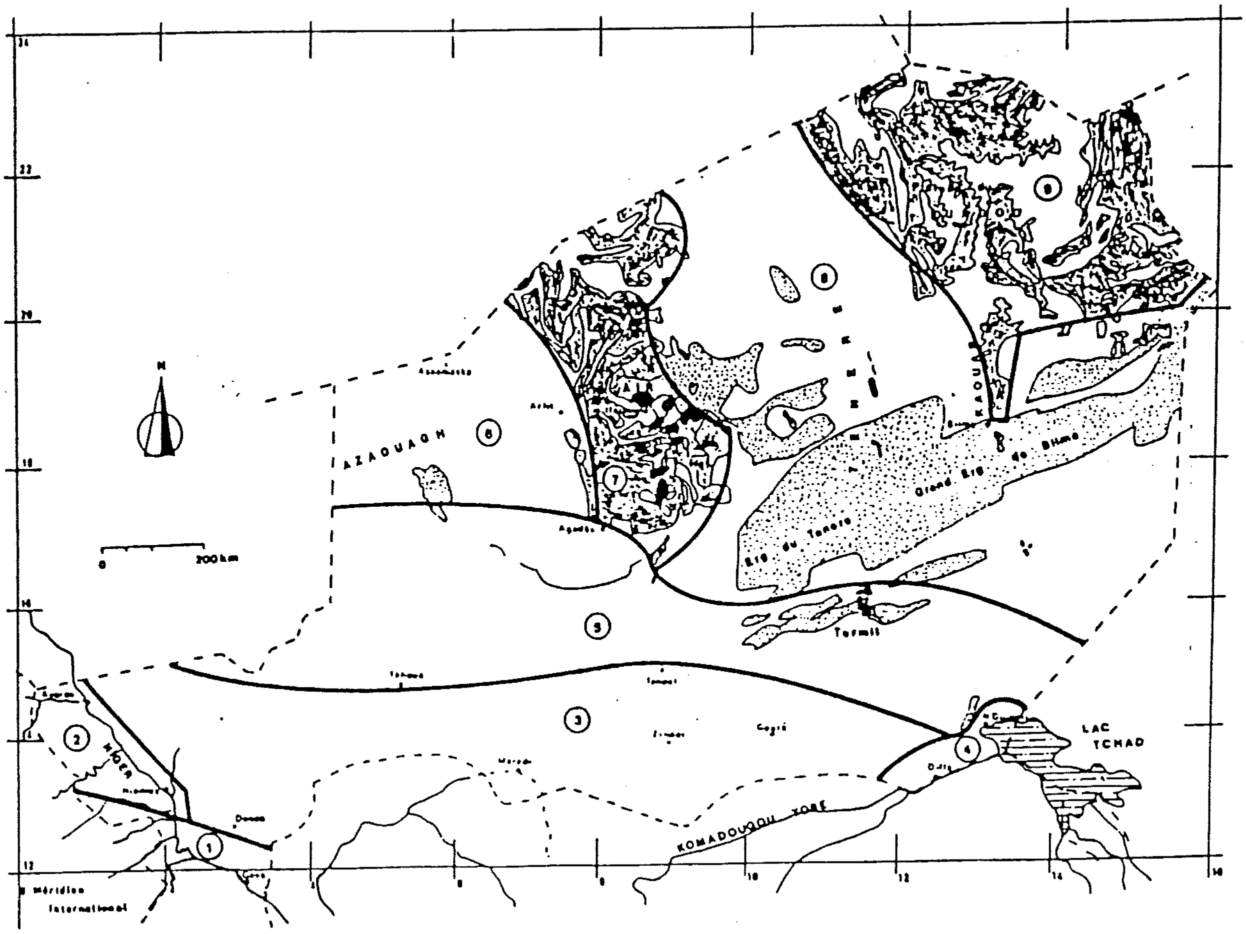
V. Taylor and P. M. Rose (1994):
The January 1994 African Waterfowl Census reported only 3 Black Crowned Cranes from Mali (Inner Delta), 1 from Nigeria, 101 from Niger, 518 from western Senegal, none from Mauritania. However, at least one pair nested in the

Diawling National Park in Mauritania during 1994 (Hamerlynck *et al.* 1995).

During the January 1995 census 48 Black Crowned Cranes were counted in Niger (Mullié *et al.* 1995); 549 were counted near the mouth of the Senegal river, mostly in Senegal but over 200 also in Diawling in Mauritania (Triplet *et al. in press*).

E. K. Urban *et al.* (1986):

Shown as breeding along Niger river, in area where Niger, Burkina and Mali meet, and along border with Nigeria; Mali, Niger, Burkina, Ivory Coast and Ghana combined a few thousand at most.



1. North Sudanian savanna zone
2. Central Sahelian zone along Niger River
3. Central Sahelian agricultural zone with rainfall of 300-600 mm
4. Central Sahelian zone along Komadougou Yobé and L. Chad
5. North Sahelian/transitional pastoral zone with rainfall between 150-300 mm
6. Sub-saharan plains and fossil valleys with steppe vegetation
7. Aïr mountains up to 1,800 m
8. Ténéré desert with oases
9. Mountainous plateaus of 800-1,000 m altitude

Figure 1. Ecological zones of Niger (after Giraudoux *et al.* 1988).

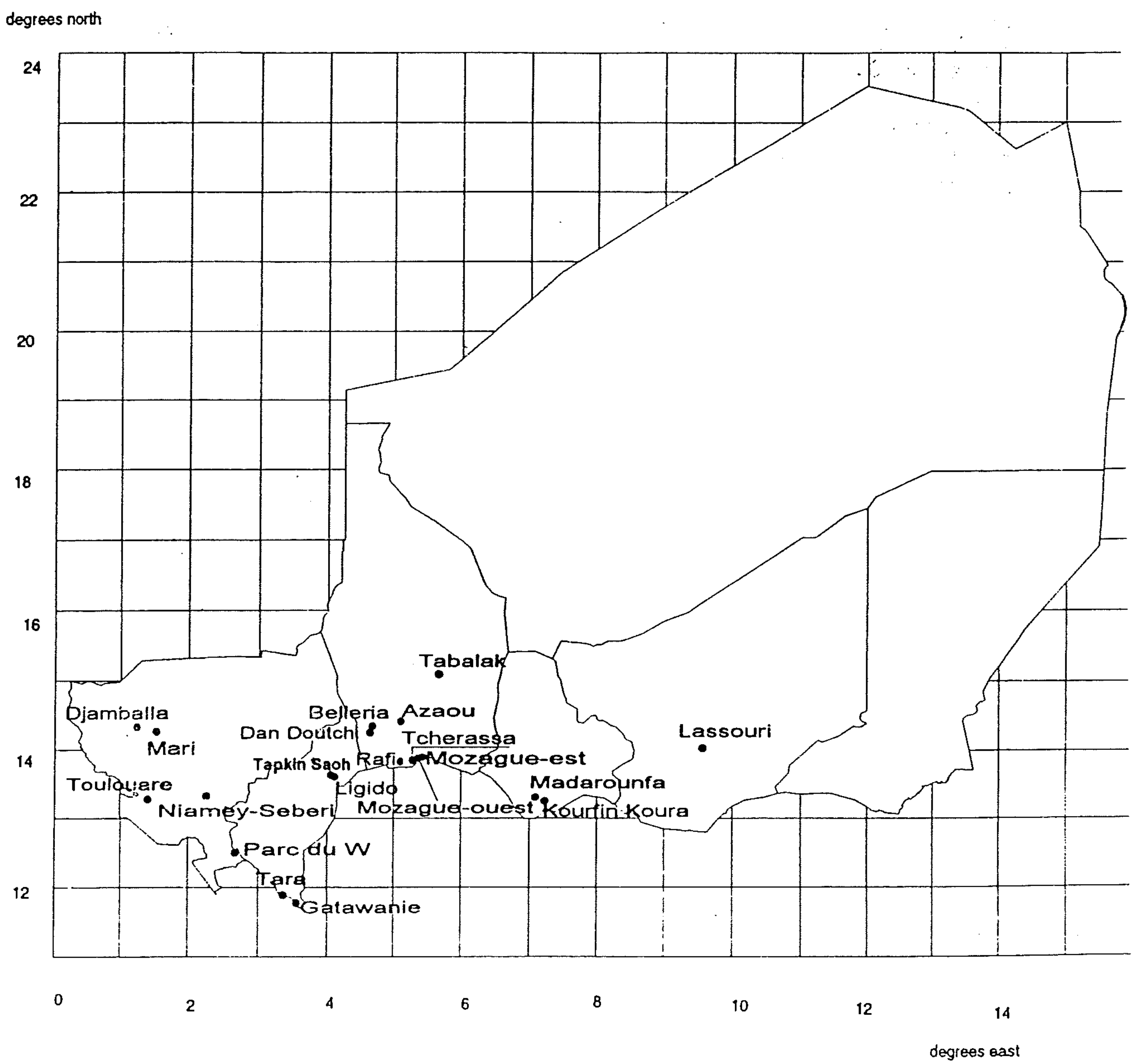


Figure 2. Wetlands censused (shown as •) during surveys in 1992 and/or 1993 (after Mullié *et al.* 1993).

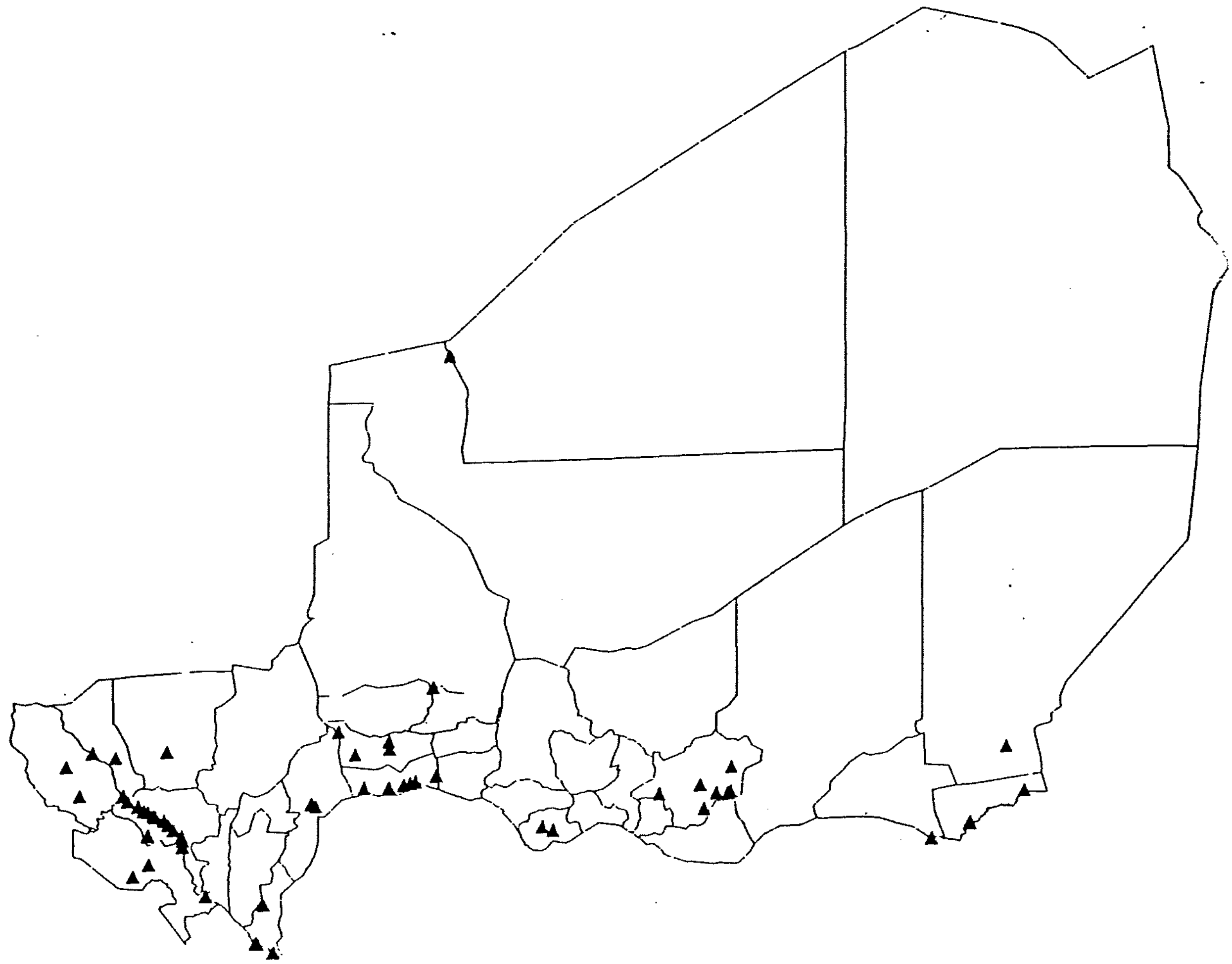


Figure 3. Wetlands surveyed (shown as ▲) in January 1992, 1993, and/or 1994.

STATUS AND REINTRODUCTION POTENTIAL OF THE BLACK CROWNED CRANE IN NIGERIA

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INTRODUCTION

The Black Crowned Crane (*Balearica pavonina*) was once widespread in northern Nigeria and has the status of national bird. In the 1960's and 1970's cranes were sighted frequently, mostly around grasslands, rice fields, and groundnut farms in our local villages, but now they are rarely seen in their former ranges. Where sightings once were made in the thousands, now hardly a pair can be sighted. This sharp decline in the crane population of Nigeria results mainly from habitat destruction, caused by numerous factors including: the pressure of the human population for land for settlement; the development of large agricultural schemes in floodplain wetlands; the construction of upstream dams which reduce flooding; the use of agricultural chemicals such as fertilizer and insecticides; and the uncontrolled disposal of industrial wastes, especially from tanneries, into large water catchment areas. Other factors in the decline may be connected with natural disasters, like the prolonged drought of 1973 which affected almost all the areas inhabited by cranes, resulting in drying up of wetlands and grasslands that once supported a large number of cranes.

The urgent need to arrest the rapid decline of the population of the Black Crowned Crane resulted in the organization of an international conference on this particular species and its wetland habitat in west and central Africa. The conference, held in Kano State, Nigeria in February 1992, aimed at discussing and identifying the causes of the decline and suggesting a strategy for crane conservation in the West African sub-region. The conference was sponsored by the Kano State Ministry of Agriculture and Natural Resources and the Royal Netherlands Embassy in Nigeria.

At the end of the conference a pair of captive-bred cranes were released into the wild in the Hadejia-Nguru wetlands, the first step in a reintroduction program for Black Crowned Cranes under the Black Crowned Crane Coordinating Centre. The release has proven to be positive. The release site, Likori Village in Kirikasama District of Jigawa State, attracted large numbers of people from local communities in the area. Several people have since indicated interest in the cranes' well-being, and the local community living in the wetlands where the cranes were released have undertaken to give them adequate protection. They are proud that the cranes are entrusted to the entire community around the wetland, and are glad the cranes may come back to an area where they once occurred in a flock of over one thousand.

STATUS OF BLACK CROWNED CRANE IN NIGERIA

The Black Crowned Crane is the national bird of Nigeria, but in some parts of northern Nigeria this crane is taboo. In Bida Town, Niger State, for example, the people feel it is unlucky for anybody to carry a Crowned Crane through their town. In Pankshin Town, Plateau State, flocks of cranes flying over the town should not make any call; if they do call, something bad is bound to happen. When cranes appear, therefore, people make loud noises so that the flocks leave quickly. Opinions vary from one locality to another; some people strongly believe that anyone who captures and eats a crane will soon be acting like an insane person. In many parts of the world, cranes are a sign of good luck and are thus accorded protection even in areas where they are taboo.

In the 1960's and the early 1970's thousands of these birds were found all over northern Nigeria, from the Niger River up to Lake Chad Basin. In the last 10 years or so a dramatic reduction in the cranes' range and abundance has occurred, such that the total population now numbers only a few hundred in Nigeria.

In former Gongola State (Adamawa and Taraba) these birds are occasionally seen at Gulak in Madagali District of Michika Local Government Area in pairs, either in flight (4 pm and later) or feeding (7-9 am). Another sighting of a similar number is occasionally made at Yelwa Dam Site in Toungo District of Ganye Local Government Area. Lake Gerieyo around Yola is also known to harbor small groups of cranes. Sightings have also been made in Karun, Lamido, Numan, and Mubi areas. In Plateau State occasional sightings of cranes have been made in Foron, Barikin Ladi Local Government Area. The birds are sighted in Burtinga Village, Bokkos Local Government Area either in flight late afternoon or feeding on grasshoppers and other insects in the morning. Similar sightings are also occasionally made at Ankwal Dam around Kura Falls, the UTC mechanized farm around Tenti, and in a fish farm around Panyam. The birds move in groups of four to six.

Fifty to one hundred birds have been sighted around Burtinga, Kakuruki, and Kai areas especially after the March-April burn of the area. In Borno State (Borno and Yobe) nests with eggs are observed in Buratura Oasis. The birds are also occasionally sighted in Aulgo and Chingurmi Game Reserve and the Lake Chad Game Sanctuary bordering the Chad and Cameroon Republics. These birds are sighted either in flight or feeding in the Sambisa and Chingurmi Reserves. Hardly any cranes now remain in the former dry season range around the Hadejia-Nguru Wetlands. In Borgu and Mokwa Local Government Areas, surveys were made several times, particularly around the Kainji Lake Basin bordering the Kainji Lake National Park and the Tatabu flood plains in Jebba District, but no sightings were recorded. In Kano State (Kano and Jigawa), one or two pairs of cranes have been recorded in the Duddurun Gaya Forest Reserve in Gaya Local Government Area and around the Iggi River in the Iggi Forest Reserve. In June 1993, we received a report from a lecturer in the Department of Biological Sciences, Bayero University, Kano, who sighted about six cranes around 4:30 pm between Kiyawa in Jigawa State and Jama'are in Bauchi State.

REINTRODUCTION POTENTIAL

Because of the success of the crane release in the Hadejia-Nguru wetlands in Kirikasama District of Jigawa State, other areas with the potential to support cranes should be considered for reintroduction. These areas include Duddurun Gaya Forest Reserve, Bunkura Forest Reserve, Tiga Dam Water Catchment Area, and Challawa Gorge Dam area in Kano State; the Hadejia/Nguru wetlands in Yobe and Jigawa States; the Ibbi Game Reserve in Taraba State; the Chad Basin National Park in Borno State; and many other places where Crowned Cranes once lived, from the River Niger up to the Lake Chad basin. The Kano Zoological Garden and the Jos Wildlife Park can be of great importance in breeding Crowned Cranes for reintroduction.

FACTORS CONTRIBUTING TO POPULATION DECLINE

Because Black Crowned Cranes are so dependent on wetlands, the crane population in Nigeria has declined sharply and is nearing extirpation as wetlands are destroyed to meet human needs. The impact of wetland destruction on the crane population has been compounded by other factors such as drought, dams, and poisoning.

In the subregion of west Africa, droughts have been known to occur about every seven years. The 1973 drought was the most severe, hurting agricultural production and drying up wetlands that once supported a large number of cranes and other aquatic life. Carcasses of both domestic and wild animals littered the wetlands. Worse still, the 1973 drought introduced a chain of reaction that altered the natural 7-year pattern of drought. Since then, drought has become more or less an annual feature.

As a result of persistent drought, people started migrating and looking for new settlements, and many more areas have been opened up to accommodate this need. Many more trees were felled to provide wood for construction and energy for domestic purposes. This in turn caused the government to embark on the mass construction of dams in order to facilitate increased agricultural production to meet human needs. The hope of environmentalists at that time was that the constructed dams would provide new wetland habitats without necessarily destroying the existing ones. Unfortunately, persistent drought delayed the filling up of the dams, thereby preventing the early release of water that was needed to reap the expected benefits from the projects. Similarly, wetlands located upstream suffered a reduction in size, and in a number of places have totally disappeared.

Irrigation activities received a big boost as a result of dam construction. This is the case in Nigeria, where natural marsh lands that characterized the lower valley of Hadejia/Jama'are River were replaced by crops. Large irrigation schemes suddenly became a feature of agricultural expansion. Expanses of natural wetlands turned into irrigated marshlands. Schemes like the Kano River Project, the Challawa Gorge, the Dadin Kowa, and the Lake Tchad Basins are typical examples.

Another factor which may have helped reduce the crane population in Nigeria is the indiscriminate use of pesticides. These chemicals are used to kill agricultural pests such as locusts, Golden Sparrows, *Quealea* birds, rodents, aphidis, and others. Such chemicals are also used to coat seeds against agricultural pests. Chemical fertilizers applied in rice fields or irrigated farms may also contribute to the decline in the crane population. Because they habitually feed on these insects, grains, fish, shoots, etc., cranes could be exposed to the danger of consuming chemically dressed seed, poisoned fish, or insects. Concentration of these poisonous chemicals in the cranes may cause a reduction in their number either by killing the cranes directly or by reducing their fertility.

Shooting and trapping of cranes throughout northern Nigeria is reported to have a very low impact on the crane population. In a number of places the bird is regarded as a sign of good will, so killing, trapping, or consumption of the Black Crowned Cranes is tabooed. In Plateau State of Nigeria, however, occasional shooting and trapping were reported around Tenti Dam, the UTC farm, and the Panyam fish farms for food and money. In these areas locally made traps of wire and snare placed on the ground were used for this purpose. In April 1985 four cranes were shot using a dane gun in the Tenti area of Plateau State. But because of the decline in the crane population, hunters no longer take interest in shooting cranes.

In Nigeria cranes have been accorded protection since 1963, but unfortunately, the law has never been sufficiently enforced, with the result that the bird is regarded by all and sundry as not legally protected. Worse still, the Endangered Species Decree 11 of 1985 accorded no legal protection to this bird. This serious omission further weakened the protection accorded this bird by the 1963 Northern Nigeria Wild Animals Law. This could be another factor in its decline.

EFFORTS MADE TO CONSERVE THE BLACK CROWNED CRANE

It is pleasing to realize that the Black Crowned Crane is receiving attention in a number of countries. In Mali, the bird is used as a logo for an association devoted to bird conservation. In the Cameroon, efforts are now geared towards protecting this bird legally. In Nigeria, efforts are being made to enlighten the public on the significance of having cranes in the environment. To realize this objective, a number of Nigerians have attended courses in the USA at the International Crane Foundation and in the UK at the Jersey Wildlife Preservation Trust to acquire more knowledge and techniques on how to approach the problem. A captive breeding program has also been started at Kano Zoological Garden with a flock of few birds.

RECOMMENDATIONS

The survival of cranes rests on the welfare of wetlands. In Africa most people are unaware of the importance of wetlands in water conservation, water quality, and in fisheries. The greatest problem facing the survival of cranes is the belief that cranes and wetlands have no beneficial role in the welfare of humanity. Natural resources with no apparent monetary value to people are believed to be useless. But people cannot live on money alone; we need a healthy environment with clean air, fresh water, and the beauty of nature. The following recommendations should help achieve this goal.

1. Wildlife management is principally people management. Particular emphasis must be placed on conservation education which will permeate the society, reaching policy makers, land users, students, and organizations, both governmental and non-governmental.

2. There is an immediate need for a short-term fact- finding missions to determine the population of cranes, the habitats they occupy, and the type of protection they receive in their home range.

3. The bird should receive adequate protection in both protected and unprotected areas.

4. Research into the biology of cranes should be carried out with a view to reintroducing this beautiful bird.

5. Captive breeding should be encouraged and releases into the wild should be conceived and implemented.

6. A West and Central African working group should be established with financial support. Member countries should be prepared to contribute funds towards conserving the rich wetland habitats and the vast natural resources, including cranes, with which the sub-region is endowed.

7. Non-governmental organizations like the International Crane Foundation, World Wide Fund for Nature, International Council for Bird Preservation, Ford Foundation, the Wildlife Federation, Food and Agricultural Organization, United Nations Environmental Program, International Union for Conservation of Nature and Natural Resources, Vender Hutcht Funds, African Wildlife Foundation, and others should help to ensure the establishment and full functioning of the working groups.

8. Member countries in the working group should formulate uniform conservation polices to ensure full realization of the benefits derivable from a development program.

9. Finally, any development must ensure the survival of renewable resources that relate directly to the welfare of people as well as wildlife. Sustainable and rational use of wetlands will provide a future for the Black Crowned Crane.

THE STATUS OF NIGERIAN FRESHWATER WETLANDS AND THEIR POTENTIAL FOR BLACK CROWNED CRANE CONSERVATION[1]

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ABSTRACT

This paper evaluates Black Crowned Crane (*Balearica pavonina*) distribution and status in relation to some fairly well-known Nigerian savanna freshwater wetlands. The links between the various destructive types of wetland use and the annual cycle of flooding and drying have led to an aggravated impoverishment of suitable habitats and consequent remarkable decline in the population and distribution of cranes and other wildlife. A reverse of the present level of ecosystem exploitation is necessary for recovery of the crane population. A strategy to achieve this is discussed.

INTRODUCTION

Wetlands are open systems which are constantly exchanging energy, materials, and organisms with the adjoining environment. The organisms in their different forms coexist and play an important role in the maintenance of the wetland and functioning of the ecosystem. Some of these organisms are also hunted to supply bushmeat to people in the rural areas, and are of socio-cultural interest in Nigeria where they constitute base or raw materials for industry, tourism, food, and medicament.

The Black Crowned Crane (*Balearica pavonina*) enjoys a prestigious status within its geographical range in Nigeria. It is the National Bird and its image is engraved on coins and the coat of arms. Because of its royal treatment and cultural significance in the recent past, hunting or killing the crane is taboo (Stopfords 1986). Some emirs and prominent personalities keep it as symbol of beauty and authority. The bird's preferred habitats include the grasslands and Sahelian savanna in flooded lowlands, particularly during the rainy season. Thus, availability of "healthy" stretches of wetlands in the preferred habitats is the basic requirement for nesting success and survival of cranes. Presently, little detailed information is available on the extent of wetlands in Nigeria and the rate of wetland loss. That information which is available, however, gives rise to considerable concern that most ecosystems are now under threat.

This paper attempts to evaluate crane distribution and status in relation to wetlands and wetland resources utilization and management. The paper advances some strategies for enhancing the wetlands' potential for crane conservation.

WETLAND STATUS AND BLACK CROWNED CRANE DISTRIBUTION

Specific studies on the ecology and biology of the Black Crowned Crane in Nigeria are few. Because the current information is limited to checklists from ornithologists, it is rather difficult to extract quantifiable data for a detailed analysis. According to Elgood (1982), the bird is locally common in valleys of the great rivers northward, usually in marshy areas or on sandy river banks or bars, while in north-central Nigeria, breeding occurs during the peak of the rainy season, from July to September. The northern part of Nigeria falls within the savanna vegetation zone, characterized by extensive floodplains of about 11,120 km^2 in area. This zone contains more than half of the estimated 21,500 km^2 of freshwater wetlands in Nigeria (Moses 1990). In updating Sikes' (1964) records of birds of Yankari, Dyer and Gartshore (1975) include Black Crowned Cranes but remark that they are "not common and seen only in small numbers in scattered localities." To further confirm the status of the crane, Hall (1977) in a survey indicates an "occasional presence in the dry season from December to March, the most being 25 at Lake Alo in the Northeastern part of the country". Sharland and Wilkinson (1981), in a bird survey of the former Kano State, list Black Crowned Cranes as one of the 25 bird species that have suffered a decline and are now rare, although they were previously common in the dry season around the Kiri Kasama wetland area. In the Kano area, the hitherto extensive floodplain would have accounted for the earlier observed presence of numerous migrant and resident birds while the recently increasing number of water development projects (Ita *et al.* 1985) likely accounts for the remarkable reduction in the population of cranes and other birds. Further appraisals of the status of the bird (Garba 1986; Meduna *et al.* 1988) indicate that the Black Crowned Crane is now confined to only two locations (the Kiri Kasama-Hadejia wetlands and the Kazaure area) out of the four originally identified locations in the present day Kano and Jigawa States.

In a summary of available reports, Urban and Gichuki

[1]Addendum to the Proceedings. Paper submitted 1 September 1993.

(1987) clearly indicate that the population of Black Crowned Cranes has continued to decline in recent years. The major factor responsible for the situation is the marked reduction in wetland areas resulting in habitat loss. Reversing the trend of declining crane populations requires a good knowledge of representative wetlands and their resources, functions, and limitations, as well as information about how to enhance these factors in relation to the present utilization and management patterns.

CURRENT UTILIZATION AND MANAGEMENT OF A TYPICAL SAVANNA WETLAND

There is no doubt that with a small human population in the savanna zone, the traditional pattern of wetland use, which was surprisingly well integrated with the ecology and natural cycles of the environment, existed from prehistoric time. But this traditional use is now breaking down under the impact of outside influences (e.g., trappers), human population growth, and increased farming and industrial activity. Many of the wetlands are largely unmanaged. For example, Tatabu floodplain, located at 9°12'-9°14'N/4°53'-4°57'E falls within the central savanna vegetation zone of Nigeria with a total rainfall of about 1,052 mm (Kowal and Knabe 1972). Tatabu wetland serves as the principal resource from which the entire Tatabu community derives its livelihood.

The annual cycle of flooding and drying of Tatabu floodplain, apart from its ecological importance, determines the extent and use of the ecosystem for fishing, agriculture, animal husbandry, forestry, and other uses (Figure 1). In spite of these activities some waterbird species (Table 1) still find the ecosystems suitable for their foraging and nesting activities. The bigger and/or more aesthetic birds, however, are hunted for meat or captured and sold as live birds. Local communities blame these activities for the near extinction of some birds, such as cranes.

Fishing

The wetland-fringed lake in Tatabu has long been a major fishery center, based primarily on the high productivity of the floodplains. The productivity arises from migration of fish species to the floodplain during floods when spawning and growth take place. The lake is communally fished, mainly with hooks, cast nets, and traps. The fishermen use mainly non-motorized fishing boats but at high-water level a few motorized boats are used. Some of the commercially important fish species include *Tilapia*, *Clarias*, *Gymnachus*, *Heterotis*, *Heterobranchus*, *Protopterus*, and *Polypterus*. Fishing takes place at all times of the year, with different kinds of gear appropriate to the different seasons and environments.

In the wet season most fishermen farm the uplands including the floodplain fringes and seasonally waterlogged areas resulting in low fishing intensity in the core floodplain area. Although low fishing intensity does not disturb the cranes' nesting activities, the fishing nets mostly left hanging on trees or old nets carried by the current and entangled in trees create mist nets that trap birds. Also, farming of the flooded areas where nesting usually takes place impairs the birds' breeding. As soon as the flood starts to recede, fishing activities increase and become intensified as the floodplain dries and fish concentrate in depressions and pools. Fish are usually caught with traps or scooped by hand nets. The high intensity of fishing, particularly at the dry phase of flooding, coupled with an influx of fishermen is threatening the future of the Tatabu lake fishery.

Other threats exist as well. *Protopterus annectens* buried in soil are dug out as the flood recedes, without any consideration for conservation. Litter and discarded hooks, lines, and lead weights pose a danger to humans and animals. There have been cases in other countries of waterfowl being poisoned by accidental ingestion of discarded lead weight (Bell *et al.* 1985).

Agriculture

Tatabu floodplain agriculture involves dryland farming on upland along the fringes and seasonally flooded fadama. Upland farming is rain-fed and based on millet, maize, and guineacorn. Rice is one of the most important crops grown on seasonally flooded areas. Land preparation, which usually commences in April, requires the felling and pollarding of trees. The dry wood is either collected as fuelwood or left in a heap at the base of bigger trees that cannot be felled with the available simple tools. This usually results in death of more trees with consequent damage to the ecosystems and also loss of resting sites. Apart from simplification of the vegetation communities, there is direct pollution of aquatic systems through pesticides and other agro-chemical used (Table 2) and carried by run-off from surrounding farmlands. Though assessments of the effects of agrochemicals on aquatic communities are still few in Nigeria, reports from Senegal indicate that the use of carbofuran (Furadan) on rice fields results in deaths of many non-target species such as frogs and fish (Verdwey *et al.* 1986).

Flood recession crops such as guineacorn, cassava, and late maize are grown as the water retreats. But at the dry phase spices and vegetables (pepper, tomatoes, amaranthus) are grown and maintained with a simple traditional irrigation system. Farming activities are relatively less during this period as compared to the wet season because more man-hours are spent on fishing and other activities (Figure 1). However, the near complete removal of shoreline and seasonally flooded vegetation further threaten the survival of cranes as a result of habitat degradation. Also year-round visitors and farming activities could lead to disturbance of the flora and fauna communities, thus reducing the population potential of birds.

Pastoralism

Tatabu floodplain vegetation, mostly consisting of grasses, depends on the annual flooding cycle. The seasonally flooded area contains herbaceous vegetation ranging from terrestrial grasses and sedges to semi-aquatic plants capable of withstanding limited desiccation. The permanently waterlogged vegetation zone contains both submerged and floating macrophytes, especially *Echinocloa* spp. The contribution of these plants to livestock production, particularly in the Niger River Basin and including Tatabu floodplain, has been documented (Ayeni 1983; Okaeme 1983; Daddy *et al.* 1986). There is always a mass movement of cattle, goat, sheep, and donkey during the dry season from November to May. The residual moisture after flood recession sustains the growth and development of some plants. The lush vegetation serves as fodder resources for the nomadic livestock and at times the vegetation is excessively grazed as the upland vegetation is dried and burnt. The low-grazed vegetation coupled with lopping of available browse plants further compound the unavailability of suitable habitat for waterfowl and other wildlife.

Forestry

In the dry season some forest trees such as *Daniella oliverii*, *Vitex doniana*, *Terminalia avicenoides*, and *Mitrygna inermis* along floodplain fringes are felled for use as dugout boats, timber for construction, fuelwood, and other uses. Some of the fuelwood is sold to commuters and in some cases carted to bigger settlements. Apart from the effects of exploitation of the tree resources on the floodplain hydrology, most available bird species prefer the fringing/riparian evergreen vegetation for resting (Table 3). However, the aquatic species utilize the littoral and sandbank niches and these ecosystems are more extensively farmed (over 60% of cultivable areas) thus increasing the habitat loss for waterfowl.

STRATEGY FOR WETLAND AND CRANE CONSERVATION

The preferred habitats of the Black Crowned Crane include the grasslands and Sahelian savanna but flooded lowlands, particularly in the rainy season, provide ideal places for their nesting. According to Sanford (1982), savanna covers nearly 80% of the land surface of Nigeria, while the wetlands cover 3.2% (Moses 1990). Thus, apart from threats posed by human activities, the country is blessed with suitable and extensive habitat for the survival of cranes. This is because the greater proportion of the freshwater wetlands are surrounded by savanna vegetation type. However, incomplete baseline data on the national wetlands prevent an accurate appraisal of the status of the associated natural resources.

Black Crowned Cranes are a renewable resource, and despite the remarkable decline in population, a well-articulated wetland conservation strategy would ensure their recuperation. Providing a future for the Black Crowned Crane would involve a national inventory of wetlands, the conservation and management of productive wetlands, conservation of wetland resources for rural development, and international cooperation and technical assistance.

National inventory of wetlands

In the development of an effective conservation program for cranes, one of the first steps is the compilation of an inventory of the wetlands. Presently, only a few of the most important wetland areas have been surveyed while most other important sites remain nearly unknown. No systematic attempt has been made to document the major wetlands and their associated resources except, in some cases, the fisheries. A detailed inventory that would update the status, extent of resources, and wetland structure, functions, and limitations is highly desirable. These surveys should identify wetland areas that can serve as waterfowl sanctuary based on available avian species and their productivity.

Conservation and management of productive wetlands

The Nigerian government has long initiated programs for the conservation, management, and rational utilization of wildlife, particularly those of terrestrial origin (Brown 1967; Afolayan 1980; Ayeni 1985). But surprisingly little effort has been directed at the aquatic systems including their associated resources. Other than wetland areas that occur within the national parks, forests, and game reserves (Figure 2) there are no specific aquatic systems reserved solely for their conservation, historic, or research value. Nevertheless, the threat to the continued existence of the Hadejia/Nguru wetland areas of the present Jigawa and Yobe States, which are of immense importance to the large population of waterfowl that utilize the area every year, has aroused some international concerns. Concern for the survival of the wetland areas led the Royal Society for the Protection of Birds (RSPB) in conjunction with the Nigerian Conservation Foundation (NCF) to launch an international campaign in April 1989 to save the valuable wetlands from further over-exploitation. However, there is still urgent need for conservation of representative wetland areas based on separate criteria including geographical location and importance to local communities.

Wetland resources conservation for rural development

Most major threats to Nigerian wetlands and other ecosystems include general disturbance from human activities such as hunting and over-fishing. But the local communities whose means of livelihood depend on the exploitation of the overflow from the available natural resources have evolved several traditional and rational utilization strategies that only require some refinement. The Black Crowned Crane in Nigeria, apart from its stature as the National Bird and its cultural value, was kept by prominent emirs and obas (G. Haliru *pers. comm.*) as a symbol of beauty and authority. Thus, the involvement of emirs and obas in preservation of bird would be most stimulating. In addition, the bird is highly attractive to both local and foreign tourists; revenue generated from their visits could be used to further improve conservation efforts for the crane. Apart from direct preservation of the bird, a communally based inland wetland resources conservation scheme (Daddy *et al. in press*) would further enhance the productivity potential of associated resources including the avian species.

International cooperation and technical assistance

The issue of ecological stability, in particular the conservation of natural resources that cannot be immediately assigned a monetary value, usually receives very little attention in most third world countries, including Nigeria. Wetlands and large bodies of water constitute major landmarks for migratory bird species. Since the bird depends on these ecosystems for sustenance, their maintenance requires an interrelationship between the industrialized and less industrialized countries. The cooperation should involve boosting of conservation efforts and training of personnel. Initiation of research activities and acquisition of adequate scientific equipment through external funds would help ensure the adequate execution of conservation programs.

CONCLUSIONS AND RECOMMENDATIONS

The cranes hitherto locally common in some of the northern savanna wetlands are now rare due to unorganized wetland use. The ecosystems are exploited in response to the annual cycle of flooding and drying for fishing, agriculture, pastoralism, forestry, and other uses. These activities directly affect other biological communities through either habitat loss, disruption of the existing food web, or pollution, resulting in remarkable decline in biodiversity. To forestall further destruction of the wetland ecosystems and associated resources calls for a systematic and rational approach.

1. Of utmost priority is the need to verify the current status and distribution of cranes through systematic questionnaire and field surveys.

2. The next step is further investigation of populations identified during the field survey. The study should cover habitat use and population structure and dynamics. Viable populations should be given absolute on-site protection by creating sanctuaries with generous buffer zones.

3. Captive propagation of cranes in suitable zoological gardens should begin. This can be complemented with translocation from locations where they occur in fair numbers to areas where they were once present.

4. Sustained awareness and educational campaigns aimed at showing the importance and value of wetlands and cranes to Nigerian socio-cultural activities should be started.

5. Finally, to ensure continual monitoring and study of cranes, external grants should be made available to institutions with wildlife departments or aquatic resources research programs.

REFERENCES CITED

Afolayan, T. A. 1980. A synopsis of wildlife conservation in Nigeria. Environmental Conservation 7(1): 207-212.

Ayeni, J.S.O. 1983. Rangeland problems of the Kainji Lake Basin area of Nigeria. Environmental Conservation 10(3): 239-245.

Ayeni, J.S.O. 1985. Strategies for conservation of wild animal resources of Nigeria. An invited paper presented at the Seminar organized by Federal Department of Forestry Nigeria in Bagauda, Kano, Nigeria.

Bell, D. U., N. Odin, and E. Torres. 1985. Accumulation of angling litter at game and course fisheries in South Wales, UK Biological Conservation 34(4): 369-379.

Brown, D. 1967. Borgu Game Reserve: a survey. Unpublished manuscript. Kwara State Forestry Department, Kwara State, Nigeria. 17 pp.

Daddy, F., E. A. Obot, and M. Wari. 1986. Woody plant utilization in the Kainji Lake Basin of Nigeria: impact on rangeland ecosystem. Journal of Tropical Forestry Resources 2: 42-49.

Daddy, F., J.S.O. Ayeni, and A. N. Okaeme. In press. The Nigerian inland wetland resources: a proposal for conservation. Paper presented at the National Conference on Conservation of Aquatic Resources held at Calabar, Nigeria. May 11-14, 1992.

Dyer, M. and M. E. Gartshore. 1975. Birds of Yankari Game Reserve, Nigeria. Bulletin of Nigerian Ornithologists Society II(70): 77-84.

Elgood, J. H. 1982. Birds of Nigeria. British Ornithologists' Union Check-list No.4. 246 pp.

Garba, B. 1986. The Crowned Crane: its status and distribution in Kano State. HND Special Project. Federal School of Wildlife Management, New Bussa, Niger State, Nigeria. 24 pp.

Hall, P. 1977. The birds of Maiduguri. Bulletin of the Nigerian Ornithologists Society 13(43): 15-36.

Kowal, J. M. and D. D. Knabe. 1972. An agroclimatological atlas of the northwestern states of Nigeria. Ahmadu Bello University Press, Zaria, Nigeria.

Meduna, A. J., G. P. Stopfords, and B. Garba. 1988. Status and distribution of the northern crowned crane in Kano State. The Nigerian Field 53: 157-160.

Moses, B. S. 1990. Distribution, ecology and fisheries potentials of Nigerian wetlands. Pages 35-46 *in* T.V.I. Akpata and D.U.U. Okali, eds. Nigerian wetlands. UNESCO/MAB, Port Harcourt, Nigeria.

Okaeme, A. N. 1981. Significance of migrant Fulani's cattle and present developments around Kainji Lake Basin, Nigeria. Journal of Agricultural Extension 1(1): 38-43.

Sanford, W. W. 1982. Savanna: a general review. Pages 3-21 *in* W. W. Sanford, H. M. Yesufu and J.S.O. Ayeni, eds., Nigerian savanna. MAB/ UNESCO, KLRI, New Bussa, Niger State, Nigeria.

Sharland, R. E. and R. Wilkinson. 1981. The birds of Kano State, Nigeria. Malimbus 3(7): 7-30.

Sikes, S. K. 1964. A game survey of the Yankari reserve of northern Nigeria. The Nigerian Field 29: 54-92 and 127-141.

Stopfords, G. P. 1986. Pages 678-688 and 695-696 *in* Deforestation and wildlife management: the case of the Nigerian national bird. Pages 695-696 *in* Proceedings of the 16th Annual Conference of the Forest Association of Nigeria.

Urban, E. K. and N. N. Gichuki. 1987. Recent research and conservation activities with cranes in Africa. Pages 351-355 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Verdwey, P. J., A. G. Berends, and J. W. Everts. 1986. The impact of pesticides on palaearctic migratory birds in the Senegal River Delta. Draft manuscript. Agricultural University, Wagenegen, The Netherlands.

Table 1. Common waterbird species on Tatabu floodplain.

Species	Migrant		Resident
	Palearctic	Intra-Nigerian	
Longtailed Shag	-	-	+
Tiger bittern	-	-	+
Cattle egret	-	-	+
Greenbacked Heron	-	-	+
Great White Egret	-	-	+
Little Egret	-	-	+
Grey Heron	+	-	+
Purple Heron	-	-	+
Hammerkop	+	-	+
Openbill Stork	+	+	+
Saddlebilled Stork	+	-	-
Hadada Ibis	-	+	-
Whitefaced Tree-duck	-	-	+
Pigmy Goose	-	-	+
Common Teal	-	-	+
Greythroated Rail	-	-	+
African Crake	-	-	+
Allen's Reed-hen	-	-	+
King Reed-hen	-	-	+
Lily-trotter	-	-	+
Water Thick-knee	-	-	+
Spurwinged Plover	-	-	+
Senegal Wattled Plover	-	-	+
Common Sandpiper	+	-	-
Crocodile Bird	-	+	+

Table 2. Common pesticides and crop applications in Nigeria (Agricultural Development Programme Office).

Name	Herbicide	Insecticide	Crop
Acetellic dust	-	+	Maize
Acetellic 2b EC	-	+	Soybeans
Atrazine	+	-	Maize, Millet, Maize
Basagram P112	+	-	Rice
Basadin	-	+	Maize, Horticulture
Codal	+	-	Cowpea, Maize
Cotoran Maleate	+	-	Cassava
Cynbush super Ed	-	+	Cotton
Cynbush 10EC	-	+	Cowpea
Decis 25EC	-	+	Cowpea
Dimetheorate	-	+	Cowpea
Dual	+	+	General
Fernsad D	-	+	Maize, Sorghum
Galex	+	-	Cowpea
Gesgard	+	-	Maize
Gexapax	+	-	Banana, Oil palm
Gramazone	+	-	General
Gramiron	+	-	Cassava
Karate	-	+	Cowpea
Laddook	+	-	Maizo
Pisane	+	-	Rice
Preforan	+	-	Rice, Cotton
Primextra	+	-	Maize
Roundup	+	-	General
Ronstar	+	-	Rice
Salut	-	+	Cowpea
Sherpa plus	-	+	Cowpea
Stomp	+	-	Maize, Sugar Cane
Sogoprim	+	-	Sorghum
Ultracide	-	+	Vegetables

Table 3. Diversity (bird species observed in one habitat divided by total species observed in all habitats) and relative abundance (number of birds observed in one habitat divided by total birds observed in all habitats) of birds by habitat types in Tatabu floodplain.

Habitat	Diversity	Abundance (%)
Littoral	0.29	29.14
Sandbank	0.07	6.23
Open water	0.17	4.27
Fringing vegetation	0.42	48.75
Riparian/Evergreen forest	0.24	10.61

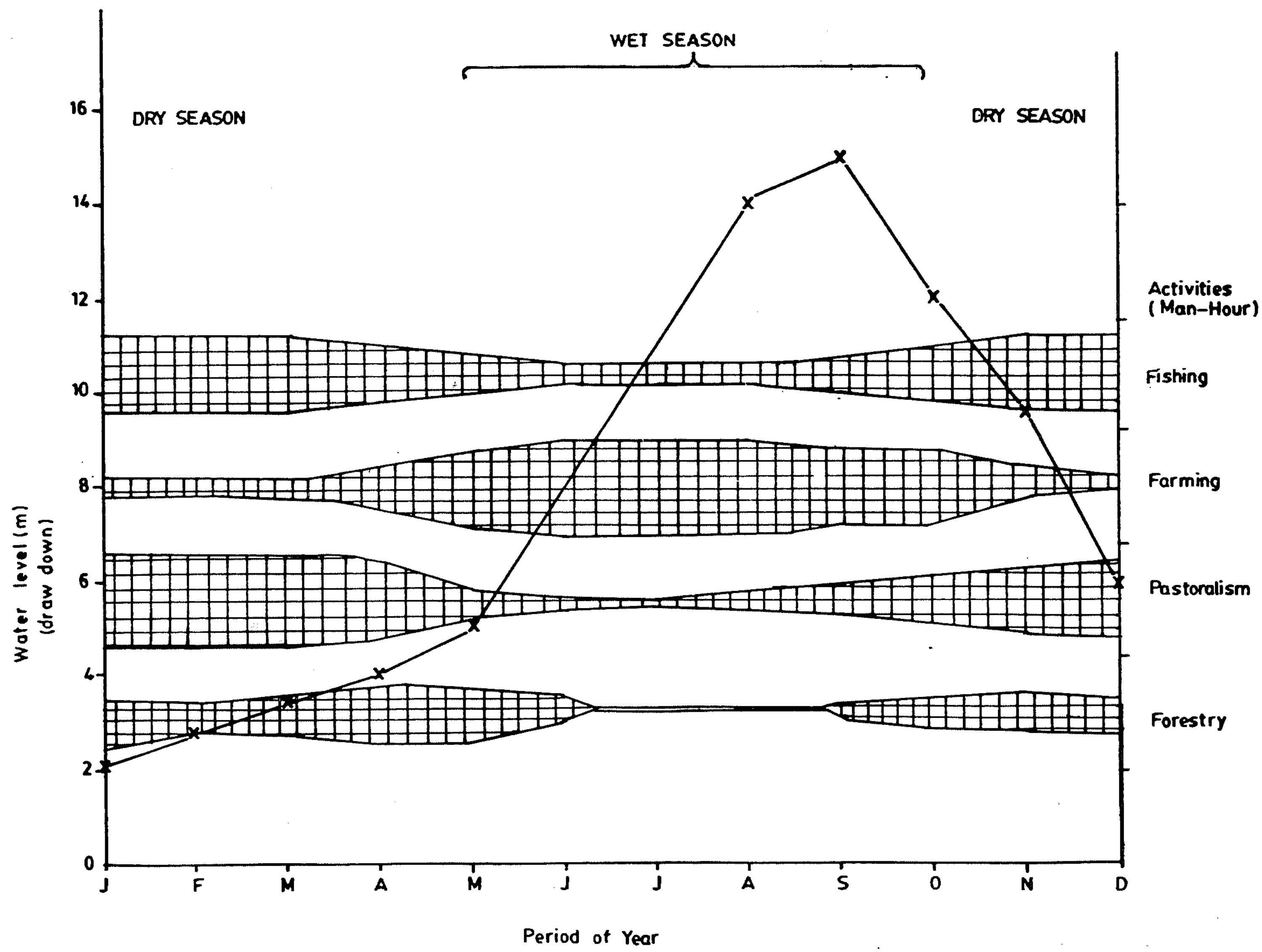

Figure 1. The flooding pattern and associated land use types of Tatabu floodplain, Nigeria.

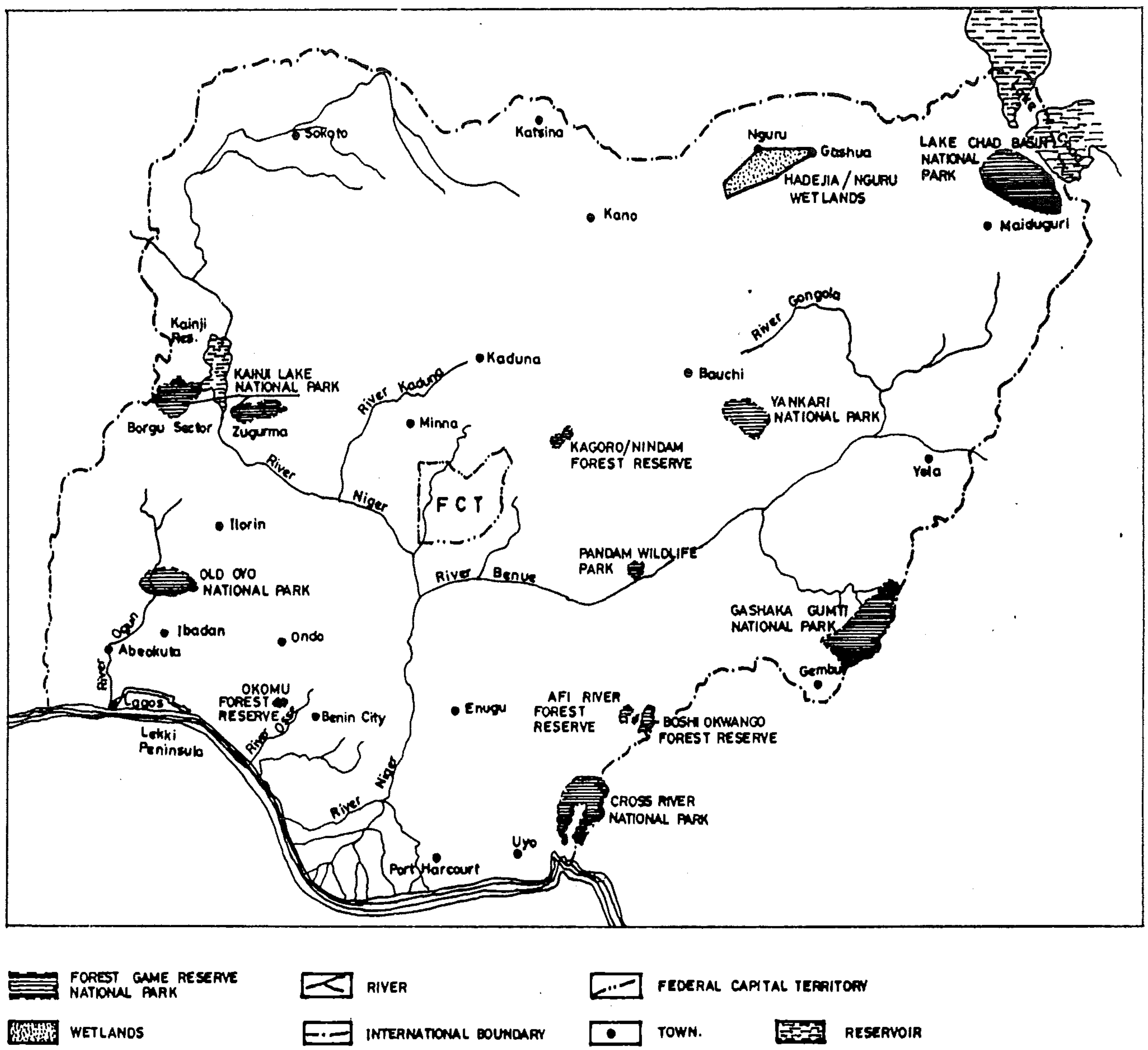

Figure 2. Map of Nigeria showing some conservation areas.

DAM-INDUCED DRYING-OUT OF THE HADEJIA-NGURU WETLANDS, NORTHERN NIGERIA, AND ITS IMPLICATIONS FOR THE FAUNA

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ABSTRACT

The Hadejia-Nguru Wetlands, an extensive floodplain complex of the Hadejia and Jama'are river systems, is located in the Sudan savanna zone of Nigeria. The complex covers about 530,000 ha, of which over 150,000 ha. provided wet areas during the dry-season in the days before dam construction. Today, less than a third of the pre-dam wetland area, or less than 10% of the floodplain complex, is flooded. Three main factors are responsible for this condition: continuing aridity in the region; impoundment of water behind numerous dams upstream; and excessive extraction of water on the floodplain for an increasing hectarage of irrigated land. It is argued that the last factor is an aftermath of the construction of dams while the trend in aridity has been broken several times by wet years sufficient to restore the wetlands if there were no other factors involved. The critical factor therefore is the construction of dams with the impoundment of reservoirs behind them in the last twenty-four years. The drying-out has endangered some resident birds, including some species of ducks and geese, as well as Palearctic and Afro-tropical migratory species, including the Black Crowned Crane. The threat has been such that an international corporate body has been set up to preserve parts of the wetlands for these birds and other wildlife. It is suggested that to achieve the aim of the corporate body, new large dams should be prohibited in upstream reaches, while certain areas should be declared as nature reserves and protected by legislation. Such areas may be kept constantly wet by constructing dikes at strategic points. Certain specific lines of research are also suggested to encourage proper implementation of the suggested actions.

INTRODUCTION

The Hadejia-Nguru Wetlands are contained approximately between latitudes 12°15' N and 12°55' N, and between longitudes 10°E and 11°E in the Sudan savanna of Nigeria. The area contains the extensive floodplains of Rivers Hadejia and Jama'are, the four corners of which are marked by the following points: Hadejia, Katagum, Nguru, and Gashua (Figure 1). Over 150,000 ha. of the area qualified as dry season wetlands earlier in this century (Adams and Hollis 1989) and remained largely wet until the impoundment of reservoirs upstream. The Hadejia- Nguru Wetlands were noted not only for their agricultural production, particularly rice, but also for their avifauna, including Palearctic and Afro-tropical migratory birds for which they offer temporary but vital habitat.

Now, however, a substantial portion of the wetlands have dried up and the remaining parts are still drying as conflicting claims on the available water for agriculture, animal husbandry, and conservation continue to mount. The issue of conserving the wetlands for their avifauna became so demanding that the federal government of Nigeria in partnership with the International Union for the Conservation of Nature and Natural Resources (IUCN), the Royal Society for the Protection of Birds (RSPB), the Nigerian Conservation Foundation (NCF), and five state governments embarked on a corporate project to save the wetlands. Several project reports have been written by the body.

This paper argues that the main cause of the current drying-out of the wetlands is the impoundment of reservoirs behind numerous dams upstream; that the increasing aridity in the region merely enlarges the effects of the dams; and that the ongoing encroachment of cultivation and pastoral activities and their concomitant overpumping of groundwater are but human responses to the primary drying-up effects of the dams. A general overview of the implications of such drying-up of large areas for resident and migratory avifauna is given.

THE DRYING-OUT OF THE WETLANDS

The extent

Until the late 1960s, about 150,000 ha. of the Hadejia-Nguru wetlands could be classified as wet. It is known that the drying-out became noticeable during the 1968-73 drought period which reached a climax in 1973 when Kano received just 48% of its long-term average annual rainfall. This coincidence has fixed it in the minds of observers that the drying-out of the wetlands is caused mainly by the increasing aridity in the region. It should be remembered, however, that some recovery of the wetlands occurred in 1974, but was short-lived because the giant Tiga reservoir (1.97 billion m^3) was completed in late 1974 and commissioned for full operation in 1975. Consequently, a steady drying-out resumed in 1975/76 and no recovery has been witnessed since then. Thus, today not more than one-third of the former dry season wetlands are flooded, and these remaining wetlands are flooded for a shorter duration than under natural conditions. Also, an ever-increasing area of hitherto uncultivated tracts is falling under the tractors of the cultivators who are backed by the World Bank-sponsored Agriculture Development Projects.

Causes

From the discussion above, three important factors can be identified which, combined, caused the drying-out of the wetlands. One is the persisting aridity in the region; the second is the impoundment of reservoirs upstream; and the third is the increasing encroachment of cultivators and pastoralists on ever-decreasing wetlands.

Rainfall amounts have steadily decreased in areas north of latitude 11°N since the 1970s. For example, in Kano (12°N), rainfall amounts have fallen below the long-term average of 864 mm (Olofin 1980) in 16 of the 23 years since 1970, and no annual amount has reached 1,000 mm since 1962 (Akintola 1985). The number of rainy days has also been on the decrease. There have been years with rainfall above the long-term average, such as 1978, 1980, and 1988; these have, however, had hardly any impact on the wetlands. Surely, if the drying-out were the result of increasing aridity alone, the wetlands should have shown signs of recovery, however temporary, during the very wet years. This has not been so, not even during the extremely wet year of 1988.

It is known that up to 22 earth-filled dams are operating on the Kano and Chalawa headstreams of the Hadejia (Olofin 1992), and a few are emerging in the Jama'are basin. The first three dams in Kano-Chalawa system were built between 1969 and 1971 (drought years) and were not large enough to make clear impacts, but Tiga dam (filled to capacity for the first time in 1975) controls about 95% of the pre-dam mean annual flow of the Kano River (approximately 33 m^3/s). Initially management allowed a mean annual discharge of 9.6 m^3/s (less than a third of the pre-dam flow) in the natural channel (regulated to flow throughout the year including the dry season when evaporation is excessive) for needs downstream. Later, following several multi-sector agreements, about 13.2 m^3/s was discharged into the natural channel, although this discharge was also regulated to flow throughout the year rather than during the flooding season (Olofin 1987). It needs to be emphasized that no discharge is maintained in the natural channels downstream of other dams in the area, thereby denying downstream areas the much needed water. Even in cases where rivers lost their channels into the sediments of the Chad Formation in pre-dam times (e.g., Jakara and Tomir), the waters still recharged groundwater in the wetlands through subsurface flow. With impoundment, however, the water is no longer available to recharge the wetlands' groundwater.

No wonder the effect of the dams, particularly Tiga Dam, was immediate. By 1977 a village head in the Hadejia Emirate complained to the officials of the Water Resources and Engineering Construction Agency (WRECA) of Kano that "the land is dying" (Kulatunga *et al.* 1977), as large tracts of the Hadejia-Nguru wetlands dried up and threw many cultivators and fishermen out of production.

Furthermore, the placement of Tiga and other dams resulted in channel and valley-side erosion in downstream reaches and the incision of a narrow "new" effective channel into the pre-dam storm channel. For example, the "new" Kano channel downstream of Tiga Dam is incised into the former storm channel to a depth of 1.5 m and its top width measures about 30 m instead of the 240 m pre-dam top width of the storm channel. Other dams that do not have the regulated perennial discharge of Tiga Dam have caused similar, but less stable, channel incisions.

The channel incision automatically lowers the water table in downstream reaches, contrary to the general expectation of a higher water table in such areas. Consequently, former river low terraces are left high and dry while the new overbank zones lie higher than the level of annual floods. In cases where perennial discharge has not been maintained in the natural channel, the erosion phase persists and the lowering of the water table is continuous. This is occurring in the Hadejia-Nguru wetlands.

In addition, some of the sediments generated through channel and valley-side erosion subsequent to dam construction have blocked the entrances of several downstream tributary channels, especially in the wetlands, thereby cutting them off from normal discharge. The Kaffin Hausa channel is a good example of this phenomenon.

Following from these observations, it should be clear that dams, rather than the much-feared aridity, constitute the main cause of the drying-out of the Hadejia-Nguru wetlands.

The third factor responsible for the drying-out of wetlands is the increasing encroachment of human activities on a decreasing area of wetlands. More areas are being cleared for cultivation under the Agricultural Development Project (ADP) program which has led to a change in the system of cultivation from the pre-dam residual moisture utilization technique to one of small- scale irrigation through tubewells, the use of water pumps for lifting water, and the adoption of agro-chemicals (fertilizers, herbicides, pesticides, etc.) and new crops including maize and wheat. While the pre-dam system is believed to be nature-friendly, the new techniques and exotic inputs are proving to be unfriendly to nature and conservation. Overpumping aggravates the lowering of the water table initiated by the channel incision in the area described above.

The combined effect of channel incision and overpumping must be the reason behind the findings of Ahmed (1992) that the average depth to water table in the wetlands is 30 m in the dune areas, 7.2 m (ranging between 4.7 and 9.9 m) below the old lower river terrace, and 2.0 m (ranging between 1.0 and 2.5 m) on the new overbank zone of the present floodplain. The average depth to water table in the dune areas is estimated to have lowered at the rate of 0.26 m/yr. between 1970 and 1989. The depth to water table in the lower river terrace is lowering at the rate of 0.1 m/yr. since 1970. It should also be noted that more and more of the old and current floodplains are being opened up for cultivation thereby driving the pastoralists into wildlife reserves and bringing about the invasion of pests, and also turning some of the favored avifauna into crop pests.

These human activities, however, are responses to the aftermath of dams. In other words, they came to be as a result of the drying-out of the wetlands caused by the construction of dams upstream.

It should thus be clear that the construction of dams upstream and the human responses to the initial drying- up effects constitute the main cause of the drying-out of the wetlands. The much publicized persisting aridity is playing but a secondary role. In other words, the drying-out of the wetlands and their failure to recover even in wet years is dam-induced. Overpumping of groundwater and persisting drought merely aggravate the problem.

The threat these dams hold for the ecology of this and other areas of Nigeria has been highlighted by Synge (1991) who opined that the construction of the Chalawa and Tiga dams will eventually dry up the wetlands with catastrophic effects on migratory birds. The rejoinder by the federal government of Nigeria through Aminu (1991), that the benefits of irrigation schemes far outweigh the supposed threat to ecology, should be given a very hard look. The effects of the Tiga dam have been very serious. Now that the Chalawa Gorge dam has been commissioned, ecologists should expect the combined effects to be very devastating.

IMPLICATIONS FOR THE FAUNA

Although this author has not studied the fauna of the Hadejia-Nguru wetlands to any extent, it is known that the wetlands harbor a considerable number of local and migratory birds, including Palearctic and Afro-tropical ones. Garba Boyi and Polet (*this proceedings*) shows the most common species of waterfowl at the counting points between 1988 and 1993. Of these, six species appear to be still in large numbers and/or are generally on the increase during the count period. These are Fulvous Tree-duck, Whitefaced Tree-duck, Spurwinged Goose, Knobbilled Duck, Pintail, and Garganey. Others are relatively few and/or decreasing in number, but the total number of birds shows an increasing trend.

However, this trend is believed to be misleading. It is feared that the absolute number of birds is not increasing, but rather the remaining birds are concentrating on fewer favorable areas (Ahmed 1992). Waterbird counting has been concentrated in only one of the four potential areas, the Dagona site. This point is emphasized by the observation of Dyer (1990) that the presence of the Whitefronted Finch-lark (*Eremopteryx leucotis*) "a typically Sahelian species--in large numbers well down into the wetlands may be indicative of the southerly encroachment of the Sahelian conditions into the area." I argue that it is not a southerly encroachment of Sahelian conditions, but a creation of Sahelian conditions in situ by the drying-out of the wetlands described above. Dyer (1990) has also lamented the virtual disappearance of the Black Crowned Crane (*Balearica pavonina*), and noted the sighting of the more northern occurring Eurasian Crane (*Grus grus*) and Whitefronted Goose (*Anser albifrons*), which appear new to the wetlands or could be of regular but infrequent occurrence in the area. He confirmed that the wetlands used to have a small, but thriving population of cranes, "but now the nearest known breeding area is 40 km to the north in the oases of the relatively uninhabited Manga Grasslands" (Dyer 1990).

The drying-out of the wetlands and the increasing encroachment of human activities (habitation) on them have combined to drive off the cranes and some Palearctic waders from the wetlands to give room to more arid zone birds such as the *E. leucotis*. If nothing is done quickly to arrest the drying-out trend, the catastrophic decline in migratory birds predicted by Synge (1991) may prove to be very prophetic. The Hadejia-Nguru wetlands are of socioeconomic importance for food production, avifauna, and cultural flora. They, or parts of them, should be preserved. The question of convincing decision makers of the importance of this ecological phenomenon should no longer be an issue of debate. The issue should be what should be done to conserve parts of the wetlands.

SUGGESTIONS

In order to save parts of the wetlands for the preservation of its resident and migratory avifauna while still deriving cultural and economic returns from the area, several actions are suggested.

1. Since the dams already constructed cannot be demolished, they should be managed such that adequate levels of water are made available in downstream reaches at specific places and at appropriate times. It may also be necessary to stop building new large dams on any of the rivers flowing into the wetlands.

2. Certain areas already identified as suitable nature reserves in the wetlands should be preserved as such, backed by legislation with deterring punishment for any infringement. Four sites identified are: Dagona-Dallah; Lakes Nguru and Punjamu; Matara Ganji-Matafari-Madachi; and Dumbari-Damasa sites. Such reserves would provide ideal habitats for local and migratory avifauna as well as other fauna and flora (excluding, of course, pests).

3. It may also be necessary to build dikes at strategic locations in such reserves in order to keep them adequately wet throughout the year; thereby ensuring particular levels of water as needed at particular times and in particular places.

4. Research is required to determine a number of issues including but not limited to:
   - the amount of water necessary to maintain the ecological balance in particular places at particular times;
   - the avifauna and other fauna that constitute crop pests and how best to deal with them;
   - the appropriate hunting limits necessary to maintain viable populations of the avifauna.

CONCLUSION

The number and diversity of resident and migratory waterbirds and other species of fauna using the wetlands, and the economically useful flora of the area are sufficient evidence of the importance of the Hadejia-Nguru wetlands to both man and nature. The dam-induced drying-out is a threat to this important ecological zone. The drying-out must be arrested and parts of the wetlands must be preserved for the future.

REFERENCES CITED

Adams, W. M. and T. Hollis. 1989. Hydrology and sustainable resource development of a Sahelian floodplain wetland. Hadejia-Nguru Wetland Conservation Project, London, UK.

Ahmed, K. A. 1992. Hadejia-Nguru Wetlands Conservation Project: agriculture, wildlife and water security issues. Paper presented at the National Conference on the Conservation of Aquatic Resources, organized by the National Advisory Committee on the Conservation of Renewable Resources. Calabar, Nigeria, May 1992.

Akintola, J. O. 1985. Rainfall distribution in Nigeria 1892-1983. Federal Ministry of Statistics, Lagos, Nigeria.

Aminu, A. G. 1991. Rejoinder to an article on the threat of dams to ecology in Nigeria "Livelihoods at risk". West African magazine. 28 October-8th November 1991.

Dyer, M. 1990. Ornithology in the Hadejia-Nguru wetlands. Mimeographed report, Hadejia-Nguru Wetlands Conservation Project, Nguru, Nigeria.

Garba Boyi, M. 1991. Water bird surveys in the Hadejia-Nguru wetlands: January to February, 1991. Project report, Hadejia-Nguru Wetlands Conservation Project, London, UK.

Kulatunga, V. S., S. Almassy, S. Iliasu, T. Cox, and D. Presland. 1977. Approach to water development in Nigeria: Kano State experience. Water Resources and Engineering Construction Agency, Kano, Nigeria.

Olofin, E. A. 1980. Some effects of the Tiga Dam on the environment downstream in the Kano River Basin. Ph.D. Thesis. Ahmadu Bello University, Zaria, Nigeria.

Olofin, E. A. 1987. Channel response to streamflow control in a savanna environment. Pages 663-680 *in* V. Gardner, ed., International Geomorphology 1986, Part I. Wiley and Sons, Chichester, UK.

Olofin, E. A. 1992. The gains and pains of putting a water-look on the face of the Nigerian drylands. Text of an Inaugural Lecture for the Chair of Geography, Bayero University, Kano, Nigeria.

Synge, R. 1991. Threat to ecology in Nigeria: livelihoods at risk. West African magazine. 16-22 September, 1991.

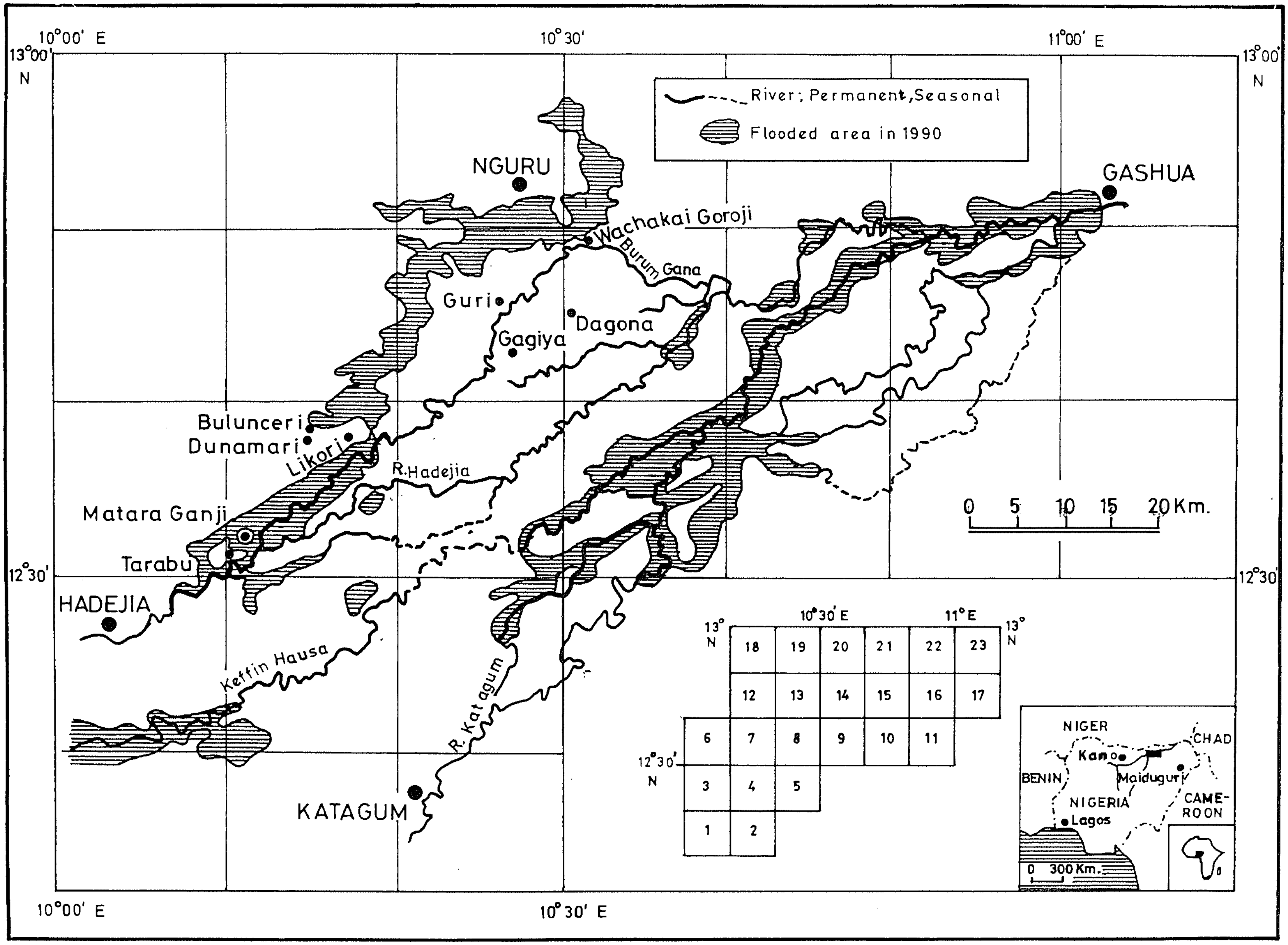

Figure 1. The Hadejia-Nguru Wetlands. The grid shows the Hadejia-Nguru Wetlands Project area (adapted from Garba Boyi 1991).

BIRDLIFE UNDER WATER STRESS: THE CASE OF THE HADEJIA-NGURU WETLANDS, NORTHERN NIGERIA

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ABSTRACT

The floodplain of the Hadejia-Nguru wetlands in northern Nigeria is a crucial habitat for bird life. Waterbird counts from 1987 to 1993 showed that the area supports large numbers of wintering Palearctic ducks, trans-African waterfowl, migrant passerines, and several resident species. Over 60 individual waterbird species from 15 families were recorded in the area, and the total number of waterbirds counted varied between 19,800 and 58,000 in a single year. The wetlands fulfill a wide range of economic functions for the inhabitants of the area, providing drinking water, agricultural surpluses, grazing resources, fish, and other valuable resources, including fuel wood, honey, timber, and so on. In recent years, however, the wetland areas have been under severe threats and the flooded areas are shrinking, because of both diminishing precipitation and upstream development of waterworks. This paper discusses threats to the avian population resulting from habitat loss because of rapid decline of flood volume midstream in the Komadugu Yobe Basin.

INTRODUCTION

Wetlands are an important habitat for a wide variety of birds. They provide superb resting, roosting, breeding, and feeding sites to a variety of water birds. Wetlands in the harsh, dry Sahel, such as the Hadejia-Nguru wetlands, provide indispensable habitat for resident, Palearctic, and inter-African migratory birds.

In northeast Nigeria, the extensive floodplains of the Hadejia and Jama'are Rivers, situated in the Komadugu Yobe River Basin (Figure 1), are a crucial habitat for over 60 waterbird species (Benthem 1988) and provide the basis of life for a local population of approximately 1.6 million people. The wetland provides agricultural surpluses and a wide range of other resources such as doum palm leaves for mat making, honey, timber, and fuel wood.

The activities of both agriculturists and wildlife in the wetlands are closely related to the hydrological cycle of the wetlands. During maximum flooding, the local population is mainly involved in rice farming and fishing during the period when large areas of suitable habitat for water birds are available. With the receding of flood waters, farmers plant their residual moisture crops, beans, groundnuts, and vegetables. In the dry season irrigated crops are grown along the permanent water bodies and swamps. After the rains have become established, irrigated crops like rice are planted in the floodplain in anticipation of the coming flood. The natural flooding cycle maintains the integrity of the wetlands ecosystem and also provides resources (i.e., water and silt) for a highly efficient and sustainable farming system in the floodplain.

STUDY SITE

The Hadejia-Nguru wetlands are situated in the Komadugu Yobe River Basin, formed by the seasonal flooding of the Hadejia, Burum Gana, and Jama'are rivers. These rivers carry water originating from the Jos Plateau and drain into Lake Chad. The wetlands cover parts of Bauchi, Jigawa, and Yobe states in Nigeria (Figure 1). The extent of flooding in the area is determined predominantly by the amount of rainfall upstream. The maximum flood level occurs at the end of the rainy season in October/November. Most of the area dries out before the rain starts again in June or July. During the peak of the flooding two flooded corridors are formed, divided by an area of higher ground. These flooded corridors provide resting, roosting, and feeding sites for thousands of water birds utilizing the area.

METHODOLOGY

Waterbird surveys are conducted in January/February every year. Before the actual counting starts, a preliminary survey of the area is undertaken to map-out sites with a high concentration of waterbirds. Visits are then made to these sites to count the number of birds present.

Birds are counted on a given body of water from a good vantage point with the aid of binoculars and telescopes. Birds are counted individually, but when large numbers are present in a flock, the flock is split up into groups of 50 or 100 and the total number of birds is estimated. Counts are repeated several times until similar results are obtained.

RESULTS

The bird counts undertaken demonstrate that the diversity of waterbird species in the area is high. Over 60 individual waterbird species from 15 families, both resident and migratory species, were identified (Table 1). Within the wetland areas, four key sites (Dagona-Dallah, Punjumu/Nguru lakes, Matafari/Matara Ganji, and Dumbari/Damasa) were identified and are known to hold significant populations of waterbirds. Counts of each species and total number of species vary from year to year. In summary, an estimated total of 28,000 waterbirds were recorded in these wetlands in 1988, 19,000 in 1989, 58,000 in 1990, 36,000 in 1991, 45,000 in 1992 and 50,000 in 1993. (Benthem 1988; Stowe and Coulthard 1990; Garba Boyi 1990, 1991a, 1992; Ezealor and Garba Boyi 1993). Pintail (*Anas acuta*), Garganey (*Anas querquedula*), Whitefaced Tree-duck (*Dendrocygna viduata*), Knobbilled Goose (*Sarkidiornis melanota*), Spurwinged Goose (*Plectropterus gambensis*), and Ruff (*Philomachus pugnax*) were the most numerous species recorded (see Table 1). The highest count over the period was recorded during maximum flooding in 1990. Other species recorded include Eurasian Crane (*Grus grus*), Demoiselle Crane (*Anthropoides virgo*), Avocet (*Recurvirostra avocetta*), Egyptian Goose (*Alopochen aegyptiaca*), and Secretary Bird (*Sagittarius serpentarius*).

Results of breeding bird counts undertaken between April and August 1991 show that the wetlands support an estimated total of 7,500 breeding pairs of thirteen different species in seven locations monitored during the surveys (Garba Boyi 1991b) (See Table 2). The estimate of the total breeding bird population is likely higher since only a part of the wetlands was covered in the survey.

Annual counts of waterbirds throughout the wetlands areas have provided baseline data on population levels and habitat use. Collated information has showed that the waterbird populations fluctuate considerably between years (Table 3). The phenomenon is thought to be caused by annual variation in seasonal water cover and movements of birds between wetlands in west Africa and other sites of ornithological significance within Nigeria.

Observations over the years revealed that populations of waterbirds in years with poor flooding are depressed. This is apparently because species diversity and abundance are closely related with ecological diversity. It is believed that limited flooding results in a diminished carrying capacity of the ecosystem, and results in a reduction in both the number and diversity of birds.

DISCUSSION

The extent of flooding in the Hadejia-Nguru wetlands has seriously decreased in recent years. Observations indicate that the area flooded diminished from 3,262 km² in 1950 to 700 km² in 1987 (Adams and Hollis 1988). Several factors contributed to this loss of wetlands in the middle stream of the Komadugu Yobe Basin.

1. **Diminishing rainfall.** Several annual rainfall amounts during the past two decades have been below 50% of the long-term mean annual rainfall.

2. **Upstream water development projects**. About 25 dams have been constructed in the upstream of the Komadugu Yobe Basin in the past decades (Figure 5). The two largest are Tiga Dam on the Hadejia river in Kano State and Challawa Gorge Dam. Construction of Tiga Dam in the period of 1971 to 1973 and the filling of the reservoir up to 1977 have clearly changed the nature of flows in the midstream of Komadugu Yobe Basin. Tiga Dam controls 25% of the catchment area that drains into the Hadejia river (Adams and Hollis 1988). Last year Challawa Gorge Dam was closed, resulting in a further reduction of available water for flooding in the Hadejia-Nguru wetlands. Recently a contract was signed to construct a third large dam, Kaffin Zaki. Kaffin Zaki Dam will tame the last free flowing river of the Komadugu Yobe Basin, the Jama'are. These dams are constructed for large formal irrigation projects. These projects have, however, proved to be difficult to manage and only part of the area planned for irrigation is actually under cultivation. Most of the water in the reservoirs is not being utilized, therefore, and is evaporating from the artificial lakes.

3. **Uncontrolled irrigation.** Since the early 1990s small irrigation pumps became widely used in the Hadejia-Nguru wetlands. The subsidy schemes of the Integrated Agricultural Development Projects of Kano and Bauchi States, financed by the World Bank, boosted their utilization (Barbier *et al.* 1991). These pumps are mainly used to lift water up from the rivers onto irrigated plots adjacent to the rivers. The cumulative effect of small pumps within the Hadejia-Nguru wetlands has contributed to reduced river flows and a drop in level of the groundwater table.

4. **Other human activities.** With an increasing human population and a more intensive economical interaction with towns like Kano and Maiduguri, an intensified utilization of natural resources (e.g., fuel wood, timber, fish) in the Hadejia-Nguru wetlands is observed. Signs of overutilization of these resources have been reported already (Abubakar 1990).

CONCLUSION

It is clear that the integrity of the Hadejia-Nguru wetlands ecosystem is under severe threat. The flooded area is diminishing year after year, hampering agricultural production and destroying the habitats of large numbers of birds. Fluctuations in bird populations provide useful insights into the ecological status of the wetlands. Birds seem to play a role as a biological early warning system of environmental changes which might be harmful to people.

The Hadejia-Nguru Wetlands Conservation Project seeks to promote the concepts of wise use of the wetlands. The project tries to achieve this aim by monitoring wildlife (especially birdlife) and biodiversity, by promoting the integrated management of water resources for the whole Komadugu Yobe Basin, securing the release of water from upstream dams, and by promoting appropriate technologies for a more efficient utilization of wetland resources.

This integrated strategy of the Hadejia-Nguru Wetlands Conservation Project is believed to be more effective in maintaining the ecological integrity of the wetland ecosystem than concentrating on conservation only.

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REFERENCES CITED

Abubakar, J. M. 1990. Fuelwood-fisheries activities in the Hadejia-Nguru wetlands. Unpubl. MS.

Adams, W. M. and T. Hollis. 1988. Hadejia-Nguru Wetlands Project. Hydrology and sustainable resources development of a Sahelian floodplain wetlands. Unpubl. MS.

Barbie, E., K. Kimmage, and W. M. Adams. 1991. Economic value of wetland benefits in the Hadejia-Jama'are floodplain. Unpubl. MS.

Benthem, W. 1988. Flood mapping and waterbird census in the Hadejia-Nguru wetlands, northern, Nigeria. Unpubl. MS.

Ezealor, A. and M. Garba Boyi. 1993. Annual water birds counts in the Hadejia-Nguru Wetlands. Unpubl. MS.

Garba Boyi, M. 1990. Annual water birds counts in the Hadejia-Nguru wetlands. Unpubl. MS.

Garba Boyi, M. 1991a. Annual water birds counts in the Hadejia-Nguru wetlands. Unpubl. MS.

Garba Boyi, M. 1991b. Breeding birds surveys in the Hadejia-Nguru wetlands. Unpubl. MS.

Garba Boyi, M. 1992. Annual water birds counts in the Hadejia-Nguru wetlands. Unpubl. MS.

Stowe, T. J. and N. Coulthard. 1990. The conservation of a Nigeria wetland: The Hadejia-Nguru Conservation Project. R.S.P.B. Conservation. Unpubl. MS.

Table 1. Waterbird species recorded in the Hadejia-Nguru Wetlands.

Pinkedbacked Pelican (*Pelecanus rufescens*)
Longtailed Shag (*Phalacrocra africanus*)
Little Bittern (*Ixobrchus minutus*)
Night Heron (*Nycticorax nyticorax*)
Grey Heron (*Ardea cinerea*)
Blackheaded Heron (*Ardea melanocephala*)
Purple Heron (*Ardea purpurea*)
Cattle Egret (*Ardeola ibis*)
Squacco Heron (*Ardeola ralloides*)
Great White Egret (*Egretta alba*)
Black Heron (*Egretta ardesiaca*)
Little Egret (*Egretta gazetta*)
Yellowbilled Egret (*Egretta intermedia*)
Openbill Stork (*Anastomus lamelligerus*)
Yellowbilled Stork (*Ibis ibis*)
Abdim's Stork (*Ciconia abdimii*)
White Stork (*Ciconia ciconia*)
Black Stork (*Ciconia nigra*)
Glossy Ibis (*Plegadis falcinellus*)
Sacred Ibis (*Threskiornis aethiopica*)
European Spoonbill (*Platelea leucorodia*)
Fulvous Tree-duck (*Dendrocygna bicolor*)
Whitefaced Tree-duck (*Dendrocygna viduata*)
Egyptian Goose (*Alopochen aegyptiaca*)
Pygmy Goose (*Nettapus auritus*)
Spurwinged Goose (*Plectropterus gambensis*)
Knobbilled Goose (*Sarkidiornis melanota*)
Pintail (*Anas acuta*)
Northern Shoveler (*Anas clypeata*)
European Teal (*Anas crecca*)
Hottentot Teal (*Anas hottentota*)
Eurasian Widgeon (*Anas penelope*)
Garganey (*Anas querquedula*)
Common Pochard (*Aythya ferina*)
Tufted Duck (*Aythya fuligula*)
Ferruginous Duck (*Aythya nyroca*)
Osprey (*Pandion haliaetus*)
Marsh Harrier (*Circus aeruginosus*)
Eurasian Crane (*Grus grus*)
Demoiselle Crane (*Anthropoides virgo*)
Moorhen (*Gallinula chloropus*)
Purple Gallinule *Porphyrio porphyrio*)
European Coot (*Fulica atra*)
Lily-trotter (*Actophilornis africana*)
Lesser Lily-trotter (*Microparra capensis*)
Painted Snipe (*Rostratula benghalensis*)
Blackwinged Stilt (*Himantopus himantopus*)
Avocet (*Recurvirostra avosetta*)
Pratincole (*Glareola pratincola*)
Kentish Plover (*Charadirius alexandrinus*)
Little Ringed Plover (*Charadirius dubius*)
Ringed Plover (*Charadirius hiaticula*)
Kittlitz's Sand Plover (*Charadirius pecuarius*)
Grey Plover (*Pluvalis squatarola*)
Spurwinged Plover (*Pluvalis spinosis*)
Blacktailed Godwit (*Limosa limosa*)
Curlew (*Numenius arquata*)
Spotted Redshank (*Tringa erythropus*)
Wood Sandpiper (*Tringa glareola*)
Greenshank (*Tringa nebularia*)
Green Sandpiper (*Tringa ochropus*)
Marsh Sandpiper (*Tringa stagnatilis*)
Redshank (*Tringa totanus*)
Common Snipe (*Gallinago gallinago*)
Little Stint (*Calidris minuta*)
Ruff (*Philomachus pugnax*)
Greyheaded Gull (*Gullarus cirrhocephalus*)
Lesser Blackbacked Gull(*Gullarus fuscus*)
Whiskered Tern (*Sterna hybrida*)

Table 2. Estimated number of breeding waterbirds at various sites in the Hadejia-Nguru wetlands, 1991.

Species	Tabawa	Arin	Dagona	Garmag	Gorgoram	Nguru	Karagi	Total
	Location							
Cattle Egret	2,982	506	0	908	483	0	700	5,575
Little Egret	152	52	0	70	10	0	18	332
Yellowbilled Egret	411	23	0	30	2	0	22	493
Great White Egret	102	7	0	15	3	0	10	137
Gray Heron	0	3	0	1	5	0	0	8
Squacco Heron	200	50	0	21	17	0	3	291
Purple Heron	0	5	0	0	2	0	0	7
Longtailed Shag	300	51	0	33	19	0	254	661
Sacred Ibis	5	0	0	0	0	0	0	5
Lily-trotter	0	0	0	0	0	58	0	58
Knobbilled Goose	0	0	1	5	0	0	0	6
Spurwinged Goose	0	0	3	1	0	0	0	4
Whitefaced Tree-duck	0	0	0	1	0	0	0	1
Total	4,182	702	4	1,080	543	58	1,007	7,583

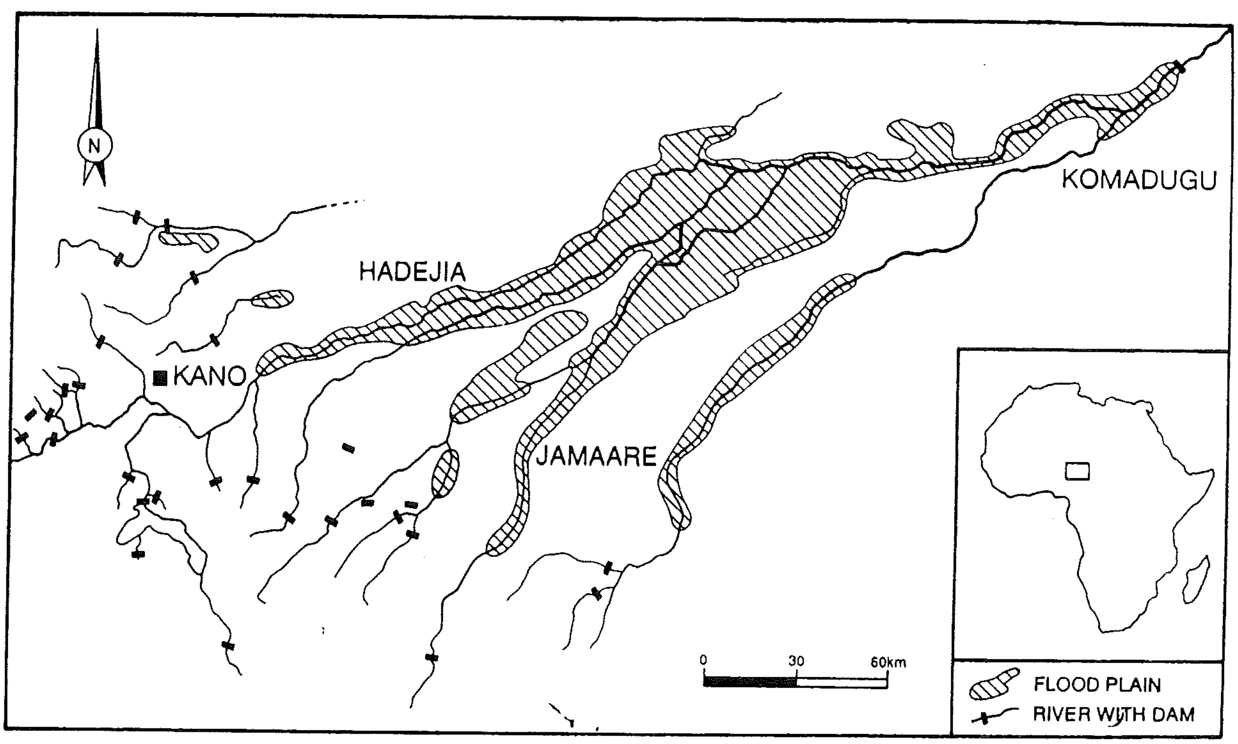

Figure 1. The Hadejia-Nguru Wetlands, Northern Nigeria.

Table 3. Estimated total population of waterfowl in the Hadejia-Nguru Wetlands, 1988-1993.

	Year					
Species	1988	1989	1990	1991	1992	1993
Fulvous Tree-duck	274	1,234	1,248	1,160	4,080	2,531
Whitefaced Tree-duck	1,608	3,279	6,329	6,498	5,019	10,154
Pygmy Goose	11	0	17	35	16	0
Egyptian Goose	0	3	0	0	0	0
Spurwinged Goose	143	1,682	1,039	2,177	1,448	2,244
Knobbilled Duck	225	2,784	1,763	678	1,330	923
Pintail	13,937	1,745	20,618	17,323	20,820	5,950
Northern Shoveler	700	324	79	175	5	0
European Teal	176	115	22	1	0	0
Hottentot Teal	4	0	5	1	0	0
Eurasian Widgeon	71	17	31	1	1	0
Garganey	9,235	8,538	22,458	11,812	12,395	35,550
Gadwall	7	0	5	0	2	0
Common Pochard	615	60	1	0	5	0
Tufted Duck	5	11	26	5	0	0
Ferruginous Duck	1,594	15	280	150	8	0
Unidentified duck spp.	160	0	3,777	0	0	0
Total	28,775	19,808	57,698	36,597	45,129	57,352
No. species	16	13	16	13	12	6

CONSERVATION STATUS OF CRANES IN NORTH CAMEROON AND WESTERN CHAD[1]

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STUDY AREA

The following account of the status of Black Crowned Cranes is concentrated on the part of the Lake Chad Basin covered by the territories of Cameroon and Chad. For information about the Lake Chad Basin area covered by Nigeria and Niger, the reader is referred to other contributions in this volume (Brouwer and Mullié *this proceedings*; Daddy and Ayeni *this proceedings*). This paper covers the area in Cameroon north of the 8th parallel, although the area has been intensively visited only north of the 10th parallel, especially from 1993 onwards. In Chad, regular observations have been made from 1990 to 1993 in the area delimited by the 200-800 mm average annual rainfall isohyets and west of the 19th parallel.

WETLANDS OF IMPORTANCE TO CRANES IN NORTH CAMEROON AND WESTERN CHAD

For general information on the wetlands of the Lake Chad Basin, see Hughes and Hughes 1992.

1. **Lake Chad** (all territories). The size of the lake and associated marshes fluctuate between 1.4 and 2.5 million hectares, with an open water area as low as a quarter million hectares during prolonged droughts (Hughes and Hughes 1992).

2. **Lake Fitri** (Chad). The average size of this lake is fifty thousand hectares, but occasionally it dries up completely, like for instance in 1985. Although often called "small Lake Chad", Lake Fitri has distinct characteristics such as having a high water table early in the rainy season and being far less influenced by large scale human interventions.

3. **Chari River floodplains** (Chad, to some degree also in Cameroon). Although draining a larger area, the Chari River floodplains are far less extensive than the Logone River floodplains. For reasons of convenience parts upstream are separated from parts downstream of N'djamena.

4. **Logone River floodplains** (Chad and Cameroon). Already well developed around Lai in Southern Chad), it reaches its most extensive part in the Yagoua-Logone Birni area (>10,000 km^2). The construction of a dam near Maga has caused major degradation of the downstream area. Efforts are presently carried out to redivert water into this floodplain (IUCN/CML 1994; Scholte *et al.* 1995b).

5. **Sahelian wetlands** (Chad). Most of these areas are associated with the Bahr el Ghazal. Also other wetlands situated in Chad outside the main drainage lines of the Logone and Chari (mainly north of the line N'djamena-Ati) are included.

STATUS OF CRANES IN NORTH CAMEROON AND WESTERN CHAD

Species accounts

Common Crane (Grus grus)

Status: Never mentioned for Cameroon and Chad, in contrast to neighboring countries such as Nigeria (Elgood *et al.* 1994), Niger (Brouwer and Mullié *this proceedings*), and Sudan (Urban *et al.* 1986). This is probably due to the low observation frequency in most of the wetlands in North Cameroon and Chad.

Demoiselle Crane (Anthropoides virgo)

Status: Very rare passing migrant during the period August to October. Wintering has not been confirmed by any recent observations. Urban *et al.* (1986) mentioned main wintering populations in northeast Nigeria and central and southern Chad ("several hundred in Bahr Salamat drainage"). According to Elgood *et al.* (1994), only 1 individual has been observed on the Nigerian side of Lake Chad since 1972! Our observation made in the Sahelian zone of Chad (Abou Idjlidj, northwest of Ati), on October 10, 1991 of 24 individuals seemed to be the only recent record of any importance. Descriptions by Newby (1979) and Salvan (1967) suggest that already by the 1960's and 1970's, this species was only sporadically observed. **Habitat:** Inland and riverine wetlands. **Abundance:** Fewer than 50. **Threats:** Decline most likely due to events in breeding area than in study area. **Needed information:** Confirmed observations.

[1]Addendum to the Proceedings. Paper submitted 24 October 1994.

Black Crowned Crane (Balearica pavonina pavonina)

Taxonomic note: No clear confirmation can be given on the subspecies *B.p.pavonina* at Lake Fitri, according to the description by Urban *et al.* (1986). **Status:** Breeding in wetlands all over the Lake Chad basin. Seasonal movements seem to be very limited and restricted to the rainy season. **Abundance**: At least 5,000. In the Waza Logone area, population estimated at more than 2,000. Lake Fitri at least 2,500, elsewhere in total several hundreds, but possibly more. **Threats:** Wetland degradation leading to a loss of suitable breeding habitat and a loss of dry season habitat, which is very much bound to perennial grasses such as *Echinochloa stagnina* and *E. pyramidalis*. Recent observations suggest disturbance by high densities of livestock (Scholte *in prep.*). Scattered reports of cranes being trapped for pets. **Needed information:** The huge wetlands of Lake Chad have not been surveyed sufficiently and may still harbor an important Black Crowned Crane population. The same hold true for various other Lake Chad Basin wetlands such as those in the Mayo Kebbi system, near Lai and along the upper Chari. More information is urgently needed about the precise habitat requirements of Black Crowned Cranes in order to take their conservation into account during the formulation of management plans of Waza National Park and its surroundings. Recent research shows a low breeding success (less than 25% of the population consisting of juveniles, three months after the end of the breeding season), even during good flooding conditions like in 1994 (Scholte *in prep.*)

REFERENCES CITED

Elgood, J. H., J. B. Heigham, A. M. Moore, A. M. Nason, R. E. Sharland, and N. J. Skinner. 1994. The Birds of Nigeria. British Ornithologists' Union, UK.

Hughes, R. H. and J. S. Hughes. 1992. A directory of African Wetlands. IUCN, Gland, Switzerland and Cambridge, UK / UNEP, Nairobi, Kenya / WCMC, Cambridge, UK.

IUCN/CML. 1994. Annual report 1994. Waza Logone project. Maroua, Cameroon.

Louette, M. 1981. The birds of Cameroon, an annotated Check-list. Verhandelingen van de Koninklijke Academie voor Wetenschappen, letteren en schone kunsten van België. Brussel, Belgium.

Newby, J. 1979. The birds of Ouadi Rime-Ouadi Achim Faunal Reserve. A contribution to the study of the Chadian Avifauna. Malimbus 1:90-109.

Perennou, C. 1991. Les recensements internationaux d'oiseaux d'eau en Afrique tropicale. IWRB Special Publication no. 15. IWRB, Slimbridge, UK.

Salvan, J. 1967. Contribution à l'étude des oiseaux du Tchad. L'oiseau et la Revue Française d'Ornithologie 37(4).

Scholte, P.T.R. Azombo, E. Battakok, S. de Kort, and M. van Weerd. 1995a. Waterfowl census Waza-Logone area, Far North Cameroon February 1995. Waza-Logone Project and Ecole de Faune Garoua. Maroua, Cameroon.

Scholte, P. T., E. Pamo, S. Kari, S. Kersten, and P. Kirda. 1995b. Floodplain rehabilitation in N. Cameroon: Expected impact on vegetation, pastoralists and wildlife. International Rangeland Congress, Salt Lake City, Utah, USA.

Urban, E. K., C. H. Fry and S. Keith. 1986. The Birds of Africa. Vol. 2. Academic Press, London, UK.

Wetten, J. v. and P. Spierenburg. 1993. Wader and Waterfowl in the Floodplains of the Logone. Ecole de Faune, WIWO. Haarlem, the Netherlands.

APPENDIX

Details of observations of Demoiselle Cranes in North Cameroon and Western Chad

Salvan (1967):

Lake Fitri: wintering in Lake Fitri and Lake Iro established by Malbrant, 1934.

Sahelian wetlands: observed by Gillet passing above the Ennedi Mountains (580827; "1963"). Six birds observed 70 km northwest of Abeché (630902).

Newby (1979):

Ouadi Rimé-Ouadi Achim: An erratic passage migrant. "Its presence as suggested by my records seems unrelated with the amount of suitable stop-over places".

Lhouette (1982):

Not yet recorded from Cameroon, "although once in Nigeria and once in Chad".

Scholte 1991:

Sahelian wetlands: At Abou Idjlidj (northwest of Ati), a group of 24 flying "looking" for water. Several waterholes partly filled in the direct surroundings (911010).

Details of observations of Black Crowned Cranes in North Cameroon and Western Chad

Lhouette (1982):

Logone floodplain: Common at Waza National Park and in the inundation area of the Logone and breeding in the rains.

Benoué plain: Recorded more sparsely than in Waza

Adamawa plateau: Recorded more sparsely than in Waza.

Newby (1979):

Widespread but common in the Ouadi Rimé - Ouadi Achim reserve. Arriving in July, they breed as far north as Ouadi Achim. Nests are usually built in tall Acacia and similar trees within the dense wadi habitat. Towards the end of the wet season this species may move on and concentrate around the larger waters before moving southward.

Salvan (1967):

Indicated as a common species all over Central and Southern Chad, and not uncommon in the dry season in the woody vegetation bordering the dry rivers in the Saharo-Sahelian regions. Egg laying period observed as being from the end of August till early September.

Sahelian wetlands: Observed by Gillet on the Basso plateau (Ennedi) (580909). One juvenile, not being able to fly yet, observed near Matadjena mare (631016).

Scholte (1991-95):

Lake Chad

A few near the lake shore (911201).

Lake Fitri

Lake Fitri: At least 1,500 in groups of 10-150 birds. Total could well have reached 2,500. Birds were flying over Yao direction east (910218).

Alifa - Gala (Lake Fitri): 2 flocks of 100 (910430).

Regularly seen between Am djamena Bilala and Yao (910513/18). Several hundreds Fitri amongst others: 55 bourgoutières just west of Yao (920314).

Fitri near Yao: 2 also several ones heard. Note, no massive presence like earlier despite several days of observations (930101).

Chari Floodplain

Upstream of N'djamena-

Just north of Bousso 1 flock of 50 and 1 flock of 10 (910423).

Downstream of N'djamena-

Dougia: a few in pond (911215).

Kalamaloué NP: 2 in "bras mort" (920216); 6 flying east 920223, several groups 2-15 in Chari and especially north of the lodge 920510; 2 in Chari (920517); 2 at the end of the "bras mort", 2 bras mort (920524); 1 heard (921114); continuously 2 (930404); 50 in Mimonsa strang (930411); 73 at Chari (930417); 84 (930418); 7 (950227).

Near Miskine (Chari): 60 (940604).

Near Seiba: 60 (940606).

North of Fadje (Chari): 62 (940607).

Chari Seiba: 7 (950227).

Logone Floodplain/Waza Logone area

Waza National Park: each morning hundreds flying east (920113&14); very early morning many flying east over Waza (920418/20); in total 100, several heard at night(930114/17); 590 (930116/25); 69+112 at Bodeleram, 8+10 near Bodeleram, 2 at Saouwara, 2 at Talabal, 20 near Talabal (940101); 6 at Tchikam (waterhole), 1 at Magala (940421); 11 at Dourbatassa (waterhole), 4 at Zeila (waterhole), 5 at Anané (waterhole) (940424); Mahé artificial waterhole, drinking (940506); 7 at Vo artificial waterhole (940507); 30 behind lodge Waza (941018); 447 (950212&13); 164 (950213); 25 at Bodeleram, 5 at Tchikam (950225); 508 near Waza lodge, 252 flying to forest zone (950309); 519 arriving in marsh area behind Waza lodge with one third of birds involved in social interaction and intensive foraging behavior (950310); 15 at Bodeleram, 4 at Goumbouremerum, 4 at Talabal, 3 at Mandarou, 2 at Mbouyet (950310); 15 at Bodeleram, 26 at Mahé, 15 remaining in the trees around Mahé (950322); 188 (950321); 788, with greater than 95% flying in from the west (950322); 200 at Bodeleram (950420); 8 at Kalya (950421); 18 at Waza Camp (950422); 107 in many small groups, 74 at Bodeleram, 53 at Kingeroua, 150 at Dourbatassa (950423); 60 at Mindei (950503); 145 at Mindei, 6 (3 pr) at Talabal, 2 at Gamzamia (950504); 150 at Bodeleram (950520); 10 near Tchikam (959521); 150 at Bodeleram (950526); all cranes dispersed in the area Bodeleram-Dourbatassa, especially concentrated around the numerous small ponds (950601&2); 150 at Mindei (the same concentration of the last few months), elsewhere the cranes already well dispersed in pairs or in groups of 3-6, in the Bodelaram- Dourbatassa area, the cranes are well dispersed (95065/6).

Waza-Maltam Road: 100 located 5 km north of Waza (930808); 80 located 3 km south of Maltam (930808).

Tekele: 7+15+5 (930116/25); 95 (930116/25); 50 at Tekele-Zina (930513/19); 72 at Zina-Douloum (940515); 90 at Zina- Nkodeni (940516); 60 at Sarassara-Zina (931209); 6 located 16 km south of Zina, 4 located 8 km south of Zina, 300 flying (940513); a few at Zina-Tchikam (940616/20).

Maga: 7 (930116/25); 21 (950203&5); 5 (950528).

Zilim: 361 (930116/25).

Piste central: 70 (930513/19).

Logone: 1 (930116/25); 3 (950204&7); 15 near Pouss (940416).

Doing: group of 45 (931029/31); 50 (940415); 2 (2940906).

Andirni: 20 flying north (940612).

Zama: 1 (941010).

Logomatya: 2 (9410101); 1 (941118); 20 (950227); 2+11+12 near Sarassara (941010); 2 at Goromo I (940906).

Mares: 41 (950205/7).
Holom: 5 (950214).
Ivye: 22 (950224).
Daguin: 28 (950226).
Badgassi: 270 (950215).

Sahelian wetlands (Chad)

South of Ngoura: several groups (910523).
between Moussoro and Am djamena bilala: (4910827).
near Efete (15 km north of Moussoro): (2910827).
Abou Hidjlidj: 8 (911011).

Other wetlands (Cameroon)

Lagdo: several (920405).
2 above Faro (near Tchamba): the only observation in the savanna parks south of Garoua, despite several weeks of observations during the period October till May (940408).

Perennou (1991):
Black Crowned Cranes observed during waterfowl counts.

Location	1984	1986	1987
Lake Fitri	300	20	51
Logone flood plain	5	681	774
Lake Maga	0	312	555
Maga Logone upstream	6	-	717
depression de Toubouri	192	122	8
Cuvette de M'bourao	0	0	520
Lac Tikem	105	2	12
Total	608	1,137	2,637

AN OVERVIEW OF THE STATUS OF BLACK CROWNED CRANES IN SUDAN[1]

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INTRODUCTION

Sudan is the largest country in Africa with an area of 2,599,000 km². It has a population of 26,530,000 (1991 census). Sudan's great diversity of habitats and ecological zones is reflected in its abundant fauna: 224 species and subspecies of mammals in 91 genera are found within the borders of Sudan (Zester 1956 *in* Hassaballa and Nimir 1985) as are 938 bird species (Niklaus 1986).

Several remarkable areas in Sudan have exceptional ornithological significance. The Nile Sudd in the southern part of the country (approximately 1,650,000 ha.) is the largest floodplain in Africa, and is a major wetland habitat for hundreds of species of birds, especially large populations of waterbirds and the spectacular African endemic Shoebill. The White and Blue Nile confluence is a major route for Palearctic migrants which winter or pass through the Sudan. More than 700 miles of coastal Sudan territory borders the Red Sea, and supports unique habitat for mangrove and coral reefs. Other important waterbird sites include Lake Nubia (10,000 ha.), Lake Abyed (1,000 ha.), Lake Keilack (300 ha.), Lake Kundi (1,020 ha.), and the Sennar, ElRoserries, and Gabal Aulia dams. Sudan is currently preparing to join the Ramsar Convention to identify some of these areas as wetlands of international importance.

DISTRIBUTION

The East African subspecies of the Black Crowned Crane (*Balearica pavonina ceciliae*) occurring in Sudan differs from the West African subspecies (*B. p. pavonina*) by having an extensive red area behind its eyes. The cranes are distributed over a large area, especially south of latitude 12° N. The major localities where large numbers of cranes can be seen include Lake Kundi and Randam N. Park in Darfur (western Sudan), Lake Abyed and Keilack in Southern Kordofan (central Sudan), and Dinder N. Park in eastern Sudan near the Ethiopian border (although reports indicate the population is declining in this area). Major concentrations of cranes can be seen in the southern part of the country, particularly in the upper Nile State where thousands flock along the Nile when they are moving from their feeding and roosting grounds.

ECOLOGY

There is a general lack of ornithological research in Sudan, and therefore no reliable scientific information on the ecology of Black Crowned Cranes in Sudan is available. During our field studies, the cranes were observed eating various types of insects and vegetation and digging in the soft ground searching for food in wet meadows. Our observation also indicated that the Black Crowned Crane extends its range northward in the rainy season, to small semi-flooded pools hidden beneath acacias.

In January 1993, we censused Black Crowned Cranes and other waterbirds at Lake Kundi, a typical African wetland (1,020 ha.) dominated by *Balanalies aegyptiaca* and *Acacia seyal* palm species in the surrounding fringe, *Cyndon dactylon* grass on the exposed lake soils, and papyrus in the flooded areas. We used a four-wheel drive Toyota to slowly circle the edge of the lake. The survey was conducted at mid-day, and took two hours.

A total of 5,000 Black Crowned Cranes were recorded in Lake Kundi. The area surrounding the lake in a 40 km radius supports about 2,000-3,000 additional cranes. Other important avifauna of the lake include Knobbilled Goose, Spurwinged Goose, African Pochard, Whitefaced Tree-duck, White and Pinkbacked Pelican, African Jacana, Blackwinged Stilt, and many other species.

The area is inhabited by the Habania tribe, who depend on the lake water for their thousands of cattle. Fishing and agriculture (in the rainy season) are relatively minor activities. Further studies in crane movement, nesting success, natural enemies, and wetland usage are needed.

PROTECTION

The Black Crowned Crane is protected under Schedule II of the Wildlife Protection Act of 1986. It cannot be hunted or captured without a license. In addition to this legal protection, people in Sudan normally do not hunt Crowned Cranes, nor do they consider them to be eatable birds. Although no direct threats to the birds are known, major threats to their wetland habitats include expansion of agricultural schemes and overgrazing of livestock around some of the important lakes. In the Sudd, the effects of the future Jungali canal developmental project must be considered.

[1]Addendum to the Proceedings. Paper presented at the Conference on the Black Crowned Crane and its Wetland Habitats in West and Central Africa, Kano State, Nigeria, 25 February 1992.

CONCLUSION AND RECOMMENDATIONS

Based on our field observations, the Black Crowned Crane status in Sudan can be described as common to very common in the areas where they occur. Further studies about the different ecological aspects of Black Crowned Cranes and their wetland habitats is needed, however, to assure their future conservation. To this end, promotion of inter-African cooperation in research, information exchange, and wetland protection is essential.

ACKNOWLEDGMENTS

On behalf of myself, the wildlife administration, and the government of Sudan, I would like to express my deep appreciation and gratitude to Nigeria Conservation Foundation and to the planning committee for organizing this historic conference on Black Crowned Cranes.

REFERENCES CITED

Hassaballa El Rigk Omer and Nimir B. M. 1985. Towards a national conservation policy. Pages 11-13 *in* Proceedings of the Seminar on Wildlife Conservation and Management in Sudan. March 16-21, 1985, Khartoum, Sudan.

Nikolaus, G. 1986. Distribution atlas of Sudan birds with noted habitat and status. Harcourt Brace Jovanorish Publishers, Inc., New York, USA.

Urban, E. K., C. H. Fry and S. Keith. 1986. The birds of Africa. Vol. 2. Academic Press, London, UK. 552 pp.

THE WETLANDS OF SOUTHERN SUDAN

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ABSTRACT

South Sudan, with an area of 624,454 km² and approximately 5 million people, has some of the most important and extensive wetlands in Africa. These are highly productive ecosystems and homes to a variety of abundant, important, and rare flora and fauna. The wetlands in southern Sudan include permanent and seasonal swamps, floodplains, natural lakes, temporal ponds, and artificial impoundments. The permanent and seasonal swamps are interspersed with natural lakes to form the center of the wetland system in southern Sudan. The floodplains are next to the permanent and seasonal swamps and rivers. The ponds occur throughout southern Sudan particularly during the rainy season. The artificial impoundments are recent creations. Of the 43,631 km² of wetlands in southern Sudan, only 23% are protected. Before the onset of the current civil war, the center of the wetland system--the permanent swamps known as the Sudd--had come under threat from several supposedly developmental programs such as the Jonglei Canal Project. This canal was to drain the swamps, thus triggering a series of environmental catastrophes of untold magnitude to the fauna, the flora, and the inhabitants of the area and those far afield. Most of the inhabitants of the wetlands system in southern Sudan are pastoralists. They practice traditional livestock husbandry throughout the year and fishing as well as hunting in dry season. Some agricultural production takes place on alluvial soils found on the banks of the rivers.

INTRODUCTION

Southern Sudan is the southern part of the Republic of Sudan which includes the states of Bahr El Ghazal, Upper Nile, and Equatoria. It has an area of 626,454 km² and a population of more than 5 million people, i.e., about 8 people/km², as determined by the census of 1983 (Figure 1).

The land comprises vast flat interior plains, and elevated plateaus in the east (Ethiopia highland) and in the west (Nile/Zaire watershed) which fall towards the Nile Valley, which passes through southern Sudan. The south has three major catchment areas: the East African highlands, the Ethiopia highlands, and the Nile/Zaire plateau. The three all drain into the White Nile (Figure 2).

More than 7% (43,631 km²) of the south may be classified as wetlands. This includes permanent and seasonal swamps, floodplains, temporal ponds, lakes and artificial impoundments. Of the total wetland area, only 23% is protected of which 12% is in the south of the country (84,795 km²). The wetlands in southern Sudan, like any other "undisturbed" wetlands, are highly productive ecosystems. They provide important wildlife habitat, store water and reduce floods, protect human life and property, and to some extent are important recreation areas (Figures 3 and 4). Day and King (1987) define wetlands as places where water accumulates seasonally, temporarily or permanently. Hughes and Hughes (1992) say that wetlands can be natural or man made.

If we follow above definition and classification, then one would say that in the south there are at least five types of wetlands: the permanent represented by the Sudd (the Arabic word for barrier) and Ambadi Lake, permanent and seasonal represented by Lotagipi, seasonal represented by floodplains, temporary represented by the ponds and the artificial impoundments represented by the Aweil rice scheme (Tables 1 and 2).

The permanent swamps intersperse with lakes from the center of the wetland system in the south, while the floodplains are found next to the permanent swamps and rivers. The ponds on the other hand occur throughout the southern part of the country, especially during the rainy season (Southern Sudan Investigation Team 1955). The artificial impoundments at Aweil and other locations are a recent creation.

Most of the inhabitants in and around the wetlands are pastoralists who rear livestock. In the rainy season, they practice small scale cultivation around the settlements. In the dry season, apart from cattle herding, most of the activity is restricted to fishing and hunting of game that has come to share with livestock the resources (grass and water) in the floodplains and swamps.

In the south most of the land is owned communally. In this system a village community, usually an ethnic or sub-ethnic group, owns the land. Individual clans or family members may own a piece of land, a water hole, etc., but common resources such as water, fishing areas, and hunting and grazing grounds are utilized by all. Excursions into adjacent tribal or ethnic lands sometimes end up in violence, resulting in cattle raids, forcible occupation, and so on. Most of the inhabitants in and around the wetlands are conservative pastoralists, and deeply resistant to change (Howell *et al.* 1988).

TYPES AND DISTRIBUTION OF THE WETLANDS OF SOUTHERN SUDAN

Wetlands

The Sudd and other permanent swamps

The Sudd is the largest wetland system in the south, covering 38% of the total wetland area in southern Sudan, and only 47% (7,825 km²) is protected. The swamps of the Sudd begin below Mongalla, 75 km south downstream from Juba, and end some few km south of Malakal. At the upper reaches of the Sudd, the banks are clearly defined; further south, they become lower and finally disappear below Bor. Here the swamps widen, with numerous lakes, lagoons, channels, parallel and subsidiary streams, and fringing rivers, all beset with islands of floating vegetation.

The permanent wetlands, including lakes and open river surface, covers approximately 1.65 million ha, to which can be added at least 1.5 million ha. of seasonally inundated floodplain (Mefit-Babtie 1983). The vegetation of the permanent swamps includes 250 km² of *Vossia cuspidata*. This occurs mostly in the southern part of the Sudd close to water. The vegetation here is a floating type and is in association with *Eichhornia crassipes*. A 3,900 km² floating mat of *Cyperus papyrus* occurs in most of the swamp, in association with climbers like *Coccinia grandis*, *Cayratia ibuenis*, *Luffa cylindrica*, *Zehreria minutiflora*, and *Vigna luteola*, and the fern *Cyclosorus interruptus*. Another 13,600 km² of *Typha domingensis*, occur in the central and north of the Sudd, and away from main river channels. This vegetation is rooted. The associated plants include *Lemna aequinoctialis*, and *Spirodela polyrrhiza*. The wetter areas have water hyacinth and duck weeds (Howell *et al.* 1988).

Permanent swamps outside the Sudd cover about 3 million ha. The vegetation is similar to that of the Sudd which is away from main river channels.

Fauna

The Sudd and other permanent swamps are important habitat for invertebrate zooplankton (abundant and high species diversity), but the zoobenthos comprise mainly Oligochaetes. About 100 species of fish have been recorded from the Sudd: 31 siluroids, 16 characoids, 14 cyprinoids, 11 mormyrids, 8 cichlids, and 7 cyprinodontids. Many species leave the rivers and move onto floodplains to spawn as the flood rises, and return to the permanent water courses when the flood recedes (Howell *et al.* 1988; Hughes and Hughes 1992). The most numerous species are: *Alestes dentex, Auchenoglanis biscutatus, Chelaethiops bibie, Citharinus citharinus, Distichodus rostratus, Eutropis niloticus, Heterotis niloticus, Hydrocynus forskalli, Labeo niloticus, Lates niloticus, Micralestes ocutidens, Mormyruns cashive, Oreochromis niloticus, Synodontis frontosus, Aplocheilichthys* spp., *Epiplatys* spp., *Gymnarchus niloticus*, and *Polyoterus bichir* which are associated with the Papyrus and Typha swamps.

Frogs are abundant and there are several snakes species in the swamps; *Crocodylus niloticus* is also widespread. The Sudd is important for migratory birds and has a high diversity of avifauna such as *Anas acuta, A. clypeata, A. crecca, A. penelope, A. querquedula, Anthus cervinus, Circus macrourus, C. pygargus, Glareola nordmanni, Larus fuscus, Limosa limosa, Philomachus pugnax, Tringa glareola, T. nebularia, T. ochropus*, and *T. stagnatilis*. Numerous weavers, warblers, flycatchers (including *Alseonax aquatica*), kingfishers, ducks, herons, ibises, egrets, storks (including *Balaeniceps rex*), kites, crows, and vultures (such as *Necrosyrtes monachus*) are also present. Large mammals found in this type of wetland include *Alcelaphus buselaphus, Damaliscus korrigum, D. lunatus, Hippopotamus amphibius, Hippotragus equinus, Kobus ellipsiprymnus, K. megaceros, Loxodonta africana, Panthera pardus, Redunca redunca*, and *Syncerus caffer*.

Protection and Conservation Status

Although the Sudd is one the most important wetland areas in Africa, only three areas have been designated as game reserves: Zeraf/Fanyikyang, a traditional hunting reserve for the Nile lechwe, 675,000 ha.; Shambe, 100,000 ha. for the preservation and protection of the endangered northern race of the white rhino (*Ceratotherium simum cottoni*); and part of Mongalla (7,500 ha.) on the east bank. This is insignificant or inadequate. The Sudd is quite important for its high species diversity and is a migratory staging center for many Palaearctic birds.

Lakes

The lakes in the south are divided into three size categories, small, medium and large. The large lakes have considerable surface area and are close to and connected with the main channels. The exchange of water between these lakes and the rivers is significant in relation to volumes of the lakes. They have extended retention times and less fringing vegetation; consequently they have a large portion of old water of good quality. Among the large lakes are Shambe, Fajarial, Nuong, and No.

Medium size lakes form chains parallel to river channels. They have a high degree of exchange with a river system and with each other. They have short retention times and therefore young and turbid water at peak river flow; as such the water quality is moderate. These lakes are common in the southern half of the Sudd. They are represented by the Wutching, Dhiam-Dhiam, Jonglei, Pagak, and Kobek series.

"Black water" small lakes are isolated lakes, with no connections to flowing river channels or other water bodies. The lakes are enclosed in the swamp vegetation. The quality of water is poor.

The vegetation of the lakes varies with the type of water in the lake. Lakes with flowing water are unsuitable for submerged macrophytes except for *Caratophyllum demersum*, marginal vegetation in association with *Eichhornia crassipes* (water hyacinth), *Commelina diffusa*, *Cayratia ibuensis*, and *Lemna aequinoctialis* (duck weed).

Eichhornia crassipes is the primary vegetation in most stable lakes, with *Vossia cuspidata*, itself encircled and colonized by *Cyperus papyrus*, at the edges. The primary vegetation of clear lakes is *Ceratophyllum demersum*, with two *Otellia* spp. The open water with firm substrates is vegetated by *Najas pectinata, Vallisneria aethiopia*, and *Ceratophyllum demersum.* Sheltered sites of the lakes with soft organic muds have *Nymphaea lotus, Trapa natans, Otellia* spp., *Potamogeton* spp., *Najas pectinata*, and *Ceratophyllum demersum.* Small lakes have no plants due to low oxygen content in the water. There is, however, considerable similarity of fauna between the lakes and Sudd swamps.

Of all the natural lakes covering about 60,000 ha., only approximately 25,000 ha. are under some form of legal protection.

Seasonal wetlands

The seasonal wetlands surround the banks of rivers, permanent swamps, and natural lakes. The extent of the area covered by this type of wetland in southern Sudan is not known, but it is believed to be greater than that of the Sudd as it includes areas surrounding the Sudd, permanent swamps, minor wetlands, and floodplains of the southern rivers and natural lakes.

These seasonal wetlands are useful as dry season grazing areas as well as fishing and hunting grounds. The water level in these areas fluctuates and performs a number of useful functions including providing breeding shelter for young fish and bringing new food into the aquatic system. The floods occur during the summer rains when there is abundant food available in the form of plants and invertebrates. In drought years, the conditions are less suitable for fish breeding and growth.

The cycle of events starts with a pre-flood: upstream migration of fast-swimming fish species and slow movement away from the floodplains into higher land by mammmals (game). This is followed by flooding of previously dry land next to the river channel, which brings a nutrient pulse resulting from the incorporation of detritus and decaying plant and animal matter into the water, encouraging the movement of fishes from the river channel onto floodplains. This enhances the breeding, feeding, and growth of larval and juvenile fish. At the same time this completes the movement of the game animals out of the floodplain onto the high land.

The final cycle ends when the receding of the flood brings high mortalities through predation of fish concentrated in shallow waters. The remaining fish move back into the river channel and finally disperse in the rivers. Fish like *Clarias gariepinus* prey on other fish species and can forage on land at night; in this way it survives longer in the floodplains.

The most important characteristic of a wetland flood is that it restores the system by bringing in new food and a different set of conditions. In pristine wetlands change is a constant. Fish stocks have proved to be resilient in response to naturally occurring changes and can withstand heavy fishing pressure by man as long as the flood regimes are not severely disrupted.

In the south, the size of the floodplains fluctuates greatly, being extensive in wet seasons and years, and shrinking in the dry seasons and drought years. In severe cases, the floodplains dry altogether.

The vegetation of the floodplain varies with the location of the floodplain. Those close to the large swamps have two vegetation zones: *Oryza longistamitata*, a perennial, rhizomadous grass interspersed with *Cyperus albomarginatus* (sedge). The low grounds are occupied by *Melochria corchorifolia* and the high spots are vegetated by *Sporobolus pyramidalis* and *Hyparrhenia rufa.* The second zone, further from the river, floods less frequently than the *Oryza* grasslands. This area is covered by *Echinochloa pyramidalis*, interspersed with the following plant species: *Oryza longislaminata, Sporobolus pyramidalis, Digitaria debilis, Echinochloa haploclada* as well as legumes like *Desmodium hirtum* and *Cassia minosoides.*

With the exception of the very aquatic animals like the hippopotamus and other vertebrates, zooplankton and zoobenthos, most of the fauna occurring in the Sudd swamps also occurs in the floodplains. Although the floodplains cover a considerable area, only 6% are protected for conservation.

Ponds

Ponds are found in shallow depressions filled by rain and runoff. They occur throughout the south. Their extent is not known, but is believed to be enormous. The ponds are important concentration areas for waterfowl during the rainy season. In the dry season, they attract both game and livestock and as such are important grazing and hunting areas.

Artificial impoundments

Artificial impoundments are found in areas of large agricultural schemes and behind dikes in flood-prone areas. At Aweil rice scheme, large artificial impoundments are used to irrigate the rice fields during dry season or whenever there is a long dry spell. The other artificial impoundments, for protection against floods, occur in the Upper Nile region, mainly in the Jonglei Province in Kongor District. The size of these impoundments is not known. The artificial impoundments, like the temporary floodplains, are important centers for waterfowl, livestock, and game.

DISTRIBUTION AND STATUS OF CRANES

Distribution

Three species of cranes are known to occur in southern Sudan; the Demoiselle Crane (*Anthropoides virgo*), Black Crowned Crane (*Balearica pavonina*), and Grey Crowned Crane (*Baleatica regulorum*).

The Demoiselle Crane, a Palaearctic migrant, has not been recorded recently in southern Sudan, but small parties have been reported overwintering (October to March) as far south as the Sobat river. They inhabit dry acacia grassland and river margins (Nikolaus 1982) (Figure 5).

The Black Crowned Crane is both a local migrant and a resident bird, throughout the south except along the Zaire border, which is forested, and in the extreme southeast, which is semi-arid. The species inhabits the drier margins of rivers and cultivated areas where they often occur in large flocks. The nesting period is from August to October; which is also the period when the birds are resident. Most of the nesting take place in marshy areas of the Sudd and River Lol (Figure 4).

The Grey Crowned Crane occurs as a visitor from Uganda along the southern border. The species breeds in Uganda as well as the rest of East Africa.

CONSERVATION STATUS

From Figures 4 and 5, it is clear that most cranes occur outside the protected areas; this means that their future appears uncertain and vulnerable. The most immediate threats to the survival of the cranes as well as to other rare wildlife (e.g., the Shoebill and the Nile lechwe) include the construction of the Jonglei canal which was built partly to drain the swamps of the Sudd (Figure 6), plans for oil exploration, which would remove the papyrus, a cycle of low flows from the Upper Nile which are likely to shrink the swamps as well as the effects of war.

The Jonglei Canal, the largest in Africa (360 km long, 5.2 m deep, and 100 m wide), would bring the most significant change to waterflow in the Nile Basin since the Aswan Dam. It would divert 10 to 35% of the water flowing into the Sudd daily, i.e., 20-30 million m^3 per day. This reduction of waterflow to the Sudd would definitely reduce the breeding habitat of cranes, other waterfowl, and rare antelopes such as Nile lechwe and sitatunga. Even the fishery potential would be reduced considerably.

The reduction of flood pulse, would reduce the size of the river-fed grasslands (breeding grounds for most of the waterfowl, including the cranes) and therefore the ability the wetlands to support most of the wildlife, cattle and humans of the area.

Oil exploration opened previously-inaccessible areas (sanctuaries for the birds), by clear-cut lines that run through the swamps.

Although the Sudanese war is more about oil, religion, and political autonomy than the Jonglei Canal, all work on the canal, water management, conservation, and wildlife-related tourism have come to a standstill. The nature preserves go unguarded, conservation and management plans cannot be implemented, and the conservation societies as well as many aid groups have pulled out. War can and has hindered the best conservation. One year of guerrilla warfare has "crippled" painstaking efforts to save the Giant Grebe of Lake Atitlon, and since the Soviet Union invasion of Afghanistan, the Siberian Crane, Bactrian deer, and Marco Polo sheep have all suffered from the loss of protection.

When Idi Amin began his rule in Uganda, the national parks were devastated. Amin's army, the rebels, and then the Tanzanian army saw wildlife as free meat and ivory to supplement their wages. The result was the end, in only two years, of 30 years' efforts and conservation programs.

Although the current civil war has halted the Jonglei Canal program, it has also ended many years of plans and planning for establishment and implementation of conservation work in the Sudd area, especially in Zambe, Zeraf, and Fanyikak.

RECOMMENDATIONS

If and when the current civil war permits, several things should be done.

1. A national and state wetlands policy should be established.

2. The wise use concept should be adopted in regard to the drainage of the Sudd, in accordance with the Ramsar convention.

3. A comprehensive inventory of wetlands and their status should be undertaken (this should be done with collaborative effort of national universities, the National Council for Research, and international organizations concerned with the conservation of wetlands).

4. An environmental impact assessment should be done for any proposed construction, or development programs involving a wetland, before the implementation of such a program.

5. A program to train competent personnel for wetlands management should be implemented.

6. Adequate funding and staffing of the conservation areas in wetland ecosystems should be established and maintained.

CONCLUSION

The wetlands in southern Sudan cover 43,631 km², of which only 10,035 km² are under some form of protection. The Gruidae family in southern Sudan is represented by *Balearica pavonina* (a common resident), *B. regulorum* (a visitor from Uganda), and *Anthropoides virgo* (a wintering migrant from central Europe and western Asia).

The threats to the wetlands in southern Sudan, include the Jonglei Canal, oil exploration, a cycle of low flows from the Upper Nile and environmental damage associated with war. If the wetlands of southern Sudan are to survive, there is need for a comprehensive national and state policy to govern their utilization and conservation.

ACKNOWLEDGMENTS

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REFERENCES CITED

Day, J. and J. King. 1987. Why wetlands matter. African Wildlife 41(5): 218.

Hillman, J. C. 1982. Wildlife information booklet. Department of Wildlife Management, Ministry of Wildlife Conservation and Tourism. Juba, Sudan.

Howell, P., M. Lock, and S. Cobb, eds. 1988. The Jonglei Canal: impact and opportunity. Cambridge University, Cambridge, UK.

Hughes, R. H. and J. S. Hughes. 1992. A Directory of African Wetlands. IUCN, Gland, Switzerland and Cambridge, UK / UNEP, Nairobi, Kenya / WCMC, Cambridge, UK.

Ipoto, L. O. 1982. Why do some animals in the Jonglei Canal area migrate and others do not? B.S. Thesis. University of Juba, Sudan.

Mefit-Babtie, M. R. 1983. Technical assistance contract for range ecology, livestock investigation, and water supply: final Report. Glasgow, UK/Rome, Italy/Khartoum, Sudan.

Ministry of Wildlife and Tourism. 1977. Wildlife resources in southern Sudan: a monthly review of events in the southern regions. Regional Ministry of Culture and Information, Juba, Sudan.

Nikolaus, G., 1982. Birds of south Sudan. Scopus, Special Supplement Number 3: 24.

Southern Development Investigation Team (SDIT). 1955. Natural resources and development potential in the southern provinces of Sudan: a preliminary report. Government of Sudan, Khartoum and London, UK.

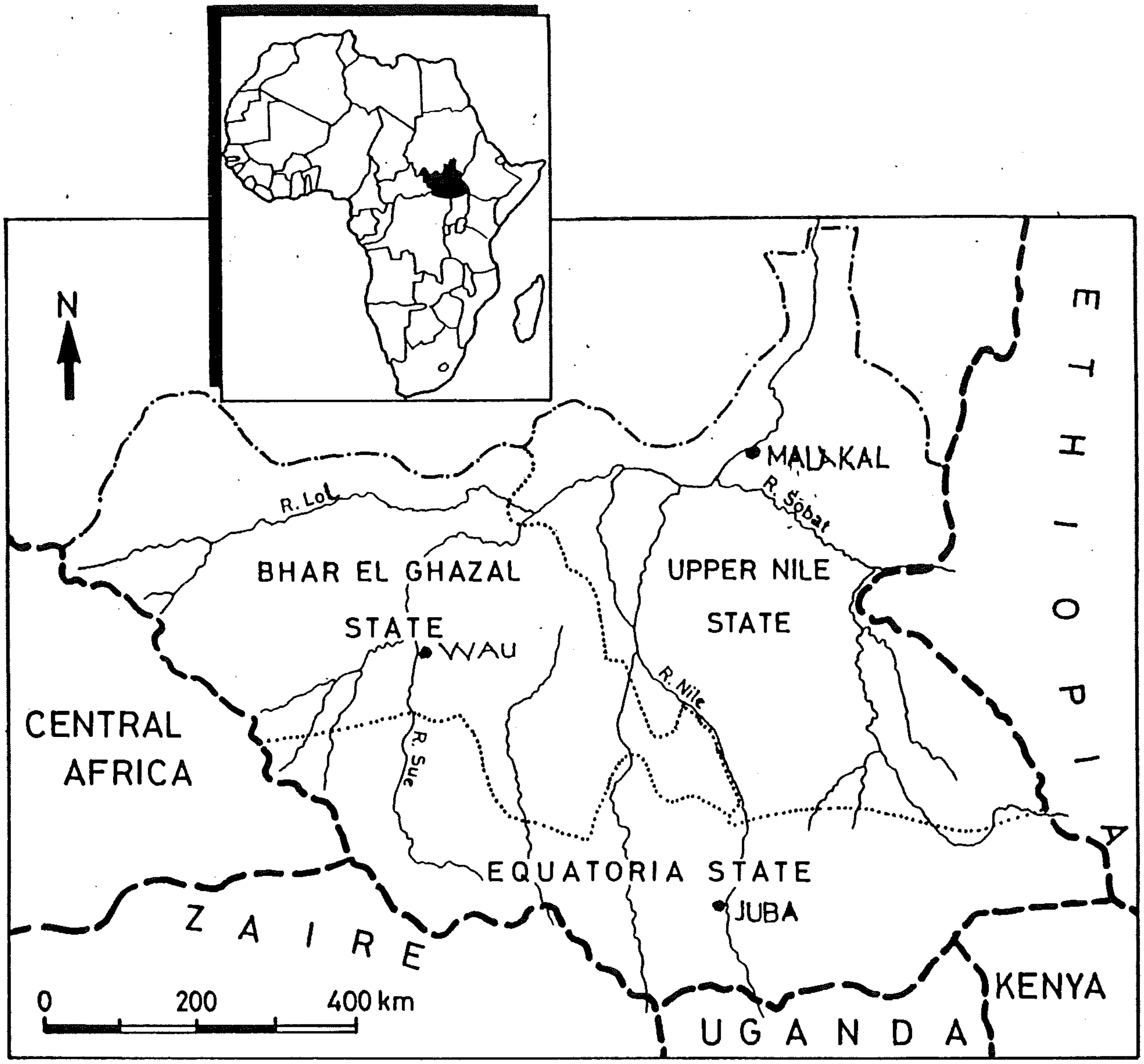


Figure 1. Map of southern Sudan.

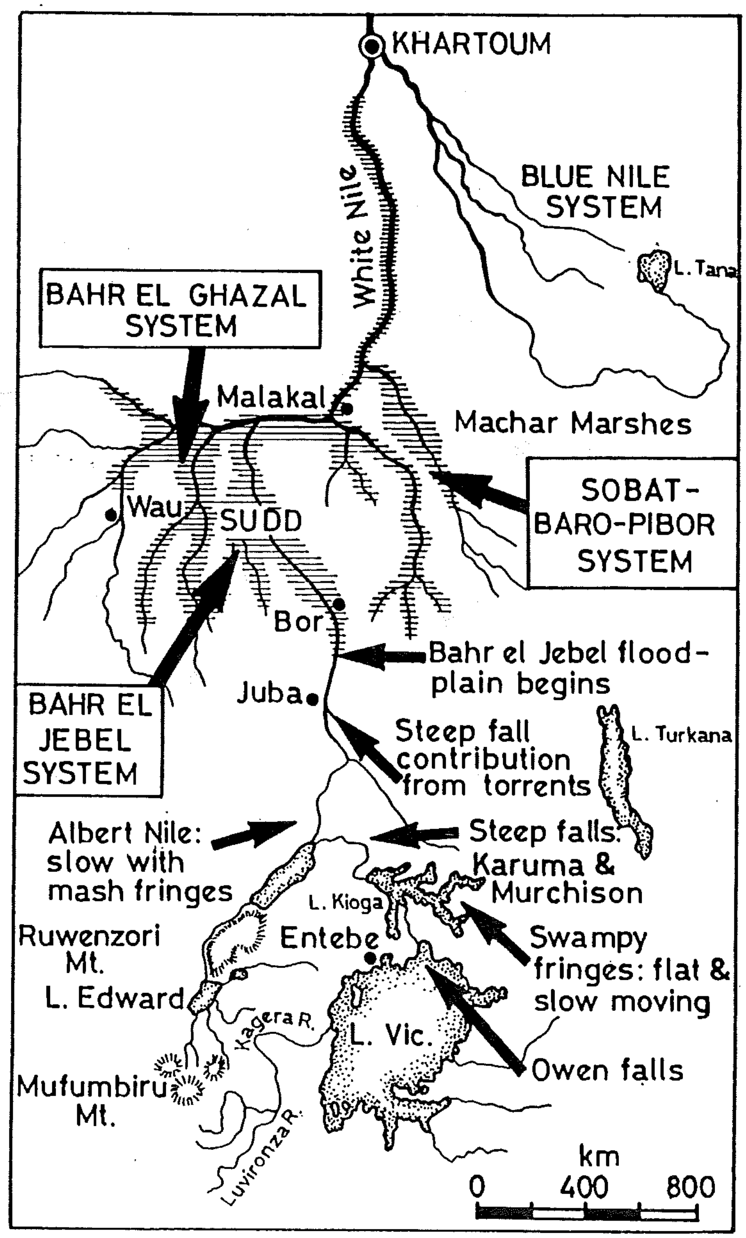
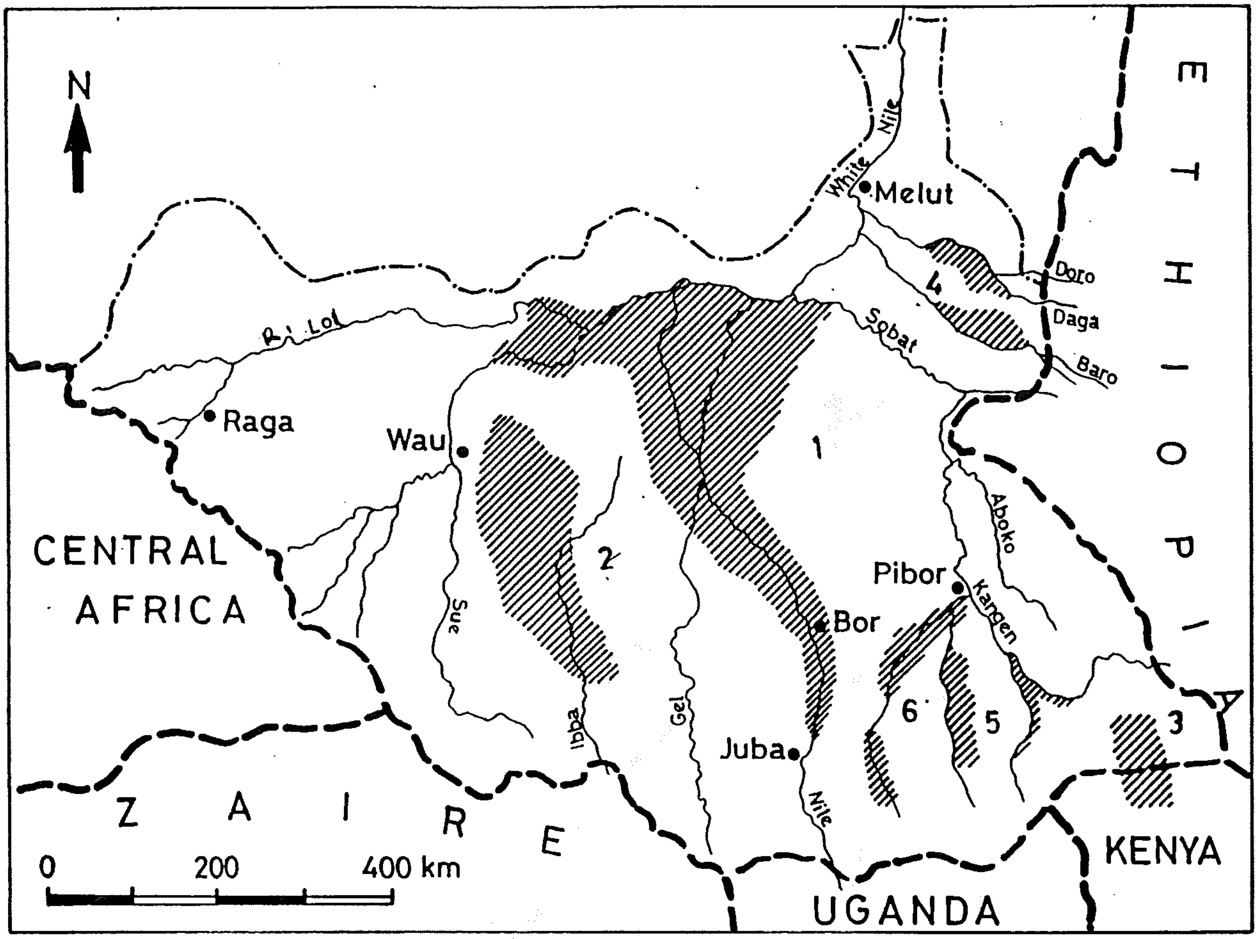
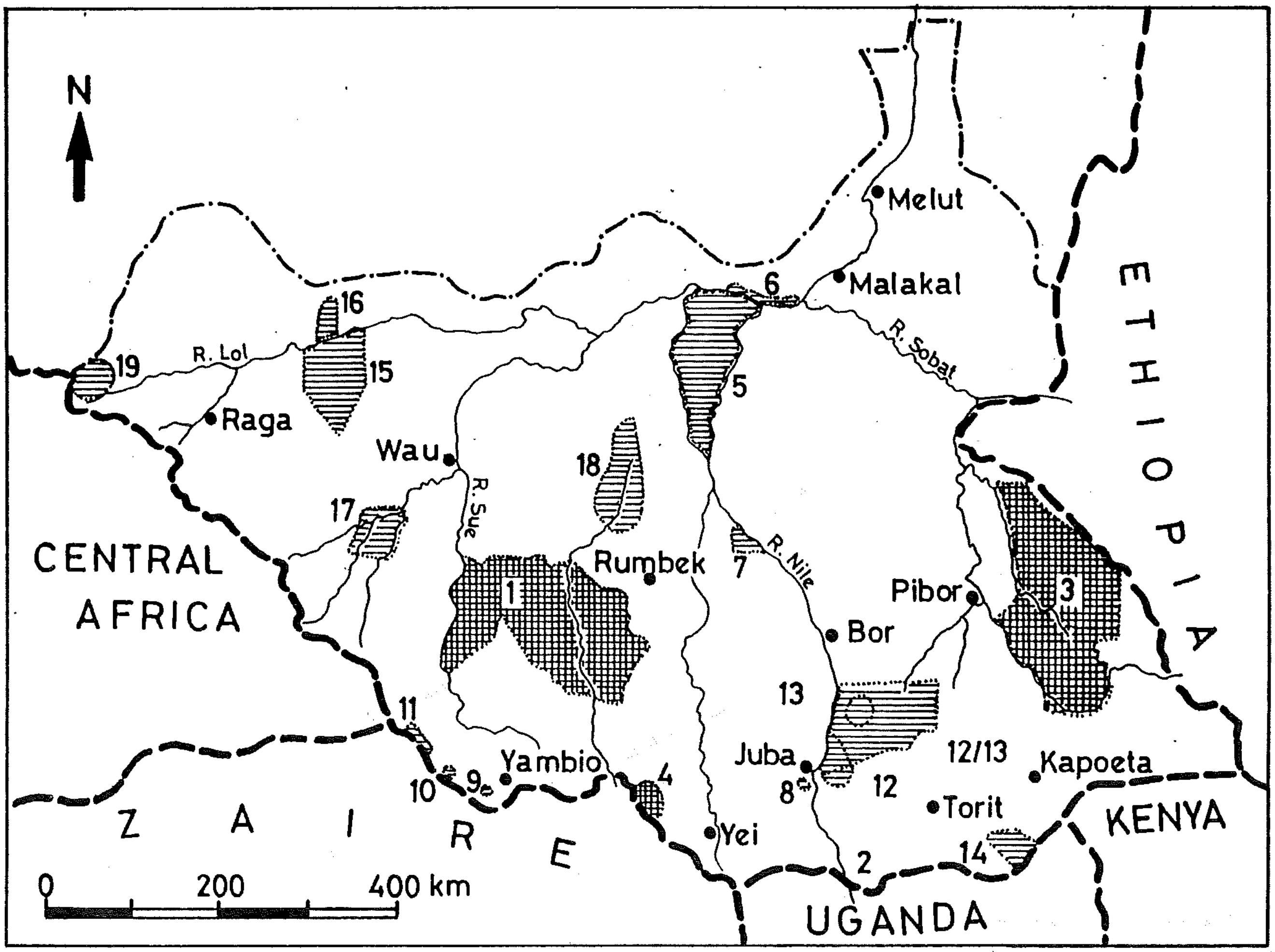


Figure 2. Hydrology and topography of southern Sudan.



1. The Sudd
2. Lakes Yirol, Anyi, Nyiropo, and Maleit; Ibba, Maridi, and Lau Rivers
3. Lotagipi
4. Machar
5. Lotilla
6. Veveno-Adiet and Lilebook

Figure 3. Wetland areas of southern Sudan.



1. Southern National Park
2. Numule National Park
3. Boma National Park*
4. Lantoto National Park*
5. Zeraf Game Reserve
6. Fanyikang Game Reserve
7. Shambe Game Reserve
8. Juba Game Reserve
9. Bire Kpatuos Game Reserve
10. Game Reserve
11. Bangangai Game Reserve
12. Mongalla Game Reserve#
13. Badingeru Game Reserve#
14. Kidepo Game Reserve
15. Chelkou Game Reserve
16. Ashana Game Reserve
17. Numatina Game Reserve
18. Meshra Game Reserve*
19. Boro Game Reserve*

National Park
Game Reserve
Legislated Conservation Area
Proposed Conservation Area
River
Town
International boundary
Regional boundary

*Proposed, undergoing legislation
#12/13 combined as Badingilo Game Reserve

Figure 4. Conservation areas of Southern Sudan.

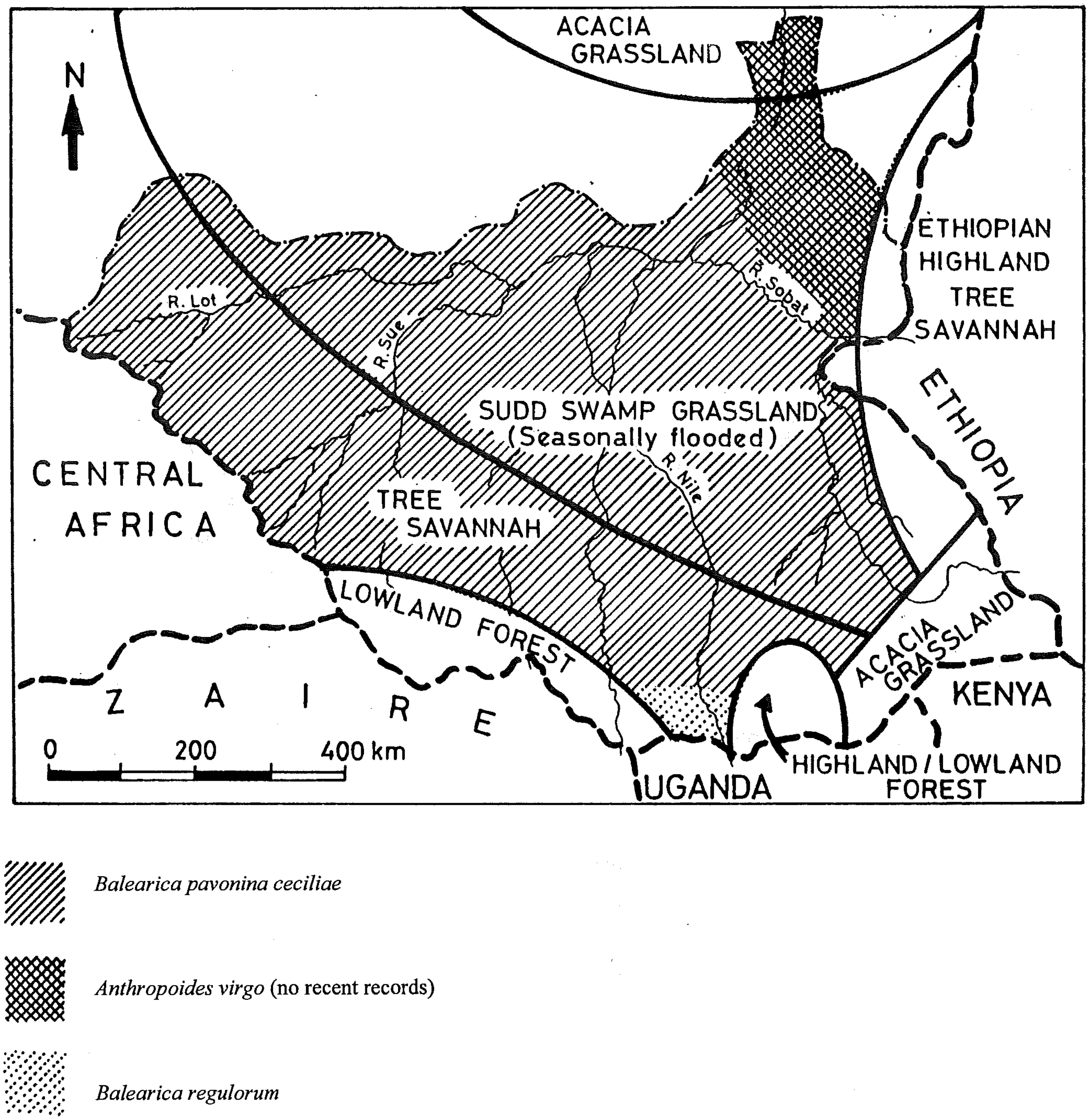


Figure 5. Distribution of cranes in Southern Sudan.

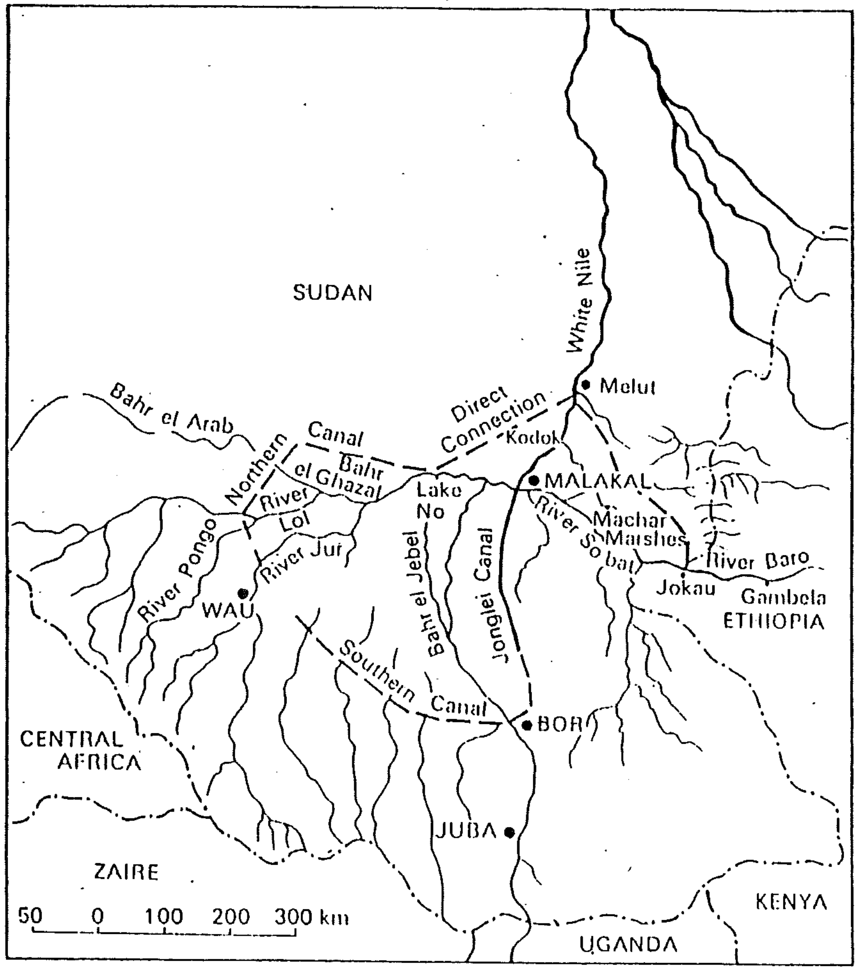


Figure 6. Future drainage and conservation schemes.

Table 1. Major wetlands of Southern Sudan, their characteristics, influence of human activities, and conservation status.

Name	Dominant vegetation	Area (ha.)	Human activity	Conservation status
Sudd	*Cyperus papyrus*, *Phragmites karka*, *Vossia cuspidata*, *Typha domingensis*, *Eichhornia crassipes*	1,650,000	Grazing, hunting, and fishing	Protected: Zeraf Island (675,000); Shambe (100,000); Mongalla (7,500)
Veveno, Adiet, Lilebook	Swampy papyrus Phragmites, Miscaphtidium and Typha grassy floodplain	645,000	Settlements, hunting,, and fishing	Unprotected
Machar	Grassy floodplains, swampy papyrus, phragmites and Typha	900,000 (500,000 in Ethiopia)	Settlements, grazing, hunting and fishing	Unprotected
Lotilla	Grassy floodplains, permanent swamps; *Cyperus papyrus*, *Phragmites mauritianus* (*P. karta* and *Typha domingensis*)	219,000	Hunting and fishing	Unprotected
Lotagipi	Grassy floodplain, reeds, and papyrus	720,000 (505,000 in Kenya)	Some hunting	Unprotected
Kenamuke, Koboweni	Floodplain	172,000	Hunting and fishing	Protected: Boma N.P.
Bandigeru	Swampy papyrus and grassy floodplain	55,000	Hunting and fishing	Protected: Bandigeru G. R.

Table 2. Minor wetlands of Southern Sudan, their characteristics, influence of human activities, and conservation status.

Name	Dominant vegetation	Area (ha.)	Human activity	Conservation status
North of Malakal (eastern)	Permanent swampland	85,000	Sparsely populated, little utilization	Unprotected
North of Malakal (western)	Some semi-permanent lakes	4,100	Sparsely populated, little utilization	Unprotected
South of Malakal, west of Sudd	Permanent swamp	169,000	Sparsely populated, little utilization	Unprotected
Bahr El Ghazal	Perennial swamps	90,000	Fishing	Unprotected
Floodplains of s. rivers (east)	Perennial swamps	500,000	Grazing and fishing	Unprotected
Floodplains of s. rivers (west)	Seasonal wetlands	?	Grazing and fishing	Unprotected
Lake Ambadi	?	1,000	Fishing	Unprotected
Lake Maleit	?	25,000	Fishing	Unprotected
Lake Virol	?	30,000	Fishing	Unprotected
Lake Anyi	?	1,600	Fishing	Unprotected
Lake Nyiropo	?	1,400	Fishing	Unprotected

SECTION 4

CRANE AND WETLAND CONSERVATION IN EASTERN AFRICA

FACTORS AFFECTING REPRODUCTIVE SUCCESS IN CROWNED CRANES

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ABSTRACT

The characteristics of individuals and environmental factors influence reproductive success in birds. By using a model that traces the life cycle of Grey Crowned Cranes *(Balearica regulorum)* from eggs to fledglings, the paper outlines some measures that could be used to estimate reproductive success in this species. Since the factors that affect reproductive success operate in all stages development, each measure of success should be associated with a particular stage of the life cycle. The paper examines the factors affecting survival at each stage and eventually the recruitment of offspring into the breeding population, and discusses the use of proximate measures in predicting reproductive fitness in birds.

INTRODUCTION

At the end of his chapter entitled "Struggle for Existence," Charles Darwin (1859) concluded that only the vigorous, the healthy, and the happy survive and multiply. This statement implies that successful reproduction and viability of individuals are crucial for existence. Trade-offs between fecundity and viability of individuals are crucial in the evolution of life-history strategies in different species of organisms. (Williams 1966; Stearns 1976; Lessells 1991).

Reproductive success is the number of adult offspring that an individual contributes to the next generation (Hamilton 1970, Clutton Brock 1988). In birds fecundity varies with the number of clutches laid, the number of offspring produced from each clutch and the number of breeding attempts. All these components of reproductive success are influenced by environmental factors such as variation in local food supply, breeding habitat quality, weather conditions and predation. Successful reproduction in birds is also constrained by demographic factors, mate choice, early development as well as age and traits related to it (Clutton Brock 1988).

It is difficult to obtain all the data needed to assess ultimate reproductive success because of a wide range of constraints: For instance, individuals of some species take a long time to reach reproductive maturity while others disperse so widely that the probability of re-encountering marked offspring is very low (Greenwood and Harvey 1982). Hence, proximate measures of reproductive success are useful in predicting the ultimate fecundity especially if the measures correspond with the appropriate stages of a species life cycle. This paper focuses on the estimates of reproductive success and the main factors influencing it in the Grey Crowned Cranes (*Balearica regulorum*). These large birds are endemic to sub-saharan Africa where they build nests in freshwater swamps and marshes.

STUDY SITE AND METHODS

This study was carried out in Saiwa Swamp National Park (01°04'-01°07'N/35°06'06''-35°07'E). The park is 197.8 ha. in size, lies at an average altitude of 1,70m (above mean elevation) and is surrounded by fertile farmland with cereal and pasture fields. The annual rainfall approaches 1,00 mm while ambient temperature averages 26° Celsius.

The park has a population of 48 to 60 Grey Crowned Cranes, of which 32 to 36 birds breed in the swamp along River Saiwa. The birds breed and roost in the park but spend 60-80% of the daylight hours feeding in the farmland outside the park (Gichuki 1993).

The data used to estimate reproductive success were collected from 32 pairs of cranes marked with colored leg-bands during the period between September 1988 and October 1993. The reproductive output of each nest was followed through the various stages of the life cycle, from the clutch initially laid, through hatching, fledging, and recruitment into the breeding population. The loss of offspring between one stage of the life cycle and the next are shown in a system model.

RESULTS AND DISCUSSION

The lifecycle of Grey Crowned Cranes

Crowned Cranes are monogamous and share parental duties. The pair defends its breeding territory against conspecifics and predators. The tasks of nest-building, incubation of eggs, and care for the young are also shared between the male and female partners (Gichuki 1993).

The female crane lays 2-3 eggs, which hatch in 27 to 30 days. The chicks are fed by the parents during the first 50 to 60 days and thereafter share food patches with their parents until the age of 120 days. The juveniles are capable of flying at the age of 100 to 120 days and after that, they continue to share feeding grounds with their parents but not food.

Juvenile cranes associate with parents for a period of 7-10 months. Thereafter they disperse, often in aggregations containing a few non-breeding adults. The birds form pairs at the age of 2-3 years, nearly one year before the pair actually breeds for the first time. The pairs breed once a year but may breed in alternate years, for a full reproductive period of 16 years.

Reproductive success

The life cycle of the Grey Crowned Cranes can be represented by a systems model with the actual or estimated mean output values (Figure 1). The factors that affect reproductive success operate in all stages of the life cycle and hence the total output could be viewed as being filtered or regulated by taps is it flows from one stage of the life cycle to another. The model focuses on the proximate fecundity components starting with the initial clutch size, survival of eggs up to hatching, through brood size after hatching and at fledging, and the relationship between these components and the reproductively mature adults recruited into the breeding population.

Proximate components of reproductive success

Grey Crowned Cranes breeding in Saiwa Swamp National Park laid eggs, mainly, between July and September in each year. The mean clutch size of 32 pairs was 2.41 eggs per nest. Total nest failure (X1) occurred in six nests while 26 nests had partial nesting success (X2). The mean clutch size at hatching was 2.08 eggs in initially complete clutches which survived during the incubation period.

The mean brood size of chicks leaving the nest was 1.96 birds per nest. Thus 94.3% of the chicks that hatched left the nest. This hatching success is partial but relatively high. The transition between leaving the nest and fledging is critical for cranes. Of 22 pairs whose young left the nest, 7 pairs experienced complete brood loss (X4) while 15 had partial brooding success (X5).

The brood size at fledging was 1.32 young per pair, indicating that 67.3% of the chicks, leaving the nest survived to fledging age. After fledging, survival varies with the age of the individual . This is because age of the fledged birds tends to be positively correlated with body size, and the ability to compete for food and to avoid predators. Thus, survival improves with age; older birds surviving better than younger birds (X6). This process continues until young adults start reproducing.

Relationship between fecundity components

Total nest loss (X1) occurred during the incubation period due to predation, habitat deterioration, and unfavorable weather. Such total nest failure was independent of the total clutch laid. Similarly, total brood loss (X4) occurred before fledging, irrespective of the brood size at hatching. Reproductively mature adults may have failed to breed because of infertility (X8) which is not linked with the number of offspring recruited into the adult population by a pair. These relationships define a linear model because the transitions are independent of the preceding state variables.

The linear system implies that one does not need to consider the transitions between components when measuring fecundity at each stage of the life cycle. If partial losses (X2, X3, X5, X6, X7) are also considered to be independent of the preceding state variable, especially because cranes have small but relatively constant clutch size, any multiplicative fecundity decrement could be applied to all individual females regardless of the clutch size laid, hatched or fledged.

In general, small clutches of two or three eggs and small broods of one or two chicks are more likely to suffer total nest failure and, total loss brood. In cranes, total nest loss affected 18.8% of the nests with complete clutches while total brood loss affected 9.1% of the pairs that hatched chicks in the study area.

Relationship between proximate and ultimate measures of fecundity

Recruitment in Grey Crowned Cranes was measured for males and females because individuals of the species were resident in the study area. A marked individual was considered recruited if it was found at a nest or resighted while paired to an unrelated adult conspecific. Four different mean numbers of adult recruits per clutch or brood of initial size of two or three were obtained. Each of the four sets of means corresponded to the four proximate fecundity measures; i.e., total clutch laid, clutch size at hatching, young leaving the nest, and brood size at fledging.

Correlation of coefficients were calculated between the measures of proximate fecundity and recruitment (Table 1) according to the stage of the breeding cycle. The sample size on which the correlations were made were small (n=6-9) but the correlations indicated that the relationship between fecundity component was approximately linear. The transitions between components are therefore not strongly dependent on the preceding state variables.

The correlations also indicate that proximate measures of fecundity are good indicators of relative recruitment for complete clutches as well as for broods assessed at different, but specific stages of the life cycle. Rockwell *et al.* (1987) examined the interdependence of various state variables for the Lesser Snow Goose (*Anser caerulescens)* and, as in the present study, concluded that proximate fecundity measures are useful indicators of reproductive success and powerful predictors of recruitment rate of reproductively mature adults into the breeding population.

The systems model described in the present study is useful in assessing reproductive fitness. It is appropriate because it takes into account losses associated with each stage of the life cycle of a species. Hence, it is useful in predicting demographic trends, which is essential for evaluating the potential of a species for economic utilization and conservation. However, linearity between proximate and ultimate measures of reproductive success needs to be established prior to its use.

REFERENCES

Clutton-Brook, T. H., ed. 1988. Reproductive Success. University of Chicago Press, Chicago, Illinois, USA.

Darwin, C. 1859. On the origin of species by means of natural selection or the preservation of favored races in the struggle for life. John Murray Publishers, London, UK.

Gichuki, N. N. 1993. Factors affecting the reproductive success of the Grey Crowned Crane. Ph.D. dissertation. University of Cambridge, Cambridge, UK.

Greenwood, P. J. and P. H. Harvey. 1982. The natal and breeding dispersal of birds. Annual Review of Ecology and Systematics 13: 1-21.

Hamilton, W. D. 1970. Selfish and spiteful behaviour in an evolutionary model. Nature 228: 1218 -1220.

Lessels, C. M. 1991. The evolution of life histories. Pages 32-68 *in* J. R. Krebs and N. B. Davies, eds., Behavioural ecology: an evolutionary approach. 3rd ed. Blackwell Scientific Publications, Oxford, UK.

Murray, B. G. 1991 Measuring annual reproductive success with comments on the evolution of reproductive behaviour. Auk 208: 952 - 991.

Rockwell, R. F., C. S. Finlay, and F. Cooke. 1987. Is there an optimal clutch size in Snow Geese? American Naturalist 30: 839-863.

Stearns, S. C. 1979. Life-history tactics: a review of ideas. Quarterly Review of Biology 51: 3-47.

Williams, G. 1966. Natural Selection, the costs of reproduction and a refinement of Lack's Principle. American Naturalist 100:687-690.

Table 1. The relationship between the proximate measures of fecundity of adult offspring in Grey Crowned Cranes breeding in the Kitale area, Kenya. Values shown in the table are correlation coefficients of determination between the proximate measures of fecundity, where X1 = total nest failure; X2 = partial nest success, X3 = partial hatching success; X4 = total brood loss; and X5 = partial brood success. See also Figure l for the appropriate location of these events in the life cycle model.

Proximate fecundity measures	Multiplicative (dependent) factors					
	None	X2	1-X1	X3	X5	1-X4
Total clutch laid	0.890	0.891	0.912	0.881	0.839	0.834
Clutch size at hatching	0.914	-	-	0.961	0.819	0.952
Young leaving nest	0.867	-	-	-	0.875	0.883
Brood size at fledging	0.872	-	-	-	-	-

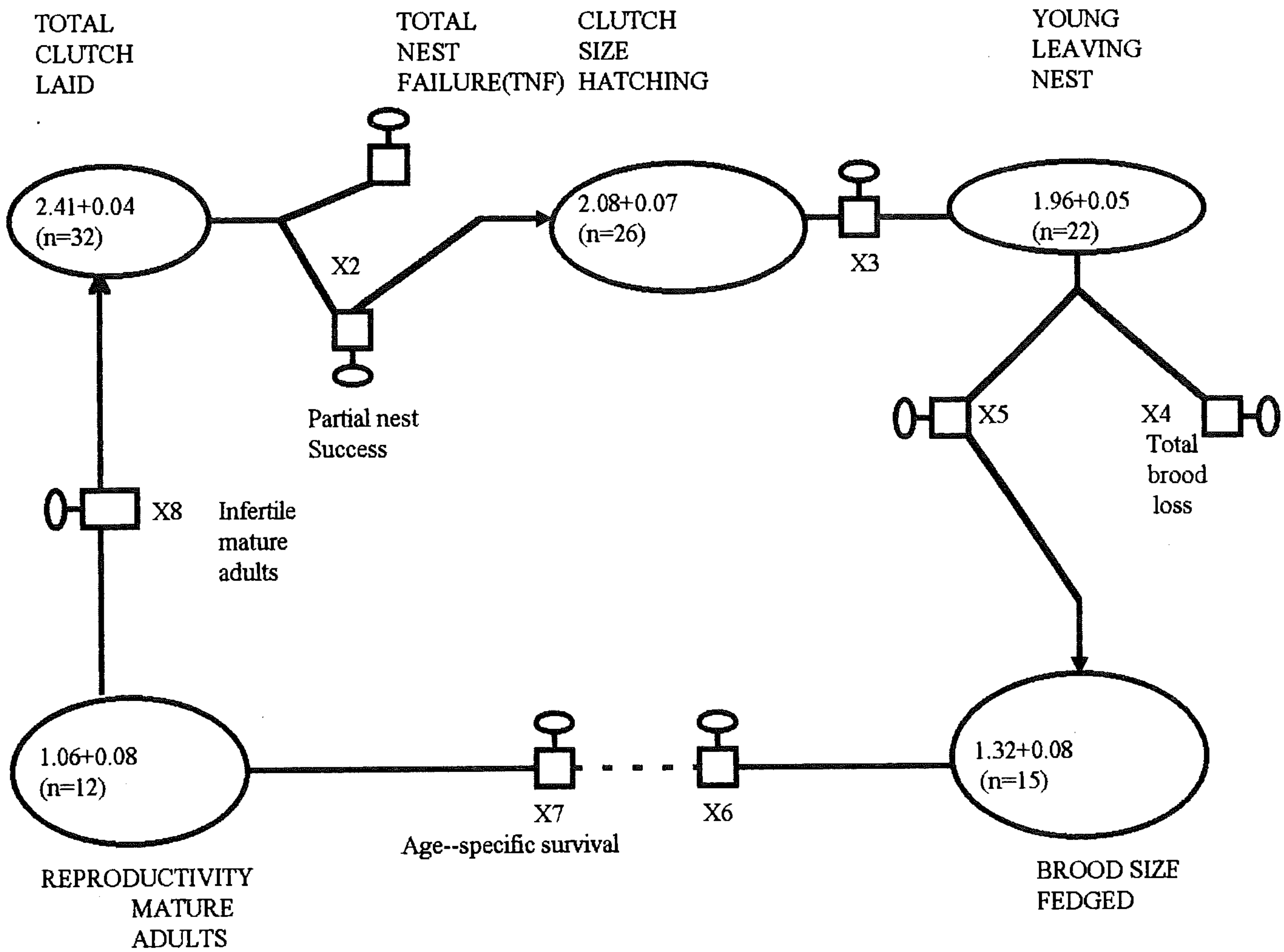

Figure 1. Proximate components of reproductive success in Grey Crowned Cranes according to major stages of life cycle.

DEVELOPMENT OF A NATIONAL POLICY FOR THE CONSERVATION AND MANAGEMENT OF WETLAND RESOURCES: THE UGANDAN EXPERIENCE

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ABSTRACT

Crowned Cranes are large terrestrial birds which breed exclusively in wetlands, with a marked preference for seasonal grass swamps. However, these wetlands have come under great human pressure and in many instances have been converted to rice fields, and other agricultural activities. Article 3.1 of the Convention on Wetlands of International Importance especially as Waterfowl Habitats stipulates that "the Contracting Parties shall formulate and implement their planning so as to promote the conservation of wetlands included in the List, and as far as possible the **wise use** of wetlands in their territory". The third and fourth meetings of the Conference of the Contracting Parties defined the concept of wise use and identified the formulation and implementation of wetland policies as one of the key actions aimed at achieving wise use. Over the last three years or so, the Government of Uganda has been involved in developing a long-term policy for the conservation and management of wetland resources. This paper examines some of the issues related to the formulation of a national policy. The relationship between national wetland policies and other environmental policies is discussed, highlighting some of the key linkages and potential conflicts between the former and the latter. The paper also discusses some of the issues to be considered when developing a national wetlands policy, such as: political will, bottom-up approach and vice-versa; consultations; inter-sectoral and holistic approaches; as well as socio-economic considerations. The need for legislation to back up implementation of a national wetlands policy is discussed with emphasis on a mixture of incentives-based and punitive, rather than purely punitive or incentive-based laws. In all the above cases, the paper draws on Uganda's experience in formulating and applying a long term policy for the conservation and management of wetland resources.

INTRODUCTION

Generally, Uganda's wetlands consist mostly of: permanent swamps; swamp forests; floodplains and areas of impeded drainage. Wetlands cover about 10% of the total land surface area exluding open waters. Despite this relatively large area, there is not a lot of traditional wise use knowledge in Uganda compared to other parts of Africa which have floodplain areas and where the local communities have developed a cultural tradition of interacting with wetlands. So, wise use has to deal with adjusting relatively modern inventions of farming.

In addition, wetlands have largely been regarded as wastelands. Lind E. writing in 1956, stated that "although they occupy such a large area of the protectorate, they are considered useless except for a few fish in a country where good agricultural land was plentiful". Earlier on, Sir Churchill had described Uganda as the "Pearl of Africa" meaning that it was so green, so lush , so plentiful.

Previous government policies have tended to regard wetlands as potential areas for development. The geography, perhaps up to now, states that land does not expand expect by reclaiming it from swamps. The Gibb's report of 1954-55 recommended that some peat swamps could be developed for agriculture. In addition, several rice schemes were set up by government either to increase food production or control floods.

This paper defines a policy for wetlands and its implication for the conservation of cranes, and discusses some of these issues that should be considered when developing such a policy.

WHAT IS A WETLANDS POLICY?

This paper attempts to define a policy on wetlands and discusses some of the issues that should be considered when developing such a policy. These include:

- a set of objectives for management and conservation;
- a guide to wetland use, planning, and management;
- a set of proposals which are transformed into objectives and principles.

WHY DEVELOP NATIONAL WETLANDS POLICIES?

There have been several arguments as to whether a country should develop a national wetlands policy, or an environmental policy. There are even further arguments that perhaps the existing policies on some aspects of the environment such as: water, land etc. are adequate.

The experience in Uganda is that these are clearly not adequate. The following are some of the issues.

1. Present policies are sectoral and inflexible and do not give wetlands adequate coverage. Some of the policies either directly or indirectly lead to wetland modification.

2. Many of the policies and laws are obsolete and no longer suited for the changed circumstances.

3. Wetlands are a multi-sectoral resource. One resource, many interests. A policy is therefore necessary to harmonize the various interests.

4. Wetlands are an ecological entity and not wastelands as is often perceived. They have important functions and values that need to be protected and conserved. Some of the functions are interrelated to other aspects of the environment.

5. There is an inter-relationship between various components of wetlands.

6. The process of making a wetlands policy creates vital awareness about wetlands and gives them a new lease of life.

7. Developing national wetland policies offers no new commitments. If anything it helps to mobilize the communities and empower them to manage their wetland resources.

NATIONAL WETLANDS POLICIES VERSUS ENVIRONMENT POLICIES

It is indeed true that states should develop environment policies under the NEAP process or National Conservation Strategies. However, it should be noted that there is no apparent or potential conflict between the two (environment and wetland policy). If anything they complement each other. The experience in Uganda is that the formulation of a national environment policy has to consider all aspects of the environment, including wetlands. Otherwise it will not be complete. However, this does not in any way mean that environment policies replace wetland policies. Indeed environment is such a wide subject that it is often difficult to decide where it begins and where it ends. The main issues are:

- wetlands are one resource with many possible uses and users;
- formulation of environmental policies often leads to marginalization of wetlands since an environmental policy addresses a bit of everything and does not provide adequate coverage of wetlands;
- a framework is needed for environmental management and integration of environment in national planning process.

Developing national wetland policies requires courage, vision, and consultations. Sometimes, what is required is to improve institutional and organization arrangements. This requires a good vision and amounts to a policy because often it means a review of a state's administrative machinery to ensure that wetland priorities are fully integrated into the planning process. It may also mean a complete overhaul of the national administrative structure.

The experience in Uganda is that a lot of multidisciplinary consultations had to be carried out and an Inter-Ministerial Committee set up to advise the Wetlands Programme and provide inputs to the wetland policy development process.

The following are some of the specific lessons learned from the process of formulating a national wetlands policy in Uganda.

The need for political will

There is need for political will at all levels of government i.e., the central government, district administration, and the village level, because lack of this will at any of these levels can jeopardize the process of policy formulation. The Ugandan case study was able to achieve some result because of the political will at the national level. In 1986, the government issued a ban on large-scale drainage of wetlands pending a policy and guidelines. This ban was issued through the District Administrators. But because some districts did not follow up this issue seriously, drainage continued (in some districts) even after the ban was issued.

The need for a bottom - top approach and vice versa

For many years, decisions have been always taken from the top and supposed to be implemented by the bottom. In terms of conservation, this has not been very successful. The Wetlands Programme in Uganda recognizes this fact and that is why the development of the national policy involved the District Development Committees and peoples committees (Resistance Councils) since these have a stake in the decisions regarding natural resources in their areas.

A multi-sectoral approach

This provides a holistic approach especially given that wetland management cuts across several sectors of the country. In Uganda there were many departments with responsibilities for wetland management, such as Agriculture, Fisheries, and Water Development.

The establishment of an Inter-Ministerial Committee

(IMC) has facilitated coordination and sharing of information. This has enabled institutions with existing power over wetlands not only to make inputs into the national wetlands policy but to consider using these resources wisely.

The need for awareness

The need for awareness can not be over-emphasized, because it is generally believed that one of the main causes for mismanagement of wetlands is lack of awareness of the values and importance. As mentioned earlier, the entire process of formulating a wetlands policy generates a lot of awareness especially within government, which has often taken wetland management for granted.

Throughout the District Development Committee (DDC) consultation, the need for technical inputs from the Department of Environment Protection was expressed. It is expected that these technical inputs will be provided to the DDCs through the parent ministries based upon practical interventions in wetlands.

Review of existing policies and laws

Enactment of a law to support the policy and ensure the principles enshrined in the policy are adhered to is very crucial. But equally important is the need to review existing legislation and policies to ensure that the wetlands policy to be formulated is consistent with existing policies and laws. The Experience in Uganda is that there are several Acts (laws) which relate to wetland management, but only as water resources or for health reasons, not as ecological entities. The word wetland is not even mentioned in existing policies and laws. Legislation is also important to control the activities of ministries and influence their understanding of wetlands.

Catchment area considerations

There is need to emphasize the proper management of catchment areas, especially the control of erosion, use of agrochemicals, and disposal of industrial waste. This is because many activities not actually in wetlands impinge upon wetlands, and functionally, no precise borders could be put around such a habitat. There is, however, need for caution that this approach can lead to problems where catchment boundaries do not coincide with civic boundaries as is the case in Uganda. So it may be impossible for committees to arrive at an independent decision. However, consultation across administrative boundaries can, in principle, resolve these matters. The provision of technical information and public awareness is also important. This further emphasizes the need for a multi-sectoral approach to wetland management.

Socio-economic considerations

It is generally assumed that the generation of cash profits from rice growing per se will necessarily benefit the local community as a whole. This is in fact not a safe assumption unless the cash profits can be recycled, or reinvested in the project, or spent on community amenities. Environmentally well designed development projects should incorporate culturally suitable methods for guaranteeing increased local standards of living, and opportunities for spin-off entrepreneurial activities. The wetlands program recognizes this fact and has now embarked on a social-economic assessment of rice growing in the Doho Rice Scheme.

The other socio-economic consideration is that many a time wealthy people drain wetlands and deny rural communities some or all of the traditional benefits. In some cases, the wealthy people use the rural poor to help them drain the wetlands by encouraging them to grow crops in the wetlands and eventually they take over and use them for raising livestock.

One way to address this problem is to encourage diversification of uses of wetland. There is also need to address the land tenure question. From the consultation with the districts it becomes apparent that ownership of wetlands should largely remain in the public domain.

However, there are economic considerations which sometimes dictate that some wetlands should be privately owned. For example the issue of security of tenure. It is generally believed that this could lead to better management of wetland resources. Experience in Uganda shows that unless the leases are accompanied with proper environmental safeguards, they are likely to be abused. Leasing in itself gives ownership to one individual and in most cases there is no mechanism to ensure adherence to proper environment management principles.

The other consideration is that wetlands perform a numbers of functions which are closely interrelated. Therefore, entrusting them in one individual could jeopardize other uses and users.

CONCLUSION

From the foregoing account it is clear that proper management of wetlands, and the conservation of cranes that depend on them, requires commitment to a Wetlands Policy. This could take different forms depending on local situations. Formulating a wetlands policy offers an opportunity for the protection of cranes, since wetlands provide important habitat during the critical stage of their lifecycle.

The mere fact that a country proclaims a wetlands policy is a sign of commitment and this should be encouraged. More important, a country loses nothing by developing a wetlands policy.

TRAINING WATER BIRD COUNTERS TO MONITOR WETLANDS IN KENYA: PROGRESS AND PROSPECTS

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ABSTRACT

Waterbird counts are useful for monitoring the ecological character of wetlands. However, regular, sustained counts at a national level are hard to achieve. Since 1990, the Kenya Wetlands Working Group has been combining waterbird counts at important wetland sites with training for volunteer counters. The aim is to develop and equip a team of Kenyan counters who can continue to collect data on waterbird numbers in a consistent manner. Volunteers contribute their time and energy, while the organizers provide food, accommodation, transport and materials. More than 200 volunteers had participated in the counts by the end of July 1993, including students, professional biologists and wildlife managers, and amateur birdwatchers. Of these, a core group of 40-50 people have shown sustained interest. The training and count sessions have been successful in developing a competent waterbird count team and providing consistent census data; they have also proved a very effective way to create awareness of wetland values and conservation problems. The challenge now is to find the means to sustain the waterbird counts on an annual basis.

INTRODUCTION

Waterbird counts can be very useful as part of an overall strategy for monitoring wetlands. To be effective they need to be regular, sustained over a reasonably long period so that the normal pattern of fluctuations in number can be assessed, and conducted in a strictly consistent manner.

Regular, consistent counts can yield at least three important types of information. First, they provide a baseline against which any changes in waterbird numbers can be assessed. Since water birds are sensitive biological indicators, this can provide an "early warning" of any deterioration or change in the ecological character of a wetland system. To interpret the changes continuous, data are required. It is also important to know as much as possible about the biology (especially feeding ecology and habitat preferences) of the species involved.

Second, counts can show the relative importance of different wetland areas in terms of waterbird numbers and species richness. Accurate and reliable data of this type are important for decision making in conservation. They are also often required to support any recommendation for the addition of a site to the Ramsar list of wetlands of international importance. Several of the Ramsar criteria are based on waterbird numbers.

Third, when conducted as part of Africa-wide surveys (the IWRB African Waterfowl Census), waterbird counts contribute to our understanding of the status of migratory species. Conservation of such species is an issue of international concern, but in most cases we know remarkably little about their wintering populations and distribution.

While regular, sustained waterbird counts at key wetland sites are highly desirable, at a national level they can be very difficult to achieve. In Kenya, as in many other African countries, many factors make it hard to organize a waterbird monitoring scheme. The most critical factor is the lack of trained personnel, funds and equipment. This paper describes the efforts of the Kenya Wetlands Working Group to tackle these problems, and reports on progress so far and challenges still to be faced.

WATERBIRD COUNTING IN KENYA

Counting of water birds in Kenya has a long history. As early as 1974, a Wildfowl and Wetlands Working Group was founded by C. E. Norris and G. Cunningham-van Someren, with the aim of collecting data on waterbird distribution and numbers. The group was active for a short time and then subsided. Between 1976 and 1989 surveys of Palaearctic ducks and waders were carried out by D. Pearson, B. Meadows, T. Stevenson, P. B. Taylor, and others. Some of these findings have been published (e.g., Pearson and Stevenson 1980; Meadows 1984; Pearson and Meadows 1992; Pearson *et al.* 1992), and some of the data submitted to IWRB for addition to their waterbird census database.

The earlier surveys, carried out by a few dedicated individuals, have contributed enormously to our understanding of the distribution of water birds in Kenya. However, from the monitoring point of view, they were not ideal. In only a few cases were particular wetlands surveyed consistently at the same time of the year. The emphasis was almost entirely on Palaearctic migrants, ignoring Afrotropical birds that may in many cases be better indicators of local conditions. Furthermore, the work was not sustainable. It was not formalized under any program; no coordination took place and no indigenous Kenyans at all were involved. When the counters left the country, the waterfowl surveys they were doing ceased.

In June 1990 the Kenya Wetlands Working Group (KWWG) was formed, its primary aim being to promote the "wise use" of Kenya's wetlands as stipulated under the Ramsar Convention. One of the group's first exercises was to initiate waterbird counts at several key wetland sites, as part of the African Waterfowl Census. It became immediately clear that a strategy was required to make the counts successful and sustainable. In brief, what was required were planning and coordination; training; and the provision of equipment and opportunities to count.

KWWG'S WATERBIRD COUNT PROJECT

Counting waterfowl is an exacting occupation. Species identification, particularly of migrants, is difficult, as is accurate estimation of numbers. Experience is required, and those who lack experience must be carefully trained. When the KWWG program began there was only a tiny number of experienced birdwatchers or ornithologists in Kenya who were able and willing to participate in the counts. Very few of these were Kenyans. For continuity, a major aim had to be to train a team of Kenyans to a high level of expertise. This trained team, and others that they would train in turn, could then ensure that the counts would continue not just for one or two years, but for as long as wetland monitoring needs to be performed.

An important aspect of this training program was the participation of the Kenya Wildlife Service (KWS). The KWS is the body designated to implement the terms of the Ramsar Convention in Kenya. Lake Nakuru, Kenya's first Ramsar site, is also a National Park managed by KWS. Since KWS lacked sufficient trained personnel to undertake monitoring efforts, a special focus of the project was to train KWS staff, so that a team of professional wildlife managers with skills in waterfowl counting could be developed within the organization itself.

Most Kenyans do not have the resources to go out and count water birds independently. Basic equipment, such as field guides and binoculars, is also in short supply. So a major aim of the project was to provide the opportunity for enthusiastic volunteers to take part in the censuses, and to supply the equipment needed to make their participation meaningful.

The project started in 1990 with training sessions at Lakes Magadi and Nakuru (Figure 1). In January 1991, larger training sessions, combined with counts, were organized at Naivasha and Nakuru. Support for these initial efforts came from the East African Wildlife Society (EAWS) and the East Africa Natural History Society (EANHS). Later in 1991 an application for training support was made to the Ramsar Bureau's Wetland Conservation Fund. This was successful, and these funds have been used to maintain the project for the last eighteen months.

STRATEGY AND ORGANIZATION

The specific aim of the project is to lay a foundation for regular, sustained monitoring of waterbird populations at important wetland sites in Kenya, through training of Kenyans in appropriate techniques. Because the need to collect data on waterbird numbers is urgent, training takes place simultaneously with census work.

A number of wetland sites are covered in the counts, including most of the main lakes in the southern Rift Valley. Some sites are counted by a small team of experienced counters and involve no training component. Eleven combined training sessions and counts have been undertaken since the Ramsar-funded project began (Table 1). Group sizes for these sessions have been around 70 counters at Lake Nakuru, 40 counters at Lake Naivasha, and 20 to 30 counters at the other sites.

The main emphasis has been on Naivasha and Nakuru. These two very important wetlands (an existing and a potential Ramsar site) contrast in the species of water birds present and the challenges involved in counting them. Nakuru is counted from the shore, on foot. Very large numbers of birds, especially flamingos, are often present, and a main focus of the training is to improve the consistency and accuracy of counters' estimation techniques. Naivasha is counted from the water, in boats. Training here emphasizes identification (over 70 waterbird species are regularly recorded) as well as the ability to count and record continuously, while the boat is moving.

All training sessions have a common organizational framework. Participants are volunteers who are asked to donate their time and energy. In return the organizers make available basic food, accommodation and transport. These costs are met from the project funds. As far as possible, equipment is also provided for those lacking their own binoculars or field guides. Those living or working around Naivasha and Nakuru are particularly encouraged to take part, but the majority of volunteers are based in Nairobi. Naivasha and Nakuru are convenient sites in this respect, since they are relatively accessible from the capital city. Training and counting at other important wetlands, for example, Lake Turkana, would be very difficult to organize.

Training is provided in several ways. Direct training involves sessions at the lake shore practicing the identification and counting of birds as a group, under the supervision of the project executants and other experienced counters. This involves, for example, basic techniques such as how to use binoculars; the field markings of particular groups and species; estimation techniques (and attempts to standardize estimates across the whole group); instruction in the use of recording forms; and the count protocol and rules. Newcomers are also given an explanation of why the counts are undertaken, and their importance for wetland conservation. All counters are expected to attend these sessions. A slide show, sometimes supplemented by videos, is generally organized on the evening before the main count to focus attention on the field characteristics of particular species; this is primarily aimed at the less experienced counters. On the day of the count the group splits into teams, each of which is assigned a particular stretch of the wetland to cover. Each team includes at least one experienced counter, who is expected to provide as much training as possible during the count itself, and to ensure that team members are properly applying the skills they have been taught.

To maintain interest among the volunteers, reports of each count are sent out to everyone who took part. These reports also go to KWS and other decision-makers. The last three reports have been formalized as part of the research report series of the Department of Ornithology, National Museums of Kenya (Bennun 1992a, 1992b, 1993). IWRB also plays its part by distributing a summary account of the year's work across Africa to all the counters (Perrenou 1991, 1992).

This organizational approach has been successful. In part, this is because the project must cover only a small proportion of the "real" costs of each training session. Experienced counters, although few, have proved willing to attend and make their expertise available for training. The organizers donate their time. Participants with vehicles have generally provided them to transport other volunteers, often donating fuel as well. A number of boat owners at Naivasha, after some initial reluctance, are now prepared to donate the use of their boats for the counts. Kenya Wildlife Service, a partner in the project, has provided the use of their hostels and vehicles at Lake Nakuru without charge. The overall cost to the project of each training session is in the region of $400; about one-third the sum required to sponsor a single Kenyan delegate to this conference!

PARTICIPATION

To date, more than 200 volunteers have participated in the training sessions (this includes those involved in 1991 before the Ramsar project officially began). Of these, around 27 were staff of the National Museums or Kenya Wildlife Service; some 54 were students (mainly studying for degrees or diplomas); 60 were amateur Kenyan birdwatchers or conservationists; and 63 were expatriates or short-term visitors (Figure 2). This last group, while not a primary target of the training program, is extremely important to the success of the sessions, since they include the majority of the experienced counters and the majority of the volunteers able to assist with transport.

The 141 Kenyans who have so far participated in the counts, form a much larger group than originally anticipated. However, the number is a little misleading. There is in fact a core group of about 40 to 50 volunteers who have attended consistently and shown sustained interest. So far the counts have been open to all, subject to the constraints of space (novices have had to drop out on some occasions). The original address list has been considerably expanded, and many additional volunteers learn of the exercise by word of mouth. The counts have also been advertised in publications of the EANHS and once (to the organizers' surprise) in a national newspaper. The counts generate considerable interest, particularly among students; usually this is because of a genuine conservation commitment, but a few novice volunteers seem to see the exercise simply as a "free" weekend outing. This has not been a serious problem so far.

Those volunteers who have been attending consistently have now gained considerable experience. Beginning in July 1993, participation was restricted largely to this core group, but room was left for a few volunteers who appear to have a genuine interest in and commitment to the exercise.

The training sessions have certainly had a marked effect on the volunteers' technical skills. Perhaps equally important, however, they have proved to be a tremendously effective method of conservation education. Many volunteers originally knew very little about wetland conservation issues; the counts have made them aware of the importance and fragility of wetlands, and they in turn have spread the message to others.

CENSUS DATA

By making the training sessions an integral part of the counts, we obtain data on waterbird numbers simultaneously. The accuracy of these data are unknown, and it is likely that considerable biases exist in counting some species. However, because the methodology is consistent, the data are sufficient to allow comparison between years, and clearly show up trends. This, of course, is what a monitoring program aims at. Fig. 3 shows some examples of trends in a few species at Nakuru.

At times enormous numbers of flamingos flock at Lakes Elmenteita, Nakuru, and Bogoria. These represent a real challenge to counter, and much time is spent trying to obtain consistent total estimates. Counting from high ground, with a telescope, has been attempted as an alternative, but the results are not very consistent with the ground counts. In July 1993, the high ground telescope count gave around 750,000 flamingos on Lake Nakuru, while the low ground count revealed more than 1.4 million. In view of this inconsistency, more work is required to calibrate these method, especially since the telescope counts is likely to become a routine monitoring method. In the case of flamingos, it is important to know the actual numbers that are present: ground counts and telescope counts may in future be combined with an occasional accurate aerial survey.

SUSTAINABILITY

The training project has nearly fulfilled its aim of producing a trained team of counters. However, keeping the counts going will take resources, as well as continued commitment by the organizers and volunteers. The Ramsar funding is nearly at an end, and other local or international donors will have to be persuaded to support the counts on a long-term basis. To convince them to do so, it will be necessary to demonstrate that the information collected is indeed valuable. This type of monitoring is long-term in nature, but already the results have some demonstrable value. As the institution responsible for overseeing the implementation of the Ramsar Convention in Kenya, the Kenya Wildlife Service has a responsibility to monitor Lake Nakuru, and these counts assist them in tracking the wetland's health. They also proved helpful during a recent research planning workshop to decide research and monitoring priorities for the lake and its catchment. Data for Lake Naivasha have been used to support an application by local residents for Ramsar listing. More generally, the counts have provided hard data to demonstrate the critical conservation problems faced by such waterbird species as the Great Crested Grebe and African Darter.

ACKNOWLEDGMENTS

The waterfowl counter training project is funded by the Ramsar Bureau's Wetland Conservation Fund. Many organizations and individuals, too many to mention here, have helped in making the counts and the training sessions a success: I thank them all.

REFERENCES CITED

Bennun, L. A. 1992a. Summary results of the January 1992 waterfowl counts. Research reports of the Centre for Biodiversity, National Museums of Kenya: Ornithology. 7 pp.

Bennun, L. A. 1992b. Water birds at Lake Nakuru July 1992. Research Reports of the Centre for Biodiversity, National Museums of Kenya: Ornithology. 8 pp

Bennun, L. A. 1993. Water birds in the southern Kenyan Rift Valley, January 1993. Research Reports of the Centre for Biodiversity, National Museums of Kenya: Ornithology. 13 pp.

Meadows, B. S. 1984. Numbers and seasonality of filter feeding ducks in Kenya. Pages 441-459 *in* G. C. Backhurst, ed., Proceedings of the Sixth Pan-African Ornithological Congress. Nairobi, Kenya.

Pearson, D. J. and T. Stevenson. 1980. A survey of wintering Palaearctic waders in the southern part of the Kenyan Rift Valley. Scopus 4: 59-63.

Pearson, D. J., T. Stevenson, M.A.C. Coverdale, H. Shekkerman, and J.C.J. van Wetten. 1992. Estimates of Palaearctic wader and duck numbers wintering in the Kenya Rift Valley. Pages 23-35 *in* L. Bennun, ed., Proceedings of the Seventh Pan-African Ornithological Congress. Nairobi, Kenya.

Pearson, D. J. and B. S. Meadows. 1992. Numbers, distribution and seasonality of Palaearctic duck in Kenya. Scopus 15: 109-119.

Perrenou, C. 1991. African Waterfowl Census 1991. International Waterfowl and Wetland Research Bureau, Slimbridge, UK.

Perrenou, C. 1992. African Waterfowl Census 1992. International Waterfowl and Wetland Research Bureau, Slimbridge, UK.

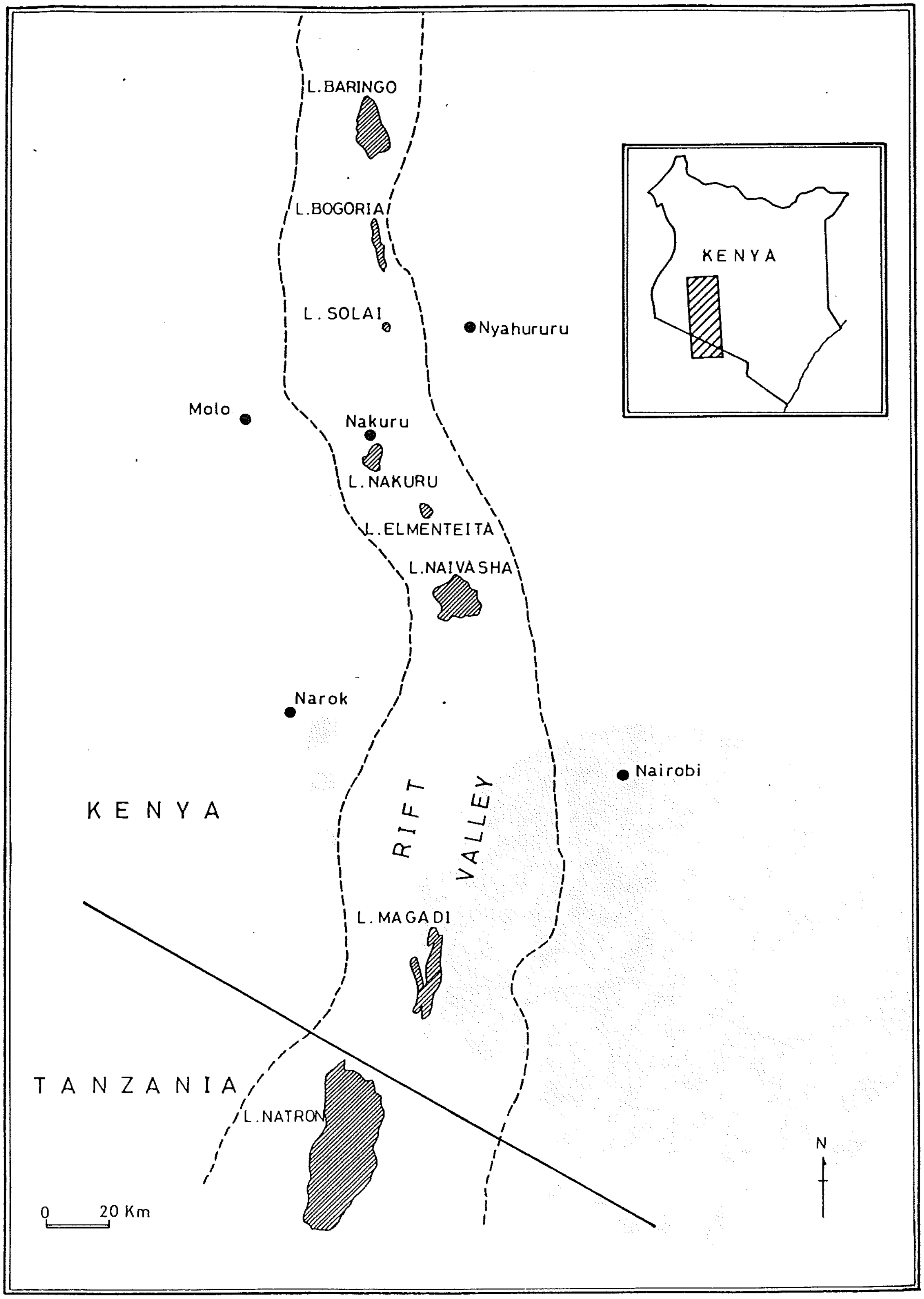

Figure 1. The Gregory Rift Valley in southern Kenya and extreme northern Tanzania, showing the location of major wetland sites.

Table 1. Combined training sessions and counts since January 1992.

Date	Number of Counters	Site
11-12 January 1992	71	Lake Nakuru
13 January 1992	21	Lake Elementeita
17-19 January 1992	55	Lakes Naivasha, Oloidien, and Sonachi
25-26 January 1992	16	Lake Bogoria
4-5 July 1992	62	Lake Nakuru
9-10 January 1993	36	Lakes Naivasha, Oloidien, and Sonachi
16-17 January 1993	79	Lake Nakuru
18 January 1993	25	Lake Elementeita
23-24 January 1993	16	Lake Bogoria
30 January 1993	12	Dandora Sewage Treatment Works
4-5 July 1993	69	Lake Nakuru

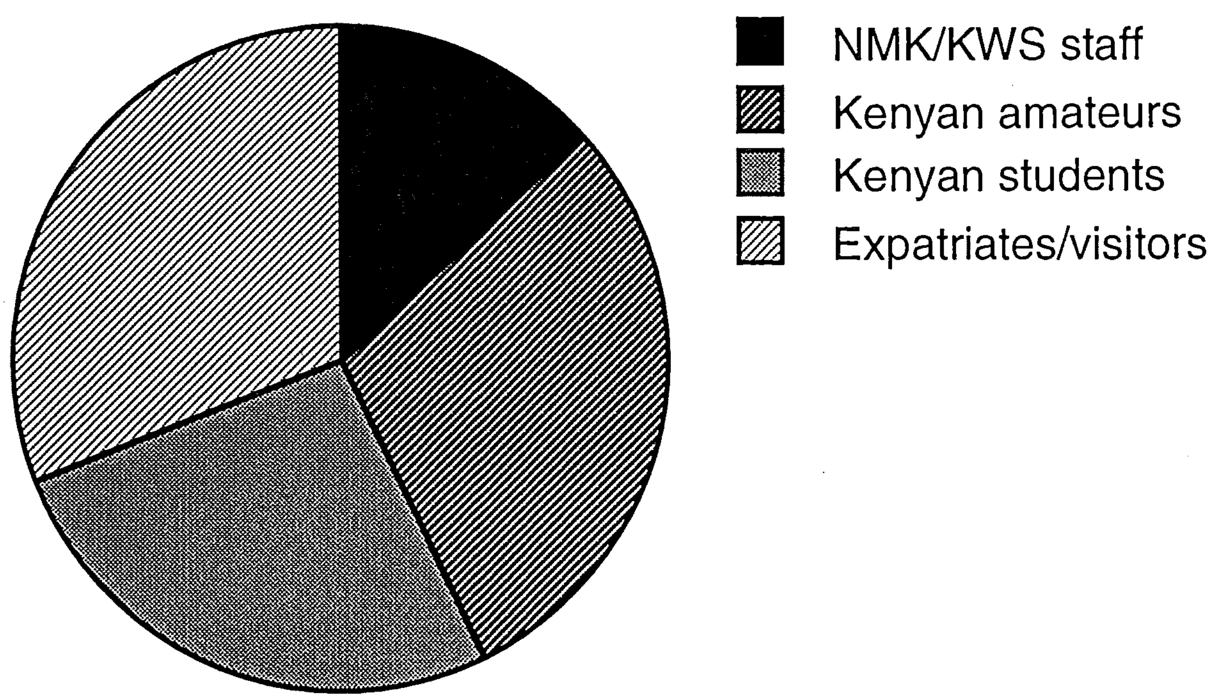

Figure 2. The proportion of waterbird count volunteers (total = 204 persons) in various categories, January 1991 to January 1993.

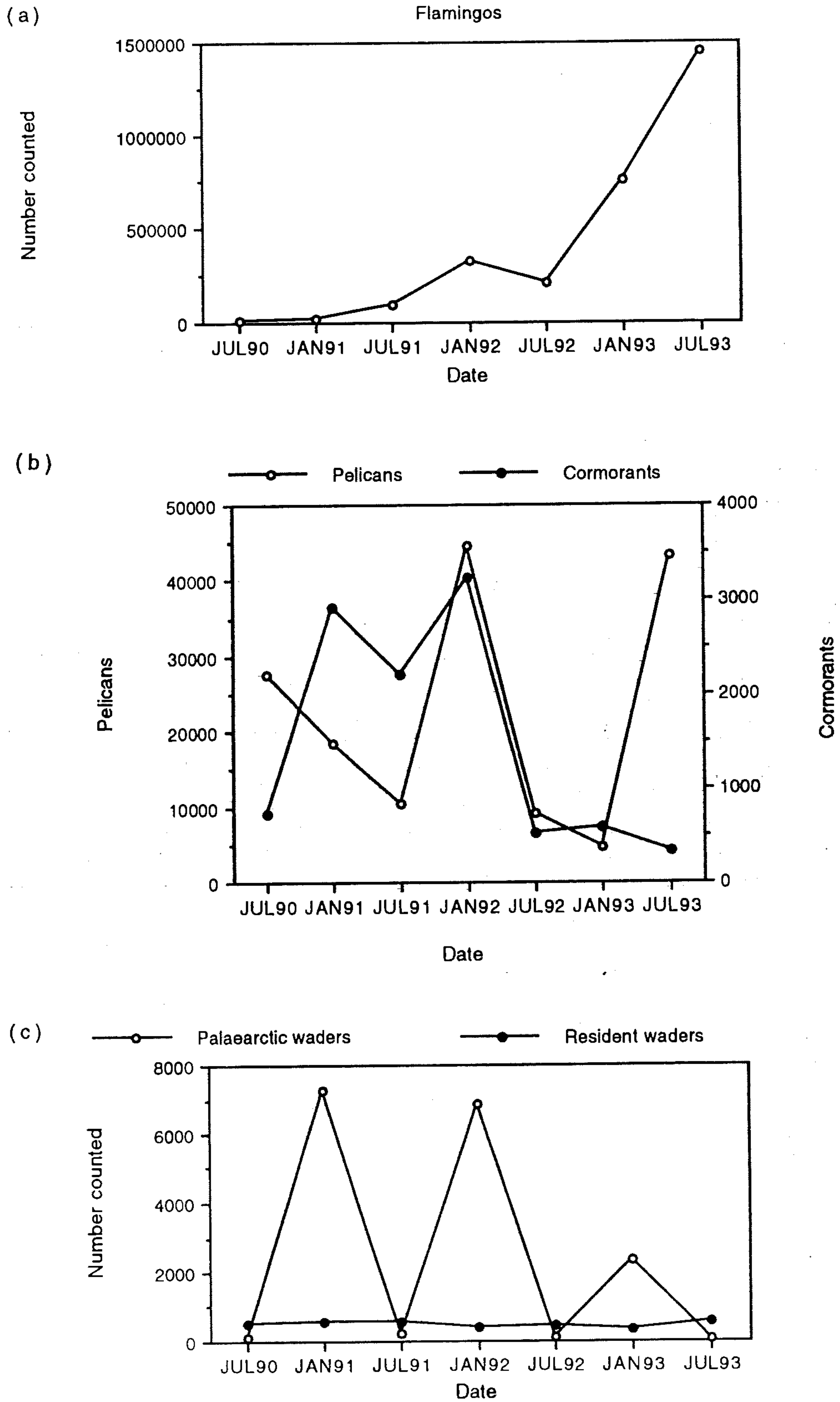

Figure 3. Trends in total numbers counted for some groups of waterbirds at Lake Nakuru, July 1990 to July 1993. (a) Flamingos; (b) Pelicans and cormorants; (c) Palaearctic and Afrotropical waders (plovers and sandpipers).

WILDLIFE CLUBS OF KENYA: THE CRANE CENSUS

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The Wildlife Clubs of Kenya (WCK) is a charitable non-governmental organization supported by the Kenyan government through the Ministry of Tourism and Wildlife. Over the last 25 years the organization has experienced rapid growth, and today there are more than 2,000 school club members across the country. The WCK members undertake many projects, including controlling pollution, raising awareness of the great need to protect our environment, planting trees, conserving soils, and counting and monitoring cranes.

In East Africa, despite a ban on hunting, Grey Crowned Cranes (*Balearica regulorum*) and Black Crowned Cranes (*Balearica pavonina*) are threatened through the destruction of the wetlands where they breed. Cranes require wetlands for building their nests and raising their young. The birds build a simple platform nest in the tall wetland vegetation, choosing the most remote part to protect their eggs and chicks from predators. Wetlands are safe places to rest and roost. The splashing of a predator walking through the marsh alerts the cranes to danger.

Because humans are careless in the destruction of crane breeding grounds (swamps, streams, estuarine deltas, and dams), the Wildlife Clubs of Kenya in conjunction with the International Crane Foundation conducted a national census of cranes in Kenya in July 1993.

The nationwide census studied the distribution of cranes and wetland areas across country. A total of 2,241 Grey Crowned Cranes were counted at 140 observation sites. A total of 104 Black Crowned Cranes were sighted in the northwestern part of Kenya near Lotagip Swamps.

Some of the results were encouraging and indicated that cranes are still undisturbed in some rural areas. The most disappointing results came from urban areas; the situation for cranes is worst in Nairobi where many ecosystems have been cleared to make way for new roads, houses, and industries. The few dams which used to be clean are now polluted and as a result the cranes have been driven away or perished. The Wildlife Clubs of Kenya believe it is vital to continue to focus attention on the crane because of the increasing encroachment on the cranes' habitat by humans.

COMMUNITY YOUTH GROUPS CAN HELP SAVE WETLANDS: THE CASE OF THE KIPSAINA WETLANDS CONSERVATION YOUTH GROUP

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INTRODUCTION

The future of this planet lies in the hands of the youth, who are the leaders of tomorrow. Nature should be protected, promoted, and cared for by people, rather than being destroyed. Youth participation in wetland conservation will ensure a better future for both people and wildlife.

HISTORY AND COMPOSITION

Kipsaina Wetlands Conservation Youth Group started off as a Catholic youth group in the locality. It was initiated by the church in 1990, with a broad agenda of environmental conservation. Today, the group has members from different denominations. There are 30 members, 11 of them girls and 19 boys. Most of the members are below 25 years of age, 17 of them have attained secondary education, and the rest have attained primary education.

For youths to participate fully and effectively in group activities, they need permission from various elders, such as parents, institutional heads, guardians, etc. Some of these authorities do not readily allow youths to participate in many activities. All the same, the youth are always ready to work and share their success.

LOCATION

The group is based at Saiwa Swamp National Park in Sinyereri location, Cherang'ani division of Trans-Nzoia district. Their center of activity is Kipsaina Village. The main economic activity in the community is agriculture, with maize growing becoming dominant, both as a cash crop and for subsistence. The soils of the region erode readily, due to degradation by farm practices and forest cover removal, hence a need for environmental conservation. Saiwa Swamp National Park is a very small park which protects an important wetland with populations of Sitatunga antelope and Grey Crowned Cranes.

ACTIVITIES

Kipsaina Wetlands Conservation Youth Group is involved in various activities that support wetland conservation and benefit the communities.

1. **Indigenous tree nursery.** The group runs a tree nursery to provide indigenous tree seedlings to be distributed free of charge to farmers within the Saiwa wetland zone. The species include forest trees such as *Olea welwestchii* and *Prunus africana*, and trees that grow in swamps such as *Syzygium* spp. Exotic trees are avoided, so as to make the wetlands as natural as possible.

2. **Erosion control and fodder plants.** The group grows Napier grass (elephant grass) to provide planting material for farmers to plant along terraces to control soil erosion. The grass is cut at maturity, and farmers are encouraged to use it as fodder to feed their animals during the dry season, in addition to this soil conservation function. Leaves of *Calliandra* and *Sesbania sesban* are added to the Napier grass to enrich it for livestock feeding.

3. **Fish ponds.** Kipsaina Wetlands Conservation Youth Group has functional fish ponds to demonstrate fish farming as a sustainable use of wetlands and an income generating activity.

4. **Organic farming.** To keep wetlands healthy, farmers are encouraged to fertilize crops with farmyard manure and spray them with insecticidal substances made from plants.

5. **Bee-keeping.** The group practices bee-keeping within the wetland zone by hanging beehives on the trees within the catchment, and sells the honey harvested to generate income for the group.

6. **Awareness-raising.** The group has a choir that is instrumental in creating public awareness on crane and wetland conservation in schools, the community, and the public as a whole. Group leaders also give public lectures to gatherings in villages, schools, and so on.

7. **Monitoring tree-planting success.** Group members monitor on-farm development of tree seedlings given to the farmers. This is done in conjunction with other agroforestry extension officers, such as Ministry of Agriculture and Forest Department staff and others.

8. **Monitoring threats to cranes and their habitat.** The group monitors threats to the survival of Grey Crowned Cranes and their habitat, such as poisoning or land degradation (e.g., mining of sand, marsh burning, deforestation). The members give progress reports during their

monthly meeting held at the Kipsaina Village center or at a member's house.

9. **Promotional activities.** Kipsaina Wetlands Conservation Youth Group members promote crane and wetland conservation on national days dedicated to the environment, such as World Environment Day, Elephant Day, Tree Planting Day, etc. Promotional activities include tree planting, educational film shows, and public lectures, and are covered by reporters from the press, TV, and radio.

10. **Networking.** The group has made an effort to set up information networks with other groups, especially those with similar interests, to share experiences and compare notes.

COMMUNITY WATER PROJECT

To meet their water needs, the community requested the construction of 12 boreholes. Eden Trust, a conservation organization whose representative in Kenya is Mr. Ed Goss, has already funded four boreholes. The donation was arranged by Mr. Sam Forsythe of the BBC. These four boleholes will provide the community with clean water for better health. Eight other boreholes are needed, and we appeal to other donors to come forward to fund them. The boreholes will help reduce pressure on Saiwa Swamp.

ACKNOWLEDGMENTS

The group has been helped in many ways by many people. We wish to thank most sincerely the Kenya Wetlands Working Group for sponsorship that enabled us to attend the National Wetland Workshop and the International Crane Foundation for sponsoring the group's secretary to the Crane and Wetland Training Workshop in Botswana. We also thank the Ministry of Agriculture of the government of Kenya, for surrendering their former soil conservation tree nursery complex at Kipsaina to the youth group. Many thanks go to the Kenya Wildlife Service for the initial working site, National Museums of Kenya for film shows, World Wide Fund for Nature for educational materials, Kenya Broadcasting Corporatiou for publicity, and Environmental Liaison Centre International for networking.

We would also like to thank the following for their individual support, both moral and material: Dr. George Archibald, Director, and Mr. Richard Beilfuss, Ecologist, International Crane Foundation; Dr. Nathan and Ms. Cecilia Gichuki, Dr. Leon Bennun, and Ms. Damaris Rotich, National Museums of Kenya; Ms. Fleur Ng'weno, Editor, Rainbow children's magazine; Mr. Richard Brock and Mr. Sam Forsythe, Executive Producers, BBC; Dr. Richard Goodwin, President, Conservation and Research Foundation; Dr. Donald Messersmith, President, World Nature Association; Ms. Christine Lambrechts, Poison Working Group; Ms. Elna Kotze, Wakkerstroom Natural History Association; Mr. Eddy Goss, Eden Trust; Ms. Irene Njumbi, WWF; Cllr. John Kamau Kibe, Nzoia County Council; Mr. John Ndame, Warden, Saiwa National Park; Ms. Mary Kikovele, Lady Patron, KWCYG; Ms. Christa Budde, crane researcher; Mr. Caleb Anyanzwa, KBC; Ms. Francesca Lusweti, agricultural extension officer; Ms. Consolata Muliro, special education teacher; Ms. Caroline Muthoni, community development assistant; Mr. Martin Tanui; Mr. Astarico Nyaro, Chief, Sinyereri Location; Mr. and Ms. John Wilson, vegetarian ecologists; and Mr. Ernest Kwalima, farmer. The group has now made them all honorary members.

BIODIVERSITY AND CATCHMENT AREA ON ITS WAY OUT

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INTRODUCTION

For a long time, most of human society has considered wetlands as wastelands, which could be converted to more productive use. As a result, wetlands today are among the most threatened ecosystems in the world. Wetlands are among the most biologically productive ecosystems, but they also have the important role of controlling flood waters and regulating water quality. These are functions which would otherwise involve an enormous amount of money that countries, especially developing ones, cannot afford.

Swamps are marvelous reservoirs. They soak up rain waters like a sponge, serving as natural flood controllers. During dry periods, they replenish the water table. Plants that grow in swamps consume dissolved nutrients, filtering out pollutants before the water flows into lakes. When we preserve the swamps, we also protect countless other species that might otherwise fade from the earth.

Effective systems of management ensure that biological resources survive and even increase while being used. This is sustainable utilization. Current processes of development are set in such a way that they deplete many biological resources at a rate which render them essentially nonrenewable. The main problem is that some people earn immediate benefits from exploiting wetland resources, and they forget the social and economic costs of resource depletion which must be paid now or in the future by society as a whole.

People living in and around wetlands (or any other ecosystem, like a forest) often exercise more power than governments over the use of these biological resources. They require incentives and appropriate education on how to manage the resources sustainably for their own benefit. In Kenya, most of the peasant farmers who live near wetlands or own small patches of them lack basic knowledge about managing their wetlands. They still view these areas as sources of such diseases as malaria and bilharzia. The people feel that if they drain swamps, they can get rid of mosquitoes and water-borne diseases. Growing vegetables using water from the swamps also generates a little new income. Since people are poor, they have little time to think of the beautiful scenery of these areas. Daily needs are top priority.

In order to get the attention of governments and those who make decisions on conservation policy, it is necessary to demonstrate in economic terms the values of biological diversity for the country's social and economic development. Such values include things that are consumed directly (like thatching material and livestock fodder), things that are commercially harvested (such as fish), and direct and indirect values such as groundwater recharge and climate regulation. All too often these advantages of biological diversity are taken entirely for granted until it is too late.

After working with the Kenya Crane and Wetland Project for a number of years (since 1981), we have realized that in order to save wetlands and their flora and fauna, it is essential to understand how the local people view them and use them. At the same time, it is necessary to work with the government decision-makers and also to help the local community to implement recommendations set out based on research findings. The following report on Lake Ol'bolossat provides information from a study tour to collect routine data on the lake and its environs.

LAKE OL'BOLOSSAT

Lake Ol'bolossat (36°26'E/0°09'S) is an internal drainage basin which lies in Nyandarua District. The lake lies to the south of Nyahururu Municipality at an average altitude of 2,340 m above sea level, in a wedge-shaped fault (Figure 1). The surface runoff from Nyandarua mountains and Dodori Ridge, and springs that flow from Sattima Escarpment, drain into this lake and the swamps surrounding it. The swamps have a high salt content, possibly because of the nature of the sediments constituting the area.

Lake Ol'bolossat is 90 km^2 in area and consists of 80% marshes, 15% open water, and 5% dry land which appears as small islands in the marshes. Annual rainfall in the area exceeds 1,000 mm. The lake is shallow with a mean depth of 1-4 m. The water level in this lake fluctuates seasonally. Grey Crowned Cranes (*Balearica regulorum)* and hippopotamus (*Hippopotamus amphibius*) are the most conspicuous wild animals. The lake has a rich community of birds with up to 185 species recorded and the area is vital for such breeding species as the Redknobbed Coot (*Fulica cristata*), the African Jacana (*Actophilornis africanus*), the Blacksmith Plover (*Vanellus armatus*), and the African Snipe (*Gallinago nigripennis*). Unfortunately, the lake has no legal protected status, and people use it unsustainably.

Apart from its wildlife, the lake basin plays a very important hydrological function of holding the excess water from the Ewaso Narok System during the wet season. During the dry season the underground aquifers feed the nearby springs. The faulted zone to the west of the Ol'bolossat valley acts as a channel for feeding springs in the mid-catchment, and in this way add to the volume of the flow in River Ewaso Ngiro. The waters of Ol'bolossat Swamp valley drain northwards and supplement flow in the Ewaso Narok River.

THE LAKE VISIT, APRIL 1993

The Kenya Crane and Wetland Project executants visited the Lake Ol'bolossat area from April 21-25, 1993. During this visit, the group consulted with the local farmers in connection with land subdivision noted during the field work. The farmers were very receptive and told us what was happening around the lake. According to them, some people have been allocated plots around the lake. There were present two Range Rovers from the Ministry of Lands and Settlements (Survey of Kenya) conducting the survey.

When we inquired from the surveyors what was happening, they told us with confidence that they were fixing boundary lines of the plots since the plots had already been allocated. At one plot a church and a house probably for the pastor had recently been erected, and a few other plots had been fenced and plowed. The previous day, the main surveyors had been there to see the progress of the survey. The Nyahururu District Officer in charge of environment protection told the Kenya Wildlife Service warden and us that the surveyors were not actually demarcating the lake, but doing what they called a "block survey" to mark the boundaries of the lake. But, what we saw and were told by the surveyor was that they were fixing plot boundaries of the new settlement scheme in order to accommodate new people in the area. The people around the lake were not happy, since most of them depend on the lake for grazing their animals, especially during the dry seasons.

As a result of land subdivision, the existing peasant farmers in the area who hold five-acre plots will not be able to get access to the lake area for their animals or even for water. Many more families will get into the lake area and this will result in overcrowding and consequently more exploitation of the meager existing resources. There is now a lot of encroachment on the lake and the surrounding escarpment by the farmers who own plots there. For example, the local farmers are very hostile to the forester at Muruai Station, because he does not allow them to cultivate the slopes of the escarpment and also to graze their livestock at the proposed lake reserve area.

Little of the lake is remaining now. If the whole exercise of plot demarcation is stopped, however, some part of the lake could be saved. The KWS warden and the forester at Muruai forest station were waiting for the lake to be gazetted as a game reserve. It is vital to consider the biodiversity of the area before confirming the reserve boundaries if the reserve is to be a viable conservation unit. It now seems unlikely that the proposed boundary can be realized, since the lake has already suffered heavy encroachment apparently with government approval.

RECOMMENDATIONS

The continuation of encroachment on the lake could lead to serious ecological disasters, including destruction of vegetation, destruction of wildlife habitat, degradation of fragile swamp soil, loss of groundwater recharge, higher flood flows and consequently a much lower lake water level during the dry season; the death of the Ewaso Ngiro Riverine forest; and social and economic problems. In view of these potential problems, I would recommend the following.

1. The 300 or more peasant farmers who were originally allocated 5-acre plots should be reallocated to another more suitable area. The reason for this is that the family sizes of people who have lived there since 1970 have increased. The 5-acre plots are no longer enough to sustain these families with their descendants. Most of the springs that originate from the adjacent escarpment have dried up mainly because the families depend heavily on the spring waters for domestic use and for growing vegetables for sale. The families however cannot readily get the vegetables they grow to market, because of poor roads. Firewood is very scarce, and people are forced to battle with the forest officer when they try to get firewood, rafters, or any other building materials from the adjacent Muruai forest reserve.

2. The proposed settlement scheme should be stopped immediately as the area is too fragile to support any more people.

3. The proposed Kirima Scheme should probably be used to relocate the 300 peasants settled at the lake. No new families should be encouraged to settle in the lake basin because it is already overloaded beyond carrying capacity.

4. The Director of Forests should increase support for Muruai Forest Station and immediately start a community afforestation program for the area. The forester should also have enough power to stop encroachment and gross destruction of the forest on the escarpment.

5. The 1990 Nyahururu District Development committee and Kenya Wildlife Service (KWS) plan to make Lake Ol'bolossat a National Reserve should be finalized, the reserve gazetted and active conservation work started by KWS and Nyandarua County Council.

ACKNOWLEDGMENTS

I would like to thank WWF International for supporting this study, Kenya Wetlands Working Group for supporting and publishing my appeal for conservation of Lake Ol'bolossat in the local newspapers, and the National Museums of Kenya who stood by me during the campaign.

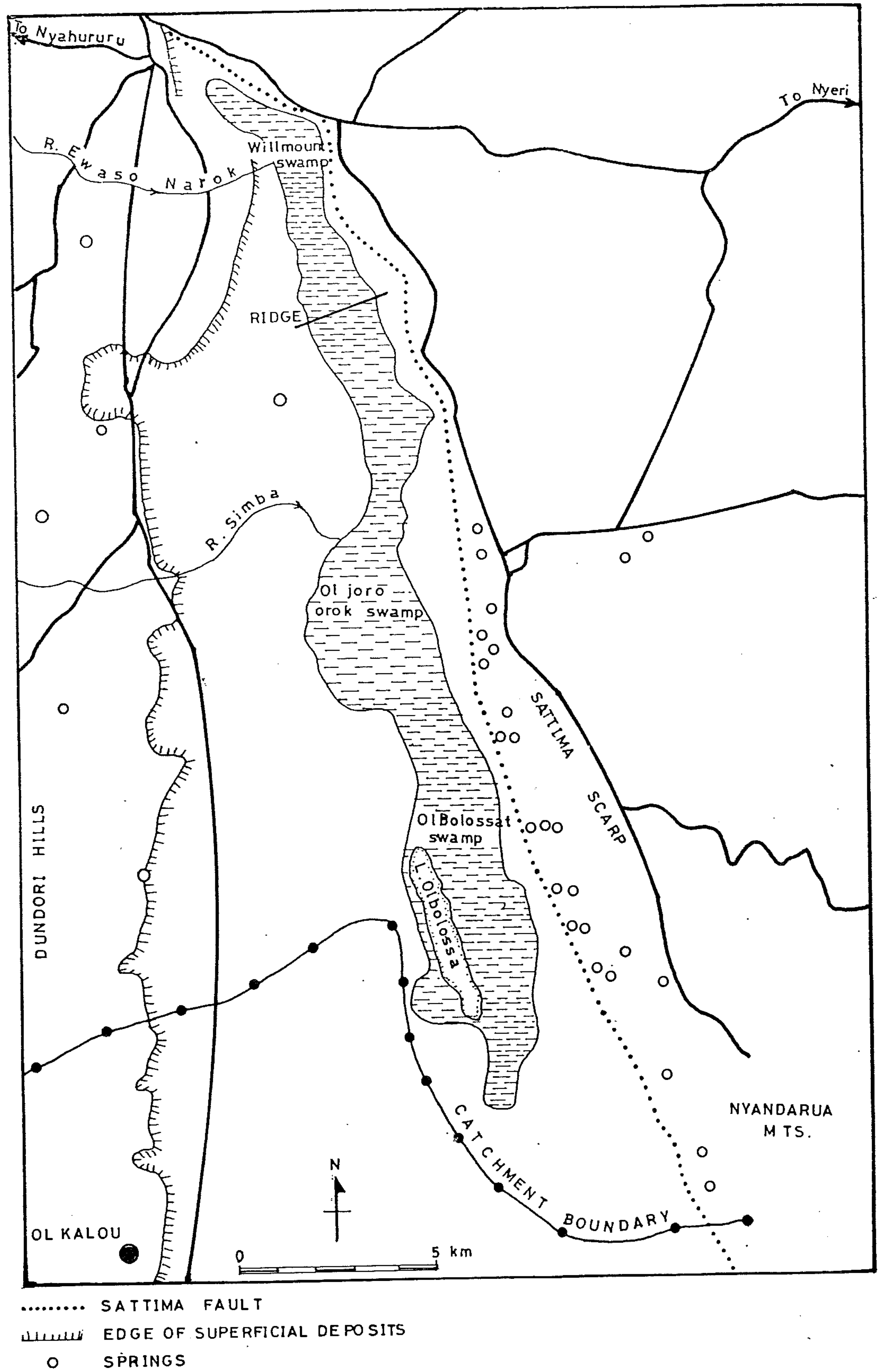

Figure 1. Lake Ol'bolossat and its immediate environs, Kenya.

GREY CROWNED CRANES AS INDICATORS FOR WETLAND CONSERVATION IN RWANDA

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ABSTRACT

Located in the Great Lakes area of central Africa, Rwanda is occupied by important wetlands which support a large number of avifauna. Human pressure, however, affects natural areas, especially the marshes zones which are mainly transformed for agriculture. This has heavy consequences concerning the loss of the biological diversity and decline of natural populations. The population of Grey Crowned Cranes in Rwanda, which are wetlands-dependent, is decreasing, but no study has been done. This paper tries to show how the Grey Crowned Crane should be considered as an indicator of wetland quality. A general discussion, with reference to conservation needs in heavily populated areas, is presented.

INTRODUCTION

Wetlands are recognized as very important in maintaining a large part of biodiversity around our planet. This richness of wetlands is related mainly to their productivity, which supports a variety of plants and animals. Wetlands are also important in improving the quality of waters flowing through them, and humans' living pattern. People find in wetland ecosystems many kinds of food, water, and economic opportunities (Nickerson 1991; Van Der Ven 1991).

Wetlands have been maintained in stable condition for a long time, because they are not easy to invade by non-adapted organisms, especially man who preferred to exploit other habitat. The human pressure on wetlands has increased in recent years. The wetland habitats have become easy to invade because of advances in technology in developed countries, and the always-increasing human population in less developed countries. Now, draining, clearing, and reclaiming are easy ways to gain a short-term profit, but a start for new environmental disasters (Clark 1973).

In Rwanda in particular, the high human pressure on wetlands is leading now to a loss of biodiversity in the country. The remaining relatively natural wetlands are found only in national parks and reserves (mainly Akagera National Park, and some wetlands in montane forest ecosystems). Other wetlands dispersed in the country are highly threatened with degradation for agriculture. Many plant and animal species which were common in the country in the past years are now only located in national parks and reserves, or highly threatened by fragmentation.

The magnitude of the problem of reduction of wetland habitats and the loss of related biodiversity is not yet well known in Rwanda and is limited to theoretical observations. In order to measure this impact and to conduct a functional assessment of wetlands, Crowned Cranes constitute an ideal model to examine this problem, because cranes are well known in all the country, and are recognized as symbol of beauty for the country.

This paper reviews the problem at four levels of action: the local population in their villages, the national authorities, international collaboration, and the importance of technicians and researchers at all those levels.

WETLANDS IN RWANDA

Rwanda is biogeographically situated between the western tropical rainforests and the Lake Victoria Basin. The country is dominated by thousands of hills, between which are wetlands, occupying almost 10 percent of the country's total area (26,338 k^{m2}). The wetlands are of different sizes, but many of them are small. The wetlands are used by many resident as well as migrant species from the Palearctic or the Afrotropical region.

The largest remaining natural wetlands are found in Akagera National Park, where marshes are connected to the wetlands of Victoria Basin and are among "important bird areas" recognized by the International Council for Bird Preservation (Bibby *et al.* 1992; Fishpool *this proceedings*). We suppose that recruitment and immigration of many marshland birds could be high in Akagera marshes.

An important line of wetlands occurs along the Akagera and Nile basin, which begins far in the southwest of the country, crosses to the north and joins the southeast in Akagera. This line collects more than 90 percent of water of the country, while a small quantity belongs to the Zaire basin.

This long line of wetlands as well many small wetlands connected to it in a system of a thousand hills, are threatened

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by high pressure from agriculture. Many species of birds and aquatic animals are threatened by human activities in and around wetlands in Rwanda.

CRANES AS WETLANDS INDICATOR SPECIES

Often, ecologists and conservationists start work after a problem already exists, saying that this given problem has led to particular consequences. Nevertheless, it is very important, but difficult, to know everything before beginning management of a given area. In areas with high human pressure like Rwanda, it is urgent to gather information in order to prevent some ecological disasters.

For this reason, the choice of indicator species is very important in conducting research. Crowned Cranes are considered to be good indicators of wetland habitat degradation. They are also well known by local people and can therefore be used to promote environmental education (Gichuki 1991).

The quality of a wetland could be measured by its ability to sustain a breading population of cranes (Gichuki 1991). Many studies have shown that the feeding and breeding ecology of cranes are linked to their habitat. The main reason cranes are disappearing from a large part of their range is the loss of habitat. This is the case in Rwanda, because of pressure from humans. Naturalists, conservationists, and some local people recognize an apparent decrease of the Grey Crowned Crane population in Rwanda, especially near human settlements.

THREATS TO WETLANDS AND CRANES IN RWANDA

No quantitative study concerning cranes has been conducted to date in Rwanda, and specific studies related to the conservation of wetlands are very limited.

Wildlife management is preferentially oriented toward managing new wetland habitats. Agriculture is increasing in wetlands, because they are considered to have high production, so basic agricultural techniques have not been changed significantly since many years ago. New wetlands areas, however, are often the only alternative for satisfying human needs.

These activities destroy wetlands for short-term benefits, and lead to long-term consequences such as flooding and soil erosion, without appreciating how the two events are linked. In addition, it is not possible to use wetlands sustainably without a sound management program and agricultural techniques in the hillsides. Agricultural chemicals are widely used but preventing greater use requires education.

Some cases have been observed where people catch young cranes for selling to others (mainly to white people), who maintain them in captivity. This is a challenge to conservationists, to educate people who need money and food not to sell natural products.

RECOMMENDED WETLANDS CONSERVATION STRATEGY

We suggest a strategy for wetlands conservation and sustainable use, which could be considered for other natural ecosystems, based on the following actions, classified at four levels.

Local level

A program of public education is necessary to explain the importance of wetlands, their richness and fragility. People at their villages always rely on wetlands for food, water, and other necessary natural products. In many situations, degradation of natural habitats occurs because of the lack of information about the consequences even in the short term.

A program for establishment of wildlife clubs in various schools and villages has shown success in many countries such as Ghana, Sierra Leone, Kenya, and Uganda. The "Association pour la Conservation de la Nature au Rwanda," was initiated recently in Rwanda with assistance of BirdLife International. The goal of this club is to learn more about wildlife and their environment, to limit stress to wildlife habitats, and to find alternative ways for sustainable use. A wildlife bulletin (*Le Nectar*) is produced three times a year in order to improve exchanges of information between members. We organize excursions and competition for members.

Considering cranes as wetland indicator species, the public education activities will focus on the importance of conserving cranes and other birds that are dependent on wetlands in Rwanda.

National level

The national approach is important for maintaining the biodiversity of the country and developing the priority actions at the national level.

Authorities are also concerned with providing education so decision that makers have enough knowledge for integrating land use and management of natural habitats. This is why collaboration between authorities and technicians and researchers is very important at this level.

Technicians and researchers

Technicians and researchers are very important in giving basic information to the local community and the government.

Research on wetlands and cranes conservation in Rwanda could be subdivided into three steps to:

- collect enough data on the status of cranes in Rwanda and related habitats;
- examine the effect of fragmentation of wetland habitats on the biology and the population dynamics of the Crowned

Crane;

- conduct long-term studies on the population dynamics and recruitment of cranes in Akagera National Park, where immigration seems to occur between the park and human settlements.

The first step of research will profit from wildlife clubs, which could give data from their areas. The second and third steps will need a specific program involving mainly students from the national university. The suggested studies will be accompanied with general information regarding a wide range of activities, in order to plan the future of wetlands and crane conservation in Rwanda. All the results and other data on the wetland environment should be integrated.

International level

A sound wetlands management policy adopted by the government is a basic step in civil law. However, wetlands are of international concern, a fact recognized by many nations that are signatories to the Ramsar Convention. Protection of wetlands within a given country is in the interest of every other country as well.

This is particularly important for migrant species. Many cases do exist, especially for Palaearctic species which have been studied for a long time such as the White Stork (*Ciconia ciconia*) and herons (Kanyamibwa *et al.* 1990; Kanyamibwa 1991). The survival rate of migrant species depend upon international cooperation to assure the conservation of wetland ecosystems on bird migration route and wintering areas. Cooperation with foreign organizations is also very important.

CONCLUSION

It is important that human use of wetlands and their products not be all consuming. All life (plants, animals, and human society) is linked to them.

While survival of many migrant species is linked to the wetlands where they winter, resident species are dependent upon wetlands for both their survival and their reproduction. This is the case for many avian species in Africa, especially cranes. Destruction of wetland habitats contributes to decrease of wetland species.

The conservation of wetlands should be conducted at all levels, from local to international. Research and education programs are very important to develop sound methods and give the necessary information for sustainable use of wetlands, especially in countries like Rwanda with high population pressure. This is what we plan to do with our cranes and wetlands conservation action plan during the coming years.

ACKNOWLEDGMENTS

I would like to thank the International Crane Foundation for inviting me to attend the workshop and BirdLife International for supporting my travel and accommodation.

REFERENCES CITED

Bibby, C. J., N. J. Collar, M. J. Crosby, M. F. Heath, Ch. Imboden, T. H Hounson, A. J. Long, A. J. Stattersfield, and S. J. Thirgood. 1992. Putting biodiversity on the map: priority areas for global conservation. International Council for Bird Preservation, Cambridge, UK.

Clark, C. W. 1973. The economics of overexploitation. Science 181: 630-634.

Gichuki, N. N. 1991. Relationships between habitat selection and flock characteristics in foraging Grey Crowned Cranes *Balearica regulorum* in Kenya. Pages 357-361 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Kanyamibwa, S. 1991. Dynamique des populations de cigogne blanche (*Ciconia ciconia L.*) en Europe occidentale: Contribution a la conservation des populations naturelles. These de Doctorat. Montpellier University. Montpellier, France.

Kanyamibwa, S., A. Schierer, R. Pradel, and J. D. Lebreton. 1990. Changes in adult annual survival rates in a western European population of the white stork *Ciconia ciconia*. Ibis 132: 27-35.

Nickerson, N. H. 1991. Preserving wetland values for people and wildlife. Pages 205-208 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Van Der Ven, J. 1991. Nature management: to balance wildlife and human use. Pages 209-217 *in* J. Harris ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

AN OVERVIEW OF STATUS AND DISTRIBUTION OF GREY CROWNED CRANES IN TANZANIA

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ABSTRACT

Grey Crowned Cranes are widely distributed in Tanzania. They occur in various areas in the Lake Victoria area, northern, central, western, and southern highlands, and eastern and southern regions of the country. The species is reported to damage some food crops in certain rural areas, and is sometimes poisoned by farmers. The government occasionally allows exportation of these birds, mainly from areas where they are a problem. This paper provides some information on the status and distribution of cranes in mainland Tanzania.

INTRODUCTION

Grey Crowned Cranes (*Balearica regulorum*) are large terrestrial birds inhabiting open grassland, marshes, and cultivated plains (Williams and Arlott 1980). They occur in many countries in Africa, including Tanzania, Kenya, Uganda, Zaire, Zambia, Malawi, Mozambique, Zimbabwe, Botswana, Angola, Namibia, and South Africa (Schoff 1991).

Cranes are very important birds in that they have ecological and socioeconomic values. Cranes are ambassadors of wetlands' well-being. Their presence tells us that the wetland is healthy enough to support them and other wildlife species (Schoff 1991; Kemin and Zhongqin 1987). The beauty of these birds attracts many people to watch and even study them. Some people trap and sell them as bird pets thereby earning income. But for proper utilization of this species, thorough understanding of their distribution and abundance in various habitats is important. Pomeroy (cited in Mafabi 1987) estimated the population of cranes in East Africa to be about 70,000 birds. This population estimate was made in 1982 and was based on scanty data from Tanzania. The crane population has not been accurately assessed in Tanzania and its status is not yet known.

This paper provides some information on status and distribution of Grey Crowned Cranes in the Tanzania mainland. More scientific studies are required, however, to identify more habitats as well as to establish their abundance.

METHODOLOGY

Information was collected from various people, mainly those involved in the bird trade, from published literature, and from the author's personal observations.

RESULTS AND DISCUSSION

Preliminary results show that cranes are widely distributed in Tanzania. According to some reports, cranes occur abundantly in Rukwa, Dodoma, Mara, and Arusha regions (Table 1). They inhabit wetlands including swamps, areas bordering bodies of water, river basins, and plains. The problem of crop damage (maize, millet, and rice) is reported to occur in areas where cranes occur in large numbers. In order to control them some farmers poison them. However this needs confirmation. The Department of Game in the Ministry of Natural Resources, Tourism and Environment has recently launched studies to establish areas where cranes cause damage to crops, and particularly where poisoning of cranes takes place. The aim is to allow trapping and exportation of some cranes in order to reduce the population of these destructive birds. Threats to cranes include poisoning and encroachment by local cultivators, bird trade, and grazing.

CONCLUSION

The collected information so far indicates that cranes are widely distributed in Tanzania. More studies however, need to be carried out to establish habitats of cranes in all regions of the country as well as to assess the extent of damage to food crops and control methods being used.

REFERENCES CITED

Frame, G. 1986. Crowned cranes at Ngorongo and Serengeti. Swara 9: 28-30.

Kemin, F. and Z. Zhongqin. 1987. The importance of wetlands in protecting birds. Pages 35-36 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

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Mafabi, P. G. 1991. The ecology and conservation status of the Grey Crowned Cranes in Uganda. Pages 363-367 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Schoff, G. 1991. Reflections: the story of cranes. International Crane Foundation, Baraboo, Wisconsin, USA.

Williams, J. G. and N. Arlott. 1980. A field guide to the birds of East Africa. Collins, London, UK.

Table 1. Grey Crowned Crane habitat in Tanzania.

Zone	Region	Habitats	Source
Lake	Mwanza	Mahaha, Bariadi, Geita Riharamulo	Reported
	Kagera (Bukoba)	Ngara swamps and along border with Rwanda	Reported
	Shinyanga	Kahama	Reported
Northern	Arusha	Serengeti National Park, Ngorongoro, Lake Manyara, Magugu, Babati, Mbugini, Arusha National Park	*Pers. obs*
	Kilimanjaro	West Kilimanjaro, Lower Moshi	*Pers. obs.*
	Tanga	No report	
Central	Singida	No report	
	Dodma	Bahi Swamps, Kondon	*In lit.*, Reported
	Kigoma	Uninza belt, Banda along border with Burundi	Reported
Southern Highlands	Iringa	No report	
	Mbeye	Nvawa Basin, Mlowo Mbozi, Itaka Forest	Reported
	Rukwa	Lake Rukwa, Mpanda	Reported
Eastern	Morogoro	Mtibwa Plains, Tuliana, Mvormero along Maskati River	Reported
	Dar es Salaam	No report	
	Coast region	No report	
Southern	Lindi	Masai along Rukuredi Valley, Nachingevea Forests	Reported
	Mtwara	No report	
	Songea	No report	

DAMAGE TO RICE BY GREY CROWNED CRANES AT LOWER MOSHI RICE IRRIGATION SCHEME, TANZANIA

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ABSTRACT

Grey Crowned Cranes are reported to cause to damage food crops in Tanzania. During two-year studies (July 1991-June 1993) on bird pests of rice at Lower Moshi Irrigation Scheme, covering over 1,300 ha., it was found that cranes occasionally cause damage to sowed seed and germinating seedlings in nurseries. Information is provided on foraging behavior, seasonal abundance, control methods being used by farmers, and the need for future research work.

INTRODUCTION

Grey Crowned Cranes (*Balearica regulorum*) are known to inhabit wetlands, but feed in a wide range of habitats including grasslands and agricultural fields (Gichuki and Gichuki 1987a, 1987b). Feeding in such crop fields as maize, wheat, and rice fields sometimes leads cranes into conflict with farmers, particularly when the cranes cause considerable damage to crops, inflicting loss to farmers (Filmer and Holtshausen 1988). Consequently, farmers may apply hazardous control methods like poisoning.

The problem of damage to food crops by Grey Crowned Cranes in Tanzania has recently been reported to occur. Crops damaged the most include rice, maize, wheat, groundnuts, and millet. No research had been done to evaluate the extent of damage or crop losses, however. In January, 1992, rice farmers at Lower Moshi Rice Irrigation Scheme reported to the author that cranes also cause noticeable damage to sown rice seed in nurseries. Only ducks and geese (*Anatidae*) had previously been known to cause such damage. In response to these reports, the Topical Pesticides Institute carried out studies on cranes' foraging behavior and monitored the seasonal fluctuations of cranes together with other rice bird pests, i.e., Weaverbirds (*Quelea quelea*), *Ploceus* spp., *Euplectes*, waxbills, ducks, and geese. The aim was to evaluate extent of crop losses due to cranes so that appropriate and safer control strategies can be developed. This paper provides information on seasonal abundance, foraging behavior, damage caused, and control methods being used by farmers.

STUDY AREA

Lower Moshi Rice Irrigation Scheme is located 3-15 km southeast of Moshi Town in Kilimanjaro Region, Northern Tanzania (Figure 1). Rice fields cover a total area of over 1,300 ha. of irrigated land in four closely located villages along the Moshi-Tango Line. Water for irrigation comes from the Rau River which originates on Mt. Kilimanjaro. The scheme was established in 1987 by opening more upland areas originally used for maize cultivation. The main objective was to increase and stabilize rice yield throughout the year through improved crop husbandry and use of a modern irrigation system. The three planting phases ensure availability of rice all the year. This cultivation practice attracts many granivorous birds and waterbirds. Of these about 21 species are pests because they regularly cause damage to crops. Lower Moshi receives short rains (October-December) and long rains (February-June).

METHODOLOGY

Ground surveys were conducted at least monthly from January 1991 to June 1993 to monitor occurrence and abundance of cranes in all fields under the scheme. Feeding habits were studied by killing some of the passerine birds for food content analysis as well as by observing their foraging activities in various feeding habitats, i.e., nurseries, flooded rice fields, uncultivated rice fields, and other nearby maize fields. Binoculars were used for making observations. An assessment of damage or crop loss was made in December 1992 by estimating the ratio of bare area with no seedlings to total nursery area. The assessments were made on one-quarter hectare plots. Control methods were evaluated on the basis of their effectiveness in preventing cranes from coming into cultivated rice fields and nurseries.

RESULTS

Cranes exhibited irregular occurrences with maximum flocking in November and December 1992. The birds were absent for 50% of total observations. They mostly occurred

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in pairs but flocked up to 26 birds in November and December 1992, and thereafter appeared in small numbers again. Point sample observations showed that cranes foraged mostly in uncultivated fields (70% total sampling time) and rarely in fields with either rice paddy (20%) or in nurseries (10%) (Table 1).

Examination of the stomach contents of two cranes shot while foraging in uncultivated rice fields on 7 March 1992 suggests that these birds are mainly feeding on rice seeds (Table 2).

Cranes arrived at the foraging site between 6 am and 7 am, mostly perching in trees within rice fields for about one-half to one hour before landing to feed. Landing place, duration in a particular feeding area, coverage, and concentration in foraging were influenced by flock size, presence or absence of other feeders, human disturbance, and food availability. Departures to roosting sites started between 5 and 6 pm. The damage to rice was assessed using standard crop damage assessment methods and found to be about 5-10% of total sample area. Seedlings in two other nurseries had been removed for transplanting. Farmers were unsuccessfully controlling the cranes by trying to scare them, by shouting, using noise-making appliances, and flying polyethylene flags. Birds did not fly away unless chased, in which case they flew to land within 200-500 m, then returned after a short time.

DISCUSSION

Results show that cranes exhibit seasonal abundance in the rice scheme. Two reasons may account for this habit: (a) cranes were feeding in grassland and in maize fields far away from rice fields; or (b) they may be spending most of the time in breeding habitats or other wetlands away from the habitats, and hence were not detected by the author. Such seasonal abundance is in agreement with observations by Filmer and Holtshausen (1988) who reported that although the flocks of Crowned Cranes often used agricultural fields, they were more frequently seen on vleis and grasslands. Staying in breeding sites is supported by Frame (1986) who observed that Grey Crowned Cranes in the Serengeti plains (northern Tanzania) nest from January to May. Studies are still needed, however, to establish the breeding habits of cranes coming to the rice scheme.

Foraging frequently in uncultivated fields results from the presence of dropped seed left over from harvesting a too-dry paddy. Optimal foraging in uncultivated fields is enhanced by a lack of human disturbances. In fields with rice, cranes may be feeding on insects (Gichuki and Gichuki 1991) but such foods are likely to be scarce because hundreds of insectivorous waterbirds like egrets, Blacksmith Plovers, ibises, etc., compete with them for food. Scarcity renders these insects a less preferred form of food. In nurseries there is abundant food because sown seeds are on the surface and visible to cranes. If cranes chance to get in, i.e., in the absence of human disturbance, they optimize their feeding efficiency. In this case they congregate together to utilize the resource, causing crop losses or crop damage. Such damage in nurseries have been caused by ducks and geese for many years.

On most occasions, cranes have been observed feeding with Egyptian Geese, Spurwinged Geese, and rarely Knob-billed Ducks and European White Storks. Such social behavior ensures security because geese and ducks are always sensitive to approaching man. Cranes are not easily scared possibly because they are accustomed to people who do not harm them. They also see other waterbirds feeding close to farmers and easily learn that scare crows are not injurious. Ducks and geese always fly away because they are hunted by people for food. Perching in trees helps cranes to view co-feeders and areas with no disturbance. Pairs or small flocks of up to 5 birds fed close together, but large flocks of 26 birds foraged in extended positions while advancing forward, then making U-turns, and maintaining spatial distance of up to 150 m wide from people. Large flocks were seen foraging with goats and sheep.

CONCLUSION

Results obtained indicate that cranes occasionally cause damage to sown rice seed and newly germinating seeds in nurseries. The damage can be severe where flocks of cranes are large and in the absence of effective control methods. Safer pest management techniques like effective use of bird scaring devices or human scarers should be encouraged.

FUTURE RESEARCH

Future research for this area should include the establishment of the breeding habitat of cranes coming to feed in the rice scheme, and country-wide studies on the ecology of Grey Crowned Cranes, evaluation of damage to various food crops, and consideration of safer control measures.

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REFERENCES CITED

Filmer, R. and M. Holtshausen. 1988. National crane census. Crowned crane II: 22.

Frame, G. 1986. Crowned cranes at Ngorongoro and Serengeti. Swara 9: 28-30.

Gichuki, N. N. and C. M. Gichuki. 1987a. Crowned crane update. Conservation bulletin (The Wildlife Clubs of Kenya) 1(1): 5-6.

Gichuki, N. N. and C. M. Gichuki 1991. Relationships between habitat selection and flock characteristics in foraging Grey Crowned Cranes *Balearica regulorum* in Kenya. Pages 357-361 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Table 1. Number of cranes spotted in different habitats in Mt. Kilimanjaro area, northern Tanzania, from January 1992-July 1993, where u = uncultivated fields; c = cultivated fields (rice); and n = nurseries.

		Month											
		Jan.	Feb.	Mar	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.
1992	No.	0	2	5	0	0	2	0	0	0	0	21	26
	Habitat	-	u	u	-	-	-	-	-	-	n,u,c	n,u,c	-
1993	No.	0	0	0	0	2	2	0	-	-	-	-	-
	Habitat	-	-	-	-	-	c,u	u	-	-	-	-	-

Table 2. The composition of food items found in the esophagus and gizzard of a male and female crane.

Sex	Body wt.	Gonad size	Food Composition by weight (gm) Rice seeds	Grits	Total
Male	ca 5 kg	small	3.5	8.0	11.5
Female	ca 5 kg	small	2.8	6.5	9.3

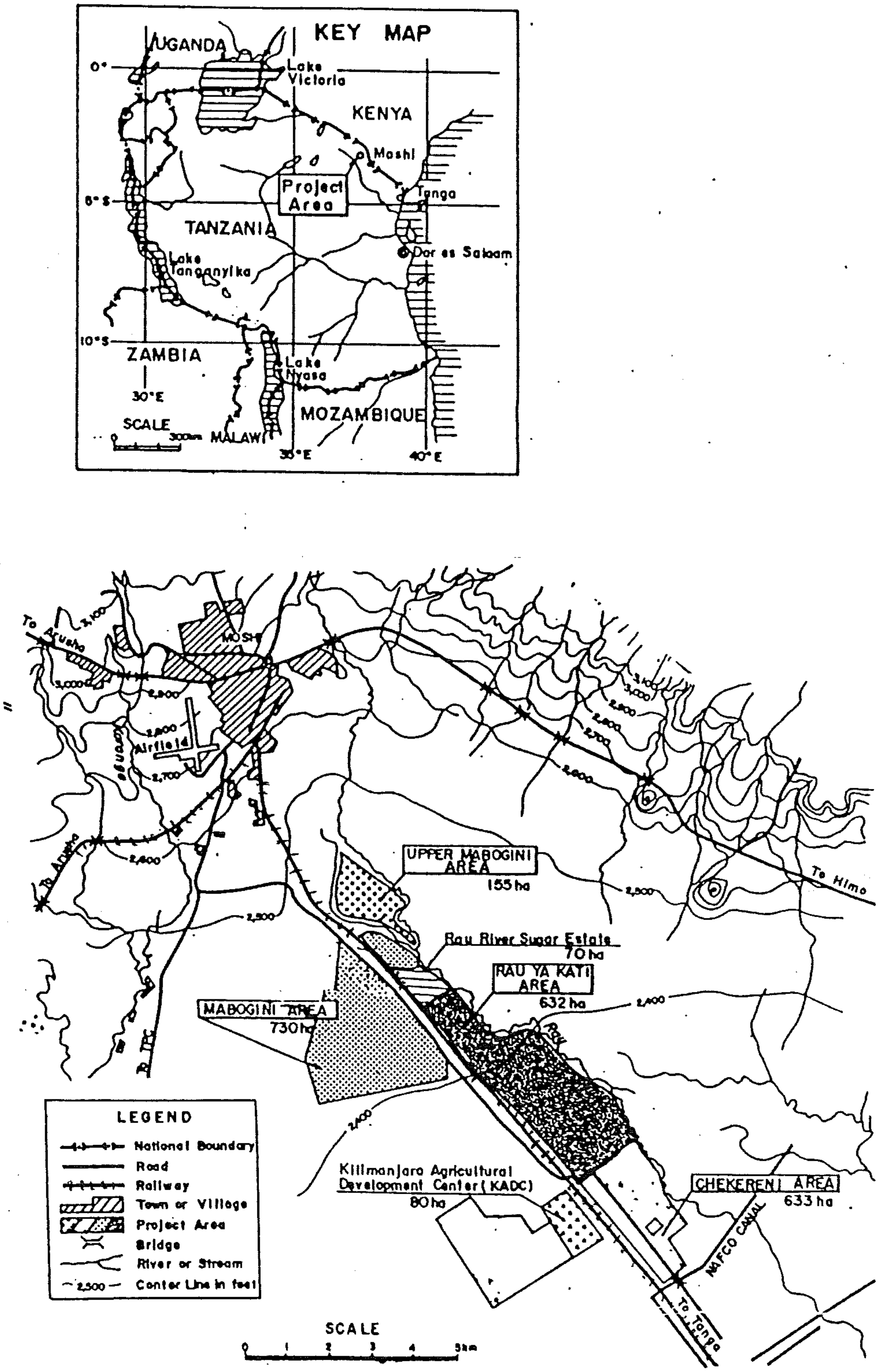

Figure 1. Map of Lower Moshi Irrigation Scheme

THE EFFECTS OF PASTORALISM ON GREY CROWNED CRANES AT WEST KILIMANJARO RANCH, TANZANIA

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ABSTRACT

The Grey Crowned Crane (*Balearica regulorum*) is a large stately terrestrial bird which inhabits open grasslands, cultivated areas, and marshes. West Kilimanjaro Ranch is located in the northeastern part of Tanzania's Kilimanjaro region, on the western slope of Mount Kilimanjaro. West Kilimanjaro Ranch comprises two farms joined in 1976 under the Ministry of Agriculture. This study was carried out on that state farm which deals with agricultural crops and livestock production. The 1,200 km^2 area is cultivated on rotating basis with wheat and pasture. During this study, the farm had about 1,200 cattle that grazed on the same feeding grounds as cranes, sheep, and goats. We made preliminary observations in November 1992 while we were researching the effects of organochlorine compounds on higher fauna. When we observed cranes in West Kilimanjaro Ranch, I decided to carry out a point survey to determine the roosting and feeding behavior of cranes. We conclude that grazing cattle affects the feeding and foraging behavior of cranes.

INTRODUCTION

Grey Crowned Cranes (*Balearica regulorum*) forage for food in a wide range of terrestrial and semi-aquatic habitats. They forage singly, in pairs, in family groups, and often in flocks (Gichuki and Gichuki 1987). Pastoralism has been found to affect the feeding and roosting behavior of Grey Crowned Cranes (Flavian 1988).

The West Kilimanjaro ranch is located on the western slope of Mount Kilimanjaro, about 150 km from Arusha (Figure 1). The ranch focuses on cattle rearing as well as the production of pasture and wheat.

METHODS

The observation was done intermittently for a period of 28 days, between 10 June and 15 July, 1993. We monitored the cranes in an area of about 1,200 acres where the cranes forage, drink, and roost. The continuous observation method was used, conducted from 6 a.m. to 7 p.m., in order to determine the following:

- time of arrival and number;
- time of feeding and drinking;
- time of departure and return for feeding and drinking;
- interaction of cattle grazing with foraging behavior of cranes;
- the records of birds foraging alone or in groups.

RESULTS

The time of arrival, departure, foraging, and drinking are shown in Table 1. The activities recorded were performed by 90% of all birds observed during each hour of observation. The birds stayed at the drinking place for about 5 minutes and then dispersed to the feeding grounds.

The cattle apparently interfere with the cranes' eating and drinking. When feeding cattle approached the cranes in their feeding grounds at a distance of about 15-20 m the cranes flew away, but when the cattle fed far away, the cranes continued to feed in extended lines and to move in a forward direction. When the cranes were approached on their feeding ground by cattle or human beings, they formed a group, then ran away and dispersed.

The cattle were observed to destroy the cranes' drinking place by stumbling and blocking the water channel and by defecating and urinating into the water, contaminating it. The cattle also ate the grasses, leaving the water area bare or open; this increased evaporation. Finally, after weekly dipping for pest control, the cattle rested at the drinking places, possibly contaminating the water with acaricide. Research is needed to ascertain this.

CENSUS

The census was established by counting the number of cranes during arrival at the drinking places very early in the morning, at 6:15 a.m., and during late evening when the cranes returned to roost. We counted 200 cranes at West Kilimanjaro ranch.

BEHAVIOR

Before coming to drink water the cranes were observed to survey environs of the drinking site as if to make sure there were no cattle, people and other hazards. Their roosting sites were on top of thorn trees, close to a drinking site.

DISCUSSION

From our observations, it seems that:

- disturbance by cattle and human beings affects foraging and feeding behavior of cranes when they are approached;
- cranes do, sometimes, feed in groups which shows that they increase foraging efficiency and feeding;
- food dispersion may be the reason why cranes disperse in small groups in different parts of the field.

CONCLUSION

From the results observed, it can be concluded that grazing activities of livestock affect the feeding and foraging behavior of the Grey Crowned Crane. Cattle and sheep compete for grain food with cranes. Research should be undertaken to determine the effects of human activities on feeding behaviour of cranes. Human disturbance reduces the time spent feeding as the level of vigilance increases.

In 1991, about 15 cranes were caught alive from this area for export (*pers. obs.* and questionnaire). This off take of the cranes should be studied so as to determine its effects on the population. Finally, I would recommend a thorough study of cranes in West Kilimanjaro ranch at different times of the year so as to determine the cranes' ecology and breeding sites.

ACKNOWLEDGMENTS

I would like to take this opportunity to thank NAFCO management for allowing me to carry out my research on their premises and for giving me information from their offices. I would also like to thank the International Crane Foundation for providing me with literature on cranes, and the Director of my institute, Dr. F. W. Mosha, for giving me time and assistance to carry out this research.

REFERENCES CITED

Gichuki, N. N and Gichuki C. M 1988. The behaviour of the Grey Crowned Cranes *Balearica regulorum* in North Swamp, Naivasha, and its implications for their conservation. Pages 63-70 *in* L. Bennun, ed., Proceedings of the Seventh Pan-African Ornithological Congress. Nairobi, Kenya.

Gichuki, N. N and Gichuki C. M. 1991. Relationships between habitat selection and flock characteristics in foraging Grey Crowned Cranes *Balearica regulorum* in Kenya. Pages 357-361 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Mafabi, P. 1991. The ecology and conservation status of the Grey Crowned Crane in Uganda. Pages 363-367 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Mafabi, P. 1988. The effects of swamp reclamation on grey crowned cranes in Doho Uganda. Pages 75-80 *in* L. Bennun, ed., Proceedings of the Seventh Pan-African Ornithological Congress. Nairobi, Kenya.

Urban, E. K. and Gichuki N. N. 1991. Recent research and conservation activities with cranes in Africa. Pages 351-355 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Table 1. Activity chart of the Grey Crowned Crane at West Kilimanjaro ranch, June-July 1993.

Activity	Time 7am	8am	9am	10am	11am	12am	1pm	2pm	3pm	4pm	5pm	6pm	7pm
Plucking	-	-	-	-	+	-	-	+	-	-	+	-	-
Arrival	-	-	-	-	-	-	+	-	-	-	-	-	-
Feeding	+	+	+	+	+	+	+	+	+	+	+	+	-
Drinking	-	-	-	-	-	-	+	+	-	-	-	+	-
Playing	-	-	-	-	-	-	-	-	-	+	-	-	-
Flying	-	-	-	-	-	-	-	+	-	-	-	+	-
Resting	-	-	-	-	-	-	-	-	-	-	-	-	-
Perching	-	-	-	-	-	-	-	-	-	-	-	-	+
Walking	+	+	+	+	+	+	+	+	+	+	-	+	-

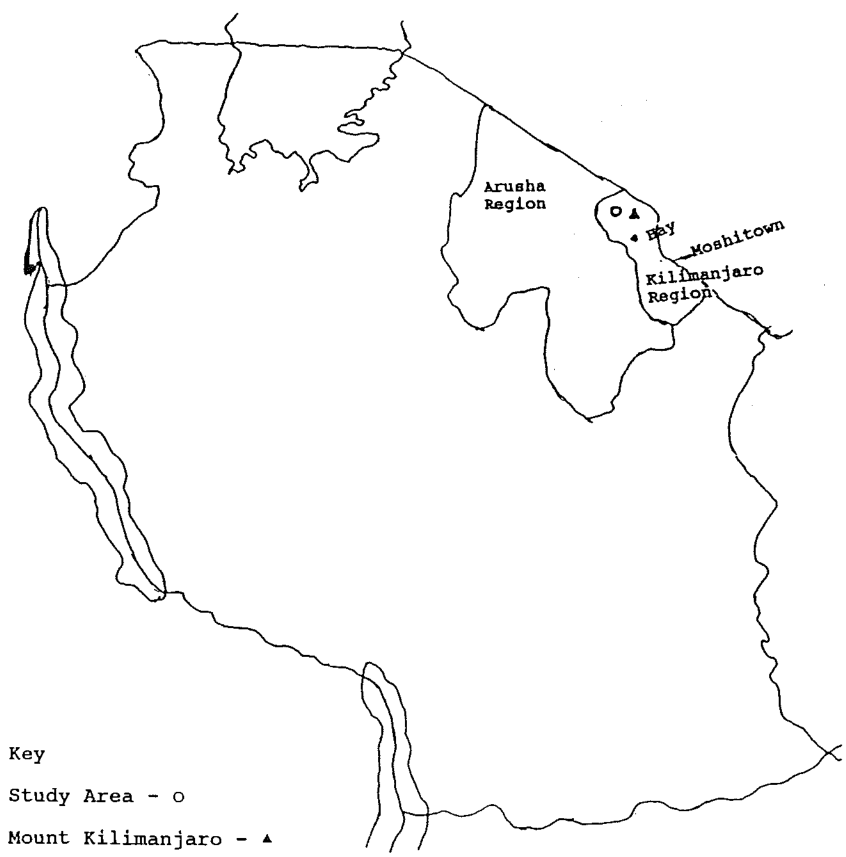

Figure 1. Map of Tanzania showing the study area near Mt. Kiliminjaro.

CONSERVATION EDUCATION IN TANZANIAN SCHOOL CURRICULUM

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ABSTRACT

This study is an assessment of conservation education in the Tanzanian schools curriculum. Because of the youth-heavy age distribution of the Tanzanian population, more emphasis is given to the primary schools curriculum assessment. The information was collected through visits and interviewing teachers, education administrators, and officials from schools, government organizations, and non-governmental agencies. The scope of the study includes descriptions of the work being done by governmental education agencies and that of non-governmental organizations, the interests and needs of schools compared with the plans and work of policy makers, the theoretical conflicts involved with planning and implementing conservation education, and recommendations for creating effective, value-based, behavior-altering programs. It finds conservation education projects in place which offer some reasons for hope, but limited funding, lack of coordination, and the slow nature of affecting attitudinal change currently prevent these programs from achieving the expansions and improvements they require. This paper recommends the immediate review of the primary schools syllabi to include relevant and practical environmental education, and argues for the design of problem-solving oriented curricula as a proper approach to providing instruction in conservation education.

INTRODUCTION

The population of Tanzania is growing at an alarming rate. The 1988 census showed that over 45% of the population is under fifteen years of age (Bureau of Statistics 1993). As this population exerts increasing pressure on the country's natural resources, environmental problems multiply at a rate to match the multiplying humans.

In the last half of a century, a nation historically populated by small tribes who lived in balance with nature has suddenly been confronted with environmental problems, among them deforestation, desertification, loss of biological diversity, and pollution of the air, soils, and water. As in other developing countries, the primary concern of most people is not how the environment can be protected for the future, but rather on how it can be used now to improve socioeconomic development and the material standard of living (Osaki 1991). Such an attitude, combined with existing population pressure and land use trends, seem to preordain a national future of insurmountable social, health, political, and economic problems.

It is clear that if catastrophe is to be avoided, action must be taken immediately to alter the course of present trends. The most obvious solution is education, the distribution of information that will enable people to understand their own impact on the earth and ways they can live sustainably upon it, both for their own health and economic benefits and for the benefit of future generation. Many Tanzanian projects are based on the idea that economic incentives alone will motivate the country's population to conserve natural resources. However, conservation education is based on a broader concept that people need to be empowered through awareness.

The historic path of Tanzania's formal educational system has not been easy, frequently interrupted, misdirected,and manipulated to meet the ends of colonial governments, and in 1969 the government announced the long-term goal of providing primary education to the whole nation. The result of this project, called Universal Primary Education, has been that in the intervening years the percentage of people attending primary education has swelled from 47% in 1969/70 to near 100% today (Ministry of Education and Culture 1993), and the greatest proportion of these people are children. Given the age distribution of the country's population, targeting primary school children for massive conservation education campaigns makes excellent sense, since such an effort would reach nearly half the citizens at a time when they have yet to make inflexible lifestyle decisions. Any knowledge they gain now and internalize may directly affect the environmental quality of their life choices. Since only 4% of children go on to secondary schools, that educational level is clearly too late to be an effective mass outreach tool.

This paper intends to examine the conservation education work that has been done and that which is currently being carried out in the context of Tanzania's political, economic, and cultural history, and to assess the future needs for implementation of this essential subject. It also looks at the history of education in Tanzania before, during and after colonialism, and the evolution of conservation education in school curricula in Tanzania.

METHODS

Research took place in two phases. First, four primary schools in the Arusha area were visited. These schools were selected in an attempt to see a range of types of primary schools, and to balance the much less common English-medium schools with more representative Swahili-taught schools.

In each school teachers and administrators were interviewed to gain a sense of their view of conservation education in the schools and the state of education in general. Syllabi, schemes of work, textbooks and other materials were examined. Several classes were observed to gain an understanding of how classes are taught and perhaps to observe the imparting of environmental and conservation information.

Each interviewee was informally asked his or her opinion of whether conservation education exists now in primary schools, and if so in what form. This question was included to ascertain the level of awareness of what conservation education is.

Other questions included the subjects' views on the importance of conservation education and the ideal manner in which it should be taught, how lessons and syllabi are created and how much flexibility teachers have in this area, their school's greatest needs and concerns, and whether children were affected differently by the use of oral literature and African-created texts than by ones which feature Anglo-American situations and people.

The second phase involved obtaining information on conservation education from the officials at various government agencies and non-governmental organizations (NGOs). Among the agencies visited were the Ministry of Education and Culture, Institute of Curricular Development, Arusha Regional Education Office, National Environmental Management Council of Tanzania, World Wide Fund for Nature, Mali Hai Clubs of Tanzania, Wildlife Conservation Society of Tanzania, Tanzania Society for the Protection and Care of Animals, Journalists' Environmental Association of Tanzania, and Family Planning Council of Tanzania.

The intention of conducting these interviews was to compare the action and opinion of the decision makers with the reality, opinions and needs of the schools, and in each case the interview questions were similar to the ones asked in the first stage of this research.

RESULTS AND DISCUSSIONS

Traditional heritage, colonial, and post-independence education

Tanzania's educational history may be divided into a traditional heritage period, a colonial period, and a post-independence period. The first took place from the earliest African societies until the 1880s, when Arab and Islamic influences arrived in Africa.

Education in these early societies was informal, holistic, and practical, focusing on things that were important to life within the particular community, useful plants and animals, survival skills, family history, tool-making, hunting, agriculture, fishing, and so on (Osaki 1991). Contrary to the long held European belief that education had been nonexistent in these societies prior to the introduction of Western schooling (assumed because Africans had no system of reading and writing), traditional education was oral, based on myths, legends, proverbs, poems, songs, and daily conversation. Along with skills, these methods imparted the culture's attitudes, morals, and values to their children (Lusweti 1992), and thus shaped the early society of Tanzanians.

The colonialist period took place between 1885 and 1961, when Tanzania was controlled first by Germany (1885-1919), and then by Britain (1919-1961). In instituting their own educational systems, the two European countries aimed at creating docile, dependent society who could provide a market for colonial goods, not to educate children in a manner consistent with their needs and way of life. Britain's curriculum was actually an imported one originally designed for British children, and its advocates worked to wipe out any remnants of traditional African education (Osaki 1992).

In the 1940s and 50s, Britain established what was known as "education for adaptation," a suspiciously practical program that emphasized farming, carpentry, crafts, and other vocational instruction while aiming to develop "attitudes of loving the village environment" (Osaki 1992). As with all colonial government decisions, though, this was made with an ulterior motive to further colonial ends since after World War I Europe was desperately in need of raw materials. Therefore, "education for adaptation" taught Tanzanians to grow, make, and supply materials to meet this demand (Lawuo 1977). The textbooks used for Tanzanian children during this time were adaptations of those created for American slaves, while the white colonialists' children studied "academic" subjects in separate schools (Osaki 1992).

It is not surprising, then, that when Tanzania gained independence in 1961, people scorned educational practices that might be termed "practical" or "agricultural" in favor the academics they had been exposed to but denied during colonialist rule. In this early post-independence period, more than 75% of teachers were still European, and the chance of a modern education leading to a white collar job was a dream of most Tanzanians (Osaki 1983).

In 1967, though, the Arusha Declaration outlined a plan for education for self-reliance, proclaiming that theoretical colonial academia could not meet the needs of the newly socialist, self-reliant nation. Education for self-reliance intended to prepare pupils to live the kind of life which would enable them to survive and contribute to the development of their own villages and towns. The focus was on practical agriculture; for example, agriculture was designed as a subject and no longer just a topic within the science syllabus. Soon after this, Universal Primary Education was launched and shifted the next two decades of educational energies into building enough schools for all children, equalizing the education gender ratio, and increasing the national literacy rate for both youth and adults (Ministry of Education 1989).

In the last few years, rumblings of discontent have become audible concerning education for self-reliance. While it is reported that the number of primary schools has been greatly improved, females are now equally represented in primary schools, and illiteracy among the youth has nearly been eradicated. However, there still exists a vast need for technical knowledge that will equip the youngest generation with the skills they need to live.

Education theorists re-examining the curriculum hence declare that it is still dominated by colonial values and expectations that bear little relation to life in Tanzania and the Third World at large. Policy makers at the Ministry of Education and Culture and Institute for Curricular Development join the leagues of academics who have grappled with questions of the real educational needs of today's Tanzanian youth, searching for the balance between knowledge necessary for much-desired white collar jobs, jobs typical of the developed world, and work necessary for agriculture and rural subsistence.

We still expect to see some changes in educational trends in Tanzania, especially after the collapse of socialism and the adoption of a free market economy. Unlike socialism, a free market economy advocates for privatization as the best approach to improving the local and national economy. Therefore, many schools may fall into the hands of individual business people and mislead the schools' curricular review and development efforts in Tanzania. The converse may also be true, however, as most individuals are now aware of the fact that human survival is behind the cries to conserve the natural environment.

Present curriculum

There was general agreement among those interviewed that in the curriculum currently being used in public schools in Tanzania, conservation education exists as a topic integrated into a number of subjects, and is particularly visible in science, history, geography and agriculture.

Opinions varied as to the quality of what is taught. Both the government curriculum defining what is to be taught and the syllabi created by teachers for their own use supported this response.

Topics visible in teachers' lesson planning included soil erosion, and fertility, the importance of national parks, types of protected areas, relationships between animals and plants, energy source and flow, how trees grow, and animal adaptations to the environment. Many of the topics, especially in environmental knowledge in Tanzania are presented in agriculture classes, including fertilizers and pesticide use, reforestation, soil erosion, and cultivation methods.

All schools sampled organized occasional visits to national parks and equivalent reserves for some classes or some students, but even with park entrance fees waived, the cost of transportation to the parks prohibited many pupils from participating in the trips. Also the way the trips were organized and conducted was important in order to impart to students relevant environmental knowledge.

Situation in schools

The budget constraints, shortages, and non-availability of materials in this country is felt even in the wealthiest schools and the most central subjects. Nearly every teacher complained not only of the lack of maps, charts, supplementary books, reference books, and other teaching aids, but also the dearth of such basics as textbooks, exercise books, pencils, desks and classrooms. The salaries are not high enough, making teachers' morale very low. It was observed that teachers are forced to take on additional jobs which affects their participation and attendance in classes.

It is not uncommon to see classrooms which are overcrowded. Many schools have resorted to having half of their pupils come in the morning and the other half in the afternoon since they don't have sufficient classroom space to house all their students at once. Communities, government agencies, and NGOs are all aware of the situation, however, and are engaged in local and national campaigns, and other efforts to improve it.

The limited availability of relevant books sometimes constrains the conduct of teaching. A set of British-made books found in one English-medium school pictured fruits, birds, and amphibians not found in East Africa. Although the subject of the books related to the natural world, they raised the question of whether pertinent environmental teaching can be done using such materials. Use of common examples of East African origin and context (i.e., songs, traditional stories, etc.) would be more meaningful to our children in primary schools.

A new syllabus

The National Environmental Management Council's 1991 recommendations were considered when the Institute for Curricular Development made broad curricular revisions that are currently being tried experimentally in a few schools. Preliminary evaluations of the new curriculum have been positive, and it will likely to expanded to more schools and then implemented nationwide within the next five years.

The most drastic change in the curriculum is the reduction of subjects from thirteen to seven. Kiswahili, mathematics, English, science, and religion remain discrete subjects as before, but history, geography, and political education have been combined into "social studies," and domestic science, agriculture, art, sports, and music have been combined into "life skills."

This new curriculum integrates more environmental education into its subjects that the old did, since curricular developers are being encouraged to reflect environmental topics within all subjects. Also, this curriculum concentrates more on theoretical teaching though the word "practical" is included in virtually every line of the new syllabi. Practical learning including hands-on out-of-classroom experience needs to be emphasized for primary school children to get the intended message.

Other environment-related topics in the new science syllabus include identification of clean drinking water and safe drinking water sources, water boiling and filtering, establishment and cleaning of latrines, benefits of plants and animals, prevention and control of communicable diseases (including AIDS and STDs), necessary elements for growth and survival of plants and animals, symptoms and avoidance of malnutrition, features of a balanced and healthier diet, prenatal care and the importance of breast-feeding, and the importance of soil, plants, animals, and wetlands to humans.

Other actions

Beyond government curricula, many people and organizations are engaged in work related to environmental education. Because of the recent advent of environmental education in this country, additional undertakings are constantly beginning and new organizations are being formed.

The National Environmental Management Council (NEMC) established in 1986, has been making efforts to collaborate with other agencies working on common issues. Over the last few years they have organized a number of workshops, seminars, panels, and committees intended to create a forum for government and non-government environmentalists to pool their knowledge and designated responsibilities, so they may use their collective energies most effectively.

As a result of this designation of duties, NEMC has been responsible for carrying out environmental education seminars for primary school teacher trainers, people who are responsible both for the training of new teachers and the in-service training of existing teachers. It is hoped that by sensitizing tutors to the importance of environmental issues, equipping them with a solid background of information, and suggesting ways teachers can incorporate the topic into their lessons, this target group will be a good vehicle of information dissemination.

The World Wide Fund for Nature's (WWF) environmental action program in Tanzania began work only in May 1992, but has already established strong ties with other organizations, undertaken several major projects, and is in the planning stage of a multitude of others.

WWF focuses on conducting seminars for primary school inspectors who help teachers to improve, leading formal and informal motivational educational sessions for teachers, and providing feedback to the government on the quality of education they observe. Inspectors encourage teachers to take students outside the classrooms to explore their environment I believe that this is a right approach for giving more practical environmental education for primary school children.

Also, WWF is in the process of beginning workshops to train journalists on environmental reporting, workshops for various religious leaders to suggest ways in which religious teaching can spread a conservation message, and workshops for curriculum developers on how environmental topics may be included within virtually any syllabus.

The Ministry of Education and Culture (MoEC) on the other hand has been working on tutor and inspector environmental training since 1986, and their efforts have been supplemented recently by the work of NGOs. The MoEC has led approximately one training workshop a year for secondary school teachers and tutors since 1986, and last year began workshops for inspectors aided by WWF.

In the mid-1970s a German organization helped the government to begin a Polytechnical Education Support Program (PESP) to train agriculture teachers and distribute them to schools. The project concentrated on environmentally-sound, sustainable, high yield methods of agriculture that had previously been unheard of in rural villages, and was deemed so successful that the government extended the program to the whole country. A result of this ongoing program is that every primary school in the country now has at least one teacher specially trained in sustainable agriculture.

Mali Hai Clubs of Tanzania is an organization centered mostly on the creation and running of extracurricular conservation clubs for secondary school students. Mali Hai Clubs considered secondary school children a better target group than primary because at their age are able to mobilize active clubs that require minimal adult supervision. Mali Hai also produces a magazine, organizes field trips (mostly to natural or degraded sites rather than national parks), and conducts classroom visits where children receive environmental information through games and experimental learning.

Recently, Mali Hai received a grant to participate in a national biodiversity and wetlands campaign, and their role will be to prepare Swahili primary and secondary school educational materials, a videotape, posters, tapes, slides and a teacher's kit, and to organize workshops to present the kit to teachers.

The Wildlife Conservation Society of Tanzania's (WCS) main function is to raise funds for distribution to other environmental organizations and to organize secondary school wildlife clubs that engage in similar activities as the Mali Hai Clubs. WCS is fully involved in tree-growing and planting campaigns, picking up garbage, viewing wildlife films, and making trips to natural and degraded sites, and it distributes a handbook containing ideas on club activities. The society organizes occasional student essay contests with prizes including cash, environmental books, and trips to national parks.

Recently, in conjunction with the Soil Erosion Control Agro-forestry Project, the society conducted a needs assessment study, and designed and produced a book for distribution in schools and villages. This book has recently been incorporated into lessons in six different subjects in the primary school curriculum, mostly for standards three and four.

The Serengeti Conservation Education Project is one of the national park community conservation projects that has a unit working specifically on education of children. This project runs conservation clubs for children in standards five and six and organizes essay contests and other competitions, and it has just prepared a teacher's handbook containing conservation lessons and activity ideas.

Tanzania National Parks is expected to create multifaceted visitor education centers in almost every national park in the country, and they will be major sources of funding for nationwide environmental education programs related to national parks. These educational centers will also be sources of environmental information for children who visit the parks in Tanzania.

Community conservation projects in other national parks are helping local people living adjacent to the parks in the construction of classrooms in primary and secondary schools. Lake Manyara National Park has recently constructed one classroom for Mto wa Mbu secondary school.

The Journalist's Environmental Association of Tanzania (JET) was started in 1991 to fill a need the NEMC recognized, namely a lack and or improper coverage of environmental issue in the media in Tanzania. JET has plans to begin a traveling primary school environmental education program soon.

CONCLUSION AND RECOMMENDATIONS

Several environmental topics are present in the primary school curriculum and NGO projects being undertaken in Tanzania. The only serious backsliding may be the apparent reduction in importance of agriculture by compressing it into life skills, where it cannot receive the time allotment it requires. Conservation education in the primary school curriculum needs to be a discrete subject for the children to understand the concept.

All the work being done to raise environmental awareness is commendable, but there are drawbacks: the lack of coordination between the government institutions' and NGO programs, and the absence of two broad elements in these projects. The first missing element is an emphasis that human activity is the cause of all environmental problems, and that modification of human lifestyles can avert environmental catastrophe.

The second is a provision of alternatives and suggestions for practical action. Many materials in the Tanzanian schools curriculum contain negative messages, and rarely include alternatives. Unfortunately, our current environmental knowledge includes a much greater awareness of the problems than the solutions.

Other important issues which are lacking in Tanzanian schools' curricula are the effects and control of human population growth. The most important step and approach to conserving the natural environment is to control the potentially disastrous growth rate of human population.

Therefore, curriculum development and changes can most efficiently be reviewed by adapting to the changing needs and technology, and looking at the current issues facing conservation in Tanzania (Manongi *this proceedings*).

The limitations of the teaching methods most often used in Tanzania's schools will degrade the quality of environmental education. The present approach to teaching and learning in Tanzanian schools is restrictive.

Another limitation in the educational methods currently being employed in the Tanzanian curriculum is the repetition of exactly the same topics each year of school, to be covered in supposedly increasing depth. Although spaced repetition of information has indeed been shown to be an effective learning tool, excessive repetition loses children's interest, may cause confusion, and wastes valuable time during which a broader range of environmental topics could be covered.

The lack of morale among teachers can also affect the quality of environmental education being offered. Enough and proper facilities and teaching aids are necessary in schools and would always improve the teaching-learning environment.

The current trend toward "practical education" and outside-of-classroom learning is a good approach to teaching environmental education. The use of practical, relevant and common example is vital. Traditional oral literature, beliefs, customs, and songs that contain conservation ethics, can provide relevant information about the value of conservation to children.

Regular evaluation of the quality of existing conservation education programs is necessary in order to determine whether these programs are effective enough not only to convey the facts, but also to change people's attitude and actions. This should be our goal.

REFERENCES CITED

Bureau of Statistics. 1993. Statistical abstract. Planning Commission, President's Office, Dar es Salaam, Tanzania.

Lawuo, Z. E. 1977. Education and change in rural community: a study of colonial education and response among the chagga and Kilimanjaro between 1920 and 1945. Ph.D Thesis. University of Dar es Salaam, Dar es Salaam, Tanzania.

Lusweti, B. M. 1992. The hyena and the rock: a handbook of oral literature for schools. General Printers, Nairobi, Kenya.

Ministry of Education and Culture. 1989. Implementation of Universal Primary Education. Printpak (MTUU), Dar es Salaam, Tanzania.

Ministry of Education and Culture. 1993. Basic education statistics in Tanzania: 1988-1992. Ministry of Education and Culture, Dar es Salaam, Tanzania.

National Environmental Management Council. 1992. Recommendations for incorporating environmental education in school programmes. NEMC, Dar es Salaam, Tanzania.

Osaki, K. 1983. The environmental "problems" and Tanzania: unimparted wisdom or underdeveloped science teaching? M.A. Thesis. Chelsea College, University of London, UK.

Osaki, K. 1991. Factors influencing the use of the environment in science teaching: a study of biology teaching in Tanzania. Ph.D. Thesis. University of Alberta, Alberta, Canada.

Osaki, K. 1992. Perspectives on environmental education and research: a review of the literature. University of Dar es Salaam, Dar es Salaam, Tanzania.

WETLANDS IN WILDLIFE MANAGEMENT TRAINING

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ABSTRACT

Wetlands support dense populations of wild animals and plants in and outside protected areas, but the management of wetlands for wildlife entails managing externalities than of managing forces inside protected areas. The College of African Wildlife Management trains middle cadre protected area staff from anglophone Africa. Today, there are few (if any) training institutions which provide instruction with a multidisciplinary approach to wetland management. Currently, the College is in the process of reviewing its syllabus. Curriculum changes in wildlife management training can most efficiently be reviewed by adapting to changing needs and looking at the issues facing wildlife conservation and management in the region. In the initial stages of its development, the need to include and improve some aspects of holistic wetland resource management and conservation in the College curriculum has evolved.

INTRODUCTION

From the wildlife management standpoint, wetlands could be defined as those areas that are inundated or saturated by surface or under ground water at a frequency and duration sufficient to support natural vegetation and wild animals. Wildlife embraces all life which is not tamed, ranging from microscopic fungi (and zooplankton) to giant forest trees (and elephants).

Wildlife management by definition is the management of human activities that affect wildlife and human use of resources, or manipulation of wild animal (or plant) populations, their habitat, and interaction between the two in order to achieve predetermined objectives. The main objectives of managing wildlife populations are to make sure that balance is achieved between wildlife populations and their habitat, and that wild animals and plants survive to the next generations; and to ensure that use of wildlife resource is sustainable for the benefit of mankind.

Management of wildlife may therefore consist of complete protection of habitat in order to keep it suitable for animals and plants (passive management). Under other circumstances, drastic modification of habitat must be effected if wildlife populations are to be produced and maintained (active management).

The College of African Wildlife Management was established in 1963 to train middle-level wildlife managers from anglophone Africa. To date, the College has trained more than 1,500 protected area staff from Africa and abroad.

WETLANDS AND WILDLIFE MANAGEMENT

Many wetlands support dense populations of wild animals that feed on the nutrient rich waters or substrate, or graze on the lush pastures. Wild animals may breed in wetlands or visit them during migrations. Wetlands have great potential to support biodiversity including birds, reptiles, mammals, amphibians, fishes, and insects, as well as plants.

The distribution and abundance of wildlife and the movements of wild animals in and around protected areas are controlled by the quality and availability of water. Basically, management of water sources and resources is vital in managing wild animals and plants in protected areas.

Most wildlife reserves in East Africa (and elsewhere) are based upon a wetland (lake, swamp, floodplain, etc.). This is the reason for concentration of large mammals and birds inside parks. More often than not, wetlands originate in, pass through, or occur in the protected areas. The siltation, pollution, and alteration in water flow that threaten many wetlands have their origins beyond the protected areas. Unfortunately, management of wildlife in many African countries is confined to within the boundaries of national parks and equivalent reserves.

Thus it is clear that the quality and quantity of water available to wildlife in protected areas and wetlands depends very much on other land users, and that this has significant effects on the survival of wildlife species elsewhere. We should understand and appreciate that wetlands, their teeming life, land ecosystems and different land use practices are ecologically interdependent, and that they are parts of a whole.

Therefore, management of wetlands for wildlife is managing externalities, and this must take place within the broader context of river basin and coastal zone management.

The college has basically four major courses: special course, certificate, diploma, and postgraduate Diploma in wildlife management. Several classes in the current curriculum address various aspects of wetland management. (Table 1.)

IMPROVING WETLAND MANAGEMENT TRAINING

As stated earlier, managing wetlands for wildlife is management of external forces. Looking at the current College syllabus suggests that more emphasis is given to the inventory and management of wetlands inside protected areas.

In our curriculum review workshops we identified problems facing protected areas and wildlife management in Africa. The effects of external pressure to wetlands, intensive and uncontrolled use of many wetlands (and their resources) by local people and siltation were some of the most important problems identified.

It is therefore necessary to improve the current wildlife management training at the College to include the community-based multiple-use management systems, which is the most effective means of protecting a wetland and its resources for wild plants and animals, and indeed for the local people.

Currently, the College is working closely with the World Conservation Union (IUCN-Eastern Africa Regional Office) to improve the quality of wetland training which is being offered at the College. During the last academic year (1992-93), Dr. Geoffrey Howard (Wetlands Coordinator, IUCN-EA Regional Office) gave a series of lectures on case studies, values, ecology, and multiple-use of wetlands.

IUCN has also sponsored my participation in several workshops (including this one) in its effort to build institutional capacity necessary to providing practical training for a holistic approach to wetland management in the region.

WETLAND TRAINING

Even with an appropriate integrated structure for managing wetlands, much greater investment is required to provide an adequately trained personnel to manage wetlands.

The College of African Wildlife Management is suitable for wetlands management and conservation training in the region for a number of reasons.

It is a wildlife management and conservation training institute. The majority of participants in this workshop are working with wildlife management institutions and conservation agencies from around the world. This shows close linkage between wildlife management and wetlands conservation on the one hand, and the training at the College of African Wildlife Management on the other.

The College enrolls students from all English-speaking countries in Africa. It is therefore a regional institute where regional wetland issues could be addressed.

There are good facilities already in place, including lecture rooms, staff and equipment. The College is surrounded by wetland ecosystems that could be studied, and by protected areas facing the same practical problems faced by many countries in the region, and with programs to which the students could be exposed.

CONCLUSION

Since it is unlikely that any training institution will be established to focus exclusively on wetland management, existing training institutions should develop courses or topics on integrated management of wetland resources.

It is our hope that the College of African Wildlife Management is appropriate and would be the first regional institute to have a course (or topics) in integrated wetland resources management. However, much greater investment is required to build institutional capacity for providing theoretical and practical training in wetland management, planning and sustainable use.

REFERENCE CITED

College of African Wildlife Management. 1990. Unpubl. syllabus. Moshi. Tanzania.

Table 1. Coverage of wetlands in the current college curriculum. Adapted from College of African Wildlife Management, 1990.

1. NS 51mc/161mc (Soil and Geomorphological Science)
    - groundwater recharge and discharge
    - water catchment
2. NS 52mc/162mc (Fisheries Science)
    - fresh water fisheries
    - marine water fisheries
3. NS 56rc/166rc (Introductory Ecology)
    - fresh water communities
    - estuary and marine water communities
4. EM 82rc/182rc (Protected Area Management)
    - conserving special habitats, e.g., marine and coastal environments and wetlands
5. NS 57r (Introductory Ornithology)
    - characteristics, natural history, and economic importance of freshwater and marine wetland birds
6. NS 102r (Game Bird Management)
    - avian adaptations to man-made habitats (including man-made wetlands)
7. WM 118r (Introduction to Range Ecology)
    - range development and improvement (including water development)
8. WM 178 (Advanced Range Ecology)
    - water quality and distribution and their effects on wild animals and plants
9. WM 214 (Principles of Range Management)
    - range improvement and rehabilitation
    - soil and water conservation
    - water development
10. EM 286r (Protected Area Planning)
    - planning for marine and wetland protected areas

SOCIO-CULTURAL VALUES OF WETLANDS: A CASE STUDY OF NORTH KIRURUMA VALLEY, KABALE DISTRICT, UGANDA

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ABSTRACT

The concept of wetlands as productive ecosystems which play a key role in strategies for sustainable socioeconomic development contrasts with the traditional image of wetlands as inaccessible, waterlogged, marginal lands. As wetlands have been lost and severely degraded, society has grown to appreciate the many diverse goods and services provided free by wetlands. It is now evident that the people are in a unique position to provide insights into appropriate resource management options. Our findings indicate that: (1)rural communities currently obtain a wide variety of benefits from the different activities undertaken in the wetland ecosystem. although unfortunately many wetland activities have led to total change, and preclude continued community use of these resources; (2)the land tenure system is the socio-cultural mechanism which regulated the way land is owned, occupied, and used and it influences the nature, character, and quality of resource conservation; (3) efforts toward the conservation of these wetlands will depend on the mode of access and utilization of wetlands, be it communal or leased; and (4) the already-established administrative structures could be used successfully for conservation work.

INTRODUCTION

Wetlands have since time immemorial served as centers for human population. Even today, they continue to influence the health, welfare, and safety of many people who live in or near them. The cumulative importance of many small wetlands is increasingly being realized, and while threats to wetlands still persist, the case for wetland conservation has begun to rest more and more frequently on the demonstration of the functions and services that wetlands provide to human society. It is only when conservation measures are seen by rural communities as being for their benefit, and are designed in close consultation with the communities, that governments and the development community are likely to succeed in achieving the goal of sustainable development (Dugan 1988).

The concept of wetland ecosystems which can play a central role in strategies for sustainable socioeconomic development contrasts with the traditional view of wetlands as inaccessible, waterlogged, marginal lands harboring disease-carrying vectors. As some wetlands have been lost and others severely degraded, society has grown to appreciate the many diverse goods and services provided free by wetlands. For example, in Kigezi, in southwestern Uganda, there is a rising concern over environmental and social consequences of wetland loss.

As efforts to integrate wetland conservation and rural development increase, it is evident that the target communities are in a unique position to provide insights into appropriate resource management options.

Although some wetland loss is inevitable and can benefit man, much of it is both detrimental and avoidable. This inefficient use of resources by society is the consequence of a range of factors, including inadequate planning, inconsistent policies, and inadequate management institutions and tools. Underlying all this is a poor understanding of the economic values that determine decisions affecting wetlands. More often, however, wetland degradation occurs at the hands of rural communities who are perfectly aware of many of the consequences of their actions, but through poor economic status, or for other reasons, are obliged to pursue practices that are not sustainable.

Uncoordinated exploitation at local and national levels have destroyed many wetlands and placed others under threat. In view of this the government found it necessary to have a decentralized program of wetlands management.

Such a decentralized program must, however, incorporate wetland functions for the local communities, aiming at sustainable use of resources by local people. People who use wetlands have a major role to play in the decision-making process. Successful conservation of wetlands will depend on consultation with the local communities and their participation and conservation efforts. In searching for suggestions the role of social structures must be evaluated. People's perception of wetland values and functions must also be evaluated.

The objectives of the study reported here were to evaluate the social and cultural values of wetlands; assess the extent to which local people could be involved in the management of wetlands; assess people's perceptions of wetland values and functions; and assess the circumstances under which participatory approaches could have success in effective management.

METHODOLOGY

Study areas

North Karuruma Swamp in Kabale district is representative of an upland valley swamp of over 1,840 meters above sea level. The district is small, yet heavily populated. The land area is 2,315 km^2, with a population density of 197 per km^2, a total population of 455,400 (1980 census), and an annual growth rate of 1.2%.

North Karuruma swamp is dominated by papyrus *Cyperus papyrus* and other *Cyperus* species. It has been reclaimed for dairy farms mainly by cutting an extensive network of drainage channels.

Research sites

Particular villages were selected as representative samples by systematic random sampling procedure. These were chosen from villages adjacent to and on either side of the wetland. This meant taking villages falling within an approximately 3-km radius of the swamp. An assumption was made that people directly depending on wetlands live adjacent to it. The first unit in the sample (the villages) was selected at fixed intervals, i.e., every Kth unit in the population was taken until the required sample size was obtained, where K was the sampling interval determined by multiplying the total population N by the sample ratio n [K = N(n)] where n = 5% (Zar 1984).

During the study a list of villages in the corresponding study area was obtained from the parish leader or Resistance Council Chairman. There were 120 villages around the wetland. Thus 6 villages were selected according to the method described above.

Types of data collected

In the course of the research, data were collected on sex, age, family size, occupation, and educational level, land tenure, land use systems, religious practice and magic, and conservation.

The principal research technique used to collect data was administering a questionnaire in an interview. Direct observation was used as a supplemental method of collecting data.

The sample and evaluation of wetland characteristics

Individuals interviewed belonged to the following categories: village residents selected randomly; Resistance Council and government officials, especially in the departments of agriculture and forestry; people who own land on the swamp; people who work on the swamp by cutting grass, hunting, brick-making, collecting firewood, etc.; and herbalists.

It was important for some respondents to be hand-picked in order to get responses on specialized themes in the study, e.g., hunting and local medicine. A total of 300 respondents were interviewed.

In the valuation of the wetland resources, services, and attributes, we used two approaches, the indirect opportunity cost approach and the indirect substitute approach. In the first, the time spent harvesting was valued in terms of foregone rural wages and the opportunity cost of labor was based on other employment. In the second, the opportunity cost of using a substitute for the wetland resource was the measure of its value.

RESULTS

Land tenure

In the study area land was held almost exclusively by men. A man would give part of the land to his son on the son's marriage and part of it to the widow. Upon the death of the widow, the whole land is inherited by the sons.

This has led to increasing fragmentation due not only to such a division but also to the augmentation of inherited plots with those purchased, often at some distance from each other.

Following the 1969 Public Lands Act (under which Crown land became public land and the Land commission had power to lease and manage all public land) there has been an increasing encroachment of what were common lands, especially the swamp valley bottoms.

It was clear that majority of the people had very small land holdings, less then 10 hectares (Table 1). The limited size of land holdings puts pressure on the fertility of the land and on the marginal areas on hillsides.

Swamp uses

In an attempt to show social and cultural affiliations of people to swamps the following hypotheses were made.

1. Use of swamp products varies with age (Figure 1a). The youth, like the aged, were seen to be more involved in craftwork, hence the two age groups showed a high score for craft materials. The middle aged on the other hand are more actively involved in construction, so construction materials showed the highest percentage among this age group.

2. Use of swamp products varies with education levels (Figure 1b). Education may have a significant role to play in resource exploitation and/or conservation. As people advance in knowledge they become armed with a technology to utilize a resource.

3. Use of swamp products varies with family size (Figure

1c). Population pressure is a leading factor in the use of marginal areas like swamps.

4. Use of swamp products varies with sex (Figure 1d). Women, unlike men, were involved in activities that did not have any financial or monetary implication.

A number of traditional values of swamps persist (Figure 2). Swamp grass is used to thatch houses. This was the roof of either a major house or a kitchen. Swamp sedges including *Typha abyssinica* are used to make mats and carpets, and papyrus is used to make baskets. The swamp edges serve as a major grazing area for livestock. Also some swamp fringes have been given to cooperative societies for growing vegetables, including carrots, cabbage, asparagus, and cauliflower.

Local medicines are collected from the swamp in the form of herbs, leaves, seeds, fruits, and tree bark. These are used to treat diseases like cough, skin rash, stomachache and fever.

Conservation

Kabale is a hilly area, and cultivation is done on the slopes. During the colonial administration, people were forced to construct anti-erosion bunds. Permanent cultivation with short rotation periods prevailed. Mineral fertilizers were not used. The respondents were aware that frequent burning of fallow land vegetation or crop residues deplete the soil fertility.

Self-help projects

Farmers in the study area were organized in cooperative societies. The most prominent was an organization of dairy farmers, which included all people on the swamp with dairy farms. Another one was that of the youth, made up to 160 individuals, who had been given part of the swamp to cultivate. Members of this group grew horticultural crops for sale.

DISCUSSION AND CONCLUSION

The most beneficial feature in the present land tenure system is the concept that all land in Uganda is owned by the state. This enables the state, as ultimate owner of land and consequently all natural resources, to assume direct control of natural resources, including the wetlands. The state has now taken it upon itself to enact appropriate legislation for the protection and conservation of the wetland.

In whatever aspect of land tenure, communal rights to land will be revived, including access to water and common rights to passage, grazing, and collection of firewood, materials for thatch, and mulch.

The survey respondents generally recognized the social and cultural values of wetlands, but there is no easy financial interpretation of such values. This does not imply that they are of no value, but the large proportion of people involved in wetland exploitation is well enough known to demonstrate the value of wetlands to the local people. This would go a long way to show why the resource is indispensable. It is clear that more research should be done to look into the sustainable utilization of these values for long term economic, ecological, and environmental reasons. Also, more research should be done to determine ways of enhancing the natural productivity of wetlands and devising optimum management strategies such as harvesting and utilization of resources.

For successful conservation work in the wetlands, local communities must be involved. Education of the people is thus very vital. During the study it was evident that current local administrative structure in Uganda can help generate political support for wetland conservation and environment protection in general.

REFERENCES CITED

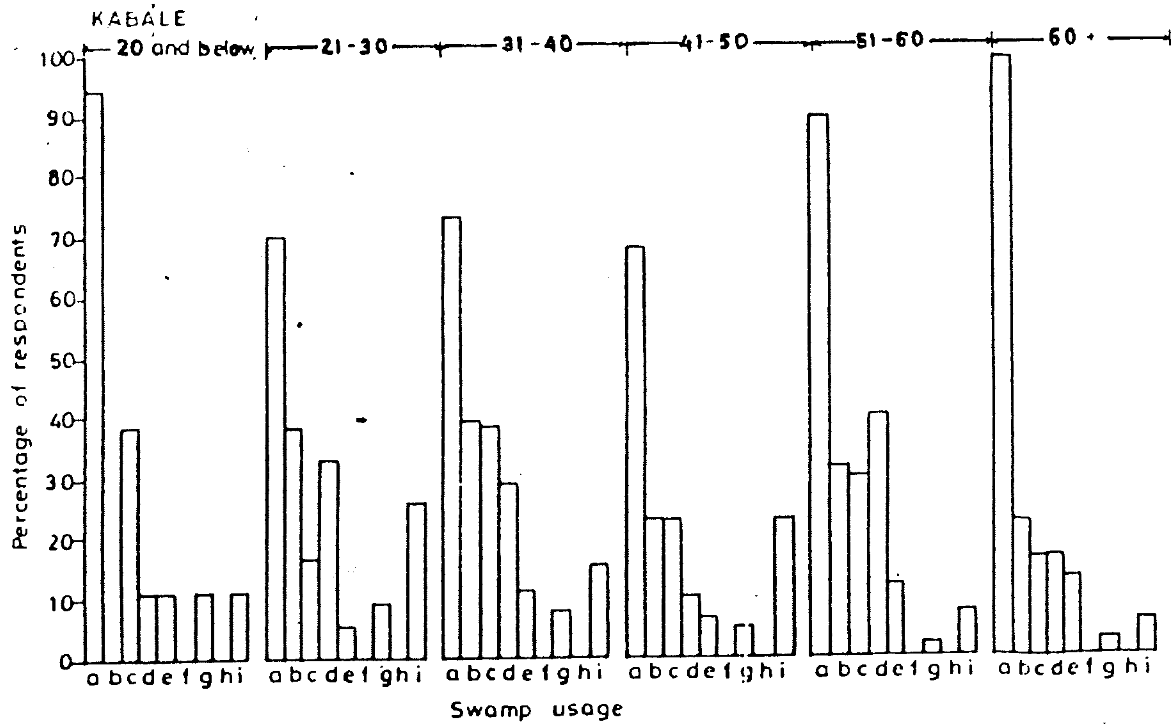
Dugan, P. J. 1990. Wetland conservation: a review of current issues and require action. IUCN, Gland, Switzerland.

Zar, J. H. 1984. Biostatistical Analysis. Prentice-Hall, Inc., New Jersey, USA.

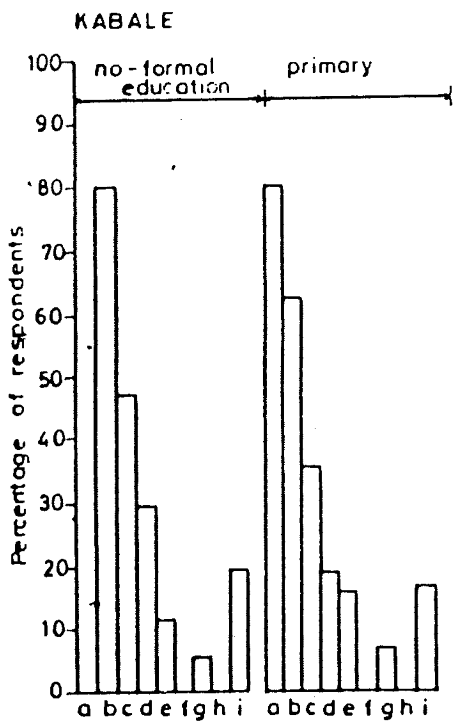
Table 1. Average size of land holding as a percentage of respondents.

Size (ha.)	<10	10-29	30-49	>50
% respondents	55	31	10	4

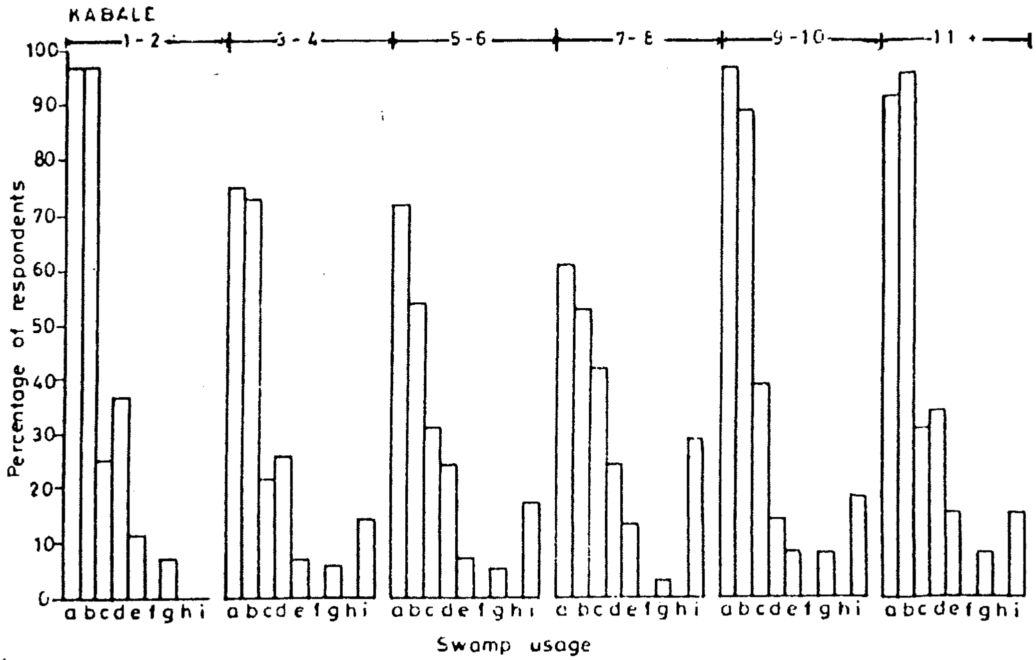
(a)


KABALE
20 and below
21-30
31-40
41-50
51-60
60+
100
90
80
70
60
50
40
30
20
10
0
Percentage of respondents
a b c d e f g h i
Swamp usage

(b)


KABALE
no-formal education
primary
100
90
80
70
60
50
40
30
20
10
0
Percentage of respondents
a b c d e f g h i

(c)



(d)

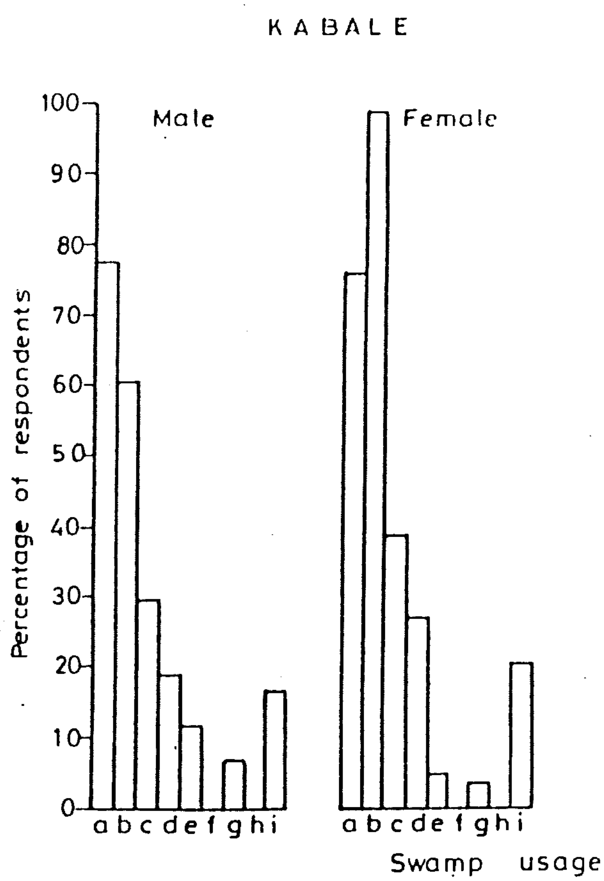


Figure 1. Relationship between swamp usage and (a) age; (b) education level; (c) family size; and (d) sex, where a = building material; b = crafts material; c = cultivation; d = firewood; e = grazing; f = meat; g = medicine; h = mulching material; and i = water.

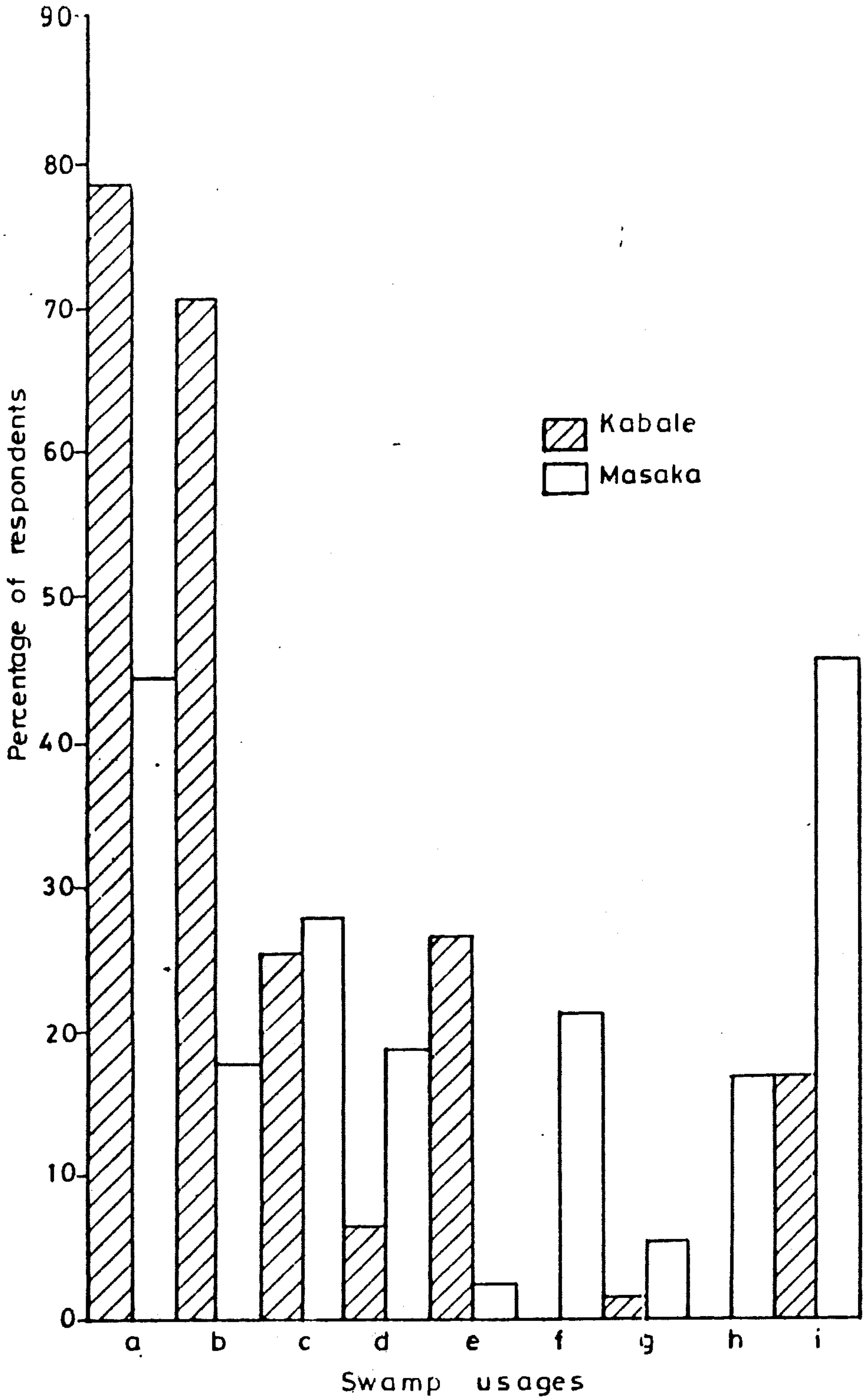


Figure 2. Swamp utilization as a percentage of respondents for Kabale and Masaka.

WETLAND DISTRIBUTION AND UTILIZATION IN SOUTHWESTERN UGANDA: A CASE STUDY OF LAKE MBURO NATIONAL PARK AND ENVIRONS

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ABSTRACT

Wetlands in Uganda contain numerous resources, which are variously utilized for commercial purposes and support human livelihood. As a result, the area and distribution of wetlands have been greatly changed over the years. Lake Mburo National Park in southwestern Uganda is an example where more than 50% of the former wetland area has been lost to agriculture and urban-related developments. The case study presented here is a demonstration of how some forms of sustainable utilization of wetland resources can promote conservation.

INTRODUCTION

Lake Mburo National Park is situated in southwest Uganda. It covers an area of 260 km^2 of savanna ecosystem containing a great diversity of habitats. The park represents Uganda's only protected example of the larger Akagera ecosystem and contains plant and animal communities that are unique in the country (Figure 1). The park has hills which are covered with a mixture of dry acacia savanna and woodland, open grassy valleys, swamps, lakes, and forests. As a result of this diversity, there is a rich mosaic of habitat types which accommodate a considerably high biodiversity.

The savanna rangeland, part of which is in the boundaries of Lake Mburo National Park, was originally occupied by the pastoral Bahima/Banyankore and a few Bakooki/Banyankole cultivators and fishermen. The rangeland was home to much game which was traditionally protected, although some hunting for game meat and hides occurred. Large carnivores (especially lions, leopards, and hyenas) were killed when encountered. The various vegetation types (trees, grass, shrubs, and swamp vegetation) were variously utilized for constructing Kraals (traditional livestock enclosures in which animals spend the night) in traditional huts, craftwork, and medicine (Tindigarukayo 1993).

Conservation activity in this region dates back to the early 1930s, when part of the rangeland was pronounced a Controlled Hunting Area (CHA). The CHA status in the region was formalized through the creation of Masha CHA (1961), Kikagati CHA (1961) and Mburo CHA (1963) (Figure 2). In 1964, the status of Mburo CHA was upgraded to Game Reserve (Lake Mburo Game Reserve). Similarly, in 1983 the game reserve was declared a National Park - the Lake Mburo National Park.

These events were paralleled by other developments in the region. Several people acquired land leases, and fenced and developed them. The government established the Ankole Masaka Ranching Scheme and a dairy cross-breeding farm in the region between 1964 and 1967. More people were encouraged to settle in the region between 1964 and 1983 and in 1985-6. The outcome of these events was a reduction in the communal grazing land, an increase in resource utilization and intensified conflict between conservation efforts and the stake-holders. Presently, the former savanna rangeland is divided into several land uses (Figure 3) as opposed to the former pastoral-dominated land use. The northeast and eastern parts are used for commercial ranching, and the north, west and south are predominantly crop agriculture with livestock.

The indigenous inhabitants of the Mburo region rely culturally on the wetlands. Because the local inhabitants use the wetlands as water sources during the dry seasons and as a source of important and rare medicinal plants for livestock, the remaining wetlands have high cultural value.

WETLAND TYPES AND DISTRIBUTIONS

There are three major types of wetlands in the Mburo region (Figure 4).

1. Open water lakes: the large lakes in the region are Mburo, Kachera, Nakivali, Kaijanebalola, Bwara, Kibikwa, and Kazuma.

2. Permanent swamps: these form a chain along the southern boundary of the park.

3. Seasonal swamps: the majority of the low-lying valleys in the region seasonally flood.

The wetland system in the Mburo region is part of the Ruizi watershed which is situated between Kagera and Katonga drainage systems (Figure 4). The swamp/lakes wetland complex along the southern boundary of Lake Mburo National Park was formed as a result of a series of geological events involving tectonic movements that led to the formation of the Western Rift Valley. This series of events resulted in the formation of the Lake Mburo basin that later filled with water when the drainage pattern of the

Ruizi River reversed during the same period.

MAJOR WETLAND BIOLOGICAL FEATURES

Vegetation

The dominant vegetation of the Mburo region was originally classified as Acacia/Themeda association (Pratt 1966; Lind and Morison 1974). However, because of human activities such as livestock grazing, burning, cultivation, construction of valley dams and cattle kraals, as well as agriculture, the present vegetation is now in the form of modified acacia savanna grassland (Figure 5). The flat seasonally-flooded valleys are dominated by open grassland vegetation composed of *Sporobolus pyramidalis, S. africanus, S. stapfinus, Echinocloa pyramidalis, Cyperus* spp., *and Kyllinga* spp. The permanent swamps are dominated by *Cyperus papyrus* and grasses (Hoag *et al.* 1991).

FAUNA

Birds

Lake Mburo National Park and adjacent rangelands are very rich in fauna diversity. There are 310 bird species recorded in the park out of which more than 93 species are wetland birds (Pomeroy and Kasoma 1993).

The wetland birds of Lake Mburo National Park and the adjacent rangeland can be divided into four major groups:

Species of international concern

These include:
- Shoebill (*Balaeniceps rex*): although this species occurs widely in equatorial Africa it is always in small numbers. It is threatened wherever it occurs due to habitat loss.
- Papyrus Yellow Warbler (*Chloropeta gracilirostris*): a scarce papyrus endemic with limited distribution and threatened by swamp drainage (Britton 1980; Collar and Stuart 1985).

Red Data Book "near threatened" and "candidate" species

These include:
- Saddlebilled Stork (*Ephippiorhynchus senegalensis*): this species us widespread in Uganda.
- Brownchested Wattled Plover (*Vanelus Superciliosus*): this species is rare outside Mburo area.
- White Ringed Warbler (*Bradypterus carpalis*): this species in the papyrus swamp.
- Carruther's Cisticola (*Cisticola carrythersi*): this species is a papyrus endemic.

Species of regional importance in East Africa

These include:
- African Darter (*Anhinga rufa*): is declining in numbers; prone to being caught in fish nets.
- African Finfoot (*Podisa senegalensis*): an elusive bird that is nowhere common.
- Great Snipe (*Gallinago media): this* is species is uncommon.
- Abyssinian Ground Hornbill (*Bucorvus abyssnicus*): Mburo region is the southernmost record for this species.
- Tabora Cisticola (*Cisticola Eulvieapilla*): this species is only found in Lake Mburo National Park in Uganda.

Species of national importance

These include:
- Rufousbellied Heron (*Ardeola rufiventris*): an uncommon species.
- Woollynecked stork (*Ciconia episcopus*): an uncommon species.
- Saddlebilled stork (*Ephippioshynchus senegalensis*): an uncommon species.
- Grey Crowned Crane (*Balearica reguloram*): a common species.
- Painted Snipe (*Rostratula* benghalensis): an uncommon species.
- Greater Swamp Warbler (*Acrocephalus rufescens*): a papyrus endemic.
- Papyrus Gonolek (*Laniarius mufumbiri*): a papyrus endemic.
- Northern Brownthroated Weaver (*Ploceus castanops*): a papyrus endemic.

Palaearctic migrants are also of conservation interest. So far, about 30 species have been recorded in this category in Lake Mburo National Park of which 19 are wetland species.

Fish

The wetlands in the region are rich in fish especially Tilapia. The five common species include:
- *Clarias lazera*
- *Protopterus aethiopicus*
- *Hapagochromis* spp.
- *Astatotilapia* spp.
- *Aplocheilichthys* spp.

Mammals and reptiles

Lake Mburo National Park houses 68 mammal species (Monday 1993). The most wetland dependent species include:
- Spotted-necked otter (*Lutra maculicollis*)
- African clawless otter (*Aonyx capensis*).

- Hippopotamus (*Hippopotamus amphibius*).
- Sitatunga (*Tragelaphus spekei*).
- Nile crocodile (*Crocodilus niloticus*).

WETLAND USE AND CONSERVATION IMPLICATIONS

Livestock

The wetlands of the Lake Mburo region are an important grazing area for to livestock. The land was formerly occupied by pastoral Bahima people with large herds of cattle, goats and sheep. Because of the climatic regime in the area, which entails severe dry seasons and scarcity of permanent water sources, the Bahima pastoralists were forced to lead a semi- or fully nomadic life. During the dry seasons, most of the water holes in the rangeland dried up and the pastoralists were forced to drive their animals southwards to permanent water sources (Figure 6).

Today, the original rangeland is subdivided into paddocked ranches and farms. During the dry seasons there is restricted access to permanent water sources which are enclosed within the park. Nevertheless, large populations of cattle invade the park during severe drought, e.g., 1986/87 (Table 1).

Fishing

Fishing activity in the Mburo wetlands occurs in three forms.

1. **Commercial fishing**. Took place on the larger lakes before 1986. Today, it is concentrated on lakes Mburo, Kachera, Nakivali and Keijanebalola. For example, there are 106 persons engaged in fishing activity at Rwonyo fish-landing on Lake Mburo in the park. Recent study on fisheries management of Lake Mburo (Busulwa 1992) revealed that there is annual catch of approximately 2.5 million fish which gives a total income of $62,000 per annum.

2. **Subsistence fishing.** Commonly carried out in the permanent swamps and lake shores for *Clarias* and *Protopterus* species.

3. **Seasonal fishing**. Occurs in the seasonally flooded swamps when *Clarias* and *Protopterus* fish move upstream and become easy to catch. Unfortunately, it is not known how much is caught.

Craft material, medicinal plants

The communities bordering the swamps harvest various plants for domestic craft and thatch material. The most important plants harvested are *Cyperus* sp. and *Echinocloa pyramidalis*. Similarly several plant species including *Melanthera scandens, Polygonum setosulum, Solanum incanum* and *Fagara chalybea* are harvested for medicinal purposes.

WETLAND UTILIZATION VERSUS CONSERVATION

The different wetland resources were originally utilized by the neighboring communities. Under national park status, access to these resources is restricted. The outcome has been a long-standing conflict between park management and the community.

Water is the major resource under conflict. The park management is attempting to become sufficiently flexible to permit temporary access to the park for cattle along specified routes to water points. If this program is successful, it will, hopefully, enhance the park-community relationship. This implies that the park will regain control over the management/protection of the wetlands within the park.

The fish resource in these wetlands is of special conservation concern. The communities adjacent to the lakes and permanent swamps depend on fish for proteins and for sale. This largely benefits the non-pastoralist people (i.e., the non-Bahima) who own few or no cattle at all. The fact that park management allows licensed fishing on Lake Mburo and seasonal fishing in the flooded valleys (seasonal swamps) has assured the neighboring communities of coexistence with the park. This is a positive step towards conservation.

The use of craft material and medicinal plants is of less significance in terms of wetland conservation. People appreciate the need to sustainably harvest these resources. This situation is being realized because craft work is largely subsistence and the medicinal plants can be obtained from many other places.

CONCLUSION

Utilization of wetland resources has been a major cause for reduction in the quality and extent of wetlands in southwestern Uganda. However, in the Mburo region, the levels and types of utilization may not be a threat to conservation at the moment. The main concern is the socioeconomic developments taking place in the catchment areas and along the major river (the Ruizi) which feeds these wetlands. There is intensified cultivation upstream, and signs of siltation in the swamps around Lake Mburo are beginning to appear.

Elsewhere in the neighboring ranches and communal grazing areas, overgrazing is increasingly a problem. Unless pasture management is improved, livestock numbers reduced, provision of infrastructure, and farm/ranch facilities improved, environmental damage which leads to soil erosion will greatly affect wetland habitats.

ACKNOWLEDGMENTS

Many thanks are due to the African Wildlife Foundation (Lake Mburo Community Conservation Project) and USAID for funding the work in and around Lake Mburo National Park which forms the basis for this paper, Professor Pomeroy, Dr. Kasoma, J. Arinaitwe, J. Tindigarukayo, J. Kamugisha, and H. Busulwa for allowing me to use some of their data. Finally thanks are due to the International Crane Foundation and WWF-Makerere University Project for co-sponsoring my attendance at this conference.

REFERENCES CITED

Busulwa, H. 1992. Lake Mburo fisheries management study. Unpublished report to Lake Mburo Community Conservation Project.

Hoag, A., A. Clements and G. Monday. 1991. A study of the vegetation composition and animal use of the major terrestrial habitats in the park. Unpublished report to Uganda National Parks.

Kamugisha, J. and P. Kasoma. 1993. Study on the livestock management in Mburo rangeland. Unpublished report to Uganda National Parks.

Lind, E. M. and M.E.S. Morrison. 1974. East African vegetation. Longman, London, UK.

Muhweezi, A. B. 1993. The management plan for Lake Mburo National Park. Uganda National Parks, Uganda.

Pomeroy, D. E. and P. Kasoma. 1993. The birds of Lake Mburo National Park: their significance for management. Unpublished report to Uganda National Parks.

Pratt, J. 1966. Classification of East African rangelands. Journal of Applied Ecology 3: 369-382.

Table 1. Livestock populations in Lake Mburo National Park during different periods, 1982-1992 (from Kamugisha and Kasoma 1993).

Year	Cattle	Goats/Sheep
1982	[a]29,690	1,461*
1986/7	36,424	3,653
1990	650	26,624
1991 (January)	11,266	-
1991 (March)	16,517	-
1992	11,621	-

*The figure is for the Game Reserve which was about twice the size of the present park area

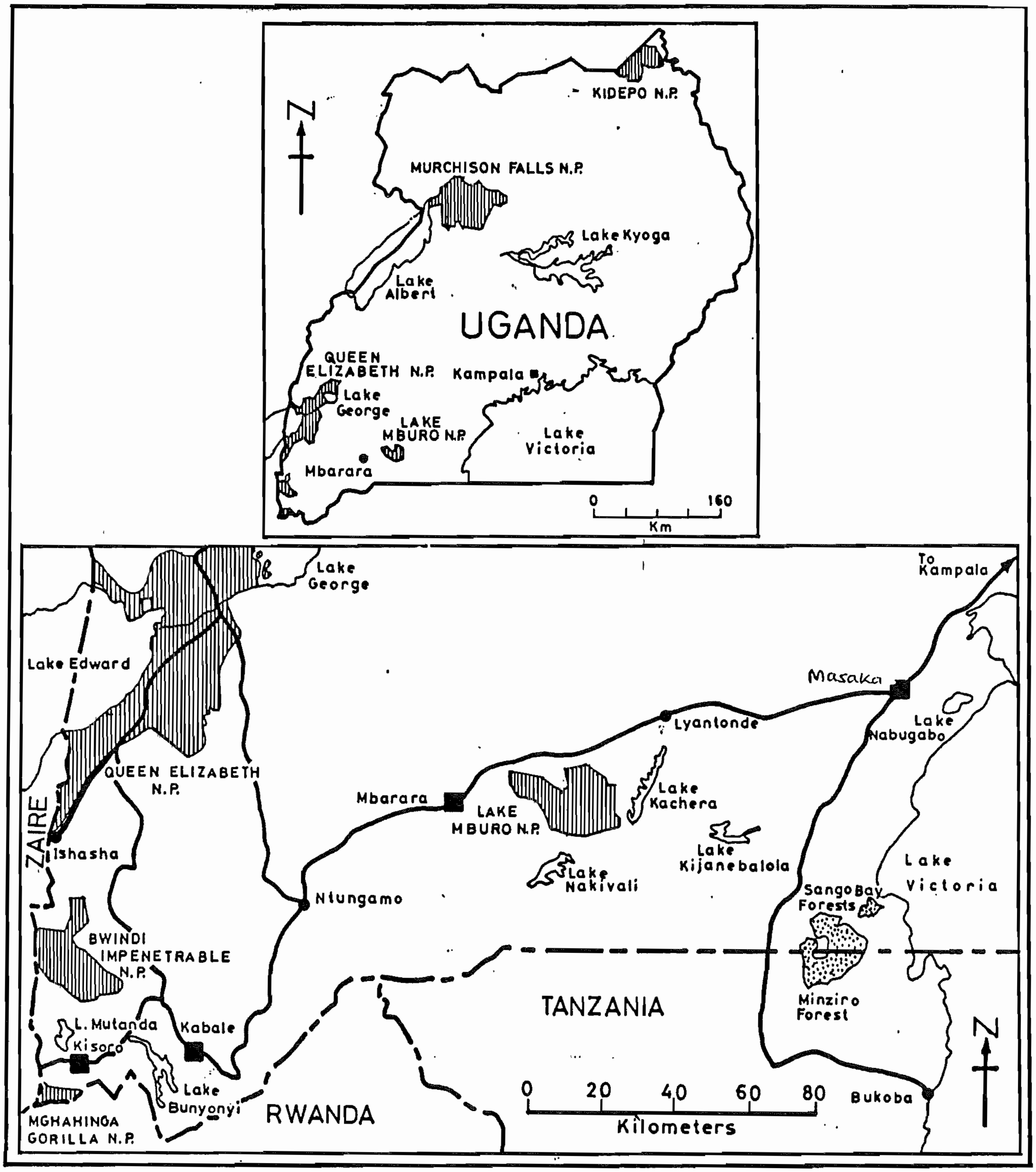

Figure 1. The location of Lake Mburo National Park, Uganda.

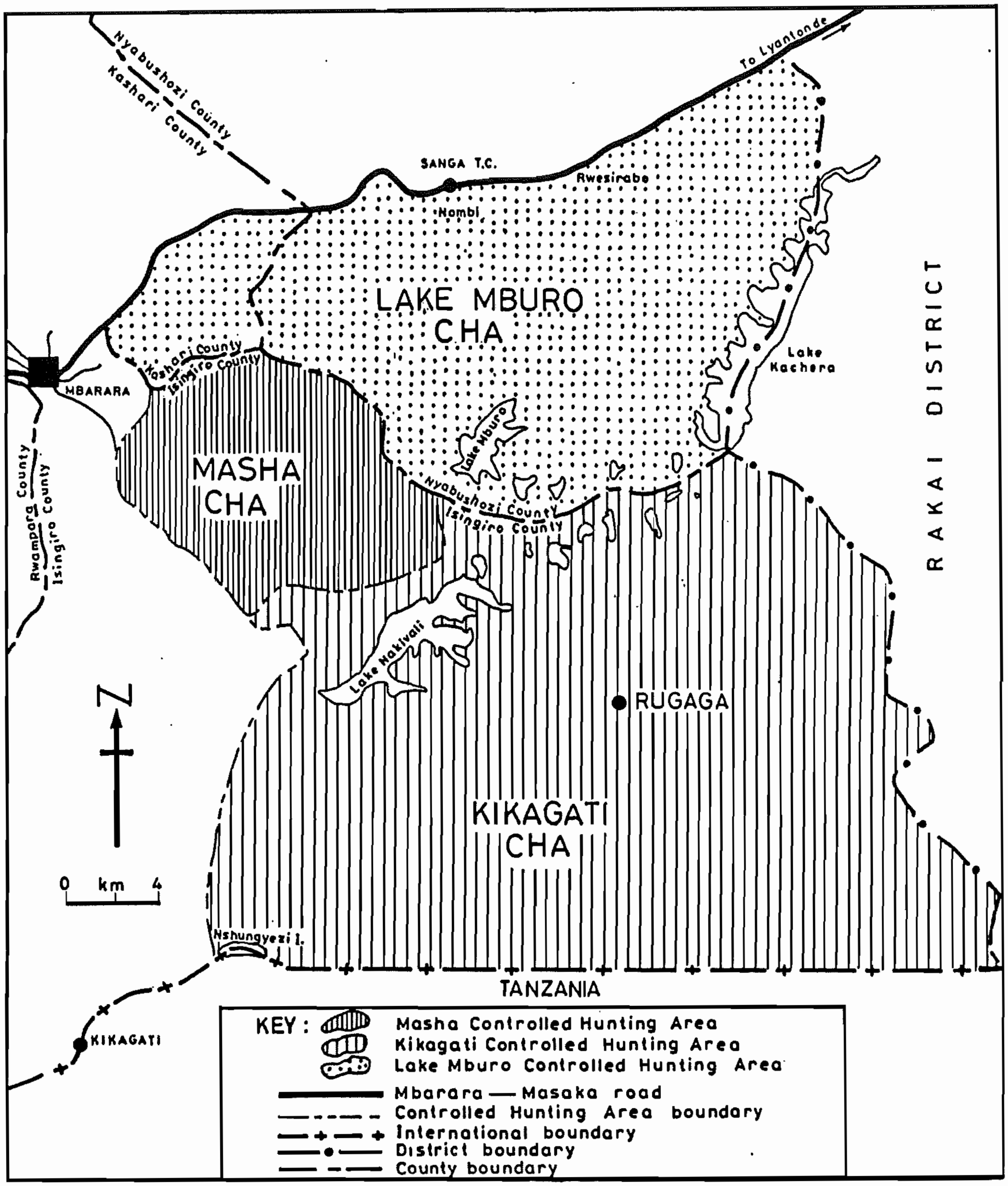

Figure 2. The controlled hunting areas in the former Mburo rangeland.

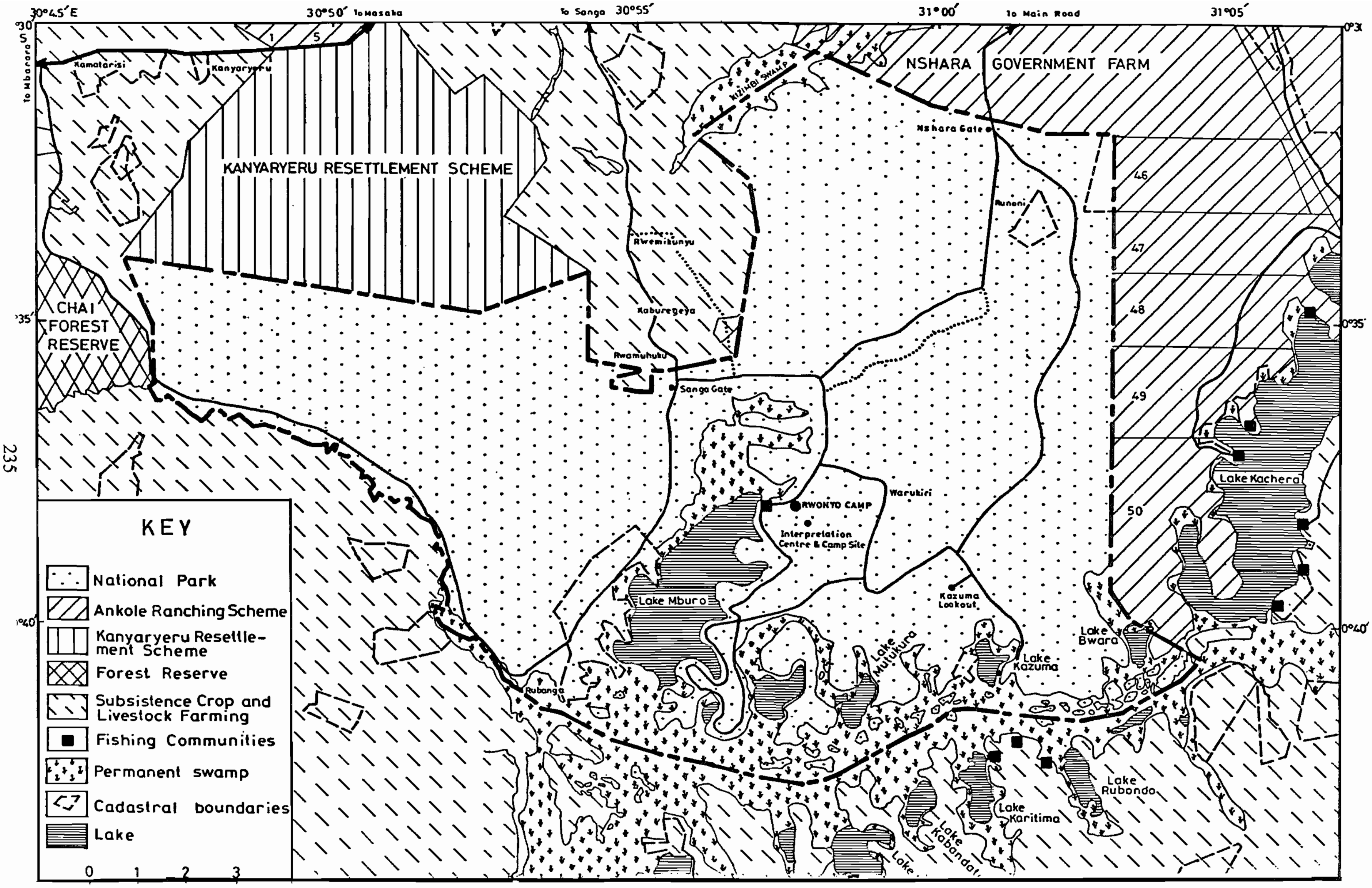

Figure 3. Major land use forms in and around Lake Mburo National Park.

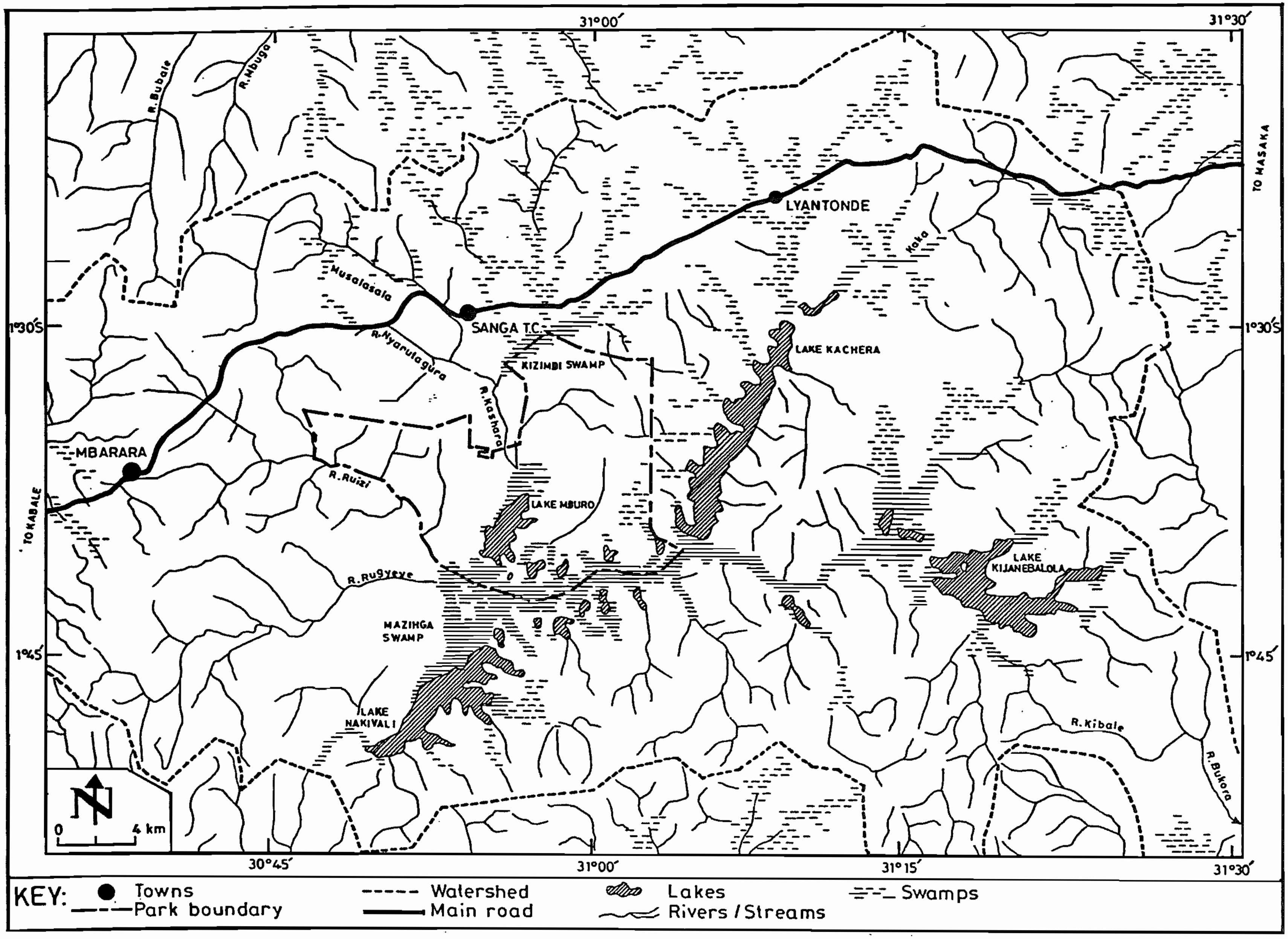

Figure 4. Drainage patterns in and around Lake Mburo National Park (from Breyer 1993).

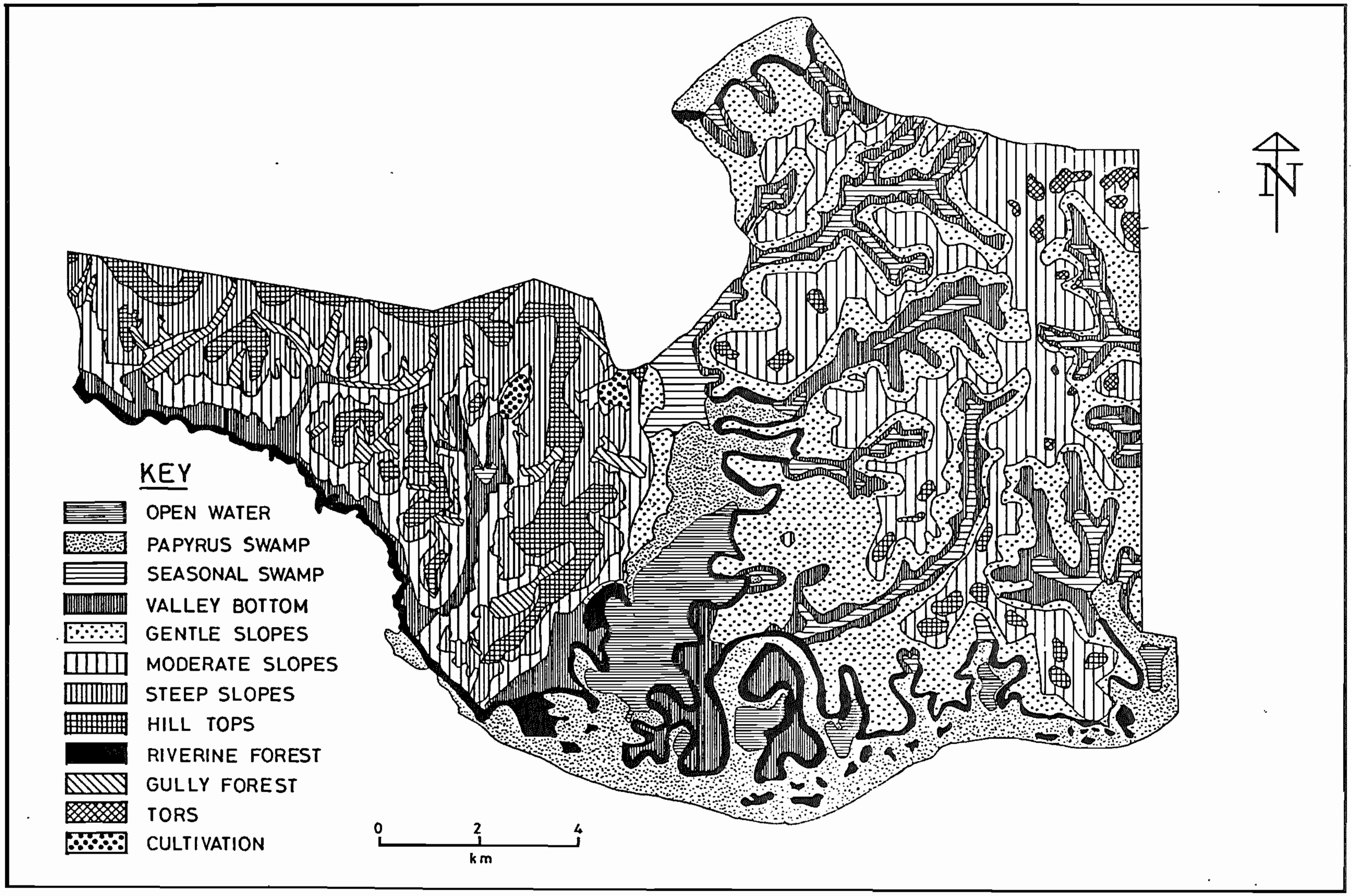

Figure 5. Vegetation types in Lake Mburo National Park according to topographic classes (from GAF Consult 1992).

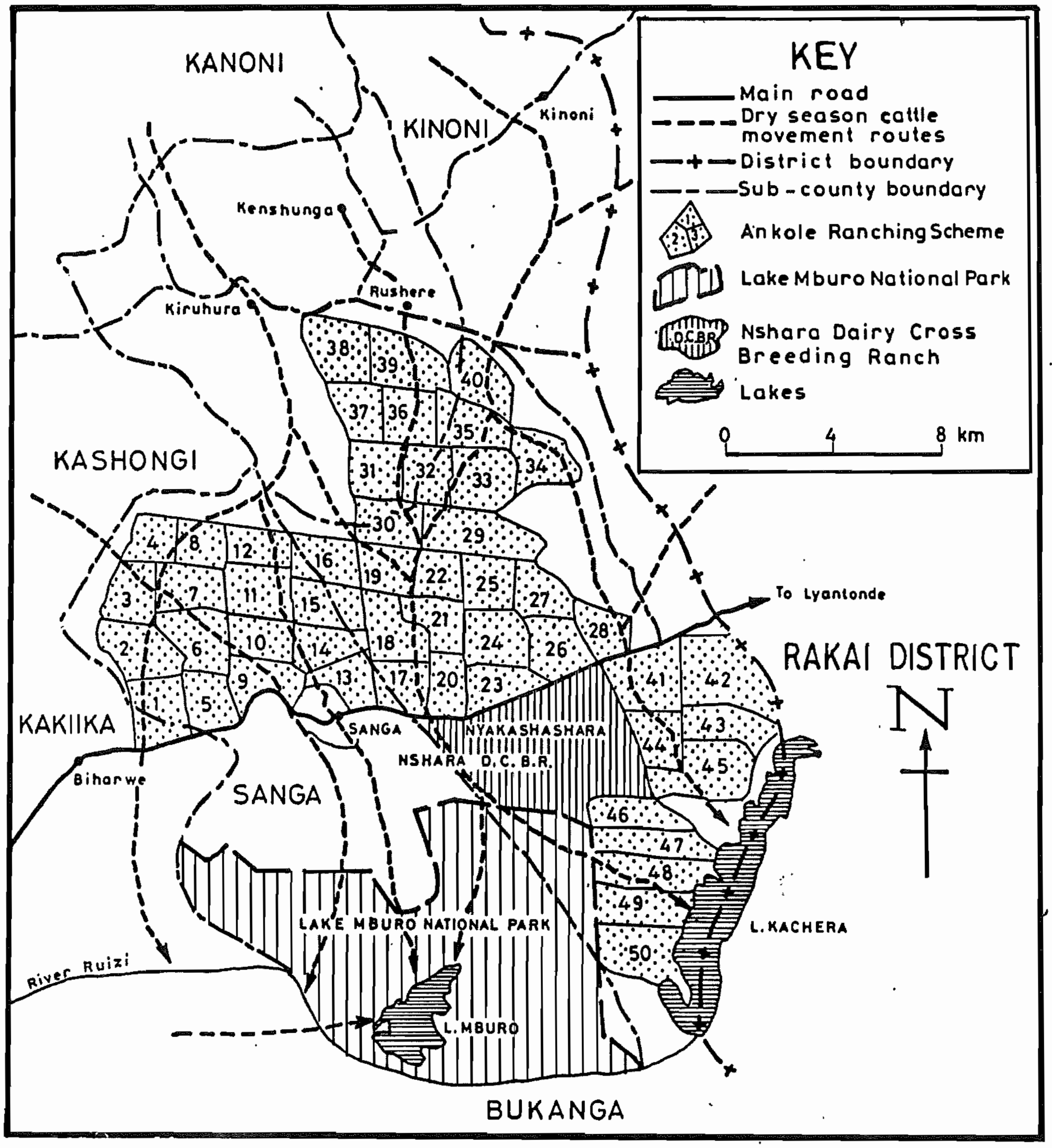

Figure 6. Dry season cattle movements in Mburo rangelands (from GAF Consult 1992).

LAKESHORES AND WETLANDS AS HABITATS FOR CICONIIFORM WADING BIRDS IN UGANDA

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ABSTRACT

A total of 22 and 21 species of ciconiiform wading birds were recorded during studies along a lakeshore in Queen Elizabeth National Park in western Uganda and the rice scheme at Doho wetland in eastern Uganda, respectively. The birds showed a preference for particular microhabitats along the lakeshore, and specific swamp types within the Doho wetland. For many species the pattern of dispersion along the lakeshore was basically territorial. At the rice scheme, however, dispersion pattern varied between territorial and gregarious depending on the stage of rice-growing. It would appear that the food resource base was a factor in determining dispersion.

INTRODUCTION

Lakes and wetlands in Uganda have to a large extent been ignored as far as legal protection is concerned. Protected status to habitats and sites has mainly involved savanna areas and forests. This is despite the fact that the former habitats are also known to be important for the survival of many wildlife species (e.g., Kemin and Zhongqin 1991; Nickerson 1991). Furthermore, wetlands have a variety of other important functions many of which are highlighted by Dugan (1990).

Wetlands form no less than 10% of Uganda's total area (Taylor and Mafabi 1991). The overall area of this habitat is, however, under threat through various forms of human activity including reclamation and other aspects of unsustainable utilization.

With the exception of fisheries research, lakes and wetlands have previously attracted little attention as regards vertebrate ecological studies (e.g. Greenspan and Torre-Bueno 1971; Eltringham 1973, 1975; Din 1979a, 1979b). More recently, research by Sumba (1984), Kasoma (1989), Mafabi (1989), and Arinaitwe (1992) has stimulated interest in lakes and wetlands as important habitats for vertebrates other than fish. This paper reports some of the findings of research by Kasoma (1989) and Arinaitwe (1992).

STUDY AREA

The study was conducted along a 30 km stretch of shoreline of Kazinga Channel and Lake Edward in western Uganda and the Doho wetlands in eastern Uganda. Both areas have a bimodal rainfall pattern. Detailed descriptions of those areas are given elsewhere (Kasoma 1989; Mafabi 1991; Arinaitwe 1992). An initial survey along the lakeshore in western Uganda led to the identification of several microhabitats (Kasoma 1991), whereas in the Doho wetlands, the swamp was categorized into Doho rice scheme, outgrower gardens, grass swamp, and papyrus swamp.

METHODS

Between 1985 and 1987, regular surveys were carried out by boat along a 30 km stretch of shoreline. Species of ciconiiform wading birds were recorded and note was taken of the microhabitat in which they were foraging. The general pattern of dispersion within the habitat was also noted.

From November 1990 to June 1991, timed species counts (Pomeroy and Tengecho 1986) were carried out in the Doho wetlands by walking slowly through specific wetland types and listing all ciconiiform species in the order that they were detected for one hour. Furthermore, within the Doho rice scheme, it was possible to make group size counts along 7.5 km long and 100 m wide transects.

RESULTS

Species present

Table 1 shows the species that were found along the lakeshore and in the Doho wetlands. The Night Heron, Cattle Egret, and Abdim's Stork were not recorded in the wetlands whereas the Dwarf Bittern, Black Heron, and Shoebill were missing from the lakeshore. Table 2 shows the numbers of individuals, percentage presence, and relative abundance of ciconiiforms along the shoreline. Since counts were not done in the various wetland types, Table 3 shows the presence of species in the different wetland types and the relative importance of each type to different species.

Habitat preference

Along the lakeshore, ciconiiform wading birds had preference for particular microhabitats (Tables 4 and 5). The Grey Heron, Goliath Heron, Little Egret, and Yellowbilled Stork, for example, spent most of their foraging time either at the water's edge or in "vegetation in water." The Hadada Ibis preferred "vegetation in mud" whereas the Cattle Egret foraged mainly in "short grass." A similar analysis was not carried out for the Doho wetlands but a general trend may be discerned from Table 3 which shows the wetland types preferred by different species. The Dwarf Bittern, Black Heron, and Shoebill were not recorded on rice fields at all. The Little Bittern and Hamerkop were more common on natural wetlands than on rice fields. All the remaining species were relatively common on rice fields particularly Doho Rice Scheme. Many species were restricted to rice fields between November and March, spreading out to other habitats in April to May.

Dispersion

Figures 1 and 2 show the results of group size counts at the Doho Rice Scheme. The Hamerkop, Hadada Ibis, and Marabou, Yellowbilled, Woollynecked, and Saddlebilled Storks were only rarely recorded and have not been included in the analysis. Blackheaded and Squacco Herons, Yellowbilled Egret, Openbilled Stork, and Glossy and Sacred ibises were gregarious. This may be deduced from the large average group sizes which were more or less maintained throughout the study period. Grey and Purple Herons, as well as Little and Great White Egrets were mainly territorial. This is evident from the low average group sizes with peaks in November/December and May/June.

Along the lake shoreline, group sizes were not recorded but observations over the study period showed that Squacco, Goliath, and Grey herons, and Little and Great White Egrets were always territorial, as they were spaced out individually along the shore. Antagonistic encounters were often observed between neighboring conspecifics. Some species such as the Purple Heron, Little Bittern, Black-crowned Night Heron, and Woollynecked Stork were seen only once and no information could be gathered about dispersion patterns. Others such as Yellowbilled Egret and Abdim's Stork were always either single birds or occasionally two in the study area. Nothing much can be said about the dispersion pattern of these either. Species such as the Hamerkop, Openbilled and Yellowbilled Storks, Hadada, Glossy, and Sacred Ibises, and the African Spoonbill occurred singly or in twos, threes, or small groups. There was no evidence of territorial defense among themselves.

DISCUSSION

Both the lakeshore and wetlands had a relatively large number of ciconiiform wading species. However, the lakeshore tended to have relatively low numbers of individuals of most species. The relative abundance of these birds along the Lake Edward and Kazinga Channel shoreline has been discussed elsewhere (Kasoma *in press*). The overriding issue seems to be the shortage of suitable foraging habitat along the lakeshore. The lake apparently becomes too deep for most species to wade beyond 5 m from the shoreline (Kasoma 1989). This limits the birds to a narrow strip of littoral zone, which, given the territorial nature of many of the species, can only accommodate a limited number of individuals. This limitation of lakes as habitat for wading birds has been noted elsewhere (Gibbs *et al.* 1987).

In the Doho wetlands, judging from the average group size of most species, the numbers of ciconiiformes are greater than along the lakeshore. This may be the result of availability of more feeding habitat in the form of shallow water and soft exposed mud. Local wading bird abundance is often correlated with wetland abundance (Burger 1981; Gibbs *et al.* 1987).

The partitioning of microhabitats along the lakeshore may have several causative factors such as avoidance of interspecific competition, availability of suitable prey, body size, and so on (e.g., Kasoma 1989, 1991). It enables a variety of species to be accommodated within the same general habitat. The distribution of ciconiiformes on the Doho wetlands is also basically a function of habitat requirements for the different species. Uniform stands of papyrus have little ecological diversity (Britton 1978). Such habitat is therefore expected to support only a few highly specialized species. Indeed only the Dwarf Bittern, Black Heron, and Purple Heron were recorded inside the papyrus swamp. Grass swamps, on the other hand, are highly diverse ecologically. This explains why they supported a large number of Ciconiiformes including the threatened Shoebill.

The rice scheme is a monoculture and would therefore be expected to be less diverse and hence support fewer species than natural wetlands. On the contrary, most species except the Dwarf Bittern, Black Heron, and Shoebill were recorded in this habitat. This is because activities associated with rice growing sometimes create conditions that are extremely favorable for foraging, such as shallow water and sparse vegetation, especially for species that hunt for fish and other vertebrates (e.g., herons) or invertebrates (e.g., ibises and spoonbills).

Many of the large Ciconiiformes are known to defend feeding territories (See Brown *et al.* 1982; Kasoma *in press*). Species such as the Grey Heron, Goliath Heron, Great White Egret, and Little Egret showed this behavior all the time along the shoreline in western Uganda. In the

Doho wetlands, the same species as well as the Purple Heron were also territorial during most of the study period. However, with the exception of the Goliath Heron, the other species were sometimes found foraging in congregations. The fact that such congregations were more frequent in November/December and May/June implies that during those periods there existed circumstances which favored non-territorial foraging. Although there is no strict synchronization of rice growing activity, October/November tends to be the beginning of the second growing season and April/May/June is usually the close of that season. During both periods, plots are cleared of vegetation thus exposing areas of soft mud and shallow water. It is such areas that attract individuals of different ciconiiform species to aggregate. It may be that at such times, those areas have large quantities of prey that was not being exploited when the vegetation was thick. It would not be profitable to defend such a superabundance of prey and the normally territorial species respond to this abundant but unpredictable food supply by feeding in flocks.

The restriction of most species to rice fields between November and March is because the grass swamps are to a large extent dry at this time. With the onset of rains in April and May, such swamps flood and the birds spread out to those areas.

CONCLUSION

Lakeshores and wetlands are suitable sites for ciconiiform wading birds. It would appear, however, that certain wetlands provide larger foraging areas than lakes when total surface area is considered. It would therefore not be advisable to reclaim all wetlands merely because there are lakes, because the two complement each other in providing ciconiiform habitat. In case reclamation is unavoidable, then the use to which the reclaimed wetland is put should be such that as much of the avian diversity as possible is maintained.

REFERENCES CITED

Arinaitwe, J. 1992. Effects of wetland drainage on the diversity and abundance of waterbirds at the Doho wetlands eastern Uganda. M.S. Thesis. Makerere University, Kampala, Uganda.

Britton, P. C. 1978. Seasonality, density and diversity of birds of a papyrus swamp in western Kenya. Ibis 120: 450-466.

Brown, L. H., E. K. Urban, and K. Newman. 1982. The birds of Africa, Vol. 1. Academic Press, London, UK.

Burger, J. 1981. A model for the evolution of mixed species colonies of Ciconiiformes. Quarterly Review of Biology. 56: 143-167.

Din, N. A. 1979a. Ecology of pelicans in Rwenzorie National Park, Uganda. Starling Press, Tucson, Arizona, USA.

Din, N. A. 1979b. Notes on bird counts from Hippo Point in Rwenzorie National Park, Uganda. Pakistan Journal of Zoology 11: 149-162.

Dugan, P. 1990. Wetland conservation, a review of current issues and required action. International Union for the Conservation of Nature, Gland, Switzerland.

Eltringham, S. K. 1973. Fluctuations in the numbers of wildfowl on an equatorial hippo wallow. Wildfowl 24: 81-87.

Eltringham, S. K. 1975. Territory size and distribution in the African fish eagle. Journal of Zoology (London) 175: 1-13.

Gibbs, J. P., S. Woodward, M. L. Hunter. and A. E. Hutchinson. 1987. Determinants of great blue heron colony distribution in coastal Maine. Auk 104: 38-47.

Greenspan, B. and J. Torre-Bueno. 1971. Aspects of the biology of the African fish eagle Haliaaetus vocifer with special reference to vocalisation and territoriality. Unpublished report, Rockefeller University Field Course in Animal Behaviour, Uganda.

Kasoma, P.M.B. 1989. Aspects of the feeding ecology of some large wading birds in Queen Elizabeth National Park, Uganda. Ph.D. Thesis. University of Cambridge, Cambridge, UK.

Kasoma, P.M.B. 1991. The utilization of the lakeshore and littoral zone by large wading birds in Queen Elizabeth National Park: A preliminary report. Pages 65-67 *in* F. I. B. Kayanja and E. L. Edroma, eds., African Wildlife: Research and Management. ICSU Press, Paris, France.

Kasoma, P.M.B. 1992. Distribution and abundance of ciconiiform wading birds around Mweya, Queen Elizabeth National Park, Uganda. Pages 45-62 *in* L. Bennun, ed., Proceedings of the Seventh Pan African Ornithological Congress. Nairobi, Kenya.

Kemin, F. and Z. Zhongqin. 1991. The importance of wetlands in protecting birds. Pages 35-36 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Mafabi, P. G. 1989. Ecology and status of the grey crowned crane (*Balearica regulorum gibbericeps* Reich) in Uganda. M.S. Thesis. Makerere University, Kampala, Uganda.

Mafabi, P. G. 1991. The ecology and conservation status of the grey crowned crane in Uganda. Pages 363-367 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Nickerson, N. H. 1991. Preserving wetland values for people and wildlife. Pages 205-208 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Pomeroy, D. E. and B. Tengecho. 1986. A method of analyzing bird distributions. African Journal of Ecology 24: 243-253.

Sumba, S.J.A. 1984. The biology of the African fish eagle in Queen Elizabeth National Park, Uganda, with special reference to breeding. Ph.D. Thesis. University of Nairobi, Nairobi, Kenya.

Taylor, D. and P. G. Mafabi. 1991. Management of wetlands for sustainable use. Pages 8-10 *in* C. M. Finlayson and D. E. Pomeroy, eds., Wetlands and waterbirds in eastern Africa: Proceedings of the IWRB Workshop, Uganda 1990. IWRB, Slimbridge, Gloucester, UK.

Table 1. Presence of ciconiiform wading bird fauna recorded over a stretch of Lake Edward and Kazinga Channel shorelines and various swamp types in the Doho wetlands.

Species	Lake Edward and Bazinga Channel	Doho wetlands
Little Bittern (*Ixobrynchus minutus*)	+	+
Dwarf Bittern (*I. sturmii*)	-	+
Black-crowned Night Heron (*Nycticorax nyetiorax*)	-	+
Grey Heron (*Ardea cinerea*)	+	+
Blackheaded Heron (*A. melanocephala*)	+	+
Purple Heron (*A. purpurea*)	+	+
Squacco Heron (*Ardeola ralloides*)	+	+
Great white Egret (*Egretta alba*)	+	+
Black Heron (*E. ardesiaca*)	+	+
Little Egret (*E. garzetta*)	+	+
Yellowbilled Egret (*E intermedia*)	+	+
Cattle Egret (*Bubuleus ibis*)	+	-
Shoebill (*Balaeniceps rex*)	-	+
Hamerkop (*Scopus umbretta*)	+	+
Openbilled Stork (*Anastomus lamelligenus*)	+	+
Abdim's Stork (*Ciconia abdim*)	+	-
Woollynecked Stork (*C. episcopus*)	+	+
Saddlebilled Stork (*Ephippiorhynchus* sp.)	+	+
Marabou (*Leptoptilos crumeniferus*)	+	+
Yellowbilled Stork (*Myeteria ibis*)	+	+
Hadada (*Ibostsyehia hagedash*)	+	+
Glossy Ibis (*Plegadis falcinellus*)	+	+
Sacred Ibis (*Threskiornis aethiopica*)	+	+
African Spoonbill (*Platalea alba*)	+	+

Table 2. Ciconiiform wading bird fauna recorded in 80 counts over a 30 km shoreline of Kazinga Channel and Lake Edward during the study period. Percentage presence is the proportion of the total number of months in which counts were made when species was present in the study area. Relative abundance is the percent of all birds present.

Species	Mean (SE)	Number per km	Percentage presence	Relative abundance
Grey Heron	14.5 (0.688)	0.48	100	9.6
Black-Headed Heron	0.2 (0.068)	0.007	38	0.1
Goliath Heron	6.6 (0.216)	0.22	100	4.4
Purple Heron*	0.01	-	-	-
Great White Egret	6.4 (0.36)	0.21	96	4.2
Yellowbilled Egret	0.7 (0.094)	0.02	65	0.5
Little Egret	22.5 (1.603)	0.75	100	14.9
Cattle Egret	22.4 (4.297)	0.75	100	14.8
Squaco Heron	5.3 (0.805)	0.118	73	3.5
Black-Crowned Night Heron*	0.03	-	-	-
Little Bittern*	0.03	-	-	-
Hamerkop	1.3 (0.18)	0.04	73	0.9
Openbilled Stork	0.3 (0.121)	0.01	15	0.2
Abdim's Stork*	0.01	-	-	-
Wollynecked Stork*	0.06	-	-	-
Saddlebilled Stork	1.7 (0.154)	0.06	96	1.1
Marabou Stork	32.0 (2.556)	1.07	100	21.2
Yellowbilled Stork	18.5 (0.62)	0.62	100	12.2
Hadada Ibis	8.2 (0.574)	0.27	100	5.4
Glossy Ibis	0.4 (0.114)	0.01	19	0.3
Sacred Ibis	8.2 (0.622)	0.27	100	5.4
African Spoonbill	2.0 (0.296)	0.07	85	1.3
Total	151.3	5.04	-	-

*Counted only once or twice

Table 3. Distribution of Ciconiiformes on different wetland types at Doho Wetlands. The wetland types indicated are: Doho rice scheme (D,d); Outgrowers gardens (M,m); grass swamps (G,g); and papyrus swamp (P,p), where the most important wetland type for each species is indicated in upper case; less important ones are indicated in lower case. Those of minor importance are ignored. Percentage presence is the proportion of the total number of months in which surveys were done when species was present in the study area.

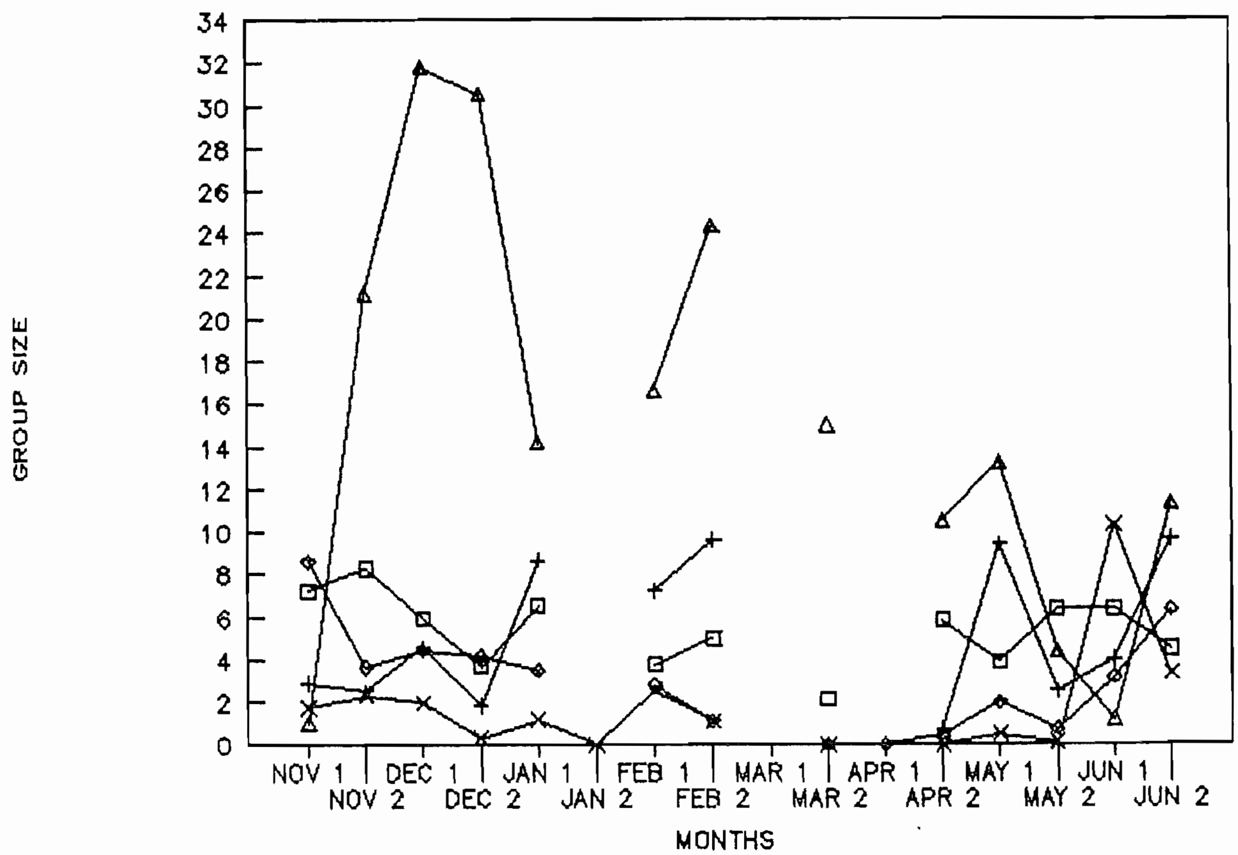
Species	Nov.-90	Dec.	Jan.-91	Feb.	Mar	Apr.	May	Jun.	Percent presence
Little Bittern	-	-	-	-	-	MG	dmG	-	25.0
Dwarf Bittern	P	-	Pg	-	-	Gp	Gp	-	50.0
Grey Heron	Dg	D	Dg	Dg		D	Dm	Dm	87.5
Blackheaded Heron	Dmg	Dm	Dmg	dmG	dmG	Dg	Dmg	Dm	100.0
Purple Heron	DGM	DG	d	mg	dmg	dm	dmg	dMg	100.0
Squacco Heron	DM	DM	DMg	DMG	DMG	DMg	DMgP	Dmg	100.0
Great White Egret	D	-	-	D	m	m	Md	DM	75.0
Black Heron	-	-	-	p	-	-	-	-	12.5
Little Egret	DM	Dm	Dm	Dm	DM	DM	DM	DM	100.0
Yellowbilled Egret	D	D	D	G	dmG	m	Dg	DMg	100.0
Shoebill	-	-	-	G	-	-	-	-	12.5
Hamerkop	g	-	-	g	D	-	-	-	62.5
Openbilled Stork	DM	DMg	DM	DM	DM	DMG	DMG	Dmg	100.0
Woollynecked Stork	-	-	-	-	-	D	-	-	12.5
Saddlebilled Stork	d	d	-	d	d	-	d	-	62.5
Marabou Stork	-	d	D	g	-	D	-	d	62.5
Yellowbilled Stork	d	-	Dg	g	-	d	dm	-	62.5
Hadada Ibis	d	-	-	-	d	-	Mg	M	50.0
Glossy Ibis	D	D	Dm	DMG	DM	DM	DM	d	100.0
Sacred Ibis	D	D	Dg	Dg	dMg	dM	Dm	DMg	100.0
African Spoonbill	d	d	D	g	d	d	d	Dm	100.0

Table 4. Relative occurrence of wading bird species in various microhabitats during the wet seasons.

Microhabitat	Wading bird species										
	Grey Heron	Goliath Heron	Great White Egret	Little Egret	Cattle Egret	Squacco Heron	Saddle-billed Stork	Yellow-billed Stork	Hadada Ibis	Sacred Ibis	African Spoonbill
Short grass	0	0	0.013	0.002	0.941	0	0	0	0.091	0.166	0
Mud pools	0	0	0	0.005	0	0	0	0	0	0.014	0.173
Vegetation in mud	0.014	0.028	0.017	0.016	0.051	0.016	0.063	0	0.629	0.303	0.037
Flooded channels	0.005	0.004	0	0.005	0	0	0	0	0.004	0	0.198
Water's edge	0.389	0. 409	0.419	0.557	0.005	0.116	0.156	0.448	0.178	0.276	0.247
Lake pools	0.109	0.117	0.059	0.043	0	0	0	0.017	0	0.007	0.123
Vegetation in water	0.292	0.300	0.347	0.365	0.005	0.869	0.781	0.488	0.100	0.234	0.037
Open lake	0.192	0.142	0.144	0.008	0	0	0	0.046	0	0	0.185

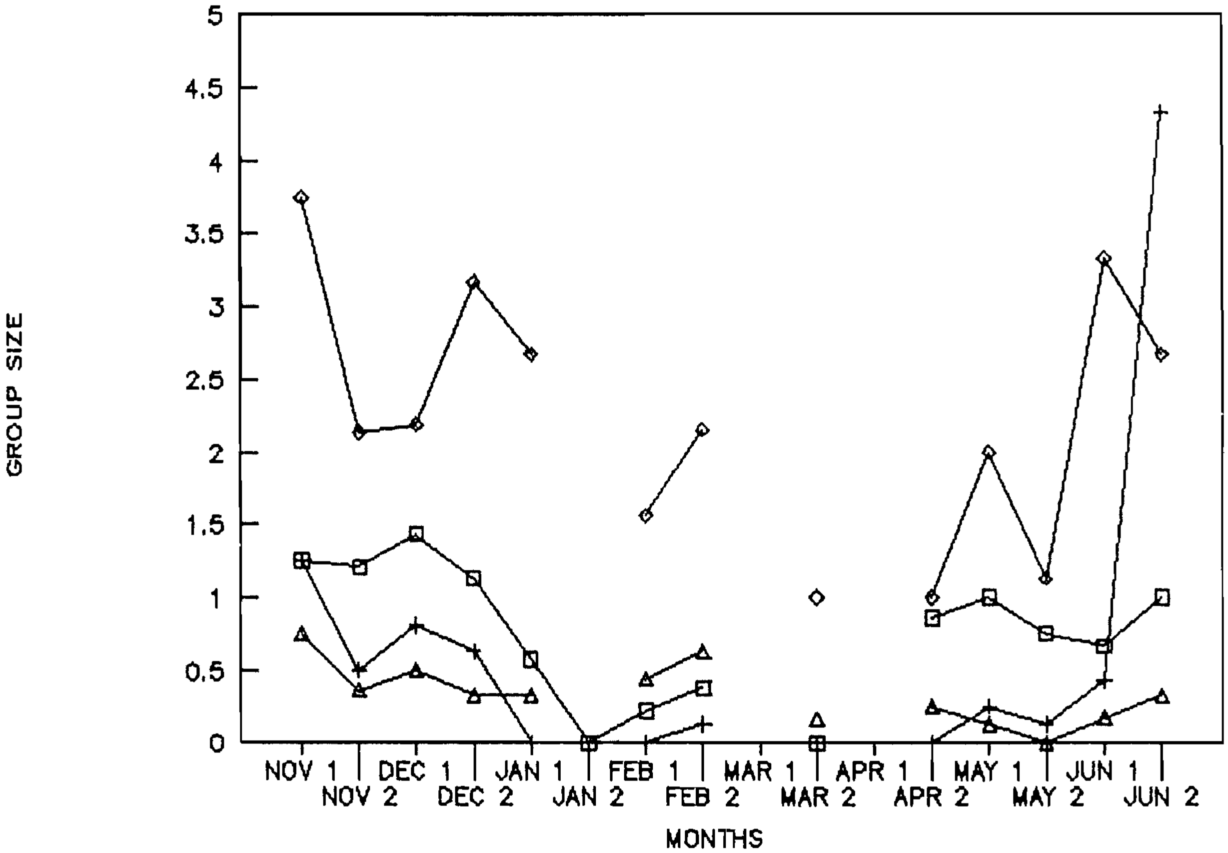
Table 5. Relative occurrence of wading bird species in various microhabitats during the dry seasons.

Microhabitat	Wading bird species										
	Grey Heron	Goliath Heron	Great White Egret	Little Egret	Cattle Egret	Squacco Heron	Saddle-billed Stork	Yellow-billed Stork	Hadada Ibis	Sacred Ibis	African Spoonbill
Short grass	0	0	0	0.005	0.906	0	0	0	0.167	0.217	0
Vegetation in mud	0.004	0.005	0	0.018	0.075	0	0.130	0	0.478	0.261	0
Water's edge	0.498	0.392	0.384	0.508	0.008	0.107	0.217	0.370	0.304	0.383	0.300
Lake pools	0.087	0.097	0.055	0.054	0	0	0	0.043	0	0.009	0.300
Vegetation in water	0.266	0.235	0.299	0.399	0.011	0.893	0.565	0.500	0.051	0.130	0.100
Open lake		0.144	0.272	0.264	0.016	0	0	0.087	0.087	0	0 0.300



□ Squacco Heron
+ Openbilled Stork
◊ Sacred Ibis
Δ Glossy Ibis
× Yellowbilled Egret

Figure 1. Group size of gregarious species of Ciconiiformes.



□ Grey Heron
+ Great White Egret
◊ Little Egret
Δ Purple Heron

Figure 2. Group size of territorial species of ciconiiformes.

SECTION 5

CRANE AND WETLAND CONSERVATION IN SOUTHERN AFRICA

THE CONSERVATION MANAGEMENT OF CRANES IN ZAMBIA

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BACKGROUND

The conservation of Wattled Cranes (*Bugeranus carunculatus*) and Grey Crowned Cranes (*Balearica regulorum*) in Zambia has advanced little since the early promulgation of protected (royal game) status for the species. IUCN and WWF initiatives in the mid-1980's provided the first external support for wetlands conservation in Zambia and endorsed existing interest in threatened wetland bird and antelope populations.

Prior to these recent developments, information on the two crane species in Zambia was collected under the auspices of the Zambia Ornithological Society (ZOS), the Wildlife Conservation Society of Zambia (WCSZ), and the now defunct Kafue Basin Research Committee (KBRC) of the University of Zambia. WCSZ/KBRC work provided limited aerial census data for Wattled Cranes on the Kafue Flats in the early and mid-1980's (Howard and Aspinwall 1984). This has since been continued and expanded to the southern Bangweulu Basin in northeastern Zambia by the WWF-Zambia Wetland Project. Few data exist for the Grey Crowned Crane in Zambia outside the Luangwa Valley, in Eastern Province.

Since 1991 the International Waterfowl and Wetlands Research Bureau (IWRB) has encouraged the regular counting of waterfowl in both the Bangweulu and Kafue Flats areas, using both aerial and ground-based surveys. The ZOS Bird Atlas Project now has good presence/absence coverage for cranes in most parts of the country. Nevertheless, most data collected to date have been assembled as by-products of more general activities and not as part of specific crane strategies. At this stage the data raise more questions than they answer and as such have permitted little output to the generation of crane conservation plans in Zambia.

DISTRIBUTION AND ACTIVITY PATTERNS

The limited existing information base indicates that Wattled Crane movements and activities pose a considerable challenge to the successful management of their conservation in Zambia. In both Wetlands Project areas (Bangweulu and Kafue Flats) the following characteristics are emerging:

- numbers appear to fluctuate considerably both between years and within years, with destinations of moving birds being unknown;
- nesting activity is spread throughout the year, peaking between April/May and August (Benson *et al.* 1973);
- nesting sites are widely distributed and frequently outside areas with statutory protected status;
- activity zones such as feeding, flocking, courtship, and nesting areas can be widely separated.

As noted earlier, much less is known of the Grey Crowned Crane, especially outside high density localities in the Luangwa Valley.

PROTECTION

National park or similar protection status covers a very limited proportion of the potential crane habitat areas in Zambia, in spite of an 8% state appropriation for national parks. For example, on the Kafue Flats some 20 km of floodplain frontage in the Lochinvar and Blue Lagoon National Parks is protected, within an overall 800-900 km of potential habitat frontage on both sides of the Kafue Flats. Similar ratios pertain in the Isangano National Park and the Chikuni Hunting-Free Zone within the Bangweulu Game Management Area.

Elsewhere in the country there are protected areas covering principal crane distributions in the Liuwa Plains National Park in western Zambia, the Kafue National Park (Busanga Plains) in central Zambia and the South and North Luangwa National Parks in the east. The Nyika National Park in the northeast, which is shared with and predominantly within Malawi, shelters a montane wetland habit area.

Other national parks in the northwest and north of the country have small crane populations, but equally offer very limited coverage of potential habitat areas. The paucity of existing knowledge of crane movements and resource requirements within Zambia, therefore precludes any present attempt to match existing protected areas to crane conservation needs.

THREATS

The extensive and mobile nature of threats to crane status in Zambia mitigate against straightforward conservation management strategies. Observation would suggest that the principal threats to cranes, and particularly crane breeding are:

- uncontrolled grass and deep litter fires in the period May to November;
- year-round human disturbance from fishing operations and associated ad hoc egg collecting and nest raiding;
- resident and non-resident large mammal and duck hunting activities;
- unseasonal flooding associated with water resources management by the hydroelectric power generating utility

(on the Kafue Flats);
- uncontrolled cattle grazing (chiefly on the Kafue Flats and in western Zambia).

The wide range of these influences indicate complex solutions are required in each of the legal, operational, and educational elements of possible conservation strategies. Target groups for each of these inputs range from traditional, low literacy, rural communities, to the educated, urban elite, and state enterprises.

The importance of natural predation on crane eggs, nestlings, and molting adults within their Zambian range is unknown.

CONSERVATION INITIATIVES

As explained, the research data base for crane species in Zambia is limited. This has consequent constraints on the inputs to crane conservation management plans. Thus the immediate requirement of any domestic crane conservation strategy would appear to be an expanded research input. In particular, activity patterns and associated movements, habitat needs, longevity, and natural and introduced predation and disturbance, warrant priority attention.

The observed but untested close correspondence in the local distributions on Wattled Cranes and black and Kafue lechwe (*Kobus leche smithemani* and *K. l. kafuensis*, respectively) in the Bangweulu Basin and on the Kafue Flats, respectively, may also reward research input.

Immediate conservation plans are also needed, however. In most range areas of Zambia the control of grass and deep litter fires offers a useful primary conservation objective likely to benefit the nesting success of Wattled Cranes. The difficulties in achieving effective fire control, especially in open flood plain areas, is not underestimated.

The control of resident and itinerant fishing activities through the peak wet season (December to February) is likely to benefit nesting success in both Grey Crowned and Wattled Cranes. This initiative would correspond to governmental controls on fishing over this common breeding period.

Large mammal hunting is not permitted between December and May; this offers useful theoretical controls on disturbance of crane habitat areas in hunting zones over this period. Bird shooting is less carefully controlled to date and unlawful off-take of birds and antelope species in wetland areas would still appear to be in excess of the licensed quotas (Jeffery 1991). In this context work aimed at matching crane ranges and protected areas is an important priority.

CONCLUSIONS

To date the use of faunal populations as indicators of wetland condition has been limited to the monitoring of Kafue and black lechwe populations on the Kafue Flats and in the Bangweulu Basin, respectively. This is doubtless due to the greater abundance and observability of these antelope species.

The few data available for bird species are insufficient for definite trend analysis on Wattled Crane populations in Zambia and inadequate for any assessment of the status of the Grey Crowned Crane. The immediate utility of these two species as indicators of wetland condition is therefore limited.

Nevertheless, within the WWF-Zambia Wetlands Project areas at least, improved crane conservation per se, is an objective. The opportunity then exists for current conservation efforts to demonstrate achievements in improved conservation and management of crane populations. In the longer term, it is hoped that these trends will reflect improved management of wetland areas as a whole.

REFERENCES CITED

Benson, C. W., R. K. Brooke, R. J. Dowsett, and M.P.S. Irwin. 1973. The birds of Zambia. 2nd ed. Collins, London, UK.

Howard, G. W. and D. R. Aspinwall. 1984. Aerial censuses of Shoebills, Saddlebilled Storks, and Wattled Cranes at the Bangweulu Swamps and Kafue Flats, Zambia. Ostrich 55: 207.

Jeffery, R.C.V. 1991, Project proposal for the continuation of WWF Project 3515. Lusaka, Zambia.

DISTRIBUTION OF CRANES IN ZAMBIA

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Zambia is a land-locked country in Central Southern Africa covering some 750,000 km² (Figure 1). Of this area around 6% comprises vast wetlands and swamp forests (WWF 1991), while about 13% of the country consists of wetland areas including dambos (Chabwela and Chinjanga 1992). As cranes are predominantly wetland birds, there is therefore a large extent of suitable habitat potentially available to them in Zambia.

Two species of crane live and breed in Zambia, the Wattled Crane (*Bugeranus carunculatus*) and the Grey Crowned Crane (*Balearica pavonina*). Zambia is more or less central to the world distribution of both of these birds.

Figures 2 and 3, respectively, show the distribution patterns of Wattled Cranes and Grey Crowned Cranes in Zambia, according to their recorded presence in quarter degree squares (D. Aspinwall *pers. comm.*). Probably the most central area for both species in the country is the Kafue Flats, but thereafter the distribution patterns are surprisingly different.

The Wattled Crane is much more widespread than the Grey Crowned Crane, especially in Western Province, where the latter is only resident around the Liuwa Plains. The Wattled Crane is widespread throughout this relatively flat area, occurring usually in small numbers on scattered dambos and in the Barotse floodplain. Interestingly it is the Grey Crowned Crane whose distribution more clearly represents the main wetland systems (Figure 1), with the Wattled Crane rather opportunistically exploiting minor wetland sites and probably moving more readily between them and the major wetlands. However, it is the Wattled Crane whose requirements are more closely aligned with true wetlands, and its wide distribution over the country indicates the extent and importance of Zambia's wetlands and seasonally inundated areas for this globally-threatened bird.

The greatest number of Wattled Cranes probably occurs in the Kafue Flats, seconded by the Bangweulu Basin. Western Province, especially the Liuwa Plains, also holds a good population. The Grey Crowned Crane is only poorly represented in Bangweulu, probably because of the extent of inundation and the relative paucity of short grasslands close to water.

Probably the greatest concentration of Grey Crowned Cranes is in the Luangwa Valley, where flocks of 300 to 500 were recorded in 1992 (ZOS 1992). Although the Luangwa Valley is not an extensive wetland system as such, it does contain a large number of seasonal ox-bow lakes and several minor plains. The Grey Crowned Crane is a breeding resident here (Scott 1991) and the Wattled Crane an occasional vagrant (Berry and Stjernstedt 1989). Certainly this is not a suitable place for the Wattled Crane to breed, as water resources do not tend to last well through the dry season. The level of protection afforded by the parks and the general lack of disturbance in short grassland areas may also contribute to the suitability of this area to the Grey Crowned Crane.

The Wattled Crane is reported to show altitudinal preferences, usually occurring above 2,000 m in breeding season and below 1,000 m in non-breeding season (Urban in Urban, Fry, and Keith 1986). Benson *et al.* (1971) also note that it is uncommon at low altitudes, citing its absence from the Middle Zambezi Valley. However, in Zambia such factors must be regarded as secondary to the availability of suitable habitat - Wattled Cranes occur in most open areas where shallow water with sedges is present.

Other areas in Zambia where both cranes occur are the plains between Lakes Mweru Wantip and Tanganyika and in parts of Kafue National Park.

Although we have a fairly clear picture of the distribution of both cranes in Zambia, more information is needed on their status, particularly in Western and Northern Provinces, and on the vulnerability and threats facing the different populations. The importance of dambos, particularly for the Wattled Crane, should also be assessed and any regular migration patterns more clearly understood. Such information will help greatly in ensuring the conservation of these two important cranes in Zambia.

ACKNOWLEDGMENTS

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REFERENCES CITED

Benson, C. W., R. K. Brooke, R. J. Dowsett, and M.P.S. Irwin. 1971. The birds of Zambia. Collins, London, UK.

Berry, F.S.M. and R. Stjernstedt. 1989. Luangwa bird list. Unpubl. MS.

Chabwela, H. N. and I. M. Chinjanga. 1992. Wetlands as

[1]*Present address:* International Waterfowl and Wetlands Research Bureau, Slimbridge, Gloucester, GL2 7BX, United Kingdom.

potential sites for the future of tourism development. Pages 71-73 *in* R.C.V. Jeffery, H. N Chabwela, G. Howard, and P. J. Dugan, eds., Managing the wetlands of Kafue Flats and Bangweulu Basin. IUCN, Cambridge, UK.

Scott, A. J. 1991. A revised and annotated checklist of the birds of the Luangwa Valley national parks and adjacent areas. Zambian Ornithological Society, Occasional Paper No. 3. Lusaka, Zambia.

Urban, E. K., C. H. Fry, and S. Keith, eds. 1986. The birds of Africa. Vol. II. Academic Press, London, UK.

World Wide Fund for Nature (WWF). 1992. WWF international country profile: Zambia. World Wide Fund for Nature, Gland, Switzerland.

Zambian Ornithological Society (ZOS). 1992. Newsletter. Vol. 22.

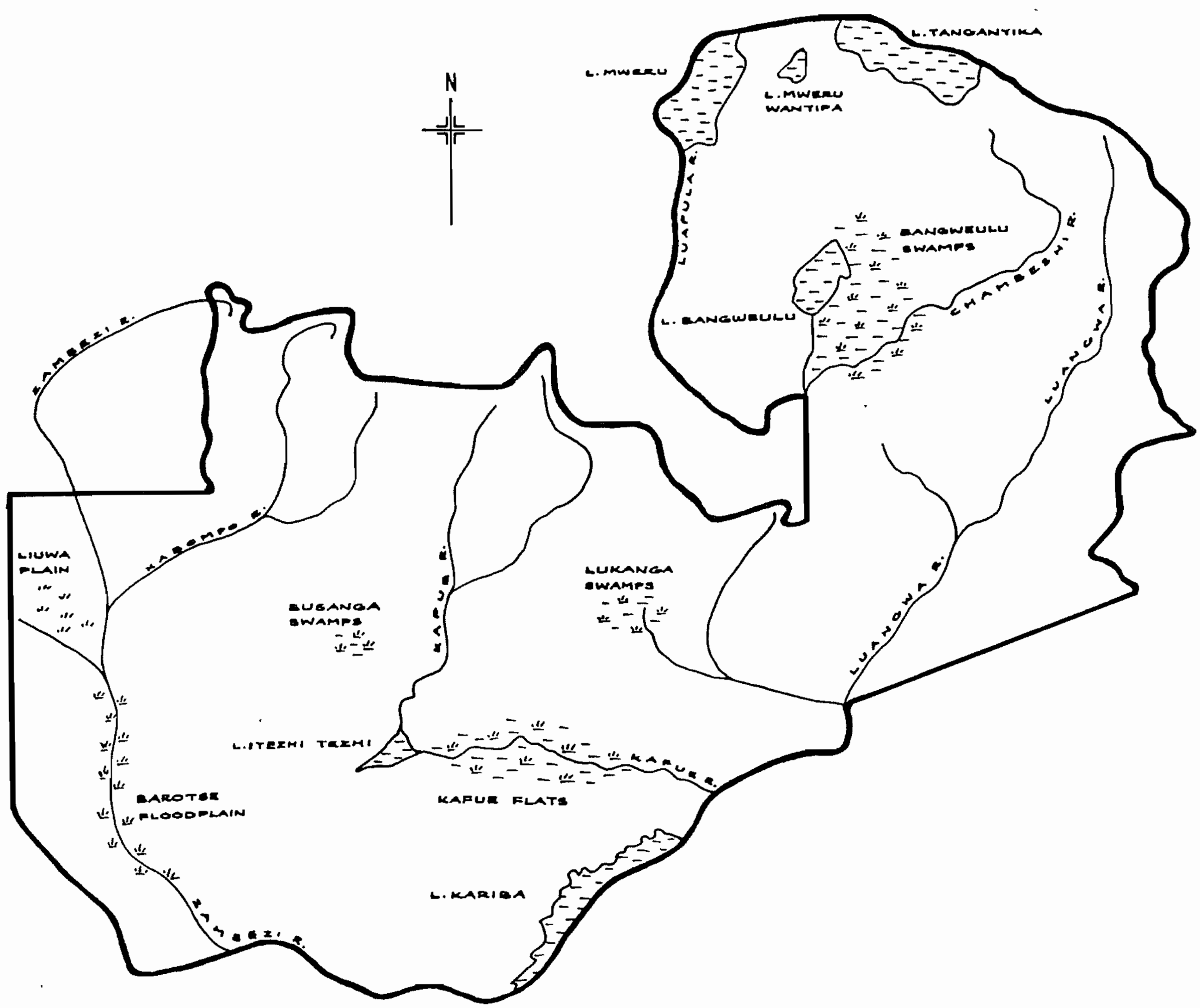

Figure 1. The main rivers and wetlands of Zambia.

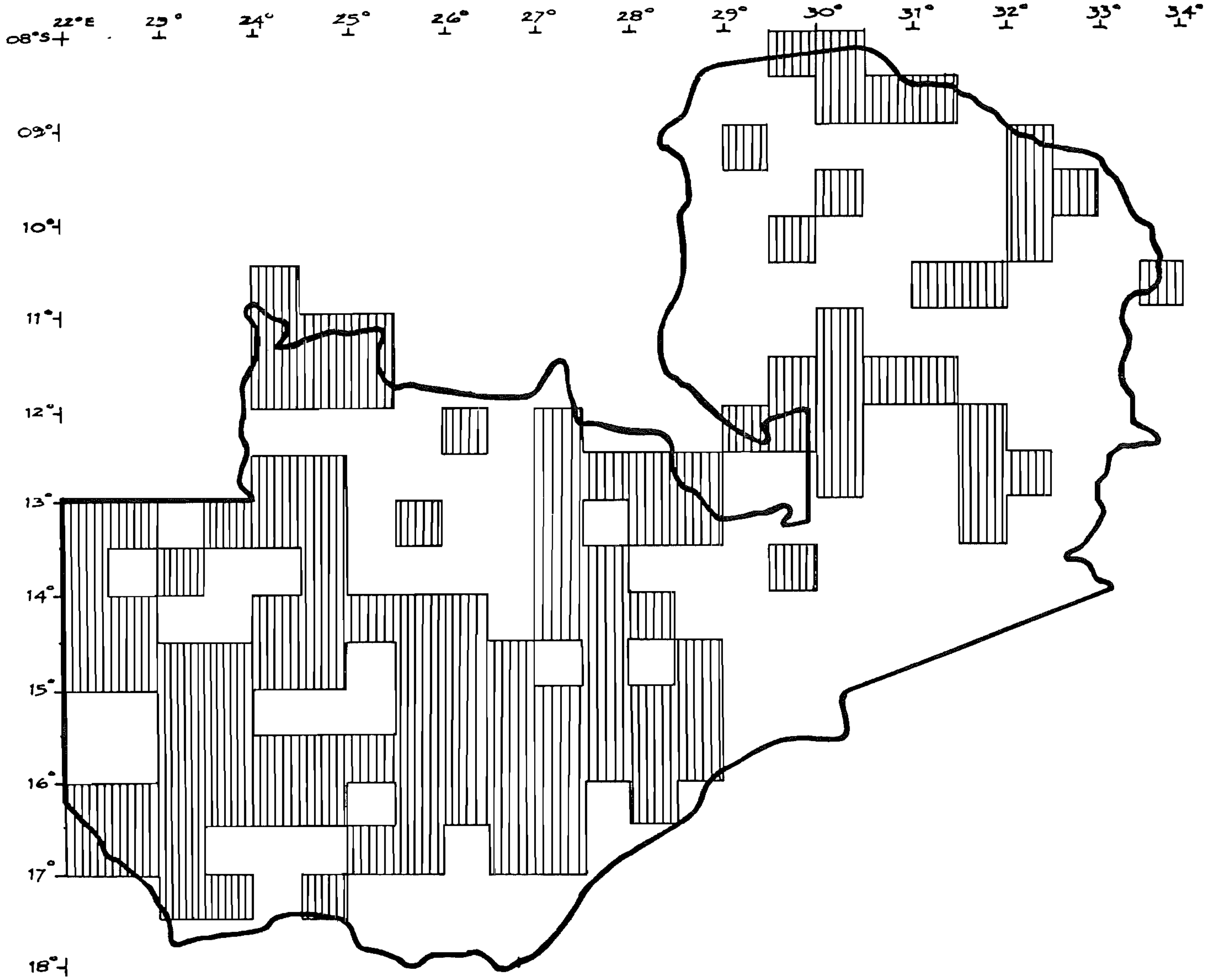

Figure 2. Distribution of the Wattled Crane in Zambia.

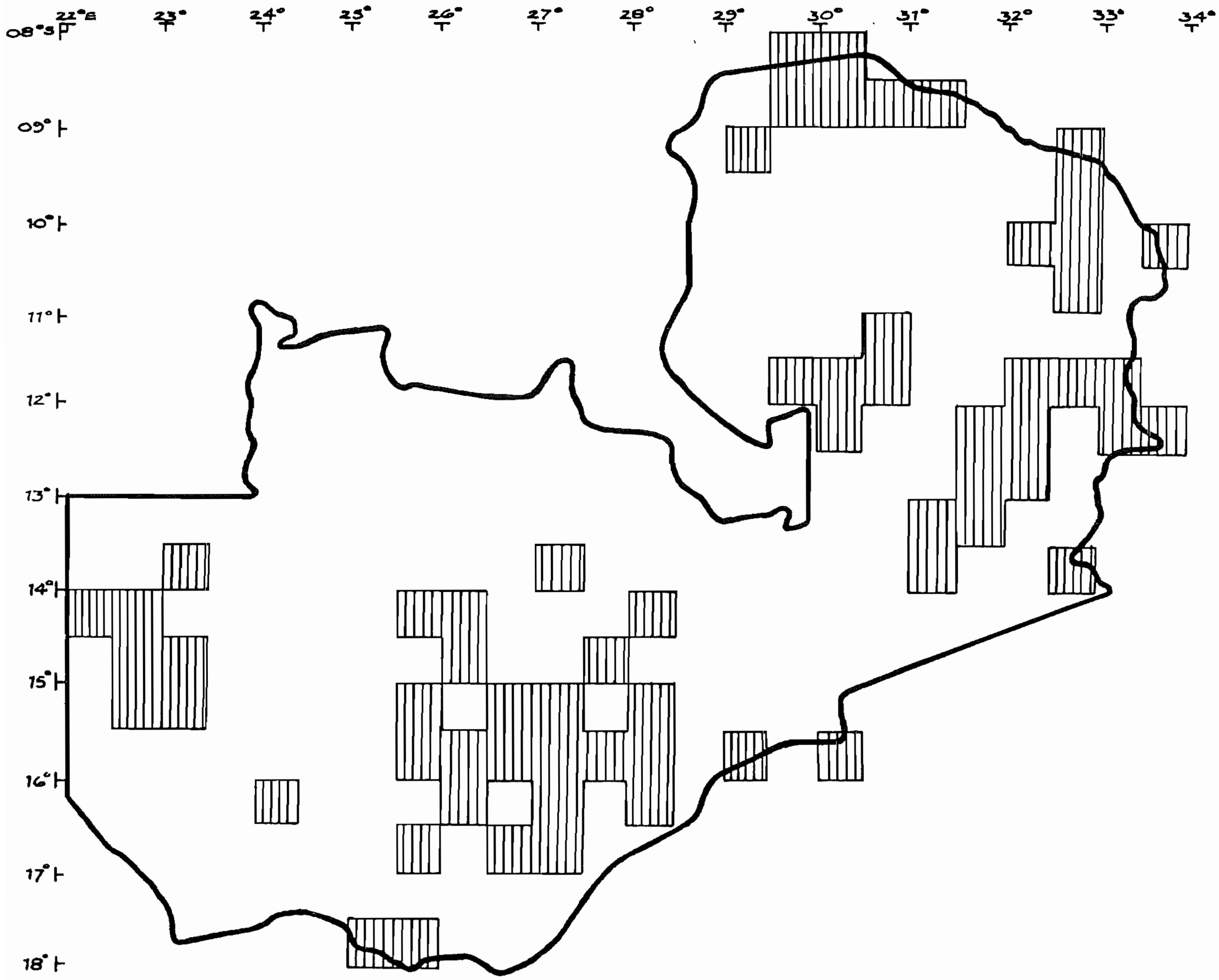

Figure 3. Distribution of the Grey Crowned Crane in Zambia.

PRESENT STATUS AND DISTRIBUTION OF CRANES IN THE KAFUE FLATS, ZAMBIA WITH REFERENCE TO POPULATION ESTIMATES OF THE 1980'S

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INTRODUCTION

The Kafue Flats cover an area of approximately 6,500 km² (Figure 1) and include two national parks, Lochinvar and Blue Lagoon, together comprising 830 km², and a game management area. Although the Wattled Crane (*Bugeranus carunculatus*) and Grey Crowned Crane (*Balearica regulorum*) are conspicuous birds of the Kafue Flats, no systematic and detailed research has been undertaken on either species in this important wetland site. This short paper brings together information gathered from casual sightings and observations in 1992 and 1993, especially focusing on Lochinvar National Park, and from three IWRB Waterfowl Counts conducted over the same period. Results are then discussed in comparison with results of the 1980's and a recommended research program briefly outlined.

PRESENT STATUS AND DISTRIBUTION OF THE WATTLED CRANE

The Wattled Crane is a breeding resident within the Kafue Flats, though it may make excursions into other areas; e.g., to the Makgadigadi Pans, Botswana during the wet season (Konrad 1981). However, the Kafue Flats is a large area, covering some 6,000 km² of floodplain, over which cranes move readily, especially seasonally.

The greatest numbers of cranes tend to be seen during the rainy season (December to April), when large non- or pre-breeding flocks gather in feeding parties. Favored areas are partially inundated grasslands, such as the Gwisho Plain, Lochinvar in December 1992 and the Nampongwe Plain, Lochinvar in February 1993, when over 250 birds were recorded in a single flock. As the rainy season proceeds these large flocks gradually disperse, but also make local movements, when they cannot always be detected easily, except from the air.

Dancing displays commence early on in the rains and continue for several months. Pairs segregate from the main flocks from about March onwards, but large flocks persist throughout the year, presumably composed of non-breeders and other cranes, late breeders initially, and early and failed breeders later on. In July 1993 two large groups were found, one a fairly scattered flock of over 300 birds to the west of Lochinvar and one of close to 200 birds (split into two main groups of 134 and 50 birds) in the eastern flood plain of Lochinvar (Figure 2). Both were in flooded grasslands. Single birds, pairs, and groups of less than 10 were scattered over a much wider area, mostly within the flooded plains. In June 1992, a loose flock of around 250 birds was present at Blue Lagoon National Park. Thus it is evident that even in the supposed middle of the crane's breeding season a large proportion (maybe 70%) remained in flocks.

However, dancing displays have been observed as late as June and July, so it is possible that some members of the population breed significantly later than others. Douthwaite (1974) suggested that numbers breeding are related to the extent of flooding, with as few as 3% of the population breeding in limited flooding years and 40% breeding in normal years. The year 1992 was therefore likely to have been a particularly poor breeding season, when much of southern Africa experienced severe drought. By contrast, 1993 saw water levels rising to normal flood heights (though the whole ecosystem is now dependent on the control of water release from the Itezhi-Tezhi Dam upriver). In July 1993 it was likely that at least 20% of the population was breeding.

PRESENT STATUS AND DISTRIBUTION OF THE GREY CROWNED CRANE

The Grey Crowned Crane, like the Wattled Crane, is a breeding resident within the Kafue Flats. However, it tends to follow a rather more straightforward cycle of events throughout the year. Pairs start to form in the early rains, around November, and the birds are usually rather difficult to find in the rainy season; e.g., only 13 were seen during January 1992 ground counts, Lochinvar and Blue Lagoon, with approximately 50 birds seen from the air in the same month.

As the rainy season proceeds, pairs and their new offspring start to form into groups, gradually building up into sizable flocks by June and July. Quite well-developed juveniles were observed as early as April in 1992. In July 1993 one large flock of 91 birds, including immatures, was found on the Bwanda Plain at Lochinvar (Figure 2). Such flocks are then regular within the Flats for the rest of the dry season (e.g., 150 birds, Lochinvar, September 1992), often found in burnt grasslands close to water. Throughout the dry season of 1992 one main flock fluctuating between 70 and 150 birds was present at the eastern side of Chunga Lagoon,

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Lochinvar, comprising both adults and juveniles. By breeding early in the rains it is likely that this species is a more successful breeder in years of poor flooding than the Wattled Crane.

The Grey Crowned Crane is definitely less numerous in the Kafue Flats than the Wattled Crane, possibly numbering between 200 and 300 birds. Additionally, the two species are rarely found together, unlike in the Liuwa Plains, where they have been observed in mixed feeding flocks (A. Pope, pers. comm.). It is unclear why the population is not higher, as breeding success seems to be quite good. Possibly the habitat is not optimal for this species, which can be found in greater concentrations for instance in the Luangwa Valley, East Zambia. At times of the year, short grassland areas are quite scarce within the Kafue Flats and there is certainly a lack of good roosting trees close to the water. Additionally, no Grey Crowned Cranes were seen outside the central Lochinvar/Blue Lagoon area in either aerial count of 1993; human activity is quite high in the drier areas which this crane seems to favor. This may explain their concentration within the two main, but limited, protected areas.

The July ground counts at Lochinvar revealed 100 birds in 1992 and 94 birds in 1993 (actual numbers). These cranes also occur at Blue Lagoon, but are rather less in number (52 in June 1992). The dry season maximum number recorded at Lochinvar is 150 (October 1992) and it is unlikely that the true population is much higher than this.

STATUS OF WATTLED CRANE IN RELATION TO PAST POPULATION ESTIMATES

The present population estimates for Wattled Crane within the Kafue Flats are rather less than previous estimates (Table 1).

The figure for Lochinvar and Blue Lagoon (January 1993) is based on ground counts, all others are aerial counts. The flights of January and July 1993 both covered part of the Kafue Flats, estimated at 15% of total area for January and 50% of total area for July.

All the 1993 figures show a marked decline from previous years. The result of Jeffery *et al.* (1993) is interesting as it is directly comparable with the population estimate of 1984. However, it is likely that this method for counting cranes is less applicable to them than it is to lechwe, although as Howard (1988) points out, this data should continue to be collected for comparative analyses.

It is possible that the population estimates of the 1980s are too high; it seems there is a difficulty in extrapolation of data, particularly for large flocks. These flocks tend to be quite widely scattered (i.e., each flock may spread over a wide area), but generally occur within the central region of the flats around Lochinvar and Blue Lagoon, where they are quite likely to be found from the air. It seems that these flocks are quite localized, with only a few other cranes being found in the same sort of area or stratum. Thus, though an estimated population based on dividing the total birds counted by the percentage of stratum sampled may be suitable for single birds, pairs, and small groups, it may lead to overestimates when taking account of medium to large flocks, based on the perceived distribution patterns of 1993. Likewise, extrapolation of the 1993 aerial count data may not be applicable for large flocks, and it is infinitely preferable that all large flocks are physically counted with a high degree of certainty. It is of course also possible that there has been a genuine decline in the population to about a third of its size in around 10 years, which would be very alarming if this were the case. The average population estimate for the three counts in 1993 is 1,150 birds.

The group sizes of Wattled Cranes change throughout the year, though no doubt no two years are the same. It would seem from Table 2 that more Wattled Cranes are breeding in November that in July. This seems rather surprising as to start breeding after July leaves little time for rearing offspring before gathering in large flocks again for the onset of the next rains. It is likely that those birds in singles or in small groups were also breeding, or about to breed, as they were found close to the main nuclei of visibly breeding pairs. During this count, it is likely that the main flocks of cranes were all detected (though a group of 55 was discovered in a subsequent ground count at Blue Lagoon), with possible under recording of singles and pairs. The proportion of birds in singles, pairs, or small groups was 49% in November 1987, 18% in January 1993, and 21% in July 1993.

RESEARCH RECOMMENDATIONS

All waterfowl

Continue extensive IWRB surveys for Lochinvar and Blue Lagoon every January and July, and carry out one aerial census of the Kafue Flats in each of these months, aiming to cover as much as possible of suitable crane habitat, particularly for large flocks of Wattled Crane. This should help in improving the picture of distribution during these two census months, before the breeding season starts (January), and during the breeding season (July).

Establish a fixed method for aerial survey of waterfowl and in particular of Wattled Crane.

Carry out waterfowl counts in April and October at Lochinvar and Blue Lagoon to supplement the IWRB counts.

Cranes

Introduce a color-ringing scheme for cranes (especially Wattled Cranes) within the Kafue Flats. Ringing should be of young birds (before they are able to fly). This will help in determining the movements of cranes, as well as providing much other useful information if the scheme can be organized efficiently.

Wattled Cranes

Continue with random stratified sampling counts around May, when conducting lechwe surveys. Although this may not be the best means of estimating the crane population, there are compatible data from previous years which will allow comparative analysis.

These recommendations are applicable to other wetland areas, in particular the Bangweulu Swamps.

ACKNOWLEDGMENTS

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REFERENCES CITED

Benson, C. W., R. K. Brooke, R. J. Dowsett, and M. P. S. Irwin. 1971. The birds of Zambia. Collins, London, UK.

Berry, F. S. M. and R. Stjernstedt. 1989. Luangwa bird list. Unpubl. MS.

Chabwela, H. N. and I. M. Chinjanga. 1992. Wetlands as potential sites for the future of tourism development. Pages 71-73 *in* R.C.V. Jeffery, H. N. Chabwela, G. Howard, and P. J. Dugan, eds., Managing the wetlands of Kafue Flats and Bangweulu Basin. IUCN, Cambridge, UK.

Dodman, T. 1993. IWRB censuses: Kafue Flats, January 1993. Unpubl. MS.

Dodman, T. 1993. IWRB waterfowl surveys in the Kafue Flats and Bangweulu Basin, 1993. Unpubl. MS.

Douthwaite, R. J. 1974. An endangered population of Wattled Cranes *(Grus carunculatus).* Biological Conservation 6(2), 134-142.

Howard, G. W. 1988. Recent counts of Wattled Cranes on the Kafue Flats, Zambia - February 1987. Unpubl. MS.

Howard, G. W. and D. R. Aspinwall. 1964. Aerial censuses of Shoebills, Saddlebilled Storks and Wattled Cranes at the Bangweulu Swamps and Kafue Flats, Zambia. Ostrich 55: 207-212.

Howard, G. W. and R.C.V. Jeffery. 1987. Kafue lechwe population census, November, 1987. Report to the director, National Parks and Wildlife Service, Chilanga, Zambia. 8 pages, mimeographed.

Jeffery, R.C.V. *et al.* 1993. Results of aerial stratified random sampling census of Wattled Crane on the Kafue Flats (17th-18th May 1993). Unpubl. MS.

Konrad, P. M. 1981. Status and ecology of Wattled Crane in Africa. Pages 220-237 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world. International Crane Foundation, Baraboo, Wisconsin, USA.

Malambo, C. H. 1990. Census of Wattled Cranes, Saddle-billed Storks, Spur-winged Geese and Shoebills (Whale-headed Storks) in the Kafue Flats and Bangweulu Swamps (1987-1990). Unpubl. MS.

Scott, A. J. 1991. A revised and annotated checklist of the birds of the Luangwa Valley national parks and adjacent areas. Zambian Ornithological Society, Occasional Paper No. 3. Lusaka, Zambia.

Urban, E. K., C. H. Fry, and S. Keith, eds. 1986. The birds of Africa. Vol. II. Academic Press, London, UK.

World Wide Fund for Nature (WWF). 1992. WWF International Country Profile: Zambia. World Wide Fund for Nature, Gland, Switzerland.

Zambian Ornithological Society Newsletter, Vol. 22 and 23: 1-5. Jan. 1992 - May 1993.

Table 1. Population estimates for Wattled Cranes in the Kafue Flats, 1982-1993.

Month	Year	Population	Location	Researcher(s)
May	1982*	3,282	Kafue Flats	Howard and Aspinwall
November	1987*	2,508	Kafue Flats	Howard
May/June	1988*	2,724	Kafue Flats	Malambo
August	1989*	3,273	Kafue Flats	Malambo
January	1993	499	Lochinvar/Blue Lagoon	Dodman
January	1993	1,373	Kafue Flats	Dodman
May	1993*	809	Kafue Flats	Jeffery *et al.*
July	1993	1,268	Kafue Flats	Dodman

*These counts followed the stratified random sampling technique, as used for the survey of the Kafue Lechwe population (Howard and Jeffery 1987)

Table 2. Frequency of observation of Wattled Crane group sizes and sum of birds in each group size, in the Kafue Flats. Aerial census data from Howard (Nov. 1987) and Dodman (Jan. 1993, July 1993).

Group size	November 1987		January 1993		July 1993	
	Frequency	Sum	Frequency	Sum	Frequency	Sum
Single birds	0	0	0	0	5	5
Pairs	67	134	5	10	32	64
Small Groups (3-30)	13	47	4	30	9	62
Medium Flocks (10-50)	9	188	1	16	1	50
Large Flocks (>50)	0	0	1	150	2	453
Total		369		206		634

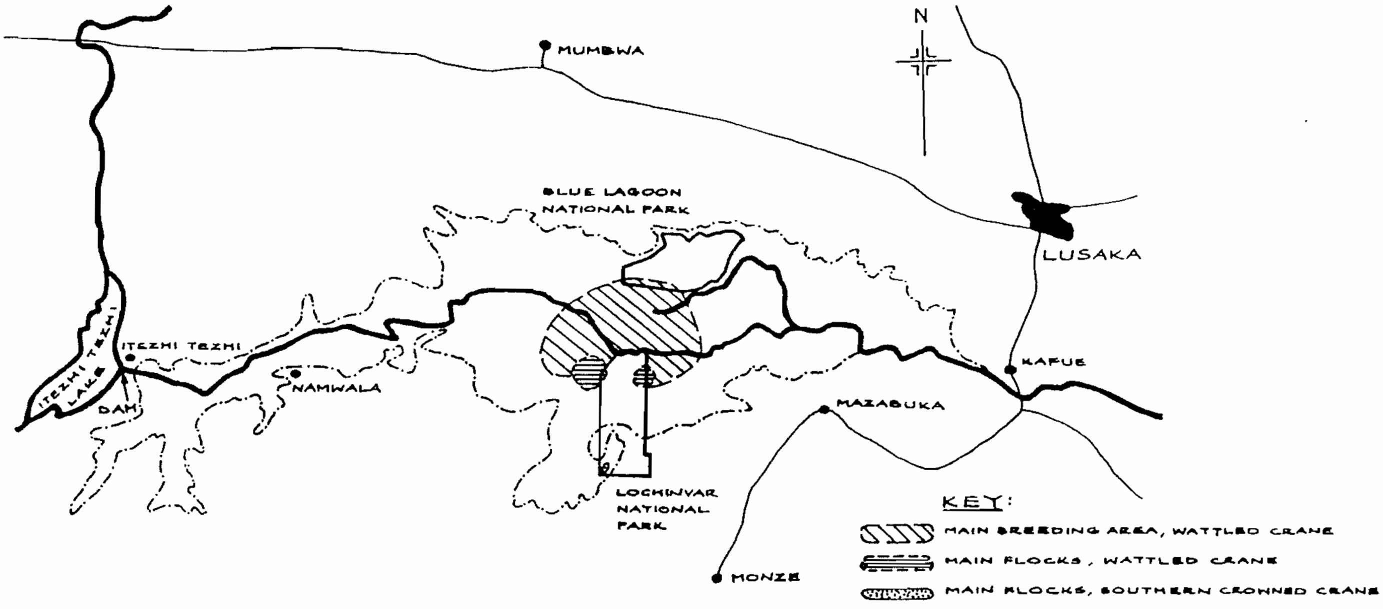

Figure 1. Map of the Kafue Flats, Zambia.

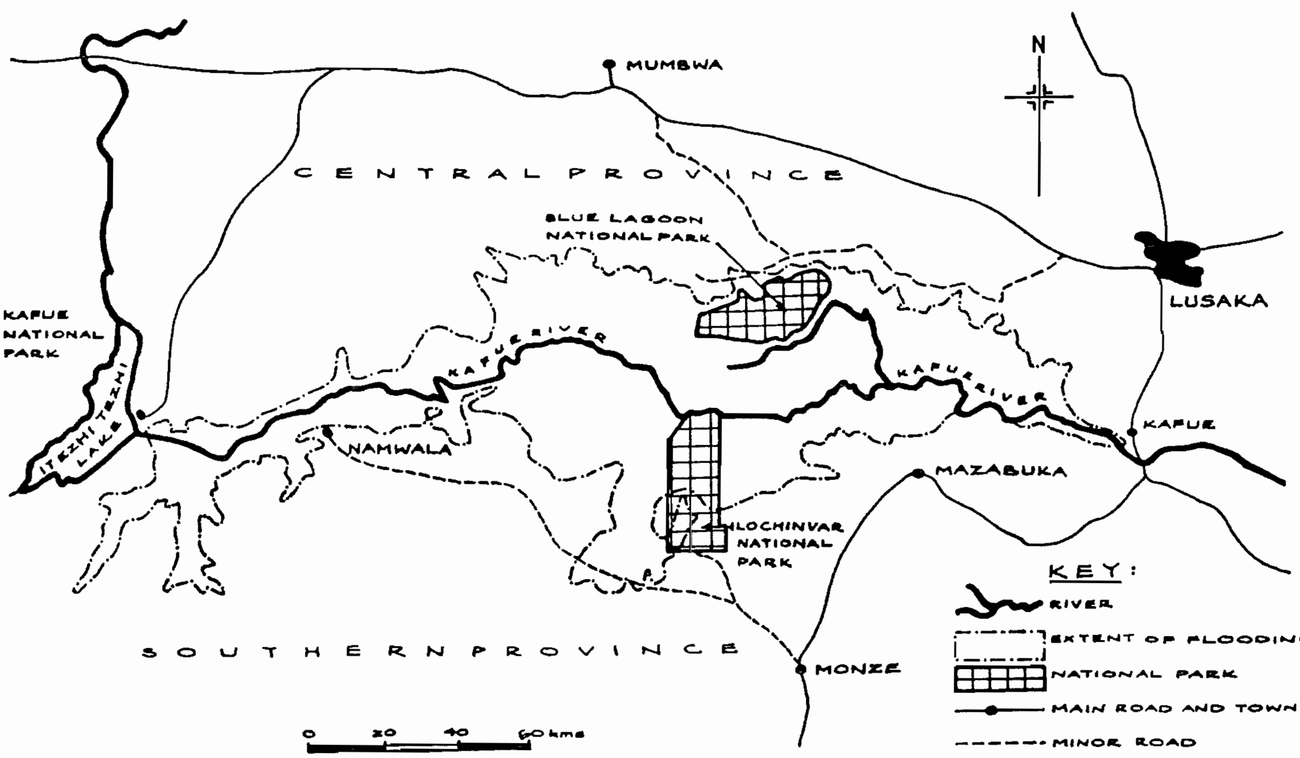

Figure 2. Approximate distribution of Wattle and Grey (Southern) Crowned Cranes in the Kafue Flats, Zambia, July 1993.

STATUS AND ECOLOGY OF WATTLED CRANES IN BANGWEULU BASIN, ZAMBIA

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ABSTRACT

Wattled Cranes (*Bugeranus carunculatus*) are widely spread out in the southern African region. The Kafue Flats and the Bangweulu Basin are known to harbor the highest Wattled Crane population in the area. The Bangweulu Basin provides extensive floodplains, swamps, and grasslands which are attractive to the species. There is, however, concern over the reduction of their range due to encroaching human activities which are the immediate threat facing their status. A population survey of Wattled Cranes in the Bangweulu has indicated that there are at least 1,455 individuals. Measures for conservation and understanding of the status of Wattled Cranes in Bangweulu are outlined.

INTRODUCTION

Zambia is one of the landlocked countries in Africa. Its land surface is predominantly an elevated plateau (over 1,000 m above sea level) with two major river systems, the Zambezi and the Laupula. It is one of the few countries in Africa which is endowed with extensive and diversified wetland systems. Approximately 12% of the country's land surface (750,000 km^2) is occupied by wetlands, which include lakes, rivers, swamps, floodplains, pans, and dambos.

The major wetlands in the northern part of the country are Bangweulu and Mweru-wa-ntipa which form part of the Luapula-Zaire river system. The Zambezi floodplains and the Kafue Flats are situated in the south. Another important wetland in the center of Zambia is the Lukanga swamp on the Kafue River.

The Wattled Crane (*Bugeranus carunculatus*) is considered to be "a species of Special Concern" (Collar and Stuart 1985). Its distribution ranges from Ethiopia to South Africa, with the highest concentrations in the Kafue Flats and the Bangweulu swamps in Zambia (Johnson and Barnes 1985). The Bangweulu swamps in the northeastern part of the country are a refuge for an appreciable population of Wattled Cranes. Other populations are found in the other major wetlands in Zambia, including Kafue Flats, Busanga plain, Liuwa plain, Lukanga swamp, and Sioma-ngwezi plain of the Zambezi basin. The species has also been sighted in smaller wetlands, which are less disturbed, throughout the country (Douthwaite 1974). The smaller wetlands make up an important portion of the total habitat available to the Wattled Cranes. These habitats, however, are much more prone to disruption by human habitation. This has led to the decline in the geographical range for the species, consequently threatening it.

There have been attempts in the past to estimate the Wattled Crane population in the Bangweulu swamps (Howard and Aspinwall 1984; *pers. obs.*). In spite of these, the status of the Wattled Crane is still not well known because there is no regular population monitoring. Population estimates have been reported for Kafue Flats, Busanga plain, and Lukanga swamps (Douthwaite 1974) and for other parts of Africa (Konrad 1981; Tarboton 1984; Johnson and Barnes 1985).

In July, 1993, as part of a routine bird census monitoring wetland birds in the Bangweulu swamps, data were collected on Wattled Cranes. The purpose of this paper is to describe the status of Wattled Cranes and to outline conservation measures to be taken.

AREA DESCRIPTION

Bangweulu Basin is located in the northeast part of Zambia, 10°45'-12°40'S and 29°30'E. It covers an area approximately 20,000 km^2. The wetland system measures approximately 11,900 km^2 which makes it the largest and most diverse wetland in Zambia.

The Bangweulu catchment lies in the highest rainfall belt in Zambia with the mean annual rainfall up to 1,300 mm. Most precipitation takes place between November and March. The basin also receives its water from the system's 17 principal rivers, the Chambeshi being the largest. The water level over its wetland varies seasonally between one and three meters causing the flooding to advance and recede by as much as 45 km at the periphery (Grimsdell and Bell 1975).

The Luapula River, headwaters of the Zaire River, is the only river draining the Bangweulu system. Water meadows formed along the floodplain are marked by an association of the sedges *Cyperus latiforians* and *Eleocharis fistulosa* (Verboom 1971). This habitat provides feeding grounds for black lechwe (*Kobus leche smithemanii*) and Wattled Cranes and other various waterbirds.

Bangweulu is an important wetland for wildlife, supporting a diverse fauna including sitatunga (*Tragelaphus spekei*) and the rare Shoebill Stork (*Balaeniceps rex*). Large numbers of local and migrant waterbirds use the bountiful resources available here. Bangweulu supports one of Zambia's largest fishing industries with fishing villages and camps scattered along the wetland perimeter and islands.

Except for a small area included in the Isangano National Park, a large area of the Bangweulu Wetlands are included in game management areas which protect wildlife but allow hunting of predetermined numbers of certain species, using permits issued by the National Parks and Wildlife Service.

MATERIALS AND METHODS

Both ground and aerial surveys were undertaken. Most sites which are important to birds were flown using a single engine Cessna 182 aircraft, at approximately 61 m altitude. A total area of approximately 800 km^2 was covered. Equipment used during the ground count included binoculars, telescope, bird field guides, and 1:250,000 topographic maps covering the area. A total area of about 50 km^2 was covered. A small team of counters was split to cover a wider range to search for the presence of Wattled Cranes.

RESULTS

The results of the aerial survey are given in Table 1. During the ground census, a total of 468 individuals were observed out of which 10 pairs had a chick and 14 breeding pairs were sighted. Any two cranes observed together isolated from others or displaying to each other were considered to be a mating pair and hence a breeding pair. The rest appeared either singly or in flocks. Five nests were sighted with a single egg clutch.

DISCUSSION

Population status and distribution

The present population of 1,453 birds indicates a decline of 15% of birds when compared to Howard and Aspinwall's (1984) population estimate. This decline in population could not necessarily mean a reduction in population as such, since the methods employed are different. Table 2 below shows results of the surveys done in the area.

Differences in the populations from the three censuses could also be attributed to the different sizes of areas covered and also the times of the year when the censuses took place. The 1984 and 1991 censuses were carried out in July.

In both the 1984 and 1991 surveys, the method employed was specifically established to estimate black lechwe population sizes, so it may not have been very practical for Wattled Crane censusing. As Howard and Aspinwall (1984) suggested, probably some birds were overlooked in high black lechwe densities and thus, the total population is likely to have been underestimated. The results presented show that there was a slight decline in the species between 1984 and 1991. However, the population showed an increase in 1993.

In the present survey misleading estimates, particularly from the air, could have been possible for larger flocks as appropriate photography was not possible. Double counting and crossing of birds cannot be ruled out.

The largest crane population is confined to the eastern floodplains and the surrounding swamps of the Bangweulu wetlands. They utilize large expanses of the Chimbwi floodplain which gets inundated from January to May. Smaller populations are, however, widely spread out in the swamps during the breeding period.

Their movements seem to follow the water level pattern. They tend to move towards the central swamps during the dry season. They feed on sedge tubers and rhizomes, grass seeds, and insects (Douthwaite 1974). They have apparently been observed to feed on small tubers of the water lily *Nymphoides spp.*

Breeding

During the breeding period, mating pairs are rather dispersed as they need expanses of wetlands. Hence in reality, the number could be much higher than were seen.

From the general observations made since 1989, it is apparent that most nesting takes place from May to September with a peak in July, and that most birds pair up. This phenomenon was also recorded by Konrad (1981).

The number of pairs nesting each year is probably dependent on the amount of flooding (Douthwaite 1974). Nesting has been observed to take place around shallow water and at a distance from human disturbance. Although the breeding period is apparently from May to August, it is most probable that nesting continues in small wetlands as long as there is adequate water and a low level of disturbance.

Very little work has been carried out on the breeding capabilities of the Wattled Cranes in Zambia. Nevertheless, it is worth pointing out that the breeding status of the Wattled Cranes and some other waterbirds could have been negatively affected by habitat alterations in their traditional habitats in recent years.

During the non-breeding periods, Wattled Cranes usually congregate on grasslands of the floodplains, in flocks ranging in size from 10 to 40 individuals. When flushed, they all fly in tight flocks. Movements of the Wattled Crane species in and out of Bangweulu are poorly understood. A good number of them, however, start arriving at the beginning of floodwater recession in April. Most of them at this time are either in pairs or accompanied by a fully fledged chick.

A successful breeding pair is the one with a chick. Although the chick attains its parents' size quickly, it can easily be differentiated by its whitish head and light colored body plumage. In the present survey some pairs were observed with big chicks, that they had successfully raised them beyond fledgling.

Threats

Food, water, cover, and human activities are the four major habitat factors affecting the status of cranes. Human encroachment into the swamps is common in the Bangweulu. In some areas, sedges and other kinds of hydrophytes used as cover in the birds' nesting sites are removed for construction of makeshift shelters, mat making, and basket-making. In some cases, this activity abets the decrease of breeding and living areas for cranes.

Bush fires pose the greatest threat to breeding of cranes and other waterbirds. Eggs and chicks which are not fledged are caught in fierce fires which are quite common from July.

Although pollution may have adverse effects on the status of cranes, it is not very common in Bangweulu and most other Zambian wetlands in general.

There are reports (from local villagers) that Wattled Cranes are sometimes hunted for meat. It is also most likely that eggs can be picked for food by local people once found. The author once observed a fully grown crocodile (*Crocodilus niloticus*) feeding on nestlings of egrets and cormorants, which means that it can probably feed on non-fledged crane chicks once they are in sight. Because it takes a long time for the chicks to fledge, crane chicks are at a great disadvantage with predators.

CONSERVATION MEASURES TAKEN

The fluctuation in waterbird populations is closely related to the quality of their habitat. Cranes and other waterbirds are, therefore, important indicators of the status of the wetland habitats.

Scientific study of the current habitat management and environmental monitoring are essential for the sound management of the habitat. Public education flanked by law enforcement play an important role in the same fight.

Local governments are instrumental at the grassroots level in the implementation of wetland conservation. The central government also needs to assist in drawing up policies in line with the conservation and management of these fragile habitats, which are vital for cranes.

The Bangweulu Basin has an important conservation status in that it falls in the WWF-Zambia Wetland Project core area. The Project was established under the Department of National Parks and Wildlife Service in the Ministry of Tourism. It is currently financially supported by the WWF. The Project was instituted in order to integrate local people with the management, conservation, and sustainable development of the area. The fundamental aims of the Project are to conserve and manage natural resources and enhance their productivities, consequently maintaining the biological diversity.

Zambia is one of the few countries in Africa which is taking a step toward the formulation of a national wetland policy. There have been no guidelines in the management of the country's wetlands in the past. A large area of the Bangweulu is partly protected as Game Management Area. The wetlands are not fully protected, however, since settlement and other human activities are allowed within. This results in conservation conflicts at times. Zambia is a signatory to the Ramsar Convention, and the Chikuni area in the Bangweulu has been ratified as a wetland site of international importance.

RECOMMENDATIONS AND CONCLUSION

In order to gain proper understanding of the status of Wattled Cranes in the area, frequent censusing and coordinated research should be undertaken. A date for national censusing of Wattled Cranes and other important wetland bird species should be established. This could be conducted through the National Parks and Wildlife Service, conservation groups such as Zambia Ornithological Society, and individual ornithologists. Information on feeding, roosting, and particularly breeding and the population status should be collected. Banding or ringing at this stage should also be encouraged. At a regional scale, this census network could be coordinated throughout the distribution areas of Wattled Crane in Africa.

This important work will be able to furnish us with information pertaining to the species' seasonal movements and assist in identifying areas which could be safeguarded by legislation as national parks or sanctuaries for the perpetuation of the Wattled Cranes, plants, and other animal species.

Public education, going side by side with law enforcement, should be stepped up in all areas of importance for the species. Fishermen should be restricted to areas outside suitable breeding sites.

Finally, there is need for coordinated research on the Wattled Cranes using methods specifically formulated for the species. In conclusion, the Bangweulu Wattled Cranes population is viable and may breed well once their habitats are properly maintained.

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REFERENCES CITED

Bell, R.H.V. and J.J.R. Grimsdell. 1973. The persecuted black lechwe of Zambia. Oryx 12: 77-92.

Chabwela, H. N. 1986. The ecology and resources use of the Bangweulu Basin and the Kafue Flats in managing the wetlands of Kafue Flats and Bangweulu Basin. Pages 11-24 *in* R.C.V. Jeffery, H. N. Chabwela, G. Howard, and P. J. Dugan, eds., Managing the wetlands of Kafue Flats and Bangweulu Basin. Proceedings of the WWF-Zambia Wetlands Project Workshop, Kafue National Park, Zambia. IUCN, Gland, Switzerland.

Collar, N. J. and S. N. Stuart. 1985. Threatened birds of Africa and related islands: the ICBP/IUCN red data book, part I. ICBP and IUCN, Cambridge, UK.

Douthwaite, R. J. 1974. An endangered population of Wattled Cranes (*Grus carunculatas*). Biological Conservation 6(2): 134-142.

Grimsdell, J.J.R. and R.H.V. Bell. 1976. The Bangweulu Basin of Zambia. Pages 257-262 *in* Symposium on the Okavango Delta. Botswana Society, Gaborone, Botswana.

Howard, G. W. and D. R. Aspinwall. 1984. Aerial census of Shoebill, Saddlebill, and Wattled Cranes at Bangweulu Swamps and Kafue Flats, Zambia. Ostrich 55: 207-212.

Johnson, B. and B. Barnes. 1985. The conservation of the Wattled Crane in South Africa. African Wildlife 39(5): 188-195.

Konrad, P. M. 1981. Status and ecology of Wattled Cranes in Africa. Pages 220-237 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world. International Crane Foundation, Baraboo, Wisconsin, USA.

Malambo, C. H. and H. N. Chabwela. 1989. Preliminary observation on the distribution and abundance of Wattled Cranes in Zambian wetlands. A paper presented at the Sixth Pan-African Ornithological Congress, Nairobi, Kenya.

Tarboton, W. R. 1984. The status and conservation of Wattled Crane in the Transvaal. Pages 665-670 *in* J. A. Ledger, ed., Proceedings of the Fifth Pan-African Ornithological Congress. Southern African Ornithological Society, Johannesburg, South Africa.

Verboom, W. C. 1971. The floodplain. Vol II. N.C.S.R. and Institute for Aerial Surveys and Earth Sciences, Enschede, Netherlands.

Table 1. Frequency of observation of Wattled Crane group sizes and sum of birds in each group size, in the Bangweulu.

Group size	Frequency of observation	Sum of birds in group size
1	8	8
2	40	80
3	30	90
8	15	120
9	6	54
10	3	30
60	3	180
70	1	70
75	1	75
96	1	96
100	1	100
150	1	150
200	2	400
Total		1,453

Table 2. Results of Wattled Crane Census in the Bangweulu area.

Year	Population estimate	Source
1984	1,718	Howard and Aspinwall (1984)
1991	1,367	Kamweneshe, unpubl.
1993	1,453*	Kamweneshe, present

*Total count

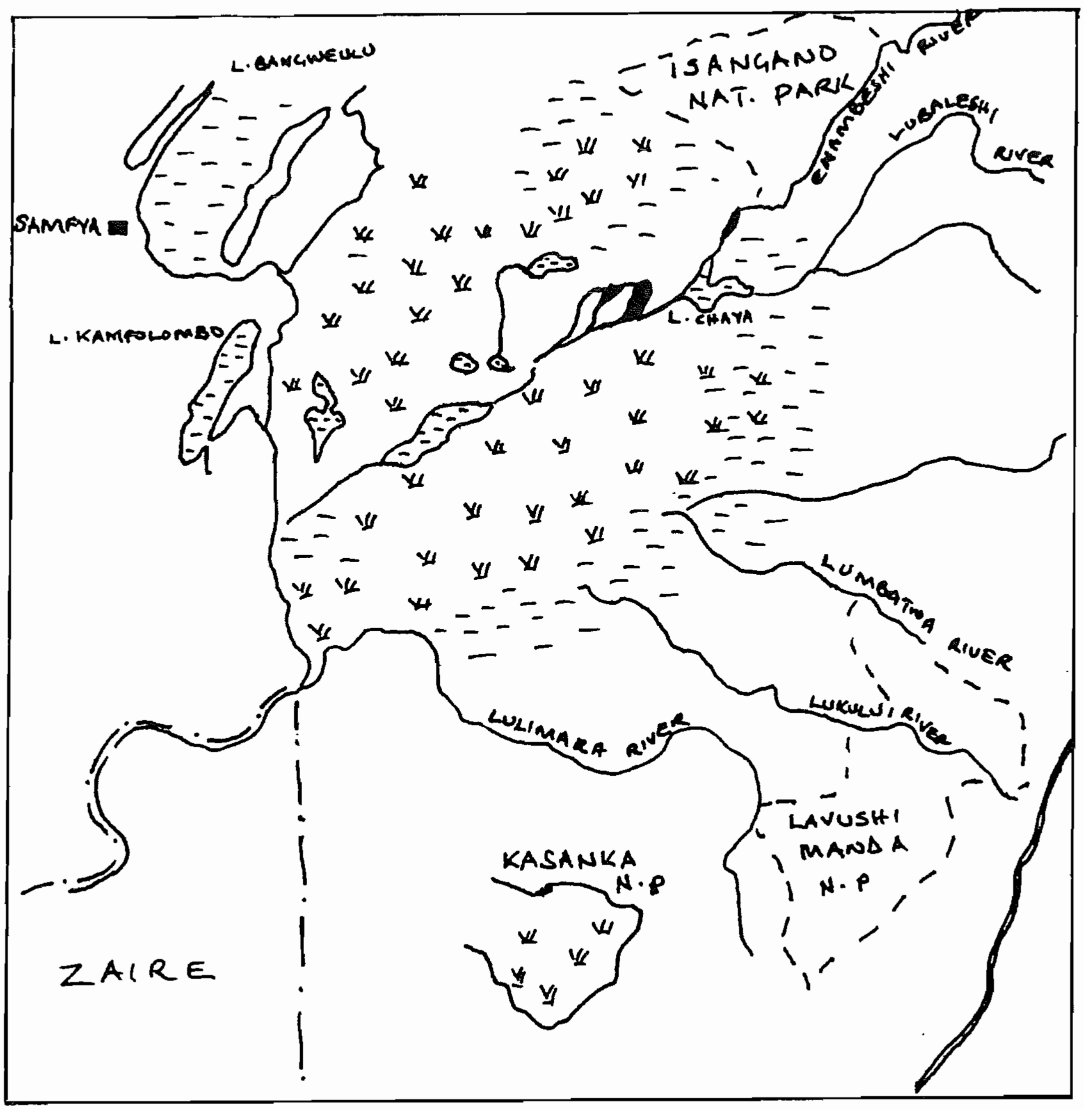

Figure 1. Bangweulu basin with its associated wetland and floodplain.

LOCAL PEOPLE AS PARTNERS IN WETLAND CONSERVATION: A CASE STUDY OF COMMUNITY BASED MANAGEMENT

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INTRODUCTION

Traditionally wetlands have been considered to be unhealthy places, best to be avoided, and a hindrance to development. Even though this notion still exists to some extent, wetlands are recently being recognized as very valuable ecosystems to the people living in and around them for three major reasons:

- they contain economically important resources in the form of fish, wildlife, and potential for increased agriculture;
- they play a cardinal role in the water cycle and regulation of flow that most social functions depend upon;
- their biological diversity is considerable and they contain many endemic species.

The importance of wetlands and their values to society is pivotal to the argument for wetland protection and proper management. Most critics have argued whether conservation could succeed without considering human actions when in fact most of the problems in conservation are caused by people (Chabwela 1986). It is contended that people must therefore be part of the solution.

The conservation of nature and the environment in Zambia has been the responsibility of the government through its relevant ministries (e.g., Ministry of Environment). More recently, non-governmental organizations have become increasingly involved in conservation. The WWF-Zambia Wetlands Project was initiated in August 1986 as a special project under the Department of National Parks and Wildlife Service which deals with the conservation and management of the wetland's natural resources. This is a community-based project in the Kafue Flats and the Bangweulu Basin. This paper discusses community participation in nature conservation and economic incentives derived from the project in the Bangweulu Basin, although most observations also apply to the Kafue Flats.

DESCRIPTION OF THE BANGWEULU BASIN

The Bangweulu Basin is located in northern Zambia between 29°30'-30°40'E. and 10°45'-12°40' S. The Bangweulu Basin contains one of the world's most important wetlands. The wetland measures 11,900 km² which makes it the largest and most diversified in Zambia. The system is mainly comprised of floodplain with shallow lakes and swamps.

The Bangweulu system is fed by 17 rivers of which the chief is the Chambeshi, the headwaters of which are actually the source of the great Zaire River system. The outlet river is the Luapula River that flows into Lake Mweru. Water levels vary and are dependent on rainfall. Water levels rise between January and April and are lowest in November. The first rise in water levels occurs within the river channels. As flooding continues, the rivers flow overbank into the swamps and replace stagnant swamp water. Floodwaters eventually reach the lakes and spread over the floodplains.

The whole Bangweulu area is generally flat without rocky coastlines although a few rocks occur near Samfya. The great feature of the Bangweulu is its vast swamps interspersed with canals, channels, and lagoons, that are used as waterways for canoes and boats. Alongside these channels, canals, and lagoons papyrus (*Cyperus papyrus*), hippo grass (*Vossia* spp.), and reeds (*Phragmites* spp.) are the most common vegetation species. Hippo grass and wild rice (*Oryza* spp.) are dominant vegetation in the shallow areas of the swamp margins. In the lagoons, a variety of underwater plants occur and include water lilies (*Nymphaea* spp.), bladderwort (*Utricularia ceratophylum*), pondweed (*Potamogeton limnophillia*), and bushy pondweed (*Naja* spp.). In certain areas mashinge reeds (*Eliocharis* spp.) dominate.

Both the islands inside the swamps and the fringes of the wetlands are densely populated. The area is famous for its wildlife and fisheries. The principal wildlife species are tsessebe (*Damaliscus lunatus*), sitatunga (*Tragelaphus spekei*), and the black lechwe (*Kobus leche smithemanii*) which is a semi-aquatic antelope endemic to the area. Bangweulu provides suitable and diversified habitats for several hundred species of waterbirds, including the most commercially important species of ducks and geese. It also provides a home for appreciable numbers of Wattled Cranes (*Bugeranus carunculatus*) and the Shoebill Stork (*Balaeniceps rex*). Because of its uniqueness, Bangweulu was recently added to the Ramsar Convention list of Wetlands of International Importance.

BACKGROUND PROBLEMS

The vast amounts of resources in Zambia's wetlands sharply contrast with the extreme poverty of the inhabitants. The Bangweulu wetlands are remote from any center of development and communication. They are generally inaccessible and have always been ignored and isolated from most forms of development. The fact that people have access to very few community service facilities and receive very little external support and guidance means that the residents depend completely on nearby natural resources for nutrition, energy, and income. The poverty and lack of external support lead to bad resource management, and therefore some resources are threatened with overuse while others yield lower benefits than they could.

Before the time of colonization of Northern Rhodesia (which is now Zambia) by Britain, wildlife was an integral part of African life. Certain tribes inhabiting particular areas owned the land together with all natural resources including wildlife.

During colonization, legislation was enacted that changed the ownership of wildlife, which became totally vested in the state. The game laws also discriminated against Africans. Some were removed from their ancestral areas to pave way for big game reserves. People affected by such development received no compensation in return. Because this discriminatory act prevented local long-term residents from having access to the resources which were theirs to use by custom, some resorted to hunting in defiance of the law, resulting in the problem of poaching (Dale *et al.* 1990).

ZAMBIA WETLANDS PROJECT

The conservation and management of Kafue Flats and Bangweulu Basin project also known as the WWF-Zambia Wetlands Project was initiated in 1986 as a pilot initiative for a regional wetland project of the Southern African Development Coordination Conference (SADCC) member countries. The project's long-term goal is to contribute to the sustainable improvement of the well-being of the local communities dependent on the Kafue Flats and the Bangweulu Swamps, through establishment and implementation of an integral program for management of the renewable natural resources of these areas.

The basic strategy of the project is conservation and management of the wetland natural resources in the project areas through working with the local communities. The WWF-Zambia wetlands project operates within the framework of ADMADE (Administrative Management Design for Game Management Areas) under the Department of National Parks and Wildlife Service.

PROJECT LOCATION AND EXTENT

The Wetlands Project core area in the Bangweulu covers about 7,500 km². This encompasses the Bangweulu, Kalasa Mukoso, and part of the Kafinda Game Management Areas. It is divided into two management units, the Bangweulu and Chikuni Units. Operational costs for the former are being financed by WWF-Denmark and the later by WWF-International. The Bangweulu Unit is made up of seven chiefdoms and the Chikuni Unit covers three chiefdoms. It falls in three districts, Mpika, Samfya, and Serenje.

PROJECT ACTIVITIES

The project activities include: organization of local communities to participate in administration of the project and assessment of their priority needs and development requirements; research (biological, environmental, and sociological) and management; and training and education. Research includes monitoring available natural resources and assessing community needs, aspirations, and attitudes. Management includes elements of anti-poaching, hunting controls, and infrastructure development. Education involves extension work, public relations, and conservation awareness development. The target communities include indigenous residents and to some extent non-indigenous populations (immigrants) who also depend on the local resources. Public servants from various authorities concerned with management, regulation, and control of the natural resources have also been instrumental in the running of the affairs.

HUMAN SETTLEMENT

The population of the Bangweulu area is made up of several different tribes. The Unga and BaTwa occupy the swamps and the Ng'umbo live on the northwestern and western shores of Lake Bangweulu. The Mukulu live to the north, the Ushi to the southwest, the Kabende to the south, and the Bisa to the southeast and east. The BaTwa are presently settled on islands inside the swamps and on the fringes of the floodplain. Although some clusters of village huts may show no distinct pattern of distribution, most of them are linearly confined to edges of the swamps and rivers.

The acidic soils basically account for the low agricultural productivity of the area. There are no job opportunities to give them wages. The main activities are fishing and hunting; the people therefore depend mainly on fish and wildlife. As a result, fish and wildlife populations are being depleted. It is out of this concern - that conventional management of Zambia's important wetlands was failing to coordinate development and regulation of natural resource utilization - that the Wetland Project was born.

COMMUNITY PARTICIPATION IN NATURAL RESOURCE CONSERVATION

It has been realized that no conservation strategy can succeed at the exclusion of local people's support. For people to put in their valuable effort in the conservation of resources, some tangible benefits are crucial. The basic strategy of community participation is to obtain conservation of natural wetland resources of the project area through working with the local communities on activities of natural resource management and protection in cooperation with the local people. The project's intention is to design and implement activities to enhance sustainable local benefits derived from the natural resources of the wetlands.

IMPLEMENTATION AND INSTITUTIONAL ARRANGEMENT

In developing and implementing the wetland project, existing institutions provide the framework within which the project operates. Extensive consultations with the traditional chiefs and political and government officials and public meetings with local communities were carried out to win confidence of the people and solicit support (Chooye 1991). The planning and implementation of the wetlands project at a grassroots level included the important step of consulting local leaders such as chiefs, ward chairmen, village headmen, local businessmen, and prominent farmers for the purpose of seeking their views on the conservation of resources in their area. This included their felt needs and how they were being reassured in relation to the available resources.

This initiative led to the formation of one Community Development Unit (CDU), also known as Management Sub-authority, in each chiefdom. The CDU is chaired by the chief or ordinary member elected to the chairmanship. At the district level there is the Wetland Management Authorities (WMA) comprising members from the CDUs. The members of the WMA are elected to represent each CDU from the chiefdoms and is chaired by a senior council official.

The area's Member of Parliament is also opted in as a member of both the CDU and the WMA. Extension workers (most of them are local people) provide extension service. Extension work of the project was put in place to promote the integration of local communities interests with the environmental interest. By far the major aim of the extension program was to create community awareness and work closely with other organizations dealing with conservation and development. The WMA has been empowered to do a number of activities, which have been included in their terms of reference.

1. Enforce the National Parks and Wildlife Act in liaison with the National Parks and Wildlife Service (NPWS) staff.
2. Act as a planning organ for formulating new wildlife policies and appropriate management activities in collaboration with appropriate technical authorities.
3. Select local people for training as village scouts.
4. Liaise with the Director (NPWS) on the issuance of hunting licenses for their hunting areas.
5. Approve the allocation of sustainable field quotas of wildlife as recommended by NPWS with appropriate guidance from technical authorities.
6. Monitor both legal and illegal wildlife off-take.
7. Initiate projects for improved wildlife management.
8. Administer the 35% of the revenue generated from the exploitation of wildlife resources on development projects.
9. Ensure that 40% accrued from the exploitation of wildlife resources is committed to the management costs of the wildlife resources within the unit.
10. Collaborate with district development officers and other organizations to reinforce and coordinate community development activities in the project area.
11. Manage self-help schemes by appointed committees.
12. Encourage applied management research and solicit outside expertise when needed (Lewis *et al.* 1987).

Technical management and research will remain a function of the various technical authorities concerned in the project areas.

Most of the staff who administer the project at the grassroots level are recruited from within the project area. Care is taken to consult and keep local communities and their leaders well informed at every step of project development to ensure it fulfills both its own objectives and the aspirations of the local people.

Local communities have the say and share in the management and benefits of their traditional wetland resources. Nevertheless, because of contemporary pressures on land (mainly from human population growth and expansion) it is not realistic to revert to traditional authority as it was. What is being developed is the revival of traditional authority supported by contemporary technology, politics, and government.

The early stage of the projects have already brought some assistance to local communities mainly via community development programs funded so far by the project. Programs are largely provided in response to priorities outlined by the communities themselves. Civil service also benefits from the project as it provides incentives and improved services to government officers operating within the project areas.

In the long term, however, the projects' effort will depend on the successes and function of CDUs and WMA. In order to support these requirements, the CDUs and WMA will become statutory bodies within an already-established infrastructure of the Ministry of Tourism. The CDUs through their WMAs will exercise their traditional rights to participate in both the management and utilization of resources and the development of their standards of living.

ECONOMIC AND SOCIAL BENEFITS FOR CONSERVING NATURAL RESOURCES

Natural resources earn profits from tourism, wildlife utilization, and harvesting. The mechanism for accruing the revenue to realize these aims has been established through a system of "rights" surcharged on statutory fees paid to the central government for the use of various resources. The local communities who share land with wildlife have already started benefiting from their conservation efforts. The project has used the ADMADE program policy framework to establish a means of funding the activities in the area from wildlife revenues. The facility allows the authority to retain 50 percent of statutory government revenues and all non-statutory revenues from certain categories of wildlife utilization, including revenues from hunting, cropping, and donations. These revenues are accrued by the Wildlife Conservation Revolving Fund (WCRF) which later apportions them to the authority according to the following formula (from the 50% of the statutory and non-statutory fees):

- 40% to local wildlife management activities;
- 35% to local community development activities;
- 15% to National Parks and Wildlife Service for program administration;
- 10% to ADMADE for the costs of program administration.

The authorities have also developed their own funding generating ventures, e.g., a self-catering camp, shop, grinding mills, etc. Other benefits being appreciated by local communities include:

- some local residents are trained and deployed as village scouts to protect the wildlife in their own areas;
- increased employment for local residents improves the manpower base for wildlife management and stimulates a local economy based on sustainable development of wildlife;
- local residents are now able to purchase affordable game meat legally made available from the sustainable off-take of selected species;
- wildlife-related employment has become a major source of income earnings for local residents (the motivation and conscientiousness of village scouts proved greater than that of government scouts, contributing to increased cost-effectiveness in law enforcement and data collection);
- collection of wildlife revenues for recycling back into the resource management costs became legally possible for management authorities who can operate more independently than they could with the limited funds earned by the WCRF;
- the project team and the villagers are enjoying the new cooperation, although there is still sporadic poaching of lechwe and other key species in Bangweulu;
- some local people can now arrest or provide information leading to the arrest of poachers.

These economic and social benefits have encouraged the local communities to get involved in conservation activities because they are now able to realize that wildlife is valuable.

CONSTRAINTS IN PARTICIPATION IN CONSERVATION PROGRAMMING

Education has been a cardinal tool for enhancing participation in management, but this has not been an easy task in that education is targeted at rural people who are generally too poor and powerless. Since they depend on the natural resources in their environments for their livelihoods, it is a slow process which will only be accepted when some benefits are harvested.

There have been a few oversights in the past that have probably contributed to the failure of education to deliver the goods to the local communities. These include:

- a lack of trained and dedicated personnel to carry out the work properly;
- the absence of infrastructures and adequate prior research;
- little collaboration among disciplines and sectors in data collection and analysis;
- flawed land use planning that focuses on a narrow technical view, rather than considering overlying social and economic complexities of farming and firewood systems in general.

Outsiders have been defining local needs and there is little use of local expertise, knowledge, and skill. Effective participation implies not only involvement in information collection but in analysis, decision making, and implementation as well.

An appropriate approach to sensitize local communities about sustainable use of wetlands, that they may yield the greatest continuous benefits for the present generations while maintaining their potential to meet the needs and aspirations of future generations, may not have been applied. This is being carried out by the WWF-Zambia Wetlands Project under ADMADE program. While participation of local people in conservation and management of the Bangweulu Wetlands provides the opportunity for changing local attitudes towards conservation, the expected output is for local inhabitants to accept the responsibility to initiate and maintain programs in their area (Chabwela 1987). The largest constraint is the extreme poverty among the indigenous local communities. The deterioration of the standard of living for both rural and urban dwellers seriously threatens most natural resources in the country through illegal off-take of wildlife resources, over-fishing, and indiscriminate destruction of the forests for fuel wood or charcoal to earn a living.

In the author's view, any community-based natural resource conservation projects should seriously address the problems of major poverty and unemployment by small-scale industries. This should include craft work, leather work, blacksmithing, and so on.

CONCLUSION

The WWF-Zambia Wetlands Project through the ADMADE program seeks a reconciliation between the interests of wildlife and rural residents by promoting human needs through the wetland conservation and management and local responsibility. The ultimate goals for the program is to make the project areas capable of supporting their own resource management costs while also providing revenue for community improvements. It is intended that this will become a joint function of government authorities and local communities (through the Civil Service, WMA, and CDU) supported by the Central Government funds and revenue from the project area treasury.

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REFERENCES CITED

Chabwela, H. N. 1986. The ecology and resource use of the Bangweulu Basin and the Kafue Flats. Pages 11-23 *in* R.C.V. Jeffery, H. N. Chabwela, G. W. Howard, and P. J. Dugan, eds., Proceedings of the WWF-Zambia Wetlands Project Workshop: Managing the wetlands of Kafue Flats and Bangweulu Basin. IUCN, Gland, Switzerland.

Chooye, P. M. 1991. Community-based natural resources conservation. Presented at the Workshop on Social and Economic Benefits from Managing the Environment. Livingstone, Zambia.

Grimsdell, J.J.R. and R.H.V. Bell. 1975. Ecology of the black lechwe in the Bangweulu Basin of Zambia. Final report NCRR/TR31. Lusaka, Zambia.

Mwenya, A. N., D. M. Lewis, and G. B. Kaweche. 1990. ADMADE policy, background, and future. National Parks and Wildlife Service, Zambia.

MANAGEMENT AND NATURAL RESOURCE UTILIZATION PATTERNS IN THE BANGWEULU SWAMPS, ZAMBIA

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INTRODUCTION

A frequent assumption has been that wetlands are only marginally useful to people. Far from being wastelands, however, wetlands support a large diversity of biota, many of which are economically important, and play a vital role in the lives of rural communities (Chabwela 1986). The wetland system of the Bangweulu Basin is the largest and most diversified in Zambia.

The Bangweulu swamps provide, directly and indirectly, valuable resources and benefits to the local communities that exist within and around them. Consequently, the costs and benefits of conservation and sustainable use of the wetland resources lie mostly in their users, fishermen and farmers living in settlements within the wetlands.

It is with this background that the Zambia Wetlands Project was established in the area in 1986. This is a community-based natural resource management project which aims to maintain or enhance natural productivity of the wetlands by promoting their sustainable use for local community development. The Wetlands Project falls under the Department of National Parks and Wildlife Service, Ministry of Tourism.

Although the Zambian Government has set up an extensive national park system (8 percent of Zambia's land area or 750,000 km²), the Bangweulu swamps are under-represented in this protected area network. Only a small portion falls under Isangano National Park. Even though a large portion of the swamps are currently classified as Game Management Areas, the status of part of the swamps needs to be upgraded to national park to allow more effective control and wardening.

This paper describes the biological importance of the Bangweulu swamps focusing on the patterns of resource use and the socioeconomic values derived. In line with the concept of sustainable development, creation of a national park within the wetlands is proposed, after consultation and negotiations with the local people.

THE BANGWEULU WETLANDS SYSTEM

Location and extent

The Bangweulu Basin is located in the northeastern part of Zambia (Figure 1). Geographically, it is located between 10°45'-12°40'S latitude and 29°30'-30°40'E longitude.

The basin covers approximately 20,000 km². The wetland system of the Bangweulu is a vast swamp/floodplain complex of channels, open lakes, low swamp islands, permanent swamps, and seasonally flooded marginal grasslands. Seasonally inundated floodplains cover about 6,800 km² and permanent swamps about 5,200 km² (Grimsdell and Bell 1975; Chabwela 1986).

Climate

There are three distinct seasons in the area. The cool dry season begins in May after the rainy season and continues into early August when temperatures reach a mean minimum of 16-17 °C. The warm dry season begins with the temperature rapidly rising through September, and reaches a mean maximum of 23-24 °C in October. The warm rainy season begins in early November and continues until late April, with temperatures gradually falling to around a mean of 21 °C.

The annual rainfall exceeds 1,300 mm, with most of it falling between February and April. When the rains start in early November, the floodplains gradually get flooded, with the peak being reached in March/April.

The most important river of the Bangweulu system is the Chambeshi River. The Luapula River is the only outlet which the system has. This forms a headwater of the Zaire River and flows into Zaire.

BIOLOGICAL RESOURCES

Fauna

The wetlands are of prime importance for wildlife. The low swamp islands and the seasonally flooded marginal grasslands support large herds of black lechwe (*Kobus leche smithemanii*). This is the most conspicuous ungulate living in the area. Other important species include tsessebe (*Damaliscus lunatus*), sitatunga (*Tragelaphus spekei*), buffalo (*Syncerus caffer*), and elephant (*Loxodonta africana*). Species rarely seen are roan (*Hippotragus equinus*), lion (*Panthera leo*), and leopard (*Panthera pardus*). In the rivers and deep swamps, hippopotamus (*Hippopotamus amphibius*) and crocodile (*Crocodilus niloticus*) are found.

The region is of renowned ornithological value. The seasonal flooding of the marginal grasslands play a vital role in the annual migration pattern of waterbirds. The swamps provide habitats for a profusion of bird species. Almost all major families such as pelicans, cormorants, darters, herons and egrets, storks, ibises and spoonbills, geese and ducks, and grebes are represented. The swamps are extremely important as refuge for the endangered Wattled Crane (*Bugeranus carunculatus*). Only here and the Kafue Flats (in southern Zambia) does it occur in such large numbers. The swamps are also a refuge for one of Africa's rarest birds, the endangered Shoebill Stork (*Balaeniceps rex*). Birds of prey include several species of eagles, vultures, and hawks.

Another biological attribute of the Bangweulu swamps is its variety of fish species. Evans (1978) recorded 84 species, with 10 of these being endemic to the Bangweulu fishery. *Tilapia* spp. and *Clarias* spp. are very common.

Vegetation

The vegetation of the area has been described by several authors (Fanshawe 1971; Verboom 1971; Grimsdell and Bell 1975). The vegetation formations in the area can be grouped according to determinant hydrologic and edaphic factors. Four major zones can be found.

1. Woodland mainly of the miombo *Brachystegia/Julbernadia* spp. association, occurring on the outskirts of the basin.

2. Woodland and grassland, with characteristic species including *Syzygium cordatum* and the palm *Phoenix reclinata*, occurring in the zone of termitalia.

3. Floodplain grasslands, inundated for up to five months during the rainy season, with characteristic species including *Hyparrhenia* spp., *Echinochloa pyramidalis*, and *Vossia cuspidata* associated with *Oryza barthii*, occurring in the swamp proper.

4. Permanent swamps dominated by aquatic macrophytes including *Cyperus papyrus*, *Vossia cuspidata*, *Phragmites communis*, and *Eleocharis plantaginea,* occurring in lowland depressions.

Soils

Unlike the soils of the plateau and outer basin which are generally derived from deeply weathered and leached *in situ* materials, the soils of the basin are sandy and acidic depositional sediments. These present a complex alluvial mosaic (Grimsdell and Bell 1975), as is typical in the floodplains, with heavy alluvial clays together with sand and sandy loams which are poor in nutrients.

HUMAN POPULATION

The population of the swamps is not accurately known. However, heavy clusters of people occur on islands and in areas which are rich fishing grounds. The interior of the swamps have not been permanently inhabited; the only settlements are fishermen's temporary huts built on floating vegetation. The majority of the people who have arrived and settled in the swamps recently have been attracted by the fisheries production and wildlife utilization.

The majority of the people living in the swamps are engaged in fishing. Agricultural activity is very limited due to constraints that will be outlined below. Other socioeconomic activities, discussed below, are husbandry of vegetation products, hunting and trade in wildlife, and use of water resources.

RESOURCE UTILIZATION PATTERNS

Fisheries

Fishing is the most important economic activity in the Bangweulu swamps (Mulongo 1979; Kalapula 1986). Apart from being an important source of protein, it is also an important barter exchange medium for items like essential commodities, food, etc.

Lakes and lagoons provide major fishing grounds for perennial fisheries, while seasonal fishery predominates on the floodplains. The nature of the vegetation of the swamps can only allow the use of small dugout canoes in shallow waters. There are many parts of the swamps that are not fished due to the dense vegetation.

The core areas of exploitable fisheries are located around Kapata peninsula, Lifunga peninsula, and Lakes Kampolombo and Kangwena. Commercial fishers mainly use gill nets, while artisanal fishers use traditional gear such as spears, baskets, weirs, and seine nets.

Fishing activities on the floodplain are very dependent on inundation during the rainy season. Spawning of most fish species appears to coincide with the high water period. When flooding starts, many fish on their way to breeding sites in the floodplain are caught, mostly using traditional gear. During floodplain drawdown, many fish are successfully killed in drying pools and on their way back to the river and lake systems. This practice poses a conservation dilemma, because it occurs at the most critical period for fish stocks. The *Clarias* spp. are the most affected by this phenomenon.

The most important commercial species are tiger fish (*Hydrocynus vittatus*), torpedo robber (*Alestes macrophthalmus*), spotted squeaker (*Synodontis nigromaculatus*), hump-back bream (*Tylochromis bangwelensis*), red-breasted bream (*Tilapia rendalli*), banded bream (*Tilapia sparrimani*), and sharp-tooth barbel (*Clarias gariapinus*) (this species forms a considerable portion of the catch in the swamps).

Because infrastructure facilities are lacking in the swamps, most of the fish is dried before being sold. The fish is, however, poorly dried due to lack of fuel wood. Fish is sold in the fishing camps to tradesmen who mainly come from the urban areas. A 25 kg mealie meal bag of dried fish (approximately 15 kg of dry fish) currently costs ZK 7,000 (US$13) directly from the fishermen, but fetches about twice the price in the urban areas. Commonly, fish is exchanged for mealie meal, essential commodities, and clothing.

Agriculture

There is no large scale agricultural development in the area owing to poor soils and lack of infrastructure (Mulongo 1979; Chabwela 1986). Agriculture is basically subsistence in nature. In the past, on the outer basin, generous yields of millet and cassava were obtained in the shifting cultivation system. The expansion of population has limited the amount of agricultural land available. Consequently, shifting cultivation is difficult to practice and people are forced to repeat cropping on the same pieces of land. Over time this exhausts the soils and results in poor cassava yield.

In the swamps, apart from small home gardens where crops such as maize, pumpkins, sweet potatoes, rice, and bananas are grown, there is no significant agriculture. The swamp settlers thus obtain their staple food (cassava meal) through barter with people from the mainland. Fish, and sometimes game meat, is the main medium of exchange.

Husbandry of vegetation resources

Some shrub species found in the Bangweulu wetlands have pharmaceutical potentials. For instance, *Rhus quartiniana* is used in the treatment of diarrhea and *Hymenocardia acida* in the treatment of wounds. Oil from the castor plant *Ricinus communis* is used as a cosmetic and has a high potential of being used in the cosmetic industries if exploited. *Trichilia emetica* produces oil that is good for cooking and can also be used to relieve sprains.

Hydrophytes are commonly used as materials for building huts, mats, and baskets. Papyrus is favored for providing material for mats and durable ropes for building. Reeds are also used for building and making mats. Several species of grass are used in hut thatching. *Hibiscus diversifolius* also is favored for its strong rope.

The Bangweulu swamps lack adequate fuel wood because of the nature of the vegetation. Wood requirements for fuel, hut construction, punting poles, and paddles have to be bought from the mainland or exchanged for fish. *Pterocarpus angolensis* from the mainland is one of the species used for dugout canoes.

Use of water resources for transport

The transport system is largely self-maintaining canoe routes. The nature of the swamps with a lot of papyrus, reeds, grass, and shallow water with sandbanks makes it difficult to use larger boats or boats with motors.

Hunting and trade in wildlife

Wildlife culling

Wildlife culling was first attempted by the Wetlands Project in 1990 on an experimental basis. The major objectives were to provide game meat for local communities and deter illegal hunting. A quota of black lechwe is hunted and the meat is sold to the local people at a subsidized rate. This is currently being developed to maximize income from the culled animals by processing and sale of skins and trophy. The intention is that this should be a sustainable and commercially viable management option.

Safari hunting

Foreign tourists can purchase licenses to hunt in the Bangweulu area. This is one of the most beneficial forms of wildlife utilization in terms of economic returns. A substantial amount of money is realized in the sale of licenses and hunting rights to foreigners and non-resident hunters. A proportion of this income (35 percent) is contributed to development activities in the area and a slightly larger amount (40 percent) to natural resource management work.

Subsistence hunting

Game meat makes a significant contribution to the diet of people in the swamps. Hunting is usually performed with dogs, spears, and sometimes snares. The most successfully hunted species is black lechwe followed by tsessebe. Hunting by locals is generally for subsistence purposes. Though it is difficult to estimate off-take through such hunting, the impact seems not to be very detrimental.

The outstanding wildlife management concern is hunting by people from the mainland. These people approach local hunters who, under contract, kill animals (often numerous) which the mainlanders then take back to the mainland for lucrative trade. These tradesmen benefit at the expense of the local hunter who is poorly paid for his effort.

Game license hunting

Through the effort of the Wetlands Project, for the first time in 1992, local people had the privilege of purchasing District game hunting licenses within their area. In the past, purchase of these licenses was cumbersome because it was only done in far away towns.

Avifauna

Some local people hunt and kill birds, including Wattled Cranes, for meat. The most favored birds are the ducks and the geese. The Shoebill Stork is not utilized directly for meat, but their survival is greatly jeopardized due to encroachment and destruction of their suitable breeding habitats and by international trade in eggs and live birds.

Trapping of young Shoebills traditionally occurred in the month of September. The fishermen would collect the young birds from their nests in the floating vegetation. These would be kept until a certain stage when they would be sold off to interested tourists at high prices. With the introduction of the Wetlands Project, this activity has been partially reduced. Nevertheless, some fishermen have admitted recently to removing the young birds from the nests or just destroying the nests and eggs (D. Renson *pers. comm.*). The Shoebill population is believed to be highly threatened.

Tourism

Recently, there has been an upsurge of people coming into the area who are more interested in photography, game viewing, and birdwatching. At present, the local people do not benefit from these visits, apart from the accommodation charges at the tourist rest camp run by the Local Authority. Tourists do not pay a direct fee for game viewing, birdwatching, and photography because such activities are free in a game management area.

A PLAN FOR THE SUSTAINABLE DEVELOPMENT OF BANGWEULU SWAMPS

The Bangweulu wetlands are a large undisturbed representative example of diverse swamp ecosystems. Part of these unique wetlands is in need of immediate protection measures under the jurisdiction of a national park. Zambia has acceded to the Ramsar Convention and part of the Bangweulu swamps (Chikuni Ramsar Site) is a listed wetland site of international importance.

The Wetlands Project has delineated a hunting free zone of approximately 48 km^2. Though the area is within a game management area, no form of hunting is permitted. The author proposes extension of this zone to cover about 1,000 km^2 and the establishment of full protection of the area as a national park.

The legislation responsible for creating a national park is the National Parks and Wildlife Act, Section 27. Section 44 Subsection (1) of this legislation provides for restrictions on hunting any wild animal or fish, and on disturbing or removing any bird's nest. Hence the national park status would provide protection to the indigenous animals, birds, and plants essential for the future of the Bangweulu. The Act restricts entry into and residence in the national park, and thus would offer the opportunity to earn income from fees from visitors to the park.

The establishment of a national park in the area would require initial, patient negotiations with community leaders. A sensitive public education campaign needs to be embarked on to raise awareness about the area's natural values and the need to give full protection. The local people should be made to realize that the park is not being "set aside" *per se*, although it may require the removal of small numbers of seasonal immigrant settlers, but that it would offer socio-economic benefits and sustainable development. A park can only achieve full potential to sustainable development if effectively managed.

One of the major benefits to the local community will be the protection of core spawning areas for fish, breeding grounds for birds (particularly Wattled Cranes and Shoebills), and local animals like black lechwe. If effectively managed, the park will act as a biological reservoir for the surrounding buffer zones, and thus offer potential support to sustainable utilization in those areas. Another benefit is that local people will gain from tourism. If it is well organized, a considerable amount of income would be realized from gate fees and community-based guide charges linked to controlled access to threatened species.

The conventional thought, that the concept of parks free from human exploitation of natural resources is somehow preposterous, must be safeguarded against in considering national park areas and sustainable development. The major value of parks for sustainable development lies in their contribution in a broader and indirect way. If properly and effectively managed, national parks can achieve their full potential to sustainable development.

ACKNOWLEDGMENTS

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REFERENCES CITED

Chabwela, H. N. 1986. The ecology and resource use of the Bangweulu Basin and the Kafue Flats. Pages 11-24 *in* R.C.V. Jeffery, H. N. Chabwela, G. W. Howard, and P. J. Dugan, eds., Proceedings of the WWF-Zambia Wetlands Project Workshop: Managing the wetlands of Kafue Flats and Bangweulu Basin. IUCN, Gland, Switzerland.

Evans, E. W. 1978. Lake Bangweulu: A study of the complex and fishery. Terminal Report. Central Fisheries Research Institute, Chilanga, Zambia. 156 pp.

Fanshawe, D. B. 1971. The vegetation of Zambia. Forest

Research Bulletin, No. 7. Forest Department, Kitwe, Zambia. 67 pp.

Grimsdell, J.J.R. and R.H.V. Bell. 1975. Black Lechwe Research Project final reports: ecology of black lechwe in the Bangweulu Basin. Report AR 1, N.C.S.R., Lusaka, Zambia.

Kalapula, E. S. 1986. Settlement patterns and resource utilization in the Bangweulu Basin and the Kafue Flats. Pages 25-33 *in* R.C.V. Jeffery, H. N. Chabwela, G. W. Howard, and P. J. Dugan, eds., Proceedings of the WWF-Zambia Wetlands Project Workshop: Managing the wetlands of Kafue Flats and Bangweulu Basin. IUCN, Gland, Switzerland.

Mulongo, A. H. 1979. Ecological constraints in economic development of the Kafue Flats and Bangweulu Swamps regions, 1920-1964. Pages 37-46 *in* D. S. Johnson and W. Roder, eds., Proceedings of the National Seminar on Environment and Development. Zambia Geographical Association Occasional Study No. 10, Lusaka, Zambia.

Parliament of Zambia, National Parks and Wildlife Act No. 10 of 1991.

Verboom, W. C. 1971. The floodplain. Vol II. N.C.S.R. and Institute for Aerial Surveys and Earth Sciences. Enschede, The Netherlands. 156 pp.

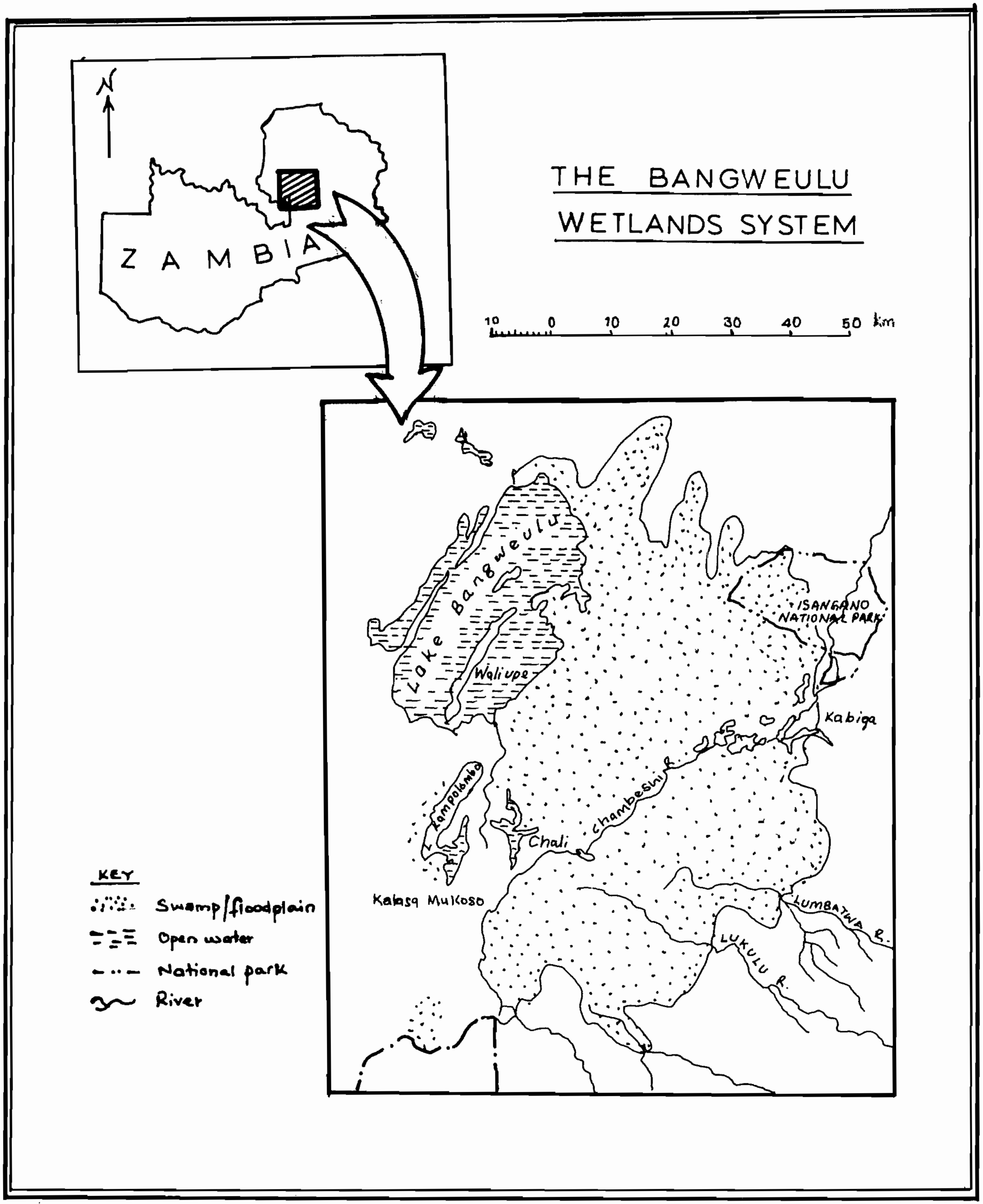

Figure 1. The Bangweulu Wetlands System.

A COMMUNITY DEVELOPMENT AND CONSERVATION TRAINING PROGRAM IN THE KAFUE FLATS, ZAMBIA

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INTRODUCTION

The WWF-Zambia Wetlands project has operated in the Kafue Flats since 1986/87 at two units, Lochinvar on the south bank and Blue Lagoon on the north bank. The main aim of the project is to establish a fair system of sharing the costs and benefits of sustainable conservation and management of wetlands and their natural resources between local communities and government (WWF-Zambia Wetlands Project 1992).

The Lochinvar Unit is the larger of the two units on the Kafue Flats, comprising four chiefdoms as opposed to two at Blue Lagoon. There is also a more established infrastructure and a greater number of visitors to Lochinvar National Park than to Blue Lagoon. Thus, when the project initiated a community program and operational headquarters within the Kafue Flats, Lochinvar was the logical choice.

The project worked closely with local communities in all units to form Wetlands Management Authorities (WMAs) which support a Community Development Unit (CDU) in each chiefdom. (These are in the process of becoming Integrated Resource Development Authorities (IRDAs) and Community Resource Development Authorities (CRDAs), respectively). The project follows closely the structure of ADMADE (Administrative Management Design for Game Management Areas), which aims to manage all Game Management Areas in Zambia by close collaboration between Government and local communities.

The Wetlands Project established the Community Development and Conservation Training Centre (CDCTC) just outside the main entrance to Lochinvar National Park to act as the focus for extension work within the community. This community support by extension has continued throughout the project's life span, under the local direction of a Project Extension Officer (PEO). However, full community training programs were not underway until 1992. Other income-generating ventures were set up by the project for Lochinvar WMA, including the Lechwe Community Shop, a hammer mill, and Sebanzi Camp Site (with chalets and camping facilities for visitors) in the park.

THE COMMUNITY DEVELOPMENT AND CONSERVATION TRAINING CENTRE

The CDCTC comprises project offices, a classroom, a large traditional-style thatched meeting hall (insaka), an accommodation block sleeping around 20 people, an outside kitchen, and a small workshop. Recent developments have included a tree nursery, vegetable garden, orchard, agroforestry/village woodlot demonstration area, and a community carpentry and borehole repair workshop, and plans have been proposed for a small-scale tannery, poultry unit, and arboretum.

The insaka is used regularly for local meetings, such as health functions, court sessions, and staff and wetland authority meetings. It is now also used regularly for community and staff training in the form of workshops, seminars, and practical demonstrations.

There is currently greater emphasis placed on self-sustaining initiatives at the CDCTC. Already, rooms are occasionally hired out to visitors and trees and vegetables are sold. The project is considering bringing electricity to the CDCTC so that in the future the community can offer it for hire for conferences. All small-scale initiatives have been self-financing since June 1994, though further infrastructural assistance is needed before other developments can go ahead.

THE COMMUNITY TRAINING PROGRAM

Before the present series of training courses started, the communities of all six chiefdoms of the Kafue Flats Wetlands Project area were interviewed to find out what people were most interested in learning. The suggested training areas covered natural resource management, agriculture and livestock, appropriate technology, handicrafts, health and nutrition, and business management.

The main aim of the program is to offer training to a cross-section of the community in a variety of areas, essentially to improve the abilities of individuals. A conservation component figures in all programs and it is hoped that participants link the training benefits with wildlife and natural resources. A secondary aim of training people in skills is to provide alternatives to poaching and other common illegal activities within the area. All training is coordinated by a Training Officer. Four main target groups were identified for training:

- community leaders (e.g., chiefs, village headmen, councilors, CDU chairmen);
- community members/groups (e.g., women's clubs, youth

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groups, local craftsmen);

- local project/government employees (e.g., staff of the Wetlands Project, National Parks and Wildlife Services (NWPS), ADMADE and local government extension workers);
- school groups (e.g., conservation clubs, Youth Conservation Volunteers).

Community leaders

For community leaders the main training emphasis is on encouraging them to take a more active role in the conservation and management of their natural resources. In July 1992 all six chiefs of the Kafue Flats came together for the first time to learn more about their resources, discuss them together and come up with resolutions for presentation to government and the project. Various topics were presented by local and national governmental and non-governmental organization (NGO) representatives, including those involved in agriculture, veterinary care, forestry, wildlife conservation and management, fisheries, health, and environmental education.

A large chiefs' workshop took place in October 1993, when seven chiefs from the Bangweulu Swamps joined those from the Kafue Flats, thus bringing together the traditional guardians of several thousand square kilometers of prime wetland habitat. This workshop investigated practical options for the involvement of the community in natural resource management. Highlights of their visit included flights over the Kafue Flats, a tour of Lochinvar National Park, and a leaving party at Lochinvar Lodge. The workshop later gave rise to a series of finance workshops in all units, where leaders worked out systems for managing their own WMA and CDU finances. Several chiefs also held subsequent meetings at their palaces to discuss what they had learned and seen. One chief explained to his people how he wanted as many lechwe in his area as he had seen from the light aircraft over Lochinvar; another held a snare-collection exercise.

These workshops were uniquely for local traditional leaders, rather than for government employees working with them. Together such leaders can stimulate each other to work towards improving the well-being of their subjects and resources and can present a formidable force for initiating change. And clearly, with nearly half the world's population of Wattled Crane (*Bugeranus carunculatus*) and almost the entire population of Kafue and Black Lechwe (two of three subspecies of *Kobus leche*) dependent on these leaders' chiefdoms, the importance of individual chief's attitudes to their natural resources cannot be underestimated.

Community members/groups

The main aim of these courses is to increase the abilities of participants, thereby improving their income-generating potential. It is generally preferable to invite members from local clubs for training, so that when they return to their home area they will be obliged to tell their fellow club members their new or improved skills and knowledge. There is much emphasis on skill-sharing. Perhaps the most successful courses have been for women's clubs, when up to 25 women have stayed at the CDCTC for a week or two, learning and sharing skills together. The project has employed a Home Economics Officer to work more closely with these clubs (as well as organizing catering and other activities at the CDCTC). A great variety of skills have so far been taught in these workshops from mat- and basket-making to pottery, gardening, cookery, child care and nutrition and home economics.

Other target groups are youth clubs and men's clubs, who are generally most keen to learn about carpentry and tool-making. Local artisans are also included, especially if they have a skill to develop or share.

Project/government employees

Although this group may not necessarily be construed as local, all are working actively in the area and are thus capable of disseminating information to a wide cross-section of the local community. Most seminars for staff and local extension workers last just a couple of days, with the main aim of explaining in detail about the project and the value of natural resources. Local health, veterinary, and agriculture assistants have all participated, as have NPWS, ADMADE, and Wetlands Project staff.

A few specific courses have also been held, notably in bird status, identification, and counting. NPWS rangers and scouts, ADMADE village scouts, and wetlands biologists have learned how to identify and count waterbirds and how they can act as important indicators of wetland health. Extension workers have also learned about birds, so that they are able to then explain to the community in their public meetings that Wattled Cranes, for instance, are endangered birds with a world population less than the population of their nearest market town.

School groups

School groups have been brought to the CDCTC from time to time, though it is more usual for staff, especially the Training Officer, to visit the schools themselves. Children are taught about different aspects of nature, usually accompanied by games or an activity such as tree planting.

All target groups

In all these target groups the value and benefits of wetlands and particularly their wildlife are discussed, along with the aims, objectives, and benefits of the Wetlands Project. Participants are fed, accommodated, and looked after well at the CDCTC, and are always taken for a visit around Lochinvar National Park. For many, it is the first time for them to see some of the wildlife species, and to use binoculars and/or a telescope. Few facial expressions can match those of a ninety-year old traditional chief as he watches wildlife through a telescope for the first time! There are also historical sites in the park and other attractions such as hot springs, which interest local people keenly.

EVALUATION AND SUCCESS OF THE TRAINING PROGRAM

All participants are questioned before departure about their course, and ways are discussed how it might have been improved. For instance, the first women's club participants unanimously agreed that two weeks would be better than one. However, no formal evaluation has been carried out yet to quantify the relative success of the program, for instance the level of adoption of newly-learned skills.

Nevertheless, informal observations indicate that the program is very successful because:

- courses are extremely popular, and talked about for a long time after they have passed;
- the Chiefs' Workshops produced a comprehensive list of resolutions, many of which have since been acted on;
- women's clubs have remained active and have all repaid small loans which they received;
- there is a more active participation in project activities, and a greater perception of its benefits;
- regular inquiries are received about future training courses.

However, community training is a time-consuming activity, with much input for the benefit of a relatively small percentage of the local population. There is a question mark also over the long-term sustainability of the program. Could it operate by itself in the future, with participants paying the course costs, or would the community decide to fund it with their own revenue generated from wildlife hunting and other operations?

Community development and conservation is a slow process, one whose real benefits may not be realized for generations. A local training program helps reduce this time span and can instill a sense of community participation not attainable by other means. It is a valuable component to any conservation program, offering unlimited opportunities to present a clearly beneficial front to a project whose objectives may at first seem antagonistic to the local community way of life.

REFERENCES CITED

WWF-Zambia Wetlands Project. 1992. Information brief for wetlands management authorities (WMAs) and community development units (CDUs). Chilanga, Zambia.

REDUCTION IN DISTRIBUTION OF THE CROWNED CRANE: A CASE STUDY OF THE BAROTSE FLOODPLAINS

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ABSTRACT

The distribution of the Grey Crowned Crane (*Balearica regulorum*) in the Barotse Floodplains and the associated floodplains of the Liuwa, Luena, and Matebele Plains, has been reduced over the past two decades. The four areas visited in this survey over a period of two years revealed that the Crowned Crane distribution is now restricted to a small area of the Liuwa Plains, where 80 birds were counted. This observed decline in habitat can be attributed to anthropogenic factors such as hunting and agriculture required for increasing populations and to environmental factors such as successive droughts, siltation of some wet areas, and deforestation of edges of the plain.

INTRODUCTION

The distribution of the Grey Crowned Crane (*Balearica regulorum*) is generally described as sparse in Zambia. Though the Crowned Crane is recorded in all the wetlands of Zambia it congregates in large numbers in a few areas such as the Kafue Flats, Luangwa Valley and the Bangweulu Swamps (Benson *et al.* 1971). The records of flocks of Crowned Cranes in those date back to the end of the last century. Sandberg (1908) records the Crowned Crane as present in small groups in all low-lying river valleys. It was recorded in the Luangwa Valley and in the Chinsali area, where it was found to be breeding, by Winterbottom (1939).

In the Western Province, the Crowned Cranes are reported to have patronized the central parts of the Barotse floodplains. Taylor (1965) recorded the Crowned Cranes in Kalabo District in the Liuwa National Park and also in the Mashi-Kwando area. The local people give account of flocks of the Crowned Cranes to have been found as far as the southern limit of the Barotse Plain close to Senanga.

In the 1960s, workers in the area recorded a much reduced distribution. Most of the records show that the populations at that time were mainly in the northern and central parts of the plains with few vagrants in the Luena Flats and a considerable population in the Liuwa Plains (Dowsett and Aspinwall 1979).

This paper attempts to review the spatial distribution of the Crowned Cranes in the Barotse Plain from early in this century. It goes on further to discuss the factors which could have led to the decline in sporadic distribution of the cranes in the Barotse Plain.

METHOD AND STUDY AREA

The Barotse Plain stretches from 14°30'S and 16°10'S, extending up to about 35 km on either side of the Zambezi River at the widest place. The plain occupies the central part of the Western Province. In the north, the Barotse Plain fans out into the plains of its tributaries, the Lwanginga and Luena rivers, giving the Liuwa Plains and the Luena Flats, respectively. In the south the Barotse Plain extends into the Matebele Plain which forms a transition from the wetland plain to the dry grass plains found in the extreme western part of the province.

The Barotse floodplain is inundated by floodwater from March through early or mid-June. Dambos, oxbow lakes, and ponds are very common. The plains are populated, with the human populations concentrating along the levee of the river and at the edge of the floodplains. The river forms the main lifeline of the people in the area.

During the 1990-92 period a total of 13 visits were made to the following areas: central parts of the Barotse Plain (4 visits); northern Barotse Plain above 15°S (3 visits); Luena Flats (2 visits); and Matebele Plains (2 visits). The visits were conducted during the months of July to September and November to December, which coincided with the end of the flood season and the start of the rainy season, respectively. During these periods large concentrations of wetland birds are not uncommon.

Each visit was limited to a day. On each of the visits, the counts of cranes seen were taken and their distribution mapped. The few counts which were done were taken from a vehicle with the help of 8 x 30 mm field glasses. Time was also taken to find out from the local people if they could recognize the Crowned Crane from a series of bird photographs and when they last saw the birds in their area at all. The ages of those who could recognize the bird and claim to have seen them in their areas were taken. From this it was hoped that the original distribution of the cranes could be determined.

RESULTS

Out of the 13 trips made, only the two trips into the Liuwa

Plains yielded some counts of Crowned Cranes. A single population of 80 birds in central Liuwa Plain was recorded. According to the local people Crowned Cranes were last seen in central parts of the Barotse Plains in the 1950s and in the Luena plain in the mid-1960s. Although people rarely travel out of the area, the average age group of people who could recognize the Crowned Crane was 45 years, suggesting that the cranes have been declining for some time. In the northern parts of the Barotse Plains, the people reported seeing them occasionally but they have become rare visitors.

From the accounts of local inhabitants, it is evident that the distribution of the Crowned Crane has declined considerably. In the 1950s, the Crowned Crane was a common sight along the full stretch of the river in the Barotse Plain, the Luena Flats and the Liuwa Plains (Figure 1a), especially in areas which were swampy and with short grass. By the 1970s, they were only reported to be found in the central parts of the Barotse Plain. Even at this time they were rather uncommon (Figure 1b); this apparently agrees with the sporadic distribution of the birds given in the manuscript of the Zambia Bird Atlas (Dowsett and Aspinwall 1979).

The current study has revealed an even further reduction in distribution to a single population in the central part of Liuwa Plains and a few vagrants to the adjoining areas (Figure 1c).

DISCUSSION

The observed reduction in the distribution of the Crowned Crane in the Barotse Plains indicates that there has been a shift in the ecological character of the area. The river has changed course in one or two places, and some areas which are said to have been very wet are now dry. This has affected not only the Crowned Cranes but a host of other animals, too, like the red lechwe (*Kobus redunca*), which is extirpated from most of the area.

The Crowned Cranes are inclined to inhabit wetter areas with little disturbance, thus maintaining its survival processes, especially reproduction.

The earlier reported widespread distribution is evidence of the wide presence of suitable habitats on the floodplains. The restricted nature of their distribution and their confinement to a few areas could be suggestive of reduced habitat range. The changes in the environment which led to the loss in habitat over a wide area of the floodplain could have been caused by several factors.

Population pressure

There has been a substantial increase in human population on the Barotse floodplains over the years. This has led to increased exploitation of the resources of the wetland in an effort by the people to eke out a living. Patterns of exploitation of resources have changed and have become increasingly more environment-hostile.

On the Barotse Plains, people are settled on the river "levee" and in the catchment areas, on the banks of ponds, ox-bow lakes and lagoons, and on termite mounds. Their agricultural activities are concentrated on termite mounds for crops such as maize, and in the depression for crops such as rice and vegetables. Some of these areas are the wet areas suitable for Crowned Cranes. This, compounded by livestock grazing, could have put the cranes in direct conflict with the people. Also one of the end results of increased cultivation is increased soil erosion which could have led to the disappearance of some of the suitable areas.

Hunting

The Crowned Cranes were traditionally protected. The local people were charged with the responsibility to ensure that the killing of the cranes was by special permission of the local traditional authorities. This has changed now with the change in legislation. In 1969, the Western Province Land and Miscellaneous Act was enacted, transferring the control and policy of natural resources in the area to the central government. This antagonized the people who saw the new arrangement as an imposition. From then on the controls were no longer effective, leading to increased exploitation of mammal, fish, and bird resources. One very destructive traditional hunting practice is the harvesting of bird colonies before the fledglings can leave the nests. Once the birds are discovered to be big enough, the community is alerted and on a set date men congregate and invade the colony, harvesting any birds they can. This type of hunting is directed mainly to herons (Ardeidae), storks (Ciconiidae), and the Ibises and Spoonbills (Threskiornithidae), but cranes may be taken opportunistically.

This practice could be responsible for the extirpation of several populations of habitat sensitive species or a complete shift in populations to areas which offer more protection and a better chance of successful breeding.. From this it is evident that the success of any conservation act directed at the cranes depends very much on the involvement of the local people.

Climatic shifts

The recurrence of droughts has had an indirect effect on the habitat of the Crowned Crane. Prolonged drought has lowered the water table causing some of the ponds and marshes to dry out, leading to the loss of most of the vegetation. This coupled with the increased anthropogenic factors such as farming activities have led to the siltation of these water bodies. Some of these areas served as the refuges for birds. The loss of such areas forced a shift in the population distribution to different localities with the necessary habitat factors for their survival. For birds like the Crowned Crane, which does not seem to adapt easily to new breeding environments the change could have resulted in a complete shift in distribution.

Overgrowth of vegetation

In the Luena Flats, there was a close association between the wild mammals, especially the red lechwe, and the Crowned Cranes and other bird populations. Through their grazing activities, the animals kept the grass short, allowing for the foraging activities of the birds. Hunting pressure has led to the depletion of the animal population to insignificant numbers, leaving most of the grazing areas unchecked and eventually overgrown.

The decline in the habitat of the Crowned Crane can be seen as a result of a conflict between the need to conserve the plain as a wetland habitat and the need to exploit it for the benefit of the people. Most of the projects being introduced today do not take the sensitive nature of the area into consideration and programs are being implemented without adequate feasibility studies and without the involvement of the local community. This reduces community participation which is of prime importance in any project. As the situation is, there is need for a little more conservation effort to serve and build the Crowned Crane population on the Liuwa Plains.

RECOMMENDATIONS

To reverse the process of the decline in habitat of the Crowned Crane, there is need to:

- sensitize the local people on the value of the plains as a wetland, so that they may fully appreciate its functions and roles;
- mount a campaign to educate the people about the adverse effects of some traditional practices such as harvesting of bird colonies;
- encourage proper and balanced management of resources, to prevent accelerated degradation of some of the habitats.

The Crowned Cranes are losing ground in Western Province, at a very fast rate. This calls for the study of the characteristics of crane populations and their dynamics so that the present resident crane population of the Liuwa Plains could be helped to grow.

REFERENCES CITED

Benson, C. W., R. K. Brooke, R. J. Dowsett and M.P.S. Irwin 1971. The birds of Zambia. Collins Press, London, UK.

Dowsett, J. and D. R. Aspinwall. 1979. Bird atlas of Zambia. Unpubl. MS.

Sandberg, A. 1908. The fauna of the Barotse Valley. Proceedings of the Rhodesian Science Association 7(2): 31-42; 8(1): 94-98.

Taylor, M. A. 1965. A collection of birds from Barotseland, Bechuanaland. Ibis 107: 137-172; 257-384.

Winterbottom, J. M. 1939. Revised check list of the birds of Northern Rhodesia. Government Printers, Lusaka, Northern Rhodesia (now Zambia).

Winterbottom, J. M. 1942. A contribution to the ornithology of Barotseland. Ibis 84: 18-27, 237-389.

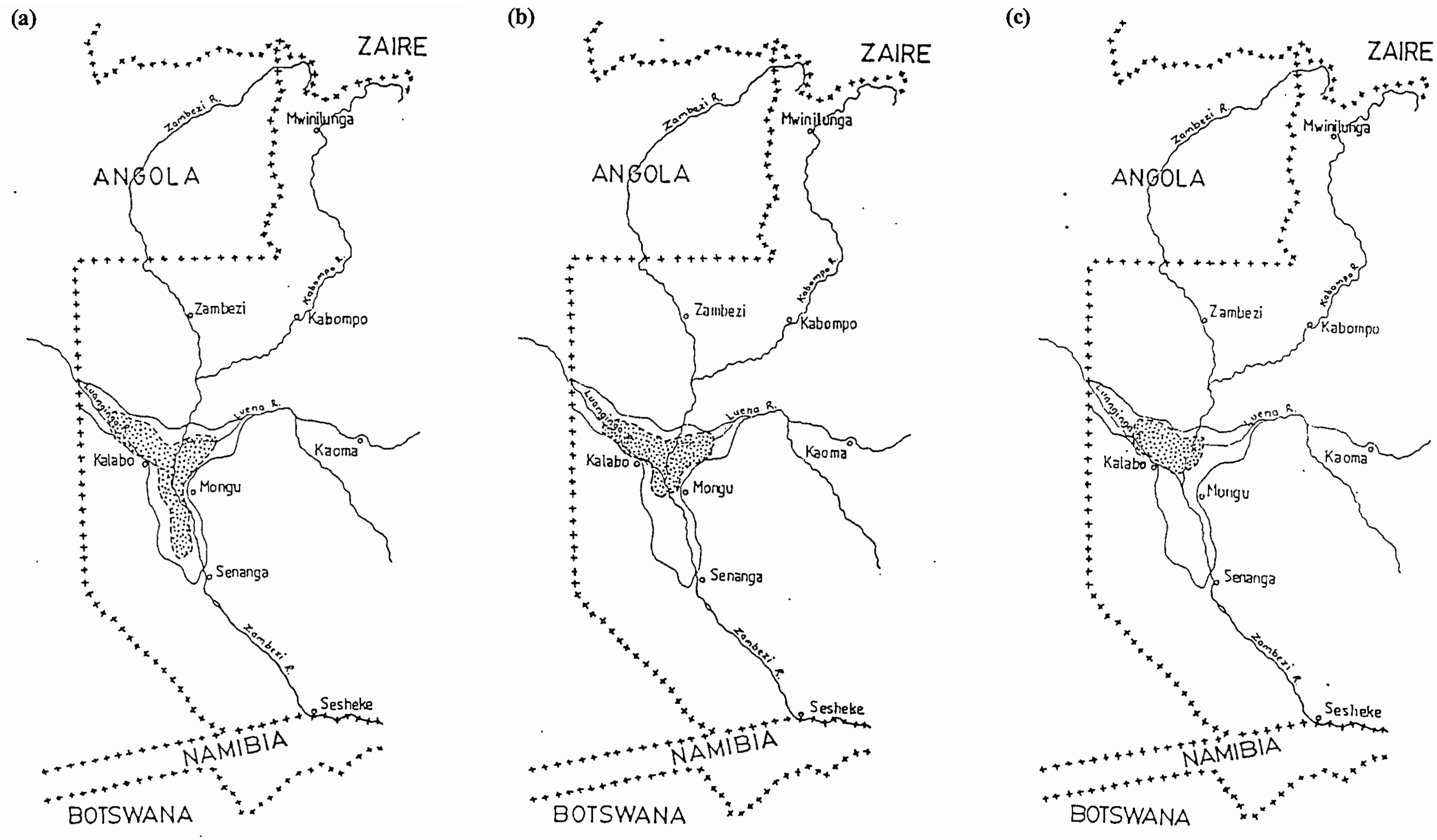

Figure 1. Distribution of the Crowned Crane in the Barotse Plain (shown as ▨): (a) before 1950; (b) in the 1970s; (c) in the 1990s.

WETLANDS POLICY FORMULATION FOR ZAMBIA

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ABSTRACT

Wetlands are an important ecosystem. They provide numerous natural resources for human beings and are a habitat for both animals and plants. They are also very fragile and vulnerable to many different disturbances, mainly from humans. Southern African Development Community (SADC) countries have been urged to produce a wetlands policy to conserve and manage the wetlands. Zambia has created a multi-sector task force to initiate this process through surveys and interviews with the local communities and other wetland resource users. A project proposal for the floodplain of the western province has been designed by an IUCN consultancy team on behalf of the Environmental Council of Zambia to provide an impetus for the formulation of the wetlands policy in Zambia. The task force intends to visit other areas outside Zambia to gather more data on wetlands management and conservation. This, it is hoped, will speed up the process of formulating the wetlands policy.

INTRODUCTION

The definition of a wetland is not an easy one. So far, there are more than 50 definitions but for the purpose of this paper we shall adopt the RAMSAR (1990) definition which describes wetlands as "areas of marsh, fen, peatland and water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt...".

A simpler definition can be that a wetland is an open flat field of grasses growing in water or water-soaked soil. It can be a shallow pond surrounded by a soggy carpet of mosses or a thickly wooded swamp overgrown with entangled shrubs, ferns, and other plants. It is hard to find a lot of characteristics that apply to all wetlands.

Around the world and despite their small total area, wetlands are of major environmental and economic significance. Their rich and varied ecosystems are important centers for biodiversity. They often sustain and regulate major river systems downstream. They support a range of economic activities including fisheries, crop production, and livestock raising.

Many people think of wetlands as wastelands--fit only for ducks! This view is not surprising. Wetlands are often unsheltered, soggy places, that become humid and buzzing with mosquitoes when the weather is hot. But to think of wetlands as wastelands is a big mistake. Hundreds of thousands of wading birds, geese, and ducks use wetland sites for feeding, molting, and breeding, and as staging posts on their annual journeys to their summer or winter homes. Because wetlands are often remote places, rather difficult for people to invade, they are havens for plants and animals. Many threatened or endangered plants and animals either live in wetlands or depend upon them in some way.

But despite all this, wetlands are under great pressure to meet the increasing needs of people. Often people want to get rid of wetlands. They want to make the ground drier and firmer. To do this, they try to drain wetlands by digging ditches and canals that will draw off the water. Sometimes they straighten and deepen rivers to make the water flow more easily. They try to use the reclaimed land for farming or building. This is a true disaster for wetlands. With less water, plants, insects, birds, and worms and other invertebrates will not be able to survive.

Another threat to wetlands is that of chemical pollution. Fertilizers and pesticides may be applied to land that borders wetlands. Rain washes these chemicals into water courses where they are joined by other pollutants such as sewage from towns and cities and chemical waste from factories.

SADC INITIATIVE TO CONSERVE WETLANDS OF SOUTHERN AFRICA

Governments of countries throughout the world are beginning to recognize the value of wetlands. This is illustrated by the number of countries that have signed the RAMSAR Convention. Contracting countries agree to include wetland conservation in national planning, promote sound utilization of wetlands, create properly wardened nature reserves, and develop management research.

It is for this reason that a survey was launched by the Southern African Development Coordination Conference (SADCC) in 1990 to begin what is now known as the SADC initiative to conserve wetlands in the Southern African region (in 1992, the Southern African Development Coordination Conference became the Southern African Development Community or SADC). Ten countries (Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, Swaziland, Tanzania, Zambia, and Zimbabwe) which comprise the SADC region were surveyed through interviews with government and institutional officials, questionnaires, and visits to wetland sites.

After this survey, a report was produced, which was divided into two major areas: social and environmental issues and the institutional and legal framework. The most pressing issues were deforestation, overgrazing, soil erosion, siltation, poor agricultural practices, overfishing, over-hunting or illegal hunting, pollution, human settlement, land tenure, water sharing, and unplanned development.

The report also pointed out the deficiencies in the structure and functions of most institutions and the weaknesses of the legal instruments. The report concluded by urging SADC to work with governments to see that the plan of action for each country was effectively implemented.

SIAVONGA SEMINAR ON WETLANDS OF SOUTHERN AFRICA

In June 1992, a seminar was convened in Siavonga, Zambia to discuss the issues raised by the SADC consultancy team. The seminar was organized jointly by IUCN-Regional Office of Southern Africa and the newly created Environmental Council of Zambia (ECZ). It drew resource people and participants from Malawi, Zambia, and Zimbabwe.

One of the resolutions passed at this meeting was that each country in the region should prepare a policy for the conservation and utilization of wetlands. It was found that most if not all the countries in the region lacked this policy, except Uganda.

It was also resolved that each country should create an institution which would coordinate all the activities in wetlands conservation. In Zambia, the ECZ was identified as such an institution.

To assist in bringing about the formulation of a wetlands policy in Zambia, a member of Parliament from Western Province, Hon. Mwanamwambwa, presented a paper and requested that more attention be given to the vast and rich wetland areas situated in the Barotse floodplain and Liuwa National Park. The Department of National Parks and Wildlife Service and IUCN agreed to carry out preliminary investigations to consider the possibility of drawing up a wetlands conservation and management plan in Western Province.

WETLANDS POLICY TASK FORCE AT ECZ

The first thing that the Environmental Council did after the Siavonga seminar was to create a national wetlands management committee in the form of a task force. This task force is multi-sectoral and includes members who are experts in their fields, from a number of governmental levels, including the Departments of Fisheries, Agriculture, and Forestry, the Department of National Parks and Wildlife, the Water Department, the University of Zambia, and the Lands Department. Representatives from IUCN and WWF sit on the task force as ex-officio members. The ECZ provides administrative support.

Objectives

The objectives of the task force include:

- to provide guidance for the development of the wetlands policy, and make the necessary interpretations of such a policy where need arises;
- to prepare support documents necessary for the formulation of the wetlands policy in Zambia;
- to make arrangements to carry out investigations, to conduct interviews on various issues, and to conduct field trips to some wetland sites and outside the country for the purpose of gathering sufficient information relevant to the development of the policy.

Action plan

The task force then drew up an action plan which would enable it to function effectively. Proposed actions included:

- to review current conservation policies;
- to review the applicable legislation and evaluate its relevance and adequacy for conservation in general and specifically whether the legislation would support the proposed wetlands policy;
- to evaluate the current status of wetlands in Zambia, including identifying critical issues and the extent of conservation problems in the country;
- to evaluate current conservation practices.

Field trips

The task force has so far conducted two field trips within Zambia. One was to the Kafue Flats in the south and the other to the Lake Bangweulu area in the north. The task force looked at the current status, use, and management of the natural resources of these two areas.

Kafue Flats

The task force interviewed officials, leaders, and private citizens where this was necessary. The team discussed a number of issues, focusing on the values of and threats to the Kafue Flats.

The major threats were found to be the existence of the Itezhi-Tezhi Dam, the increase in pollution and eutrophication, and overexploitation of fisheries and wildlife resources. Other potential threats include deforestation, excessive water extraction, and overgrazing.

The team also observed that the current initiatives by WWF-Zambia Wetlands Project in the conservation of the Kafue wetlands were inadequate, as project activities were confined to the conservation of wildlife only. The lack of knowledge about the Kafue Flats was a serious setback for any good management policy. It was also noted that there is an apparent absence of coordination among resource users, with resulting conflicts over the way wetlands resource are exploited. The creation of ECZ as an established authority will, it is hoped, result in the coordination of natural resource users in the wetlands.

Bangweulu floodplain

Here, the local people consider the wetland resources, especially the fisheries, as unlimited. This attitude has resulted in rampant overfishing. The population in the area has increased greatly in recent years because of fishermen coming from other districts. The fishermen have now resorted to catching smaller fish, since the resource has been depleted. The task force also noted that people do not observe the closed season to allow for the breeding of fish. This has had an adverse effect on the stocks. Other issues examined for the Bangweulu floodplain were wildlife, agriculture, and the socio-economic conditions.

RECOMMENDATIONS

Following discussions on the formulation of a policy for the wetlands several recommendations were made.

1. The team should carry out an inventory to gather as much information as possible;

2. The team should define priorities in accordance with the needs and socioeconomic conditions of Zambia, including power generation, fisheries, wildlife, grazing, and agriculture;

3. The team should assess the capacities of the current institutions involved in the management of the wetlands in Zambia and determine their appropriateness and strength in implementing the policy once it is in place.

Full reports of these field trips are available at the ECZ.

UPPER ZAMBEZI WETLANDS PROJECT

Early in 1993, the ECZ requested the IUCN to engage a consultancy to carry out a survey in the upper Zambezi floodplain with a view of formulating an integrated wetlands project for Western Province (IUCN and NEC 1993). The Western Province wetlands were chosen because of their extent, complexity, and integral relationship with neighboring dry land areas. The conservation and management challenge for the upper Zambezi wetlands is considerably more wide ranging than might be the case for smaller wetland areas.

The programming mission did its work in Lusaka and Western Province from March 21 to April 8, 1993 and developed a project proposal for upper Zambezi wetlands resource planning which will be integrated with environmental and development planning for four of the six districts of Western Province. The project will be the pilot provincial planning project. Its activities will be linked to the activities of the national program to maximize the benefits of the environmental assessments and environmental expertise. Institutional building will be a major goal of this project with the focus on wetlands conservation action and management.

Under this project, surveys will be carried out regarding wetlands inventory and land use, wildlife, forest resources, and fisheries, and pilot projects will be launched in these areas. It is hoped that these activities will boost the wetlands database which will subsequently prove useful for the wetlands policy formulation process.

FUTURE DIRECTIONS

Several field trips are planned both within and outside Zambia to gather more data on wetlands management and conservation. Seminars and workshops are also planned in several parts of the country after the draft policy is ready, to give a large spectrum of wetland resource users the opportunity to analyze the document.

With the help of countries like Uganda who have reached a very advanced stage in their wetlands policy formulation, Zambia will soon have a draft policy document in place.

CONCLUSION

The problems of wetland management and conservation are similar in most of the SADC countries. Most of them lack a wetland policy and a coordinating institution to address the problems of wetlands. In most instances legislation is lacking and where it exists, it is very weak and fails to address the pertinent issues effectively. In addition to this, public awareness has been lacking so that people have abused the wetlands' natural resources. Where awareness has been in existence, the abuse has been due to the abject poverty in most communities. The exclusion of the local communities in planning projects by the authorities has also had a negative effect on the people's attitudes.

With the creation of the task force at ECZ and the launching of the upper Zambezi wetlands resource planning project, it is hoped that the process of formulating the wetlands policy for Zambia will be eased. More public awareness will be created in the local communities through seminars and workshops, and the public will be able to indicate what type of wetlands policy they would like to see.

REFERENCES CITED

The World Conservation Union (IUCN) and National Environment Council (NEC). 1993. Upper Zambezi wetlands resource planning project. Unpubl. MS. Lusaka, Zambia.

Ramsar Convention. 1990. Proceedings of the fourth meeting of the Conference of Contracting Parties. Volume 1, p. 150. Gland, Switzerland.

CONSERVATION STATUS OF WETLANDS IN MALAWI WITH RESPECT TO HABITATS AND THE SURVIVAL OF CRANES

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ABSTRACT

Wetlands cover a large proportion (over 5.5%) of Malawi. They contain a number of important physical and biological resources which man has been exploiting for many years without due consideration for the resources' continued existence. As some wetlands have been degraded and most of the remaining ones largely modified, plant and animal life have been generally affected adversely. Both Grey Crowned Cranes (*Balearica regulorum*) and Wattled Cranes (*Bugeranus carunculatus*) have been documented in Malawi and their present populations show a decreasing trend. The situation is cause for concern and an immediate solution is required.

INTRODUCTION

Wetlands support the growth of interesting plant and animal communities. Some plants are hydrophilic, remaining partly or completely submerged in water or floating on water. Still more plants are associated with waterlogged conditions. These play important roles in the ecosystems as primary food producers for human beings, domesticated animals, and aquatic and semi-aquatic life forms. They also create a wide range of habitats and micro-environments for animals and spectacular scenery that, together with wild plants and animals, form part of a tourism resource base.

Out of the 118,485 km² that make up the surface area of Malawi, 21% is covered by water (chiefly in Lakes Malawi, Malombe, Chilwa, and Chiuta and the Shire River) and 5.5% by wetlands which include marshes, swamps, deltaic areas of rivers and seasonally flooded grasslands of low-lying areas (Kalk *et al.* 1977). Wetlands are also found at high elevations such as on Zomba Plateau (ca. 2,000 m above sea level).

WETLAND USE AND DEGRADATION IN MALAWI

The large number of wetlands and their varied geographical conditions provide a wide range of such natural resources as water, fish, birds, mammals, and fertile soils. Consequently there is a variety of human activities that impinge on wetlands. In many places people earn their living by making use of one or more of these wetland resources. Almost all villages are situated near reliable natural water sources such as lakes, rivers, or streams where water is used for domestic purposes. Commercial fishing is concentrated in the shallow parts of Lakes Malawi, Malombe, and Chilwa while small-scale fishing is practiced elsewhere in lakes and rivers. Apart from offering a lucrative business, fish provide protein which improve human diet.

Grasses such as *Echinochloa*, *Urochloa*, *Panicum*, *Pennisetum,* and other species that grow in wet places provide feed to domestic animals especially during the dry seasons (July to November), where arable land has been converted into farmland and human settlements. Grazing of mainly cattle and goats in wetlands is practiced throughout the year. Other plant species provide materials for building and crafts. These include grasses (such as *Typha domingensis*, *Phragmites mauritianus*, *Pennisetum purpureum*, and *Borussus aegypticum*), sedges (*Cyperus papyrus* and *C. allopeculoides*), and trees. Among the wild food plants for human beings are corms of ground orchids such as *Satyrium*, *Habenaria*, and *Disa* species and of water lily (*Nymphea lotus*). Most of the plants that are associated with nitrogen fixation in the soil such as *Faidherbia albida*, *Acacia*, and *Sesbania* species naturally grow in or near inundated areas.

The fertile soils, moisture, and the proximity to a water source make wetlands very good sites for agricultural activities. Nursery beds for tobacco are located in dambos where dry season crops are commonly grown. Maize is grown in dambos to supplement the arable crops and for sale in local markets mainly as a vegetable. Other important crops include sugar cane, rice, vegetables, and fruit trees. No reserve land for cultivation is available for the increasing human population in a country which is largely agricultural, and local people resort to cultivating in marginal land areas such as vulnerable hill slopes and wetlands. A lot of seasonally flooded areas, lakeshores, and river margins have been turned into farmland. Pressure on wetlands is more pronounced where most farmers belong to the low income sector and depend heavily on available natural resources to survive. Deforestation in arable lands and use of chemical fertilizers result in silt deposition and eutrophication respectively in wetlands. Human settlements, roads, bridges, dams, monocultural afforestation activities, and tourist resorts all have a bearing on wetlands.

Deforestation is a common problem in Malawi. Trees are cut down to allow room for crops or to provide wood resources for energy and building materials. As a corrective measure, trees are planted in an extensive afforestation campaign. The choice of exotic species in the largely monocultural plantation forests cause loss of unique habitats and biological diversity. Pine and blue-gum tree plantations, where many indigenous plant species do not grow, are a frequent sight in Malawi. The number of species of wild animals is also reduced.

CRANES AND WETLAND CONSERVATION

The human activities described above have had negative impacts on the survival of wetlands in Malawi, and environmental degradation is common. The normal functioning of most ecosystems is disrupted. A number of animal species, especially those such as cranes that require specific environmental conditions, have been endangered while human beings face socioeconomic problems.

Kalk *et al.* (1972) and Benson and Benson (1977) documented cranes on Zomba Plateau, Lake Chilwa, Mpatsanjoka Dambo, Bembeke, Kasungu National Park, and Njakwa. Grey Crowned Cranes (*Balearica regulorum*) were frequently encountered in Lake Chilwa where they were seen in breeding pairs in the margins of open waters. They were also recorded in Vwaza Marsh (McShane and McShane-Caluzi 1988). They were resident and nested in grasses growing in or near water. In 1923, Wattled Cranes (*Bugeranus carunculatus*) were seen on Mulunguzi Marsh and Viphya Plateau; they were reported to be rare on Zomba Plateau (Belcher 1930). Other areas where cranes were recorded include Upper Bua River, Nderendere, and South Rukuru River, and from Mcocha and Chitala to Lake Kazuni. The low numbers seen in Lower Shire Valley, Lake Chilwa, and Songwe River Mouth (Belcher 1930) may indicate that the Wattled Cranes were migrants there.

Literature shows a decrease in the population of cranes in Malawi. In recent years birdwatchers have not reported having seen cranes in many sites. They are unlikely to occur on Zomba Plateau, Lake Chilwa, and other wetlands. Very few are encountered in Mpatsanjoka Dambo in Salima District, Bembeke, Njakwa, etc. A flock of 133 Grey Crowned Cranes was reported in 1923 at Mpatsanjoka Dambo whereas today they are unlikely to exceed nine at this locality. A reasonable number of Wattled Cranes is said to occur at Nyika National Park but their survival also requires sound management. Dyer (1992) states that 49 pairs of Wattled Craned were spotted in 1949 and the number reduced to an estimated 25 to 30 pairs in 1985. Although the populations of cranes in Malawi cannot be accurately estimated in the absence of a specific census, a general trend of decreasing populations in a period of 70 years (1923 to 1993) is discernible throughout the country.

In the past, cranes occurred widely in Malawi and were frequently seen in many sites throughout the country. Their populations have now been drastically reduced and the distribution restricted to relict localities. Habitat modification has been mentioned as one of the factors that adversely affected the population of Wattled Cranes at Nyika National Park because of their apparent specific nesting site requirements (Dyer 1992). The proposal to construct artificial nesting sites has been put forward.

In the Kafue Flats, Zambia, the food of Wattled Cranes is chiefly the rhizomes of sedges which are dug out from soft mud. It can be said that Wattled Cranes eat similar food sources in Malawi (Dyer 1992). Among other things, Grey Crowned Cranes eat mainly grains, insects, frogs, mollusca, fresh water shells and reptiles. According to Belcher (1930) the Grey Crowned and Wattled Cranes show no clear-cut habitat differentiation but apparently exhibit differences in feeding habits.

Environmental degradation is likely to affect availability and types of food resources. Sedges, reptiles, preferred insects, etc., may become locally unavailable, forcing the birds to migrate.

Priority must be given to the conservation of wetlands in Malawi because they form part of the life support systems for human beings, wild plants, and animals. Several problems are encountered in the effort to conserve natural resources in the country, including financial constraints and a lack of knowledge about the ecological dynamics and socioeconomic values of the wetlands.

Land is classified into customary, free-hold, and public where the former is under the jurisdiction of local chiefs. The chiefs are responsible for the allocation of land to people for various uses including new settlements and cultivation. Some sites where cranes are or were recorded fall under customary land. In the case of Mpatsanjoka Dambo, the customary land has been rapidly degraded while the portion under private land is still being preserved in its natural state. This is the fate of many other wetlands. While it is unlikely that local people can manage the resources on their own, it is often difficult to intervene in the activities taking place in customary and private land as this would violate the rights of those involved. Intervention could only be preceded by de-gazetting and re-gazetting the land, and by the time this is implemented degradation may be far advanced.

Basic knowledge of the interaction between living things and their physical environment and the ecological dynamics is lacking among development planners and resource users. In most cases renewable (especially biological) resources are over-utilized, sometimes exceeding the critical point beyond which they cannot replenish themselves. This results in an overall environmental deterioration and damage to unique habitats which directly affect people and domesticated and wild animals in the immediate vicinity and far beyond the area of origin. Adequate knowledge of the mechanisms of ecological functioning is required in order to avert or minimize problems which are beyond our present perspectives.

The original strategy of preserving forest reserves in Malawi was based on strict protection of trees and completely preventing people from access to forest resources. It is being realized that this approach cannot succeed. Local people are being consulted in conservation and management of natural resources so as to incorporate their requirements. Sound management and conservation strategies must take into consideration the social and economic values of each resource to local people who largely depend on those resources for their livelihood. It is imperative that the socioeconomic consequences of alienating people from the resource base be thoroughly investigated and alternatives exploited as far as and where possible. Research, however, can go that far but the real problem may lie beyond! The involvement of local people at the planning level can minimize carrying out meaningless research.

Tangible economic benefits to local people are needed in the shortest time possible in order to enlist their support. Among other things the economy of local people must be improved by making use of under-utilized resources and other means of diversifying economic activities.

The now famous slogan of resorting to a multidisciplinary approach to the conservation of natural resources is supported by the Malawi government. With the support of the World Bank a national environmental action plan is in being prepared. Crane and wetland conservation need to be incorporated into this plan.

THE NATIONAL HERBARIUM AND BOTANIC GARDENS OF MALAWI

Among the organizations with vested interest in wetland conservation are the National Herbarium and Botanic Gardens of Malawi (NHBG). Apart from herbarium curation and vegetation and floristic studies, and research in biosystematics, biogeography, and ethnobotany, the NHBG undertakes to carry out work related to conservation of indigenous flora of Malawi. The NHBG has created a unit which deals with wetland issues. Country-wide surveys and research such as documentation of wetland resources and sociological, ethnobotanical, ecological, and conservation studies of wetlands are being conducted but we are far from completing data collection. Priority is given to conservation of the whole ecosystem as well as selected species. It is realized that a selected species approach to conservation is subject to human error when important aspects which are not yet understood are overlooked.

With the present awareness about the need to pay particular attention to the conservation of cranes, the ongoing floristic and vegetation surveys will concentrate on sites which are likely to harbor cranes. In these areas the nesting habitats, the types and availability of food resources for cranes, and the poaching risks will constitute part of the investigation. The ultimate goal will be to conserve wetlands and advise relevant organizations such as the Department of National Parks and Wildlife on areas where sound management and conservation of cranes are required while addressing the need for ecological and socioeconomic stability. Funding is required for the procurement of the much needed equipment, short-term training courses for personnel, and the initial costs of running the project.

Malawi's wetlands provide a fascinating array of physical and biological resources which are indispensable for the survival of both man and wildlife. The increase in human population coupled with unplanned development has led to environmental degradation, loss of unique habitats, and reduction in the plant and animal resources. The reduction in the population of cranes can be attributed to the loss of required habitats and poaching in wetlands. A multi-sectoral and holistic approach to conservation and management of wetlands is required. The National Herbarium and Botanical Gardens of Malawi through its wetland section is one of the appropriate institutes to form a consortium which must deal with wetland management problems.

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REFERENCES CITED

Belcher, C. F. 1930. Birds of Nyasaland. The Technical Press Ltd., London, UK.

Benson, C. W. and F. M. Benson. 1977. The birds of Malawi. Montfort Press, Limbe, Malawi.

Dyer, M. 1992. Observations on Wattled Crane nesting on Nyika Plateau, Malawi. Nyala 15(2): 57-62.

Kalk, M., A. J. McLachlan, and C. Howard-Williams. 1972. Lake Chilwa: studies of change on a tropical ecosystem. Monographs in Biology 35. Junk Publishers, The Hague, The Netherlands.

McShane, T. O. and E. McShane-Caluzi. 1988. Nyala 12(1-2).

Williams, J. C. 1972. A field guide to birds of East and Central Africa. Collins Press, London, UK.

STATUS OF THE NYIKA WATTLED CRANE AND MANAGEMENT RECOMMENDATIONS

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ABSTRACT

The Wattled Crane (*Bugeranus carunculatus*) population of Nyika National Park is distributed on part of a 500 km² plateau (1,900m-2,600m). The population is breeding successfully. From an estimate of 24 birds in 1987, the crane numbers increased by 42% to 34 in 1991. Fifteen territories were located. On Nyika, Wattled Cranes breed in the late dry season (August to October). It is recommended that all Wattled Crane populations in Malawi be monitored and their habitats continue to be protected. The general public should be educated about the importance of wetlands in relation to crane conservation.

STUDY AREA

Two species of cranes (Wattled and Grey Crowned) occur in Malawi; in this paper I discuss only the Wattled Crane. In Malawi, the Wattled Crane (*Bugeranus carunculatus*) occurs in Kasungu National Park, Vwaza Wildlife Reserve, and Nyika National Park. The species has not been studied in the first two parks but there is some information available for Nyika. This paper discusses the Nyika population with specific reference to its biology and behavior and makes some management recommendations.

DISTRIBUTION AND NUMBER

The first studies of the Wattled Crane on the Nyika plateau were done from February 1985 to March 1987 by Dyer (1992). A total of 84 sightings were made and 12 territories recorded (Figure 1). I carried out the second studies of the Nyika Wattled Crane from January 1990 to December 1991. During my study, I recorded 72 sightings on 15 different territories on the central plateau (Figure 2).

Until 1985, no accurate census of the Nyika plateau cranes had ever been conducted. One aerial count during a game census of Nyika National Park reported a total of 49 birds (Zimmerman 1969). A second subjective estimate suggested 25-30 pairs on the plateau (Collar and Stuart 1985) while Dyer (1987, 1992) estimated there to be 12 pairs of cranes. Nhlane (1990) recorded eight breeding pairs. In my recent study, I estimated the resident Wattled Crane population to number 30-34 birds. This estimate includes breeding pairs, chicks, and single birds. The reason Nhlane (1991) recorded only sixteen birds might be because of the season when he conducted his study. My study, and that by Dyer (ending in 1987) covered two year periods. My recent study indicates that there are more cranes than in Dyer's 1987 study, probably because of improved law enforcement as well as other favorable environmental factors such as temperature, moisture, and movement.

The cranes were frequently observed in valleys and grasslands, in an area of about 500 km² (45.5%) of the central plateau. This area comprises gently to moderately undulating grassland with numerous shallow valleys broken by broad convex interfluves. The valley heads have small patches of montane evergreen forests while their bottoms are frequently waterlogged. The grassland area is dominated by *Loudentia simplex*, *Themeda triandra*, and *Exotheca abysinica*, while the valley supports sedges and tussock grasses. Konrad (1981) considered small wetlands important because combining their areas results in a sizable proportion of all suitable crane habitat. Fortunately such habitats in Malawi occur in protected areas.

BREEDING CHARACTERISTICS

Habitat

Although the Wattled Crane is found in three conservation areas in Malawi, the Nyika population is breeding successfully and is probably the most secure. In Nyika, Wattled Cranes nest in dambos (valleys), which provide large areas of waterlogged, boggy terrain and support sedge growth. The areas have shallow ponds for nesting. Similar habitat preferences have been reported by Mclachlan and Liversidge (1978) for southern Africa.

Clutch size

Konrad (1981) recorded a mean clutch size of 1.6 for Wattled Cranes in Zambia. Dyer (1992) found the mean clutch size for Wattled Cranes in Malawi to have a slightly higher value (1.7) than for Zambia. This figure resulted when Dyer combined his data with those of Benson and Benson (1977) and Dowsett (1980).

The Wattled Cranes were found attending nests (67%) or with chicks (18%) during August to October, the late dry season. From November through January, the early wet season, 25% of the cranes were observed with chicks, while from February to April (late wet season) and May through July (early dry season), I did not observe either nesting birds or birds with chicks. It is possible that from February to July, the visibility of cranes is diminished because of increased vegetation density. It appears that the rise in temperatures during the late dry season, and the regrowth of vegetation, especially sedges, during the early wet season, provide the cranes with a favorable habitat and food. Although no sightings of breeding pairs were recorded during the early dry and late wet seasons, Dyer (1992) reported that the Wattled Cranes on the Nyika nest in all seasons with a preference for the late dry season. This agrees with my findings.

Breeding success

According to Dyer (1992) the overall breeding success of the Nyika Wattled Crane population is 53.3% with seasonal variations between 0% and 100%. He further indicated that the nesting cycle for these Wattled Cranes may be less than fourteen months. Considering all environmental factors to be appropriate for the cranes and each bird raising 0.6 chicks per nesting attempt, and using Dyer's figure, the number of resident birds is expected to have reached 68, but the actual estimate is 34.

ACTIVITY BUDGET

The Nyika Wattled Cranes spent 73.8% of their daytime engaged in feeding, 4.8% in flying, 2.4% in walking, and 1.2% in resting. The balance of their time (17.8%) was not defined; it may have included some of the above activities or other activities not in these categories.

MANAGEMENT RECOMMENDATIONS

Although the Wattled Crane population on Nyika is breeding successfully its management and conservation must be viewed on a long term basis. This population is small and the Vwaza and Kasungu populations have not been monitored. National parks and wildlife reserves in Malawi are established, among other reasons, to protect and conserve examples of flora and fauna, especially those which are endemic, rare, or endangered. The Wattled Crane is rare in Malawi (Clarke 1983), and thus deserves this special protection.

Another reason favoring the protection of the Wattled Crane is that it lives in important water catchment areas in Malawi and by protecting Wattled Cranes these wetland habitats, shown in Figure 3, are protected as well. This should be encouraged. In Malawi Wattled Cranes also have great aesthetic value and they are important in the ecological cycle. Their breeding territories on Nyika should be continuously monitored, and further research on their breeding and movements should be performed. This work should be extended to Vwaza Wildlife Reserve and Kasungu National Park. Finally, the public must be informed that uncontrolled fires are hazardous to the survival of the cranes because the fires destroy crane habitat.

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I am greatly indebted to the Chief Parks and Wildlife Officer, Mr. M. W. Matemba, for nominating and allowing me to attend this workshop. Also, many thanks to the Deputy Chief Parks and Wildlife Officer, Mr. J.N.B. Mphande and the Senior Parks and Wildlife Research Officers Messrs. F. X. Mkanda and S. M. Minthali for their untiring and constructive comments. Finally, I am grateful to the Nyika National Park Wildlife Research Service for data collection, to Mr. L. H. Matope for typing the draft copy, and to Miss M. Mponda for typing this paper.

REFERENCES CITED

Benson, C. W. and F. W. Benson. 1977. The birds of Malawi. Montfort Press, Limbe, Malawi.

Collar, N. J. and S. N. Stuart. 1985. Threatened birds of Africa and related islands. ICPB/IUCN Red data book. Cambridge, UK.

Clarke, J. 1983. Pages 1-18 *in* Protected areas master plan for Northern Region DNPW. Lilongwe, Malawi.

Dowsett, R. J. 1980. Birds of Nyika Plateau; a working list. Livingstone Museum, Livingstone, Zambia.

Dyer, M. 1987. The distribution, status and breeding success of wattled-cranes *Bugeranus carunculatus*. Pages 1-10 *in* Nyika National Park: report to Malawi government. DNPW, Lilongwe, Zambia.

Dyer, M. 1992. Observations on wattled-cranes nesting on Nyika Plateau, Malawi. Nyala 15(2): 57-62.

Konrad, P. M. 1981. Status and ecology of Wattled Cranes in Africa. Page 260 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world. International Crane Foundation, Baraboo, Wisconsin, USA.

Mclachlan, G. R. and R. Liversidge. 1978. Roberts birds of South Africa, 4th ed. John Voelcker Bird Book Fund, Cape Town, South Africa.

Nhlane, M.E.D. 1991. Wattled crane at Nyika National Park, Malawi. The crane 2(1): 1-4.

Zimmerman, R. P. 1969. Malawi National Park: game census. Department of Forestry and Game, Malawi, page 13.

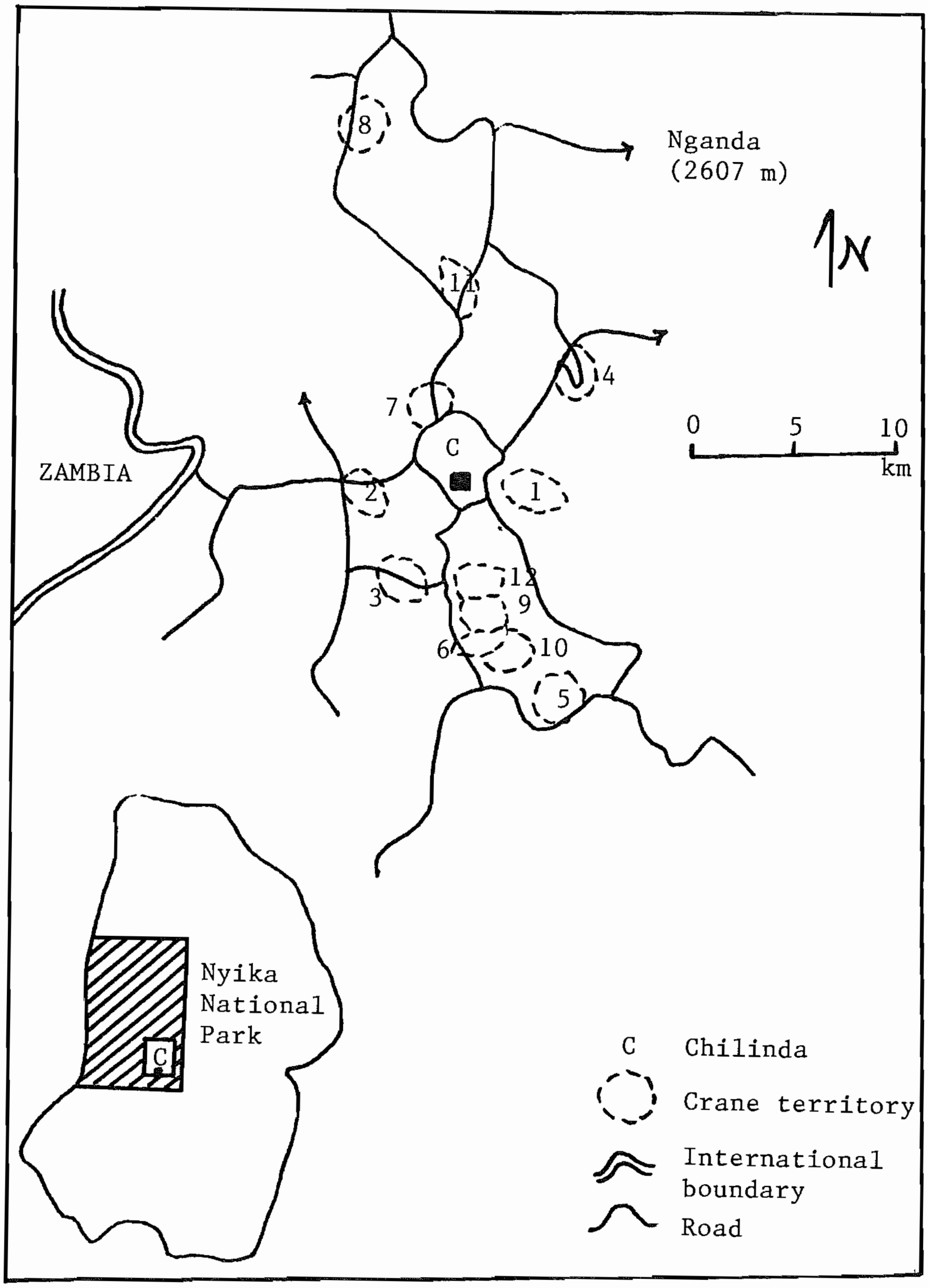

Figure 1. Distribution of Wattled Crane territories on Nyika Plateau, Malawi, February 1985 - March 1987 (from Dyer 1987).

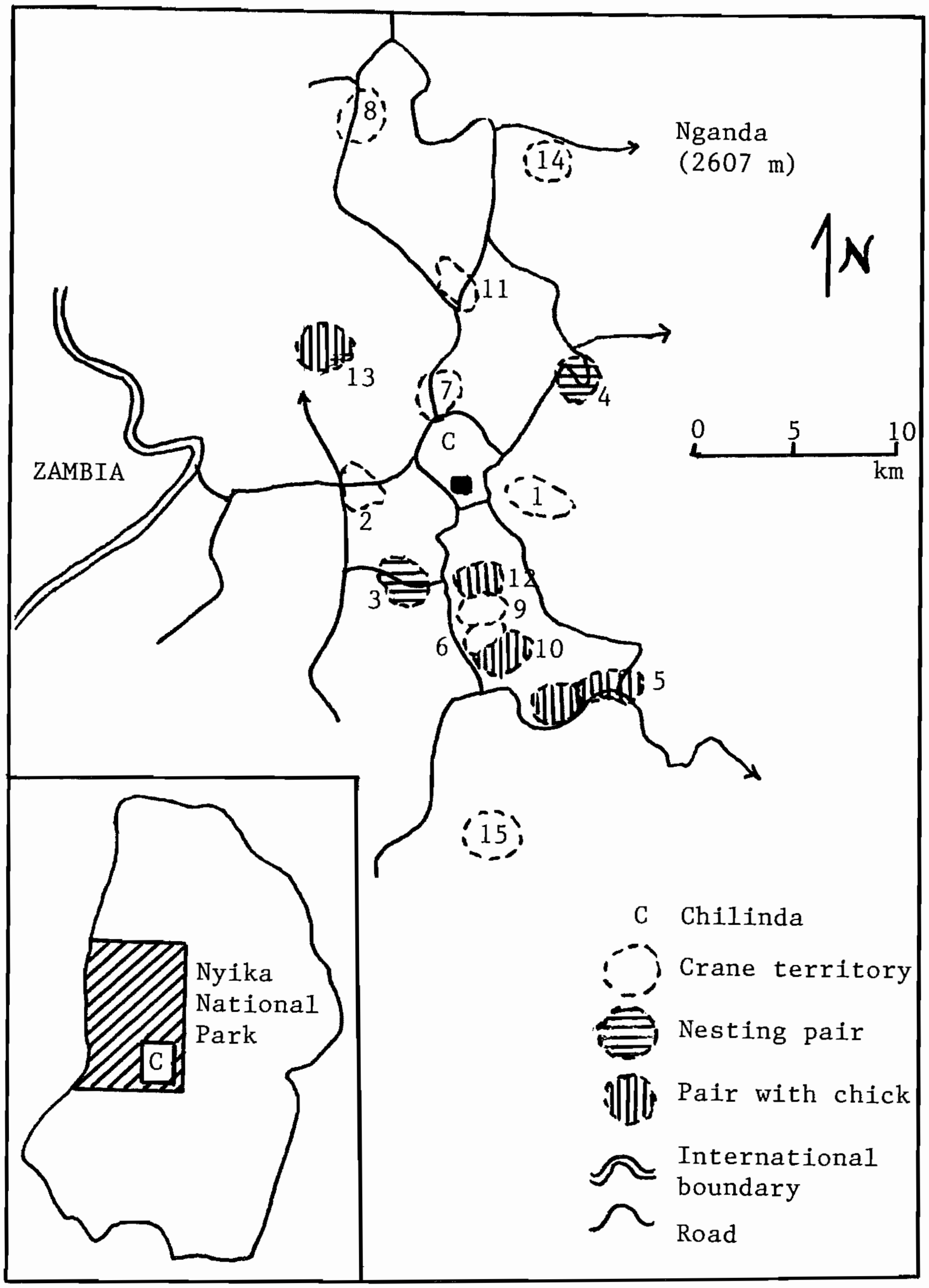

Figure 2. Distribution of Wattled Crane territories on Nyika Plateau, Malawi, January 1990 - December 1991.

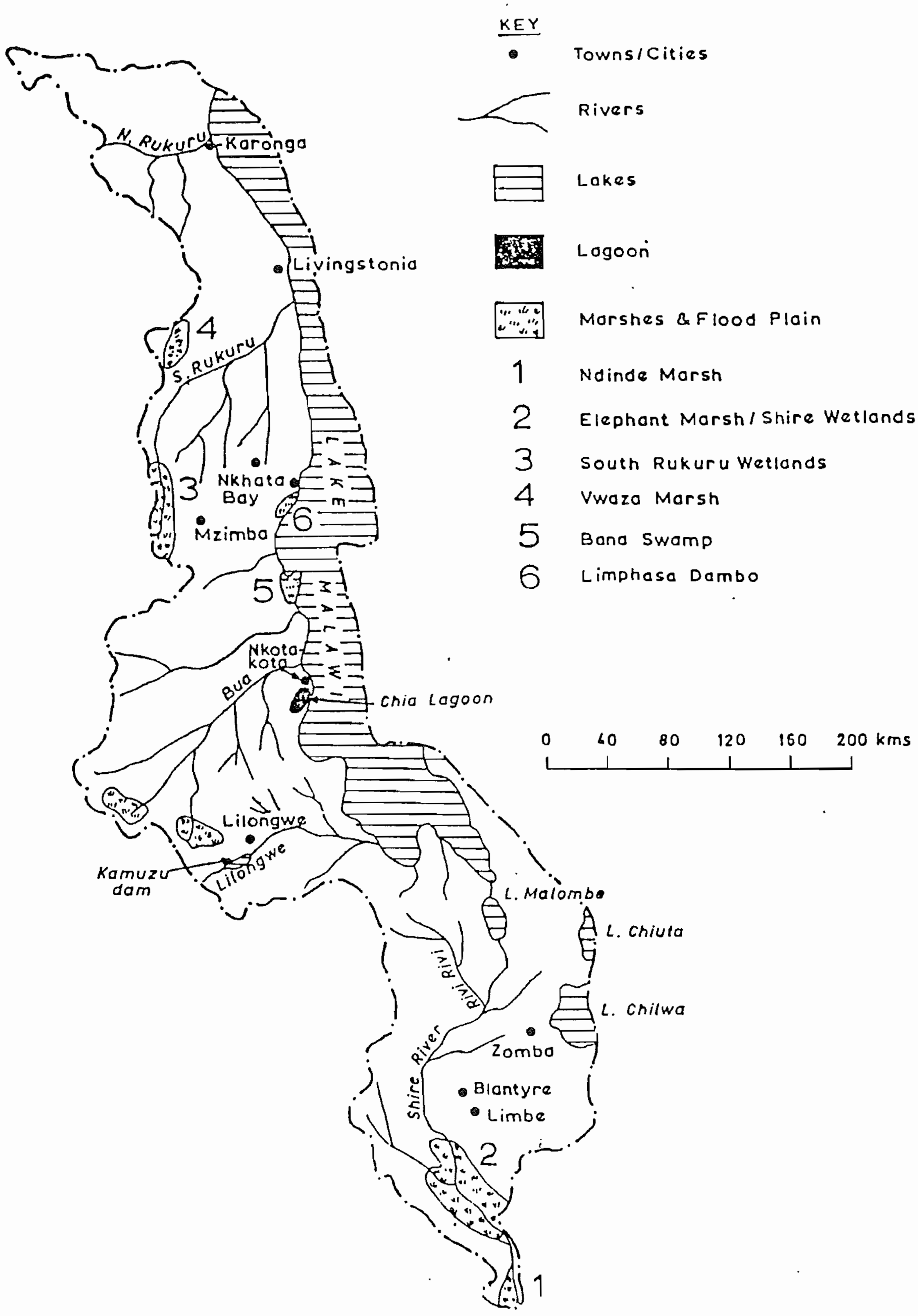

Figure 3. Wetlands of Malawi.

SOME OBSERVATIONS ON THE FEEDING HABITS OF THE WATTLED CRANES IN NYIKA NATIONAL PARK, MALAWI

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ABSTRACT

Observations on Wattled Crane (*Bugeranus carunculatus*) were made from 1989-92. The cranes fed mostly as pairs and also as social groups. Birds fed in their territories and there was indication that they used more than one feeding site. The birds spent about two thirds of the time feeding.

INTRODUCTION

Wattled Cranes (*Bugeranus carunculatus*) depend on wetlands as their natural habitat where they feed and breed. With the increase in the human population of Africa, most of these wetlands are gradually being used for agriculture, including rice cultivation. The destruction of these wetland habitats adversely affects cranes for they are unable to find suitable breeding and feeding areas.

At present the Wattled Crane is one of several birds whose existence is threatened or endangered throughout most of southern Africa (Collar and Stuart 1985). In Malawi the Wattled Crane was once more widespread than it is today. Destruction of possible feeding and breeding sites has resulted largely from population growth and increasing cultivation. The Wattled Crane is now confined to Nyika Plateau and possibly Kasungu National Park (Benson and Benson 1977). During a survey of the Wattled Cranes in Nyika from 1989-92, some observations were made on its feeding habits and habitats. The purpose of this paper is to record some of these observations which were opportunistically recorded as the cranes were encountered during the survey.

STUDY AREA

Nyika Plateau (centered on 33°52'E/10°31'S) falls entirely within Nyika National Park, Northern Malawi, with a small area (c 70 km²) extending westward into Zambia (Dyer 1992). The upper plateau (1,900-2,600 m) is gentle to moderately undulating grasslands, 1,100 km² in area, characterized by numerous shallow, impeded drainage channels (valleys) separated by broad, smoothly-convex interfluves. Small patches of montane evergreen forest occur in many of the valleys, and the valley bottoms, which are frequently waterlogged and boggy, support communities of sedges and tussock grasses.

MATERIALS AND METHODS

Extensive surveys were undertaken from 1989-92. Observations were made both in the rainy and dry seasons. A network of roads on the plateau were driven both morning and afternoon. The feeding habits of some birds were observed. Sighting of the birds was assisted by use of a 10x42 binoculars. The group size was recorded each time cranes were sighted and the activities of birds were recorded at five minute intervals during October 1991 and July 1992 in which the recorded activity was allocated to one of the following: feeding (probing); feeding (pulling); head-up; walking; courting; preening; standing inactive.

RESULTS

Feeding groups

Most observed Wattled Crane feeding groups on Nyika were as pairs (69.2% of 65 observations: Table 1). The largest feeding group of 6 birds was sighted in March during the rainy season.

Feeding habitats

Feeding birds were restricted to their territories on the plateau. Birds fed on the open plateau grasslands and also in the waterlogged valleys. There is some indication that the cranes use more than one feeding territory. One pair was consistently seen in a particular territory only in the late afternoon, but not in the morning. This indicates that in the morning the birds were feeding elsewhere.

Feeding activity and behavior

Feeding birds moved in a forward direction, each time advancing slowly between picking food up from the ground. In both October 1991 and July 1992, feeding was the most frequent activity (41.6% of total time: Table 2). Walking (27.9% of total time), and standing head-up (24.9% of total time) were the next most frequent activities and courtship, preening, and standing (5.6%) were minor activities (Table 2). The differences in activity between years was negligible.

DISCUSSION

The cranes fed mostly in pairs; trios were usually sighted in the wet season and at times up to six birds were recorded together. They fed on the upper grassland and in swampy areas. One pair was observed to feed at different sites in the morning and afternoon. To monitor feeding sites properly it would be necessary to mark the birds with leg bands. While feeding, birds frequently raised up their heads as an alert behavior against any possible danger.

ACKNOWLEDGMENTS

My thanks go to the Principal Curator of Museums of Malawi for supporting this project. I would also like to thank the Chief Parks and Wildlife Officer for allowing me to work in the park and the officer in charge of Nyika National Park for added support.

REFERENCES CITED

Benson, C. M. and F. M. Benson. 1977. The birds of Malawi. Montfort Press, Limbe, Malawi.

Collar, N. J. and S. N. Stuart. 1985. Threatened birds of Africa and related islands: the ICBP/IUCN red data book, part 1. 3rd ed. ICBP and IUCN, Cambridge, UK.

Dyer, M. 1992. Observations on Wattled Cranes nesting on Nyika Plateau, Malawi. Nyala 15(2): 57-62.

Table 1. Social feeding groups of cranes and frequency.

Group size	No. records	Percent
1	5	7.7
2	45	69.2
3	12	18.5
4	1	1.5
6	2	3.1

Table 2. Activities of Wattled Cranes recorded in October 1991 and July 1992.

Activity	October 1991	July 1992	Total
Feeding - probing	75	63	138
Feeding - pulling	26	0	26
Feeding - combined	101	63	164
Feeding - % of total	41.4%	42.0%	41.6%
Head-up	58	40	98
Walking	69	41	110
Courting	1	0	1
Preening	1	6	7
Standing	14	0	14
Non-feeding - combined	143	87	230
Non-feeding - % of total	58.6%	58.0%	58.4%
Total	244	150	394

CRANES IN NAMIBIA

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INTRODUCTION

Namibia is the driest country in southern Africa and has restricted areas of wetlands and grasslands suitable for cranes. The three species of cranes occurring in Namibia have a distribution limited to the north of the country and occupy three distinct habitats: the grasslands of the Etosha Basin; the ephemeral wetlands of the Oshana, Grootfontein, and Bushmanland areas; and the wetlands associated with the permanent river systems of the northeast.

SPECIES ACCOUNTS

Blue Crane (*Anthropoides paradiseus*)

The Namibian population of Blue Cranes is restricted to the grasslands of Etosha National Park and the Andoni flats just to the north of the park in the Oshikoto Region (Figure 1). The habitat of this species is secure as most of the 1,400 km² (Brown 1990) of short grassland falls within the Etosha National Park. Even though the habitat outside the park is suitable for this species there are few records of Blue Cranes on the Andoni flats. Expansion and establishment of a resident population outside the park is unlikely, as the area is a focus for new settlements and cattle posts. Vagrant birds have been recorded in the south of the country at Stampriet and along the Okavango River (Winterbottom 1971), and a pair was recorded from the Nyae-Nyae pans in former Bushmanland (Hines 1989).

The total population of the Etosha Basin is thought to be fewer than 100 birds, and Brown (1990) suggests there is little evidence that the population was ever much larger. The population is thought to be currently stable with little change in numbers over the past ten years (T. Archibald *pers. comm.*). The genetic viability and the relationship of the Etosha population to the South African population warrants further research, especially considering the decline of the South African population in recent years. The degree to which South African birds supplement the Etosha population needs to be determined as this may be crucial to the long term survival of the small Namibian population.

Wattled Crane (*Bugeranus carunculatus*)

Wattled Cranes are widely distributed in the wetland areas of northern Namibia (Figure 1), with several distinct populations present. Resident birds are found within the Mahango Game Reserve/West Caprivi Reserve section of the Okavango River and along the Linyanti River in the Mamili National Park. Total numbers are low with four pairs known to breed in the Mahango Game Reserve in 1992 and about 6-8 pairs recorded in Mamili National Park in 1993 (Grobler *pers. comm.*). This population is thought to move onto the floodplains of the Zambezi, Kwando-Linyanti-Chobe Rivers during high flood periods and is likely to be supplemented by birds from Botswana and Zambia. Breeding takes place in the winter when water levels fluctuate the least and when food availability is at its highest on the floodplains of the northeast. There are unconfirmed reports of Wattled Cranes breeding in the Lake Oponono and Omuramba Owambo areas during years of exceptional rainfall.

There is a distinct seasonal population of Wattled Cranes occurring in northern Namibia. During the wet season (October-April) considerable numbers of Wattled Cranes have been recorded on the ephemeral wetlands of the Bushmanland, Grootfontein, and Oshana regions. Total numbers are hard to assess but up to 95 individuals have been recorded in the Nyae-Nyae area of Bushmanland (von Plato *pers. comm.*) and 62 birds were recorded in March 1992 at Lake Oponono (Cunningham *pers. comm.*). The origins of these birds is not known but it is surmised that the Bushmanland and Grootfontein birds are part of the Okavango Delta and possibly Zambian populations. The birds occurring in the Oshana Region (especially in the Lake Oponono area) are thought to come from the poorly known wetlands of southern Angola. Counts of birds in the Bushmanland area from 1984-90 indicate that about 60% of the population is made up of two adults with a fully fledged juvenile in attendance. These areas of ephemeral wetlands are, therefore, thought to be important post-breeding dispersal areas providing abundant food in a time when the productivity of permanent wetlands (where the birds breed) is at its lowest. The regional movements of Wattled Cranes and the importance of the ephemeral wetlands in the population biology of this species warrant further research.

Threats to the species are difficult to determine. Hunting pressures in the Lake Oponono area are likely to be the greatest threat in the Oshana Region, as is the disturbance by cattle and herders in the same area. Suitable habitat for this species has steadily decreased in the Oshana Region during the recent past through the rapid growth of the human population and there is little hope that this will end. The seasonal habitats of Bushmanland and Grootfontein areas are more secure, with advances in communal resource management programs in Bushmanland securing some sort of conservation status for the Nyae-Nyae pans area. The breeding habitats on the Okavango River and the Linyanti Swamp areas fall within proclaimed conservation areas.

Unseasonal fires set in reed beds and on floodplains are the greatest threat to successful breeding in these areas.

Grey Crowned Crane (*Balearica regulorum*)

The status of the Grey Crowned Crane in Namibia is uncertain. Confirmed records are widely distributed and there are reports of this species from the Okavango River, Grootfontein, and the Chobe River (Winterbottom 1971). Discussions with older members of communities in the Okavango Region indicate that this species was well known along the Okavango River but documented historical records are few (Hines 1987). The Ekuma River mouth area in northern Etosha National Park and the Oshana Region are the only areas where this species has been reliably reported in recent years (Brown 1990).

No birds are resident in Namibia and numbers are generally low (Brown 1990). Breeding has been recorded along the Ekuma River (Brown 1990), but suitable habitat is only sporadically available and it is unlikely that a resident population will become established. Numbers fluctuate between years, with higher numbers in wetter years. The origin of these birds is unknown but it is thought that they are from the extensive wetland systems of southern Angola.

DISCUSSION

Although total numbers of cranes occurring in Namibia are small compared to other southern African populations, the country hosts some important sub-regional populations. Particularly important in this regard is the geographically isolated population of Blue Cranes occurring in the Etosha Basin. This population has been little studied, but warrants considerable investigation with regard to the viability of the population and its genetic characteristics compared to the rapidly declining South African population.

The large ephemeral wetlands of the Oshana, Bushmanland, and Grootfontein areas are utilized seasonally by significant numbers of Wattled Cranes when productive habitats are limited in the permanent wetland systems where they breed. The role of these dispersal areas in breeding success and overall population dynamics of the Okavango, Zambian, and Angolan populations warrants further study.

Threats to the major Namibian crane populations are low, the greatest pressures coming from continued agricultural expansion in the Oshana, Bushmanland, and Okavango areas. Most of the populations are at least partially protected and it is hoped that the Communal Resource Management initiative being developed by the Ministry of Wildlife will address the conservation needs of those populations outside of formal conservation areas.

REFERENCES CITED

Brown, C. J. 1990. The status of cranes in Namibia. Pages 73-78 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Hines, C.J.H. 1987. The birds of eastern Kavango, SWA/Namibia. Journal of the SWA Scientific Society 40: 115-147.

Hines, C.J.H. 1989. Wattled and Blue Cranes in Bushmanland, SWA/Namibia. Unpublished report. Ministry of Wildlife, Conservation and Tourism, Windhoek, Namibia.

Winterbottom, J. M. 1971. A preliminary checklist of the birds of South West Africa. SWA Scientific Society, Windhoek, Namibia.

WETLANDS IN ARID LANDS: VALUES, THREATS, AND CONSERVATION

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ABSTRACT

Arid zone wetlands are poorly known. The structure and functioning of these systems has not been extensively studied. This paper presents Namibian examples illustrating the social, economic and environmental importance of arid zone wetlands. The value of these wetlands is far greater than their size would suggest. Arid zone wetlands are under considerable threat as new developments increase the demand on these systems, especially for water. There is a need to develop an understanding of the structure and functioning of these systems such that management will ensure the sustainable utilization of wetlands so important to regional economies.

INTRODUCTION

The concept of arid zone wetlands is seemingly contradictory, the contradiction being largely a consequence of the poorly known and ill-defined nature of these wetlands. The hydrology, soils, and biota of these systems have not been extensively studied and the lack of knowledge regarding them is well illustrated by the failure of a number of definitions of wetlands to encompass certain types of arid zone wetlands.

The Ramsar Convention (1990), for example, defines wetlands as

> areas of marsh, fen, peatland and water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine waters....

The United States Government (in Mitsch and Gosselink 1986) defines wetlands as

> those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

The United States Government definition is clearly inadequate and does not cover any of the ephemeral wetlands of arid areas which are open evaporate basins, for example Etosha pan. Although Etosha pan is clearly of fluviatile origin (Breen 1991), the Ramsar definition only identifies it as a wetland on the basis of the irregular occurrence of shallow water.

The definition of wetlands given by Cowardin *et al.* (1979) is far more comprehensive than those cited above and identifies wetlands on the basis of excess water, soil development, and the biota of a particular site. The definition encompasses the unusual nature of arid zone wetlands and is given as

> land where an excess of water is the dominant factor determining the nature of soil development and the types of animals and plant communities living at the soil surface. It spans a continuum of environments where terrestrial and aquatic systems intergrade.

This definition is used for the purposes of this study.

Wetlands in arid zones constitute only a small percentage of the landscape; for example, only about four percent of Namibia can be classified as wetland. In relation to wetlands throughout southern Africa, Namibia's wetlands are not considered to be unique in their structure, functioning, and biota. However, the resources they provide in sustaining local economies and communities, and their high environmental values in relation to the general aridity, affords them greater importance than their size would suggest.

This paper reviews the diversity and values of arid zone wetlands using examples from Namibia. The threats to these systems are reviewed and the needs to ensure their sustained functioning are outlined.

ARID ZONE WETLANDS -- DIVERSITY AND VALUES

Namibia has a great diversity of wetland habitats (Figure 1) which vary widely in their hydrological functioning and biota. Wetland habitats in Namibia include: perennial rivers and associated floodplains; intermittently flowing rivers and the linear oases these rivers form; artificial impoundments; the periodically flooded Cuvelai drainage system of Owambo and Etosha, which may be considered an inland delta; ephemeral wetland systems of the northern Kalahari basin; the widely distributed isolated ephemeral pans of the southern Kalahari; estuarine wetlands; and coastal wetlands.

The value of the wetland resources and system attributes is summarized in Table 1. Most of the systems have high values for at least some of the resources and attributes. Wetlands in arid zones are a major cultural influence as they determine grazing patterns of livestock, cropping cycles, and food availability. The very high systems values for permanent wetlands indicate the relative importance of these systems within arid regions, their importance extending well beyond the immediate boundaries of the wetland. The pastoral nomads of the northwest of Namibia are totally dependent on permanent wetland systems as dry season water sources and food for their livestock, a system also found along the major rivers of the Sahel. The importance of wetlands in determining the distribution of human populations in Namibia is marked. Currently about 65% of the country's population lives within or on the boundaries of two wetland systems in the north, the Cuvelai drainage and the Okavango River (Figure 1).

Inland delta systems

In Owambo some 44% of the country's population lives within the Cuvelai drainage system, where a mixed subsistence economy relies on the flood regime to replenish the water table, regenerate grazing land, and provide a protein source of fish. The duration of flooding depends on upper-catchment rainfall in Angola which varies greatly from year to year (van der Waal 1991). Although severely degraded by overgrazing and environmentally insensitive developments (road and canal construction across the main direction of flow) the system still supports a great diversity of biota. Some 47 species of fish and 300 species of birds, including endangered species such as Wattled Cranes (*Bugeranus carunculatus*), occur in the system. The Cuvelai ultimately flows into the Etosha Pan, Namibia's most important tourist attraction.

Careful and well-planned management of the upper and middle drainages of the Cuvelai is necessary to ensure that the important human-related functions in Owambo continue. Wildlife in the Lake Oponono area and Etosha is also dependent on sensitive management as the irregular occurrence of floods allows thousands of flamingoes, pelicans, and other waterbirds to breed and recharges regional aquifers (Cunningham *et al.* 1992). These issues can equally be applied to the Okavango Delta in Botswana.

Perennial river systems

The Kavango (Okavango) River supports the highest density of rural population in Namibia. Some 100,000 people (about 80% of the Kavango population) live within 5 km of the river, and most of these people are dependent, one way or another, on the Kavango river wetlands for water, food, and shelter. Although less dense, the population of the Caprivi is also heavily dependent on the wetland resources of the Zambezi and Kwando-Linyanti-Chobe river systems.

In both regions the primary protein source is fish and the demand for fish is high, providing the economic base for an expanding artisanal fishery. The development of these fisheries depends, however, on the maintenance of systems components which support the fish populations. Important components include the annual flood regime, water quality, seasonally inundated vegetated shallows which provide nursery areas for breeding fish, and upland environmental quality off the floodplain. All these functions are threatened. Impoundments have been proposed on the Kavango River and together with water abstraction on a large scale, impoundments would severely alter flood regimes. As human populations have increased in both Kavango and Caprivi, water quality has decreased through pollution and increased siltation as riverine vegetation and upland sites, cleared for agriculture, have eroded. Heavy grazing of the seasonally inundated floodplain areas during the dry season has reduced the quality of fish breeding sites and this directly affects fish stock recruitment.

With the highest rainfall and high population densities, Kavango and Caprivi are priority areas for agricultural and rural development programs in Namibia. Many development projects, for instance irrigation, aquaculture, and plantation and forestry schemes, are water-based. These schemes, as well as certain veterinary and public health programs, have the potential to directly or indirectly affect the functioning of wetland systems in the region. If the local artisanal fisheries and other wetland resources (e.g., high quality water, reeds for building houses) are to continue to provide an important economic base for the peoples of the region, the continued quality of the river systems will have to be ensured through careful management and planning.

The west-flowing Cunene River is the least important of the perennial northern rivers in terms of supporting local economies, but it has high ecological values as it supports a unique assemblage of biota and has the only true estuarine system in Namibia. The planned construction of the Epupa Dams hydroelectric scheme will directly alter these values. Only through careful environmental assessment and management planning can the effects of the scheme on the ecological values be minimized such that at least some of these values may be retained (e.g., estuarine functioning through compensatory water releases).

The perennial rivers all have their sources outside of Namibia and values can be threatened by actions taken elsewhere. The Orange River wetlands are currently under threat through the construction of the Lesotho Highlands Water Scheme, several hundred kilometers upstream.

Coastal wetlands

The wetlands of the Namib coast comprise extensive mudflats, and shallow marine and limited estuarine habitats. These wetlands have high ecological as well as human-related values. It could be argued that some of the wetlands heavily altered or created by man along the coast (Walvis Bay wetlands and the Swakopmund salt works) have had their value for wildlife enhanced through the creation of a greater variety of habitats. Although a number of these wetlands have been extensively altered by man, they are internationally significant as they provide important feeding and breeding grounds for huge numbers of migratory wading birds and seabirds annually. The wetlands of Walvis Bay, Swakopmund, and Luderitz have national economic importance as they support large exporting marine industries, such as mariculture, salt extraction, and guano production. The appeal of the Walvis Bay lagoon area for water sport enthusiasts and ecotourists (birdwatchers) underlies its importance as a tourist attraction. In these systems human-related demands do not conflict greatly with ecological functions, but it would be good to remember that all human-related activities need not be detrimental to wetlands and their associated wildlife.

Artificial impoundments

Artificial impoundments in Namibia are found only on the intermittently flowing rivers rising in the central region. These impoundments are of great economic importance. Although there is concern that the impoundments have negatively affected downstream groundwater levels, they provide important sources of water for industrial and domestic consumption in an otherwise water-poor region. Ecologically, the systems provide breeding habitat for bird species normally only found breeding at the coast (e.g., pelicans and cormorants), but are generally species poor. These systems have high fisheries and amenity potentials and through careful management such functions should not compromise the ecological values.

Intermittently flowing rivers

The intermittently flowing rivers running through the Namib and Kalahari deserts provide habitats which allow relatively mesic species to intrude deep into the very arid environments of these deserts. These linear oases with their relatively dense vegetation and elevated water tables support the highest levels of biodiversity within otherwise depauperate areas. The perennial rivers of the north provide similar linear connections with the tropics, supporting a number of tropical species found nowhere else in Namibia. The riparian vegetation of the intermittently flowing (and perennial) rivers is the key to the biodiversity of the systems and forms the basis of the diffuse subsistence livestock farming found along the rivers. These values are critically threatened. Excessive groundwater abstraction and upper catchment impoundments negatively affect the vegetation along the intermittently flowing rivers through the lowering of the water table (Ward and Breen 1983). Overgrazing in catchments has altered flood characteristics which has led to excessive scouring of the river beds and the removal of indigenous vegetation which is usually replaced by alien species.

Ephemeral wetlands

The ephemeral wetland systems of northeastern Namibia and the pans of the southern Kalahari are poorly known. Because the "wet" phase of these wetlands is of short duration and of sporadic occurrence, the wetlands have low human-related values as they do not support fish stocks, have low salt-producing capacities, and have poor quality water. Nevertheless, the ecological value of the systems is high. Although the "wet" phase of individual pans is of short duration it is likely that a number of pans in a given area will be sufficiently wet in any one year to allow breeding of certain biota to take place and to provide watering and feeding grounds for other biota. These wetlands may well have been the key to the large scale migration systems of large mammals from the arid regions of southern Africa. Although this phenomenon is now a thing of the past, the wetlands continue to function and their value lies in providing rich feeding and breeding grounds especially for migrant birds. The wetlands of Bushmanland, for example, support large numbers of palearctic waders during the wet season, as well as significant numbers of Wattled Cranes and Slaty Egrets (*Egretta vinaceigula*), both Red Data species in Africa.

Estuaries

The Cunene River mouth is the only true estuarine system in Namibia and is small by comparison to other estuarine systems in the sub-region. It has low human-related values but is of special significance for several rare species. The functioning of the estuary is dependent on the continuous flow of fresh water, currently threatened by the proposed hydroelectric scheme at Epupa Falls.

THREATS

Given the Namibian examples above it is clear that arid zone wetlands have high social, economic, and ecological values. The maintenance of these values is, however, not beyond doubt. To a greater or lesser extent wetland resources and values throughout arid areas are threatened. Threats are related to escalating demands for food, water, and shelter as an ever poorer population expands, in both rural and urban environments. Overexploitation of wetland resources occurs in many cases as these resources are regarded as "free," and the traditional controls regulating their use have fallen away.

Floodplain grazing along perennial rivers is overexploited during the dry season reducing nutrient inputs essential to fish breeding. In northern Nigeria grazing systems have been so altered as demand increased and degradation occurred, that range grazing is no longer practiced. Fodder is cut by hand and livestock penned for the entire dry season. Fisheries are being overexploited as modern harvesting techniques, which are not selective, are used in preference to traditional methods. Water quality is reduced as erosion in catchments is increased through destruction of vegetative cover, both in the riparian zone and upland sites. This also affects fish breeding, reducing fisheries potential, and depressing local economies.

The increasing demand for water and power by the expanding urban populations threaten wetland functions and values in other ways. Groundwater resources are overexploited, causing depression of the water table, in some cases allowing saline water intrusion, and killing riparian vegetation. Impoundments in the upper catchments similarly affect the water table and hence the riparian vegetation. Environmentally insensitive developments have been initiated in the name of progress (canals, roads, and dams) and these have negatively affected wetland functioning in some areas. There are plans to dam rivers to provide hydroelectric power, and this is likely to affect downstream wetland attributes and values.

In a developing country, it would be naive to believe that environmental considerations will take precedence over schemes which will satisfy local demand for food, water, and electricity for many years to come, unless the values of the systems affected are clearly understood and elucidated. Only through a clear understanding of wetland functions and attributes, can management and development be formulated in such a way as to minimize losses in the systems.

NEEDS

Wetlands are recognized in the IUCN's World Conservation Strategy as an "essential life support system" and some of the world's most valuable and vulnerable wetlands are found in the arid and semi-arid regions of the world.

In order to manage and conserve arid zone wetlands effectively, a number of actions are needed.

1. Determine the hydrological parameters determining wetland functioning in arid zones such that off-site developments do not compromise wetland values.

2. Inventory arid zone wetlands, detailing their type, extent, distribution, and biota.

3. Determine the use of wetland systems and what the problems are associated with usage practices. This would require careful assessment of wetland resource values and attributes and hence, the economic potentials of these areas, their value for wildlife, and how these uses can be maximized without necessarily compromising one or another potential. The multi-functional nature of wetlands makes them extremely productive in multi-use subsistence economies. Cropping, livestock herding, and fisheries may have limited yields but as facets of subsistence economies they are of considerable importance (Drijver and Marchand 1985). Financial margins of profit are very often higher in these multi-use systems than in modern agricultural developments. Development agencies would do well to supplement and support traditional agriculture rather than promoting modern agricultural practices, which cause changes in cultural limits on resource exploitation.

4. Emphasize the importance of wetlands to their primary users and that wetland functions are inextricably linked to utilization patterns and processes. Fisheries and water quality, for example, require good floodplain management (fish breeding is dependent on vegetative cover which also acts as a sediment trap improving water quality). The work of Barbier *et al.* (1991) on the resource economy of the Hadejia-Nguru wetlands of Nigeria illustrates well the interlinked nature of the natural resources and the regional economies.

5. Emphasize the amenity value of wetlands especially for tourism development in arid countries. Botswana's third largest foreign exchange earner is wetland-based tourism and Namibia has a far greater dependence on wetlands for tourism than may be apparent. Major tourist attractions in Namibia are all areas with their attraction centered on or dependent on their constituent wetland systems, including Etosha National Park, Popa Falls and the Mahongo Game Reserve, Mamili and Mudumu National Parks, and the Namib-Naukluft Park, which includes Sossus Vlei, Sandwich Harbour, the Naukluft rivers, and the Kuiseb river.

6. Ensure that wetland system attributes, functions, uses, and conservation are adequately covered in legislation. Legislation must give recognition to the social, economic, and ecological values of wetlands such that essential processes are maintained.

Arid zone countries cannot afford to view themselves in isolation and be complacent about local achievements in wetland management and conservation. For example, wetland systems of greatest importance in Namibia lie along the borders of the country. All of these systems are either a shared resource and/or have their origins in neighboring countries. There is a definite need in this case to enter agreements to ensure sustainable wetland management on a regional basis.

Nations in the arid zone should also be made aware of the international importance of their wetlands and the obligation that this places on them to conserve them. For example, the coastal and ephemeral wetlands of Namibia provide important wintering grounds and breeding habitat to thousands of Palearctic and inter-African migrant birds. Namibia is only a seasonal custodian of these resources; Namibia's obligation to the rest of the world is to provide adequate habitat for them while they are in the country. The wetlands of Namibia are also significant in that they support the major proportion of certain species populations. For example, about 60% of the southern African populations of Chestnut-banded Plovers (*Charadrius pallidus*) and Black-necked Grebes (*Podiceps nigricollis*) occur along the coast of Namibia; Wattled Cranes and Slaty Egrets, both listed as endangered in Africa, have sizable seasonal populations within Namibia.

Arid zone countries have an obligation to the world to maintain and conserve the rich biodiversity of their wetlands such that losses are minimized. By the same token developed countries should be made aware of the costs to local economies of conservation efforts. Arid zone countries are generally poor and there is a need to develop adequate support programs such that the burden of conservation of wetlands is spread equitably.

REFERENCES CITED

Barbier, E. B., W. M. Adams, and K. Kinnage. 1991. Economic valuation of wetland benefits: The Hadejia-Jama'are floodplain, Nigeria. Draft Report. International Institute for Environment and Development, London, UK.

Breen, C. M. 1991. Are intermittently flooded wetlands of arid environments important conservation sites? Madoqua 17(2): 61-65.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. Laroc. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. United States Fish and Wildlife Service, Biological Services Program, Washington, D. C., USA.

Cunningham, A. B., D. Hubbard, J. Kinahan, E. Kreike, A. Marsh, M. Seely, and V. Stuart-Williams. 1992. Oshanas: Sustaining people, environment and development in central Owambo, Namibia. Desert Research Foundation of Namibia, Windhoek, Namibia.

Drijver, C. A. and M. Marchand. 1985. Taming the floods: Environmental aspects of floodplain development in Africa. Centre of Environmental Studies, Leiden, The Netherlands.

Mitsch, L. J. and J. G. Gosselink. 1986. Wetlands. Van Nostrand Reinhold Co., New York, USA.

Ramsar Convention. 1990. Proceedings of the fourth meeting of the Conference of Contracting Parties. Volume 1, p. 150. Gland, Switzerland.

Van der Waal, B.C.W. 1991. Fish life of the Oshana delta in Owambo, Namibia, and the translocation of Cunene species. Madoqua 17(2): 201-209.

Table 1. A subjective evaluation of resource and system attribute values for Namibian wetland systems (based on criteria outlined in Mitsch and Gosselink 1986).

Criteria	Inland delta	Perennial rivers	Coastal wetlands	Artificial impoundments	Intermittent rivers	Ephemeral wetlands	Estuaries
RESOURCES							
Water	High	High	None	High	High	Low	Low
Soil	Low	High	None	Low	Low	Low	None
Salt	None	None	High	None	None	Moderate	None
Animals	Low	High	High	Moderate	High	Moderate	Moderate
Plants	Moderate	High	Low	Low	High	Low	Low
Endangered Species	Low	Moderate	High	Low	Moderate	Moderate	High
Food	High	High	High	High	Low	Low	High
Construction Materials	Low	High	None	Low	High	None	None
ATTRIBUTES							
Flood Attenuation	Low	High	Moderate	High	Low	None	None
Aquifer Recharge	High	Moderate	None	Moderate	High	High	None
Water Modifier	High	High	None	Moderate	Low	Low	None
Aesthetics	High	High	High	High	High	High	High
Social and Amenity Value	Moderate	High	High	High	Moderate	High	Moderate

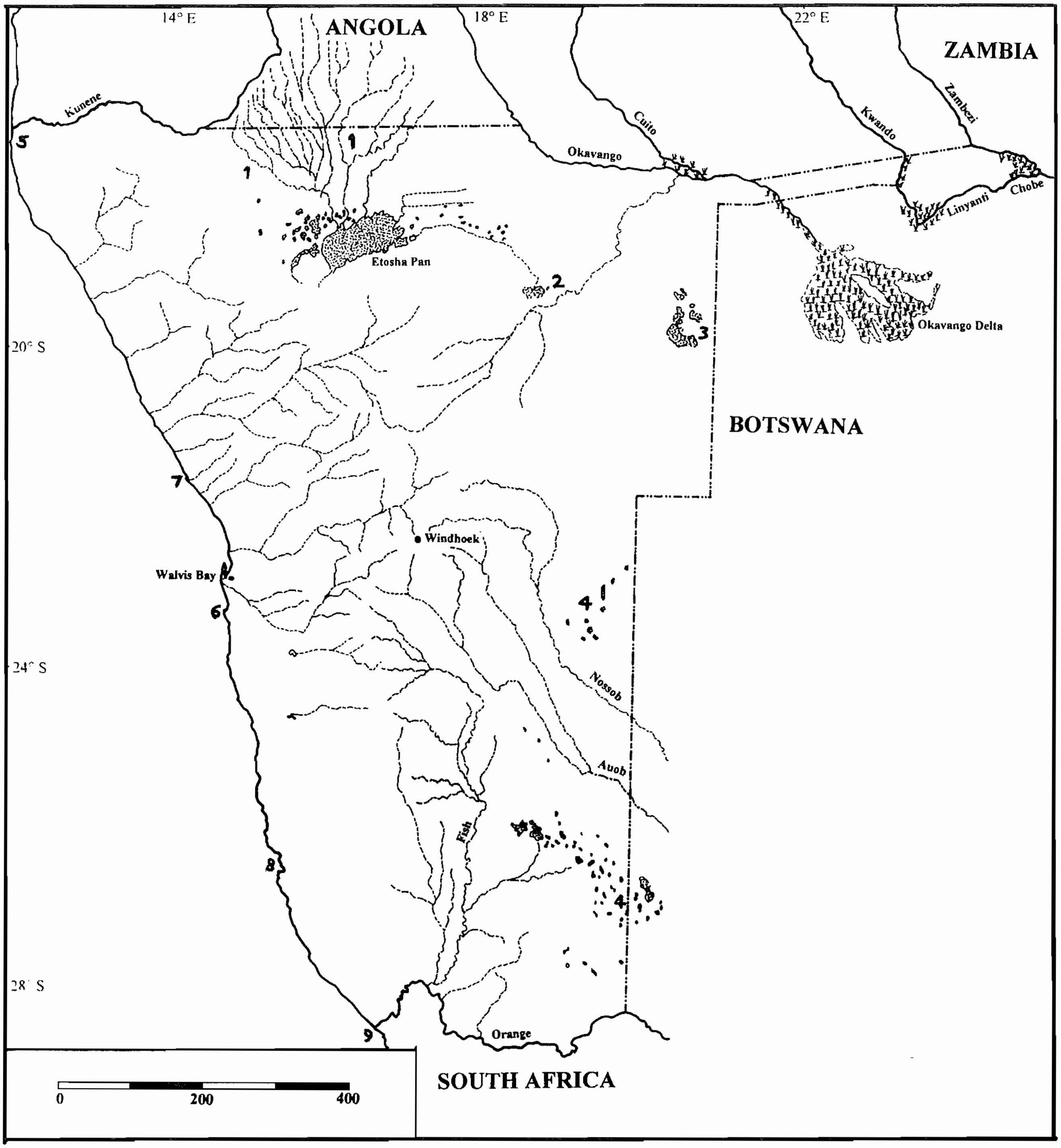

Figure 1. Map showing the distribution of the major wetland systems in Namibia. Perennial rivers ( ) and their associate floodplains ( ) are named (e.g., Okavango). Intermittently flowing rivers ( ) tend to be west flowing, but some such as the Fish, Auob, and Nossob Rivers are a feature of the east and south. The Cuvelai drainage system (1) of Owambo and Etosha Pan is an inland delta. Extensive ephemeral wetland systems are found in the northern Kalahari in the Grootfontein district (2) and Bushmanland (3). Ephemeral systems are more diffuse in the southern Kalahari (4). Estuarine wetlands are only found at the mouth of the Kunene River (5). Coastal wetlands are widely distributed along the coast, with Walvis Bay, Sandwich Harbour (6), Cape Cross (7), Luderitz (8), and the Orange River mouth (9) concentrated in the upper catchments of intermittently flowing rivers in the vicinity of Windhoek.

WATTLED CRANES IN BOTSWANA: THEIR STATUS AND NEEDS FOR CONSERVATION

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ABSTRACT

The population of Wattled Cranes (*Bugeranus carunculatus*) in Botswana is considered viable. The species is, however, rare. Possible causes of this status in Botswana are not well established and require scientific inquiry. Apart from managing Wattled Cranes as a protected species, further conservation efforts would require gaining an insight into the ecology of the species in its major habitats in Botswana with the view to secure prime habitats. Conservation of the species would also require the development of environmentally-sound water use practices in order to avoid desiccation of ecologically important sites for Wattled Cranes. Involvement of the local communities in programs that are aimed at enhancing the survival of Wattled Cranes is recommended because this is likely to generate the desired good will and support from the public for sustained Wattled Crane management.

INTRODUCTION

Northern Botswana in general, and in particular the 15,000 km^2 Okavango Delta, Makgadikgadi Pans (13,000 km^2), Savuti Marshes and wetlands around Lakes Ngami and Chobe, and the Linyanti, Khwai, and Boteti Rivers constitute habitats of major importance to Wattled Cranes in Botswana (Urban 1988) (Figure 1). The total number of Wattled Cranes found in Botswana is, however, not clearly established. About 100-200 resident breeding pairs are estimated to occur in the Okavango Delta, and 1,000-3,000 non-breeding birds visit the delta and its associated wetlands around February to March (Urban 1988).

Several hundred to 2,000 non-breeding Wattled Cranes are reported to flock and molt in the Makgadikgadi Pans during the wet season from January to May (Collar and Stuart 1985). Together, the delta system and Makgadikgadi Pans support an estimated 3,000 Wattled Cranes of which 700-1,000 are resident. Thus Botswana possibly supports the second largest population of the species, after the Kafue Flats population in Zambia.

ECOLOGY

Although Bousfield (1987) describes the Wattled Crane population in Botswana as viable and reproducing it is listed as a protected and rare species by the Department of Wildlife and National Parks (DWNP). Up to the 1960s Wattled Cranes bred both in the Makgadikgadi Pans and the Okavango Delta; more recently though, they have stopped breeding in the Makgadikgadi Pans and there have been fewer breeding pairs in the Okavango Delta (Bousfield 1987). Reasons behind this reduced breeding status of the species are uncertain. Human disturbances in the form of livestock grazing, collection of eggs, hunting, annual grass fires, water development projects, and extended droughts are among the factors thought to affect the breeding of Wattled Cranes (Bousfield 1987). The tsetse-fly control program is also suspected to have negative effects on the survival of Wattled Cranes, particularly in the Okavango area.

Not only are the reasons unclear as to why the Wattled Cranes have stopped breeding in the Makgadikgadi Pans, but the origin of the flocks coming to the pans and delta wetlands are also not well established. The significance of the breeding and non-breeding habitats for Wattled Cranes in Botswana is only vaguely understood. Since Wattled Cranes are threatened in most of their habitats in Africa (Konrad 1981; Collar and Stuart 1985; Urban 1988), more conservation-oriented efforts need to be applied to complement the already existing strategies in order to firmly secure the species in Botswana.

RESEARCH

Scientific inquiry about the numbers and distribution of Wattled Cranes in Botswana and their life history and breeding is necessary to gain an understanding about the status of the species in the country. This knowledge is needed now more than ever before, given the present trends in human populations and natural resources development and utilization programs in and around the major wetlands.

Nobody knows the origin of the flocks of Wattled Cranes visiting Botswana though they are popularly speculated to come from Zambia. The actual destination of these periodic visitors, as well as their habitat requirements, use, and availability, needs to be ascertained to facilitate adequate management of their prime habitats. Currently some of the known habitats for Wattled Cranes are outside the protected area system and thus vulnerable to destruction and loss.

WATER FLOOD MANAGEMENT

Apparently Wattled Cranes are highly water dependent and their breeding ecology in the Okavango Delta is influenced by the water flood regime. This interdependency should be studied with the goal of helping to guide water management in the delta in order to avoid loss of critical habitats for the cranes. Controversies surrounding many proposed water development projects and natural resources programs would be minimized if such knowledge existed.

PUBLIC INVOLVEMENT

Successful management of Wattled Cranes, especially in wetlands located outside the protected area system, will certainly require the positive awareness, good will, and support of the public in general, and of the neighboring local communities in particular. As the latter have been associated with wetlands for a long time, it is unrealistic to assume they would easily compromise certain wetland values, particularly the tangible ones, in favor of cranes. Consequently the conservation of Wattled Cranes should take into account the socio-economic fabric of the neighboring local communities with the intent of integrating conservation requirements in a manner that sustains both the ecology of cranes in the area and the direct tangible benefits the local communities expect to receive from the wetlands.

CONCLUSION

Not much is known about the ecology of Wattled Cranes in Botswana. This state of affairs is likely to negatively affect the conservation of the species in the long run. Much more effort is thus required to supplement existing protection measures in order to secure the species in its major habitats. Such efforts should include research, water management in the delta, and the involvement of local communities.

REFERENCES CITED

Bousfield, R. 1987. The Okavango Delta: a precious balance. Unpubl. MS.

Collar, H. J. and S. N. Stuart. 1985. Threatened birds of Africa and related islands: the ICBP/IUCN red data book, 3rd ed. Part I. ICBP and IUCN, Cambridge, UK.

Konrad, P. M. 1981. Status and ecology of Wattled Crane in Africa. Pages 220-237 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world. International Crane Foundation, Baraboo, Wisconsin, USA.

Urban, E. K. 1988. Status of cranes in Africa. Pages 315-329 *in* G. C. Backhurst, ed., Proceedings of the Sixth Pan-African Ornithological Congress. Nairobi, Kenya.

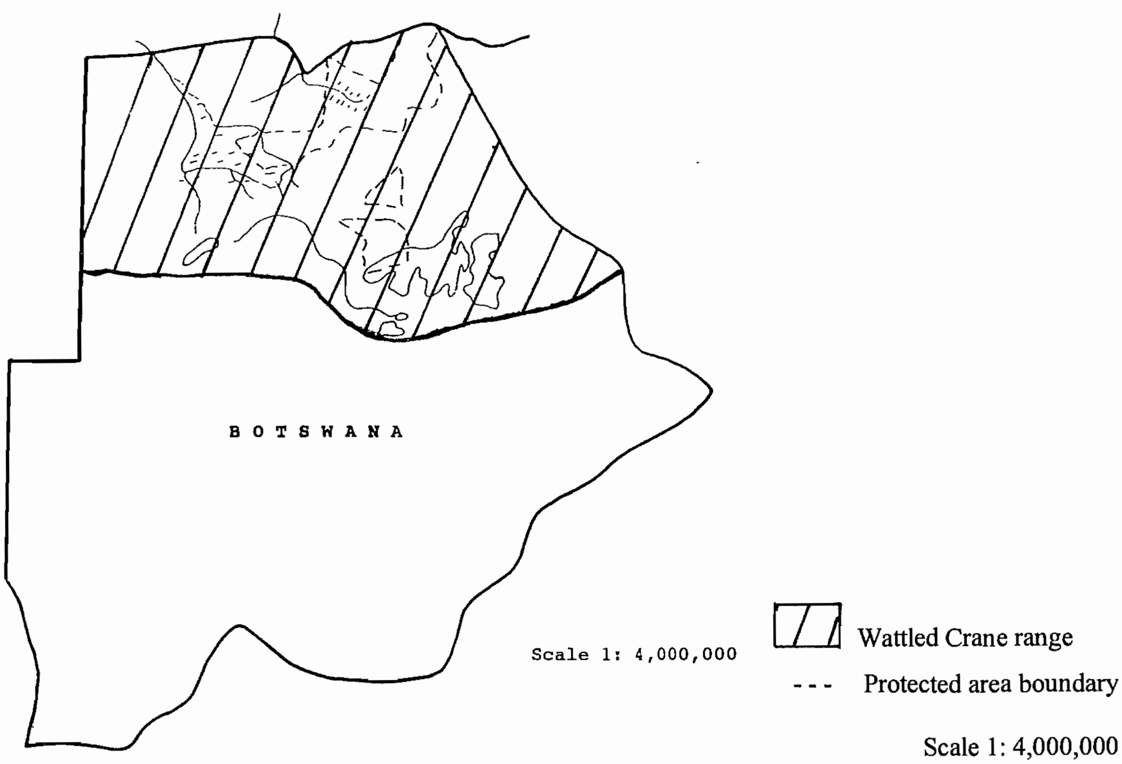

Figure 1. Area of known occurrence of Wattled Cranes in Botswana.

AERIAL SURVEY OF THE DISTRIBUTION OF WATTLED CRANES AND SADDLEBILLED STORKS IN THE OKAVANGO DELTA, BOTSWANA[1]

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ABSTRACT

An aerial survey was conducted over the Okavango Delta, Botswana from 16-17 August 1993 to inventory the distribution and numbers of Wattled Cranes (*Bugeranus carunculatus*) and Saddlebilled Storks (*Epippiorhynchus senegalensis*). Aerial line transects were established using a fixed-wing light aircraft and traversed at a speed of 120 knots at 250 m above ground level. Seven hundred and seventy-eight (778) Wattled Cranes and 286 Saddlebilled Storks were estimated to occur in the area in mid-August. There were neither Wattled Cranes nor Saddlebilled Storks immediately east of Chief's Island, a striking observation underlining the need for further study. Isolated pairs, some with nests and others with juveniles, as well as flocks of both species were confined to the Boro River area north of the Buffalo Fence and southeast of Chief's Island.

INTRODUCTION

The need to establish the precise status of Wattled Cranes (*Bugeranus carunculatus*) in the Okavango Delta, Botswana was strongly emphasized during the first African Crane and Wetland Training Workshop held 9-15 August 1993 at the Wildlife Training Institute, Maun, Botswana.

Until this time most of the available information about the numbers and distribution of Wattled Cranes was based on limited and generally opportunistically collected field evidence. It could therefore be possible that even the most widely publicized estimate of 1,000-3,000 Wattled Cranes in the Delta (Collar and Stuart 1985; Urban 1988) could be incorrect.

This aerial survey was undertaken from the 16-17 August 1993 with the view to gain an informed picture on the occurrence and numbers of Wattled Cranes in the Okavango Delta to help address some of the concerns regarding the management and conservation status of this species in its range.

This opportunity was used to also count the Saddlebilled Stork, a tropical African bird protected in Botswana.

SURVEY AREA

The survey was carried out on wetlands occurring in and around Moremi Wildlife Reserve (Figure 1). The surveyed area lies between longitudes 18°45-20°00′S and latitudes 22°15′-24°00′E. This constitutes an area of 7,815 km², or 49.3% of the 15,846 km² Okavango Delta system.

A mosaic of wetlands and drylands supporting perennial and seasonal swamps, grasslands, intermittently flooded lands, forested woodlands, and shrublands covered the area. Apart from Wattled Cranes and Saddlebilled Storks, the Okavango Delta offers magnificent scenery, game viewing, and birdwatching. It is however a nutrient-low productivity (oligotrophic) system with small local patches of higher production and high diversity of macro- and micro-invertebrates (Scudder *et al.* 1992).

The climate in the Okavango changes as one moves from north to south. It is generally more humid and cooler in the north where average annual rainfall is up to 1,300 mm/year. The warmer and drier south receives an average annual rainfall of 400 m. Rainfall occurs mainly from October to April in the north. The south receives rainfall mainly from November to April.

Annual average temperatures vary from 19° C in the north to 23° C in the south. The warmest period is generally between October-June when maximum monthly temperatures range between 22° C to 24° C while June to August are the coolest months with mean monthly temperatures in the range of 15-17° C. Daily maximum temperatures may range between 30-32° C and minimums are of the order of 3-8° C. Thus daily temperature variations of up to 20° C are not surprising in the area.

METHODS

The survey area was systematically covered using a fixed wing aircraft by flying northwest to southeast along straight transects established 1.5 km apart at a speed of 120 knots and 250 m above ground level.

[1]Addendum to the Proceedings. Paper submitted 31 August 1994.

Two observers, one behind the pilot and another to the right of the pilot, counted individuals, flocks, and nests of Wattled Cranes and Saddlebilled Storks along the transects. Although there were no restrictions on the distance from the transects within which to include sighted birds in the count, the sizes of Wattled Cranes and Saddlebilled Storks at 250 m elevation were small enough to preclude double counting. In general, the vegetation structure in the survey area made it difficult to detect and count either bird when located more than 500 m away from the transect.

RESULTS AND DISCUSSION

The numbers of birds recorded are shown on Table 1. These extrapolate to 778 Wattled Crane and 286 Saddlebilled Storks for the entire Okavango Delta as of mid August 1993. The accuracy of the estimate cannot be assessed because of the method used to collect data and the vegetation type in the survey area.

If the occurrence of nests, nesting birds, and adults in pairs or threes can be used as an indicator of breeding sites, breeding pairs, and breeding status of a bird species (Howard 1969; Konrad 1981), then the population of Wattled Crane was composed of 28.7% residents. Only 3.1% residents had nests, and 4.1% had either young chicks or juveniles (Table 2). The remaining 92.8% of the resident population had neither chicks nor nests. Unless future studies confirm that August is not the peak breeding season these statistics could indicate a low breeding status in the Wattled Crane population. It is a worrisome observation because there are speculations that the continuing tsetse-fly spraying program has affected negatively, the breeding success of Wattled Crane (Bousfield 1987).

Migratory flocks, some made up of 50-70 individuals, accounted for 71.3% of the Wattled Crane population (Table 3). Wattled Cranes are known to visit the Okavango Delta during wet winters (January to May) (Collar and Stuart 1984; Urban 1988). Seeing flocks during this time of the survey suggests that in some years migratory flocks overstay in the area. What determines the duration of the migrating flocks in the area could constitute an interesting theme of a future study. Such a study could also possibly explain why the flocks of Wattled Cranes observed in the area were confined in their distribution to the Boro River region north of the Buffalo fence and to the southwest of the Chief's Island.

The vast majority (89.3%) of the population of Saddlebilled Storks was resident (Table 2). Close to half (49.6%) of the resident individuals were in pairs or in threes whereas the remaining (or 48.2% of the population) were solitary. However only 20.7% of the paired residents had juveniles, none had young chicks or were on nests. Also 2.9% of the solitary individuals were on nests. These observations are suggestive of one or both of the following possibilities, first that August may not be the peak time for breeding in Saddlebilled Storks, it is possible that breeding was just beginning. Secondly the observation could be reflective of low breeding success in the species. These observations serve to emphasize the need for an investigation on the breeding biology of major avifaunal species in the Okavango in order to verify speculations regarding effects of insecticides used in the tsetse control program on the survival of some birds (Bousfield 1987). Presence of a mere 10.6% of migratory flocks in the population of Saddlebilled Storks is due to the fact that this species is largely solitary or in pairs (Table 3). Unlike Wattled Cranes, flocks of Saddlebilled Storks were much smaller, all consisting of 4-6 individuals.

Obviously this data is inadequate to give conclusive scientific opinion on the breeding status of the two species. For example Bousfield (1987) observed that in 1960s Wattled Cranes bred both in the Makgadikgadi Pans and Okavango Delta. Recently, Wattled Cranes seem to maintain few breeding sites only in the Okavango Delta. During this survey neither Wattled Cranes nor Saddlebilled Storks were sighted to the east of Chief's Island. The observation could suggest an alarming situation because half of the population of Wattled Cranes (50.7%) and Saddlebilled Storks (51.8%) are found outside Moremi Wildlife Reserve (Table 4; Figure 1; Figure 2) where human interventions in the form of habitat destruction, livestock grazing, annual grass burning, water development, and collection of eggs are unabated (Bousfield 1987).

CONCLUSION

The status of Wattled Cranes in the Okavango is of particular concern in so far as the management and conservation of this species in its range is concerned. Although this pilot survey could not produce a complete picture of the status of Wattled Cranes and Saddlebilled Storks, it has helped to underline the need for further surveys to supplement efforts being made by the Government of Botswana to protect the avifauna of the country.

ACKNOWLEDGMENTS

The aerial survey was organized and financed by Dr. George Archibald, Director of the International Crane Foundation. Bashir Garba, Secretary of the Black Crowned Crane Coordinating Center, Nigeria, also participated in the surveys. Mr. E. Molelekwa typed the draft. All deeply acknowledged.

REFERENCES

Bousfield, R. 1987. The Okavango Delta: A precious balance. Unpubl. MS.

Collar, N. J. and S. N. Stuart. 1985. Threatened birds of

Africa and related islands: the ICBP/IUCN red data book, part I. ICBP and IUCN, Cambridge, UK.

Howard, G. W. 1989. Recent counts of Wattled Cranes *Bugeranus carunculatus* on the Kafue Flats, Zambia, November 1987. Scopus 12: 69-72.

Konrad, P. M. 1981. Status and ecology of Wattled Cranes in Africa. Pages 220-237 *in* J. C. Lewis and H. Masatomi, eds. Crane research around the world. International Crane Foundation, Baraboo, Wisconsin, USA.

Scudder, T., R. E. Manley, R. W. Coley, R. K. Davis, J. Green, G. W. Howard, S. W. Lawry, D. Martz, P. P. Rogers, A. R. D. Taylor, S. D. Turner, G. F. White, and E. P. White. 1993. The IUCN review of the Southern Okavango Integrated Water Development Project. IUCN, Gland, Switzerland.

Urban, E. K. 1988. Status of cranes in Africa. Pages 315-329 *in* G. C. Backhurst, ed., Proceedings of the Sixth Pan-African Ornithological Congress. Nairobi, Kenya.

Table 1. Adults, chicks, total individuals, and nests of Wattled Crane and Saddlebilled Storks counted during the survey.

Species	Adults	Chicks	Total	Nests
Wattled Crane	384	2	386	8
Saddlebilled Stork	141	0	141	2

Table 2. Resident population structure as a percentage of the total surveyed population of Wattled Cranes (n=384) and Saddlebilled Storks (n=141), where N1 = percentage of solitary individuals and N2 = percentage of pairs.

	Individuals			Pairs				Total
Species	N_1	Nest	Chick	N_2	Nest	Chick	Juvenile	N_1+N_2
Wattled Crane	4.2	1.0	0	24.5	2.1	1.0	3.1	28.7
Saddlebilled Stork	48.2	1.4	0	41.1	0	0	8.5	89.3

Table 3. Migratory flock size as a percentage of the total surveyed population of Wattled Cranes (n=384) and Saddlebilled Storks (n=141).

Species	4-6	7-9	≥10	Total
Wattled Crane	9.6	6.3	55.4	71.3
Saddlebilled Stork	10.6	0	0	10.6

Table 4. Percentage sighting of Wattled Cranes (n=384) and Saddlebilled Stork (n=141) within and outside Moremi Wildlife Reserve (WR).

Species	Within Moremi WR	Outside Moremi WR
Wattled Crane	49.3	50.7
Saddlebilled Stork	48.2	51.8

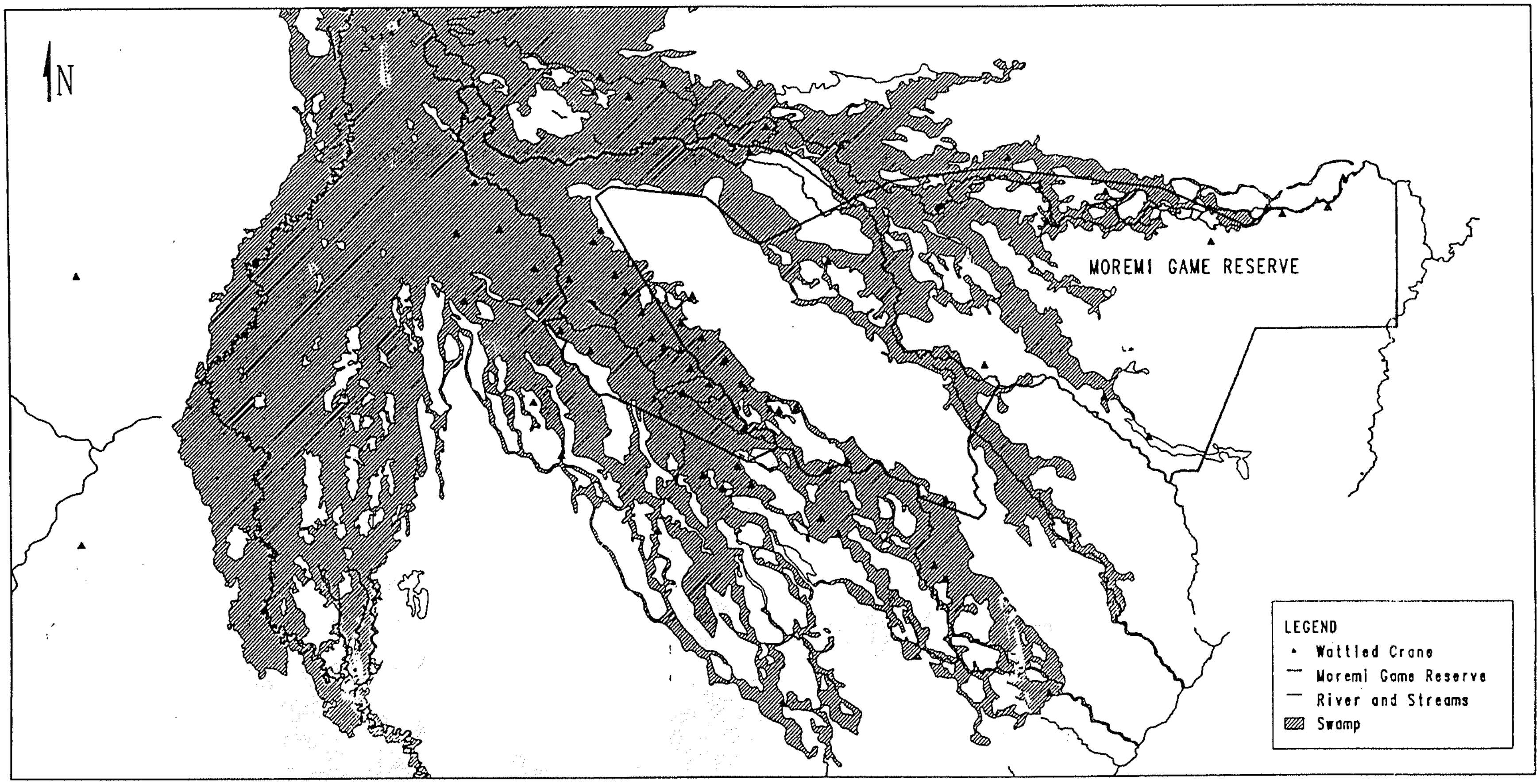

Figure 1. Distribution of Wattled Cranes in the Okavango Delta (from aerial surveys conducted 16-17 August 1993).

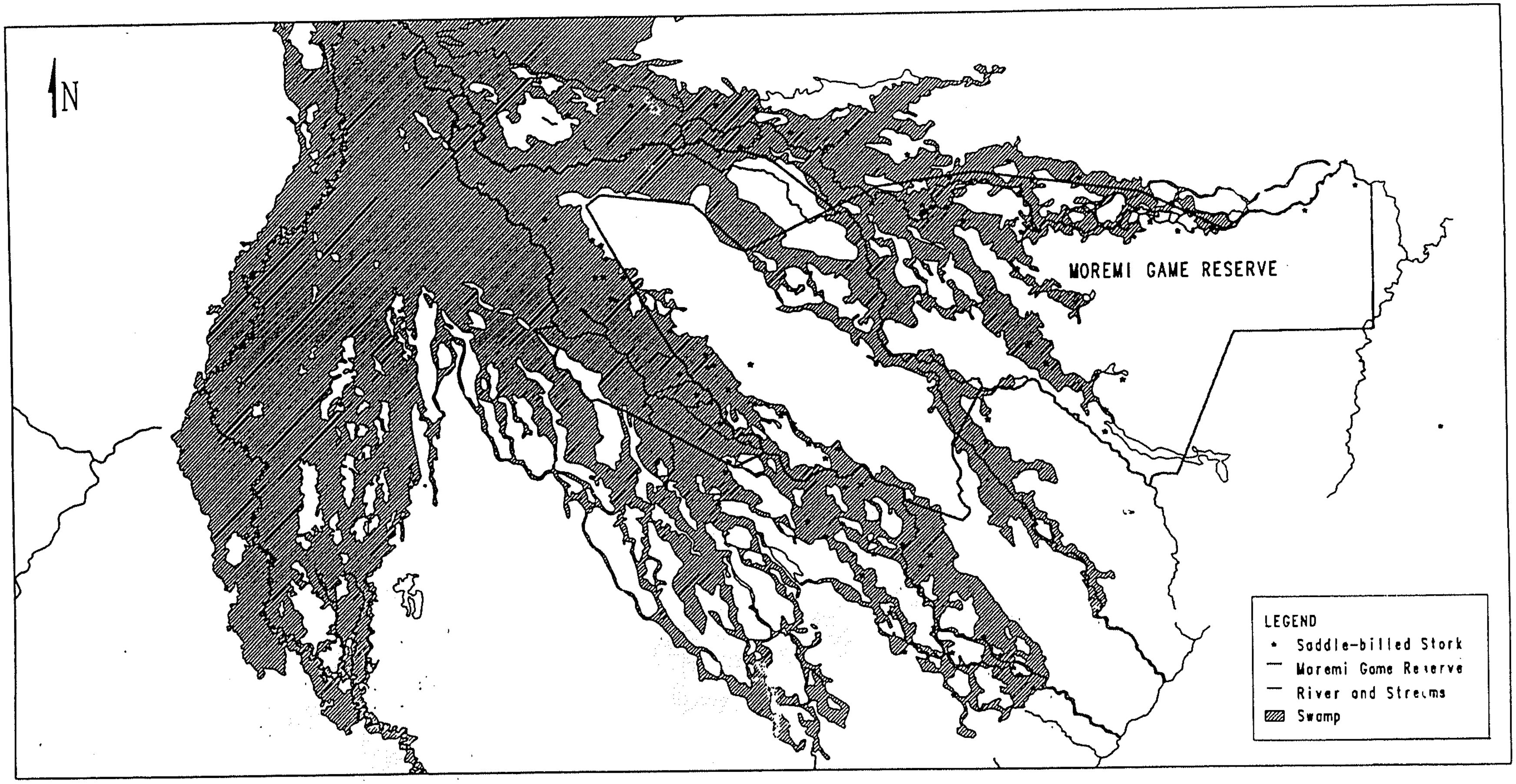

Figure 2. Distribution of Saddlebilled Storks in the Okavango Delta (from aerial surveys conducted 16-17 August 1993).

WETLAND DYNAMICS AND CONSERVATION: IDENTIFYING KEY FACTORS IN THE OKAVANGO DELTA, BOTSWANA

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ABSTRACT

The importance of considering ecosystem processes and dynamics for planning sustainable resource use and conservation is outlined. In the Okavango Delta large scale changes in the distribution of water take place over timespans of decades to centuries. These changes are partly the result of sediment introduction into channels in the upstream areas, and partly the result of neotectonic activity. Change promotes the maintenance of a mosaic of habitats in different stages of wetting and drying, and with different inherent fertility statuses, creating a mosaic with varying suitability for wildlife utilization. It also enables regeneration of surface soils on islands of the Okavango Delta, which are prone to salinization in areas which are flooded for extended periods. The disruption of this sediment supply by construction of impoundments anywhere in the catchment would have immediate negative impacts on the ecosystem as a whole. Principles that need to be considered for water abstraction, as well as for conservation planning are outlined.

INTRODUCTION

Conservation has witnessed a noticeable shift in emphasis in recent decades, from conservation of species to habitats, and even more recently to ecosystems and landscapes. At the broader scales, the biological consequences of habitat, ecosystem, or landscape degradation and fragmentation have been considered from a biogeographical perspective, with an emphasis on species loss (Wilcox 1986; Wilcox and Murphy 1985; Wilcove *et al.* 1986). A number of authors have recognized that maintaining ecosystem processes is ultimately of greater importance than the conservation of species and habitats *per se*, because species require functioning ecosystems in which to persist (Walker 1989; Grumbine 1990; Hobbs 1993). The features of an ecosystem or landscape that are generally considered important include the physical and chemical fluxes across the landscape (Saunders *et al.* 1991). However, the importance of these processes for ecosystem dynamics over timespans of decades to centuries, and their incorporation as part of conservation planning and management, do not appear to have been considered in any detail.

In the face of ever increasing development pressure in the region of the Okavango Delta, particularly for water abstraction, the question is how best to develop the water resources of the region. There need not be a conflict between conservation and development, provided that the ultimate goal is sustainability. We believe, following on from the ideas of Smith (1976), that the key to the persistence of the Okavango Delta ecosystem as we know it, lies in renewal brought about by natural changes in the distribution of water over timespans of decades to centuries. Change not only promotes the occurrence of a mosaic of habitats in different stages of wetting and drying (biotic diversity), but it also allows regeneration of saline surface soils in an environment with an extremely high potential for salinization.

REGIONAL SETTING

Introduction

The Okavango Delta, situated in northern Botswana on the fringes of the Kalahari Desert, forms part of an internal drainage basin known as the Kalahari basin. The Delta receives its water primarily from the highlands of central Angola via two main tributaries, the Cubango and Quito Rivers. The catchment of the Okavango River is underlaid largely by aeolian deposits of a once far more extensive desert which stretched from the northern Cape Province in South Africa, to the Congo Republic in central Africa (Thomas and Shaw 1991), although a small area in the northwest is underlaid by granitic rocks. This simple geology of the catchment has two important consequences. First, the total sediment load is dominated by fine sand which is saltated along the river bed as bed-load (McCarthy *et al.* 1991). Very little clay and silt are available, so suspended load in the Okavango River is low, and consists primarily of kaolinite. Second, the concentration of dissolved substances in the Okavango River is very low because of the lack of rock weathering in the catchment.

The Okavango Delta itself is situated in a collapsed section of the Earth's crust (Figure 1), which is an extension of the East African Rift Valley system (Hutchins and Hutton 1976). The region is seismically active, and suggests that subsidence of the collapsed section of the crust is still taking place (McCarthy *et al.* 1993). The Delta is more correctly classified as an alluvial fan, and is not a "delta" in the true sense of the word (Stanistreet and McCarthy 1993).

The Okavango Delta

The Okavango River enters Botswana at Mohembo, downstream of which it is confined to a narrow, linear depression known as the "panhandle" (Figure 1). At the town of Seronga, the Okavango River is no longer confined to this linear depression and it spreads out onto the fan surface. This is the result of water loss from the source channel. A number of distributary channels arise within this region of permanent swamps, and many of these discharge water seasonally onto the lower reaches of the fan, giving rise to the seasonal swamps. Within the Delta itself, particularly in the distal reaches of the fan, large islands and sandveld tongues occur which are seldom flooded.

Channels differ in character in different regions of the Delta (McCarthy *et al.* 1991a, 1992). In the panhandle the Okavango River is broad (70-100 m) and typically meandering, although there is some anastomosis. In the upper reaches of the fan the Nqoga River tends to be sinuous, but it is not meandering (McCarthy *et al.* 1991a; Stanistreet *et al.* 1993). Both of these channels have been referred to as primary channels as they contain both water and sediment derived from the catchment (McCarthy *et al.* 1991a), but we here refer to them as primary meandering (Okavango River in the panhandle) and primary sinuous (Nqoga River in the permanent swamps) channels respectively. Water is transferred to other channels in the permanent swamps as overspill from these primary channels, by flowing through densely vegetated swamp. These secondary channels do not carry sediment derived from source areas, but in their upper reaches they transport bed-load sediment derived by local erosion. Further downstream there is very little sediment transfer, and the channel beds are generally vegetated (Ellery *et al.* 1990). In the seasonal swamps channels are poorly defined, and consist of shallow depressions which receive the earliest flood waters.

The topographic relief over the Okavango Delta is minimal, with an average gradient from the top of the panhandle to the toe of the fan of approximately 0.28 m/km^{-1} (Wilson and Dincer 1976). On the fan itself the terrain is gently undulating with a local relief of 2 to 3 m. The high ground forms islands in both the permanent and the seasonal swamps, varying in size from single termitaria to several square kilometers. Floating-leaved and emergent communities characterize many of the backswamp areas at intermediate elevation. Areas of low relief form lakes which are usually several square kilometers in extent, and which generally represent ancient oxbow systems (McCarthy *et al. in press*).

Climate and hydrology

Rainfall in the catchment as well as in the Okavango Delta itself occurs in summer, mainly from December to February. Peak discharge in the Okavango river at Mohembo occurs late in the wet season, usually in February or March. Total annual discharge is 10.6×10^9 m^3 (Wilson and Dincer 1976). The flood stage rises gradually as water discharges into the swamps in the panhandle. Due to lateral confinement in this region, water level fluctuations may be as much as 2 m. At the bottom of the panhandle lateral confinement ceases, and seasonal floodwater spreads laterally over the fan itself. Water level fluctuations in the permanent swamps are therefore small, generally in the region of 0.15 m. Floodwater continues to disperse, ultimately discharging into the seasonal swamps, and arriving at the distal end of the fan some 4 months after peak flood in the panhandle. As a result there is maximum extent of floodwater in July and August, during the midwinter drought period.

Local rainfall contributes approximately 5×10^9 m^3 to the total water budget, being in the region of 500 mm/annum (Anderson 1976). Rainfall is exceeded by potential evapotranspiration during every month of the year (Sutcliffe and Parkes 1989), with annual potential evapotranspiration having been calculated as 1,860 mm (Wilson and Dincer 1976).

Both short term as well as longer term climatic oscillations have characterized the region of the Okavango Delta. Although mean figures for discharge, rainfall and evapotranspiration have been given, there is great variation from year to year. For example, annual discharges varied from 7.4×10^9 m^3 to 15.8×10^9 m^3 over the period from 1950 to 1976 (UNDP 1977). Similarly, rainfall is spatially and temporally extremely variable (Anderson 1976). Geomorphological evidence in the region, such as the presence of ancient dunefields and of former shorelines around marginal lakes, suggests that rainfall has varied from less than 150 mm/a to over 1,000 mm/annum in the last few thousand years (Shaw 1985; Thomas and Shaw 1991). The quaternary climate record for the region has been synthesized by Thomas and Shaw (1991).

GENERAL ECOSYSTEM FUNCTIONING

The water and sediment budgets for the Okavango Delta are presented in Table 1 (after McCarthy and Metcalfe 1990). Although water entering the Okavango Delta each year has low concentrations of dissolved solids, because of the large volume of water involved, large amounts of dissolved substances are introduced into the Delta. It has been estimated that the total quantity of dissolved solids entering the Delta each year is more than twice the quantity of clastic sediments (McCarthy and Metcalfe 1990). Only a small proportion of the dissolved solids leaves the system as surface outflow (Table 1). It is difficult to determine the quantities lost as subsurface outflow. However, large quantities of dissolved substances must be accumulating within the ecosystem each year, probably in the region of twice the quantity of clastic sediments (McCarthy and Metcalfe 1990). This is the result of high rates of evapotranspiration.

The processes leading to accumulation of dissolved substances beneath islands as well as at the soil surface in the center of islands in the permanent swamps (McCarthy and Metcalfe 1990; McCarthy *et al.* 1991b, *in press*), and beneath the floodplains and islands in the seasonal swamps (McCarthy and Ellery, in press), have been described in detail. From this work it is clear that the salinization of surface and subsurface soils in the Okavango Delta is localized to island and floodplain areas, and that surface waters remain extremely fresh as they move through the system. This is due to the dominance of transpiration over evaporation in the Okavango Delta, causing subsurface precipitation of dissolved substances (McCarthy *et al.* 1991; McCarthy and Ellery, in press).

ECOSYSTEM DYNAMICS

Major distributary channels of the Okavango Delta have a history of abandonment, leading to large-scale changes in the distribution of water (Wilson 1973; Smith 1976). Based on historical accounts and on more recent observations, it is possible to describe some of these changes. The earliest written account of the Okavango Delta was by David Livingstone after visiting Lake Ngami in 1849 (Livingstone 1857). His visit was followed by a number of others, notably Charles Andersson in 1853 (Andersson 1857), James Chapman in 1853 and thereafter (Chapman 1886), and Thomas Baines (1864). Lake Ngami was described by these visitors as an extensive body of shallow water, and appears to have been supplied at the time with water from the Thaoge River (Figure 2a). Andersson (1857) traveled upstream along the Thaoge River from Lake Ngami, covering a distance of approximately 80 kilometers. He described the river as 40 yards wide, and always deeper than 5 feet.

During the latter part of the last century, the upper reaches of the Thaoge River became subject to blockage by rafts of papyrus debris in two distinct areas (Figure 1), the upper and main Thaoge Blockages (Stigand 1923; Brind 1955; Wilson 1973). These were associated with the failure of the Thaoge River, which ceased to flow into Lake Ngami from about 1880. The decline of the Thaoge River appears to have been accompanied by an increase in flow along the Nqoga, Mboroga, and Santantadibe Rivers (Figure 2b). During the late 1920's the lower reaches of the Nqoga River started failing, once again associated with the development of papyrus blockages (Wilson 1973), and this was accompanied by an increase in flow along the more northerly Maunachira River, as well as along the Jao-Boro River system (Figure 2c; Wilson 1973; Smith 1976). The failure of these river systems has been well documented (Stigand 1923; Brind 1955; Wilson 1973; McCarthy *et al.* 1986a, 1992; Ellery *et al.* 1993, *in press*). The first visible signs are constriction of the channel by *Vossia cuspidata*, followed by the development of papyrus blockages and by the encroachment of papyrus from the banks into the channels themselves. These processes lead to obliteration of the channel, but are not the primary cause of change.

CAUSES OF CHANGE

There appear to be two important processes - sedimentation and neotectonics - that contribute to channel failure, and it is difficult to assess the relative contribution of each. First, the introduction of bed-load sediment into the Okavango Delta, and its confinement to in-channel areas by vegetated peat deposits flanking the channels, causes channel aggradation. Sediment in the meandering channels of the panhandle is deposited as point bars, leading to slow rates of aggradation (McCarthy *et al.* 1991). However, the deposition of sediments along the channel beds of primary sinuous channels may lead to channel aggradation rates in excess of 5 cm/a (McCarthy *et al.* 1986, 1992). This causes aggradation of several meters over the life of a channel, leading to increases in hydraulic gradients away from these channels far in excess of downstream gradients along the channel axis (McCarthy *et al.* 1986, 1992; Ellery *et al.* 1993). Furthermore, water lost in this way from an aggrading channel carries no sediment, initiating headward erosion in lines of weakness leading away from an aggrading primary channel, such as along a hippo path (Ellery *et al.* 1993).

Although the role of neotectonics as a possible cause of channel change has been alluded to in the past (Hutchins *et al.* 1976; Wilson and Dincer 1976; Smith 1976), evidence for the role of neotectonics in promoting channel change has recently been described in some detail (McCarthy *et al.* 1993). The region of the Okavango Delta is seismically active, and is associated with active rifting. It has given rise to conjugate faults tending southwest to northeast, and northwest to southeast (McCarthy *et al.* 1993). Tectonic activity and the formation of these conjugate faults is characteristic of rifting, which may cause changes in surface elevations over relatively short timespans, and may thus contribute to changes in the distribution of water in the Okavango Delta.

CONSEQUENCES OF CHANGE

Changes in the distribution of water are associated with profound changes in habitat within the Okavango Delta. At the time a channel system is active, the channel itself is flanked by virtually monospecific stands of the giant sedge *Cyperus papyrus* (Ellery *et al.* 1990). This community grades laterally to backswamp communities, whose distribution is dependent on water depth and on time since flooding (Ellery 1987; Ellery *et al.* 1991). These communities include open water areas with submerged vegetation, shallower areas with floating-leaved vegetation, and even shallower areas with short or tall emergent communities (Ellery 1987). Successional processes in these backswamp areas suggest that these communities are dominated ultimately by an emergent grass, *Miscanthus junceus*, which occurs in association with other grasses, sedges, and the swamp fig *Ficus verruculosa* (Ellery 1987).

The peat deposits associated with plant succession in backswamp areas act as a nutrient trap (Moore and Bellamy 1974; McCarthy et al 1989). Subsequent to abandonment, the peat deposits flanking a former channel system are susceptible to burning in subsurface peat fires (Ellery *et al.* 1989), which lead to the conversion of former swampland to terrestrial habitat, or to seasonal swamps. These peat fires release nutrients formerly locked up in the peat deposits, giving rise to soils with much higher nutrient status than the surrounding environment. These habitats are productive, and appear to support large concentrations of game as well as bird species in an environment that otherwise has a low carrying capacity (Ellery *et al.* 1989).

IMPLICATIONS FOR ECOSYSTEM FUNCTIONING

The ever changing distribution of water in the Okavango Delta ecosystem is important for two reasons. First, it appears to create a mosaic of habitats in different stages of wetting and drying. In the absence of change, the Okavango Delta would generally support low habitat diversity. The typical habitats that might be expected in a swamp of this kind are typically unfavorable for herbivores (Thompson and Hamilton 1983). For this reason, in the absence of changes in water distribution, the Okavango would typically support low concentrations of herbivores. Second, change enables regeneration of island soils. Surface salinization of soils by sodium carbonate and sodium bicarbonate (trona; McCarthy *et al.* 1986b) in the Okavango Delta is associated with the occurrence of the hardy grass *Sporobolus spicatus*, and even the complete absence of vegetation (Ellery *et al. in press*). The drying out of an area due to channel switching allows regeneration of these soils by leaching of these waste products into the subsurface, and possibly into the deep groundwater, so that when an area in which these islands occur is reflooded, these soils will not be toxic to terrestrial vegetation (McCarthy *et al.* 1993; Ellery *et al.*, *in press*).

IMPLICATIONS FOR CONSERVATION

Maintaining the natural dynamics

Change is brought about by a combination of sedimentation and tectonic activity. It is clearly not possible to manipulate the latter element of change, but changes in the quantity and nature of sediments introduced into the Okavango Delta each year could arise in several ways. We will focus first on clastic sediments. The construction of any impoundments (dams or weirs) in the catchment, particularly on the Okavango River itself, would have immediate and possibly catastrophic consequences. In contrast, the removal of relatively small quantities of water from upstream areas in the Okavango Delta is not considered to be a major threat to the ecosystem in itself, particularly in the context of climatic change that has taken place in the recent and not-so-recent past. However, the removal of the sediment supply that contributes to change in the distribution of water over timespans of decades to centuries could lead to a reduction in habitat diversity, and also to extensive soil salinization, and possibly to the salinization of surface water in the long-term.

Construction of an impoundment in the catchment would also affect the quality of inflowing water, and thus affect the character of dissolved sediments. The giant sedge *C. papyrus* appears to be sensitive to changes in water quality, and any impact on its distribution within the ecosystem would probably affect patterns of sedimentation. It is the only species in the Okavango capable of matching channel bed aggradation rates in excess of 5 cm/a (Ellery 1988), and plays an important role in the overall patterns of clastic sediment deposition in channels. As such its role in facilitating change should not be underestimated.

The most suitable means of water abstraction in the catchment or upper reaches of the Okavango Delta is therefore by pumping. Ideally pumping should be in phase with the flood cycle, or should peak during periods of high flows.

In the past, there has been dredging in the lower regions of the Delta, and proposals to increase outflow from the Okavango Delta have tended to focus on dredging and canalizing existing channels in these areas (Earnest 1976; SMEC 1987). A potentially serious problem associated with water development schemes at the lower end of the delta is the dynamic nature of water distribution over relatively short periods. A canal system could be rendered useless if patterns in the upper reaches change. In such an event, the temptation to extend the length of the dredged section would increase, possibly with catastrophic impacts. However, the most suitable location for storage dams is in the lower reaches of the Delta, where the impact of salinization would be local, and where plant communities are better adapted to higher salinities.

Siting of conservation areas

The water dispersal patterns of the Okavango Delta are constantly changing due to events in the upper fan area. It is important to conserve the area in which this switching process is functioning (Figure 3), because it is an essential component of the dynamics of the ecosystem as a whole. It is also important that a range of possible dispersal patterns be taken into account. If this is not done, a situation may arise where water disperses into an area that has not been set aside for conservation, and wetland habitats could be lost from the conservation area entirely.

CONCLUSIONS

A broad understanding of the structure and functioning of the Okavango Delta ecosystem has provided a useful basis for evaluating the kinds of perturbations that are likely to affect the ecosystem as a whole. Dissolved sediments are precipitated out of solution below surface in the permanent and seasonal swamps, with the exception of sodium carbonate and bicarbonate, which precipitate out at the soil surface of islands. Clastic sediment introduced into the system results in constant changes in the distribution of water on the fan surface. This promotes the occurrence of a mosaic of habitats in different stages of wetting and drying, and accounts for the overall habitat diversity in the system. It also promotes regeneration of saline soils that are locally toxic to vegetation on islands in the permanent and seasonal swamps. Water abstraction from the lower reaches of the fan by activities such as dredging, may be rendered useless by changes in the distribution of water on the fan over relatively short time spans. However, water abstraction in itself is not necessarily a problem. Ideally it should be done from the apex of the fan, provided it is small relative to the total inflow, and provided it does not disrupt sediment supply to the system from source areas. An additional impact of the construction of an impoundment in the catchment would be an increase in the total dissolved solid concentration of inflowing water. The system is adapted to low total dissolved solid concentrations, and by affecting the nature of plant communities at the apex of the fan, the system as a whole could be affected.

Proposals made here for water abstraction have a minor impact on the most important ecosystem processes, particularly the movement of bed-load sediment into the primary channels. This is important in promoting diversity and renewal through change, and must contribute to the present structure and functioning of the Okavango Delta ecosystem as we know it today.

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REFERENCES CITED

Andersson, C. J. 1857. Lake Ngami. Harper Bros., New York. Reprinted by C. Struik, Cape Town, South Africa, 1967. 503 pp.

Anderson, R.F.J. 1976. Weather of the Okavango Delta. Pages 29-31 *in* Botswana Society, Symposium on the Okavango Delta and its future utilization. Gaborone, Botswana.

Baines, T. 1864. Explorations in south-west Africa. Longman, Green, and Co., London, UK.

Brind, W. G. 1955. The Okavango Delta: report on the 1951-1953 field surveys. Unpublished report to the Resident Commissioner, Mafeking. 41 pp.

Chapman, J. C. 1868. Travels in the interior of Africa, 1849-1863. Reprinted by A. A. Balkema, Cape Town, South Africa, 1971.

Dincer, T., L. G. Hutton, and B.B.J. Kupee. 1981. Study, using stable isotopes of flow distribution, surface-ground water relations and evapotranspiration in the Okavango Swamp, Botswana. Pages 3-26 *in* International Atomic Energy Agency, Vienna, Proc. Ser. SII/AUB/493.

Earnest, H. M. 1976. Manipulation of the Okavango Delta for increased outflow: its impact and constraints. Pages 337-345 *in* Botswana Society, Symposium on the Okavango Delta and its future utilization. Gaborone, Botswana.

Ellery, K. 1987. The composition and dynamics of wetland plant communities of the Maunachira River system, Okavango Delta, Botswana. Unpublished M.S. Thesis. University of the Witwatersrand, Johannesburg, South Africa.

Ellery, K., W. N. Ellery, K. H. Rogers, and B. H. Walker. 1991. Water depth and biotic insulation: major determinants of back-swamp plant community composition. Wetlands Ecology and Management 1: 149-162.

Ellery, W. N., K. Ellery, T. S. McCarthy, B. Cairncross, and R. Oelofse. 1989. A peat fire in the Okavango Delta, Botswana, and its importance as an ecosystem process. African Journal of Ecology 27: 7-21.

Ellery, W. N., K. Ellery, K. H. Rogers, T. S. McCarthy, and B. H. Walker. 1990. Vegetation of channels of the northeastern Okavango Delta, Botswana. African Journal of Ecology 28: 276-290.

Ellery, W. N., K. Ellery, K. H. Rogers, T. S. McCarthy, and B. H. Walker. 1993. Vegetation, hydrology and sedimentation processes as determinants of channel form and dynamics in the northeastern Okavango Delta, Botswana.

African Journal of Ecology 31: 10-25.

Ellery, W. N., K. Ellery, K. H. Rogers, T. S. McCarthy, and B. H. Walker. *In press*. The role of *Cyperus papyrus* in channel blockage and abandonment in the northeastern Okavango Delta. African Journal of Ecology.

Ellery, W. N., K. Ellery, and T. S. McCarthy. 1993c. Plant distribution in islands of the Okavango Delta, Botswana: determinants and feedback interactions. African Journal of Ecology 31: 118-134.

Grumbine, E. 1990. Protecting diversity through the greater ecosystem concept. Natural Areas Journal 10: 114-128.

Hobbs, R. J. 1993. Effects of landscape fragmentation on ecosystem processes in the western Australian wheatbelt. Biological Conservation 64: 193-201.

Hutchins, D. G., S.M.R. Hutton, and C. R. Jones. 1976. The geology of the Okavango Delta. Pages 13-20 *in* Botswana Society, Symposium on the Okavango Delta and its future utilization. Gaborone, Botswana.

Livingstone, D. 1857. Missionary travels and researches in South Africa. John Murray, London, UK.

McCarthy, T. S., W. N. Ellery, K. H. Rogers, B. Cairncross, and K. Ellery. 1986a. The roles of sedimentation and plant growth in changing flow patterns in the Okavango Delta, Botswana. South African Journal of Science 82: 579-584.

McCarthy, T. S., J. R. McIver, and B. Cairncross. 1986b. Carbonate accumulation on islands in the Okavango Delta. South African Journal of Science 82: 588-591.

McCarthy, T. S.., J. R. McIver, B. Cairncross, W. N. Ellery and K. Ellery. 1989. The inorganic chemistry of peat from the Maunachira channel-swamp system, Okavango delta, Botswana. Geochimica et Cosmochimica Acta 53: 1077-1089.

McCarthy, T. S. and J. Metcalfe. 1990. Chemical sedimentation in the semi-arid environment of the Okavango Delta, Botswana. Chemical Geology 89: 157-178.

McCarthy, T. S., I. G. Stanistreet, and B. Cairncross. 1991a. The sedimentary dynamics of active fluvial channels on the Okavango fan, Botswana. Sedimentology 38: 471-487.

McCarthy, T. S., J. R. McIver, and B. Th. Verhagen. 1991b. Groundwater evolution, chemical sedimentation and carbonate brine formation on an island in the Okavango Delta swamp, Botswana. Appl. Geochemistry 6: 577-595.

McCarthy, T. S., W. N. Ellery, and I. G. Stanistreet. 1992. Avulsion mechanisms on the Okavango fan, Botswana: the control of a fluvial system by vegetation. Sedimentology 39: 779-795.

McCarthy, T. S. and W. N. Ellery. In press. The effect of vegetation on soil and groundwater chemistry and hydrology of islands in the seasonal swamps of the Okavango fan, Botswana. Journal of Hydrology.

McCarthy, T. S., R. W. Green, and N. J. Franey. 1993a. The influence of neo-tectonics on water dispersal in the northeastern regions of the Okavango Swamps, Botswana. Journal of African Earth Sciences 17: 23-32.

McCarthy, T. S., W. N. Ellery, and K. Ellery. 1993b. Vegetation induced subsurface precipitation of carbonate as an aggradational process in the permanent swamps of the Okavango (Delta) fan, Botswana. Chemical Geology 107: 111-131.

McCarthy, T. S., W. N. Ellery, and I. G. Stanistreet. 1993c. Lakes of the north eastern region of the Okavango swamps, Botswana. Zeitschrift Geomorphologie 37: 273-294.

Moore, P. D. and D. J. Bellamy. 1974. Peatlands. Paul Elek, London, UK. 220 pp.

Saunders, D. A., R. J. Hobbs, and C. R. Margules. 1991. Biological consequences of ecosystem fragmentation: a review. Conservation Biology 5: 18-32.

Shaw, P. 1985. Late Quarternary land forms and environmental change in northwest Botswana: the evidence of Lake Ngami and the Mababe Depression. Transactions of the Institute of British Geographers N. S. 10: 333-346.

Snowy Mountains Engineering Corporation (SMEC). 1987. Southern Okavango Integrated Water Development Project. Phase 1: final report.

Smith, P. A. 1976. An outline of the vegetation of the Okavango drainage system. Pages 93-112 *in* Botswana Society, Symposium on the Okavango Delta and its future utilization. Gaborone, Botswana.

Stanistreet, I. G. and T. S. McCarthy. 1993. The Okavango Delta and the classification of subaerial fan systems. Pages 115-133 *in* C. R. Fielding, ed., Current research in fluvial sedimentology. Sedimentary Geology 85.

Stanistreet, I. G., B. Cairncross, and T. S. McCarthy. 1993. Low sinuosity and meandering rivers in the Okavango Fan: channel confinement by vegetated levees without fine sediment. Pages 135-156 *in* C. R. Fielding, ed., Current research in fluvial sedimentology. Sedimentary Geology 85.

Stigand, A. G. 1923. Ngamiland. Geographical Journal. 62: 401-419.

Sutcliffe, J. V. and Y. P. Parks. 1989. Comparative water balances of selected African wetlands. Hydrological Science Journal 34: 49-62.

Thomas, D.S.G and P. A. Shaw. 1991. The Kalahari environment. Cambridge University Press, Cambridge, UK.

Thompson, K. and A. C. Hamilton. 1983. Peatlands and swamps of the African continent. Pages 331-373 *in* A.J.P. Gore, ed., Ecosystems of the world. Vol. 4B, Mires: swamp, bog, fen and moor. Elsevier Scientific, Amsterdam, The Netherlands.

United Nations Development Programme (UNDP). 1977. Investigation of the Okavango Delta as a primary source of water for Botswana. UN/FAO DP/BOT/71/506, Gaborone, Botswana.

Walker, B. H. 1989. Diversity and stability in ecosystem conservation. Pages 121-130 *in* D. Western and M. C. Pearl, eds., Conservation for the twenty-first century. Oxford University Press, Oxford, UK.

Wilcove, D. S., C. H. McLellan, and A. P. Dobson. 1986. Habitat fragmentation in the temperate zone. Pages 237-256 *in* M. E. Soule and B. A. Wilcox, eds., Conservation biology: an evolutionary and ecological perspective. Sinauer, Sunderland, Massachusetts, USA.

Wilcox, B. A. 1986. Insular ecology and conservation. Pages 95-117 *in* M. E. Soule and B. A. Wilcox, eds., Conservation biology: an evolutionary and ecological perspective. Sinauer, Sunderland, Massachusetts, USA.

Wilcox, B. A. and D. D. Murphy. 1985. Conservation strategy: the effects of fragmentation on extinction. American Naturalist 125: 879-887.

Wilson, B. H. 1973. Some natural and man-made changes in the channels of the Okavango Delta. Botswana Notes and Records 5: 132-153.

Wilson, B. H. and T. Dincer. 1976. An introduction to the hydrology and hydrography of the Okavango Delta. Pages 33-48 *in* Botswana Society, Symposium on the Okavango Delta and its future utilization. Gaborone, Botswana.

Table 1. Annual water, chemical, and sediment budgets for the Okavango Delta.

Source	Input	Surface outflow	Subsurface outflow
Rainfall[1]	$5x10^9$ m^3		
Okavango River[1]	$11x10^9$ m^3	$0.3x10^9$ m^3	$0.3x10^9$ m^3
Bed-load[2]	170,000 t	nil	nil
Suspended load[2]	30,000 t	nil	nil
Dissolved solids[3]	457,390 t	29,832 t	?

[1]Dincer *et al.* 1981
[2]McCarthy *et al.* 1991a
[3]McCarthy and Metcalfe 1990

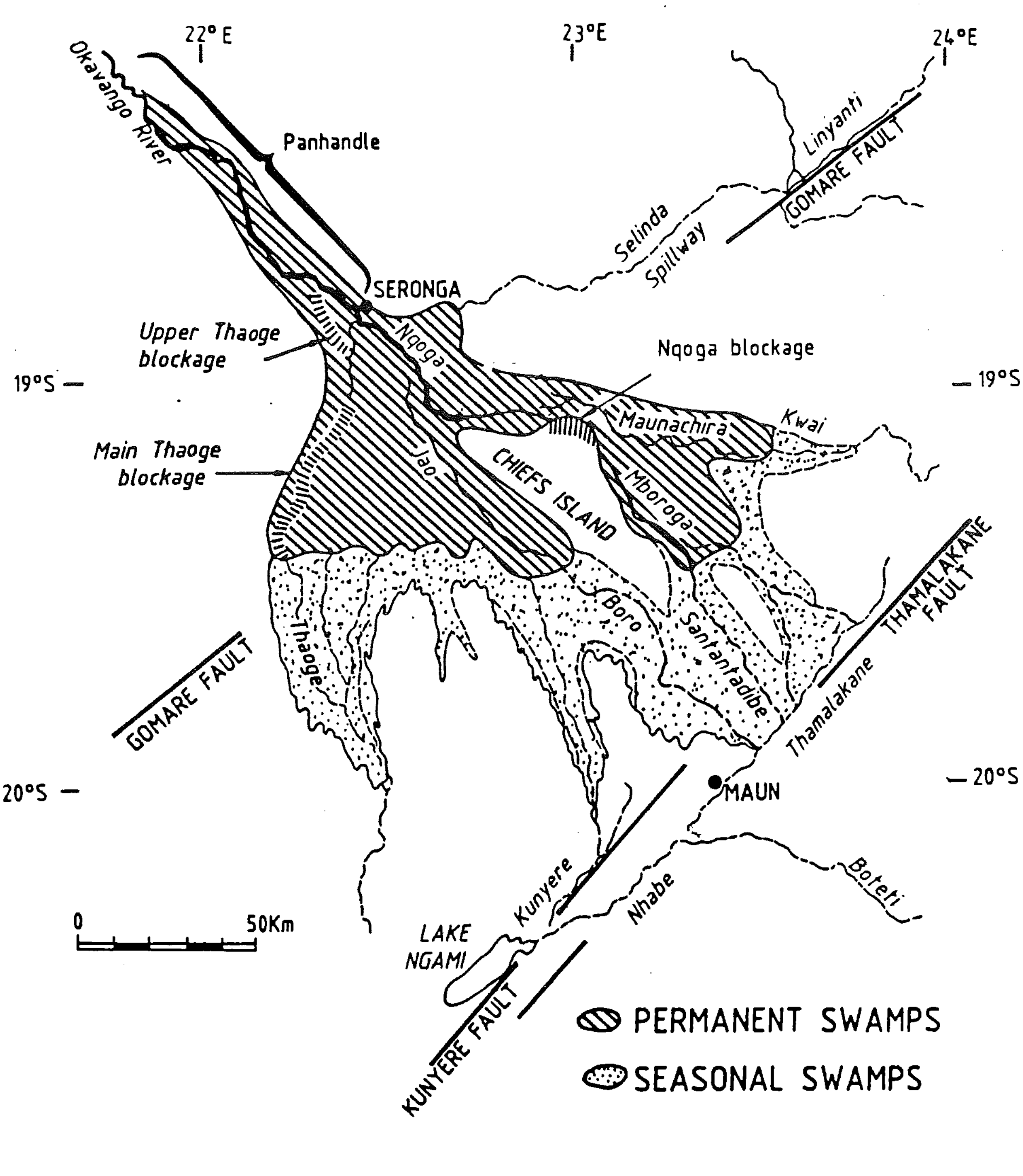

Figure 1. Map of the Okavango Delta.

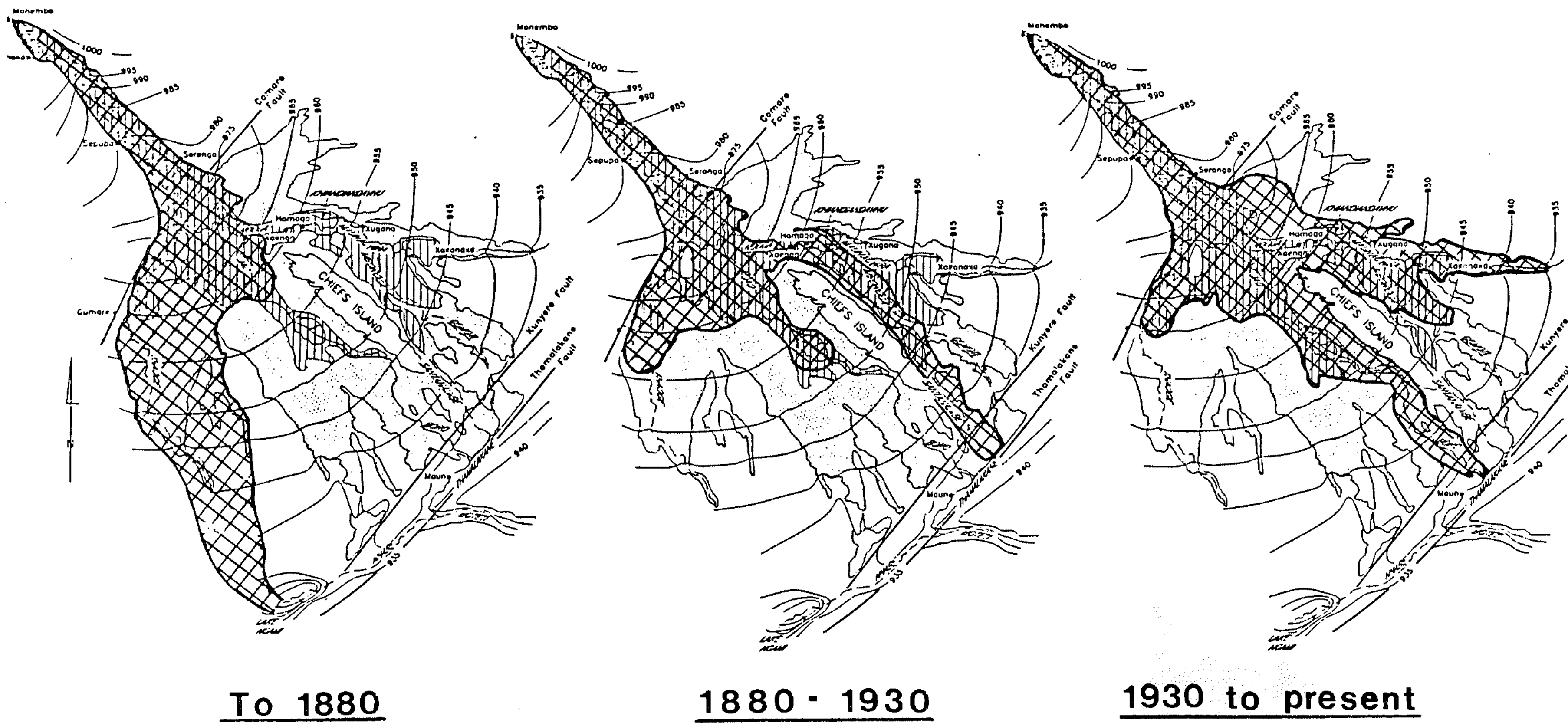

Figure 2. The distribution of water in the Okavango Delta at various times during the 19th and 20th centuries. Vertical lines and stippled areas indicate the present distribution of permanent swamp and seasonal swamp respectively; cross hatching indicates the approximate areas of main flow in the periods shown.

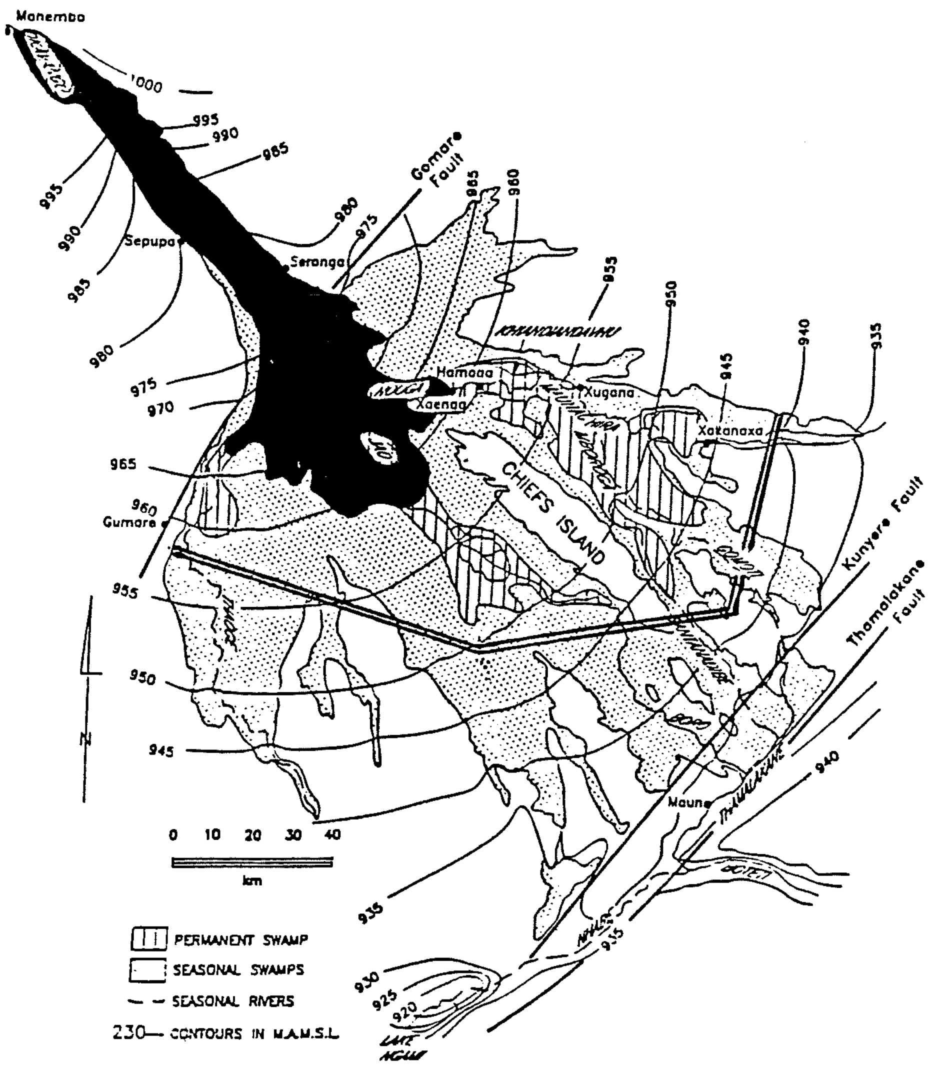

Figure 3. The area of the Okavango Delta in which the processes that contribute to channel switching are taking place (solid), and an example of the inclusion of a range of areas over which flooding may occur in the future (double solid line).

CONSERVATION OF CRANES IN ZIMBABWE

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ABSTRACT

Two cranes occur in Zimbabwe, the Wattled Crane (*Bugeranus carunculatus*) and the Grey Crowned Crane (*Balearica regulorum)*. Both are fully protected, but their future is tied to the continuation of large scale commercial agriculture, which provides suitable habitat free of disturbance.

THE WILDFOWL TRUST OF ZIMBABWE

The Wildfowl Trust of Zimbabwe (WTZ) was founded in 1985. The WTZ constitution defines "wildfowl" as those species of birds primarily associated with lakes, dams, rivers, and wetlands; this obviously includes cranes. The organization has 51 members, including three schools. The various wildfowl collections throughout the country have some 80 different species of ducks, geese, swans, and cranes. This represents almost 30% of the world total and includes such species as the Hawaiian Goose (*Branta sandvicensis*), the Laysan Duck (*Anas platyrhynchos laysanensis*), and the White-headed Duck (*Oxyura leucocephala*). Each of these species has been on the brink of extinction in recent years.

The WTZ maintains a close relationship with the Department of National Parks and Wildlife. It also has ties with the International Crane Foundation in the USA (founded 1973), the African Working Group on Cranes in Kenya (founded 1983), and the Southern African Crane Foundation in Durban (founded 1988).

CRANES, A GENERAL INTRODUCTION

Cranes throughout most of their world range have been greatly reduced in numbers or have become endangered; some species are threatened with extinction. The world's cranes can be considered as two groups: migratory cranes of the northern continents and the non-migratory cranes of subtropical and tropical regions. There are fifteen species of cranes; eight migratory, six non-migratory, and the Sandhill Crane of North America has both migratory and non-migratory subspecies.

The conservation of migratory species involves protecting widely separated breeding and wintering habitats and critical regions where the cranes rest during migration. Although the non-migratory species are easier to conserve because of their smaller ranges, human pressures are greatest in these regions and in the near future the most endangered cranes may be the tropical forms. Perhaps the greatest challenges in crane conservation lie in Africa and Southeast Asia where there are few constraints on the proliferation of humanity, where there are serious social and political problems and where there is not an historical tradition of protecting wildlife (Archibald 1981).

The North American Whooping Crane represents a migratory species which is greatly endangered. There were only 14 birds surviving in 1941, a number that has grown to more than 200 today. These cranes fly a 2,700-mile migration path. In 1990 only thirty active nests were observed.

CRANES OF ZIMBABWE

Two crane species occur in Zimbabwe, the Wattled Crane and the Grey Crowned Crane. The Blue Crane (*Anthropoides paradiseus*) is a very rare migrant to Zimbabwe from South Africa.

Grey Crowned Crane (*Balearica regulorum*)

Found near any water or on swampy ground with areas of open grassland nearby, the Grey Crowned Crane is widespread and common both on the central plateau of Zimbabwe and in the major river valley systems. In certain farming areas its numbers have increased considerably through the creation of dams, which provide suitable breeding sites and a source of food in nearby cropland. Locally it may become a pest, consuming quantities of newly planted maize, wheat, etc. (Irwin 1981). At the ARDA estate near Lupane in Matabeleland, for example, a resident flock of 500 Grey Crowned Cranes caused havoc with the wheat crops. The population of Zimbabwean Grey Crowned Cranes is estimated at 5,000 (Mundy *et al.* 1984).

Wattled Crane (*Bugeranus carunculatus*)

Found on extensive expanses of open grassland in large, generally moist vleis and marshes around pan systems, Zimbabwe's Wattled Cranes are principally found on the high ground of the watershed on the Mashonaland Plateau, although a few birds range southwards in the Midlands and westwards to the Ngamo Pans and Hwange National Park. In the Eastern Highlands it is present in montane grassland and I have even seen a bird in the Nyahode valley of the Chimanimani. They do not occur in the major river valley systems (Irwin 1981). Wattled Cranes are very specialized feeders and depend on shallow wetlands.

Wattled Cranes lay one or two eggs, and only one young is reared. The Wattled Crane has a long incubation period (up to 40 days) and a long fledging period (16 to 18 weeks) and these and the small clutch size result in a low reproductive rate; the eggs and young are also especially vulnerable to predation for a long period.

The selected species survey of the Ornithological Association of Zimbabwe (OAZ) includes both crane species (Morris 1987). This survey was initiated in 1979 and covers 10 different species of bird in Zimbabwe.

Contrary to most of the protected game species in Zimbabwe, cranes are not commonly found in our national parks. This means the future of the cranes depends on the people of the commercial and communal farming areas.

The two primary considerations in crane management are to prevent death from human-related agents and to protect critical habitats.

HUNTING AND OTHER HUMAN-RELATED AGENTS

Hunting of adult cranes does not appear to be a major problem in this country. However, predation on nests by youths with dogs in rural areas is a problem, especially when it has been estimated that every rural male in the country over the age of 14 years has at least one dog (P. Mundy *pers. comm.*). Collision with power lines and fences have also taken their toll but fortunately we do not have a high density of power lines in this country.

Apparently cranes are not as sensitive as raptors to toxic environment pollutants. Egg shell thinning and the aberrant behavior that has reduced the populations of many birds of prey as a consequence of the accumulation of toxic residues in their bodies have not been documented in cranes (Archibald and Mirande 1985). Nevertheless, the cranes may be subject to other forms of poisoning. For example, in South Africa as many as 600 Blue Cranes have been reportedly poisoned in retaliation for their damage to crops (G. Archibald *pers. comm.*).

HABITAT PROTECTION

The Wattled Crane is restricted to high altitude marshlands. Many of these have been lost to drainage, flooding, afforestation, and burning, causing a decline of the cranes (West 1977).

Surprisingly, Blue Cranes and Grey Crowned Cranes in South Africa still thrive in regions that once had Wattled Cranes. Their success is derived from the Blue Cranes' ability to breed in grasslands and the Grey Crowned Cranes' preference for small, seasonally produced wetlands. Clearly, the preservation of many species of cranes rests in the preservation of their natural, pristine habitats.

It is reckoned that a pair of Wattled Cranes has a nesting territory of one square kilometer. This area needs protection from cattle, children, dogs, and fire.

PUBLIC EDUCATION

It is estimated that two-thirds of Zimbabwe's Wattled Crane population nest in private or commercial farming land. Many of the landowners are not aware of the cranes' predicament. In South Africa, the Endangered Wildlife Trust produced a booklet entitled "Cranes, Vleis and Farmers." Similar dissemination of information about the cranes is a priority for Zimbabwe and the Wildfowl Trust of Zimbabwe has just recently set aside funds for this project.

The WTZ has also provided funds for the printing of posters focusing on the Wattled Crane. National parks game scouts will take these posters into the rural areas and to schools in an effort to educate the children.

CAPTIVE BREEDING

Cranes adjust well to captivity and they breed readily in confinement if provided with proper facilities, diet, and care. All of the world's fifteen crane species have been bred successfully in captivity.

Organizations involved with captive propagation are cooperating to develop sound genetic management and husbandry techniques. Studbooks have been developed for six species, including Wattled Cranes.

Captive populations are still small, however, and sound management is vital to maintaining their genetic diversity. For most species the number of founder individuals is low and it is desirable to collect new lines from the wild. Although this can be accomplished by collecting wild birds, it may also be achieved by collecting eggs from wild nests and hatching and rearing the chicks in captivity. Since most species raise only one young from a clutch or re-nest after their clutch is taken, this method ensures the least harm to the wild population. Another advantage of this method is that the birds will be better adjusted to captivity. A disadvantage of this method is that it then takes several years for the cranes to mature and breed. Some question the value of keeping captive collections of endangered species. This of course generates a whole new discussion.

In Zimbabwe we have a "fledgling" captive breeding program. In captivity we have approximately nine Wattled Cranes, twenty Grey Crowned Cranes, and fifteen Blue Cranes. These birds are held by some nine individuals with a further five people committed to a Wattled Crane captive breeding program. The Department of National Parks has authorized the WTZ to collect six Wattled Crane eggs from the wild for this program.

A tremendous amount of effort has been made in this field by one of the WTZ members, Mr. Rolf Hangartner, and his wife Jennifer who have established facilities to breed Wattled Cranes in captivity.

RESEARCH

An intensive survey is needed to establish the current status of the Wattled Crane in Zimbabwe, continuing the work on Wattled Cranes initiated in 1982 by Karl Lane. This program involves four aspects.

1. Map all Wattled Crane data available on OAZ field cards according to quarter degree squares.

2. Map potential Wattled Crane wetlands from topographic maps and aerial photographs.

3. Census these sites from the air.

4. Visit the Wattled Cranes found in a smaller study area several times a year to determine their breeding success.

To date, three aerial surveys have been flown; this has proved to be a successful means of spotting cranes. The main effort is to establish the "address" of each Wattled Crane nest.

The WTZ agreed to sponsor an intensive field trip by a national parks ornithologist. It is proposed to undertake a study of Wattled Cranes in the Mvuma area. A particular farm (Nyamanyoro farm, between Matayo Forest and Felixburg) has been targeted. It is known that five pairs of Wattled Cranes are nesting on the farm and flocks of seventy to eighty have been seen there (Mundy *et al.* 1984).

REFERENCES CITED

Archibald, G. 1981. Aerial censusing as a valuable technique in crane conservation. Bokmakierie 33: 60-61.

Archibald, G. and C. Mirande. 1985. Population status and management efforts for endangered cranes. Transactions of the North American Wildlife and Natural Resources Conference 50: 586-602.

Irwin, M.P.S. 1981. The birds of Zimbabwe. Quest Publishing, Harare, Zimbabwe.

Morris, A. 1987. The Status of cranes in Zimbabwe. Pages 345-348 *in* G. Archibald and R. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Mundy, P. J., A. Morris, and P. Hougaard. 1984. Aerial survey for Wattled Cranes. Honeyguide 30: 98-104.

West, O. 1977. The Wattled Crane. Endangered Wildlife 1(4): 3-5.

WATER, WETLANDS, AND CRANES IN LOMAGUNDI

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WATER AND WETLANDS

Of all water on earth, 97% is salt water. Three-quarters of the remaining 3% is locked up in glaciers and solar ice caps, so less than 1% remains as fresh water. The water in the atmosphere, rivers, lakes, and dams is only a small proportion of that one percent; most unfrozen fresh water is in the form of groundwater.

Groundwater is soil moisture. It flows to the place of least resistance and is contained within interstices between the grain and the rock, ranging in size from minute pores to large fractures and caverns. A porous rock which permits water to pass is permeable; if it is sufficiently permeable to yield useful quantities of water to wells and boreholes it is an aquifer. In Lomagundi we have dolomite where cavities occur underground, by the action of water dissolving the limestone. A good example is the Chinhoyi Caves.

When a borehole is pumped, water is removed from the surrounding aquifer and the water table is lowered. It is replenished by excess water flow to the borehole or by rain. If the pumping rate is higher than the maximum possible recharge rate, the borehole is said to be mined.

During good rainy seasons displaced borehole water is replaced by natural recharge. If replacement is more than that withdrawn it will come to the surface as sponges and springs, form streams, and become surface water.

In Lomagundi commercial agriculture has been a fact on most farms for more than 50 years. Fertilizer has been used for most of that time and return flow from irrigation may be higher in salts than it is naturally. In one small area of our aquifer pumping exceeds recharge, and salts exceed recommended standards on several farms.

Average annual rainfall at Chinhoyi is 817 mm (1901-93). We have had as little as 375 mm and as much as 1,436 mm. There are three seasons: hot, wet December to April; cold, dry May to July (having a mean maximum temperature of 16° C) and hot, dry August to November (having a mean maximum temperature of 26° C). Average height above sea level is 1,200 m, and the population density is 15 people/km^2.

The present groundwater withdrawal in the Mhangura/Chinhoyi area (Umboe Valley) is 23,000,000 m^3/year from 140 measured boreholes in 117 km^2. Around Chinhoyi, discharge exceeds recharge. Around Mhangura the recharge exceeds discharge and many springs still flow.

A wetland is a biological crossroad where water and land overlap. A place where rivers back up is a dam. Dams usually have permanent water and therefore have permanent predators and disturbance. They are a refuge in times of severe drought. There are more than 10,000 dams in Zimbabwe. In Lomagundi, we try to organize use by humans on one side of any dam only.

A place where rainwater collects in low areas is a pan, a natural collection of water mostly seasonally inundated. Pans are formed by oxbow lakes, stranded tributaries, and natural depressions often enlarged by years of large animals wallowing and carrying away silt and mud. They are often shallow and hold water seasonally. When dry they don't support predators as dams do. Because their depth and size fluctuate, pans don't support reeds and other rough grasses as dams do. Their vegetation is quick growing, followed by a period of dormancy until they fill again.

A place where groundwater seeps up from below is generally called a spring. Seepage below a dam is often commented on and holds water for a good long time before releasing it to the original natural watercourse. In flat areas vleis form and hold a good deal of soil moisture giving rise to taller grasses and marshy areas. They seldom have water more than 0.5 m deep and are often places where water seeps up from underground through pressure or is discharged from higher ground. In hilly areas like the Great Dyke one gets the same effect with water coming to the surface through the ground and creating a wetland. These are often called sponges and are much smaller than vleis. They are characterized by short wet grassland.

CRANES AND WETLANDS

Cranes are often seen on newly burnt grassland. These areas are kept dry by transpiration through the plants. When the plants burn off, excess water may come through, sometimes making streams run.

Cranes live and breed in vleis and sponges. They must have wetlands to produce their food and it must be soft enough for them to be able to dig with their beaks.

The length of beaks varies considerably. The beak of the Grey Crowned Crane (*Balearica regulorum*) is 62 mm long; of the Blue Crane (*Anthropoides paradiseus*), 88 mm long; and of the Wattled Crane (*Bugeranus carunculatus*), 168 mm long. Now if one has a vlei or a sponge or a wetland and pumps out water from a borehole onto a nearby wheatland, or a summer-supplemented crop like tobacco, maize, coffee, soya beans, or any other row crop, one has to only lower the water table 62 mm in the case of Grey Crowned Cranes or 168 mm in the case of Wattled Cranes before they fly away and look for more suitable habitat to feed in. In fact, the effect occurs before the water table is lowered that much, because as the soil moisture content of the wetland decreases, the ground gets harder, the crane food becomes dormant and more difficult to find, and the cranes move away.

As the area under discussion is so intensively farmed, the only solution would be to protect known crane habitat with all the conventional means (law enforcement, fences, etc.) and from all the conventional threats (disturbances, pressure from livestock, burning, predators, etc.), and also to replace water into suitable areas for cranes to feed and breed.

My point is that pumping irrigation water is a threat to crane habitat, and dries up the wetland, but this goes unnoticed and is therefore little thought about.

We have about as many Wattled Cranes in Zimbabwe as we have black rhinoceros (*Diceros bicornis*). If we can stimulate as much interest in crane protection as we have done in black rhino protection we should halt the disappearance of the Wattled Crane. But it may take the purchase of suitable land, at great cost, to do it. This would have to be done by a non-governmental environmental organization like the International Crane Foundation, because there is no way the Zimbabwean government could do it.

THE WATTLED CRANE

The Wattled Crane is a frequent, but getting uncommon, breeding resident which moves out of the district when circumstances get too dry. The Shona-speaking people call it Pashongwe. It is a very vulnerable bird, and of special concern. Several agencies and organizations are interested in the Wattled Crane in Zimbabwe. The International Crane Foundation keeps an eye on all cranes. Nationally the Wattled Crane is a specially protected species, and the Department of National Parks and Wildlife Management keeps a life history sheet on every nesting area of this species. The Ornithological Association of Zimbabwe monitors them closely through their Special Species Survey. About 10,500 Wattled Cranes live in Africa, about 210 in Zimbabwe, and the area under review must have 75 of these. Several nationwide aerial surveys have been done.

We have the following number of records on the birds in the different seasons: hot, wet (32); cold, dry (18); hot, dry (31). The records indicate seasonal movement, and the Wattled Crane does not occur in the north of the area, where there are no suitable wetlands.

The Wattled Cranes live on large vleis where there is a wetland, a bit of cover to get behind, and extensive moist or dry grassland with good visibility all around, approximately 18-40 ha. The ground should be wet enough and soft enough for the cranes to be able to dig with their beaks (about 160 mm long in females and 170 mm long in males). They live mostly in the highveld but some in the middleveld. The require large areas of remote open habitat. They don't allow a close approach, i.e., less than 100-200 m away from a pair, or 250-300 m away from a nest site. Single birds move off when a human is within 300 m and a pair with a chick start moving away at 500 m, always keeping the chick between them.

The cranes like to nest in a swamp where they drag up vegetation and make a platform or on a tiny island surrounded by water which they wade through to get to the nest. They lay two eggs. Incubation takes about 31-40 days; both birds incubate for shifts of between 7-60 minutes and will be off the nest for up to half an hour. If a nest is lost they will lay again in 3-4 weeks, and can relay three times in a year. They have a very low recruitment rate: when two nestlings hatch the older one kills the younger. The nestlings are fed a lot of animal matter in early life and move onto a vegetable diet later. They are incapable of flight for 15-18 weeks. The chick stays with its parents until the parents are ready to breed again. These cranes seldom breed in captivity.

The young non-breeding birds then become floaters until they get a mate and establish a territory of their own. These younger birds wander widely to forage and occasionally form flocks, the largest in the area being 12 birds, but up to 70 have been known on the Rainham Dam Vlei near Harare.

The presumed food for adults is fleshy roots, tubers, rhizomes of Gramineae and Cyperaceae, and of Juncaceae and Nymphaceae to a lesser extent. They sometimes feed on agricultural crops like groundnuts.

Conservation of Wattled Cranes

We know very little about what Wattled Cranes eat, so it is imperative to examine all dead birds and see what is in their crop and stomach. If they pick up a dropped nail or an old piece of wire and it pierces their crop or gut it could kill them. This is called hardware disease. It is important to get dead birds to a competent biologist or a museum as soon as possible. Live birds off their food can be x-rayed and operated on.

A known nest site could be managed by fencing it off, particularly from human activity. A breeding pair may cover 200 m² in eight hours of feeding. A non-breeding pair is known to have moved through an area of 550 m² in four hours of feeding. They move very slowly in their passive way. A breeding pair is intolerant of human activity within 250-300 m of a nest center.

Many nest sites have been put underwater by dam building or lost due to siltation. These swamps need to be deep enough for a Wattled Crane to wade through with a tiny island in the middle which could be man-made to encourage birds to come back. During dry years a site may not be suitable but the pair will stay in that area until conditions are favorable for them to breed. Pairs remain reproductive for several decades.

Drainage of vleis and wetlands for agriculture and development is always a problem. This can take several forms, including:

- "herringbone" drainage, which mechanically moves water out of the area to dry it up for some reason, is used for citrus groves;
- overgrazing, which reduces the water-carrying capacity of the area;
- overpumping borehole water, which lowers the water table (it only has to be lowered about 100 mm for it to be beyond the reach of the Wattled Crane's beak).

Drying up the wetland will also make the ground too hard for the crane's beak to penetrate.

Disturbance, particularly human or dog disturbance, will send the cranes away from an otherwise suitable site very quickly. An approach closer than 200-400 m may be enough to put them to flight. The only time they are ever heard calling is in flight, when they can put on magnificent aerial displays.

Monitor lizards (*Varanus niloticus*), snakes, egg-eating birds, egg collectors, and the Cape clawless otter (*Aonyx capensis*) are presumed to be the biggest threat to the nest and egg, for thirty days, and fire is the worst enemy of the chick, because it can't fly for 103 days, or about 15 weeks.

THE BLUE CRANE

The Blue Crane is a vagrant in Zimbabwe. In the area under review there is only one record of a Blue Crane. That was seen by Cecil Priest of Lucknow farm in the Umvukwes in November 1927 (Priest 1934). He saw three birds in a large acreage of sprouting mealies (*Zea mays*). He proceeded to hunt them but they moved away from him at a distance of 300 yards. They then took wing. Lucknow Farm is near the present day township of Msonedi at 17°37'S/30°52'E.

THE GREY CROWNED CRANE

The Grey Crowned Crane (also known as the Southern Crowned Crane) occurs frequently but may be getting less common in Lomagundi. It is a possible partial migrant in really dry years but otherwise a breeding resident with 35 hot wet, 20 cold dry, and 42 hot dry season records. It uses more diverse habitats than the Wattled Crane, living near any waterway, river, dam, or pan, or on the vlei with nearby grassland, pastures, or fields. It feeds on insects, frogs, lizards, mollusca, and seeds and other plant material, and is said to be particularly fond of germinating seed. Basically, however, it is a carnivore, in contrast to the Wattled Crane which is basically a herbivore. The flight of the Grey Crowned Crane is heavy with slow wingbeats; the legs and neck hang down behind and in front at an angle to the body. Flocks fly in V formations. The cranes roost in trees near water.

In about October, the hottest month of the year, the Grey Crowned Crane performs curious dances. The most I have seen is 28 birds performing their mating ritual at the Mazowe Dam, on Highbury Estate in October 1980. They breed in the hot, wet season whereas the Wattled Crane breeds in the cold, dry season. A pair may raise one young per year. Both parent birds build the nest. Two or three bluish white eggs are laid in a suitable marshy area. Incubation by both parents takes about 26 days, and the fledgling period is about 100 days. Chicks leave the nest within hours of hatching. Intruders near a nest will be treated to a broken wing act; a close approach by a dog will lead to threats with wings outspread and forward kicks and pecks. The Grey Crowned Cranes probably pair for life and prefer the highveld of the Umvukwes at 1,500 m to the middleveld near Mhangura at 1,200 m. The Shona-speaking people call it Olewane, which is very like one of its calls. They do it no harm, in fact they respect the cranes, although children have been known to take eggs and chicks. The crane sometimes calls at night.

There are thought to be two populations of the Grey Crowned Crane: one in the marshes and wet vleis of Mashonaland which during dry years retreats to the Kafue Flats; another population on the pans of Matabeleland which retreats to the Liuwa Plains of Barotseland when things get very dry in western Zimbabwe.

The only bird species which I have seen form a shadow like a passing cloud was a flock of Grey Crowned Cranes in Barotseland. They must have been in a tight flock of upwards of 600 birds. It was August 1963.

Clare Rockingham-Gill saw three Grey Crowned Cranes near the Ume River, Lake Kariba, in May 1993, so it is clear they can wander into the hot river valleys like the Zambezi, even if only in transit.

The author saw a single bird fly into a wheat field in June 1993 on Two Tree Hill Estate, at about 17:30 hours. Do the cranes feed at night? Because it could only have had a maximum of 30 minutes feeding time left that day.

There are said to be about 3,000 Grey Crowned Cranes in Zimbabwe. They suffer the same threats as Wattled Cranes but maybe even more human pressure, as they have been ornamental in collections of birds for centuries. Many chicks have been successfully reared by farmers' wives in this district, including Diana Bauer, Debbie Bowker, and Margaret Standish-White. They have been known to nest in trees and I have actually seen such a nest on the Kafue Flats with Richard Peters and Tom Savory.

EXAMPLE OF A WATTLED CRANE NEST SITE LIFE HISTORY SHEET

Farm file 163OCC MHANGURA

Suiwerspruit / Chirombozi Farms Boundary

14.1.1984 Field card 12283. 2 birds.
This pair could be Zimbabwe's most north early breeding pair of Wattled Cranes.

9-15.11.1986 Field card 12264. 2 adults, 1 juvenile. The juvenile lands between the two adults. The brown neck feathers noticed a month ago have now gone wattle's grey. Red not yet evident.

30.11.1986 Field card 12266. 2 adults, 1 juvenile.

6.12.1986 Field card 12267. 2 adults, 1 juvenile. They change their feeding habits and have left the wetlands to forage over the plowed and harrowed soya bean lands, rather than the grass vleis.

30.1.1987 Norman Melrose saw 3 Wattled Cranes on Chirombozi.

1.6.1987 D. V. Rockingham-Gill saw the presumed immature of this pair at Struthers Dam, Highbury Estate 1730 AA. I assume this to be the bird reared by the Suiwespruit/ Chirombozi pair in 1986.

18.7.1987 S. James, G. Lowe, D. V. Rockingham-Gill, and B. Wright go to look for Pinkthroated Longclaw (*Macronyx ameliae*). Two Wattled Cranes on Chirombozi. The wetland has receded because of the drought. The cranes must be preparing to nest around now.

This pair have not been seen for some years now. I put this down to disturbance; Mhangura town is too close and has doubled in size in recent years.

The Mhangura Copper Mines slimes dump waste water has an enormous reed bed for the birds to get behind if necessary.

In about 1985, a young Wattled Crane chick was brought in to Mrs. Maggie Buitendag, housewife on Suiwerspruit Farm at that time. She bought the chick and released it back to its parents quite successfully.

REFERENCES CITED

Baner, D.F.S. 1982. Notes on caring for cranes. Honeyguide 109: 14-17.

Destor, I. and R. Atkinson. 1987. Wattled Crane in Zimbabwe: a species of special concern. Unpublished project report to the Department of National Parks and Wildlife Management. Harare, Zimbabwe.

Godfrey, J. W. 1992. Natural pans: the duck factories of Zimbabwe. Honeyguide 38: 165-172.

Hopkinson, G. and A.N.B. Masterson. 1984. The occurrence and ecological preferences of certain Rallidae, near Salisbury, Zimbabwe. Pages 425-440 *in* J. A. Ledger, ed., Proceedings of the Fifth Pan-African Ornithological Congress. Southern African Ornithological Society, Johannesburg, South Africa.

Irwin, M.P.S. 1981. The birds of Zimbabwe. Quest Publishing, Harare, Zimbabwe.

Maclean, G. L. 1985. Roberts' birds of Southern Africa. The Trustees of the John Voelcker Bird Book Fund, Cape Town, South Africa.

Priest, C. D. 1934. The birds of Southern Rhodesia. William Clowes, Edinburgh, UK.

Rockingham-Gill, D. V. 1984. Some notes on underground water in the Umboe Rural Council area, Lomagundi. Unpubl. manuscript.

Schoff, G. H. 1991. Reflections: the story of cranes. International Crane Foundation, Baraboo, Wisconsin, USA.

Wagner, W. 1987. Lomagundi aquifer study: groundwater use and groundwater potential in the Chinhoyi-Umboe-Mhangura farming areas, Zimbabwe. German Agency for Technical Cooperation, Hanover, West Germany.

THE MARROMEU COMPLEX OF THE ZAMBEZI DELTA: MOZAMBIQUE'S UNIQUE WETLAND

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ABSTRACT

Mozambique covers an area of about 799,000 km² with a great variety of habitats, including numerous wetlands. This paper will focus on the Marromeu area on the south bank of the Zambezi River. This area is situated in Sofala Province, in mid-Mozambique, covering an area of approximately 360 km². Marromeu enjoyed an international reputation for its diverse and extensive wildlife populations, but little attention has been paid to its importance as a waterbird habitat. Over 2,500 Wattled Cranes (*Bugeranus carunculatus*) were counted on the floodplain during the aerial survey carried out in September 1990. Marromeu wetland is a major habitat for most of the common southern African waterfowl species, and occasionally hosts more northern species such as Pintail (*Anas acuta*) and Garganey (*Anas querquedula*). Marromeu has an outstanding conservation value. It is an important wetland deserving recognition as a World Heritage Site and a Wetland of International Importance under the Ramsar Convention.

INTRODUCTION

Mozambique covers an area of about 799,000 km² and has a great variety of wetland habitats, including Rovuma floodplain in the extreme north, Gorongosa National Park in the Great Rift Valley, and Maputo reserve in the south. The Marromeu wetland complex occurs off the southern bank of the Zambezi River in Sofala Province, central Mozambique, covering an area of approximately 360 km². The major habitats at Marromeu include: floodplain with swamp forest, papyrus swamp, oxbow lakes, and seasonally inundated grassland; deciduous miombo woodland on the better drained soils; palm savanna; acacia savanna; coastal dunes and beach; and mangrove estuaries (Anderson *et al.* 1990).

Artisanal fishing and hunting have been the principal source of protein for the local people at Marromeu for many centuries. Other biological resources at Marromeu include freshwater and marine fish, crabs, prawns, birds, bees, timber trees, palms, and reeds.

CURRENT STATUS OF MARROMEU

Marromeu once enjoyed an international reputation for its diverse and extensive wildlife populations, particularly of large ungulates. Today, the vast herds of buffalo and waterbuck in the floodplain have been decimated by the past 16 years of civil war. Between 1979 and 1992, a 90% population reduction in buffalo, waterbuck, and reedbuck, 80% reduction in hippo, and 52% reduction in zebra was observed (Goodman 1992). More recent surveys suggest an even further decline: fewer than 1,000 buffalo were observed during surveys of the floodplain in March 1995 (Beilfuss 1995), in contrast to an estimated population of 55,595 buffalo at Marromeu in 1977 (Tello and Dutton 1979). Rare ungulates such as Lichtenstein's hartebeest and sable have also been severely depleted because of hunting with military weapons.

Despite the decimation of most mammal populations at Marromeu, recent aerial surveys suggest it is still a major habitat for wintering and breeding waterbirds. Over 2,500 wintering Wattled Cranes (*Bugeranus carunculatus*) were counted in the floodplain during aerial surveys in 1990 (Anderson et al 1990). During January 1993 surveys, the endangered Wattled Cranes were found paired off near pans in the miombo woodland. In March 1995, fifty-eight pairs and several large flocks of Wattled Cranes were observed in the Marromeu floodplain (Beilfuss 1995; Beilfuss and Allan *this proceedings*).

The largest colony of White Pelicans (*Pelecanus onocrotalus*) in southern Africa has been recorded breeding in the papyrus. Marromeu is a major habitat for most of the common southern African waterfowl species, and occasionally for more northern species, including Pintail (*Anas acuta*) and Garganey (*Anas querquedula*). Thirty species of waterbird were observed during aerials surveys in March 1995, including substantial populations of Openbilled Storks (*Anastomus lamelligerus*) and Saddlebilled Storks (*Ephippiorhynchus senegalensis*) (Beilfuss and Allan *this proceedings*). The woodland and forest habitats support rarities such as the Specklethroated Woodpecker (*Campethera sriptoricanda*) and Whitebreasted alethe (*Alethe fuelcorni*).

MARROMEU'S SIGNIFICANCE

The conservation of Marromeu has global significance. It supports a substantial proportion of the world population of several important waterbird species, including Wattled Cranes, Openbilled Storks, and White Pelicans. It supports a wide diversity of important ungulate species, as well as elephant, hippo, and lion. It supports a rich mosaic of tropical wetland communities, including floodplain, woodland, and coastal mangrove. If restored and managed appropriately, Marromeu may be perhaps the most important coastal wetland in southeast Africa.

PROBLEMS

War and dams have taken a great toll on the Marromeu Complex. Impoundments on the Zambezi River at Kariba and Cahora Bassa, the third and fourth largest dams in Africa, respectively, are preventing the natural flooding regime of the floodplain and delta. This has resulted in reduction of wetland and open water areas. Much of the land is unnaturally dry, uncontrolled burning in the grasslands has intensified, saltwater intrusion is degrading the freshwater vegetation communities, and unregulated hunters have gained easy access to the floodplain throughout the year. The severe reduction of freshwater fish habitat associated with the loss of annual flooding has destroyed the subsistence and market fisheries. Ungulates are now the only significant local source of animal protein (P. Dutton *pers. comm.*).

The war has caused much of the human population to aggregate around Marromeu complex. There has been a considerable increase in the population living near the coast, on the elevated areas of floodplain-miombo woodland ecotone, causing subsequent habitat destruction.

The floodplain is also threatened by a lack of policy guidelines, educational facilities, and security, although projects are currently underway to de-mine the area, rebuild the infrastructure, and link the Marromeu Complex to Gorongosa National Park in an integrated conservation and development plan (DNFFB 1994). Only minimal information exists about the resource potential of Marromeu Complex.

POSSIBLE SOLUTIONS FOR CONSERVING AND MANAGING MARROMEU

It is essential that planning and management of the natural resources in the area follow a clearly-defined development policy so as to provide the maximum benefit for Mozambique and its people while preserving and enhancing the international value of Marromeu. There are several key issues.

1. Supporting research and monitoring that directly lead to the conservation of the area's natural resources and ensure the implementation of recommendations.

2. Enhancing the conservation value of the area by controlling wasteful forms of resource use.

3. Collaborating with the Zambezi River authorities in studying the possibility of simulating a biannual flooding of the delta, through short duration maximum volume releases from Cahora Bassa. Before this action is implemented the benefits of flooding, such as improvement in freshwater fisheries and revitalization of agricultural soils, must be explained to the people living on the lower delta and warnings must be made of impending floods to permit evacuation to elevated ground.

4. Providing technical assistance from experts and ornithologists for the formulation of management strategies for the area.

5. Communicating the management policy to funding agencies, controlling authorities, and the local people in particular.

CONCLUSION

Marromeu has outstanding conservation value as an important wetland deserving recognition as a Wetland of International Importance under the Ramsar Convention. I invite all delegates to the African Crane and Wetland Training Workshop to help persuade the government of Mozambique to establish the Marromeu Wetland Area as a World Heritage Site, so as to facilitate its registration as a candidate under the Ramsar Convention.

REFERENCES

Anderson, J., P. Dutton, P. Goodman, and B. Souto. 1990. Evaluation of the wildlife resource in the Marromeu complex with recommendations for it's further use. LOMACO, Maputo, Mozambique.

Beilfuss, R. 1995. Wattled Cranes in the great Zambezi Delta. ICF Bugle 21(3): 2-3.

Direcçao Nacional de Florestas e Fauna Bravia (DNFFB). 1994. Gorongosa-Marromeu: management plan for integrated conservation and development. DNFFB, Maputo, Mozambique.

Goodman, P. 1992. Zambeze Delta - an opportunity for sustainable utilisation of wildlife. IWRB News 8: 12.

Tello, L. P. and P. Dutton. 1979. Programa de Operacao Bufalo. Relatorio de Fauna Bravia, Maputo, Mozambique.

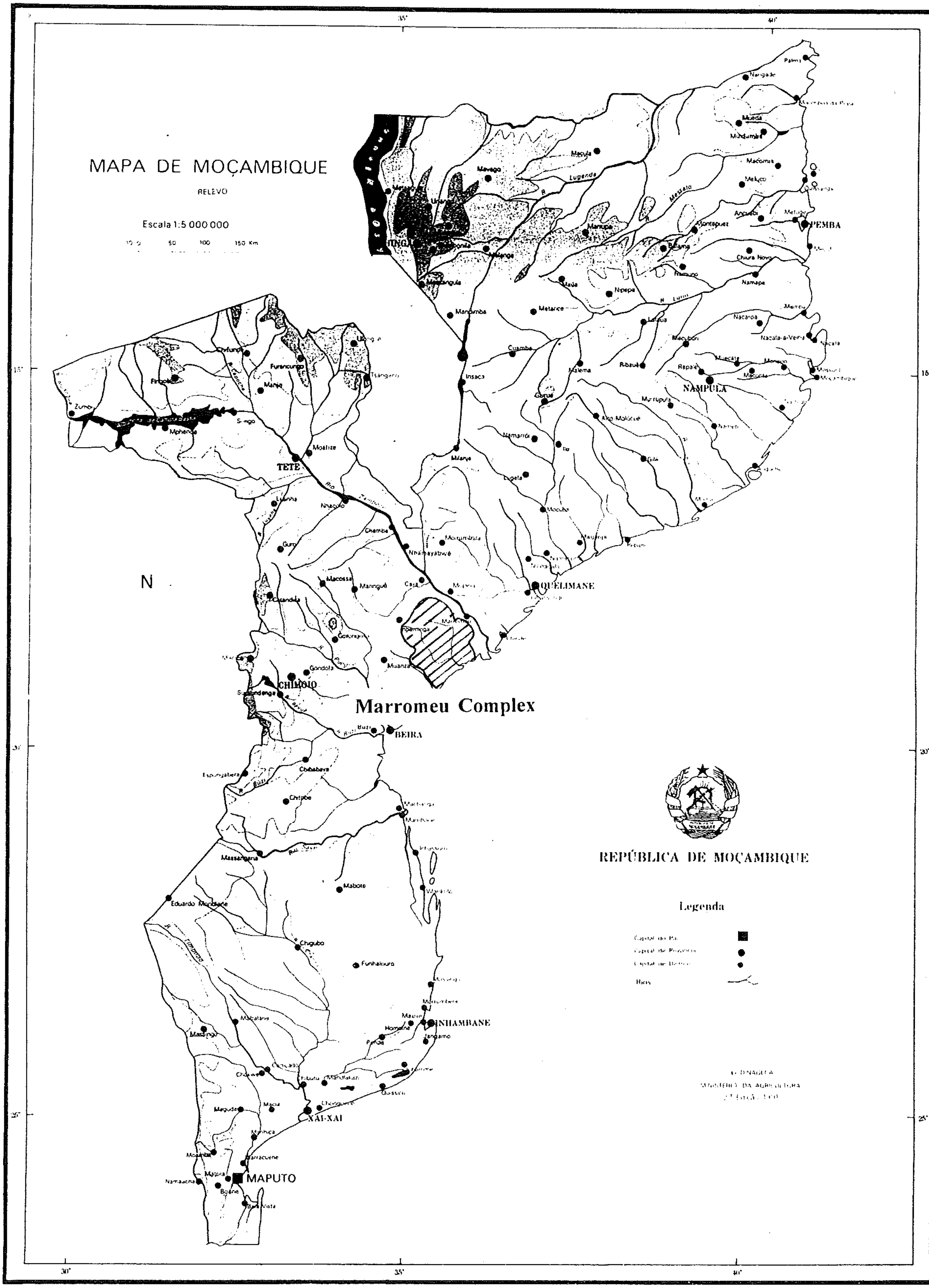

Figure 1. Map of Mozambique showing the Marromeu Complex in the Zambezi Delta.

WATTLED CRANE AND WETLAND SURVEYS IN THE GREAT ZAMBEZI DELTA, MOZAMBIQUE

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INTRODUCTION

Wattled Cranes and hydrological change

The Wattled Crane (*Bugeranus carunculatus*) is a globally endangered resident of sub-saharan Africa. The large size and unique gray and white plumage of the Wattled Crane make it a conspicuous member of the wetland communities upon which it depends, and a valuable focal point for wetland conservation initiatives.

The total population of Wattled Cranes is estimated to be no more than 13,000-15,000 birds (Urban *this proceedings*). The vast majority (more than 95%) of the population occurs in southcentral Africa, in the floodplains and dambos of the Zambezi, lower Zaire, and Okavango River catchments (see Dodman *this proceedings*; Kamweneshe *this proceedings*; Mangabuli *this proceedings;* Singini *this proceedings*) (Figure 1). Wattled Cranes in this core range are highly territorial and may defend areas greater than 1 km^2 in size (Konrad 1981). They are found in greatest numbers in large wetland systems such as the Kafue Flats, Bangweulu wetlands, and Liuwa Plains in Zambia, the Okavango Delta and Makgadikgadi Pans in Botswana, and the Zambezi Delta in Mozambique.

Fluctuations in the populations of Wattled Cranes among these and other sites suggest that there may be substantial seasonal movement depending on regional hydrological conditions. Wattled Crane pairs begin nesting as floodwaters recede after peak flooding. Nests are typically built in open grass and sedge marshes bordered by drier flat or sloping grassland meadows, with minimum-height vegetation, and water up to one meter in depth. Konrad (1981) observed that this strategy takes advantage of large areas of shallow floodplain which provides open water around the nest that is deep enough to provide some protection from predators and an abundant food supply of sedge tubers and rhizomes that cannot be successfully foraged during high floods.

The timing, duration, and extent of flooding at a particular wetland and among wetland systems depends on hydrological factors unique to each wetland, including the amount of inflow from local rainfall and the timing of floodwaters from upstream basins, and the amount of outflow via evaporation, transpiration, and natural drainage. In the Zambezi system, peak flooding begins at the end of the rainy season in February/March. In the Okavango Delta, peak flooding occurs during the dry season in August/ September.

Douthwaite (1974) observed that 40% of all Wattled Crane pairs attempted to breed in a year of average flooding conditions in the Kafue Flats, but only 3% of all pairs bred in a year of negligible flooding conditions due to drought. With Wattled Crane nesting success so highly sensitive to natural hydrological variations, artificial changes to a wetland flooding regime due to drainage, dams, or water diversions would be expected to have a substantial impact on Wattled Crane nesting success. When the hydrological regime of the Kafue Flats was altered by the Itezhi-Tezhi Dam, for example, Konrad (1981) predicted a dramatic restriction in Wattled Crane nesting sites and feeding area. To date, no research has been done to determine the impact of hydrological alteration on Wattled Cranes or other wetland species in their core range.

The Zambezi Delta

The occurrence of Wattled Cranes in the Marromeu Complex of Zambezi Delta of Mozambique offers an excellent opportunity to better understand the effect of hydrological change on Wattled Cranes and the wetland communities upon which they depend. The Marromeu complex is located off the southern bank of the Zambezi River and includes the largest floodplain of the Zambezi Delta (Figure 2). The complex includes three managed hunting units (coutadas 10, 11, and 14) and the Marromeu Buffalo Reserve.

Goodman (1992a) counted 2,570 Wattled Cranes in the 2,500 km^2 Marromeu floodplain during aerial surveys in September 1990. During April surveys of the same area, Goodman (1992b) and P. Dutton (*pers. comm.*) reported numerous pairs of Wattled Cranes across the floodplain.

The flooding regime of the Zambezi Delta has been severely degraded by the construction of the Kariba and Cahora Bassa dams (the third and fourth largest dams in Africa, respectively) on the upstream Zambezi River (Figure

1). The dams have nearly eliminated all downstream flooding, such that water in delta is now provided strictly from local rainfall during the rainy season months of October-April (approximately 1,200-1,400 mm/year) and drains away rapidly to the river and ocean. The floodplain, once inaccessible for more than nine months out of the year due to high water, is now accessible throughout the year. Saltwater intrusion, the spread of exotic vegetation in stagnant waterways and overgrazed floodplain areas, the desiccation of floodplain habitats, and uncontrolled grassland fires have resulted (Anderson *et al.* 1990).

The presence of breeding Wattled Cranes in the delta raises questions as to how well the birds have adapted to such a highly altered flooding regime, how successful is their nesting relative to the natural flooding conditions that occurred prior to upstream dams, and how might the restoration of more natural flooding conditions in the delta affect their nesting success. We hoped that the Wattled Crane could serve as a focal point for restoration initiatives to benefit the people and wildlife of the great Zambezi Delta.

In March 1995, we traveled to central Mozambique to survey the Zambezi Delta and begin to address these questions. Our goals were to:

- assess the breeding population of Wattled Cranes at the peak of the normal flooding season (March);
- assess the population of other important waterbird and mammal species using the delta at the peak of the normal flooding season;
- assess the current hydrological and ecological status of the Marromeu complex relative to the conditions observed by Davies *et al.* (1975), P. Dutton (*pers. comm.*), and others prior to the closing of the Cahora Bassa dam;
- explore the feasibility of prescribed water releases from the Cahora Bassa dam to simulate natural flooding and improve ecological and socio-economic conditions in the Zambezi Delta.

METHODS

Sixteen hours of aerial surveys of the Marromeu complex and lower Zambezi River were conducted during the period 8-10 March 1995. Surveys were conducted in a manner to be comparable to previous surveys of the area (Anderson *et al.* 1990; Goodman 1992b; P. Dutton *pers. comm.*). Surveys were flown in a six-seat Cessna 210 from the base at Beira Municipal Airport. A landing strip at Chinde, located at the mouth of Zambezi River, was also used.

Nineteen transects, spaced 4 km apart, were flown to provide uniform coverage of the Marromeu complex. The average length of each transect was 80 km toward the mouth of the Zambezi and 30 km at the upstream edge of the floodplain-miombo forest ecotone. An additional transect was flown down the length of the Zambezi River from Marromeu Village to the Indian Ocean coast. Transects were flown at an average height of 90 m above ground level, at an average air speed of 100 knots. Navigation was undertaken by the pilot using an in-cockpit Global Positioning Satellite (GPS) system. GPS target points were determined by plotting all transect lines on an aviation map and determining the exact coordinates of the beginning and end of each transect. GPS navigation accuracy was verified using visual reference points and 1:250,000 scale maps.

All waterbird species that could be accurately identified were counted (Norton-Griffiths 1975). From landmarks, we estimated that large conspicuous waterbirds, including Wattled Cranes, storks, and pelicans, could be identified to a distance of 1.5 km on each side of the aircraft. Smaller and less conspicuous waterbirds, such as ducks, egrets, and herons, could be reliably identified to a distance of no more than 1 km on each side of the aircraft.

Waterbird counts were recorded by the front right and middle left passengers. The middle right and back left passengers assisted the counters. Species observed in pairs were recorded as such. Observations of large mammals, including elephants, Cape buffalo, and hippos were also recorded.

In addition to waterbird and mammal counts, we assessed the hydrology and vegetation of the Marromeu Complex. We noted water levels in the Zambezi River and the extent of flooding in the delta during the time of peak flooding conditions. We identified the major vegetation communities of the complex, their observable hydrological conditions, and the extent of wildfires across ecotones. We also noted the quality of waterways and degree of weed infestation.

Efforts to conduct ground surveys of the Marromeu Complex were suspended due to the presence of landmines on the main road to Marromeu village and in some of the floodplain areas. Efforts are now underway to further demine this area and improve accessibility (DNFFB 1995).

RESULTS AND DISCUSSION

Wattled Crane assessment

We counted 156 Wattled Cranes in the Marromeu floodplain (Table 1), including 58 pairs (74%) on territories and others in small flocks of 3-11 birds. Two observations were made of Wattled Cranes on nests. We observed a few Wattled Crane pairs in dambos in the miombo forests on the floodplain fringe.

Approximately 25% of the floodplain was not surveyed because of the 1 km "gray zone" between the transects. Significant double-counting was unlikely because few birds were observed in flight at any time during the survey, and was likely offset by possible missed observations of other Wattled Cranes. Under the assumption that 75% of the floodplain was accurately surveyed, we extrapolate a total population of 208 Wattled Cranes and 77 breeding pairs. Only the Okavango Delta (Bousfield 1986) and Kafue Flats (Konrad 1981) have reported a greater number of breeding pairs in one setting.

Hydrologic changes in the Zambezi Delta have tremendous implications for the overall breeding success of the Wattled Crane. Several months after Wattled Crane chicks fledge, the family groups temporarily leave their breeding territories and gather in flocks prior to the onset of the next breeding cycle. Bonds between parents and young dissolve and the immature birds join other non-breeders in the flocks and sexually mature but mated birds have an opportunity to meet potential mates (G. Archibald *pers. comm.*). Then the crane pairs return to breeding areas where they defend large territories in which they breed when water levels peak with the flood (Okavango Delta) or the rains and floods (Kafue floodplains).

Goodman (1990a) reported large flocks of Wattled Cranes on the Zambezi Delta in September of 1990. Our survey was in March, a time when most large flocks of cranes had dispersed. For other crane species during the non-breeding period, approximately 15% of the population is comprised of juveniles on average. Approximately 50% of the population is of breeding age, many of which are not successful each year (C. Mirande *pers. comm.*). Assuming a population of 2,570 cranes, we would expect about 642 breeding pairs, or approximately 1,285 cranes should be in breeding pairs. However, only 77 pairs were calculated to be resident on the Delta in March of 1995. Most of the remaining pairs must be elsewhere.

. In Botswana, surveys by Mangabuli and Motalaote (*this proceedings*) during the peak breeding season revealed that only 3.1% of the resident Wattled Cranes had nests, and 4.1% had either young chicks or juveniles. Konrad (1981) observed 64.3% as breeding pairs in the wetlands of Zambia during 1978-79. More recent surveys by Kamweneshe (*this proceedings*) in the Bangweulu Basin during the peak nesting period in July report 40 adults in pairs and 30 in threes out of an estimated population of 1,453, suggesting a breeding population of no more than 11.6 %. Dodman (*this proceedings*) also notes that at least 70% of the Wattled Crane population remained in flocks during the middle of the breeding season in the Kafue Flats in 1992, and perhaps only 20% of the population was breeding during better flooding conditions in 1993.

Considering the vast distances migratory cranes cover in their annual movements, it is not unreasonable to assume that Wattled Cranes from South Africa, Zimbabwe, and eastern Zambia may move to the Zambezi Delta prior to the breeding season and that the delta is therefore important in the welfare of a much large segment of the world's population of Wattled Cranes than previously assumed. Answering such questions necessitates future research using marked birds or satellite radio telemetry.

Assessment of other waterbirds

Twenty-nine waterbird species totaling 5,930 individuals were counted during the transect surveys (Table 1). *Egretta alba, E. intermedia, and E. garzetta* were each observed but could not be distinguished with certainty in some instances.

Six species of storks were observed, including a substantial populations of 1,896 African Openbilled Storks (*Anastomus lamelligerus*) concentrated in large flocks on sandbars of the lower Zambezi River. A total of 2,234 Openbills were reported from all other areas in Southern Africa in the 1995 African Waterfowl Census (Dodman and Taylor 1995), 7,065 were reported in 1994 (Taylor and Rose 1994). Thirty-six endangered Saddlebilled Storks (*Ephippiorhynchus senegalensis*) were observed.

Nine pairs of Grey Crowned Cranes (*Balearica regulorum*) were observed. Most of the Grey Crowned Cranes observed were associated with Wattled Crane territorial pairs.

Only nine Eastern White Pelicans (*Pelecanus onocrotalus*) were observed, although major breeding colonies were reported in earlier surveys by Goodman (1992b).

The relatively few observations of ducks and geese probably reflect the inadequacies of aerial sampling, although clearly the substantial waterfowl populations reported by Anderson *et al.* (1990) during September 1990 and Goodman (1992b) during April 1992 were not present at the time of this survey.

Mammal assessment

Repeated mammal surveys have been conducted in the Marromeu complex since 1968 as reported in Tinley (1969), Tinley and Sousa Dias (1970), Tello and Dutton (1979), Anderson *et al.* (1990), and Goodman (1992b). The civil war in Mozambique prevented surveys between 1979 and 1990. Our surveys further confirm the dramatic decline in large mammal species that has occurred since the civil war and the closure of the Cahora Bassa dam.

Tello and Dutton (1979) observed 55,595 Cape Buffalo in 1977, 43,992 in 1978, and 30,394 in 1979. By 1990, only 3,696 were observed (Anderson *et al.* 1990). In the present survey, an estimated 1,000 Cape buffalo were counted. The buffalo occurred in three separate herds in the open floodplains.

Similarly, counts of 40,300 and 47,227 waterbuck were reported in 1968 (Tiney 1969) and 1978 (Tello and Dutton 1979), respectively. The 1990 survey team observed 4,480 (Anderson *et al.* 1990), and only a few hundred waterbuck were observed during the present survey. Almost no zebra were observed, down from a peak count of 2,720 in 1979 and 2,820 in 1977, respectively (Tello and Dutton 1979). A few observations were recorded of Lichtenstein's hartebeest and sable antelope.

The decline in elephant and hippo is perhaps even more recent. A population of 330-360 elephants was reported in surveys in the last 1970s and 1990. We observed only 36 elephant, all in one herd in a patch of mesic forest surrounded by floodplain. Only a few hippos were observed during our survey.

No direct signs of active hunting or hunting camps were observed during the surveys. Anderson *et al.* (1990) reported six hunting parties and five temporary camps. Hunting parties were heavily armed with automatic weapons, likely part of a commercial operation that included air lifting of dried meat by helicopter. The decrease in hunting parties observed during the current survey is likely a sad reflection of the fact that most of the mammal populations are now so low as to be of limited commercial value relative to the effort required to locate and kill them.

Wetland assessment

Vegetation communities observed in the Zambezi Delta include dry acacia savanna and thickets in the upper delta and palm savanna along elevated streambanks and upper floodplain areas, deciduous miombo (*Brachystegia*) forests on the floodplain fringe, sedge and grassland floodplain interspersed with patches of mesic forest over much of the central delta, swamp forest in lowland depressions of the floodplain, papyrus swamps in oxbow meanders, and a few shallow open water bodies. Near the coast, the floodplain gives way to extensive mangrove swamps, and then coastal dunes and beach. Dambos occur throughout the miombo forest area, many appeared to be nearly dry.

We observed agricultural and livestock grazing fields around Marromeu and Luabo villages, but no agricultural development across most of the floodplain. Widespread settlement now occurs along the banks of the Zambezi River for subsistence fishing and agriculture.

More than 90% of the input to Cahora Bassa is regulated by the Kariba, Itezhi-Tezhi, and Kafue Gorge Dams. Before the Zambezi River was dammed at Kariba a regular flood cycle was observed with peak flows of 6,000 to 28,000 m^3/s in the lower Zambezi in February-March (Hughes and Hughes 1992). The flood regime is now greatly reduced, with only erratic flood discharges. During the current surveys in mid-March, the Zambezi River was several meters below bankfull discharge in even the lowest stretches of the delta. Much of the floodplain had little or no standing water.

Extensive burned areas were noted throughout the sedge and grassland floodplain, although we observed little evidence of fire in the forests or mangroves. Overgrazing and burning have become a severe problem in the delta area, where the regulated flood regimes have favored the spread of wildfires and the encroachment of grazing and browsing animals into the interior floodplain (Hughes and Hughes 1992). The shift from a patchwork of small fires set by local villagers to the widespread wildfires now occurring has serious repercussions for Wattled Cranes and other nesting birds in the delta.

IMPLICATIONS FOR RESTORING THE ZAMBEZI DELTA

The cessation of flooding has resulted in the severe degradation of the Zambezi Delta for both people and wildlife. Cahora Bassa, which began filling in 1974, "has the dubious distinction from an ecological perspective of being the least studied and possibly least environmentally acceptable major dam project in Africa." (Bernacsek and Lopez 1984). The dams have adversely affected the living standards of thousands of downstream households by lowering the floodplain's watertable, reducing the extent of seasonally flooded land used for flood recession agriculture and grazing of livestock, and decreasing the productivity of local fisheries (T. Scudder *pers. comm.*). The shrimp fisheries along the south bank of the Zambezi River have declined due to reduced flooding (Gammelsrod 1992). Large-scale commercial hunting, which has virtually extirpated most large mammals from the delta, has been facilitated by the drying conditions as well

Davies *et al.* (1975) predicted that the dam would reduce fisheries productivity, reduce silt deposition and nutrient availability, lead to salt water intrusion and the replacement of wetland vegetation by upland species, result in the failure of vegetation to recover from grazing, and cause disrupted or mis-timed reproductive patterns for wildlife species. Scudder (1989) provides a general overview of river basin projects in Africa, many with impacts similar to these. Observations during the current surveys and by Anderson *et al.* (1990), Goodman (1992b), T. Scudder (*pers. comm.*), P. Dutton (*pers. comm.*), and others suggest that many of these predictions are or likely will occur. Future research will document these changes further.

Many of the problems facing the delta might be reversed through a program of carefully timed water releases from the Cahora Bassa Dam to simulate the natural flooding patterns in the delta. During a five-day period in March 1978, 1.27 billion m^3 of water was released from Cahora Bassa to protect the dam from over-topping after water levels in the reservoir reached an all-time high. A maximum discharge rate of 14,753 m^3/s was achieved by opening all eight flood gates simultaneously (Hughes and Hughes 1992). P. Dutton (*pers. comm.*) observed that floodplain conditions improved dramatically relative to previous years since the dam began filling, and were maintained for nearly two years afterwards.

The feasibility of future prescribed water releases to simulate natural flooding in the lower Zambezi River depends on the political and socio-economic trade-offs between water demands for hydroelectric power, irrigation, water transport, reservoir maintenance, and downstream release. The net benefits of prescribed water releases have been shown for other river systems in Africa, including the Manantali Dam on the Senegal River (Horowitz 1994), the Itezhi-Tezhi Dam on the Kafue River in Zambia (Acreman and Pirot *in press*), the Tiga Dam on the Hadejia River in Nigeria (Hollis 1989), and the Pongolapoort Dam on the Pongola River in South Africa (Bruwer *et al. in press*). Future research will test this hypothesis for the lower Zambezi.

CONCLUSION

Mozambique has only recently emerged from a brutal 15-year civil war that left it the world's poorest country, with ninety percent of the population in poverty, at least 200,000 orphans, one-third of all schools and hospitals destroyed or closed, at least three million people displaced from their homes, and more than one million lives lost, most of them civilian (Nordstrom 1990). Hundreds of thousands of landmines spread across the country have taken about 15,000 lives and will continue to do so for decades to come.

A precious resource like the Zambezi River, if managed wisely, can help form the backbone of Mozambique's recovery. Efforts to restore a home for people and wildlife in the Zambezi Delta will require international cooperation to demonstrate the national benefits of releasing prescribed floodwaters to the communities of the lower Zambezi. The plight of the endangered Wattled Crane may help serve as a symbol for the need to restore natural flooding patterns to great Zambezi Delta.

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REFERENCES CITED

Acreman, M. and J.-Y. Pirot, eds. *In press*. Hydrological management and wetland conservation in Africa. IUCN, Gland, Switzerland.

Anderson, J., P. Dutton, P. Goodman, and B. Souto. 1990. Evaluation of the wildlife resource in the Marromeu complex with recommendations for it's further use. LOMACO, Maputo, Mozambique.

Beilfuss, R., W. Tarboton, and N. Gichuki, eds., Proceedings of the 1993 African Crane and Wetland Training Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Bernacsek, G. M. and S. Lopez. 1984. Cahora Bassa. Page 62 *in* J. M. Kapetsky and T. Petr, eds., Status of African reservoir fisheries. Technical paper no. 10. FAO, Rome, Italy.

Bousfield, R. 1986. Wattled Cranes in the Okavango Delta. The Crowned Crane 2: 10.

Bruwer, C., C. Poultney, and Z. Nyathi. *In press*. Community based hydrological management on the Pongola floodplain. *In* M. Acreman and J.-Y. Pirot, eds., Hydrological management and wetland conservation in Africa. IUCN/World Conservation Union, Gland, Switzerland.

Davies, B. R., A. Hall, and P. B. N. Jackson. 1975. Some ecological effects of the Cabora Bassa Dam. Biological Conservation 8: 189-201.

Direcçao National de Florestas e Fauna Bravia (DNFFB). 1994. Gorongosa-Marromeu: Management plan for integrated conservation and development 1995-1999. DNFFB, Ministerio da Agricultura, Maputo, Moçambique.

Dodman, T. and V. Taylor. 1995. African waterfowl census 1995. IWRB, Slimbridge, UK, 192 pp.

Douthwaite, R. J. 1974. An endangered population of Wattled Cranes. Biological Conservation 6: 134-142.

Gammelsrod, T. 1992. Variation in shrimp abundance on the Sofala bank, Mozambique, and its relation to the Zambezi runoff. Estuarine, Coastal, and Shelf Science 35:91-103.

Goodman, P. S. 1992a. Wattled Cranes on the Marromeu floodplain. Pages 155-156 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern

African Crane Foundation, Durban, South Africa.

Goodman, P. S. 1992b. Zambeze Delta - an opportunity for sustainable utilisation of wildlife. IWRB News 8:12.

Hollis, G. E. 1989. Artificial flood releases for the Sahelian floodplain wetland between Hadejia and Goshua in northeastern Nigeria. Pages 236-241 *in* J. A. Kusler and S. Daly, eds., Wetlands and river corridor management. Association of Wetland Managers, Berne, New York, USA.

Horowitz, M. 1994. The management of an African river basin: alternative scenarios for environmentally sustainable economic development and poverty alleviation. Pages 73-82 *in* Koblenz, ed., Proceedings of the International UNESCO symposium: Water resources planning in a changing world. International Hydrological Program of UNESCO/OHP National Committee of Germany, Karlsrue, Germany.

Hughes, R. H. and J. S. Hughes. 1992. A Directory of African Wetlands. The World Conservation Union, Gland, Switzerland and Cambridge, UK / UNEP, Nairobi, Kenya / WCMC, Cambridge, UK, pp. 657-688.

Konrad, P.M. 1981. Status and ecology of Wattled Crane in Africa. Pages 220-237 *in* J. C. Lewis and H. Masatomi, eds., Crane Research Around the World. International Crane Foundation, Baraboo, Wisconsin, USA.

Meine, C. and G. Archibald, compilers. 1996. The cranes: status survey and conservation action plan. The World Conservation Union, Species Survival Commission, Gland, Switzerland and Cambridge, UK.

Nordstrom, C. 1993. Treating the wounds of war. Cultural Survival Quarterly 17(2):28-30.

Norton-Griffiths, M. 1975. Counting animals. African Wildlife Leadership Foundation, Nairobi, Kenya.

Scudder, T. 1989. River basin projects in Africa. Environment 31(2): 4-9; 27-32.

Taylor, V. and P. M. Rose. 1994. African waterfowl census 1994. IWRB, Slimbridge, UK. 184 pp.

Tello, L. P. and P. Dutton. 1979. Programa de Operacao Bufalo. Relatorio de Fauna Bravia, Maputo, Mozambique.

Tinley, K. L. 1969. First air count of the buffalo of Marromeu. Veterin. Mozam. Lourenco Marques 1(2):155-170.

Tinley, K. L. and A. Sousa Dias. 1970. Wildlife reconnaissance of the lower mid-Zambezi Valley, before the formation of the Cabora Bassa Dam, Mozambique. Mozambique, Reparticao Technica da fauna. Direccao dos Servicos Veterinaria.

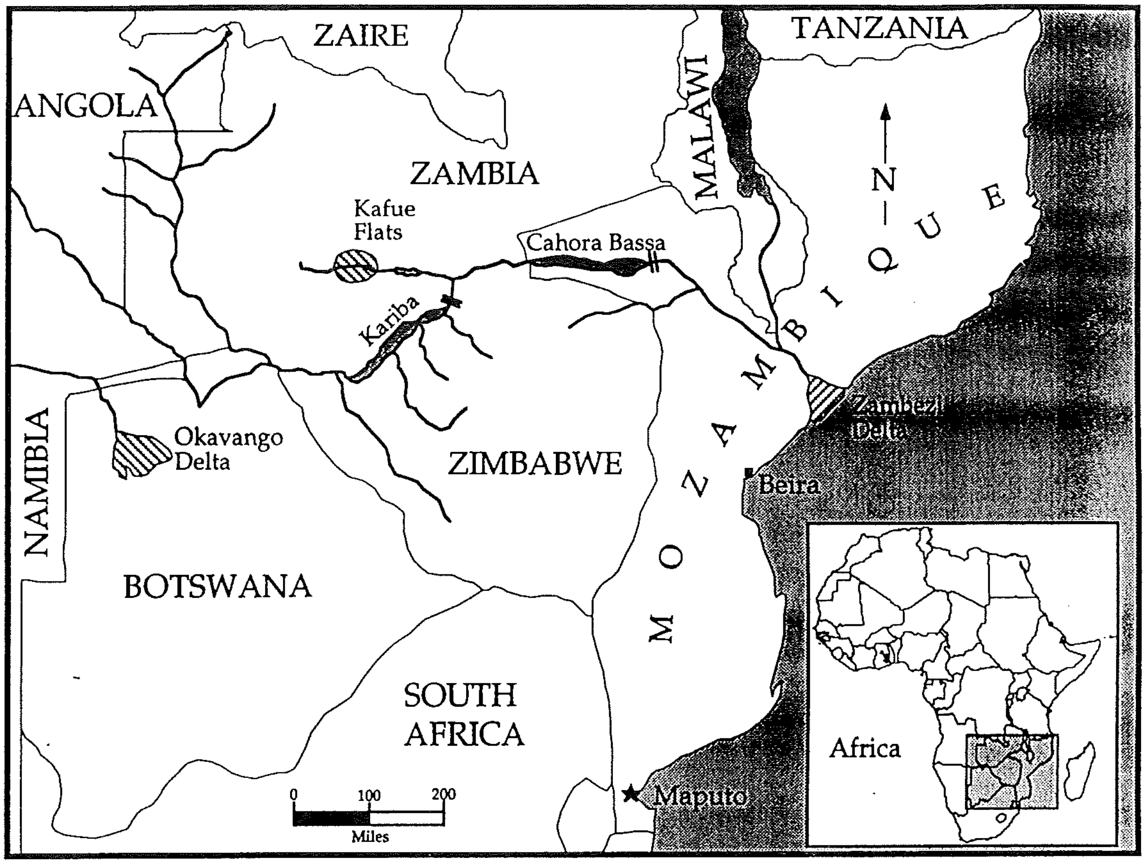

Figure 1. The Zambezi River of Southern Africa flows from headwaters in Zambia and Angola to its delta in coastal Mozambique. The massive Kariba and Cahora Bassa dams prevent most floodwaters from reaching the lower Zambezi River. Map by Milford Muskett.

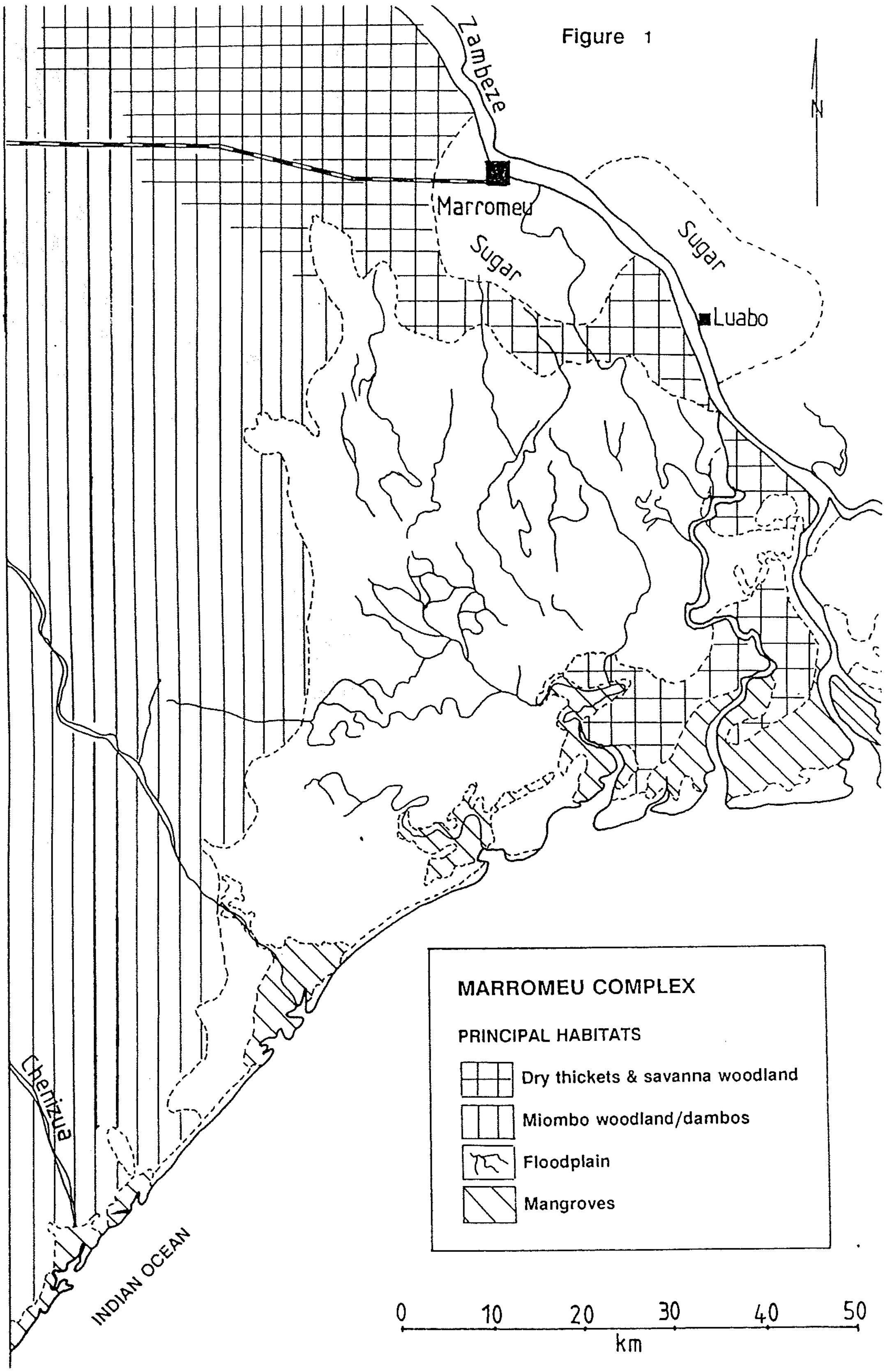

Figure 2. Major vegetation communities of the Marromeu Complex, Zambezi Delta (from Anderson *et al.* 1990).

Table 1. Results from waterbird surveys of the Marromeu Complex of the Zambezi River, March 1995.

Species	Count
Eastern White Pelican (*Pelecanus onocrotalus)*	9
Pinkbacked Pelican (*Pelecanus rufescens)*	65
Goliath Heron (*Ardea goliath)*	10
Purple Heron (*Ardea purpurea)*	2
Blackheaded Heron (*Ardea melanocephala)*	1
Egrets* (*Egretta* spp.)	289
Cattle Egret (*Bubulcus ibis)*	2,975
Black Stork (*Ciconia nigra)*	6
Abdmin's Stork (*Ciconia abdimii)*	30
Yellowbilled Stork *(Mycteria ibis)*	41
Marabou Stork (*Leptoptilos crumeniferus)*	52
Saddlebilled Stork (*Ephippiorhynchus senegalensis)*	36
African Openbilled Stork (*Anastomus lamelligerus)*	1,896
Woollynecked Stork (*Ciconia episcopus)*	6
Hamerkop *(Scopus umbretta)*	2
Glossy Ibis (*Plegadis falcinellus)*	73
Sacred Ibis *(Threskiornis aethiopicus)*	35
Spurwinged Goose (*Plectropterus gambensis)*	101
Knobbilled Duck (*Sarkidiornis melanotos)*	7
Whitefaced Duck (*Dendrocygna viduata)*	57
Fulvous Duck (*Dendrocygna bicolor)*	4
African Fish Eagle *(Haliaeetus vocifer)*	11
African Marsh Harrier (*Circus ranivorus)*	12
Wattled Crane (*Bugeranus carunculatus)*	156
Grey Crowned Crane (*Balearica regulorum)*	25
Longtoed Plover (*Vanellus crassirostris)*	21
Greyheaded Gull (*Larus cirrocephalus)*	3
Total	5,930

*Great White Egrets (*Egretta alba*), Yellowbilled Egrets (*Egretta intermedia*), and Little Egrets (*Egretta garzetta*) were not differentiated during aerial surveys, but all three species were observed

POPULATION STRUCTURE AND BREEDING HABITS OF THE BLUE CRANE IN THE WESTERN CAPE PROVINCE AND THE KAROO, SOUTH AFRICA[1]

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ABSTRACT

The mean group size of Blue Cranes (*Anthropoides paradiseus*) in the semi-arid Karoo biome was smaller than in an agricultural region of the Western Cape Province, both in South Africa. The median and modal group size in both regions, however, was two. Although groups of one to four birds comprised the most frequent group sizes, the majority of cranes were found in larger groups. Mean group sizes in both regions were smaller in summer than in winter. Mean flock sizes also were smaller in the summer in the Western Cape Province. The proportion of breeding pairs relative to the total adult population was 28% in the Western Cape Province and 47% in the Karoo. Only a minority of breeding pairs (25-33%) joined flocks in the winter. Egg-laying was earlier in the Western Cape Province than in the grassland biome. There was a dichotomy in the choice of nest sites between the Western Cape Province and the grassland biome. In the former region most nests were in agricultural fields or cultivated pastures and were distant from wetlands. In the grassland biome most nests were in natural grassland and were associated with wetlands. The most commonly recorded nest material was vegetation, followed by small stones and mammal feces. Only a minority of nests had no nest material. The usual clutch size was two eggs. The mean unfledged brood size (1.6) was larger than the mean fledged brood size (1.3). One brood apparently containing three fledged young was recorded. The proportion of pairs with fledged young in the post-breeding period was 58% and was similar in the Karoo and Western Cape Province. The percentage of juveniles in the population in the post-breeding period was 9-12% in the Western Cape Province and 14-17% in the Karoo. In the former area, reproductive success during the breeding seasons of 1991-92 and 1992-93 apparently was higher than during the previous two seasons.

INTRODUCTION

Individuals of all species of cranes, including the Blue Crane (*Anthropoides paradiseus*), rarely are found alone. Mated pairs remain together throughout the year, often accompanied by one or two juveniles from their previous breeding attempt (e.g., Tarboton *et al.* 1987a). The juvenile dependence period is protracted and young usually stay with their parents throughout most of the first year of their lives (e.g., Tacha 1988). Juveniles can be distinguished from adults by subtle differences in plumage and soft-part coloration (e.g., Lewis 1979). Many mated pairs and families join flocks of conspecifics during the non-breeding period (e.g., Nesbitt and Williams 1990) but even within these flocks, pairs and families remain in close proximity (e.g., Tacha and Vohs 1984). Flocks of cranes, however, can be found at all times of the year (e.g., Tarboton 1992). Individuals in flocks in the breeding season presumably comprise pairs that are not breeding or already have failed in that season, and unmated birds. The age of first breeding in cranes is two to six years (Cramp and Simmons 1980; Nesbitt and Wenner 1987; Nesbitt 1989; Tacha *et al.* 1989; Nesbitt 1992), and therefore many cranes in flocks probably are unmated birds. In most cranes, including the Blue Crane, only two age classes can be identified in the field, juveniles (first year) and adults. The proportion of birds occurring as non-breeders in flocks during the breeding season can be relatively high, indeed frequently over 50% (e.g., Melvin *et al.* 1990; Tarboton 1992).

Most cranes breed in wetlands, but two species, the Blue and Demoiselle (*A. virgo)* Cranes, breed in dryland habitats (Johnsgard 1983). The breeding biology of wild Blue Cranes has not been investigated in detail, except for one study in Natal (Walkinshaw 1963). Additional information on nest sites, breeding seasons, clutch sizes,

[1]Addendum to the Proceedings. Adapted from Allan, G. 1993. Aspects of the biology and conservation status of the Blue Crane *Anthropoides paradiseus*, and the Ludwig's *Neotis lugwigii* and Stanley's *N. denhami stanleyi* Bustards in Southern Africa. M.S. Thesis. University of Cape Town, South Africa.

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hatching success, and brood sizes in Blue Cranes is presented by Walkinshaw (1973), Geldenhuys (1984), Maclean (1985), Siegfried (1985), Tarboton *et al.* (1987b), Brown (1992), Filmer and Holtshausen (1992), and Vernon *et al.* (1992).

The proportion of juvenile (post-fledging) cranes in the population, as assessed during the post-breeding period, has been used to estimate the breeding productivity of many crane species (e.g., Miller and Hatfield 1974). These data also have been used as a basis for assessing the conservation status of cranes. For example, Archibald *et al.* (1981) state that healthy populations of cranes should have about 10-15% juveniles in the post-breeding period. This study presents the first data on age ratios in Blue Cranes.

AIMS

The aims of this study on the Blue Crane were to examine:

- the population structure of the species, including group sizes and the relative proportions of breeding pairs, non-breeding birds, and juveniles;
- the breeding habits of this crane, including egg-laying periods, nest sites, clutch and brood sizes, and the proportion of breeding pairs with fledged young in the post-breeding period.

STUDY AREAS AND METHODS

Most of the observations on Blue Cranes used in this study were collected during road counts made in an agricultural region situated in the southwestern part of the Western Cape Province (hereafter called the 'southwestern Cape') and also in the semi-arid Karoo biome, both in South Africa (Allan 1992, 1993). The study period spanned 1988 to 1993. The methods employed during all of the counts were similar. The vehicle was stopped briefly when cranes were seen and details of the time of day, locality, group size, age classes, activity, and habitat were recorded. During the stop, all cranes visible in the area were considered as part of the same group even if they were relatively widely dispersed. The same details were recorded for cranes seen at other times so that these additional data could be incorporated in the study where relevant.

In assessing group sizes of cranes, chicks (i.e., less than full size and incapable of proper flight) were disregarded. Data on chicks, however, were used in assessing brood sizes, breeding seasons, etc. Two age classes of fully grown cranes were discernible, adults and juveniles. Juveniles (i.e., fully grown and capable of flying but less than 12 months old) were distinguished from 'adults' (i.e., over 12 months old) by their less 'bulbous' head shape, uniformly colored heads (adults have a pale crown), brownish tinge to their upperparts, and especially their lack of elongated inner tertials (Urban *et al.* 1986; *pers. obs.*). In discussing group sizes the following terminology is used: 'singletons' refers to sightings of single adult cranes (juveniles were never seen alone), 'airs'refers to two adult cranes, 'families' refers to two adults with one or two juveniles (or chicks), and 'flocks' refers to aggregations containing more than two *adult* cranes. The term 'group' refers to all four of these combinations.

Details were recorded of all breeding Blue Cranes seen with eggs, unfledged chicks, and fledged juveniles during road counts and at other times. These details included: date, locality, habitat, proximity to wetlands, nest structure, clutch size, and brood size and age. Forty-three nests with eggs were recorded (southwestern Cape - 32, Transvaal grassland - 10, Karoo - 1), 52 pairs with unfledged chicks (southwestern Cape - 34, Transvaal grassland - 8, Karoo - 10) and 281 pairs with fledged juveniles (southwestern Cape - 253, Transvaal grassland - 5, Karoo - 23). These data were collected during the period 1982-93 (southwestern Cape - 1990-93, Transvaal grassland - 1982-90, Karoo - 1987-91). The micro-structure of nineteen nest sites with eggs in the southwestern Cape was examined from photographs taken of these sites. Additional information on breeding in South Africa was obtained from the nest record card collection of the Southern African Ornithological Society (SAOS NRCs), which provided 161 breeding records (southwestern Cape - 47, grassland biome - 98, Karoo - 16), and the Cape Nature Conservation data bank, which provided 19 records of brood sizes in the southwestern Cape.

RESULTS

Group sizes

The mean group size in the Karoo (5.7, S.D.=9.6, range=1-63, n=92) was significantly smaller than in the southwestern Cape (12.6, S.D.=32.9, range=1-309, n=592; F=1.74, d.f.=591 and 91, P<0.01, F-test). The median and modal group size in both regions, however, was two. Although the smaller group sizes (one to four) were the most common, the majority of birds occurred in groups larger than this (Table 1, Figure 1). In the Karoo, groups of between one and four birds comprised 78.3% of groups (72/92) but 70.0% of birds (366/523) occurred in groups larger than this. In the southwestern Cape, groups of between one and four birds comprised 73.7% of groups (436/592) but 86.9% of birds (6,495/7,474) occurred in groups larger than this.

The mean flock size in the Karoo (17.6, S.D.=14.9, range=4-63, n=21) was smaller than in the southwestern Cape (33.8, S.D.=51.3, range=3-309, n=194) but this difference was not significant (t=0.6, d.f.=213, P>0.05, t

test).

Mean group sizes in the summer (November-March) were significantly smaller than in the winter (May-August) in both the Karoo (summer - 3.4, S.D.=5.5, range=1-31, n=52; winter - 8.7, S.D.=12.6, range=1-63, n=40; F=2.48, d.f.=39 and 51, P<0.01, F-test) and the southwestern Cape (summer - 5.4, S.D.=14.9, range=1-129, n=259; winter - 20.3, S.D.=44.0, range=1-309, n=261; F=2.78, d.f.=260 and 258, P<0.01, F-test).

The mean flock size in the southwestern Cape also was significantly smaller in the summer (19.0, S.D.=30.3, range=3-129, n=50) than the winter (43.9, S.D.=59.2, range=3-309, n=113; z=4.19, P<0.01, z test). Data on mean flock sizes in the Karoo were meager (summer - 15.8, S.D.=12.8, range=4-31, n=5; winter - 18.2, S.D.=15.8, range=5-63, n=16) and showed no significant difference between the summer and winter (U=36.5, P>0.05, Mann-Whitney U-test).

Table 2 and Figure 2 show the number and percentage of Blue Crane adults found as singletons, in pairs, and in flocks in the southwestern Cape by months. Table 3 provides the same data for the Karoo by seasons (summer, i.e., November-March, and winter, i.e., May-August). The overall proportion of adult cranes seen as singletons in both regions was small (0.8% in the southwestern Cape and 2.5% in the Karoo) and was slightly higher in the summer than in the winter. The overall proportion of adult birds found in pairs in both regions also was small but significantly higher in the Karoo (southwestern Cape - 10.9%, Karoo - 24.0%; χ^2=76,8, P<0.001, d.f.=1). A significantly higher proportion of pairs was found in both regions during the summer (southwestern Cape summer - 27.8%, winter - 6.0%; Karoo summer - 46.9%, winter - 12.4%). Road count data from the southwestern Cape, however, suggest that a large amount of the increase in the relative proportion of adult cranes found in pairs in the summer in this region was due to the summer emigration of many birds (Allan 1992, 1993) found there in flocks during the winter, rather than due to the increase in the actual number of cranes in pairs (Table 4, Figure 3). The mean number of adult Blue Cranes recorded in pairs per 100 km of road counts only increased from 6.4 (258 cranes/4,008 km) in the winter to 9.6 (336 cranes/3,505 km) in the summer. This difference (0.33 times increase in summer) is not significant and is lower than that suggested by the change in proportion from 6.0% in the winter to 27.8% in the summer (4.6 times increase in summer). The road count data suggest that about 33% of pairs join winter flocks, while the proportion data would suggest that about 78% of pairs join winter flocks. The Karoo road count data suggest a similar bias in the proportion data. The mean number of adult Blue Cranes recorded in pairs per 100 km of road counts only increased from 0.9 (36 cranes/4,065 km) in the winter to 1.2 (48 cranes/4,002 km) in the summer. This difference (0.25 times increase in summer), which cannot be tested statistically, is lower than that suggested by the change in proportion of adults in isolated pairs from 12.4% in the winter to 46.9% in the summer (3.8 times increase in summer). The road count data suggest that about 25% of pairs join winter flocks in the Karoo, while the proportion data would suggest that about 74% of pairs join winter flocks.

A feature of particular interest is the proportion of breeding pairs relative to the total population of Blue Cranes. The above data suggest that during the summer breeding period about 28% of adults in the southwestern Cape and 47% of adults in the Karoo were found in pairs; this difference was significant (χ^2=30.3, P<0.001, d.f.=1).

Breeding

Egg-laying dates

Eggs are laid in summer (August-April) throughout the range of the species, with only slight variation between regions (Table 5). The peak egg-laying period in the southwestern Cape and in the grassland biome is between October and December. Examining the data from these three months in the two regions suggests that egg-laying is significantly earlier in the southwestern Cape, i.e., there is a significantly higher proportion of records from October in this area. Egg-laying in the Karoo appears to occur evenly throughout the period September-February but data from this biome are few.

Nest sites

Most nests in the grassland biome (97%, 67/69) were in natural grassland and only two were in agricultural fields and cultivated pastures (Table 6). This is in marked contrast to the southwestern Cape where the majority (91%, 40/44) were found in agricultural fields and cultivated pastures. In the latter area 15 nests were in harvested cereal fields, three were in recently ploughed fields and 22 were in cultivated pastures. Most grassland biome nests were situated close to wetlands (55%, 35/64), either in marshes, close to watercourses, or adjacent to open water dams or pans. By contrast, the majority of southwestern Cape nests (79%, 37/47) were situated distant from wetlands. The most commonly recorded nest material was vegetation (dry seeds, twigs, grasses, sedges, *Typha*, *Phragmites*, maize and cereal stalks, roots), followed by small stones (arranged in a pad under the eggs) and pieces of dry mammal (usually sheep and cattle) feces. All these three major categories of nest material were found in nests in all three regions.

Table 7 presents details of the nest structure materials found in 19 southwestern Cape nests with eggs which were examined in detail. Only two nest sites had no material. Five types of material were found in the remaining nests: small stones, livestock feces, twigs, cereal stalks, and seeds (in descending order of number of nests with material). The total number of nest material items in nests with material ranged between six and 400 (mean=115.2, S.D.=95.1, n=17).

Clutch sizes

The modal clutch size is two eggs (88% of records, n=129, Table 8) with the remainder (12%) containing a single egg. Only two of the 15 observed single-egg clutches in Table 8 were confirmed by repeat visits (one during this study). The apparently higher proportion of nests with one egg in the southwestern Cape (14.9%) compared with the grassland biome (8.3%) is not statistically significant.

Brood sizes

All broods contained one or two young (Table 9) except for one pair seen with three fledged juveniles in the southwestern Cape during this study (on 8 March 1992 at 34°14'S/20°11'E). This unusual record has not been included in Table 9 or in the analysis presented below. The mean unfledged brood size (1.6, n=125) was significantly larger than the mean fledged brood size (1.3, n=149; χ^2=30.78, P<0,001, d.f.=1). Mean unfledged and mean fledged brood sizes did not differ significantly between the grassland, Karoo, and southwestern Cape regions (χ^2=0.89, P>0.05, d.f.=2, χ^2=3.28, P>0.05, d.f.=2, respectively).

Data from the southwestern Cape of young seen with their parents in flocks (Table 9) were not included in any of these analyses, although mean fledged brood sizes did not differ significantly between young seen with their parents in flocks and young seen with isolated pairs (1.25, n=152 *vs* 1.31, n=101, respectively; χ^2=0.75, P>0.05, d.f.=1).

Enough data exist from the southwestern Cape to allow some inter-annual comparisons of fledged brood sizes (Table 10). A comparison of the four breeding seasons between the summers of 1989-90 and 1992-93 revealed a significant difference in fledged brood sizes (χ^2=8.31, P<0.05, d.f.=3), with the summer of 1990-91 having relatively fewer broods of two young and the summer of 1992-93 having relatively more broods of two young than would be expected by chance. Expanding this analysis to include brood sizes from pairs with juveniles seen in flocks also shows that significantly more broods of two fledged young were recorded in 1992-93 (χ^2=11.80, P<0.01, d.f.=3). The two years 1990-91 and 1992-93 are the only two years which provide enough data on unfledged brood sizes for statistical testing. More two-chick broods also were recorded in 1992-93 (57.9%, n=19) than in 1990-91 (33.3%, n=15), but this difference was not significant (χ^2=1.23, P>0.05, d.f.=1). Road count data also indicate that 1992-93 was a particularly successful breeding season. A larger number of breeding pairs were recorded per 100 km (6.9) during the early summer of 1992-93 compared to three previous three summers for which data are available (1988-89 - 3.7; 1990-91 - 5.3; 1991-92 - 3.3).

Proportion of pairs with fledged young in the post-breeding period

In the southwestern Cape, the proportion of pairs with fledged young in the post-breeding period (February-April) varied between 51.5% and 73.1% (mean 60.1%, n=108 pairs) during 1989-93 (Table 11). A comparison between each of the four breeding seasons between 1989-90 and 1992-93 revealed no significant differences between any of these years in the proportion of pairs with fledged young (χ^2=3.46, P>0.05, d.f.=3). In the Karoo the proportion of pairs with fledged young in the late summer was 53.1% (n=49 pairs, Table 11) and did not differ significantly from that found in the southwestern Cape (χ^2=0.44, P>0.05, d.f.=1). These estimates were based on pairs seen alone, as pairs within flocks, especially when unaccompanied by juveniles, could not be identified reliably.

Age ratios

Table 12 presents data on the number of adult and juvenile Blue Cranes and the percentage of juveniles recorded in the southwestern Cape and Karoo during various late summer (February-April) and winter (May-August) months between 1988 and 1993. The data from September 1988 have been included in this table but are unreliable and have been excluded from the following analyses, as juvenile Blue Cranes closely resemble adults by September and some juveniles may have been overlooked during that month. Juvenile Blue Cranes were never seen alone and always were accompanied by their parents and/or were in flocks of conspecifics. An examination of the percentage of juveniles recorded in pairs and families compared to the percentage in small (3-10 birds) and large (>10 birds) flocks showed a significantly higher proportion of juveniles in pairs and families in both the southwestern Cape (χ^2=102.1, P<0.001, d.f.=1) and the Karoo (χ^2=10.92, P<0.001, d.f.=1). The percentage of juveniles recorded in the late summer (February-April) was significantly higher compared with the winter (May-August) in the southwestern Cape (late summer - 12.0%, winter - 8.8%; χ^2=11.36, P<0.001, d.f.=1) but not in the Karoo (late summer - 13.8%, winter - 16.7%, χ^2=0.25, P>0.05, d.f.=1). Comparing the percentage of juveniles in the southwestern Cape and Karoo showed a significantly higher proportion of juveniles in the Karoo in the winter (χ^2=9.29, P<0.005, d.f.=1) but not in the late summer (χ^2=0.24, P>0.05, d.f.=1).

Comparing the percentage of juveniles between years in the southwestern Cape revealed a significant difference between years, examining both the late summer (χ^2=17.19, P<0.001, d.f.=3; data from the four years 1990-93) and winter (χ^2=9.62, P<0.05, d.f.=4; data from the five years 1989-93) data. The percentage of juveniles was smaller in the late summer of 1991 and higher in the late summer of 1992, and was smaller in the winter of 1993 and again higher in the winter of 1992 . There was no significant difference in the Karoo between the percentage of juveniles in the late summer (χ^2=2.42, P>0.05, d.f.=1) and the winter (χ^2=0.17, P>0.05, d.f.=1), comparing the years 1988 and 1989.

A more direct method of measuring inter-annual differences in the number of juveniles in the southwestern Cape is to examine the number recorded during road counts (Table 13). The number of juveniles counted per 100 km in the late summer was highest in 1993 (10.4), followed by 1992 (7.2), with lower numbers in 1990 and 1991 (3.8 and 3.1, respectively; no data for 1989). The number of juveniles counted per 100 km in the winter was highest in 1992 (16.3; no data for 1993), with lower numbers in 1989, 1990, and 1991 (8.1, 9.8, and 9.7, respectively).

DISCUSSION

Group sizes

Three previous studies have examined group sizes in Blue Cranes (Geldenhuys 1984; Filmer and Holtshausen 1992; Vernon *et al.* 1992). All three make some attempt to distinguish between 'groups' (singletons and any aggregation of cranes) and 'flocks' (aggregations other than single birds, pairs, and families). A flaw in these studies is that groups of three, four, and even five cranes were assumed to be families but this was not confirmed by distinguishing juvenile cranes on plumage characters. Blue Crane pairs with three young have never been recorded prior to the single instance reported here from the southwestern Cape. The present study also found that flocks of three to five adult cranes were not unusual. Geldenhuys (1984) found no significant difference in flock sizes (data on group sizes are not mentioned) between seasons in the Orange Free State. Vernon *et al.* (1992) suggest that group sizes (data on flock sizes are not mentioned) were larger in the non-breeding season (winter) in the eastern Cape Karoo and grasslands. Filmer and Holtshausen (1992) suggest that both flock and group sizes were larger in winter (data from throughout South Africa). The latter two studies, however, do not provide statistical confirmation of their results.

Geldenhuys (1984) and Vernon *et al.* (1992) found that the proportion of the population found in isolated pairs or 'families' was higher in the summer. The finding by Geldenhuys (1984) that the proportion of the population consisting of isolated pairs increased from 6% in the winter to 28% in the summer, but that there was no significant difference in flock size between the two periods, suggests that a large proportion of the Orange Free State Blue Crane population comprised non-breeders. This is similar to the situation found in the southwestern Cape and Karoo, although flock sizes were found to be significantly smaller in the former region in the summer during this study. Vernon *et al.* (1992) suggest that at least 75% of Blue Crane breeding pairs join winter flocks but this estimate could be grossly inflated as it is based on an examination of the relative proportion of pairs compared with birds in flocks and therefore is subject to the same bias from migratory movements identified during this study.

Group sizes in different habitat types also have been presented but without any statistical analysis (Filmer and Holtshausen 1992). The largest reported flock size known to the author is of 800-1,000 birds seen near Graaf-Reinet in the Karoo on 6 August 1983 (Els and Els 1983).

Many of the singletons encountered during the summer (breeding) period during this study in the southwestern Cape and Karoo probably represented single members of mated pairs the partner of which was incubating and out of view. The increase in the proportion of singletons recorded during the summer supports this view.

Allan (*this proceedings*) presents details of the proportion of non-breeders in ten additional species of cranes. The high proportion of non-breeders found during this study in the Blue Crane is not unusual when compared with the data from these other species.

Breeding

Egg-laying dates

The finding that egg-laying occurs in the summer, mainly during October-December, throughout the South African range of the Blue Crane is not novel (Geldenhuys 1984; Siegfried 1985; Tarboton *et al.* 1987b; Vernon *et al.* 1992). This study, however, is the first to identify that egg-laying is significantly, if only slightly, earlier in the southwestern Cape. Winterbottom (1963) identified an earlier breeding peak in the winter-rainfall southwestern Cape, compared with the rest of the sub-continent, when examining the breeding seasons of the avifauna of southern Africa as a whole.

Nest sites

Walkinshaw (1963) provides the only previous detailed study of Blue Crane nest sites. The present study reveals that there is a clear dichotomy in the choice of nest sites by the species between the grassland biome and the southwestern Cape. In the former area Blue Cranes typically nest in natural vegetation close to water, while in the latter region they usually nest in agricultural fields or cultivated pastures away from wetlands. Walkinshaw (1963) was the first to identify the frequent use of small stones as a nest platform. The present study shows that this habit is ubiquitous throughout the South African range of the species but that vegetation is the most frequently recorded nest material and that the total absence of nest lining material is rare. The closely related Demoiselle Crane also lines its nests with small stones (Schoff 1991); a habit unknown in the other 13 wetland-nesting crane species. Walkinshaw (1963) found that nests situated in wetland habitats frequently were constructed of copious wetland vegetation, while eggs laid in dryland positions usually were placed on a platform of stones.

Clutch sizes

The Blue Crane clutch size data from this study confirm existing knowledge, i.e., a modal clutch of two eggs, occasionally one and very rarely three (Walkinshaw 1973; Maclean 1985; Brown 1992; Vernon *et al.* 1992). Walkinshaw (1963) found that in Natal hatching success was high: 89% of eggs hatched and in 93% of nests at least one egg hatched. Clutch sizes in cranes are conservative. All the *Grus* and *Anthropoides* cranes typically lay two eggs (Johnsgard 1983). The Crowned *Balearica* spp. and Wattled (*Bugeranus carunculatus*) Cranes are unusual; the former regularly laying three eggs (Walkinshaw 1973; Tarboton 1992) and the latter frequently having single egg clutches (Tarboton *et al.* 1987a). Allan (*this proceedings*) presents details of clutch sizes in all 15 species of cranes.

As the incubation period in the Blue Crane is about 30 days and the second egg is laid two or three days after the first (Walkinshaw 1963), it might be expected that about 7-10% of nests visited only once would have incomplete clutches. The majority of nests visited during this study and reported in the SAOS nest record cards were visited only once. This suggests that many, if not most, of the single egg clutches reported in Table 8 represent incomplete clutches.

Brood sizes

Filmer and Holtshausen (1992), based on data collected throughout South Africa, report that 50% of unfledged Blue Crane broods consisted of two young (n=92) and Brown (1992) found that 58% of broods (information on unfledged and fledged broods not distinguished) at Etosha Pan, Namibia, consisted of two young (n=12). During the present study 60% of unfledged broods consisted of two young and 30% of fledged broods consisted of two young. Although these data suggest an appreciable intra-brood loss of a single young in two young broods between hatching and fledging, it is obvious that both young from the typical two-egg clutch frequently survive. This is contrary to many statements that cranes rarely rear two young per breeding attempt (e.g., Johnsgard 1983). Allan (*this proceedings*) presents details of unfledged and fledged brood sizes in eight additional species of cranes and discusses the rearing of two young in cranes in more detail. The brood of three fledged young recorded in the southwestern Cape during this study is the only one reported for the Blue Crane and may have involved an 'adopted' juvenile, as reported once for the Redcrowned Crane (*G. japonensis*) (Masatomi 1972).

Proportion of pairs with fledged young in the post-breeding period

The data on the proportion of Blue Crane pairs with fledged young in the post-breeding period, which was based on observations of pairs which were not in flocks, could be biased if pairs with fledged young tend to avoid flocks. The alleged avoidance of flocks by pairs with juveniles has been claimed for the Eurasian (*G. grus*) and Sandhill (*G. canadensis*) Cranes (Miller and Hatfield 1974; Tacha and Vohs 1984; Alonso, Veiga, and Alonso 1987; Bishop 1988). Allan (*this proceedings*) presents details of the proportion of pairs with fledged young in the post-breeding period for four additional crane species.

Age ratios

The proportion of juvenile (post-fledging) birds in crane populations, as assessed during the post-breeding period, has been used widely to estimate the breeding productivity of many species (e.g., Miller and Hatfield 1974). These data also have been used as a basis for assessing the conservation health of cranes. For example, Archibald *et al.* (1981) state that healthy populations of cranes should have about 10-15% juveniles in the post-breeding period. The collection and interpretation of age-ratio data for cranes, however, must be done with care as the results can be influenced by several confounding variables. For example, the proportion of juveniles may change, not as a result of changes in breeding success, but due to a change in the number of adults, especially non-breeding birds, e.g., through migration into or out of the study region (e.g., Lovvorn and Kirkpatrick 1982). Caughley (1974) is particularly critical of the interpretation of age-ratio data in biological investigations. He shows that age-ratio data alone are totally unreliable in assessing population health. He points out that such data must be interpreted in conjunction with information on other aspects of population demography (proof of stability or rate and direction of population increase or decrease, and information on survival and fecundity). However, as age ratios usually are used (incorrectly) as an indirect estimate of these demographic factors, direct information on them renders age-ratio data redundant, at least as an indicator of population health.

The finding that the percentage of juveniles in the southwestern Cape was significantly higher in the late summer compared with the winter could reflect mortality of juveniles between the two periods. Similarly, the significantly higher percentage of juveniles in the Karoo in the winter, compared with the southwestern Cape, could reflect higher breeding success in the former region. These data, however, are biased by the large influx of Blue Cranes into the southwestern Cape during the winter (Allan 1992, 1993). It could be expected that these m grants might have had a lower proportion of juveniles if successful breeding adults from elsewhere were less likely to migrate into the region than unsuccessful and non-breeding adults.

The finding that lower proportions of juveniles occurred in large flocks, compared with data from isolated pairs and family parties, identifies the need to sample all groups when assessing age ratios. The lower proportion of juveniles counted in flocks compared with isolated pairs has been interpreted as evidence that pairs with fledged young tend to avoid flocks (e.g., Miller and Hatfield 1974; Tacha and Vohs 1984; Alonso, Veiga, and Alonso 1987; Bishop 1988). It is more likely, however, to be due to the presence of non-breeders in flocks, an alternative explanation apparently not previously suggested. The proportion of juveniles found in a sample of 42 poisoned Blue Cranes from the southwestern Cape in August 1991 (Allan and Ryan *this proceedings*) was 7.1% (3/42), which accords with the percentages of juveniles found during this study. Allan (*this proceedings*) presents details of the percentages of juveniles in 12 additional species of cranes. The information revealed by the present study suggests that the percentage of juveniles in Blue Crane populations is similar to that found in most other species.

Inter-annual breeding success in the southwestern Cape 1988-93

Table 14 presents the annual data (1988-93) from the southwestern Cape on various aspects of breeding that might be expected to be associated with breeding productivity. In all entries in this table larger values could be expected to reflect higher breeding effort and success. The data in the table are incomplete, especially for the 1988-89 breeding season. These data do not unequivocally identify years of higher and lower breeding success, but they suggest that the breeding seasons of 1991-92 and 1992-93 had higher breeding productivity than the seasons of 1989-90, 1990-91 and, perhaps, 1988-89. The significantly lower proportion of juveniles counted in the winter of 1993 is surprising considering the evidence from other sources suggesting that the previous breeding season had high breeding success. As discussed above, however, this value could be biased by the influx of Blue Cranes from elsewhere into this region during the winter.

Rainfall patterns in this region during the study period do not clarify this issue (Figure 4). Rainfall immediately preceding the 1988-89 and 1990-91 breeding seasons was poor, that preceding the 1989-90 and 1992-93 was above normal, and that preceding the 1991-92 season was mixed, being above average in May-July and October, and low in August-September and November.

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REFERENCES CITED

Allan, D. G. 1992. Distribution, relative abundance and habitat of the Blue Crane in the Karoo and the southwestern Cape. Pages 29-46 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Allan, D. G. 1993. Aspects of the biology and conservation status of the Blue Crane *Anthropoides paradiseus*, and the Ludwig's *Neotis ludwigii* and Stanley's *N. denhami stanleyi* Bustards in southern Africa. M.S. Thesis. University of Cape Town, Cape Town, South Africa. Pp. 1-242.

Alonso, J. C., J. P. Veiga, and J. A. Alonso. 1987. Possible effects of recent agricultural development on the wintering and migratory pattern of Common Crane in Iberia: a study of winter ecology in a suitable habitat. Pages 277-299 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane

Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Archibald, G. W., Y. Shigeta, K. Matsumoto, and K. Momose. 1981. Endangered cranes. Pages 1-12 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Bishop, M. A. 1988. Factors affecting productivity and habitat use of Florida Sandhill Cranes: an evaluation of three areas in central Florida for a non-migratory population of Whooping Cranes. Ph.D. Thesis. University of Florida, Gainsville, Florida, USA.

Brown, C. J. 1992. The status of cranes in Namibia. Pages 73-78 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Caughley, G. 1974. Interpretation of age ratios. Journal of Wildlife Management 38: 557-562.

Cramp, S. and K.E.L. Simmons, eds. 1980. The birds of the Western Palearctic. Vol. 2. Oxford University Press, Oxford, UK.

Els, F. and M. Els. 1983. Blue Cranes (R216). Bloemfontein Bird Club Newsletter Nov. 1983: 2-3.

Filmer, R. J. and G. R. Holtshausen. 1992. The southern African crane census, 1985/1986. Pages 132-153 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Geldenhuys, J. N. 1984. The status of cranes (Aves: Gruidae) in the Orange Free State. South African Journal of Wildlife Research 14: 15-18.

Johnsgard, P. A. 1983. Cranes of the world. Indiana University Press, Bloomington, Indiana, USA.

Lewis, J. C. 1979. Field identification of juvenile sandhill cranes. Journal of Wildlife Management 43: 211-214.

Lovvorn, J. R. and C. M. Kirkpatrick. 1982. Recruitment and socially specific flocking tendencies of Eastern Sandhill Cranes. The Wilson Bulletin 94: 313-321.

Maclean, G. L. 1985. Roberts' birds of southern Africa. John Voelcker Bird Book Fund, Cape Town, South Africa.

Masatomi, H. 1972. Communal wintering of a Sandhill Crane with Japanese Cranes in Hokkaido, Japan. The Wilson Bulletin 84: 250-260.

Melvin, S. M., W. J. Stephen, and S. A. Temple. 1990. Population estimates, nesting biology, and habitat preferences of Interlake, Manitoba, Sandhill Cranes, *Grus canadensis*. Canadian Field Naturalist 104: 354-361.

Miller, R. S. and J. P. Hatfield. 1974. Age ratios of sandhill cranes. Journal of Wildlife Management 38: 234-242.

Nesbitt, S. A. 1989. The significance of mate loss in Florida Sandhill Cranes. The Wilson Bulletin 101: 648-651.

Nesbitt, S. A. 1992. First reproductive success and individual productivity in sandhill cranes. Journal of Wildlife Management 56: 573-577.

Nesbitt, S. A. and A. S. Wenner. 1987. Pair formation and mate fidelity in Sandhill Cranes. Pages 117-122 *in* J. C. Lewis, ed., Proceedings of the 1985 Crane Workshop. Platte River Whooping Crane Trust, Grand Island, Nebraska, USA.

Nesbitt, S. A. and K. S. Williams. 1990. Home range and habitat use of Florida sandhill cranes. Journal of Wildlife Management 54: 92-96.

Schoff, G. H. 1991. Reflections: the story of cranes. International Crane Foundation, Baraboo, Wisconsin, USA.

Siegfried, W. R. 1985. Relative abundance of cranes (Gruidae) in the Cape Province. Ostrich 56: 101-103.

Tacha, T. C. 1988. Social organization of sandhill cranes from midcontinental North America. Wildlife Monographs 99: 1-37.

Tacha, T. C. and P. A. Vohs. 1984. Some population parameters of sandhill cranes from mid-continental North America. Journal of Wildlife Management 48: 89-98.

Tacha, T. C., D. E. Haley, and P. A. Vohs. 1989. Age of sexual maturity of sandhill cranes from mid-continental North America. Journal of Wildlife Management 53: 43-46.

Tarboton, W. R. 1992a. The population status of the Crowned Crane in the Transvaal. Pages 10-19 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Tarboton, W. R., P. R. Barnes, and D. N. Johnson. 1987a. The Wattled Crane in South Africa during 1978-1982. Pages 353-361 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Tarboton, W. R., M. I. Kemp, and A. C. Kemp. 1987b. Birds of the Transvaal. Transvaal Museum, Pretoria, South Africa.

Urban, E. K., C. H. Fry, and S. Keith. 1986. The birds of Africa. Vol. 2. Academic Press, London, UK.

Vernon, C. J., A. F. Boshoff, and W. S. Stretton. 1992. The status and conservation of cranes in the Eastern Cape Province. Pages 47-72 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Walkinshaw, L. H. 1963. Some life history studies of the Stanley Crane. Proceedings of the Thirteenth International Ornithological Congress 13: 344-353.

Walkinshaw, L. H. 1973. Cranes of the world. Wincester Press, New York, USA.

Winterbottom, J. M. 1963. Avian breeding seasons in southern Africa. Proceedings of the International Ornithological Congress 13(2): 640-648.

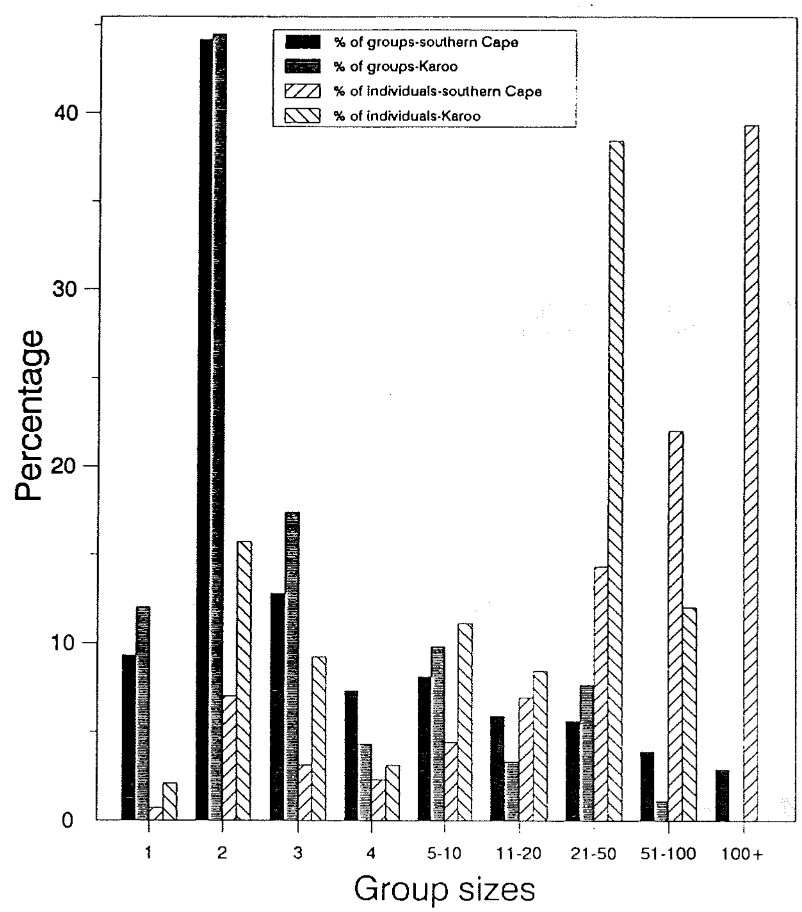

Figure 1. The percentage of groups and of individuals of Blue Cranes found in different group size classes in the Western Cape Province and the Karoo.

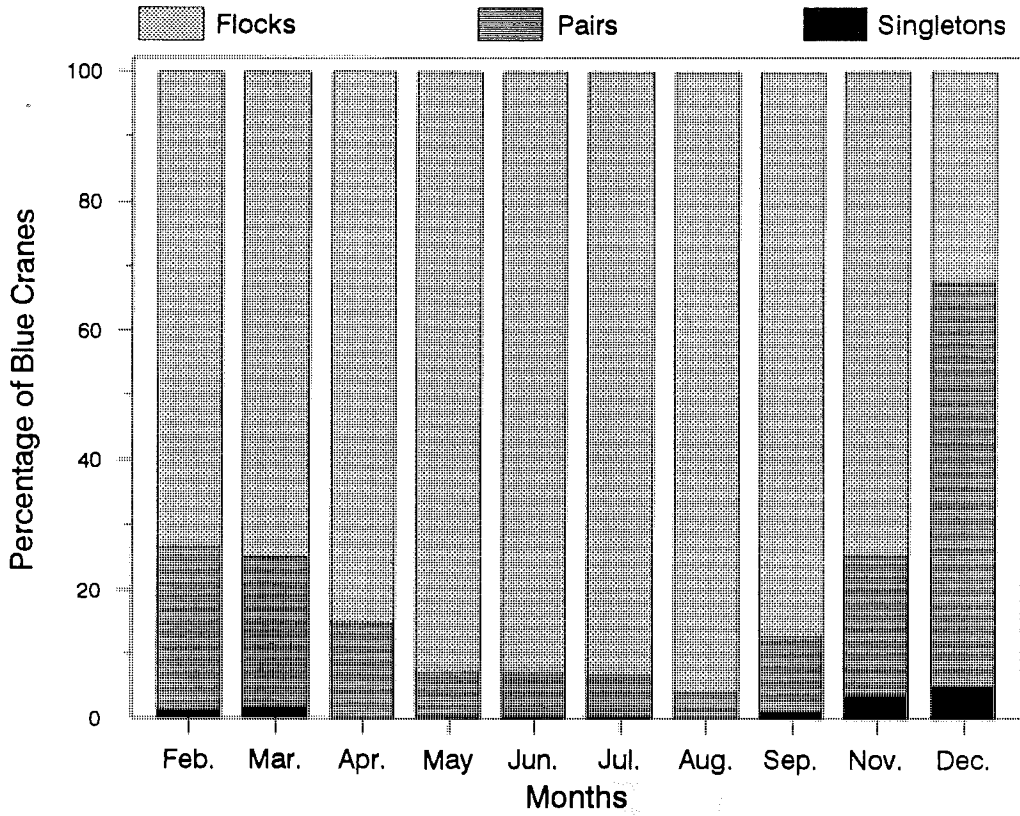

Figure 2. The proportion of Blue Cranes found in flocks, in pairs, and as singletons in the Western Cape Province during ten months of the year for which data were available.

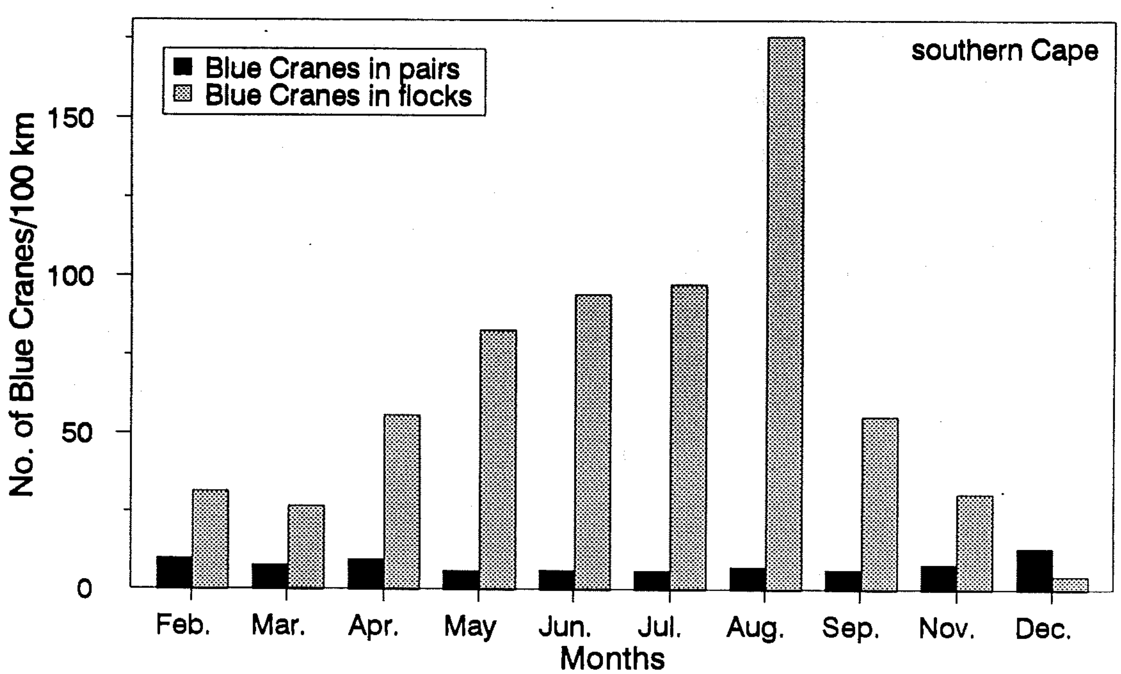

Figure 3. The number of Blue Cranes recorded per 100 km of road counts in the Western Cape Province during ten months of the year for which data were available, presented separately for cranes seen in flocks and in pairs.

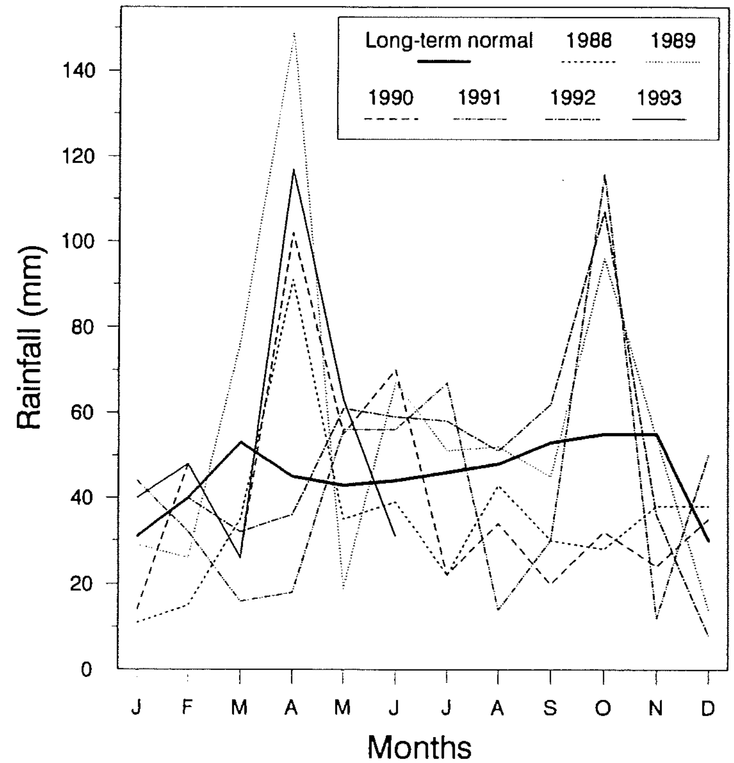

Figure 4. Monthly rainfall figures for the Western Cape Province study area for the six years 1988-93 and the long-term normal for each month. Data are the mean from three rainfall stations: Cape Agulhas (34°50'S/20°01'E), Swellendam (34°01'S/20°27' E), and Riversdale (34°05'S/21°15'E).

Table 1. Summary of group size structure for Blue Cranes in the Karoo and Western Cape Province.

Group size	Karoo No. of groups	Karoo % of groups	Karoo No. of inds	Karoo % of inds	Western Cape No. of groups	Western Cape % of groups	Western Cape No. of inds	Western Cape % of inds
1	11	12.0%	11	2.1%	55	9.3%	55	0.7%
2	41	44.5%	82	15.7%	262	44.2%	524	7.0%
3	16	17.4%	48	9.2%	76	12.8%	228	3.1%
4	4	4.3%	16	3.1%	43	7.3%	172	2.3%
5-10	9	9.8%	58	11.1%	48	8.1%	327	4.4%
11-20	3	3.3%	44	8.4%	35	5.9%	517	6.9%
21-50	7	7.6%	201	38.4%	33	5.6%	1,070	14.3%
51-100	1	1.1%	63	12.0%	23	3.9%	1,641	22.0%
100+	-	-	-	-	17	2.9%	2,940	39.3%
Total	92		523			592		7,474

Table 2. The number and percentage of Blue Crane adults found as singletons, in pairs and in flocks in the Western Cape Province by months.

Month	Singletons No.	Singletons %	Pairs* No.	Pairs* %	Flocks No.	Flocks %	Total
January	-	-	-	-	-	-	-
February	4	1.6%	64	25.2%	186	73.2%	254
March	8	1.9%	98	23.3%	314	74.8%	420
April	0	0.0%	58	15.0%	329	85.0%	387
May	2	0.4%	40	6.8%	543	92.8%	585
June	4	0.4%	74	6.7%	1,029	92.9%	1,107
July	8	0.4%	124	6.4%	1,815	93.2%	1,947
August	0	0.0%	44	4.1%	1,042	95.9%	1,086
September	4	1.3%	36	11.6%	269	87.1%	309
October	-	-	-	-	-	-	-
November	20	3.9%	110	21.6%	379	74.5%	509
December	7	5.2%	84	62.2%	44	32.6%	135
Total	57	0.8%	732	10.9%	5,950	88.3%	6,739

*Summer (Nov.-Mar.)/winter (May-Aug.) difference significant (χ^2=504.0, P<0.001, d.f.=1)

Table 3. The number and percentage of Blue Crane adults found as singletons, in pairs and in flocks in the Karoo in the summer (November-March) and winter (May-August).

Season	Singletons No.	Singletons %	Pairs No.	Pairs %	Flocks No.	Flocks %	Total
Summer	9	5.6%	76*	46.9%	77	47.5%	162
Winter	3	0.9%	40*	12.4%	279	86.7%	322
Total	12	2.5%	116	24.0%	356	73.5%	484

*Summer/winter difference significant (χ^2=75.0, P<0.001, d.f.=1)

Table 4. The number of Blue Crane adults seen in pairs and in flocks during road counts in the Western Cape Province by months.

Month	No. km	Cranes in pairs/100 km*	Cranes in flocks/100 km
January	-	-	-
February	583	10.3	31.9
March	1,157	8.1	27.1
April	588	9.9	56.0
May	605	6.3	83.3
June	1,089	6.4	94.5
July	1,723	6.2	97.9
August	591	7.5	176.3
September	483	6.6	55.7
October	-	-	-
November	1,172	8.5	31.1
December	593	13.8	4.7

*Summer (Nov.-Mar.)/winter (May-Aug.) difference not significant (U=13, P>0.05, Mann-Whitney U-test)

Table 5. **Egg-laying dates of Blue Cranes in various regions of South Africa.**

Region	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	n=	Source
			Number of records per month								
Southwestern Cape											
study area	-	*2*	*25*	*25*	*6*	*6*	*1*	-	-	*65*	*this study*
other areas	-	*3*	*13*	*14*	*12*	*4*	-	-	-	*46*	*SAOS NRCs*
total	-	5	38*	39	18	10	1	-	-	111	
Karoo											
study area	-	*3*	*2*	*1*	*5*	*2*	-	-	-	*13*	*this study*
other areas	-	*1*	*2*	*3*	*1*	*3*	*3*	-	-	*13*	*SAOS NRCs*
total	-	4	4	4	6	5	3	-	-	26	
Orange Free State grassland and Karoo											
total	-	1	9	17	15	9	3	2	1	57	Geldenhuys (1984)
Grassland											
Transvaal	*2*	*9*	*38*	*82*	*36*	*8*	*1*	*1*	-	*177*	*Tarboton et al. (1987)*
Natal	-	*2*	*9*	*20*	*11*	-	-	*1*	-	*43*	*SAOS NRCs*
Eastern Cape	-	*1*	*4*	*7*	*2*	-	-	*1*	-	*15*	*SAOS NRCs*
total	2	12	51*	109	49	8	1	3	-	235	
Total (all regions)	2	22	102	169	88	32	8	5	1	429	

*Significantly higher proportion of Oct. records in SW Cape than in grassland (χ^2=7.5, P<0.05, d.f.=2)

Table 6. Details of Blue Crane nest sites in various regions of South Africa, where Nat. veg. = natural vegetation and Agric. land = agricultural fields or cultivated pastures.

Region	Habitat: Nat. veg.	Habitat: Agric. land	Close to wetland?: Yes	Close to wetland?: No	Nest structure: Stones	Nest structure: Veg.	Nest structure: Feces	n=
Grassland								
total	67*	2*	35*	29*	8	22	3	82
Karoo								
total	3	0	1	2	1	1	1	10
Southwestern Cape								
SAOS NRCs	*4*	*8*	*5*	*10*	*3*	*4*	*1*	*19*
This study	*0*	*32*	*5*	*27*	*8*	*15*	*8*	*32*
total	4*	40*	10*	37*	11	19	9	51
Total (all regions)	74	42	46	68	20	42	13	143

*Significant difference between grassland and Southwestern Cape (habitat - χ^2=81.5, close to wetland - χ^2=11.4, P<0.001 and d.f.=1 for both)

Table 7. **Details of the nest structure of 19 Blue Crane nests in agricultural fields and cultivated pastures of the Western Cape Province.**

Nest no.	No. small stones	No. pieces livestock feces	No. short thick twigs	No. dry cereal stalks	No. dry medic seeds	Total items
1	-	-	75	-	-	75
2	-	-	-	40	-	40
3	-	6	-	2	-	8
4	60	60	20	-	-	140
5	-	20	40	-	-	60
6	-	50	75	-	-	125
7	100	-	60	-	-	160
8	-	-	150	-	-	150
9	-	75	-	-	75	150
10	-	-	10	-	-	10
11	75	-	-	-	50	125
12	100	20	-	-	-	120
13	-	6	-	-	-	6
14	-	30	20	-	-	50
15	250	-	150	-	-	400
16	100	-	10	20	-	130
17	-	-	-	-	-	0
18	-	-	-	-	-	0
19	200	-	10	-	-	210
Total nests	7	8	11	3	2	

Table 8. Clutch sizes of Blue Cranes in various regions of South Africa.

Region	1 egg	2 eggs	Total
Grassland			
Transvaal	*1*	*15*	*16*
Natal	*2*	*37*	*39*
Orange Free State	*2*	*4*	*6*
Eastern Cape	*1*	*10*	*11*
total	6*	66	72
Karoo			
total	2	8	10
Southwestern Cape			
SAOS NRCs	*1*	*17*	*18*
this study	*6*	*23*	*29*
total	7	40	47
Total (all regions)	**15***	**114**	**129**

*Not significantly different (χ^2=0.71, P>0.05, d.f.=1)

Table 9. Unfledged and fledged brood sizes of Blue Cranes in various regions of South Africa, where NRCs = data from SAOS nest record cards and from the Cape Nature Conservation data bank, out flocks = brood sizes of breeding pairs seen in family units, i.e., pair plus one or two young, and in flocks = brood sizes of pairs accompanied by one or two young and seen in flocks.

Region	Source		1 young	2 young	Total
UNFLEDGED					
Grassland					
Transvaal	*NRCs*		*6*	*6*	*12*
Transvaal	*this study*		*4*	*4*	*8*
Natal	*NRCs*		*5*	*10*	*15*
Orange Free State	*NRCs*		*0*	*1*	*1*
Eastern Cape	*NRCs*		*0*	*5*	*5*
total			15	26	41
Karoo					
study area	*this study*		*0*	*10*	*10*
other areas	*NRCs*		*5*	*1*	*6*
total			5	11	16
Southwestern Cape					
study area	*this study*		*16*	*17*	*33*
other areas	*NRCs*		*13*	*22*	*35*
total			29	39	68
Unfledged total (all regions)			49	76	125
FLEDGED					
Grassland					
Transvaal	*NRCs*		*2*	*1*	*3*
Transvaal	*this study*		*3*	*2*	*5*
Natal	*NRCs*		*1*	*1*	*2*
total			6	4	10
Karoo					
study area	*this study*		*20*	*3*	*23*
total			20	3	23
Southwestern Cape					
study area	*this study*	*out flocks*	*70*	*31*	*101*
other areas	*NRCs*		*13*	*2*	*15*
total			83	33	116
Fledged total (all regions)			109	40	149
Total fledged and unfledged (all regions)			158	116	274
(Southwest Cape	this study	in flocks	114	38	152)

Table 10. Fledged brood sizes of Blue Cranes in the Western Cape Province presented separately for each of the four summer breeding seasons between 1989-93.

Season	1 young	2 young	Total
1989-90	14	6	20
1990-91	23	3	26
1991-92	17	9	26
1992-93	14	13	27

Table 11. The number of Blue Crane pairs with and without fledged young in the post-breeding (late summer) period in the Western Cape Province and the Karoo.

Region and date	without young	with young	Total
Southwestern Cape			
March 1990	*9*	*10*	*19*
February 1991	*16*	*17*	*33*
March 1992	*7*	*19*	*26*
April 1993	*11*	*19*	*30*
total	43	65	108
Karoo			
late summer	*23*	*26*	*49*
total	23	26	49

Table 12. The number of adult and the number and percentage of juvenile Blue Cranes recorded in the Western Cape Province and Karoo between February and September, 1988-93.

Region and date	Singles ads	Singles juvs	Singles % juvs	Pairs/Families ads	Pairs/Families juvs	Pairs/Families % juvs	Flocks of 3-10 ads	Flocks of 3-10 juvs	Flocks of 3-10 % juvs	Flocks of >10 ads	Flocks of >10 juvs	Flocks of >10 % juvs	n=	Total % juvs
Southwestern Cape														
Sep.1988	*4*	*0*	*0.0%*	*36*	*1*	*2.7%*	*16*	*0*	*0.0%*	*223*	*8*	*3.5%*	*288*	*3.1%*
Jun.1989	*3*	*0*	*0.0%*	*18*	*3*	*14.3%*	*16*	*1*	*5.9%*	*435*	*34*	*7.3%*	*510*	*7.5%*
Jul.1989	*1*	*0*	*0.0%*	*32*	*2*	*5.9%*	*16*	*2*	*11.1%*	*348*	*32*	*8.4%*	*433*	*8.3%*
Mar.1990	*3*	*0*	*0.0%*	*44*	*17*	*27.9%*	*6*	*0*	*0.0%*	*172*	*5*	*2.8%*	*247*	*8.9%*
Jul.1990	*4*	*0*	*0.0%*	*20*	*6*	*23.1%*	*11*	*1*	*8.3%*	*652*	*48*	*6.9%*	*742*	*8.8%*
Feb.1991	*4*	*0*	*0.0%*	*66*	*19*	*22.4%*	*11*	*0*	*0.0%*	*175*	*1*	*0.6%*	*276*	*7.3%*
May1991	*2*	*0*	*0.0%*	*38*	*7*	*15.6%*	*38*	*8*	*17.4%*	*400*	*40*	*9.1%*	*533*	*10.3%*
Jul.1991	*3*	*0*	*0.0%*	*40*	*5*	*11.1%*	*26*	*2*	*7.1%*	*485*	*42*	*8.0%*	*603*	*8.1%*
Mar.1992	*5*	*0*	*0.0%*	*52*	*30*	*36.6%*	*25*	*0*	*0.0%*	*107*	*11*	*9.3%*	*230*	*17.8%*
Jun.1992	*1*	*0*	*0.0%*	*48*	*5*	*9.4%*	*36*	*7*	*16.3%*	*422*	*71*	*14.4%*	*590*	*14.1%*
Aug.1992	*0*	*0*	*0.0%*	*42*	*1*	*2.3%*	*27*	*4*	*12.9%*	*981*	*87*	*8.2%*	*1,142*	*8.1%*
Apr.1993	*0*	*0*	*0.0%*	*52*	*27*	*34.2%*	*49*	*6*	*10.9%*	*240*	*22*	*8.4%*	*396*	*13.9%*
Jul.1993	*2*	*0*	*0.0%*	*8*	*1*	*11.1%*	*7*	*1*	*12.5%*	*387*	*26*	*6.3%*	432	6.5%
total	32	0	0.0%	496	124	20.0%	284	32	10.1%	5,027	427	7.8%	6,422	9.1%
Karoo														
Mar. 1988	2	0	0.0%	22	4	15.4%	4	0	0.0%	30	1	3.2%	63	7.9%
Jul. 1988	2	0	0.0%	16	4	20.0%	15	1	6.3%	0	0	0.0%	38	13.2%
Mar. 1989	1	0	0.0%	28	14	33.3%	0	0	0.0%	38	1	2.6%	82	18.3%
Jul. 1989	1	0	0.0%	20	6	23.1%	20	7	25.9%	41	5	10.9%	100	18.0%
total	6	0	0.0%	86	28	24.6%	39	8	17.0%	109	7	6.0%	283	15.2%

Table 13. The number of juvenile Blue Cranes recorded per 100 km in the Western Cape Province between February and September, 1988-93.

Date	Juveniles/ 100 km	Late summer total	Winter total
1988			
September	2.0	no data	2.0
1989			
June	8.4		
July	7.8	no data	8.1
1990			
March	3.8	3.8	9.8
July	9.8		
1991			
February	3.1	3.1	9.7
May	10.4		
July	8.9		
1992			
March	7.2	7.2	16.3
June	16.0		
August	16.2		
1993			
April	10.4	10.4	no data

Table 14. Summary of information possibly associated with breeding effort and success in Blue Cranes in the Western Cape Province during the five breeding seasons between 1988 and 1993, where y = young, juvs = juveniles, and nd = no or few data.

Breeding season	Pairs/ 100 km spring	Mean unfledged brood size	Mean fledged brood size	% pairs with fledged young late summer	% juvs late summer	% juvs winter	Juvs/ 100 km late summer	Juvs/ 100 km winter
1988-89	3.7	nd	nd	nd	nd	7.8	nd	8.1
1989-90	nd	nd	1.3	52.6	8.9	7.4	3.8	9.8
1990-91	5.3	1.3	1.1*-	51.5	7.3*-	9.2	3.1	9.7
1991-92	3.3	nd	1.4	73.1	17.8*+	10.1*+	7.2	16.3
1992-93	6.9	1.6	1.5*+	63.3	13.9	6.5*-	10.4	

*- Significantly lower than the other values in that column
*+ Significantly higher than the other values in that column

MORPHOMETRICS, SEX RATIO, MOLT, AND STOMACH CONTENTS OF BLUE CRANES IN THE WESTERN CAPE PROVINCE, SOUTH AFRICA[1]

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SUMMARY

The morphometrics, sex ratio, remigial molt and stomach contents of 42 poisoned Blue Cranes (*Anthropoides paradiseus*) in the Western Cape Province of South Africa which died in August 1991 were examined. The sex ratio was exactly 1:1. Three birds were juveniles (first-year birds) and two appeared to be second-year birds. Males averaged larger than females in all dimensions but there was wide overlap between the sexes in measurements. None of the birds were in active molt during this winter non-breeding period. Primaries appear to be molted simultaneously and secondaries progressively but the pattern of secondary molt was complex and variable between individuals. There appeared to be differences between the sexes in patterns of secondary molt. Only vegetable matter was found in the stomachs in this winter sample, along with large amounts of grit.

INTRODUCTION

Cranes are monogamous and therefore can be expected to show sex ratios that do not differ significantly from parity. They do not show obvious sexual dimorphism in plumage and therefore data on sex ratios can be obtained only from specimen material (Johnsgard 1983). Detailed sex-ratio data, however, exist only for the Sandhill Crane (*Grus canadensis*). The assessment of sex ratios in this species usually is based on studies of hunted birds and is confounded by the apparently higher vulnerability of males to hunting. The only study based on specimens from natural mortality (Tacha and Vohs 1984) found that the sex ratio is slightly but significantly biased towards females.

There are relatively few published measurements of Blue Cranes (*Anthropoides paradiseus*) and, although females are thought to be slightly smaller than males, as in all other species of cranes, the magnitude of age and intersexual differences has not been described (Johnsgard 1983; Maclean 1993; Urban *et al.* 1986).

The flight feathers of most cranes reportedly are molted simultaneously, resulting in a flightless period (Johnsgard 1983). Such molt does not occur annually in each individual but only every second to fourth year (Stresemann and Stresemann 1966; Cramp and Simmons 1980). This molt pattern and associated flightlessness is found in members of at least 13 families (Stresemann and Stresemann 1966). The condition is associated with high wing-loading, which militates against gradual molt of the flight feathers, and use of aquatic habitats, which allows for predator avoidance during the flightless period (Heinroth and Heinroth 1958; Stresemann and Stresemann 1966).

Cranes are omnivorous, eating both vegetable and animal (mainly invertebrate) matter (Johnsgard 1983). They are largely vegetarian, however, and their carnivorous habits appear to have been over-estimated, or at least over-stressed, by some observers. In fact, an examination of the species accounts in Johnsgard (1983) confirms that vegetable matter predominates in at least 13 species. Only two species, the Whooping (*G. americana*) and Red-crowned (*G. japonensis*) Cranes, reportedly favor invertebrates, although both also take plant material. In the former species, diet has been studied only on the non-breeding grounds (Hunt and Slack 1989), while the diet of the latter is poorly known and requires further study to confirm the alleged preference for animal food. Cranes chicks of all species, however, appear to be fed largely on small invertebrates (Johnsgard 1983).

AIMS

The aims of this study were to examine morphometric variation, sex ratio, molt of the remiges, and stomach contents in a sample of poisoned Blue Cranes.

[1]Addendum to the Proceedings. Adapted from Allan, G. 1993. Aspects of the biology and conservation status of the Blue Crane *Anthropoides paradiseus*, and the Ludwig's *Neotis lugwigii* and Stanley's *N. denhami stanleyi* Bustards in Southern Africa. M.S. Thesis. University of Cape Town, South Africa.

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METHODS

The carcasses of 42 of 45 Blue Cranes which were killed when illegally poisoned by an unknown person near Rietpoel (34°15' S, 19°45' E) in the Western Cape Province of South Africa on 26 August 1991 were examined. They died from ingesting maize kernels soaked in diazinon, a sheep dip (A. Scott *pers. comm.*). These 42 specimens had been donated to the South African Museum, Cape Town, by the Western Cape Department of Nature Conservation and were offered to us for analysis. All of the carcasses were fresh and intact, except for five which had their stomachs removed for toxicological analysis prior to this examination.

Juveniles, i.e., cranes of less than one year old, were identified by their less 'bulbous' head shape, uniformly colored heads (adults have a pale crown), their lack of elongated inner tertials (Urban *et al.* 1986; D. Allan *pers. obs.*), and by the presence of buffy feathers, primarily in the greater, median, and lesser coverts, and on the flanks, belly, and thighs. The sex of each specimen was determined by examination of the gonads; only one specimen could not be sexed.

All of the carcasses were weighed and measured. Masses were measured to the nearest 50 g using a 10 kg Pesola spring balance. The masses of the five individuals which had their stomachs removed prior to examination were not incorporated in the results. The following morphological characters were measured to the nearest 1 mm using a stoppered wing rule: wing length (flattened chord from the carpal joint to the tip of the longest primary); the length of the longest tertial (from the feather insertion point to the tip); tail length (from the uropygial gland to the tip of the longest rectrix); and tarsus length (from the notch on the posterior side of the tibiotarsal joint to the anterior distal edge of the flexed tarsus, i.e., tarsometatarsus). Wingspans were measured to the nearest 2 mm using a tape measure, doubling the distance from the midline of the back to the tip of the longest primary on the fully stretched wing (after Pennycuick 1989). Vernier calipers were used to measure the following characters to the nearest 0.1 mm: total head length (from the occiput to the tip of the upper mandible); bill depth (measured vertically at the proximal edge of the nares); and two measures of bill length, one from the proximal edge of the nares to the tip of the upper mandible and the other from the start of the feathering on the mid-line to the tip of the bill. All measurements were made by one observer (P. Ryan).

The primary and secondary feathers of the outstretched right wing were examined for molt. Each feather was classified as 'old', 'just completed' ('very new'), 'new', or of unknown age.

The stomach contents of 36 of the 37 intact carcasses were examined. Stomach contents were sorted into food items and grit, and were then washed, counted, and weighed (to the nearest 0.01 g). Blotting paper was used to remove excess moisture from food items, which were then weighed while still damp, i.e., wet weight, while grit was dried in an oven before being weighed. Pieces of grit were too numerous in each stomach to be individually counted and therefore 100 pieces were chosen at random from each stomach and weighed. This weight was then compared with the total weight of grit in each stomach to estimate the total number of pieces. The length and width of 50 pieces chosen at random from all the combined stomach contents were measured to the nearest 0.01 mm using vernier calipers to assess the mean size of grit pieces.

RESULTS

Three individuals were juveniles, assumed to be about 9-12 months old; peak egglaying in this species occurs between September and December (Siegfried 1985). Two of the 'adults' retained a few juvenile (buffy-tipped) feathers and probably were second-year birds.

Sex ratio

The sex ratio among the 38 adults which could be sexed (out of 39) was exactly 1:1 (19 males and 19 females). The three juveniles were thought to be females, although their gonads were poorly developed.

Morphometrics

Among the adult Blue Cranes, males averaged larger than females in all dimensions (Table 1). The differences between sexes in bill length (both from the nares and from the start of the feathering) and longest tertial length were not significant (Table 1). The differences between sexes in mass, wing length, wingspan, tarsus length, total head length, and bill depth were significant. Mass, however, tended to have the greatest coefficient of variation and probably varies seasonally to a greater extent than linear measurements of size. The difference between sexes in tail length was near significant ($P<0.1$). There was considerable overlap between male and female size ranges (Figure 1), which makes univariate measures inadequate for predicting the sex of birds from external measurements. Discriminant function analysis (Sneath and Sokal 1973) was used to identify multivariate predictors of sex. Based on five variables: DF=0.29225 total head length - 0.32250 bill length (measured from the nares) + 0.01117 wing length + 0.00789 tarsus length + 0.00621 tail length., where positive DF values indicate males, negative DF values indicate females (group centroids: male-0.76, female-0.76). This technique, however, misclassified 26% of males and 11% of females. The likelihood of misclassifying birds of unknown sex would be even greater.

Increasing the number of variables had little influence on the predictive ability of DF values. It is of interest that males appear to have relatively short bills compared with females, hence the negative factor loading on bill length.

Despite small sample sizes, juvenile Blue Cranes averaged smaller than adults (Table 1) suggesting that they are not fully grown at almost one year of age. All three juveniles were thought to be females and therefore are best compared with adult females. The greatest differences were in mass, with the three juveniles averaging 80-99% of adult female mean masses, and in the lengths of the tail and longest tertial (Table 1).

Molt

Full details of the remigial (primaries and secondaries) molt of the 42 birds are given in Appendix 1. None of the 42 birds examined showed active molt of the remiges, i.e., missing or growing feathers. All birds had 10 primaries and 14-18 secondaries (one second-year bird with 14 secondaries, nine birds with 16, 13 birds with 17, 11 birds with 18, and eight birds not counted). All birds had primaries of one age except for two birds which had primaries of two ages, an adult female (no. 16) and an adult male (no. 32). In these two individuals the outermost primaries were distinctly newer than the rest.

Secondaries of two or three different ages were found in 73% (27/37) of adults and both birds thought to be in their second year. The remaining 27% (10/37) of adults and the three juvenile birds had secondaries of one age. Three birds had secondaries of three different ages, two adult females (nos. 9 and 15) and one adult male (no. 31). Each had a single secondary classified as just complete, the remainder being new and of uncertain age. In two cases the just complete feather was the innermost secondary, while in the third it was secondary number 14 and was flanked by new feathers. In most cases (24/29), of birds with secondaries of different ages, the new or just completed secondaries were not interspersed with older secondaries but were directly adjacent to one another. In addition, these newer secondaries always occupied the most proximal part of the wing, with no older feathers positioned inside of them. The exceptions to this were five adult females (nos. 13-17) which had secondaries of different ages interspersed with one another but still with newer secondaries tending to be concentrated in the proximal part of the wing.

An obvious feature was that in birds with secondaries of different ages the newer secondaries were noticeably longer than the older secondaries. This applied to 23 of the 25 birds where secondary length was noted and which had different-aged secondaries. The two exceptions were adult females (nos. 13 and 15). In number 13 one new secondary of four was the same length as the older secondaries. This secondary was on the distal part of the wing, well separated from the other three new secondaries which were positioned on the proximal part of the wing. In number 15, secondaries of three different ages were all of the same length and older and newer secondaries were interspersed and present both distally and proximally.

Among the 36 fully adult birds which could be sexed, there was a significant difference between the sexes in the proportion of birds with secondaries of different ages. A higher proportion of adult females (16/17) had secondaries of different ages than did adult males (11/19; G=4.851, P<0.05, G test). The finding that in birds with secondaries of different ages, only adult females had newer and older feathers interspersed, when compared to adult males, was near significant. Five of 16 adult females with secondaries of different ages had older and newer feathers interspersed, while this was not the case in any of 11 adult males (G=2.795, P<0.1, G test).

Stomach contents

The stomach contents consisted of the maize seeds used to poison the birds, some lucerne leaves, large amounts of grit, and a small proportion of other material, mainly green vegetable matter (Table 2, Figure 2). Maize was found in all the stomachs except one, which was entirely empty of food and held only grit. The mean mass of maize in the 35 stomachs containing this food type was 6.09 g. Many of the seeds in the stomachs were fragmented and the estimated mean number of seeds in each stomach was 16.7. Lucerne leaves were present in 11 stomachs (30.6%). The mean mass of lucerne in each of these 11 stomachs was 1.06 g and the mean number of lucerne leaves was 35.6. Grit was present in all stomachs. The mean mass of grit in each stomach was 27.64 g and the estimated mean number of grit pieces was 778.0. The mean length of grit pieces was 3.94 mm (S.D.=1.15 mm; n=50) and the mean width was 2.89 mm (S.D.=0.82 mm; n=50). The mean length of the ten largest pieces of grit found in all the stomachs combined was 12.18 mm (S.D.=2.65 mm; maximum 17.74 mm; n=10) and the mean width was 7.92 mm (S.D.=1.25 mm; maximum 11.06 mm; n=10).

Little other material was found in the stomachs and its combined mass from all stomachs was only 1.56 g, compared with a total mass of 213.01 g of maize and 11.61 g of lucerne. It consisted of unidentified green vegetable matter (1.18 g) found in 10 stomachs, eight small white bulbs (0.24 g) found in two stomachs, three twigs (0.07 g) found in one stomach, and a small bone fragment (0.07 g) found in one stomach. No trace of invertebrate material was found.

No significant differences were found between the stomach contents of adult males and females in mass of maize (U=104; P>0.05; Mann-Whitney U-test), number of maize seeds (U=104.5; P>0.05), proportion of stomachs with lucerne (χ^2=3.702; P>0.05), mass of grit (U=122;

P>0.05), and number of pieces of grit (*U*=118; P>0.05). The difference in the proportion of stomachs containing lucerne, however, approaches significance with 47% (7/15) of female stomachs containing lucerne versus only 18% (3/18) of male stomachs. The amount of lucerne in the stomachs of the females and males with this food item further suggests a sex-related difference in the choice of this food, although sample sizes are too small for meaningful statistical analyses. The mean mass of lucerne in the seven females was 1.45 g (S.D.=1.33 g; range 0.01-3.73 g; n=7) and in the three males was 0.16 g (S.D.=0.11 g; range 0.01-0.27 g; n=3). Although the median mass and number of pieces of grit in female and male stomachs were not significantly different, males had significantly higher variation in the amount of grit in their stomachs (females mean mass grit=26.42 g, S.D.=4.62 g, range 17.52-36.70 g, n=15, males mean mass grit=28.55 g, S.D.=8.84 g, range 9.81-42.31 g, n=18, *F*=3.66, P<0.01, *F*-test; females mean number grit pieces=745.3, S.D.=152.3, range 496-983, n=15, males mean number grit pieces=790.5, S.D.=257.1, range 241-1,286, n=18, *F*=2.85, P<0.05).

DISCUSSION

The data-set upon which this study is based is particularly valuable as the circumstances in which the birds were obtained means that seasonal, annual, and regional variation in the characters examined is minimized. The observed proportion of juveniles in the sample (3/42, 7.1%) agrees well with other counts of the adult:juvenile ratio in the study area (D. Allan *pers. obs.*). This and the even sex ratio suggest that the sample is representative of the Western Cape Province population.

Sex ratio and morphometrics

The accurate sexing of juvenile Sandhill Cranes can be difficult (Krapu and Johnson 1990) and therefore the suggestion that the three juvenile Blue Cranes were females should be regarded as tentative. The finding that the juveniles had not reached full size despite being almost one year old agrees with similar findings for the Sandhill Crane (Tacha *et al.* 1985). Using linear discriminant functions estimated from leg length, bill length, and body weight, Nesbitt *et al.* (1992) were able to predict the sex of Sandhill Crane individuals with a misclassification rate that did not exceed six percent. The possibly relatively shorter bills in male Blue Cranes could be genetic or result from sex-related foraging differences affecting the amount of wear on the bill tip (*cf.* Hulscher 1985; Hulscher and Ens 1992).

Molt

Simultaneous molt of the remiges was suggested as probable in at least the Eurasian (*G. grus*), Whooping, Redcrowned, Sarus (*G. antigone*), Whitenaped (*G. vipio*), Blue, and Siberian (*G. leucogeranus*) Cranes as early as the end of the last century (Blaauw 1897, in Johnsgard 1983). In addition, it has been recorded subsequently in the Hooded (*G. monachus*) (Johnsgard 1983), Wattled (*Bugeranus carunculatus*) (Douthwaite 1974; Hustler *et al.* 1992), and Sandhill (Littlefield 1970) Cranes. Flightlessness apparently is regular in at least the Eurasian, Hooded, Whooping, Redcrowned, Sarus, Whitenaped, Blue, Wattled, and Siberian Cranes, but does not occur in the Demoiselle Crane (*A. virgo*) and the Black (*Balearica pavonina*) and Grey (*B. regulorum*) Crowned Cranes (Moody 1932, in Johnsgard 1983; Douthwaite 1974; Cramp and Simmons 1980; Erickson and Derrickson 1981; Flint and Kistchinski 1981). The lack of flightlessness in the Demoiselle Crane has been attributed to its use of dryland habitats (Heinroth and Heinroth 1958). Johnsgard (1983) suggests that the same may apply to the crowned cranes. Although crowned cranes rely on wetland habitats for breeding, they frequently forage in dry habitats, sometimes relatively distant from aquatic areas (Pomeroy 1987; Gichuki and Gichuki 1991). However, the same also applies to many other species of cranes. Molt of the remiges in the Demoiselle Crane and the crowned cranes follows no clear sequence and would appear to be a derived trait from a previous simultaneous molt condition (Stresemann and Stresemann 1966).

Most information on flightless molt in cranes comes from captive birds and little information exists about wild individuals (Stresemann and Stresemann 1966). This apparently is due to the secretiveness of molting cranes. Museum specimens of individuals with growing remiges are extremely uncommon for species with simultaneous molt (Stresemann and Stresemann 1966). These authors examined 30 museum skins of Brolgas (*G. rubicunda*) and found six of these to have primaries of non-uniform age. This is indirect evidence against simultaneous molt of all the remiges. Nevertheless flightlessness has been confirmed in the wild for several species, including the Eurasian (Cramp and Simmons 1980), Whooping (Erickson and Derrickson 1981), Blue (Blaauw 1897, in Walkinshaw 1949), Wattled (Douthwaite 1974; Hustler *et al.* 1992), Siberian (Flint and Kistchinski 1981), and Sandhill (Littlefield 1970) Cranes.

It is surprising that the Blue Crane has a flightless period because, like the congeneric Demoiselle Crane (Krajewski 1989), it inhabits dry areas. It would appear to be the only crane species allegedly with simultaneous molt that is not primarily an aquatic species. Records of flightlessness in Blue Cranes come from both captive and wild individuals (Blaauw 1897 *in* Walkinshaw 1949) and therefore cannot be attributed merely to unnatural molt patterns in captive birds, which is a relatively widespread phenomenon (Stresemann and Stresemann 1966).

Much variation was found in the molt of remiges from a large sample of Sandhill Cranes (Lewis 1979b). In fact, only a minority (41%; n=108) had remiges all of the same age. This study found that molt is descending in both the primaries and secondaries and does not occur in numerical sequence. Two other studies also have found that Sandhill Cranes frequently have remiges of different ages (Layne 1981; Nesbitt *et al.* 1987). Therefore, simultaneous molt of all the remiges may not be as common in wild cranes as reports from zoos initially would suggest. It is possible that many wild birds molt in a manner intermediate between total loss of the remiges and progressive molt, perhaps with large intra- and interspecific differences. This probably allows the retention of at least some flying ability at all times.

Molt of the remiges in cranes also has attracted attention as it may reveal clues as to the age, sex, and breeding status of individuals (Lewis 1979b). In particular it has been suggested that adult breeding individuals may be characterized by remiges of one age compared to non-breeding adults which may have remiges of more than one age.

Remigial molt in most cranes, simultaneous or otherwise, appears to occur during the breeding season in at least the Eurasian (Stresemann and Stresemann 1966; Cramp and Simmons 1980; Prange and Mewes 1991), Whooping (Erickson and Derrickson 1981), Demoiselle (Stresemann and Stresemann 1966; Kovshar 1987), Siberian (Flint and Kistchinski 1981), and Sandhill (Layne 1981) Cranes. A possible exception is the Wattled Crane where flightlessness was observed during January-April at both the Kafue Flats in Zambia (Douthwaite 1974) and in Zimbabwe (Hustler *et al.* 1992), where breeding normally occurs during April-September. Only a relatively small proportion of breeding pairs attempt to breed every year in this species (e.g., Douthwaite 1974), however, and the breeding season is poorly defined and egglaying can occur in any month of the year (e.g., Tarboton 1984).

The results presented here suggest that active molt in the Blue Crane does not occur during the winter and probably is restricted to the summer (breeding) period. Only two individuals had primaries of different ages, suggesting that primary molt usually, but not invariably, is simultaneous. Further evidence for simultaneous molt of the primaries comes from a field case study. A nest site in the Western Cape Province was visited on 9 December 1992 and no molted remiges were noted in the area around the nest. When next visited two days later, nine molted primaries (six from the left wing and three from the right wing) were found in the area immediately surrounding the eggs. The size, color, and state of wear of these feathers suggested that they all came from the same individual. By contrast, the large proportion of birds in the poisoned sample with secondaries of different ages suggests that secondary molt usually is not simultaneous. The pattern and direction of molt in the secondaries follows no clear sequence and appears variable between individuals.

It has been suggested (G. Archibald *in* Lewis 1979b) that breeding cranes (mated adults) may be identified by remiges all of the same age, due to simultaneous molt during incubation, while non-breeding cranes (unmated 'sub-adults') may be identified by remiges of different ages, due to sequential molt in these individuals. This suggestion was refuted by Lewis (1979b) for the Sandhill Crane and he found breeders with both evenly and unevenly aged wings. If Archibald's (*op. cit.*) suggestion is correct, then the 10 of the 37 (27%) apparently fully adult Blue Cranes in this study which had even-aged wings would have been breeders in the previous season. However, eight of these were males, one was of unknown sex, and only one was a female. The data presented here suggest that even and uneven-aged wings are sex-related in the Blue Crane (but with overlap between the sexes in this character). In addition, these data suggest that interspersion of older and newer secondaries may be restricted to females and could be useful in diagnosing the sex of live individuals, although most females resembled males in this character. In the Sandhill Crane, by contrast, no sex-related differences in molt were found (Lewis 1979b).

The finding that a large proportion of the birds had secondaries of different lengths is interesting. It is possible that the first secondaries grown by juveniles are shorter than those grown subsequently. Shorter remiges in juveniles compared with adults occurs in some gamebirds (Phasianidae, e.g., Mueller and Seibert 1966 *in* Johnsgard 1986). If this is the case in Blue Cranes, then birds with secondaries of different lengths could be in transitional plumage between juvenile and adult secondaries, i.e. 'immatures' or 'sub-adults'. This need not mean that they are in their second year, as the loss of all the juvenile secondaries may require several years before completion. Of the 39 cranes classed as adults or second-year birds, 59% (assuming that the seven birds for which the length of the secondaries was not noted had feathers of equal lengths) had secondaries of unequal lengths and therefore could be 'immatures'. This proportion may seem high but is possible in the light of the high proportion of non-breeding birds found in many wild crane populations.

Clearly more data on molt in Blue Cranes (and other members of the family) are required, particularly from other times of the year and from individuals of know age and breeding status. For this reason the raw data from this study have been presented in full (Appendix 1) to facilitate comparisons with future studies. It was unfortunate that the molt of both wings was not recorded, as Lewis (1979b) found that 49% of Sandhill Cranes had dissimilar molt patterns on opposite wings.

Diet

All species of cranes, except for the Siberian Crane, occasionally or regularly, indeed during some periods virtually exclusively, feed on crops, e.g., wheat, maize, rice, sorghum, barley, oats, rye, sunflowers, peanuts, soya beans, beans, peas, cabbages, spinach, lucerne, etc. (Pomeroy 1980; Johnsgard 1983; Reinecke and Krapu 1986; Alonso and Alonso 1991; Fulin 1991; Youhui 1991). Cereal crops are particularly favored and the birds usually glean fallen seeds in harvested fields. Exploitation of these unnatural foods is most common during the nonbreeding period in most wetland-dependent species. The habit has obvious economic, conservation, and management implications.

Detailed dietary analyses exist only for the Sandhill Crane. One study (Mullins and Bizeau 1978) on the diet of this species on its breeding grounds, drawn from gizzard contents, found that natural plant material comprised 73% by volume and the remaining 27% consisted of invertebrate matter. Another study of diet during the nonbreeding season (Reinecke and Krapu 1986), based on gut contents, found that plant material comprised 97% by dry weight, exclusively cultivated maize, and invertebrates 3%. This latter study found that birds foraged for prolonged periods in natural grasslands and lucerne fields to obtain the relatively small proportion of invertebrates consumed, which they suggest are essential to compensate for the protein and calcium deficiencies in maize. In addition, they found that the birds ate small amounts of lucerne shoots, which also are rich in protein. Mixed farming of crops (cultivated maize) and livestock (natural and lucerne grazing lands) therefore was important for providing suitable foraging habitat for this species.

A further study on the nonbreeding diet of Sandhill Cranes from another locality (Hunt and Slack 1989), based on an analysis of fecal samples, found vegetable matter to comprise 98% by volume and invertebrate matter 2%. Although the plant material consumed consisted almost entirely of natural plants (amaizes *Quercus virginiana* and wolfberry *Lycium virginiana*), these authors state that cultivated grains are the major diet in the region and that the birds they collected, which came from a protected wetland reserve, temporarily visited the reserve to feed on natural vegetation rich in nutrients (ascorbic acid, iron, calcium, and amino acids) which are absent from maize, the main dietary component. These studies suggest that the heavy reliance of cranes on cultivated crops, which are poor in certain nutrients, could have significant physiological consequences for these birds.

The data from the Blue Crane stomach contents are of limited value due to the artificial circumstances surrounding the ingestion of the main food item (maize). It is of interest that no animal food was found. Data are required on the more natural winter and summer diets, particularly as to whether invertebrates are eaten in the summer (*cf.* Mullins and Bizeau 1978). The large grit loads in themselves are strongly suggestive of a mainly vegetarian diet (Schifferli 1985), at least during the winter non-breeding period. The larger amounts of lucerne, and the higher proportion of stomachs with this food item, in females compared with males prompts the speculation that the females were selecting this protein-rich food source during this pre-breeding period (*cf.* Reinecke and Krapu 1986).

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REFERENCES CITED

Alonso, J. C. and J. A. Alonso. 1991. Costs and benefits of flocking in wintering Common Cranes. Pages 271-276 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Blaauw, F. E. 1897. A monograph of the cranes. E. J. Brill, Leiden, UK.

Cramp, S. and K.E.L. Simmons, eds. 1980. The birds of the Western Palearctic. Vol. 2. Oxford University Press, Oxford, UK.

Douthwaite, R. J. 1974. An endangered population of Wattled Cranes (*Grus carunculatus*). Biological Conservation 6: 134-142.

Erickson, R. C. and S. R. Derrickson. 1981. The Whooping Crane. Pages 104-118 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Flint, V. E. and A. A. Kistchinski. 1981. The Siberian Crane in Yakutia. Pages 136-145 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: Proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Fulin, W. 1991. Distribution of cranes in Shanxi and their relationship to the ecological environment. Pages 91-94 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Gichuki, N. N. and C. M. Gichuki. 1991. Relationships between habitat selection and flock characteristics in foraging Grey Crowned Cranes *Balearica regulorum* in Kenya. Pages 357-361 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Heinroth, O. and K. Heinroth. 1958. The birds. University of Michigan Press, Ann Arbor, Michigan, USA.

Hulscher, J. B. 1985. Growth and abrasion of the Oystercatcher bill in relation to dietary switches. Netherlands Journal of Zoology 35: 124-154.

Hulscher, J. B. and B. J. Ens. 1992. Is the bill of the male Oystercatcher a better tool for attacking mussels than the bill of the female? Netherlands Journal of Zoology 42: 85-100.

Hunt, H. E. and R. D. Slack. 1989. Winter diets of whooping and sandhill cranes in south Texas. Journal of Wildlife Management 53: 1150-1154.

Hustler, K., T. English, and N. English. 1992. Flightless Wattled Crane at Dandanda Pan. Honeyguide 38: 72.

Johnsgard, P. A. 1983. Cranes of the world. Indiana University Press, Bloomington, Indiana, USA.

Johnsgard, P. A. 1986. The pheasants of the world. Oxford University Press, Oxford, UK.

Kovshar, A. V. 1991. The Demoiselle Crane in Kazakstan and Central Asia. Pages 23-31 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Krapu, G. L. and D. H. Johnson. 1990. Conditioning of sandhill cranes during fall migration. Journal of Wildlife Management 54: 234-238.

Layne, J. N. 1981. Observations on wing molt of Florida Sandhill Crane. Florida Field Naturalist 9: 60-61.

Lewis, J. C. 1979a. Taxonomy, food and feeding habitat of Sandhill Cranes. Pages 21-28 *in* J. Harris, ed., Proceedings of the 1978 Crane Workshop. Colorado State University Printing Service, Fort Collins, Colorado, USA.

Lewis, J. C. 1979b. Molt of the remiges of *Grus canadensis*. Pages 255-259 *in* J. Harris, ed., Proceedings of the 1978 Crane Workshop. Colorado State University Printing Service, Fort Collins, Colorado, USA.

Littlefield, C. D. 1970. Flightlessness in Sandhill Cranes. Auk 87: 157.

Maclean, G. L. 1985. Roberts' birds of southern Africa. John Voelcker Bird Book Fund, Cape Town, South Africa.

Moody, F. 1932. Water-fowl and game birds in captivity. Witherby, London, UK.

Mueller, C. J. and H. C. Seibert. 1966. Wing and tail molt in the Reeve's pheasant. Ohio Journal of Science 66: 489-495.

Mullins, W. H. and E.G. Bizeau. 1978. Summer foods of Sandhill Cranes in Idaho. Auk 95: 175-178.

Nesbitt, S. A. and A. S. Wenner. 1987. Pair formation and mate fidelity in Sandhill Cranes. Pages 117-122 *in* J. C. Lewis, ed., Proceedings of the 1985 Crane Workshop. Platte River Whooping Crane Habitat Maintenance Trust, Grand Island and U.S. Fish and Wildlife Service, Nebraska, USA.

Pennycuick, C. J. 1989. Bird flight performance, a practical calculation manual. Oxford University Press, Oxford, UK.

Pomeroy, D. E. 1980. Aspects of the ecology of Crowned Cranes *Balearica regulorum* in Uganda. Scopus 4: 29-35.

Pomeroy, D. E. 1987. The ecology and status of Crowned Cranes in East Africa. Pages 323-330 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Prange, H. and W. Mewes. 1991. The Common Crane in the German Democratic Republic. Pages 263-269 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Reinecke, K. J. and G. L. Krapu. 1986. Feeding ecology of sandhill cranes during spring migration in Nebraska. Journal of Wildlife Management 50: 71-79.

Sibley, C. G. and J. E. Ahlquist. 1990. Phylogeny and classification of birds: a study in molecular evolution. Yale University Press, New Haven, Connecticut, USA.

Schifferli, L. 1985. Grit. Page 256 *in* B. Campbell and E. Lack, eds., A dictionary of birds. T and AD Poyser, Carlton.

Siegfried, W. R. 1985. Relative abundance of cranes (Gruidae) in the Cape Province. Ostrich 56: 101-103.

Sneath, P.H.A. and R. R. Sokal. 1973. Numerical taxonomy: the principles and practice of numerical classification. W. H. Freeman, San Francisco, USA.

Stresemann, E. and V. Stresemann. 1966. Die mauser der vogel. Journal fur Ornithologie (Suppl.) 107: 1-448.

Tacha, T. C. and P. A. Vohs. 1984. Some population parameters of sandhill cranes from mid-continental North America. Journal of Wildlife Management 48: 89-98.

Tacha, T. C., P. A. Vohs, and W. D. Warde. 1985. Morphometric variation of sandhill cranes from mid-continental North America. Journal of Wildlife Management 49: 246-250.

Tarboton, W. R. 1984. The status and conservation of the Wattled Crane in the Transvaal. Pages 665-678 *in* J. Ledger, ed., Proceedings of the Fifth Pan-African Ornithological Congress. Southern African Ornithological Society, Johannesburg, South Africa.

Urban, E. K., C. H. Fry, and S. Keith. 1986. The birds of Africa. Vol. 2. Academic Press, London, UK.

Walkinshaw, L. H. 1949. The Sandhill Cranes. Cranbrook Institute of Science Bulletin 29: 1-22.

Youhui, W. 1991. A preliminary study of the wintering ecology of Common Cranes in Caohai. Pages 119-122 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

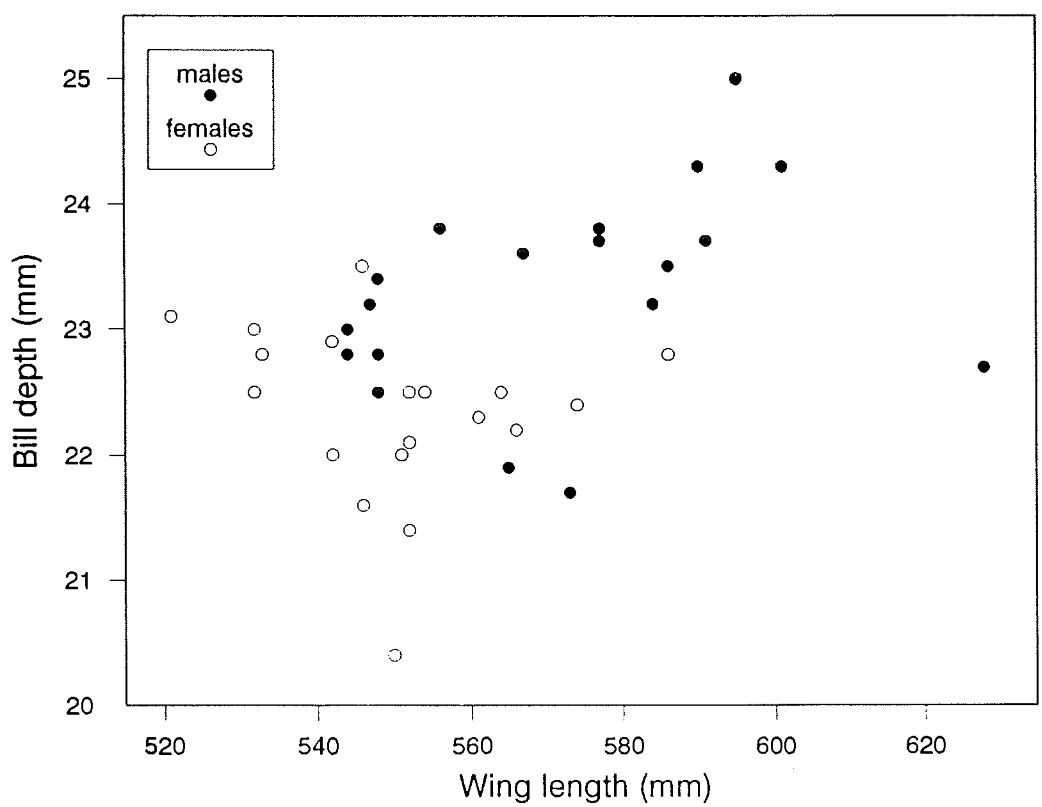

Figure 1. Biplot of bill depth and wing length among adult male and female Blue Cranes.

Table 1. Means, standard deviations, and ranges of various Blue Crane morphometric characters based on a sample of 41 birds from the Western Cape Province, with comparison between the sizes of adult males, adult females, and juveniles. Sample sizes equal 19 for males, 19 for females, and three for juveniles, except for mass where n=18 males and 15 females. All measurements are in mm except for mass which is in grams.

Morphometric characters	Males **mean** (range)	*S.D.*	Females **mean** (range)	*S.D.*	t-test	Juvs **mean** (range)	*S.D.*
Mass	**5,094** (4,220-5,820)	*486.1*	**4,645** (4,300-4,950)	*192.8*	*P*<0.01	**3,923** (3,820-4,100)	*125.5*
Wing	**572.1** (544-628)	*22.75*	**550.3** (521-586)	*15.24*	*P*<0.01	**533.0** (526-547)	*9.90*
Wingspan	**2,101** (1,916-2,290)	*104.5*	**1,988** (1,830-2,164)	*95.3*	*P*<0.01	**1,892** (1,840-1,956)	*48.1*
Longest tertial	**705.1** (535-760)	*47.87*	**687.7** (615-750)	*33.34*	n.s.	**553.7** (521-602)	*34.87*
Tail	**249.8** (223-280)	*13.32*	**242.2** (220-267)	*10.90*	*P*<0.1	**202.7** (195-209)	*5.79*
Tarsus	**253.0** (220-279)	*16.08*	**241.7** (211-258)	*13.48*	*P*<0.05	**234.3** (231-240)	*4.03*
Total head	**176.5** (157.6-186.2)	*5.77*	**171.8** (164.2-181.8)	*4.96*	*P*<0.05	**166.7** (162.1-172.4)	*4.28*
Bill length (from nares)	**73.6** (59.6-79.3)	*4.60*	**72.9** (65.5-79.3)	*3.33*	n.s.	**72.7** (68.4-76.0)	*3.18*
Bill length (from feathering)	**92.1** (77.5-98.6)	*4.35*	**89.4** (71.5-99.0)	*6.15*	n.s.	**84.7** (80.7-91.1)	*4.59*
Bill depth	**23.3** (21.7-25.0)	*0.79*	**22.3** (20.4-23.5)	*0.67*	*P*<0.001	**21.4** (19.8-22.5)	*1.16*

Table 2. Details of the stomach contents of 36 Blue Cranes from the Western Cape Province.

Item	Mean no. items/ stomach with item	S.D.	range	Mean mass items/ stomach with item	S.D.	range	No. stomachs with item
Maize	16.7	13.6	1-62	6.09g	5.08g	0.08-22.53g	35 (97.2%)
Lucerne	35.6	44.4	1-164	1.06g	1.20g	0.01-3.73g	11 (30.6%)
Unid. green veg. matter	3.8	5.9	1-20	0.12g	0.17	0.01-0.54g	10 (27.8%)
Small white bulbs	4	-	3-5	0.12g	-	0.10-0.14g	2 (5.6%)
Twigs	3	-	-	0.07g	-	-	1 (2.8%)
Bone fragment	1	-	-	0.07g	-	-	1 (2.8%)
Grit	778.0	221.4	241-1,286	27.63g	7.21g	9.81-42.31g	36 (100.0%)

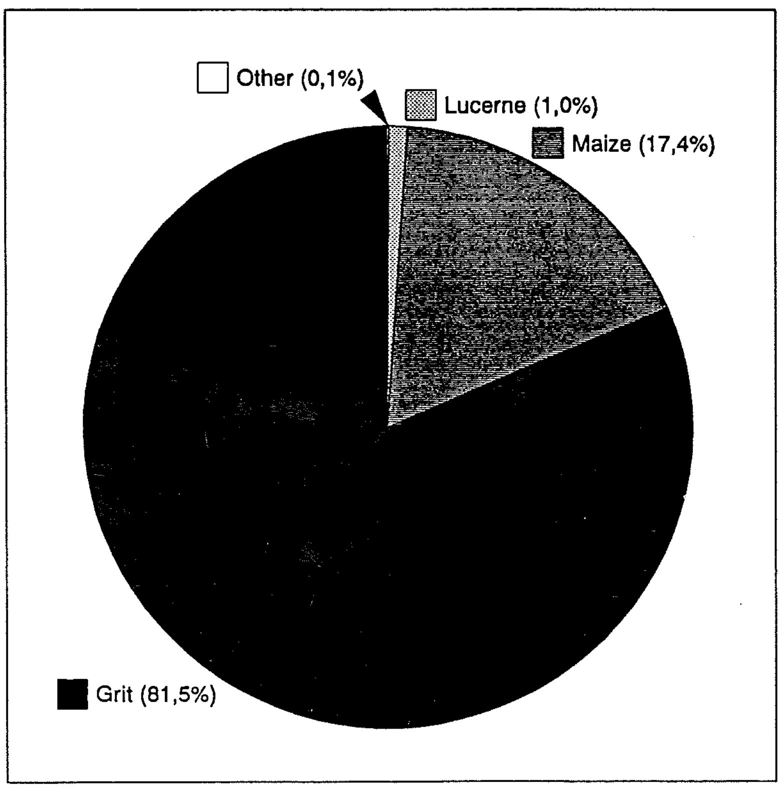

Figure 2. Stomach contents of 36 Blue Cranes by percentage mass occurrence.

APPENDIX

Details of the molt of the primaries and secondaries of the right wing of 42 Blue Cranes. The first column provides details of the specimen number, age (where ad = adult, 2yr = second year, juv = juvenile, i.e., first year) and sex (where f = female, m = male, ? = unknown). The second column provides details on the primaries, all of which were of one age except for specimens 16 and 32, where the most distal feather/s were newer than the remainder. The final columns present details of the secondaries, numbered from the most distal secondary, i.e., towards the body. Number codes: 4 = just complete, i.e., very new; 5 = new; 8 = uncertain; 0 = old. Entries in italics denote secondary feathers that were 'long' in comparison to the other secondaries. In some cases all the secondaries were judged to be 'long' in a wing with even-aged secondaries.

No./ Age/ Sex	Primaries	Secondaries																	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 ad f	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5^{*+}	-	-
2 ad f	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	-
3 ad f	5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*
4 ad f	8	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	*5*	-	-
5 ad f	0	8	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	*5*	-
6 ad f	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	*5*	*5*	*5*
7 ad f	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	*5*	*5*
8 ad f	0	0	0	0	0	0	0	0	0	0	0	0	0	*5*	*5*	*5*	*5*	-	-
9 ad f	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*4*	*5*	*5*	*5*	-
10 ad f	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	*5*	*5*	*5*	*5*	-	-
11 ad f	8	8	8	8	8	8	8	8	8	8	8	8	5	5	5	5	5	5^{+}	-
12 ad f	0	0	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	-
13 ad f	0	8	5	8	8	8	8	8	8	8	8	8	8	*5*	8	*5*	*5*	-	-
14 ad f	0	8	8	8	8	8	8	8	8	*5*	8	*5*	*5*	*5*	*5*	*5*	*5*	*5*	-
15 ad f	0	*5*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*5*	*8*	*5*	*5*	*5*	*5*	*5*	*5*	*4*	-
16 ad f	0^85^2	8	8	8	8	5	5	5	8	8	8	5	5	5	5	5	5	5	5^{+}
17 ad f	0	8	5	8	5	8	5	8	5	5	5	5	5	5	5	5	5^{+}	-	-
18 ad m	5	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5**	-	-
19 ad m	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5^{*}	-	-
20 ad m	5	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
21 ad m	5	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*	*5*
22 ad m	8	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8**	-	-
23 ad m	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8^{*+}	-	-
24 ad m	8	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	-	-
25 ad m	8	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	-	-
26 ad m	8	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	8	8	8	8	8	8	*5*	*5*	-	-
27 ad m	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*
28 ad m	8	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	*5*	-	-
29 ad m	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	5	*5*	*5*
30 ad m	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	5	*5*	*5*
31 ad m	0	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	5	*4*	-
32 ad m	0^95^1	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	5	5^{+}	-
33 ad m	0	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	5	*5*	-
34 ad m	0	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	5	*5*	-
35 ad m	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	5	5	5^{+}
36 ad m	0	0	0	0	0	0	0	0	0	0	0	0	*5*	*5*	*5*	*5*	5	5	*5*
37 ad ?	8	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8*	*8**	-	-
38 2yr f	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	-	-	-	-
39 2yr f	8	8	8	8	8	8	8	8	8	8	8	8	8	8	*5*	*5*	*5*	*5*	-
40 juv f	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5^{*}	-	-
41 juv f	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5^{*}	-	-
42 juv f	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5^{+}	-

* Number of secondaries not counted

+ Differences in lengths of secondaries not noted

BREEDING BIOLOGY OF THE BLUE CRANE IN THE SOUTHERN CAPE, SOUTH AFRICA

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ABSTRACT

Two sites in the southern Cape were surveyed for Blue Crane (*Anthropoides paradiseus*) pairs during the 1992-93 breeding season. Density of pairs did not differ significantly between the two sites (χ^2=3.6, P>0.05, d.f.=1), and a total of 48 pairs were located (0.39 pairs/km² rising to 0.57 pairs/km² excluding unsuitable habitat). No nests were found in any of the remaining natural vegetation. The breeding season started in October, peaking in the first part of November, with renests taking place into February. Harvesting activities pose the biggest threat to successful breeding. Eighty-nine percent of nesting efforts were successful, hatching at least one chick. Productivity of the population is estimated at 1.06 chicks fledged/pair/year.

INTRODUCTION

In response to reports of large-scale reduction in Blue Crane numbers from wide parts of its range in recent years (see Vernon 1991; Johnson 1992; Tarboton 1992), a study on Blue Crane ecology in the southern Cape was launched in 1992.

The southern Cape is an intensively farmed area comprising roughly 830 km² in a thin strip between the mountains and the sea on the southernmost tip of the African continent. A comparison of road counts done during 1965-66 and 1988-89 suggest a substantial increase in Blue Crane numbers in the southern Cape (Allan 1992). Very little information on any life-history parameters of this population, which could prove vital for the Blue Crane's continued survival, is available at present. This report presents preliminary results on aspects of the breeding biology of the Blue Crane in the region, based on observations made during the 1992/1993 breeding season.

The aims for this part of the project were to determine the habitat preference of breeding Blue Cranes in the southern Cape and to get an indication of the density of pairs and their breeding success.

STUDY AREA

Two study sites were chosen to investigate breeding activity. The first, comprising 54 km², is situated just west of Bredasdorp, approximately 30 km from the south coast. The second site of 44 km² is more inland, and situated virtually on the western limit of the Blue Crane's range in the southern Cape close to the town of Caledon.

Both areas consist predominantly of agricultural land. I used 1:10,000 orthophotos (maps derived from aerial photographs) of the areas to calculate the extent of the different habitat types that make up the region.

Approximately 28% of both areas are grain fields, 35% cultivated pastures (predominantly *Medic* sp., lucerne, and clover) and 5% fallow fields. Coastal fynbos covers 22% of the Bredasdorp study site, and only 8% of the Caledon study site is covered by natural vegetation, mostly renosterveld shrubland. Remnants of natural vegetation are found only on hills and slopes that are too steep or rocky to plough, and in pockets between cultivated fields. An assortment of fruit and vegetable crops cover a further 8% of the Caledon study site, and 8% is accounted for by the Riviersonderend River and adjacent marshy areas.

Due to the nature of the environment, sources of human disturbance to nesting are significant. Both study sites fall within the winter rainfall region of South Africa, with very little rain falling in summer, the breeding season of Blue Cranes.

METHODS

As mentioned earlier, habitat availability was determined by making use of orthophotos. The nature of areas of homogeneous habitat was identified by consultation with farmers and directly by ground observation. The extent of these areas was then measured by making use of a planimeter. This method gave a very direct and accurate indication of the percentage of area that can be accounted for by each of the broad habitat categories.

The two study sites were alternately visited and surveyed for a week each from the beginning of November throughout the duration of the breeding period until the families joined up and the wintering flocks formed. The areas were surveyed for breeding pairs by making use of the extensive network of farm roads, and on foot when the areas were invisible from any road. Farmers and farm workers were also questioned on whether a pair of birds were seen regularly in any specific area, and were also encouraged to report any nests or pairs with chicks found on their farms.

Each nest found was plotted on the orthophotos, and a number of nest and habitat variables were recorded, including nature of nest material, habitat type, height of adjacent vegetation, distances to nearest road or other source of human disturbance, and distance to nearest water. These habitat variables will be compared to random points once the survey of the 1993/1994 breeding season is completed and sample sizes are bigger to enable a detailed study of habitat choice to be made. Nests were observed every 5 - 10 days to determine nesting success. I monitored nests more closely during the expected hatching period so that the fate of eggs could be verified. The date of initiation of successful nests was calculated by subtracting the 30-day mean incubation period (Van Ee 1966) from the hatch date.

It was unfortunately only possible to start fieldwork in November after the start of the breeding season. A number of pairs had already finished nesting by then, and only by estimating the age of the chicks could approximate initiation dates for these pairs be calculated. As the season wore on and the development of known-age chicks could be monitored, reasonable accuracy in the aging of chicks was possible. The assumption was also made that the nest was made in the same habitat and territory a pair of Blue Cranes occupied with its offspring.

Nest visits were kept as short as possible and did not take place during the hottest part of the day. Disturbance caused by nest visits was less than the disturbances that most breeding birds were subjected to during normal farming activities.

Nesting efforts were defined as successful if at least one egg hatched. Direct observation of peeping or pipping eggs, or of one or two chicks was used to determine the outcome of nesting attempts. Although egg shell fragments were found only rarely on nests, fragments with detached egg membranes confirmed hatching in some instances. Duration of nesting activity in some cases was also taken as evidence of nesting success.

As no pairs were marked, renesting was assumed in certain cases based on knowledge of the fate of previous nesting activities and breeding territories. The outcome of both first nests and renests was included in the calculation of nesting success statistics.

Several juveniles were marked with numbered plastic leg-bands while still flightless. The chicks were monitored until the families left the breeding territories. Marked juveniles facilitated the recognition of individual families.

RESULTS

Breeding density

Throughout the breeding season 20 breeding pairs were located in the Bredasdorp area, and 18 pairs in Caledon. As there was no significant difference between the density of breeding pairs between the two areas ($\chi^2=3.6$, $P>0.05$, d.f.=1), the totals were combined resulting in a density estimate of 0.38 pairs/km². However, as birds only made use of pastures, grain or fallow fields to breed, and the extent of these habitats in both areas is known, it is possible to calculate an estimate for density of pairs only taking suitable habitat into account, which amounts to 0.57 pairs/km².

Chronology

Judging by the age of chicks already hatched at the start of November, the first birds bred in early October (Figure 1). Keep in mind that some birds could have bred earlier but were then unsuccessful in hatching or raising their chicks, in which case these attempts could not be recorded when the study started in November. The peak of the breeding season occurred in the first part of November, with one nest recorded early in February. The nests initiated later in the breeding season were most often renests.

Habitat preference

As indicated by Figure 2, nests were only found on the grain and fallow fields, and on pastures. As the grain is harvested during October, with stubble fields only becoming available during November, all earlier nests are made on pastures. No nests were found in unharvested grain fields or any of the remaining natural vegetation.

Hatching success

Of 38 nesting efforts with known outcomes, 34 (89%) hatched at least 1 chick. All nests found (n=27) contained 2 eggs, except for one nest that was abandoned after the first egg was laid because of harvesting activity. Another nest was abandoned due to disturbances caused by harvesting activities just after the first chick had hatched. The second egg was later found to contain a fully developed chick. Two clutches were crushed by combine harvesters. One clutch disappeared and a farmer reported finding a dead adult close to the nest-site. Unfortunately he had already thrown the carcass away, but there is reason to believe that the bird was shot. Two nests contained an addled egg each.

Productivity

Thirty-two pairs monitored throughout the breeding season managed to raise a total of 34 chicks to fledging age. Productivity of the population can therefore be estimated at 1.06 chicks/pair/year. Twenty-five percent of pairs managed to raise both chicks to fledging age, 56% raised one chick, while 19% were unable to successfully rear any chicks. Chicks seem to be most vulnerable in their first month, most fledging once this critical age is passed.

Renesting

All 3 pairs that abandoned or had their nests destroyed by combine harvesters renested within 1 month. Two pairs that lost their chicks within 2 weeks of hatching also renested.

Ringing

Fifteen juveniles were marked with numbered plastic leg-bands when they were between 60 and 70 days old. One marked chick died at 3+ months of age after flying into a power line. Another marked chick was found dead tangled in a fence 3 months after ringing. Families stayed on, or close to their breeding territories for varying amounts of time, but most pairs had left the territories by the time the chicks were 5 months old.

DISCUSSION

The results obtained from the study so far indicate that the southern Cape is a very important breeding area for Blue Cranes, supporting a large breeding population. Although information on density of breeding pairs from other parts of their range is scarce, indications are that nowhere are densities as high as those recorded in this study (0.38 pairs/km^2, rising to 0.57 pairs/km^2 taking only suitable habitat into account). Breeding pairs on farms near De Aar in the Karoo, occurred at a density of about 0.062 pairs/km^2 (*pers. obs.*). In the Stormberg, Eastern Cape, 7 breeding pairs were present on 6,500 ha (0.12 pairs/km^2, Stretton *pers. comm.*), and only 4 pairs attempted to breed, 3 being successful.

The number of breeding pairs has also been used to indicate the dramatic decline in Blue Crane numbers in some parts of its range. The Verloren Vallei Nature Reserve in Transvaal supported 19 breeding pairs on roughly 50 km^2 in the beginning of the 1980's; ten years later only 1 pair was left (Tarboton 1992). Numbers of breeding pairs declined from 16 - 20 pairs to 2 pairs in the Giant's Castle Game Reserve in the same period. In contrast most farmers in the southern Cape report a marked increase in breeding activity on their farms in the last ten years. In many instances the increase seems to be threefold, as many farmers report having only one or two pairs ten years ago, whereas five to seven pairs are breeding on their farms now. Their observations are substantiated by the road count data that suggest a substantial increase in numbers has taken place between surveys conducted in 1965 (Siegfried 1985) and 1988 (Allan 1992).

Blue Cranes seem to have habituated to the high level of human disturbances inevitably encountered in such an intensively farmed area. A cause for concern though is the number of nests destroyed by combine harvesters. As the area is very windy in summer, farmers cut the grain before it is completely dried to prevent losses from kernels being blown out of the ears. The grain is then left in rows where it is harvested at a later stage. Sometimes there is sufficient time for cranes to establish a territory and start breeding and the nest is then at risk when the combines arrive to harvest the grain. The Overberg Crane Group is busy with an awareness campaign to alert farmers to the fact that cranes breed in these stubble fields, and to encourage them to watch for nests during the harvesting period. As seen in the study, cranes readily renested after their nests were destroyed, which also lessens the impact of harvesting activities.

Although no nests were found in natural vegetation in this study, there are records of Blue Cranes breeding in natural vegetation on the coastal sand dunes (Allan 1992; Ryan and Dichmont 1985). Pairs did make use of the shrubby natural vegetation as a source of refuge when available, however, by leading flightless chicks into these areas when threatened. No pairs or flocks have been seen to forage in this habitat however.

Nests were often situated very close to water, in this region mostly in the form of small farm dams. Although habitat preferences will be quantified only after the 1993-94 breeding season, it is obvious at this stage that water plays an important role in determining where a Blue Crane pair will breed. This factor does not seem to be limiting density, however, as there are numerous small dams scattered throughout the region. In the arid Karoo, breeding pairs also seemed associated with manmade water points.

The high density of breeding pairs encountered in the study, coupled with the relatively high hatching success of 89% and a fecundity of 1.06 fledged chicks/pair/year bodes well for the Blue Crane population in the region. Paradoxically large numbers of cranes could also be a cause for concern due to the possible negative impact they can have on crops and supplementary feed for sheep. The biggest challenge facing conservationists in the area could well be to devise strategies whereby Blue Cranes and agriculture can co-exist peacefully.

REFERENCES CITED

Allan, D. G. 1992. Distribution, relative abundance and habitat of the Blue Crane in the Karoo and the south-western Cape. Pages 29-40 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Johnson, D. N. 1992. The status of cranes in Natal in 1989. Pages 20-28 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Ryan, P. G. and J. Dichmont. 1985. Blue Cranes breeding in the dunes. Promerops 169: 12.

Siegfried, W. R. 1985. Relative abundance of cranes *Gruidae* in the Cape Province. Ostrich 56: 101-103.

Tarboton, W. R. 1992. Extent and reasons for population declines in South Africa's three crane species. Pages 117-118 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Van Ee, C. A. 1966. Notes on the breeding behaviour of the Blue Crane *Tetrapteryx paradisea*. Ostrich 37: 23-29.

Vernon, C. 1991. The Blue Crane in the Eastern Cape. Pelea 10: 45-59.

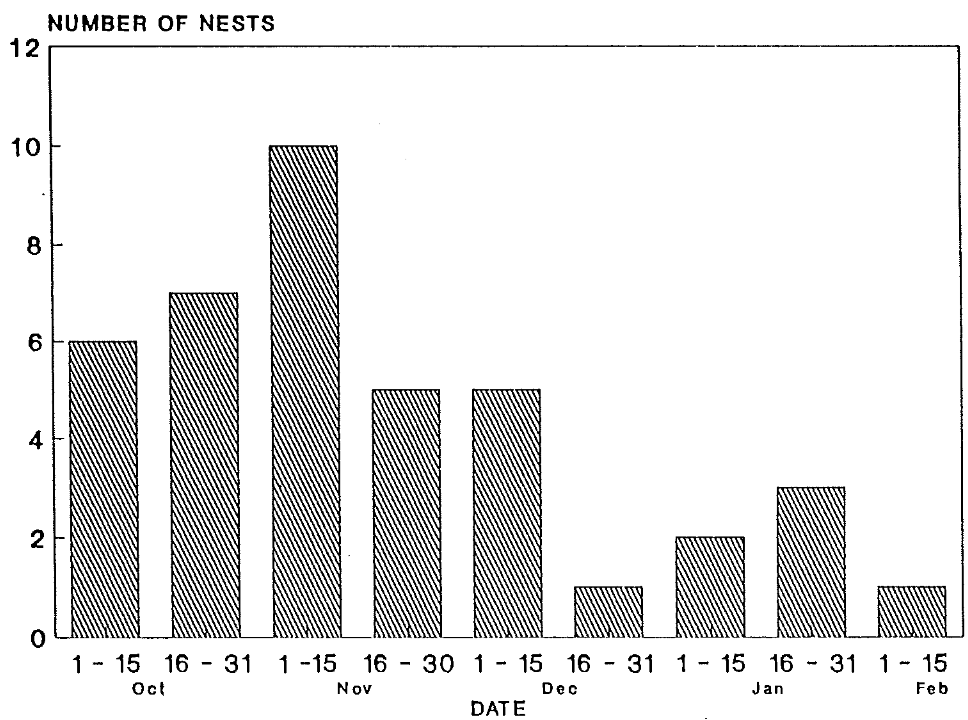

Figure 1. Initiation dates of 40 Blue Crane nests in the southern Cape, 1992-93.

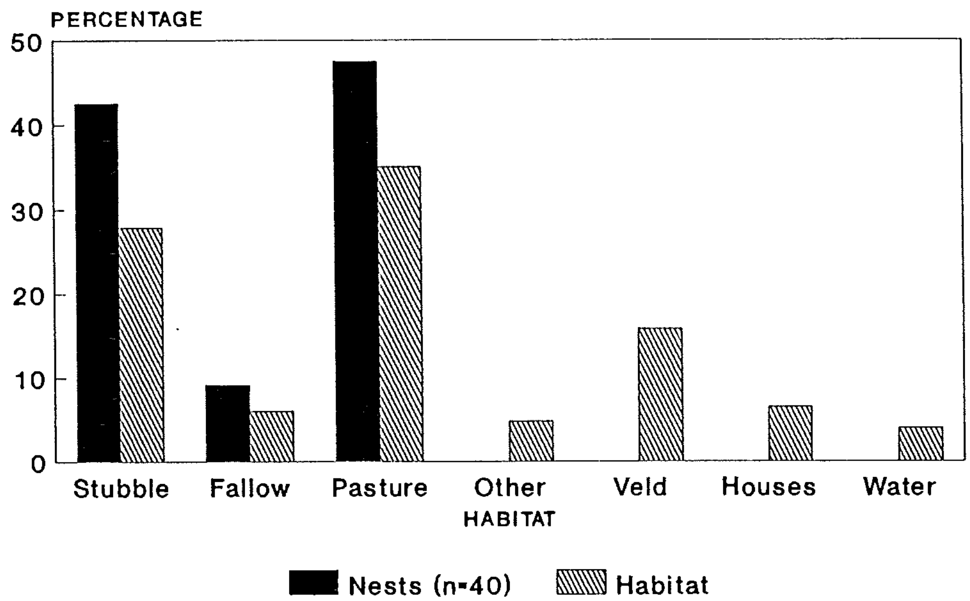

Figure 2. Habitat preference of breeding Blue Cranes in the southern Cape, 1992-93.

A CONSERVATION PROGRAM FOR THE BLUE CRANE IN THE OVERBERG, SOUTHERN CAPE, SOUTH AFRICA

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ABSTRACT

The number of southern Africa's endemic Blue Crane (*Anthropoides paradiseus*) appears to be declining. The chief cause of the decline appears to be poisoning. More than half of the 14,000 surviving birds are concentrated in the grainlands of the Overberg in the southern Cape, at least during the winter. In April 1993, Cape Nature Conservation launched a comprehensive conservation program for the species, in cooperation with the Overberg Crane Group. This strategy relies heavily on the participation of the local community and consists of nine projects.

1. To determine the present conservation status of the Blue Crane in the Overberg.
2. To address the problems caused to farmers by Blue Cranes.
3. To reduce mortality of Blue Cranes in the area.
4. To promote breeding success.
5. To launch a public awareness campaign.
6. To coordinate education activities with regard to cranes.
7. To promote cranes as an economic asset to the Overberg.
8. To promote long-term survival outside nature reserves.
9. To monitor the effectiveness of these conservation measures.

Much progress has been made to date with the successful implementation of this program.

INTRODUCTION

The Blue Crane (*Anthropoides paradiseus*) (Clancey *et al.* 1991) was once widespread in grasslands and pastures throughout the greater part of southern Africa, where it is endemic. Today, South Africa's national bird is considered to be threatened (Ledger 1988; Anderson 1990). Numbers have declined overall by more than one-third during the past ten years, and are now estimated at only about 14,000 (Allan 1994). This decline is ascribed mainly to poisoning (Ledger 1985; Tyson 1987, 1988; Johnson 1992a; Tarboton 1992). Numbers in the Overberg region in the southern Cape are presently estimated at about 3,050 in summer and 7,850 in the winter (D. Allan *pers. comm.*). In the Karoo region of the Cape, approximately 5,800 Blue Cranes occur. It is unlikely that there will ever be a conservation area large enough to meet the requirements of Blue Cranes, on account of their mobility. Their conservation therefore rests almost entirely with the private landowner (Johnson and Barnes 1986; Filmer and Holtshausen 1992).

The increase in Blue Crane numbers in the Overberg has been ascribed to the large-scale replacement of natural, bushy fynbos vegetation by grainlands (Allan 1992). The birds appear to favor open areas such as plowed or fallow fields, and roost in shallow dams or pans. These habitat preferences bring the species into conflict with agricultural activities, however, and there have been increasing reports of damage caused by cranes to crops, and depredations on sheep fodder at feedlots (especially in times of drought).

The poisoning of Blue Cranes appears to arise from three sources (Day 1979; Tarboton 1992; Vernon *et al.* 1992; Allan 1993). Cranes may be deliberately poisoned for causing agricultural damage. Their habit of trampling crops or foraging on supplementary feed at livestock feedlots is well documented (Van Ee 1981; Geldenhuys 1984; Filmer and Holtshausen 1992; Johnson 1992b; Johnson and Barnes 1986; Stretton 1992; Vernon *et al.* 1992). Inadvertent poisoning of cranes may occur when poison is placed out by farm workers as food for other species such as Egyptian Goose (*Alopochen aegyptiacus*), Spurwinged Goose (*Plectropterus gambensis*), and Helmeted Guineafowl (*Numida meleagris*), or for rodents which are causing crop damage. Third, Blue Cranes may be poisoned during the routine application of insecticides to crop fields (Allan 1993).

Table 1 and Figure 1 summarize details of known poisoning incidents involving Blue Cranes in the south-western Cape (Allan 1993). The poison was identified as diazinon, a livestock dipping agent (trade name "Dazzel"), in two cases, and as monocrotophos, a seed dressing, in another two. Where the month of the incident was reported, eight of 12 cases occurred from winter to early spring (August to October). This is the period when crops are planted or germinating and, in the southwestern Cape, when the cranes are still in large winter flocks. They are thus more vulnerable to mass mortality through poisoning. In 1991 and 1992 alone, eight incidents involving at least 100 Blue Cranes were recorded in the Overberg (Scott 1992b).

Further causes of mortality include collisions with power lines and fences, disturbance at breeding sites, and the removal of chicks from the wild (Filmer and Holtshausen 1992). Baling twine may also become entangled around the legs (D. Allan *pers. comm.*; *pers. obs.*).

In 1991, matters reached crisis proportions in the Bredasdorp area during an exceptionally dry spring, when food was short for both cranes and livestock. Only 22 mm of rain fell during August and September, compared with the combined mean of 75 mm for 1980-92 (Scott 1993b). Blue Crane depredations on sheep feeding troughs escalated and increasing reports of conflict were received. A workshop was convened by Cape Nature Conservation (CNC) in September 1991 (Scott 1991) and the Overberg Crane Group (OCG) was established in October 1991. This working group consists of members of CNC as well as a wide range of representatives from the local community and is affiliated to the Southern African Crane Foundation (SACF), which has close ties with the International Crane Foundation (ICF).

METHODS

Conservation programs for cranes (Chabwela 1987; Tacha *et al.* 1987; Lewis 1991; Johnson 1992a; Maclean 1992; Tarboton and Johnson 1992) and other threatened species (IUCN/SSC Tortoise and Freshwater Turtle Specialist Group 1989; Baard 1993; Boshoff and Robertson 1985; Coetzee 1992; Lawrence 1991) were consulted. The OCG drafted an integrated conservation program for the local Blue Crane population (Scott 1992a, 1993a, 1993c). The aims of this program are to assess the conservation status of the Blue Crane in the Overberg, to address the problems caused to farmers by cranes, and to increase conservation measures for the species in this region.

Nine objectives were identified and formulated as projects in this coordinated strategy.

1. **To determine the present conservation status of the Blue Crane in the Overberg.** Information is needed on the status, population dynamics, movement patterns, and habitat preferences of Blue Cranes in the Overberg region, in order to devise management strategies.

2. **To address the problems caused by Blue Cranes to farmers in the Overberg.** An attempt is being made to determine the extent of the problems caused to farmers by Blue Cranes in the area, and to find ways of overcoming these problems in order to reduce conflict.

3. **To reduce the mortality of Blue Cranes in the area.** Blue Crane mortality should be researched and documented, and ways must be found to reduce unnatural deaths.

4. **To promote breeding success.** Information is needed on breeding localities and habitat preferences, territories, and survival rates of Blue Cranes. Actual and potential threats to breeding birds are being investigated, and means are being found to promote breeding success and survival.

5. **To launch a public awareness campaign.** Public awareness is seen as a priority. Attitudes have been assessed and target groups identified. Information is being produced and disseminated in a variety of ways.

6. **To coordinate education activities with regard to cranes.** Education is seen as the key to the long term success of this project, especially among farmers, farm workers and the younger generation.

7. **To promote cranes as an economic asset to the Overberg.** Promoting the Blue Cranes as an economic asset to the area is regarded as a long term objective. If the birds have a commercial value, landowners are more likely to conserve them.

8. **To promote long-term survival outside nature reserves.** Promoting the long term survival of Blue Cranes in the area, and involving the private landowner in these measures, is another important project, as the survival of these birds rests in their hands.

9. **To monitor the effectiveness of these conservation measures.** The OCG needs to determine whether conservation measures are achieving their objectives, and to improve these measures where necessary. One of the easiest ways of monitoring progress is to determine whether numbers of cranes are increasing or at least stable.

The need for a holistic approach to compiling programs of this nature is stressed by Tacha *et al.* (1987). An attempt is made to represent interrelationships between the different components in Figure 2.

The Overberg Blue Crane Conservation Program was launched at a large workshop on 1 April 1993. The aim was to work through existing structures, and community leaders and other influential persons were therefore invited to participate.

RESULTS AND DISCUSSION

Considerable progress has been made with the implementation of the program. A flexible, dynamic approach has been adopted and adaptations are made as required. The projects comprising the program are discussed briefly below.

Project 1: To determine the conservation status of the Blue Crane in the Overberg

A master of science study is being conducted on the Blue Cranes in the Overberg region. Information is being collated. The methods include a questionnaire and literature survey. Research is being conducted on ecological aspects of the species. A shortage of funds is a problem, although sponsorship of a vehicle and fuel have been obtained.

Project 2: To address the problems caused by Blue Cranes to farmers in the Overberg

Channels have been established through which problems may be reported. Follow-up action on reports of problems has been instigated, including a questionnaire. Communication with farmers has been improved. Experiments have been conducted by certain farmers in order to reduce depredations on feedlots by cranes. The erection of a low strand of wire around the feeding trough has met with success, while still permitting sheep access. The cranes appear to be reluctant to enter a confined space. Research on feeding patterns has been initiated. The OCG is fortunate in having the active involvement of at least four local farmers in this aspect.

Project 3: To reduce mortality of cranes in the Overberg

An attempt is made to report all crane mortalities, to investigate the causes, and to enforce appropriate legislation. All poisoning events are logged. Education of offenders is a priority. Liaison has taken place with the distributors of agrochemicals and the safer handling and storage of poisons is being promoted. Less harmful methods of controlling other problem bird species need to be found, and less harmful pesticides sought. All collisions with power lines are logged, and markers are installed by ESKOM (the parastatal electricity supply commission of South Africa) where necessary. Discussion with ESKOM takes place prior to the siting of new power lines. Heavy fines (running to R10,000 or two years imprisonment for the harassment of Blue Cranes) are an important deterrent. Although limited by a lack of personnel, this project is operating well and is promoted by a good liaison network.

Project 4: To promote breeding success and survival

Research is being conducted on breeding activities (see project 1). Attempts are being made to protect breeding habitats, birds, and chicks, for instance by means of installing a marker near nests. A certificate for landowners with breeding pairs of Blue Cranes is being investigated. Injured or permanently disabled birds are forwarded for use in captive breeding programs. Although this aspect is not yet deemed a priority, techniques for captive breeding are being established. The removal of chicks from the wild for pets appears to be a greater problem than was initially realized, and is receiving much publicity. The OCG is fortunate in having this project coordinated by a farmer, who is also the chairman of the group.

Project 5: To launch a public awareness campaign

An attempt was made to assess attitudes towards Blue Cranes in the community and to identify key target groups. Influential people in both official as well as non-governmental conservation agencies were approached at a large Blue Crane workshop (see above) to assist with publicity and education. Information is being produced, such as the conservation program and a poster. Effective means of communication are being utilized, such as talks at farmers' meetings/farmers' days, articles in newspapers and journals, and radio and television coverage. Although funds are limited, the conservation program has been favored by the willingness of the media to disseminate this information. A good liaison network has been established within the local community. Sponsors are currently being sought for the manufacture of a Blue Crane video, and for other conservation projects, and a Blue Crane Conservation Fund has been established. The value of personal contact cannot be over-emphasized, however.

Project 6: To educate the community about the conservation plight of the Blue Crane

Educational information is being produced. Liaison has taken place with local schools, libraries, and museums to promote awareness of the Blue Crane by means of environmental education activities. Two children's art poster competitions have been organized. Schools are being encouraged to use Blue Cranes as subject material in school syllabi. A current priority project is the production of a "package" for farmers, entitled "How to Manage Your Blue Cranes." Farm workers are being educated with the assistance of the Rural Foundation. A package for school teachers is also being planned. This project is hampered by a lack of staff, but the response of the local community is positive.

Project 7: To promote cranes as an economic asset to the Overberg

The aesthetic, national, and international conservation value of the Blue Crane is being promoted. Research is still needed to determine the potential value of cranes to farmers. Blue Cranes are being promoted as an economic asset in terms of tourism, as part of an Overberg tour package. The establishment of crane restaurants (i.e., feeding areas) is a possibility. Although the present political climate does not favor tourism in general, there is a strong local interest in ecotourism, and the Blue Cranes are becoming a key tourist attraction.

Project 8: To promote the long-term survival of the Blue Crane outside reserves

Key areas where Blue Cranes occur in large numbers are being identified by research (see Project 1). After this a series of small meetings will be held with the landowners to initiate the formation of different types of conservation areas. Management plans and programs may then be drawn up and activities between these areas coordinated. This project is hampered at times by a local antipathy towards what is perceived to be a bureaucratic attempt to obtain control of farmland, although the status of Blue Cranes is increasing among landowners.

Project 9: To monitor the effectiveness of Blue Crane conservation measures in the Overberg

A combined ground-aerial monitoring program is being developed to monitor bird numbers. Recently, a successful road count was organized, involving members of local bird clubs. Landowners are also being approached in order to monitor crane numbers on their properties. An aerial census is being investigated. The results of the monitoring program will be communicated to interested parties on a regular basis. Although few landowners are interested at this stage, bird clubs are enthusiastic to assist.

CONCLUSION

In its concern for the conservation of the Blue Crane, the Overberg community is identifying with a worldwide crane conservation movement. To date, the reaction to the conservation program has been overwhelmingly positive. This commitment bodes well for the future of South Africa's national bird.

ACKNOWLEDGMENTS

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REFERENCES CITED

Allan, D. G. 1992. Distribution, relative abundance and habitat of the Blue Crane in the Karoo and the south western Cape. Pages 29-46 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Allan, D. G. 1993. Aspects of the biology and conservation status of the Blue Crane *Anthropoides paradiseus*, and the Ludwig's *Neotis denhami* and Stanley's *N. denhami stanleyi* bustards in southern Africa. M.S. Thesis. University of Cape Town, South Africa.

Allan, D. G. 1994. Cranes and farmers. Endangered Wildlife Trust, Johannesburg, South Africa.

Anderson, S. 1990. South Africa's national bird is endangered. African Wildlife 44: 363.

Baard, E.H.W. 1993. A conservation strategy for the geometric tortoise, *Psammobates geometricus* in the southwestern Cape Province. Cape Nature Conservation unpubl. report, Cape Town, South Africa.

Boshoff, A. F. and A. S. Robertson. 1985. A conservation plan for the Cape vulture colony at Potberg, De Hoop Nature Reserve, southwestern Cape Province. Bontebok 4: 25-31.

Chabwela, H. N. 1991. Wetland conservation, wildlife management, and human communities on the Kafue Flats, Zambia. Pages 369-375 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Clancey, P. A., R. K. Brooke, T. M. Crowe, and J. M. Mendelsohn. 1991. S. A. O. S. checklist of southern African birds: second updating report. Southern African Ornithological Society, Johannesburg, South Africa.

Coetzee, K. 1992. A strategy for the conservation of the riverine rabbit (*Bunolagus monticularis*) and its habitat. Cape Nature Conservation unpubl. management proposal, Cape Town, South Africa.

Day, D. H. 1979. Report on the crane study group for 1978/79. Bokmakierie 31: 61-62.

Filmer, R. J. and G. R. Holtshausen. 1992. The southern African crane census, 1985/1986. Pages 132-141 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Geldenhuys, J. N. 1984. The status of cranes (Aves: Gruidae) in the Orange Free State. South African Journal of Wildlife Research 14: 15-18.

IUCN/SSC Tortoise and Freshwater Specialist Group. 1989. Tortoises and freshwater turtles: an action plan for their conservation. IUCN, Gland, Switzerland.

Johnson, D. N. 1992a. Saving cranes: the farmer's role. Pages 119-120 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Johnson, D. N. 1992b. The status of cranes on Natal in 1989. Pages 20-28 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Johnson, D. G. and A. R. Barnes. 1986. The Natal crane census. Lammergeyer 37: 40-49.

Lawrence, B. W. 1991. Fish management plan. Murray-Darling Basin Commission, Australia.

Ledger, J. 1985. The poison people. African Wildlife 39: 6-8.

Ledger, J. 1988. Cranes for the king. Quagga 20/21: 23-24.

Lewis, J. C. 1991. International cooperation in recovery of Whooping Cranes: a model for other nations. Pages 389-394 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Maclean, G. L. 1992. A crane conservation action plan for southern Africa. Pages 121-122 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Scott, H. A., ed. 1991. Proceedings of a workshop on the interactions between larger birds and farming activities in the Bredasdorp area. De Hoop Nature Reserve, Cape Nature Conservation and Museums, Cape Town, South Africa.

Scott, H. A. 1992a. Blue Crane conservation program launched on the Overberg. The Crane 3(2): 3-5.

Scott, H. A. 1992b. Overberg Crane Group news. The Crane 3(2): 3-5.

Scott, H. A., ed. 1993a. A conservation program for the Blue Crane in the Overberg. Cape Nature Conservation and Museums in co-operation with the Overberg Crane Group, Cape Town, South Africa.

Scott, H. A. 1993b. An investigation into a decline in bontebok *Damaliscus dorcas dorcas* in the de Hoop Nature Reserve, south-western Cape. Unpubl. M.Dip. Thesis. Port Elizabeth Technicon, South Africa.

Scott, H. A., ed. 1993c. Proceedings of a Blue Crane Workshop. Cape Nature Conservation and Museums, in cooperation with the Overberg Crane Group, Caledon, South Africa.

Stretton, W. S. 1992. Some thoughts on the decline of the Blue Crane and the role of the farmer in its conservation. Pages 111-114 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Tacha, T. C., P. A. Vohs, and G. C. 1987. An integrated approach to crane research: lessons from Sandhill Cranes of mid-continental North America. Pages 463-468 *in* G. L. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Tarboton, W. R. 1992. Extent and reasons for population declines in South Africa's three crane species. Pages 117-118 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Tarboton, W. R. and D. N. Johnson. 1992. A management plan for the conservation of the Wattled Crane in South Africa, 1982. Pages 127-131 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Tyson, N. 1987. 29 Blue Cranes poisoned in the Cape. African Wildlife 4: 266.

Tyson, N. 1988. Blue Crane poisoning. African Wildlife 42: 4-5.

Van Ee, C. A. 1981. Status of the Blue Crane in south and southwest Africa. Page 259 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world: proceedings of the International Crane Symposium at Sapporo, Japan in 1980 and papers from the World Working Group on Cranes, International Council for Bird Preservation. International Crane Foundation, Baraboo, Wisconsin, USA.

Vernon, C. J., A. F. Boshoff, and W. S. Stretton. 1992. The status and conservation of cranes in the Eastern Cape Province. Pages 47-72 *in* D. J. Porter, H. S. Craven, D. N. Johnson, and M. J. Porter, eds., Proceedings of the First Southern African Crane Conference. Southern African Crane Foundation, Durban, South Africa.

Table 1. Details of known poisoning incidents involving Blue Cranes in the southwestern Cape, South Africa (after Allan *in prep.*).

Locality	Date	No.	Poison	Reference
Overberglate	1970s	12	?	Day (1979)
Bredasdorp	1984	?	?	Scott (1992b)
Napier	Sept. 1984	19	diazinon	Ledger (1985)
Bredasdorp	Sept. 1985	?	?	Scott (1992b)
Herbertsdale	Aug. 1987	15	monocrotophos	Tyson (1987; 1988)
Riviersonderend	Aug. 1987	14	monocrotophos	Tyson (1987; 1988)
Witsand	Sept. 1987	2	?	D. Allan (*pers. comm.*)
Caledon	1989	?	?	Scott (1992b)
De Mond	1991	2	?	Scott (1992b)
Botrivier	May 1991	3	?	Scott (1992b)
Botrivier	May 1991	14	?	Scott (1992b)
Rietpoel	Aug. 1991	52*	diazinon	Scott (1992b)
Riversdale	Oct. 1991	8	?	Scott (1992b)
Caledon	Jan 1992	1	?	Scott (1992b)
Caledon	Jan 1992	9	?	Scott (1992b)
Swellendam	Oct. 1992	2	?	D. Allan (*pers. comm.*)

*Forty-five died and seven recovered after being injected with Valium by Cape Nature Conservation officials

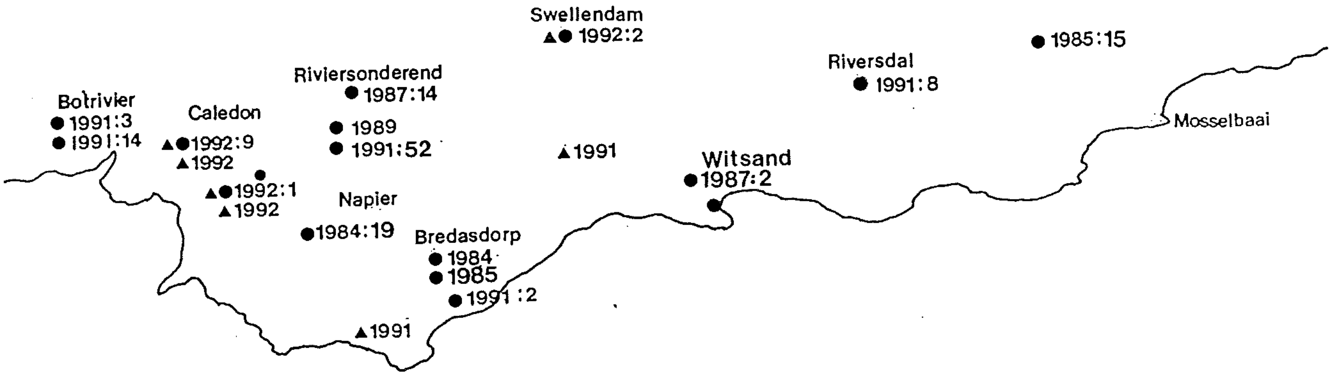

Figure 1. Location of poisoning incidents involving birds in the Overberg, southern Cape, South Africa: 1984-92 (• Blue Cranes, ▲ other bird species) (after Allan *in. prep.*).

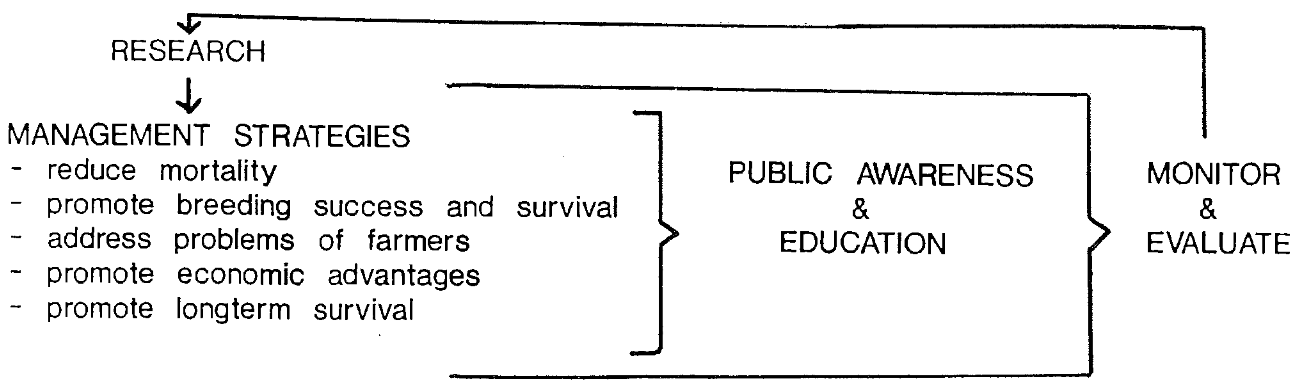

Figure 2. Interrelationships between the various projects of the Blue Crane conservation program in the Overberg, southern Cape, South Africa.

POISONS AND FARMERS: A PERSPECTIVE ON CRANE CONSERVATION

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INTRODUCTION

Agriculture can be regarded as a necessary evil--the world's growing human population constantly needs more food, while the excessive cultivation of monocultures to fill this need leads to the proliferation of plant diseases and the resultant increase in the use of pesticides and other agrochemicals.

The most recent World Health Organization statistics for population growth and global food needs provide us with a frightening scenario (Zündorf 1990):

- while there is a surplus of food in most industrial countries only **half** of the world's population of 5 billion has sufficient food to eat;
- 1.5 billion people are malnourished;
- another 1.5 billion do not now have, and will never have enough to eat;
- 15 million people die annually from starvation;
- 200,000 infants are born daily;
- by the year 2000 the earth will have 6.5 billion inhabitants, with no decrease in the population growth envisaged.

At the same time 35% of potential food production is lost to pests, weeds, and plant diseases; with a further 20% of the remaining yield lost to pests during storage. Without crop protection a further 30% will be destroyed! Inefficient and irresponsible usage of chemicals leads to even further damage and waste.

CRANES AND POISONS IN AGRO-ECOSYSTEMS

Cranes and other bird species are being adversely affected by the extensive use of agrochemicals. The illegal and irresponsible use of poisons has been identified as one of the main causes of the drastic decline in local crane populations. In the National Crane and Habitat Action Plan produced by the South African delegates at this Workshop poisoning was singled out as the greatest single threat to South African crane populations (*this proceedings*).

South Africa's three crane species all occur in agro-ecosystems and will always be vulnerable to agricultural poisons. Although deliberate poisonings do occur (especially in marginalized areas where cranes cause damage to seedlings), the majority of poisonings are either indiscriminate or due to the illegal "hunting" of gamebirds by means of poisoned grain.

It is commonly known in both the agrochemical industry and agricultural circles that it is not poison as such which is dangerous, but the way poison is used. Many farmworkers soak seeds in poisons registered for pest control; this seed is then scattered on the ground in order to kill guineafowl and other gamebirds to provide protein for their families. In the Overberg (southwestern Cape) this form of poisoning has been the main cause of deaths of Blue Cranes (*Anthropoides paradiseus*).

A hitherto unknown source of poisoning has come to my attention through discussions with both farmers and agriculture extension officers: the use of seed dressings in cereal crops. The danger to cranes is immense; as the bird uproots young seedlings or shoots with the softened grain attached, the residual seed dressing is also consumed. Although there has been a concerted move towards more environmentally-friendly chemicals by the chemical industry, there is evidence that many highly toxic active ingredients are still being used (Vermeulen *et al.* 1992). These include:

- *Benfurocarb* (oral LD_{50} 115-166);
- *Furathiocarb* (oral LD_{50} 42-53);
- *Gamma BHC* (oral LD_{50} 88-184);
- *DIELDRIN* (oral LD_{50} 38-67; dermal LD_{50} 98mg/kg)

The latter poison is one of the "dirty dozen" poisons which are banned virtually worldwide; in South Africa it was withdrawn from the market in 1980 but has been in use by many farmers who have it stockpiled. Highly toxic granular nematicides like *Temik* (aldicarb - oral LD_{50} 35-110) and *Curaterr* (carbofuran - oral LD_{50} 8-14) are widely applied as pre-emergence preventative chemicals in soil and could also be contributing to crane mortalities. They need further investigation. An overview of agro-chemicals that could affect cranes is provided in the Appendix.

FARMERS AND CRANES

At this stage it is crucial to clear up some misconceptions about farmers and cranes. In compiling The Poison Working Group data base on poisonings, we have not come across a single instance of malicious poisoning of a crane by a farmer (we do, however, know of cranes being deliberately shot as a result of crop damage).

I am convinced that we should not summarily accuse farmers of poisoning - the problem lies in the **system** which consists of cooperatives and chemical representatives aiming for maximum sales without providing necessary training (especially for farm workers) on the correct and responsible use of their products.

Fortunately for the environment, future governments in

South Africa will not be subsidizing "white" agriculture to the extent of the current regime, and farmers will be forced to look at cost effective ways of cutting input costs. This in itself bodes well for a move towards sustainable agriculture and in particular a change in attitude regarding the responsible and correct application of agrochemicals.

CONCLUSION

The Poison Working Group has taken up the challenge posed by the threat of poisons to our dwindling crane populations. An extensive data base is being compiled on poison cases and we hope to note specific trends. There has been far too much speculation about cranes, farmers, and poisons and too few facts. Additional surveys on poison use in selected rural areas will be undertaken, as well as various discussions with stake-holders within agriculture to ascertain their attitudes and points of view. This process will hopefully enable us to design an education campaign, run within existing structures, to address the true poison problem.

REFERENCES CITED

Vermeulen, J. B., M. Krause, A. Nel, N. Hollings, and J. Greyling. 1992. A guide to the use of pesticides and fungicides in the Republic of South Africa, 35th revised edition. Department of Agriculture, Pretoria, South Africa.

Zündorf, U. 1990. All climates under one roof. Bayer Reports 58/1990. Mannheim, Germany.

APPENDIX

Overview of agro-chemicals generally used as seed dressings and granular soil treatments in cereal crops in South Africa which could affect cranes (a detailed study is in progress).

There is a definite move away from highly toxic ingredients and even from moderately toxic ones (like carbamates) to new chemistry. An example is the new product *Gaucho* (imidacloprid) a water-dispersible powder applied as slurry to seeds to control black maize beetle, ground weevil and leafhoppers in maize. Manufacturers claim is it environmentally safe.

I have spoken to an agricultural extension officer who worked in the Bethal district (southeast Transvaal) during the drought period 1983/4 when we lost many cranes: he maintains that the problem could definitely have been the use of *Dieldrin*. Although its registration was withdrawn in 1980, many farmers still would have had, and still have stockpiles. *Dieldrin* was commonly used to treat maize in that district! He mentioned that it was known that the Grey Crowned Cranes "pulled out" the "seedlings" together with what he called the "suurpit" (i.e., the soft grain which of course still probably had PLENTY of *Dieldrin* on it).

The most prevalent problem with the use of agrochemicals is not necessarily a specific poison; it is the use, often against registration, which causes mortalities in non-target species and other environmental problems. Virtually every one of the following chemicals will be fairly safe to the environment IF used according to registration. Do keep in mind that during times of drought, residues (especially organo-chlorines) of previous chemicals used may pose a risk and that, as I mentioned to you, farmers tend to be more ruthless regarding the use of poisons to ward off the increased natural predation/influx of "predators," seen as a further threat to production. Examples include:

Endosulfan Schedule I (oral LD_{50} = 35-110)
Used as either ground/aerial application to control American bollworm, stalkborer, cutworms, and army worms in maize, wheat, sorghum, and cotton.

Terbufos Schedule I (oral LD_{50} = 1.3-9)
Granular application in soil prior to planting for control of nematodes and black maize beetle in maize, sorghum, sunflowers, potatoes.
Tradenames: Terrafos, Counter

Aldicarb Schedule I (oral LD_{50} = 0.5-1) (dermal LD_{50} in rabbit = 2.5-5)
Tradename: TEMIK
Granular nematicide used in maize, potatoes, sorghum.
This poison is very often used outside its registration due to its acute and high toxicity, especially in problem animal control. We have many cases on record of this specific chemical being responsible for wildlife poisoning.

Another poison used in similar way is
Carbofuran Schedule I (oral LD_{50} 8-14)
Tradenames: CURATERR, Quadrant, Furadan
Pre-emergence preventive granular chemical controlling nematodes, black maize beetle, false wire worm, stalk

borer, and leafhoppers in maize, wheat, potatoes, and sunflowers. We have received MANY reports involving this poison, and it is commonly used in the Free State for "controlling" jackal (*pers. comm.* from extension officers).

Seed dressings used to treat maize and wheat are also a potential problem. Examples include:

Benfurocarb Schedule II (high toxicity; oral LD_{50} 115-166)
Brand name: **ONCOL** (black maize beetle, ground weevils)

Furathiocarb Schedule I (very toxic; oral LD_{50} 42-53)
Brand name: **PROMET** (black maize and astylus beetles)

Thiodicarb Schedule II (high toxicity; oral LD_{50} 60-120)
Brand name: **SEMEVIN** (black maize beetle)

Triadimefon Schedule II (toxic; oral LD_{50} 363-385)
Brand name: **BAYLETON** (cob and tassel smut)

Gamma BHC Schedule II (high toxicity; oral LD_{50} 88-184)
Brand name: **LINDANE** (black maize beetle)--very cheap product and often used

A new problem which has come to our attention after recently receiving some poisoned guineafowl, is the danger of **urates** added to animal food supplements. The small granules are very "attractive" to gamebirds. We have brought the fact to the attention of the manufacturers and will place pressure on them to do something about it.

Note: Active ingredient: LD_{50} = lethal dosage mg/kg for rats

Scientific names for common pests of cereal crops in South Africa.

Black maize beetle	*Heteronychus arator*
False wire worm	*Tenebrionidae* spp.
Astylus beetles	*Astylus atromaculatus*
American bollworm	*Heliothis armigera*
Chilo stalk borer	*Chilo partellus*
Cob and tassel smut	*Spacelotheca reiliana*
Cutworms	*Agrotis* spp.
Ground weevils	*Protostrophus* spp.
Leafhoppers	*Cicadulina mbila*
Nematodes	*Paratrichodorus* spp.
	Pratylenchus spp.
	Nanidorus spp.
	Meliodogygne spp.

GREY CROWNED CRANES IN TRANSKEI, SOUTH AFRICA

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The territory formerly known as the Transkei, now incorporated in the re-defined Eastern Cape Province of South Africa, is situated between Natal to the north, the old Eastern Cape Province to the south and southwest, Lesotho to the northwest, and the Atlantic Ocean to the east. It is a region characterized by extremely dense rural settlement, with an average of 78 persons per km² (Macdonald 1989; O'Connor 1991). Land-use patterns largely involve subsistence crop and livestock farming but most of the people of Transkei are reliant on income earned outside the territory and sent into the region by Transkei people working elsewhere in South Africa. The human densities therefore far exceed those that can be supported by local agriculture alone. The natural vegetation of Transkei is mainly open grassland with scattered wetlands. There are also some areas of woodland, which are largely restricted to deeply incised river valleys, and forest.

I visited Transkei four times between September 1990 and February 1992 (Sept.-Oct. 1990, March 1991, Sept.-Oct. 1991, Feb. 1992). Fifty-eight of the approximately 85 (68%) quarter-degree-grid squares (15' by 15', *ca* 25 km by 25 km) covering this region were visited. Fifty-five days were spent in the field and about 11,800 km were traveled. Whenever Grey Crowned Cranes (*Balearica regulorum*) were encountered the following details were recorded: the locality, date, the number of cranes, whether they were adults or juveniles, their activity, and the habitat.

Grey Crowned Cranes were recorded on 51 occasions. The distributional information has been incorporated in the Southern African Bird Atlas Project (Harrison 1992) and will be presented in '*The atlas of southern African birds*' to be published in 1996. The mean flock size observed was 3.4 birds (range=1-29 birds, n=51) but the median and modal group size was two birds. Of 116 cranes observed foraging, the majority were found in agricultural crop fields: crop fields 75.9% (88 birds), dams 6.9% (8 birds), natural wetlands 6.9% (8 birds), and natural grassland 10.3% (12 birds). Crowned Cranes were observed roosting overnight on the ground in both man-made dams and natural wetlands, and above ground in tall *Eucalyptus*, wattle and pine trees, and even on wooden overhead electricity transmission towers. It was noted that juvenile birds could be identified by their grey, not red, chin wattle. Of 72 birds that could be aged, eight (11.1%) were juveniles of the year. Three pairs were accompanied by two juveniles each and two pairs had single juveniles each.

Quickelberge (1989) has pointed out that the Grey Crowned Crane is protected by the people of Transkei due to a local superstition forbidding the killing of this bird. It is also the bird emblem of Transkei. During the course of my fieldwork, I was impressed by the tameness of this bird in Transkei and individuals allowed a far closer approach than Grey Crowned Cranes elsewhere in South Africa. Two recent poisoning incidents in Transkei, however, are cause for concern. In August 1986, 30 Grey Crowned Cranes were poisoned near Nxaxo (Bennett 1986) and in October 1990 seven birds were poisoned close to Rhodes (Urquhart 1991). It is not known whether these poisoning incidents were intentional or inadvertent. Another threat to the species in the region is the degradation of wetlands, which the species depends on for breeding sites, due to overgrazing and trampling by cattle (*pers. obs.*). Further research is needed on the conservation status and requirements of this species in Transkei.

REFERENCES CITED

Bennett, G. 1986. Cranes poisoned! Bokmakierie 38: 66.

Harrison, J. A. 1992. The Southern African Bird Atlas Project - five years of growth. South African Journal of Science 88: 410-413.

MacDonald, I.A.W. 1989. Man's role in changing the face of southern Africa. Pages 51-77 *in* B. J. Huntley, ed., Biotic diversity in southern Africa: concepts and conservation. Oxford University Press, Cape Town, South Africa.

O'Connor, A., ed. 1991. This is Transkei 1991/1992. Second edition, Transkei Development Corporation, Umtata, South Africa.

Quickelberge, C. D. 1989. Birds of Transkei. Durban Natural History Museum, Durban, South Africa.

Urquhart, C. 1991. Editorial. The Bee-eater 41: 50.

THE SOUTH AFRICAN WETLANDS CONSERVATION PROGRAMME

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INTRODUCTION

South Africa is an arid country. The average annual rainfall of about 497 mm for the country as a whole is well below the world average of 860 mm. A relatively narrow region along the eastern and southern coastlines is moderately well watered, but the greater part of the interior and the western portion of the country are arid or semi-arid. Sixty-five percent of its area has a mean annual precipitation of less than 500 mm, while 21% of the country receives less than 200 mm (Figure 1). Over most of the country the average annual potential evaporation, which ranges from about 1,100 mm to more than 3,000 mm, is well in excess of the annual rainfall (Department of Water Affairs 1986).

The country consists largely of a geologically warped plateau more than 1,000 m above sea level with only a narrow coastal strip. There are therefore few lowland wetland regions of any size, but it is in these regions that 10 of the 12 South African wetlands listed as Wetlands of International Importance are found (Figure 2).

The climate combined with the geomorphology has resulted in a landscape characterized by such wetland features as:

- small rivers of erratic flow, very few with strong perennial flow;
- very few well developed floodplains, but most catchments having vleis;
- endoreic pans being a feature of the plateau;
- except for one small rockfall lake, no other natural inland lakes;
- coastal and estuarine lakes at places along the coasts of the south-western and southern Cape and in northern Zululand;
- estuaries (many with salt marshes, and those along the east coast previously with well-developed mangrove forest) and estuarine lagoons (Noble and Hemens 1978).

Wetlands in South Africa tend to be strongly seasonal, and therefore wetlands of no apparent importance may become significant at certain times. Although South Africa boasts some 20 species of ducks and geese, this high species diversity is more an indication of the variety of wetland types than the overall amount of wetland. Concentrations of Anatids in South Africa are not large by Holarctic standards, the largest only consisting of some 5,000 birds, but even these are rather unusual. The more common situation is small concentrations of ducks moving around nomadically (Directory of Wetlands of International Importance 1990).

A direct result of the highly seasonal rainfall has been the creation of numerous artificial impoundments. There is an increasing demand for water arising from the growth of the human population and the developing economy. This demand must met from a limited resource (Department of Water Affairs 1986). It follows that water ecosystems in South Africa already exhibit striking evidence of the impact of both development and increasingly intensive utilization.

Because of the biotic diversity of the wetlands in South Africa, their limited size and the inherent threats to them from development, wetlands are particularly important ecosystems. As such they enjoy a high priority for protection. Of the eighteen areas identified and rated in the Southern African Plan for Nature Conservation, eight include wetlands as a major component of their areas (Cohen and Cowan 1988). As in many areas where water is a scarce commodity, pressure on natural wetlands is substantial, leading to reductions in their area and effectiveness. At the same time numerous water storage dams (both small and large) have been constructed, particularly during the last ten years, while the country was experiencing a severe drought (Cowan 1990a, 1991; Cowan and Maller 1993).

This paper will discuss the South African Wetlands Conservation Programme which is being developed in order to help South Africa meet its obligations to the terms of the Convention on Wetlands of International Importance especially as Waterfowl Habitat.

THE RAMSAR CONVENTION

The Convention on Wetlands of International Importance especially as Waterfowl Habitat (commonly known as the Ramsar Convention, after the place of its adoption in 1971) is an intergovernmental treaty which provides the framework for international cooperation for the conservation of wetland habitats.

The Convention entered into force in late 1975 following the accession of the seventh party, Greece. As of June 1995 the Convention had 87 contracting parties from all regions throughout the world (Smart 1993).

In the preamble to the Convention, the contracting parties recognize the interdependence of man and his environment. They consider the fundamental ecological functions of wetlands as regulators of water regimes and as habitats supporting a characteristic flora and fauna, especially waterfowl (as such the Convention was one of the first to recognize habitat as opposed to animal or plant species). The contracting parties note their conviction that wetlands constitute a resource of great economic, cultural, scientific, and recreational value, the loss of which would be irreparable. The contracting parties express their desire to stem the progressive encroachment on and loss of wetlands now and in the future. They recognize that waterfowl in their seasonal migrations may cross frontiers and so should be regarded as an international resource. Finally the contracting parties express their confidence that the conservation of wetlands and their flora and fauna can be ensured by combining farsighted national policies with coordinated international actions.

With this preamble as a base, the broad objectives of the Convention are to stem the loss of wetlands; to promote wise use of all wetlands; to promote special protection of listed wetlands; to promote the training of personnel; and to promote the implementation of parties' obligations under the Convention.

In essence to ensure the conservation of wetlands, these objectives are embodied in the following two articles of the Convention:

Article 3.1 "*the Contracting Parties shall formulate and implement their planning so as to promote the conservation of the wetlands included in the list, and as far as possible the wise use of wetlands in their territory.*"

Article 4.1 "*each Contracting Party shall promote the conservation of wetlands and waterfowl by establishing nature reserves on wetlands, whether they are included in the List or not, and provide adequately for their wardening.*"

South Africa took a leading role in the development of the Convention and became the fifth contracting party to the Convention on 12 March 1975. At that stage two wetlands were designated for inclusion in the List of Wetlands of International Importance. Subsequently a further 10 wetlands have been added (Cowan 1990a, 1991; Cowan and Maller 1993; Figure 2). South Africa is one of 18 African countries which are party to the Convention (Smart 1993).

Being at the southern tip of the continent, South Africa has a special position. A number of endemic species, e.g., Bank Cormorant (*Phalacrocorax neglectus*), and Cape Shoveler (*Anas smithii*), and such highly isolated species as the Wattled Crane (*Bugeranus carunculatus*) and the Whitewinged Flufftail (*Sarothrura ayresi*) associated with wetlands are found within its borders. This country's wetlands host a number of Palearctic migrants during the northern winter, some of which come all the way from the Taimyr Peninsula in Siberia, a distance of approximately 15,000 km (Smit and Piersma 1989). South Africa also extends into the tropics, providing the southern limits to a number of tropical species including Pinkbacked Pelican (*Pelecanus rufescens*), Rufousbellied Heron (*Butorides rufiventris*), Dwarf Bittern (*Ixobrychus sturmii*), Openbilled Stork (*Anastomus lamelligerus*), and Pygmy Goose (*Nettapus auritus*). With such a diversity of species and its important geographical position, South Africa has an important position to play in wetland conservation (Cowan 1991).

ADMINISTRATIVE STRUCTURE IN SOUTH AFRICA

In essence the South Africa government structure has three tiers (Figure 3). At the national level, departments such as the Department of Environment Affairs are responsible for making policy, promulgating legislation, coordinating national planning, and monitoring the environment. The executive functions are housed at the regional level, where conservation management agencies such as Cape Nature Conservation, Kwazulu Bureau of Natural Resources, Natal Parks Board, and the National Parks Board are responsible for nature conservation in their areas or regions. In turn the regional authorities support the local level of government which is largely made up of municipalities. It should be noted that there are some Departments (e.g., Department of Water Affairs and Forestry) which operate at all three levels.

THE SOUTH AFRICAN WETLANDS CONSERVATION PROGRAMME

The Department of Environment Affairs, having responsibility at the national level for the implementation of the Convention, has established a South Africa Wetlands Conservation Programme. This program is to build on past efforts to protect wetlands in South Africa against degradation and destruction, while aiming at the ideal of wise use of resources (Cowan 1992b).

The objective of the Programme is to ensure the conservation of South Africa's wetlands in such a way that the ecological and socioeconomic functions of wetlands are sustained now and in the future. In order to meet this objective, the Programme is to be developed along eight themes. The themes are:

Interdepartmental coordination

A number of state departments' legislation and activities have either direct or indirect effects on wetlands and their conservation. This part of the Programme is addressing such issues as catchment area planning and management, ecological water requirements of wetlands, rehabilitation and protection of wetlands, and the issue of jurisdictional wetlands. It is essential that effective working relations be developed and maintained between the Department of

Environment Affairs and these other departments if wetland conservation is to make any progress.

South African Ramsar Working Group

South Africa, in common with a number of other contracting parties to the Ramsar Convention, has a variety of governmental and non-governmental agencies involved in wetlands conservation. Some member countries have found it beneficial to coordinate their national activities through a national Ramsar committee on which both government and non-government agencies are represented.

A national committee, known as the South African Ramsar Working Group, has been established. This committee serves as a working group of the Sub-committee for Nature Conservation of the statutory Committee for Environmental Management as established by the Environment Conservation Act (No. 73 of 1989). South Africa is one of only sixteen countries to have established such a committee.

The task set for the South African Ramsar Working Group is to make concrete proposals to the Sub-committee which will help South Africa meet its obligations in terms of the Ramsar Convention. The Working Group is convened and chaired by the Department of Environment Affairs and comprises representatives of those organizations responsible for the management of wetlands listed by South Africa as "Wetlands of International Importance" and the Department of Foreign Affairs and selected individuals from non-government organizations.

National inventory of wetlands

The Fourth Meeting of the Contracting Parties to the Ramsar Convention held at Montreux in 1990 recommended that "the Contracting Parties establish as far as possible ... national scientific inventories of wetlands showing, in particular, those which are of international importance according to the criteria adopted by the Conference of Contracting Parties" (Recommendation C.4.6 (Rev.)).

This supplements recommendations made in 1980, 1984, and 1987 regarding national inventories to make up a "Shadow list of wetlands" and is aimed at providing a method of selecting further sites for the List of Wetlands of International Importance, as well as to meet one of the principal obligations of contracting parties to the Convention, to "formulate and implement their planning so as to promote ... as far as possible the wise use of wetlands in their territory" (Article 3.1). This call for a national inventory in South Africa has been echoed by numerous individuals at various fora (Walmsley and Botten 1987; Walmsley and Boomker 1988; Breen and Begg 1989; Begg 1990).

One of the first tasks required of the SA Ramsar Working Group is to determine a list of priority wetlands (as defined by the Convention), based on existing knowledge, for South Africa. To date some 350 wetlands have been nominated for the list and are in the process of being verified as priority wetlands.

This list of priority wetlands will form the initial "Shadow list of important wetlands" for South Africa as recommended by the Convention. This is to be followed by a full inventory program. The inventory and its database is the foundation on which the other themes will build.

National policy on wetland conservation

Besides the other state departments whose activities impinge on wetland conservation mentioned in the first theme, South Africa has numerous management agencies whose primary function is nature conservation. In order to support these agencies in their functions, the development of a national policy on wetland conservation is seen to be of paramount importance.

A draft policy has been prepared and circulated by the Department of Environment Affairs for review. This policy was developed after reviewing policies of other countries, most notably that of Canada, which has a similar administrative structure. The recommendations made by the Conferences of Contracting Parties to the Ramsar Convention were used to form the basis of the policy with the necessary adaptations to suit the needs of South Africa. The draft is currently undergoing revision in the light of comments received. When completed, the policy will be gazetted by the Minister in terms of Section 2 of the Environment Conservation Act (No. 73 of 1989).

Research program

The continued development of scientific knowledge and expertise in South Africa is fundamental to the achievement of wetland conservation. The research strategy of the South African Wetlands Conservation Programme is aimed at promoting management of wetlands which is based on a predictive understanding of the ecology and behavior of these systems and their components.

A review of all major wetland groups (rivers, vleis, marshes, swamps, floodplains, pans, impoundments, lakes, estuaries, reefs, and islands) is being completed. Research in progress at these wetlands is being noted. Research required for each group will be identified in terms of:

- promoting an interdisciplinary and critical approach to the development of ecological theory;
- promoting management of wetlands based on a predictive understanding of the behavior of these systems and their components;
- promoting high quality scientific and technical training in an interdisciplinary program directed at research and resource management;

- promoting the exchange of information on ecological theory and resource management of wetlands.

During the budget year 1992-93 the Department spent some R 1.7 million on wetland related research. This research funding was divided as follows:

Monitoring	R 14,000
Estuaries	R 477,000
Rivers	R 358,000
Inventory and classification	R 102,000
Catchment management	R 608,000
System studies	R 156,000
Priority wetlands	R 18,000

Wetland protection

Wetlands and wetland functions are often inextricably linked to surrounding ecosystems and, therefore, wetland conservation must be pursued in the context of an integrated systems approach to environmental conservation and sustainable development.

A system of protected wetlands is to be established as part of the protected area network. This is to be achieved in cooperation with the regional and local governments, and the South African public, including landowners, non-government organizations, and the private sector. Such a system would provide a comprehensive network of protected wetlands of national significance (exemplary and strategic) which together represent the full range of wetland functions. There is no legal protection of wetland systems as wetlands in South Africa at present (Boomker 1988; Begg 1990; Cowan 1990, 1992a). As part of the strategy to implement the wetland conservation policy, relevant legislation will need to be promulgated.

Wetland information dissemination

An integral part of the Wetlands Conservation Programme is to keep those working in or interested in the wetland conservation field informed of what is happening at the national and international level.

The newsletter *South African Wetlands*, published by the Department of Environment Affairs, is the mouthpiece of the Programme. This newsletter provides information on how South Africa is meeting its obligations to the terms of the Ramsar Convention.

A number of other papers are to be published by the Department. These will include the National Policy on Wetland Conservation, a review of the conservation and ecology of wetlands in South Africa, and the "shadow list of wetlands".

In order to facilitate collaboration among the diverse groups working in the field of wetland conservation a database on wetland expertise is being compiled by the Department. All departmental publications are forwarded to those on the list. A document collection and bibliography on wetlands is being compiled and maintained by the Department's library for use by those working in wetlands. An education and information program aimed at the general public will also be developed on wetlands and their conservation.

International actions

The Programme is being used to strengthen South Africa's role in international wetland conservation and is using these international fora to strengthen its wetland conservation efforts by regularly reviewing the country's progress with relation to wetlands and by identifying gaps or weaknesses in honoring international responsibilities. Wetland conservation is being promoted through a continued commitment to the Convention on Wetlands of International Importance especially as Waterfowl Habitat, the Convention on International Trade of Endangered Species, the Convention on the Conservation of Migratory Species of Wild Animals, and the Convention on Biological Diversity, as well as by participation in the activities of the International Waterfowl and Wetland Research Bureau.

Other countries, particularly those whose wetlands are used by bird and wildlife populations shared with South Africa, will be assisted in their wetland conservation efforts.

CONCLUSION

South Africa is playing an active role in the Ramsar Convention. We have found that by developing our wetland conservation program around the Convention, it has been far easier to get support for the Wetlands Conservation Programme than would have otherwise been the case. The obligations in terms of the Convention have also helped support the conservation of South African wetlands. A Ramsar monitoring mission visited the St. Lucia System during 1992, after the site had been placed on the Montreux Record of Listed Wetlands under Threat. The mission's report highlighted a number of shortcomings in the controversial EIA and set out clearly what alternatives South Africa should consider in terms of its international obligations. As such, the support from the international community in the conservation of our wetlands is most welcome.

REFERENCES CITED

Begg, G. W. 1990. The wetlands of Natal (Part 4). Policy proposals for the wetlands of Natal and KwaZulu. Natal Town and Regional Planning Report vol. 75.

Breen, C. M. and G. W. Begg. 1989. Conservation status of southern African wetlands. Pages 254-263 *in* B. J. Huntley, ed., Biotic diversity in southern Africa: Concepts and conservation. Oxford University Press, Cape Town, South Africa.

Boomker, E. A., ed. 1988. Proceedings of the seminar and workshop on the use of existing legislation in the protection of the natural environment (land and freshwater systems), 5-6 September 1988. Department of Environment Affairs, Pretoria, South Africa.

Cohen, M. and G. I. Cowan. 1988. The South African Plan for Nature Conservation and related programs. Paper presented at the conference "Conserving Biotic Diversity in Southern Africa" held at the University of Cape Town, 13-15 June 1988.

Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1990. Basic texts and recommendations, 1971-1987. Ramsar Convention Bureau, Gland, Switzerland.

Cowan, G. I. 1990. The role of the Department of Environment Affairs in the conservation of wetland systems in South Africa. Paper presented at the Workshop at Wilderness (South Africa) on a national policy and strategy for the fresh water systems of South Africa, 2-4 April 1990. Council for the Environment, Pretoria, South Africa.

Cowan, G. I. 1990a. South Africa: national report. Pages 183-189 *in* Proceedings of the Fourth Meeting of the Contracting Parties to the Convention on Wetlands of International Importance especially as Waterfowl Habitat. 27 June-4 July 1990, Vol. III. Montreux, Switzerland.

Cowan, G. I. 1990b. Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar): Report on the Fourth Meeting of the Conference of the Contracting Parties to the Convention, 27 June to 4 July 1990, held in Montreux, Switzerland. Rivernews 1(3): 10-12.

Cowan, G. I. 1991. Wetlands of International Importance: the Ramsar Convention. Pages 5-7 *in* Proceedings of the East Rand Wetlands Symposium, 17 Oct 1991, Suikerbosrand. Wildlife Society of Southern Africa, Johannesburg, South Africa.

Cowan, G. I. 1992a. Programme to protect wetlands. Muniviro 9(12): 3.

Cowan, G. I. 1992b. Conservation programme launched. South African Wetlands 2: 4-5.

Cowan, G. I. and M. Maller. 1993. South Africa: national report to the Convention on Wetlands of International Importance especially as Waterfowl Habitat. Mimeographed, 11 pp.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. Laroc. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. United States Fish and Wildlife Service, Biological Services Program, Washington, D. C., USA.

Department of Water Affairs (1986). Management of the water resources of the Republic of South Africa. Department of Water Affairs, Pretoria, South Africa.

Directory of Wetlands of International Importance. 1990. Ramsar Convention Bureau, Gland, Switzerland.

Leitch, J. A., and F. S. Donald. 1984. Improving wetland policy through amelioration of adverse effects on local economies. Water Resource Bulletin 20(5).

McLachlan, G. R. 1978. South African Red Data Book: reptiles and amphibians. South African National Scientific Programmes Report No. 23. CSIR, Pretoria, South Africa.

Maclean, G. L. 1985. Roberts' birds of Southern Africa. The Trustees of the John Voelcker Bird Book Fund, Cape Town, South Africa.

Noble, R. G. and J. Hemens. 1978. Inland water ecosystems in South Africa: a review of research needs. South African National Scientific Programmes Report No. 34. CSIR, Pretoria, South Africa.

Management of the water resources of the Republic of South Africa. 1986. Department of Water Affairs, Pretoria, South Africa.

O'Keeffe, J. H. 1986. The conservation of South African rivers. South African National Scientific Programmes Report No. 131. CSIR, Pretoria, South Africa.

Proceedings of International Conference: The People's Role in Wetland Management. Leiden, 5-8 June 1989.

Rutherford, M. C. and R. H. Westfall. 1986. Biomes of southern Africa: an objective categorization. Memoirs of the Botanical Survey of South Africa No. 54.

Scheepers, J. C. 1981. National plan for nature conservation. Report to the NAKOR Annual General Meeting.

Skelton, P. H. 1987. South African Red Data Book: fishes. South African National Scientific Programmes Report No. 137.

Smart, M. 1993. Review of national reports submitted by the Contracting Parties. Document C.5.16 (Part One) of the Fifth Meeting of the Contracting Parties, Kushiro, Japan: 9-16 June 1993.

Smit, C. J. and T. Piersma. 1989. Numbers, midwinter distribution and migration of wader populations using the East Atlantic flyway. Pages 27-30 *in* H. Boyd and I. Y. Pirot, eds., Flyways and reserve networks for water birds. IWRB Special Publication No. 9.

Walmsley, R. D. 1988. A description of the Wetlands Research Programme. South African National Scientific Programmes Report No. 145.

Walmsley, R. D. and E. A. Boomker, eds. 1988. Inventory and classification of wetlands in South Africa. CSIR Occasional Report No. 34, Pretoria, South Africa.

Walmsley, R. D. and M. L. Botten, comp. 1987. Proceedings of Symposium on Ecology and Conservation of Wetlands in South Africa, 15-16 October 1987, CSIR Conference Centre, Pretoria. FRD, Occasional Report Series No. 28.

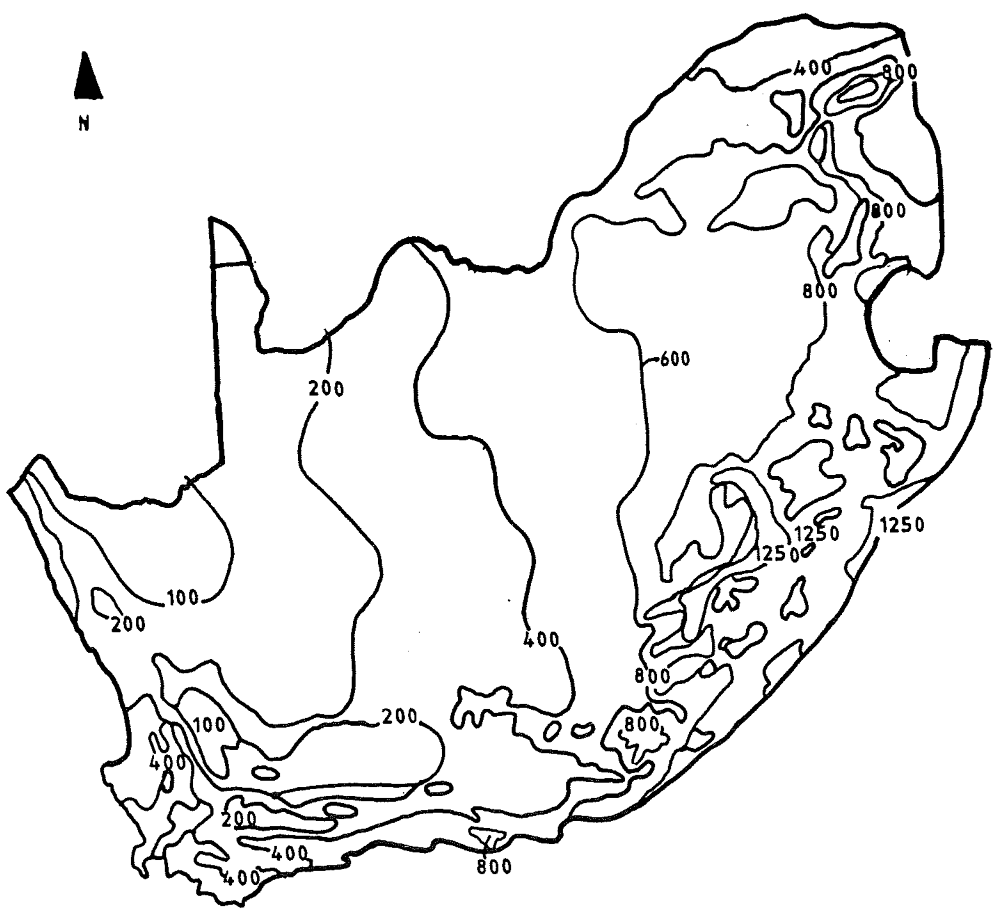


Figure 1. Average annual rainfall (isohyets at 100mm intervals) in South Africa.

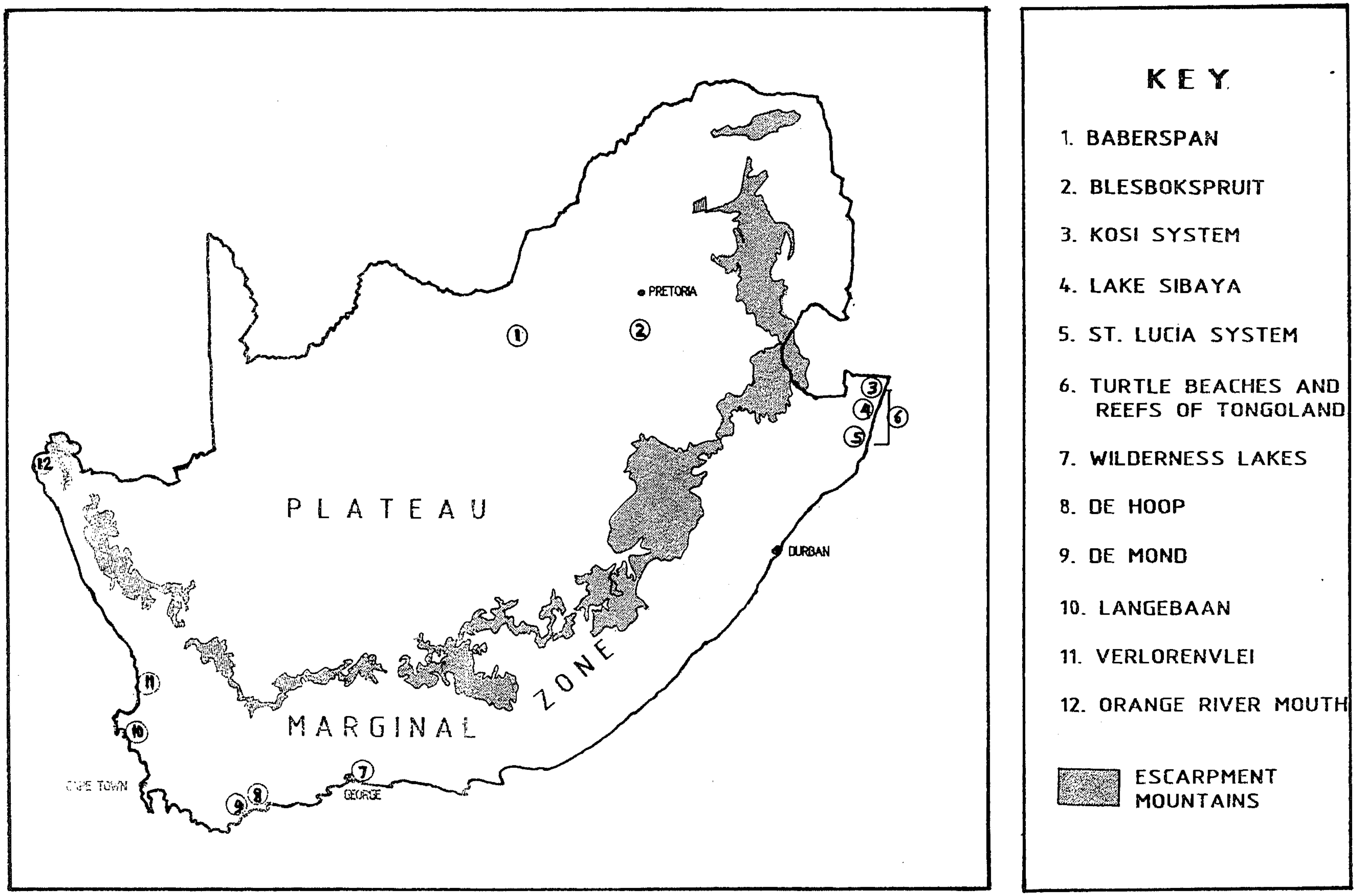


Figure 2. Wetlands of international importance designated by South Africa in relation to the physiography.

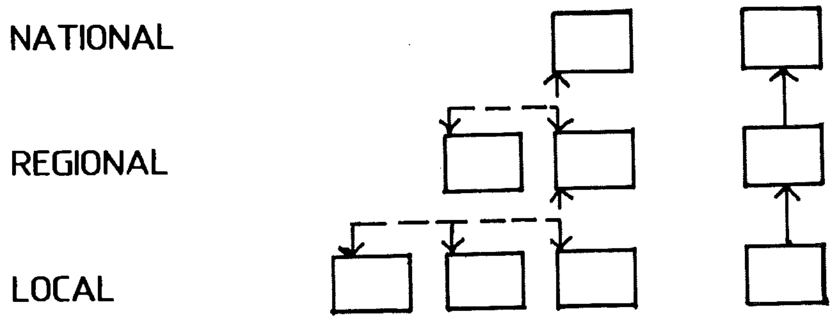


Figure 3. Administrative structure in South Africa.

THE RENFREIGHT NATIONAL WETLANDS CAMPAIGN AND A WETLAND ASSESSMENT, MANAGEMENT, AND REHABILITATION FIELD GUIDE FOR EXTENSION OFFICERS

JON WYATT

Renfreight Wetlands Campaign, P.O. Box 17090, Congella, 4013, South Africa

ABSTRACT

Historically, wetlands in South Africa have been regarded as unproductive and even unhealthy wastelands. The insidious downstream consequences of wetland abuse have become so entrenched that we now consider them virtually as normal. In 1990, a number of conservation agencies and private sponsors joined forces in a national project that strives to gain acceptance of the concept that wetlands are productive and essential ecosystems that play a central role in strategies for sustainable socioeconomic development.

The Renfreight Wetlands Campaign focuses on target wetland and river areas and landowner communities surrounding damaged or sensitive wetlands in order to nurture public awareness and provide guidelines for correct wetland management. While the campaign supports and assists in facilitating wetland awareness in the schools, it stops short of becoming directly involved with educating school children, leaving this job for trained educators. The campaign instead deals directly with adult wetland owners and managers, targeting four key user groups.

The value of looking at the long term need for materials such as a relatively simple and practical wetlands field guide for the use of the various extension services was identified. The development and use of such a field guide is presently the major thrust of the Renfreight Wetlands Campaign. Using the field guide would: (1) engender similar or common approaches to wetland assessment, management, and rehabilitation by the various extension services; (2) give confidence to extension staff, thus encouraging them to take on wetland issues; and (3) encourage the collection of information about many wetlands, especially those smaller wetlands in both rural and urban areas.

Workshops to improve the content and design of the Field Guide are being held with groups of officers from various regions. These two-day field courses generate involvement with the Field Guide, which in turn assists in ensuring the future acceptability of the document

INTRODUCTION

The Renfreight Wetlands Campaign was established for a five-year period with the help of the Southern African Nature Foundation, the Natal Parks Board, and the Wildlife Society of Southern Africa, and with sponsorship from Renfreight, the Mazda Wildlife Fund, and South African Breweries.

The goal of the campaign is to foster public support for wetland conservation throughout South Africa. The campaign is conducted in cooperation with all formal nature conservation agencies and non-government organizations active in wetland conservation in South Africa, as directed by the project steering committee. To put it simply, the campaign's mission is to "kick-start" wetland conservation and management wherever it is needed.

It may surprise some that a so-called "developed" country such as the Republic of South Africa should require injections of funds from the private sector to support the state in conserving wetlands. These patches of moist earth, ranging from seeps of a few square meters to swamps or estuaries of thousands of hectares, are acknowledged as being essential for the continuous restoration and rejuvenation of river environments and their surrounding, the very powerhouses of nature on which all land-based ecosystems ultimately depend. Yet the simple truth is that historically, wetlands in South Africa have been regarded as unproductive and even unhealthy wastelands. The symptoms of a highly stressed environment that has lost many wetlands and their functions are clearly illustrated by plumes of silt opposite river mouths, grossly polluted rivers, sterile fishing grounds, litter-strewn beaches, sediment-filled estuaries, and lagoons choked with water hyacinths.

Such activities as wastewater and industrial effluent disposal, the injudicious use of agro-chemicals, the cultivation of overly steep land, streambank encroachment, the drainage of wetlands, irrigation, canalization, and overgrazing have been recognized as factors responsible for the degradation of South Africa's rivers and water supply. The insidious downstream consequences such as oxygen depletion, the destruction of aquatic life, habitat disruption, the increased incidence and severity of floods, river flow cessation, reduced winter flows, lowering of the water table, bank erosion, and high sediment loads have become so entrenched that we now regard them virtually as a norm. Furthermore, it has been estimated that if the current rates of population growth and water consumption persist, South Africa will not have sufficient water to meet the needs of its people by early in the next century (G. Begg *pers. comm.*).

There is little doubt that education is the key word. The Renfreight Wetlands Campaign is programmed to focus on target wetland and river areas, and landowner communities surrounding damaged or sensitive wetlands, in order to nurture awareness and provide guidelines for correct wetland management. While the campaign supports and assists in facilitating wetland awareness in the schools, it stops short of becoming directly involved with educating school children, as this enormous responsibility is best left to those qualified and equipped to deal with formal education.

A recent success story, in terms of water conservation education, has been the water test kit. This test kit was developed for "Project Water," a cooperative effort by the Natal Parks Board, Umgeni Water, and the Wildlife Society. Project Water was initiated to promote water awareness in schools and has led to much excitement and success among educators in both urban and rural communities. We are proud to have played a role in the development of Project Water's "hands-on" resources.

Of more relevance is the fact that the campaign deals directly with adult wetland owners and managers. User group studies and efforts focus on the following four key user groups: commercial agriculture and forestry, communal areas, urban areas and industry, and tourists and tourism developers.

Initially, much time was given to delivering illustrated talks, usually on request, to interested groups. These talks covered topics such as the definition of wetlands and river catchments, the full range of wetlands and their functions, types of wetland mismanagement, and simple restoration methods. The concept of "catchment management" was advocated as the basic unit of environmental care. Wetlands were explained in terms of their position within the catchment. Talks illustrated how various types of wetlands, from mountain seeps, hydromorphic grasslands, and sedge and reed marshes to swamp forests, estuaries, and the open coast, are all connected by streambank riparian corridors. This appeared to clarify many misconceptions as to what the word "wetland" really implies.

Furthermore, great emphasis was placed on explaining the functions of wetlands and their unparalleled value for flood control, water storage, streamflow regulation, drought relief, soil erosion protection, water purification, wildlife protection, and superb recreational areas for people. These functions offer substantial advantages to stabilizing catchments with subsequent benefits to society. Without a reasonable grasp of these tangible benefits it is unlikely that wetland owners or managers will improve wetland protection or management.

While these talks proved to be a useful method of introducing the campaign to the general public, it became evident that to be effective we would have to be useful to the wetland managers within the four identified user groups. Furthermore, it was fairly obvious that the Renfreight campaign, employing a single field worker, had no hope of dealing with more than a very small percentage of the individuals within the user groups.

Of the four user groups, commercial agriculture and forestry was identified as the initial priority target. Within this sector, it was decided to focus attention at the level of the extension services because extension officers are seen to be the most likely to be able to effect improved wetland care and management.

THE WETLAND FIELD GUIDE

Bearing the above in mind and realizing that there is a need to look at the long term, while considering that this campaign is of short duration and only acts to facilitate wetland conservation, it was decided to develop a relatively simple to use but practical wetland field guide, *Wetlands: assessment, management, and rehabilitation of South African wetlands*, for the various extension officers (Wyatt 1993; Appendix). The field guide would provide for common wetland assessment, management, and rehabilitation techniques. The development and use of this field guide is presently the major thrust of the Renfreight Wetlands Campaign.

We are of the opinion that this Field Guide will:

- engender similar or common approaches to wetland assessments, management, and rehabilitation by the various extension services;
- give confidence to extension staff thus encouraging them to take on wetland issues;
- encourage the collection (by means of an included data sheet) of what is presently unobtainable information about many wetlands in both rural and urban areas, especially the smaller ones.

The field guide includes illustrated guidelines for baseline wetland data collection, requirements for wetland assessment and remediation, guidelines for wetland burning and wetland grazing, and information about spring protection on seepage slope wetlands, streambank rehabilitation with indigenous trees, plug construction, coastal dune rehabilitation with key pioneer plants, and alien plant control. It also includes a discussion of estuary zonation and urban and industrial wetlands. A glossary of terms, useful references on wetlands, and a list of contacts are also provided.

Workshops to improve the content and design of the field guides were held with groups of agricultural, sugar, forestry, and nature conservation extension officers from the various regions in the Republic of South Africa. These two day field courses introduced the concept to the extension services while generating involvement with the field guide's development which in turn assisted in ensuring the future acceptability of the document.

This field guide is deliberately designed to be simple and practical and is aimed at those thousands of smaller and less complex wetlands with the "common cold" ailments. They are the tucked-away, out-of-sight wetlands and it would almost certainly not be an understatement to suggest that collectively these "little wetlands" are probably as important to their catchments and rivers as the so-called priority wetlands which gain all the attention.

It would seem that this field guide is emerging as phase I of an approach to wetland conservation, which would be followed in the case of complex or more searching problems by phase II. This second phase is WETLAND-USE, a wetland management decision support system being developed by Kotze, Klug, and Breen (*this proceedings*).

The field guide has a bonus built into it in that the data sheet used to describe the wetland encourages capturing data that might be used for a national inventory of the wetlands of the Republic of South Africa, a project that is urgently required and long overdue.

ACKNOWLEDGMENTS

I wish to express my gratitude to the organizers of this workshop for allowing me the opportunity to inform you about the Renfreight Wetlands Campaign and its work in promoting wetland conservation in the Republic of South Africa. My thanks also to Southern African Nature Foundation, the Natal Parks Board, and the Wildlife Society of Southern Africa for their support, and to Renfreight, the Mazda Wildlife Fund, and South African Breweries for their sponsorship of the campaign.

REFERENCES

Wyatt, J. 1993. Wetlands: assessment, management, and rehabilitation of South African wetlands. Renfreight Wetlands Campaign, Congella, South Africa.

APPENDIX

WETLANDS

ASSESSMENT MANAGEMENT AND REHABILITATION OF SOUTH AFRICAN WETLANDS

'An illustrated field guide for practial use by land agency extension services

Compiled by:
Jon Wyatt

Renfreight Wetlands Campaign

Date:

RENFREIGHT

INTRODUCTION

Client Name: ....

Thank you for the opportunity to visit the ....wetland.

The term "wetlands" groups together a wide range of inland and coastal habitats - from mountain sponges and midland marshes to swamp forests, estuaries and even the open coast -all linked together by green corridors of streambank wetlands.

Historically wetlands have been regarded as unproductive and even unhealthy wastelands. The symptoms of an highly stressed environment that has lost many wetlands and their functions are clearly illustrated by the plumes of silt opposite river mouths, grossly polluted rivers, sterile fishing grounds, litter strewn beaches, sediment filled estuaries and lagoons choked with water hyacinth.

Activities such as waste water and industrial effluent disposal, the injudicious use of agrochemicals, the cultivation of overly steep land, streambank encroachment, the drainage of wetlands, irrigation, canalization and over-grazing have been recognised as factors responsible for the degradation of South Africa's rivers.

However the insidious downstream consequences such as oxygen depletion, the destruction of aquatic life, habitat disruption, the increased incidence and severity of floods, river flow cessation, reduced winter flows, lowering of the water table, bank erosion and high sediment loads have become so entrenched that we now regard them virtually as a norm.

The concept of "total catchment management" has often been advocated as a means of reducing the abovementioned environmental consequences. This field guide is aimed at the management of one particular landscape element within a catchment, namely wetlands. They are a component of river corridors which, by virtue of their unparalleled value for flood control, water storage, streamflow regulation, drought relief, soil erosion protection, water purification, wildlife protection and superb recreational areas for people, offer substantial advantages to stabilizing catchments with subsequent benefits to society.
(Adapted from G.A. Begg, Environmental Advisory Services.)

Processed by: Name . . . .

Address: . . . .

Telephone Number: . . . .

Extension Service & Region: . . . .

ACKNOWLEDGEMENTS

To someone such as myself - from a field management background - compiling this Field Guide has been an education. It is my pleasure to thank the Renfreight Wetlands Campaign steering committee(Chairman,)Mr Dick Parris (Natal Parks Board), Adj. Louis Nel (Renfreight), Dr Ian Macdonald (Southern African Nature Foundation and Mr Keith Cooper (Wildlife Society) for their continued guidance and support.

A special thanks to the principal funders: Renfreight, Mazda Wildlife Fund and the South African Breweries for making this document and campaign possible.

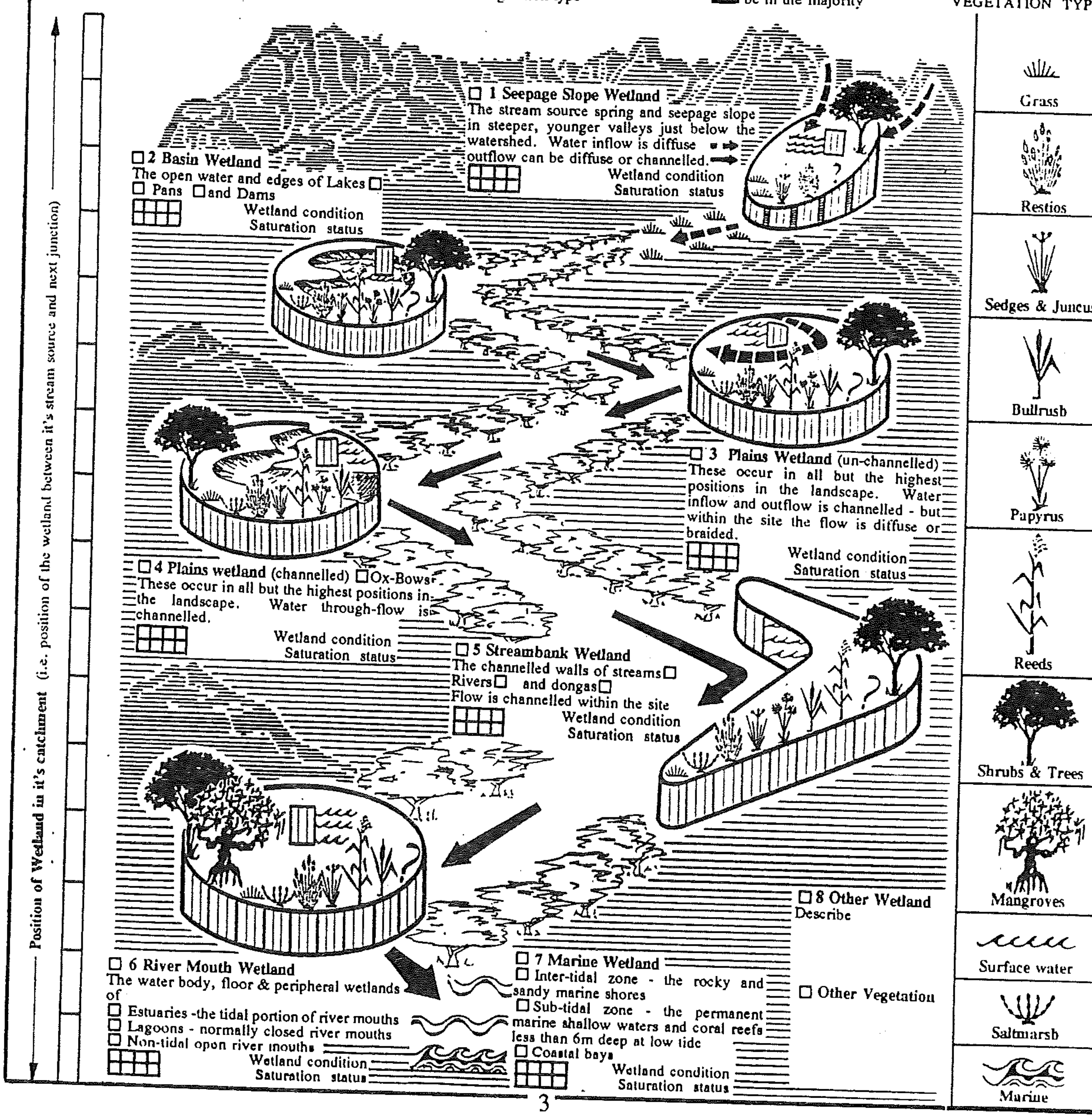
The compilation of the Field Guide would have been impossible without the willing and often outstanding help from Jake Alletson, Felicity Auld, Dr George Begg, Geoff Cowan, Ian Garland, Dr Allen Heydorn, Frank Junor and Donavan Kotze. Furthermore extensive assistance was given by staff from the South African Sugar Association, the Forestry Extension Service along with H.L. & H., Mondi and SAPPI timber companies.

Finally I would like to thank my wife Jayne and our three children Natalie, Timothy and Samantha for their support and having to put up with a "nomadic Dad" for the last few years.

Wetland Data		Completed by:	Tel No:		Date:
Wetland Name	ha/km	Landowners name:	Address:	Tel No:	Annotated sketch of Wetland
Farm, District or Town name:		Managers name:	Address:	Tel No:	
Magisterial district		1:50000 map	Road route to wetland site:		
Stream name and order		Grid ref: Lat/Long			
Catchment		No.landowners			Scale:

Instructions:-

1. Supply available wetland information above and sketch wetland layout
2. Indicate the position of the wetland in its catchment. See lefthand margin
3. Indicate the wetland type in the landscape 1☐ 2☐ 3☐ 4☐ 5☐ 6☐ 7☐ 8☐
4. Indicate the condition of the wetland as follows:-
   = Undisturbed = Partially disturbed = Severely disturbed = Relict
5. Indicate the saturation status of the wetland as follows:- The wetland is "waterlogged" or "flooded":-
   Permanently or Semi-permanently; Regularly or Tidally; Seasonally; Irregularly or Temporarily
6. Indicate the wetland vegetation as follows:-
   Slight representation of vegetation type; Fair representation of vegetation type; Vegetation type appears to be in the majority



WETLAND ASSESSMENT AND REMEDIAL REQUIREMENTS

Instructions:

1. Indicate your assessment of the impacts on the wetland by the landscape features and uses as follows:
   - = Landuse or feature is present but without any obvious effects on the wetland
   - = Slight effect on the wetland
   - = Moderate effect on the wetland
   - = Serious effect on the wetland
2. Shade in the appropriate blocks for wetland remedial requirements and Page no's for details
3. List any rare or threatened plant or animal species that occur in the wetland.

Local landscape features & uses | Effects

	Local landscape features & uses	Effects				
Development	Use of Natural Veld					
	Planted Pastures					
	Planted Crops					
	Planted Timber					
	Game - grazing					
	Sheep - trampling					
	Cattle - grazing					
	Goats - trampling					
	Drains and Channels					
	Cambered beds					
	Ridge and Furrow					
	Donga incised					
	Stream confluence					
	Streambanks on curve					
	Gradient change or Key point					
	Stream debris					
	Dams and Weirs					
	Water abstraction - domestic					
	Water abstraction - irrigation					
	Water abstraction - industrial					
	Pipelines and Pylons					
	Road construction					
	Rail construction					
	Bridges and Culverts					
	Buildings - residential					
	Buildings - urban					
	Buildings - industrial					
	Buildings - other					
	Tourist development					
	Informal settlement					
	Mining and Dredging					
	Effluent disposal					
	Infilling - waste/rubble/soil					
	Solid waste disposal site					
	Sewage disposal					
	Nutrient enrichment					
Recreation & Extractive	Angling					
	Bait collecting					
	Hunting					
	Food harvesting					
	Material harvesting					
	Boating - power/skiing					
	Boating - sail/paddle					
	Diving					
	Swimming/Surfing					
Alien	Invasive alien plants					
	Problem indig. plants					
Burns	Controlled block burn					
	Fire-break burn					
	Uncontrolled burn					

2. Wetland Remedial Requirements

Apply correct veld and soil conservation measures - Consult Extension service	See Pg27
Remove or minimize alteration to wetland and/or functions	
Ensure an adequate and manageable wetland margin	See Pg 13
Rehabilitate by allowing natural plant succession to take it's course	See Pg 13
Apply correct stocking rates - Consult Extension service	See Pg 27
Remove stock from or fence off sensitive areas	See Pg 9:13
Control timing, frequency, or pressure of grazing, trampling and water point access	See Pg 9:13
Fence off sensitive areas from damage caused by disturbance	
Discontinue excavating and allow channel(s) to consolidate	See Pg 15
Rehabilitate by allowing natural plant succession to take it's course	See Pg13:15
Plant banks with stabilizing vegetation	See Pg 13
In extreme cases support banks with masonry works	See Pg 13
Block and/or support channel(s) or keypoint with earth and/or veg. plug(s)	See Pg 15
Block and/or support channel(s) or keypoint with masonry plug(s)	See Pg 15
Remove debris from channel and flood area	
Minimize damming of wetlands. Many small dams are inappropriate and destroy valuable wetland habitat and functions	
Measure and control water abstraction	
Locate transport systems, bridges and culverts, pipelines and pylons so as to avoid wetlands and margins or -	See Pg 17:21
Design and construct to minimize alteration to wetland and functions	"
Implement regulations which disallow structural development below the 1:50 year flood level	See Pg13:17
Zone and manage wetland areas as open space	See Pg 21
Keep coastal development behind the frontal dune	See Pg 17:20
Avoid "ribbon" development along the coastline	
Control mining activities and rehabilitation of wetlands and surrounds	
Avoid using wetlands for the disposal of waste water or thermal and harmful effluents of any form	
Avoid infilling ("reclaiming") of wetlands	
Monitor solid waste and leachates into wetlands and where necessary implement ameliorative measures	See Pg 21
Identify industrial, agricultural or domestic source and minimize	See Pg 21
Recreational and Extractive activities can act as an incentive to conserve wetlands - however, these activities should not have significant negative effects on other functions or values which are of local or regional benefit to society	
Map and zone wetland into usage areas for wetland functional, recreational and public safety protection	See Pg 17
Control and manage exploitation, trampling, boat and vehicle traffic in the various zones	"
List and remove in planned phases (starting upstream, light infestations first) and maintain control via follow-ups	See Pg 23
Select and control timing, frequency and intensity of burns	See Pg 5
Implement wetland protective measures appropriate to degree of run-away or arson fires from surrounding area	

3. Ecological Data

Birds

Mammals

Amphibians

Reptiles

Fish

Invertebrates

Plants

Soil forms

- Champagne
- Katspruit
- Rensburg
- Alluvium
- Other
- Other

NOTES

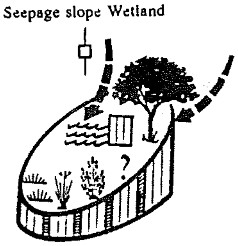
To assist with wetland management and/or rehabilitation options compile inventory of distribution and condition of wetlands in the catchment.
Where rehabilitation work is necessary select wetland functions most suitable or preferred in that portion of the catchment to accommodate the surrounding catchment uses and human population densities.

WETLAND BURNING GUIDELINES

Some freshwater wetlands in particular those from the very low rainfall or winter rainfall regions may be left unburnt providing they are safe from untimely fire and their unburnt condition does not impair normal functions.
Controlled burning of wetlands is required to prevent untimely burns, to enhance wildlife habitat or stock grazing and to assist in controlling invasive woody or alien plant infestation. Frequent "hot burns" can deplete the organic content of the soil thus decreasing the water retention capacity of the system.

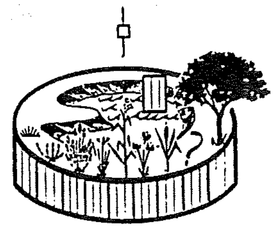
1. Wetland Site setting

Seepage slope Wetland



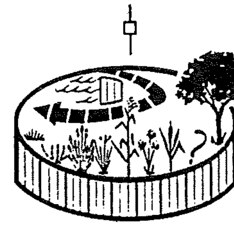
These wetlands are small areas subjected to the effects of local veld block burning and firebreak burning. Inherent dangers are:
(i) these zones have shallow organic-rich soils which are highly erodible when left exposed without plant cover for long periods out of the growing season, and
(ii) these soils ignite readily and can smoulder for long periods if burnt during very dry seasons.

Basin Wetland



Whilst temporarily wet pans and the fringes of permanently wet lakes and dams might not be of significant hydrological value they can be extremely important as wildlife habitats for breeding and migrating animals.
The timing and intensity of burns is critical in these circumstances.

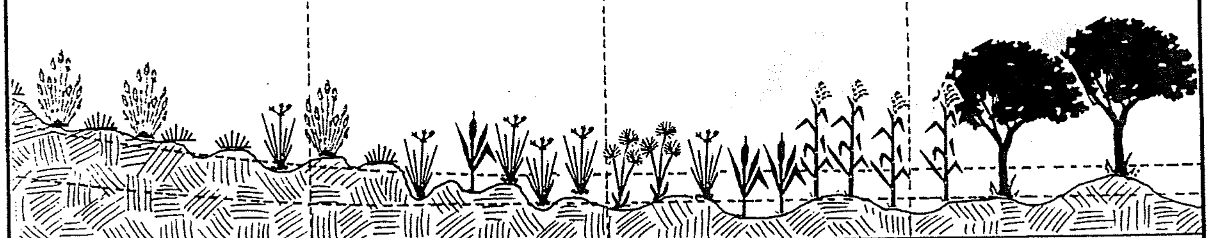
Plains Wetland (unchannelled)



The relatively flat topography and uniform vegetation cover gives these wetlands very high hydrological and ecological values.
Burning of these areas must take cognizance of the effects of fire on the various ecological zones (see below) and their wetland functions. Cool burns would encourage a patchy effect.

2. Ecological zones

Hygrophilous grassland zone Fresh Water	Wet meadow zone Fresh water	Marsh zone Fresh water	Swamp zone Fresh water



Hygrophilous grassland zone: Hygrophilous grasslands are temporarily wet and support grasses common to dry and wet areas. Regular burning is practised to enhance grazing potential, to secure a fire-break, and to regulate invasive plants.
Whilst the evaporative loss caused by burns at the end of a growing season are not likely to be significant from these temporarily wet areas, there could be detrimental ecological effects.

Wet meadow zone: Wet meadow zones are seasonally wet and dominated by short sedges and grasses.
Burns that leave the area exposed without plant cover for long periods encourage increased evaporative loss because the upper soil layers remain wet longer into the dry season.

Marsh zone: Marsh zones are usually permanently or semi-permanently wet and dominated by tall reeds, rushes and sedges. Burns that leave the area exposed without plant cover for long periods encourages significant increased evaporative loss because the water table remains close to the soil surface.

Wet meadow and marsh zones are prone to frequent run-away or arson fires during the dry season. These fires are notoriously difficult to control and can also lead to soil ignition.

Swamp zone: Swamp zones are usually permanently or semi-permanently wet and dominated by trees. Run-a-way fires during very dry periods sometimes carry through from fringing wetlands or croplands causing damage to the forest edge and even the higher lying forest floor areas.
These important and sensitive ecotones require protection from intense fires.

3. Wildlife Habitat requirements

Small freshwater wetland mammals and their predators generally prefer two to three years old post burn habitat in the summer rainfall region.
Protect areas known to be important bird breeding localities or cover for moulting ducks although even these may need to be burnt occasionally to stimulate new plant growth.
Frogs are vulnerable to hot or slow back fires which have high ground temperatures.
A combination of alternating block-burn areas and promoting patch burns by using cool fires (see below), allowing harvesting of reeds, grass or sedges, or grazing cattle (except in seepage zones) to reduce fuel loads and to create puddles assists in providing refuges for wetland dependant animals.

The habitat and animals in swamp zones are fire sensitive - thus fires should only be occasional with very low intensity burns on damp ecotones

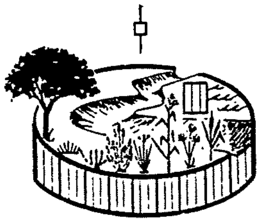
4. Burning Guidelines

Burn Frequency: Only burn when necessary and after annual inspection. Where fairly frequent burning is necessary aim to burn every 2nd year but allow for carry over to the 3rd and 4th year should conditions not be right.
Conditions: Apply cool burns by burning with the wind (against the wind raises the ground temperature) when the fuel is moist after rain or in the evenings or early mornings after dew. ie When there is high relative humidity and low air temperatures.
Time of Year: Burn after rain at the onset of the growing season to ensure rapid plant regrowth.

Instructions

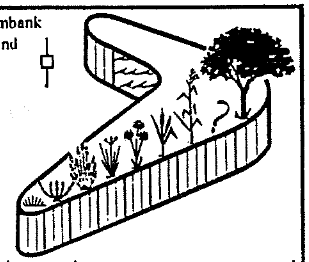
1. Identify the wetland site setting in the landscape ☒ and the predominant vegetation types
2. Using the above vegetation types, identify the ecological zones within the wetland ☒
3. Follow the flow diagram through to the wildlife requirements ☒ (habitat)
4. Apply the suggested "Burn Guidelines" whilst considering 1, 2 and 3.

Plains Wetland (channelled)



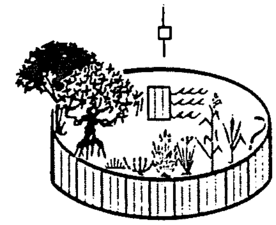
These wetlands are usually flat but uneven floodplains. They have high and low spots consisting of levees, oxbows and channels with a corresponding mosaic of vegetation types. They are important as flood- attenuators and diverse wildlife habitats. Any burns should be cool to encourage a patchy effect that favours both floodplain and wildlife functions.

Streambank Wetland



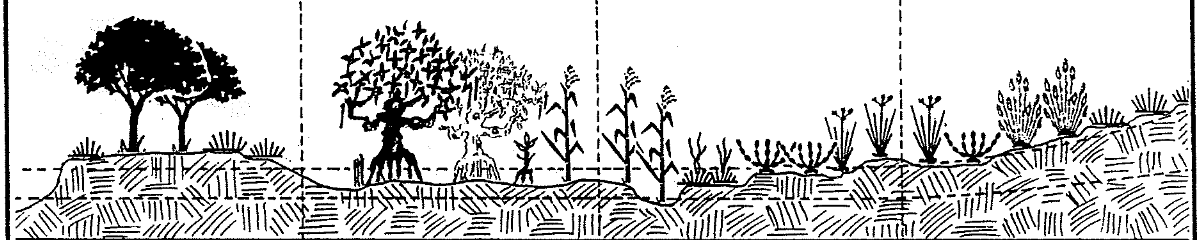
Streambank vegetation cover prevents scour and provides bank stability and corridors of wildlife habitat.
Management and in particular, fire management, will determine the herbaceous or woody vegetative cover of streambanks.

River mouth Wetland



River mouth vegetation is well adapted to harsh and changing conditions of wind, salt, tide and regular flooding from upstream - but it is a fragile habitat which is highly sensitive to mans disturbance.
As a rule, river mouth wetlands are not very flammable but should still be protected from fire

Wooded streambank zone Fresh water	Mangrove swamp zone Tidal - salt water	Marsh and Meadow zone Tidal - salt/brack water	Hygrophilous grassland zone Tidal - salt/brack water



Wooded streambank zone	Mangrove swamp zone	Marsh and Meadow zone	Hygrophilous grassland zone
Wooded streambanks are often subjected to fire from adjacent veld or croplands and are also used as block-burn firebreaks. The important and sensitive forest edge or ecotone requires protection from intense fires.	Mangrove swamp zones only require protection from the occasional adjacent reedmarsh fire which can cause damage to seedling and young mangroves on the swamp edges.	Tidal or brack-water marshes which colonize mud-flats are seldom fire threatened. In cases where fire is able to penetrate these marshes (often when there is much discarded plant material after reed or juncus harvesting) many wildlife species of estuaries and pans are temporarily deprived of vital cover and food sources.	Whilst these are relatively harsh and vegetatively unproductive zones - both the plant life and the organically impoverished soils can suffer long term damage from an occasional fire.

The woody ecotonal areas are highly productive as food and cover sources and as such any burns should be cool and of a very low intensity.

Mangrove swamps and tidal or brack-water marshes and hygrophilous grasslands support large numbers of animals - especially birds.
These areas are not normally fire threatened. Neither the habitat nor the animals are accustomed to burns - and as such should be protected from any possible fire damage, especially during very dry periods.

Apply similar burns but assist the forest edges by back-burning from the ecotone against advancing block burn.

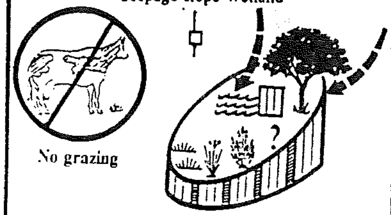
Protect from fire - except in exceptional circumstances such as where accumulated discarded plant material from reed or juncus harvesting might need to be removed via fire.

WETLAND GRAZING GUIDELINES

For the purposes of this grazing guide the integrity of a wetland is judged on the condition of it's natural vegetation - thus the primary aim will be to favour and manage wetlands from an ecological point of view, whilst recommending conservative domestic grazing practices as a mimic of possible previous wildlife bulk-grazing regimes. Certain wetland types or zones have been excluded from grazing because they either have no grazing potential or a demonstrated vulnerability to damage from stock grazing.

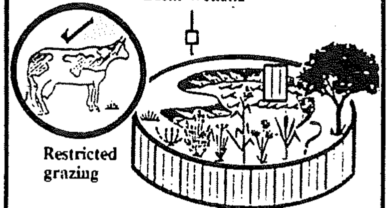
2. Wetland Site setting

Seepage slope Wetland



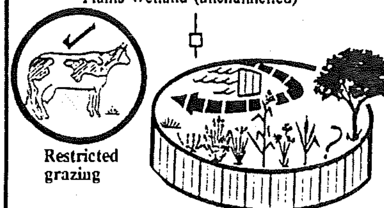
Seepage slope wetlands are often oases in the landscape - but are sensitive and prone to erosion caused by trampling damage and should be excluded from stock grazing.
Water may be 'tapped' off to a watering point beyond the wetland zone.
See page: 9

Basin Wetland



Temporarily wet pans and the fringes of permanently wet lakes and dams may be grazed.
At least ⅙ of the area should be excluded from grazing on an annual rotational basis and the stocking density further reduced by only considering areas of hygrophilous grassland.

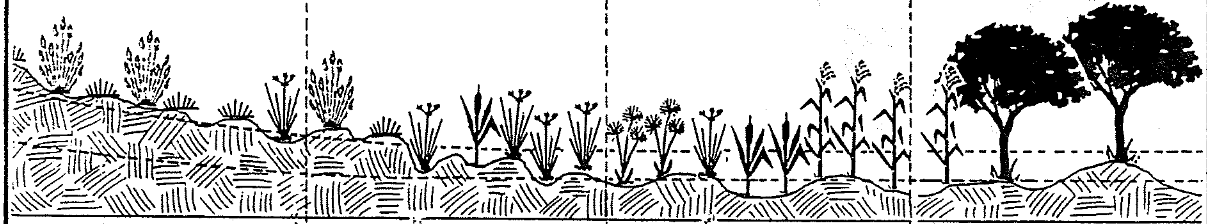
Plains Wetland (unchannelled)



The relatively flat topography and uniform vegetation cover give these wetlands high hydrological and ecological values. They may be grazed but with a stock density reduced by only considering areas of adjacent hygrophilous grassland in the calculations and by excluding ⅙ of the wetland from grazing on an annual rotational basis. The outlets of these wetlands are high risk areas to gulley erosion formation and should be fenced off to exclude stock grazing and trampling.

3. Ecological zones

Hygrophilous grassland zone Fresh water	Wet meadow zone Fresh water	Marsh zone Fresh water	Swamp zone Fresh water



Hygrophilous grassland zone — Fresh water

Hygrophilous grasslands are temporarily wet zones and support predominantly grasses common to dry and wet areas which can be grazed on a sustainable basis when dry.
Because stock usually show preference for this zone the wetlands overall potential grazing capacity is calculated on this area alone - excluding wet meadow and marsh zones which are considered as bonus overspill and opportunistic grazing areas when dry.

Wet meadow zone — Fresh water

Wet meadow zones are seasonally wet and dominated by short sedges and grasses. These areas have a moderate grazing potential when dry but should be excluded from the wetlands overall grazing capacity calculations. (See Hyg.grassland) Stock are excluded from this zone when it's wet as the trampling effect is damaging to plant roots and erosion gulleys are formed. These zones should only be considered as bonus overspill and opportunistic grazing areas.

Marsh zone — Fresh water

Marsh zones are usually permanently or semi-permanently wet and dominated by tall reeds, rushes and sedges. These zones have a low grazing capacity and should only be grazed when occasionally dry to avoid damage to plant roots and the formation of erosion gulleys.
Marsh zones are excluded from the wetlands overall grazing capacity calculations (see Hyg. grassland) and should only be considered as bonus overspill and opportunistic stock grazing areas when dry.

Swamp zone — Fresh water

Swamp zones are usually permanently or semi-permanently wet and dominated by trees.
These zones are not considered as having any useful grazing potential.

4. Grazing Guidelines

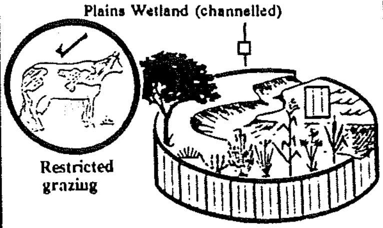
1. Determine the area of hygrophilous grassland in the wetland
2. Reduce this area by ⅙ to determine actual grazing ha's. This forms part of the annual ⅙ of the entire wetland to be rested on a rotational basis.
3. Establish the potential grazing capacity (PGC) for the region. This is obtainable from the local Agricultural Extension Office (ha per Animal Unit)
4. Adjust the PGC by accounting for the veld condition as follows:- Good veld condition = PGC x 1,0; Fair veld cond. = PGC x 0,85 Poor veld = PGC x 0,7

Example:-
— Hyg. grassland = 50ha's
— Actual graze area = 50 x 0,66 = 33 ha
— Bio.region (8) = 2,5 ha\AU
— Assuming fair veld condition 2,5 x 0,85 = 2,1ha\AU

Instructions

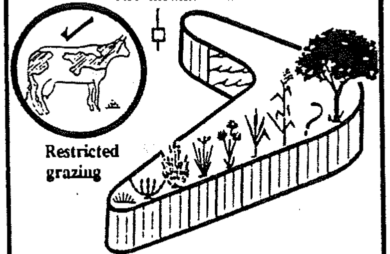
1. Because grazing capabilities of wetlands have not been tested - the users of these recommendations are requested to monitor results and to supply comment which might be useful for revising the guidelines.
2. Identify the wetland site setting in the landscape ☑ , and the predominant vegetation types ▥
3. Using the above vegetation types, identify the ecological zones within the wetland ☑
4. Follow the flow diagram through to - and apply the grazing calculations - whilst considering 1,2 & 3.

Plains Wetland (channelled)



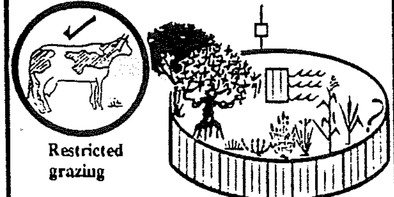
These wetlands are usually flat but uneven floodplains. They have high and low spots consisting of levees oxbows and channels with corresponding mosaics of vegetation types. They are important as flood attenuators and diverse wildlife habitats.
Grazing conditions are calculated as for unchannelled wetlands - but channel walls need to be excluded from stock grazing and trampling pressures.

Streambank Wetland



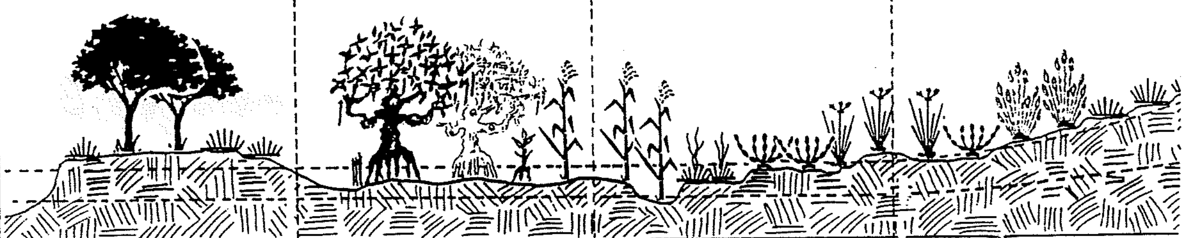
Streambank vegetation cover prevents scour and provides bank stability and corridors of wildlife habitat.
Whilst the streambank edge and channel walls should be excluded from grazing pressure - the adjacent riparian zone with herbaceous cover may be grazed.
At least ¼ of the area should be excluded from grazing on an annual rotational basis.

River mouth Wetland



Floodplains at river mouths may be grazed but with a stock density reduced by only considering areas of hygrophilous grassland in the calculations and by excluding ¼ of the wetland from stock grazing on an annual rotational basis.
The banks of river mouths should be protected from stock grazing and trampling via herding control.

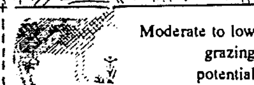
Wooded streambank zone Fresh water	Mangrove swamp zone Tidal - salt water	Marsh and Meadow zone Tidal salt or brack water	Hygrophilous grassland zone Tidal salt or brack water



Wooded streambanks are considered as sensitive to the effects of cattle trampling when seeking shade and as such should be excluded from stock.

Mangrove swamps have no grazing potential

Tidal or brack water wet meadow and marsh zones have a low grazing capacity and should only be lightly grazed when reasonably dry to avoid damage to plant roots and the formation of erosion gulleys.
These zones are excluded from the wetlands overall grazing capacity calculations (see Hyg. grassland) and should only be considered as bonus overspill and opportunistic grazing areas.



Tidal or brack water hygrophilous grassland zones vary from having moderate to low grazing potential depending on the bioclimatic region.
Because stock usually show preference for this zone the wetlands overall potential grazing capacity is calculated on this zone alone - excluding wet meadow and marsh zones which are considered as bonus overspill and opportunistic grazing when reasonably dry.

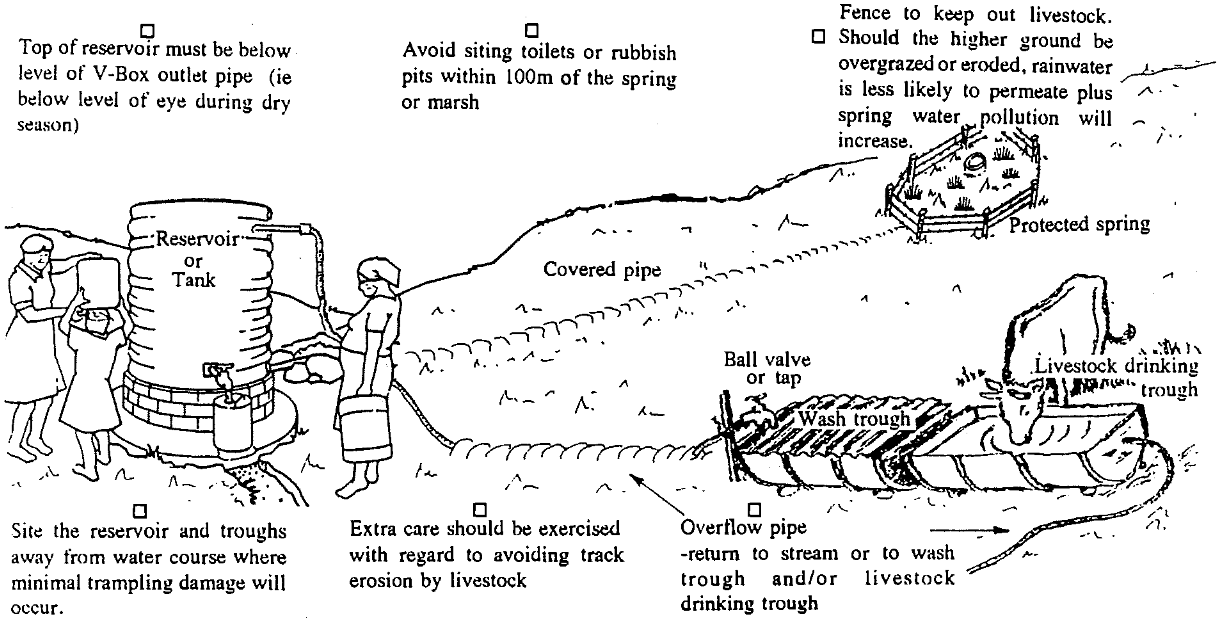
5. Calculate the wetlands stocking density by dividing the corrected PGC into the adjusted grazing area - and then multiply this sum by 3 times as there will not be any camps (except the excluded ¼ of the wetland) — Stock dens. $\frac{33}{2,1} \times 3$ = 48 AUs

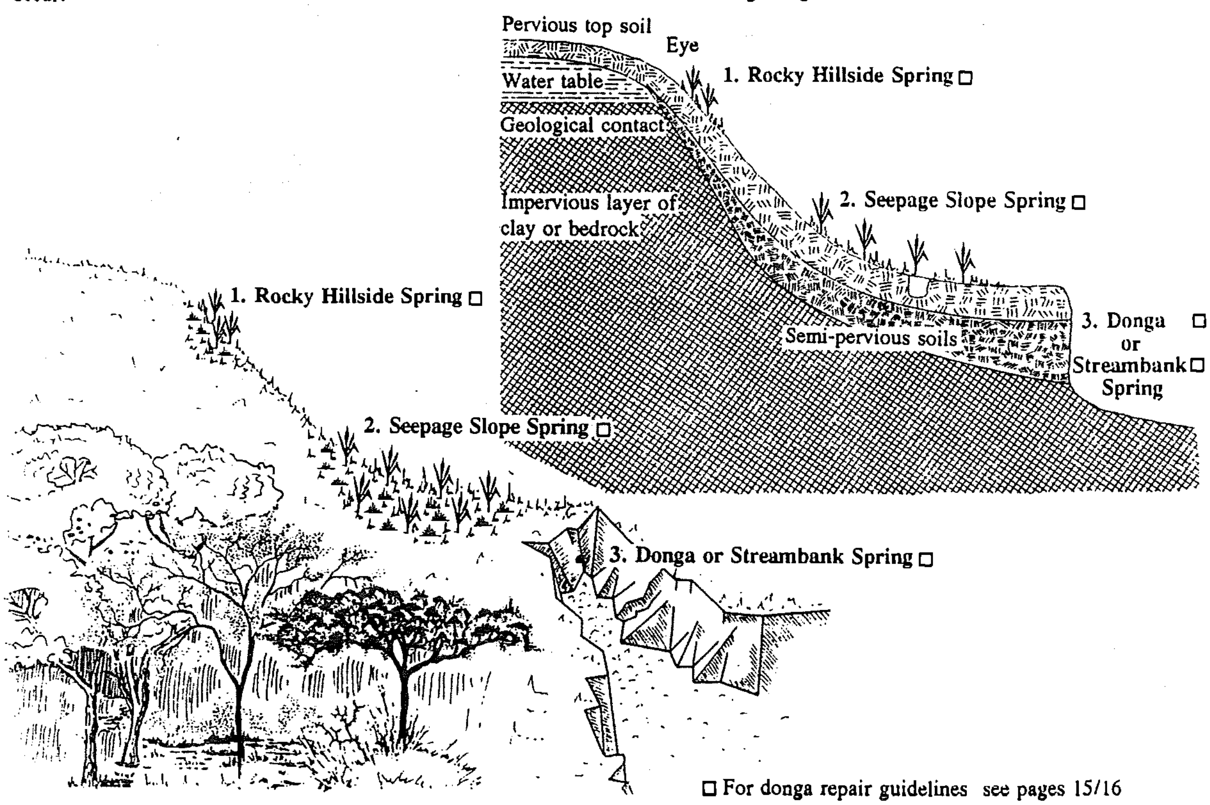
6. Apply a fixed rotational grazing system with a cycle of 14 days in the wetland and 28 days out until such time as the area is wet and soggy or the area is excessively grazed (especially during drought periods) - when all stock is removed until conditions improve. — 48 animal units grazing on 33 ha's. of Hyg. grassalnd plus the remainder of bonus wetland when dry - 14 days in the wetland and 28 days out.

SEEPAGE SLOPE WETLAND - SPRING PROTECTION

"Springs" occur in many situations such as on Rocky Hillsides, Seepage slopes, and on Stream banks or Dongas. The rationale of natural spring protection is firstly to secure the integrity of the "wetland" and its functions by protecting it from human or livestock pollution or damage, and secondly to contain, filter and store a limited quantity of spring water for local use.

The method of protection or extraction does not imply damming the spring as this could retard or stop the flow and even force the water to re-route to another eye - nor does it imply such an increased local draw-off of water that the natural water-table will lower and decrease the hydrological role of the wetland area.





□ For donga repair guidelines see pages 15/16

Method of Extraction

1. Rocky Hillside Springs □

occur as on eye at a geological contact (change in bedrock type) or at fractures/joints in otherwise solid bedrock.

Method of Extraction
A V-Box is constructed to contain the spring water and to provide a draw-off point to lead to a tap or reservoir.

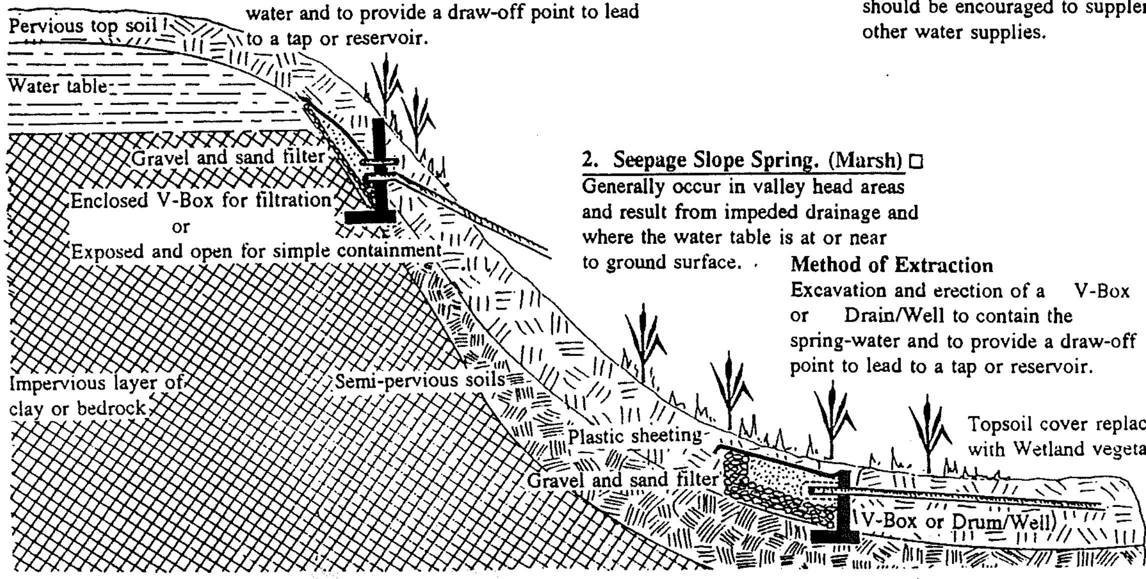
Roof Rainwater Catchment

Whilst this form of water supply is highly seasonal the collection of water from straight edged roofs via guttering to storage tanks should be encouraged to supplement other water supplies.

2. Seepage Slope Spring. (Marsh) □

Generally occur in valley head areas and result from impeded drainage and where the water table is at or near to ground surface.

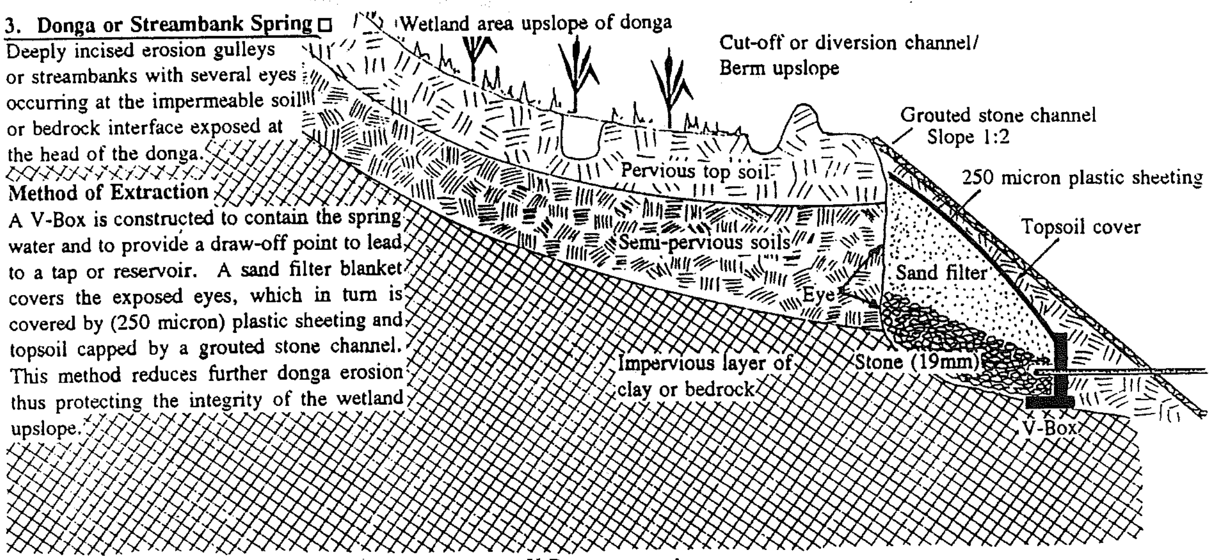
Method of Extraction
Excavation and erection of a V-Box or Drain/Well to contain the spring-water and to provide a draw-off point to lead to a tap or reservoir.



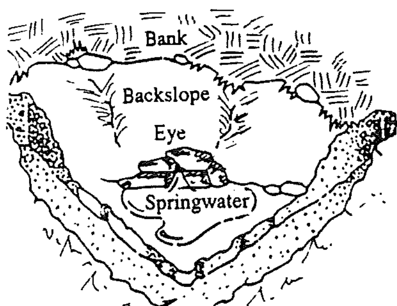
3. Donga or Streambank Spring □

Deeply incised erosion gulleys or streambanks with several eyes occurring at the impermeable soil or bedrock interface exposed at the head of the donga.

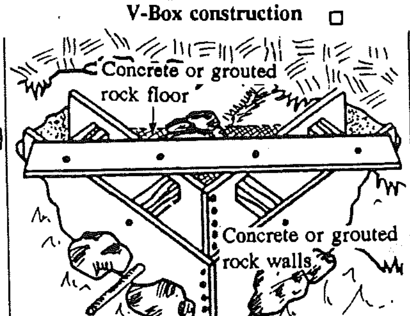
Method of Extraction
A V-Box is constructed to contain the spring water and to provide a draw-off point to lead to a tap or reservoir. A sand filter blanket covers the exposed eyes, which in turn is covered by (250 micron) plastic sheeting and topsoil capped by a grouted stone channel. This method reduces further donga erosion thus protecting the integrity of the wetland upslope.



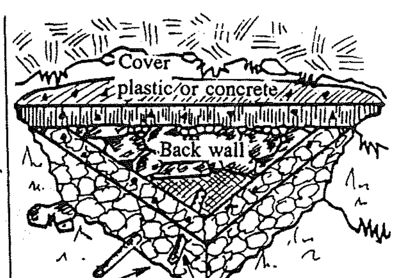
V-Box construction □



Foundation trench



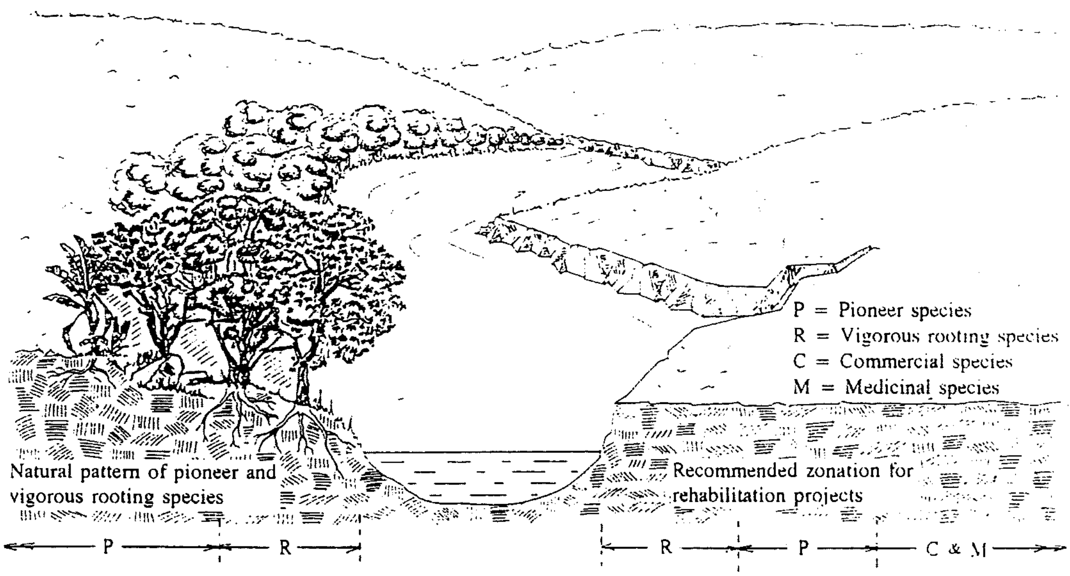
Slit plastic outlet pipe wrapped in gauze or geofabric (ensure level of outlet pipe is below level of eye during dry season)



Overflow (ensure level of pipe is below level of eye of spring during dry season.

Indigenous Trees suitable for streambank rehabilitation

1. Where there is no obvious streambank problem - rather encourage grasses, sedges or reeds to establish.
2. The degree of frost resistance is indicated by: X for slightly tolerant, XX for fairly tolerant, XXX for total frost resistance. The unmarked trees will not tolerate frost.
3. Propagation methods:
   - S — Remove flesh covering from fresh seeds and plant to depth of seed diameter. Seed material should be fresh and of local origin.
   - HS — Hard legumous seed (some can be planted direct into seed bed) - treat by pouring boiling water over seeds in a bowl and allow the whole to stand as it cools for 24 hours prior to planting
   - C — May be planted from cuttings, slips or truncheons - treated with root inducing hormone - but best results are usually obtained from seed grown plants
4. **A river showing zonation for planting of tree categories.**



5. Table of suitable trees

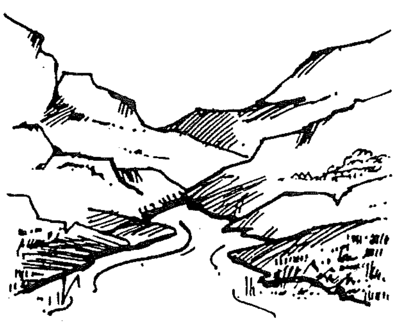
Leaf or pod shape	Distribution map	Stream zone	Botanical name	SA Tree No	Common name	Frost res.	Prop. method	Distribution map	Leaf or pod shape
		R	*Acacia albida*	159	Ana tree		HS		
		R & P	*Acacia karroo*	172	Sweet thorn	xxx	S & HS		
		R	*Acacia robusta*	183 183.1	Splendid thorn	x	S		
		R,P & M	*Bridelia micrantha*	324	Mitseeri		S & C		
		R & P	*Buddleja salviifolia*	637	Sagewood	xxx	S		
		R & M	*Barringtonia racemosa*	524	Powderpuff tree		S		
		P	*Celtis africana*	39	White stinkwood	xx	S		
		P	*Clerodendrum glabrum*	667	Tinderwood	x	S & C		
		R & M	*Combretum erythrophyllum*	536	River bushwillow	xxx	S		
		P & M	*Croton sylvaticus*	330	Forest croton	x	S		
		R & M	*Cryptocarya latifolia*	113	Broad leaved laurel	x	S		
		R	*Ficus natalensis*	57	Natal fig		S & C		

R & M	*Ficus sur*	50	Cape fig		S & C
R	*Ficus sycomorus*	66	Sycamore fig		S & C
R	*Ficus trichopoda*	54	Swamp fig		S & C
R & P	*Halleria lucida*	670	Notsung	x	S & C
R,P & M	*Harpephyllum caffrum*	361	Wildplum	x	S & C
R & M	*Ilex mitis*	397	African holly	xxx	S
R & P	*Leucosidea sericea*	145	Ouhout	xxx	S
R & M	*Macaranga capensis*	335	Wild poplar		S
R	*Maerua schinzii*	136	Ringwood tree		S
P& M	*Maesa lanceolata*	557	False assegai		S
R & P	*Myrica pilulifera*	37	Broad-leaved waxberry	xx	S
R.P & M	*Myrica serrata*	38	Lance-leaved waxberry	x	S
R	*Phoenix reclinata*	22	Wild date palm	x	S
C	*Podocarpus latifolius*	18	Real Yellowwood	xxx	S
C	*Podocarpus falcatus*	16	Outeniqua Yellowwood	xxx	S
C	*Octea bullata*	118	Stinkwood	x	S & C
R	*Raphia australis*	26	Kosi palm		S
R & M	*Rauvalfia caffra*	647	Quinine tree	x	S
P & M	*Rhus chinendensis*	380	Red currant	xx	S
R & P	*Rhus lancea*	386	Karee	xxx	S
R & P	*Rhus montana*	384.1	Drakensberg karee	xxx	S
R & P	*Rhus viminalis*	396	White karee	xx	S
R & P	*Salix mucronata*	36.1	Cape willow	xxx	S & C
R & P	*Salix subserrata*	36.2	Safsaf willow	xxx	S & C
R & M	*Syzygium cordatum*	555	Umdoni	x	S
R	*Syzygium guineense*	557	Water pear		S
P	*Trema orientalis*	42	Pigeonwood		S
R	*Voacanga thouarsii*	646	Wild frangipani		S

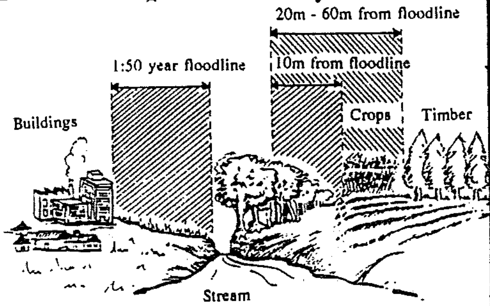
12

1. INITIAL SITE PREPARATION

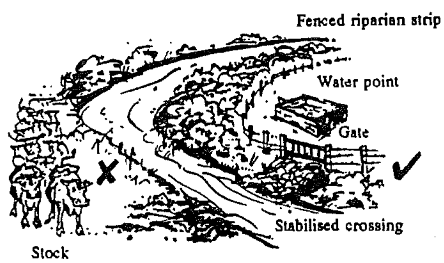
☐ Initiate streambank rehabilitation programmes as high up the catchment as is possible and progress downstream



☐ Where possible initiate rehabilitation work on prioritised riparian zones
☐ Remove crops or timber from the riparian zone
☐ Avoid building within the 1:50 year floodline



☐ Remove stock from or fence off sensitive areas



See page 7 & 9

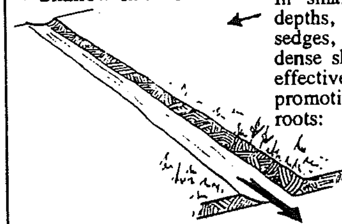
☐ Remove alien invasive plants in planned phases (starting upstream, light infestations first) and maintain control via follow ups

See page 23

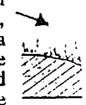
2. WHERE AND WHAT TO PLANT

☐
- It is seldom necessary or practical to plant lengthy avenues of trees
- Plant dense clumps of trees at selected weak streambank sites and estа between these areas.
- At a later stage these "gap" areas can be encouraged towards woody
- Do not plant trees in fire prone areas
- Where possible plant medicinal, commercial or other harvestable ma

☐ **Shallow channel**



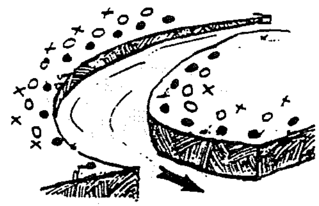
In small streams with low channel depths, a good herbaceous (grasses, sedges, reeds, rushes, etc) cover with a dense shallow root mat may be more effective against surface scour and promoting bank stability than tree roots:



However, a herbaceous cover ! effect on the staiblity of deep !

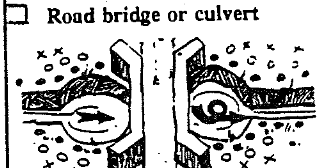
☐ Transplant local herbaceous species or allow area to regenerate and natur plant succession to take its course

☐ **Stream bend**



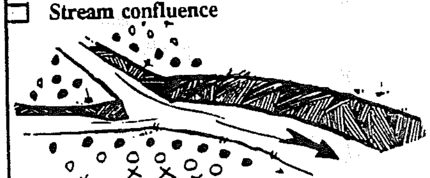
Trees contribute cohesion and stabi to deep banks - providing the rc reach down to full bank height and toe-hold and bank face are protec from undercutting by an establis herbaceous cover

☐ **Road bridge or culvert**



- ● = Vigorous rooting tree
- ○ = Pioneer tree
- x = Medicinal or commerical tree
- Plant trees at 1m-3m gaps and allow for bank slumps
- Plant supple trees eg palms in areas prone to frequent flooding
- For tree species guide see table on page 11

☐ **Stream confluence**



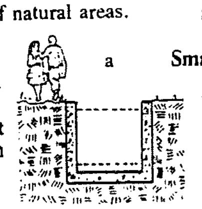
Lack of root depth undercutting allow large o to cause bank collapse

While the tree lives it weight of moisture from t once dead the root syste water into the bank

Stormwater management
In urban and industrial situations with their hardened surfaces - stormwater flood peaks which can be four-fold higher than that of natural areas.

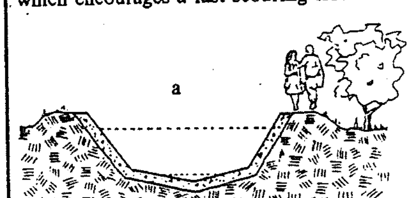
☐ 1a A stream confined to a completed hardened canal is dangerous to children and animals as it increases the peak flow. It is also visually unappealing and ecologically undesirable.

☐ 1b A semi-hardened rock-mattrass bottom that prevents erosion whilst supporting vegetation which provides for flood attenuation at peak flows.



☐ 2a Traditional engineering using full concrete walls and bottom to the canal. Whilst the design is efficient it is expensive, unattractive and of little ecological value. No silt build-up can occur due to the V bottom which encourages a fast scouring flow.

☐ b. An alternative for a hard bottom self scouring, then growth whilst the plant cover. The flood level which peak flows whilst

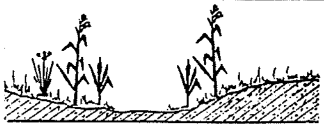


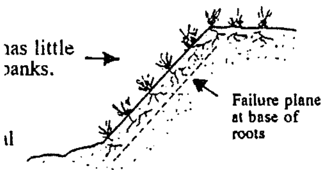
Large streams and Rivers

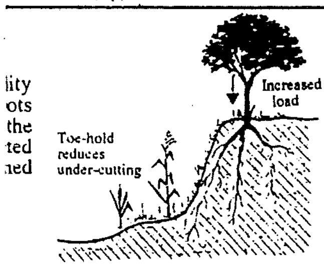
ıblish a healthy herbaceous cover

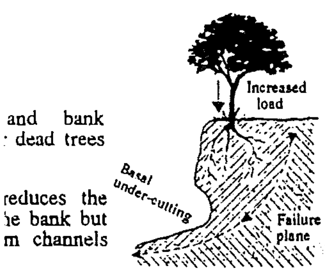
vegetation if desired

.terial

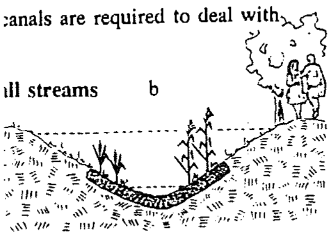




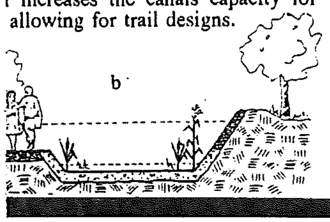




:anals are required to deal with

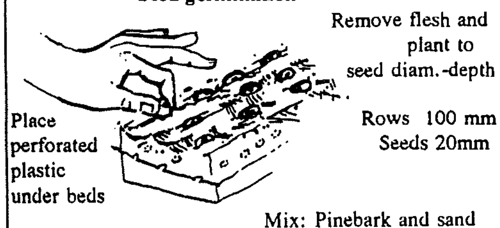


useful ecological and visual design ed canal. The flat bottom inhibits ›by collecting silt which allows plant : rock gabion walls also encourage ›y are stepped to a platform below ı increases the canals capacity for allowing for trail designs.

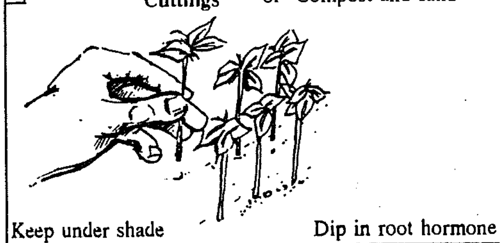


3. HOW TO PROPOGATE AND PLANT TREES

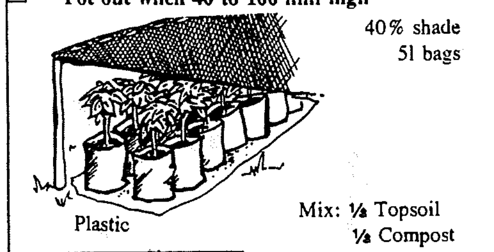
Seed germination



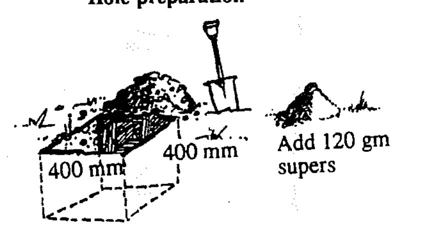
Cuttings



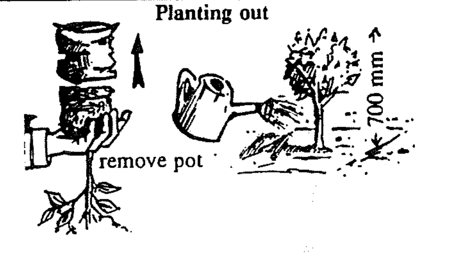
Pot out when 40 to 100 mm high



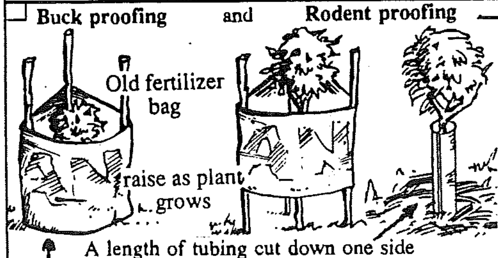
Hole preparation



Planting out

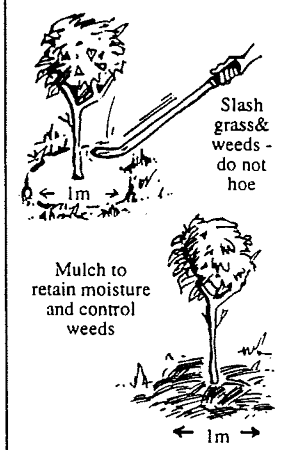


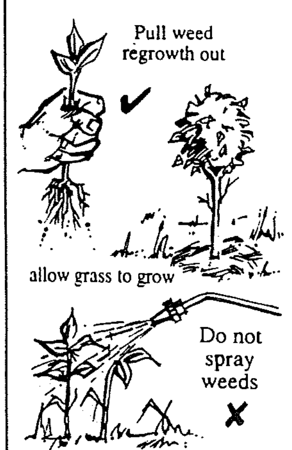
Buck proofing and Rodent proofing

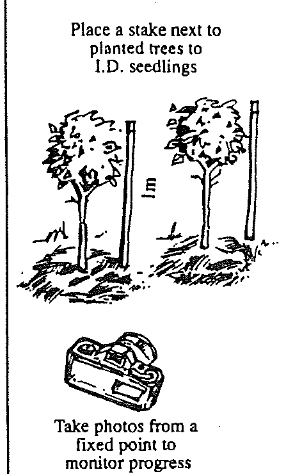


Not to be used during hot summer months.

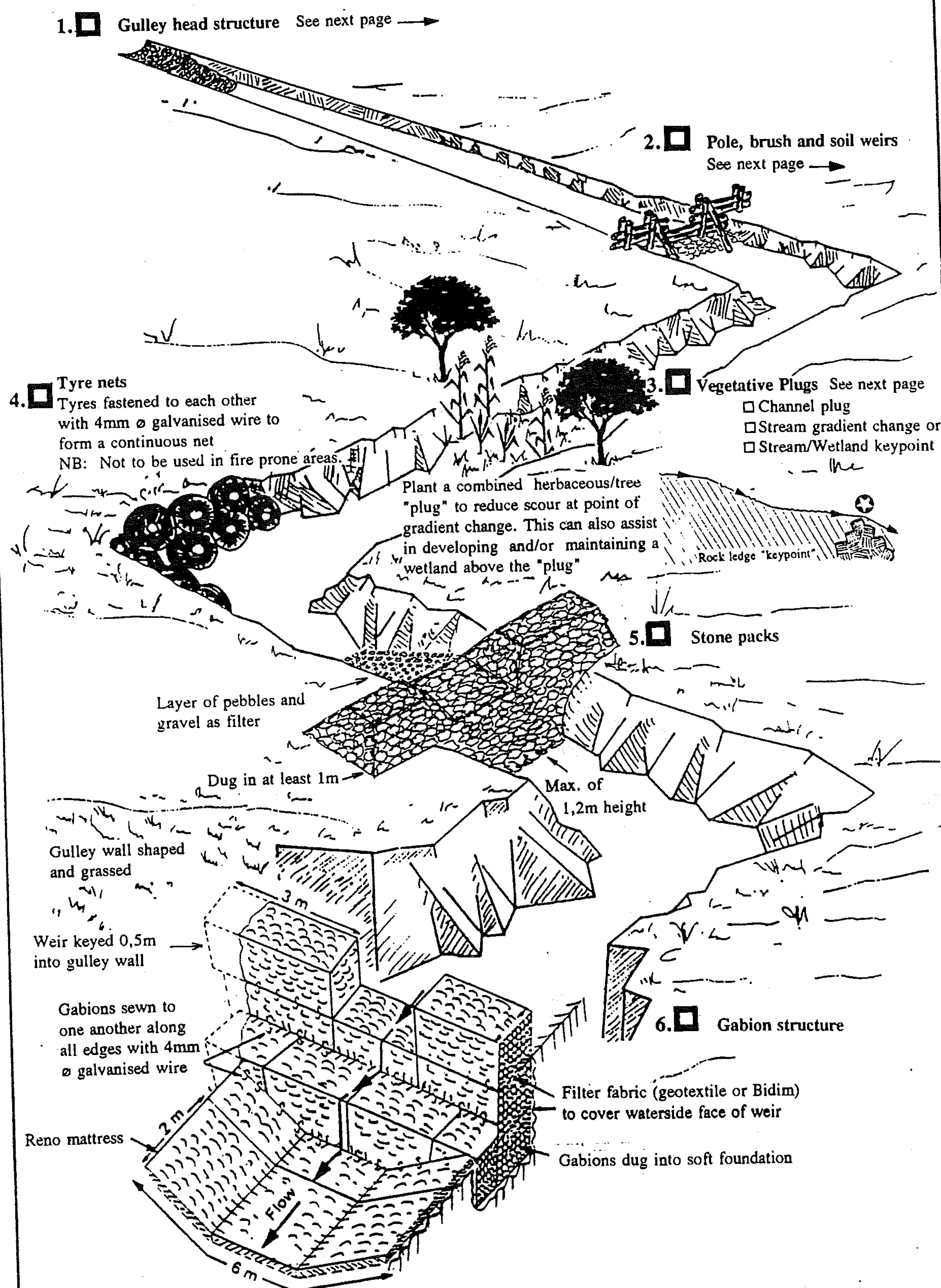
4. SITE MAINTENANCE







Plug Construction Guide - Masonry and Vegetative



1. ☐ **Gulley head** The gulley head is the most actively eroding area and requires attention first.

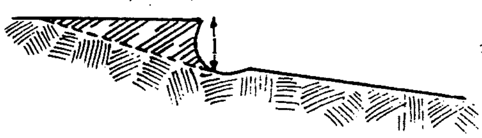
☐ Remove grazing or trampling. See page

☐ Encourage or plant a vegetation plug. See 3 below.

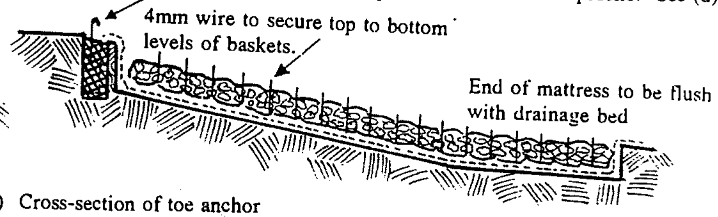
☐ Construct a reno mattress or a ☐ loose stone pack.

Reno mattress: long flat wire or veldspan baskets filled with stones.

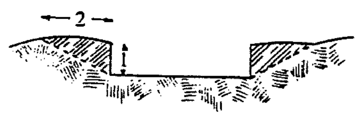
a) Excavate a 1:4 slope from the eat



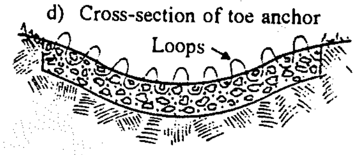
b) Concrete anchor (with wire loops to attach to mattress) 50cms deep and spade width on natural profile. See (d).



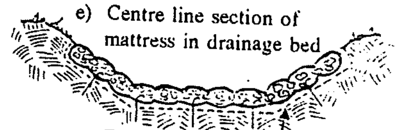
c) Slope sides to a 1:2 ratio



d) Cross-section of toe anchor



e) Centre line section of mattress in drainage bed

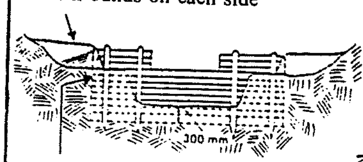


2. ☐ **Pole, brush and soil weirs**: Small structures on bed soil - to stabalize light scouring or to divert water from drains onto the wetland plain.

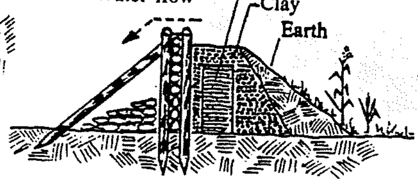
☐ Remove grazing or trampling. See page

☐ Construct a pole/earth bank barrier

Earth bunds on each side



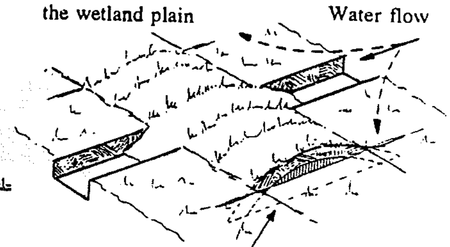
Well keyed into banks at full depth to avoid outflanking



Cross section

☐ Construct an Earth berm.

Soil raised above ground level to divert water onto the wetland plain



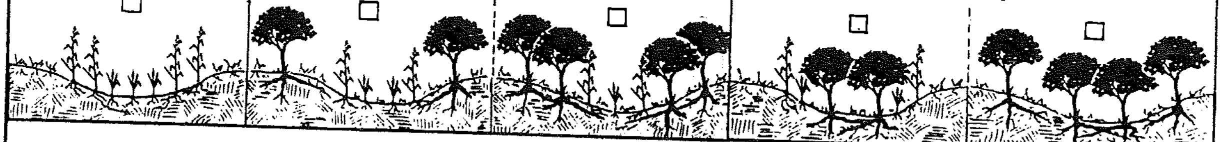
Clay or clay/stone/rubble core

3. ☐ **Vegetative plugs** These plugs will slowly collect and consolidate silt thus raising the channel floor.

☐ Remove grazing or trampling. See page

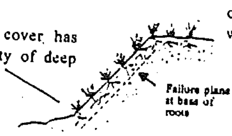
Herbaceous plug	Herbaceous combined tree plug	Tree channel plug	Tree channel & bank plug
Plant or allow natural sucession. Use where fire, climate or poor soils inhibit tree growth. ☐	Plant trees on banks - - and at water level. The herbaceous plug which matures before the trees will be slowly shaded out and the tree roots will form the "weir". The herbaceous plug will have migrated upstream. ☐ ☐	Plant trees in the channel. ☐	Plant trees in the channel and on banks. ☐

A tree plug planted in channel to form a root weir. Usually used in coastal swamp condtions.



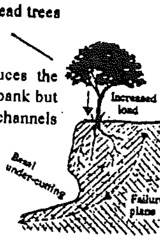
A good herbaceous (grasses, sedges, reeds, rushes, etc) cover with a dense shallow root mat may be more effective against surface scour and promoting bank stability than tree roots.

However, a herbaceous cover has little effect on the stability of deep banks.

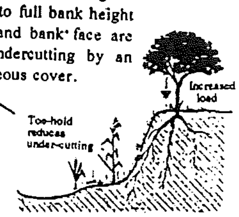


Lack of root depth and bank undercutting allow large or dead trees to cause bank collapse.

While the tree lives it reduces the weight of moisture from the bank but once dead the root system channels water into the bank.

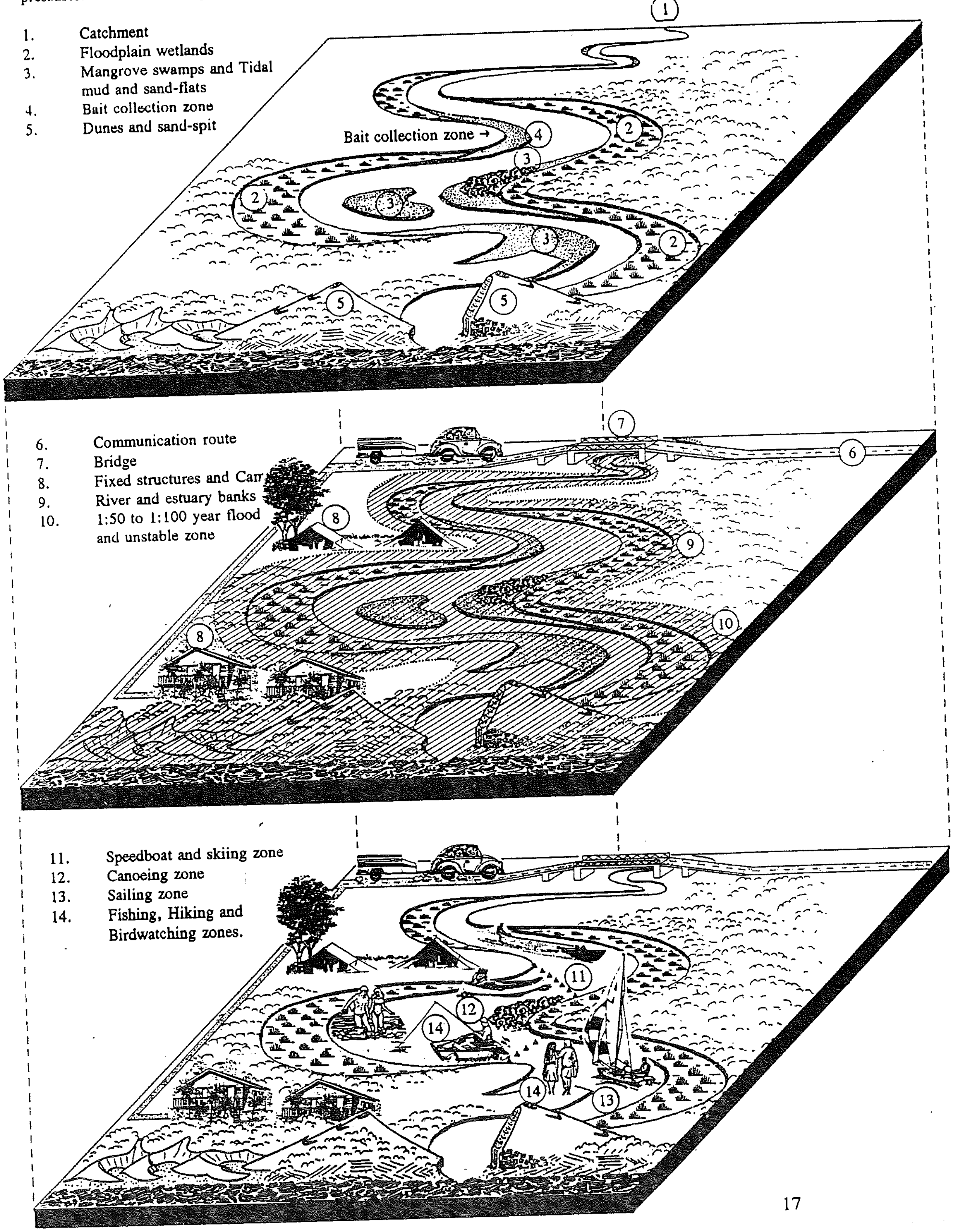


Trees contribute cohesion and stability to deep banks - providing the roots reach down to full bank height and the toe-hold and bank face are protected form undercutting by an established herbaceous cover.



Estuary Zonation Guide

Estuaries with their wealth of flora and fauna are attractive and popular and are being put under ever increasing resort and tourism pressures. This zonation guide is designed to assist in separating and controlling the multiple uses that estuaries are subjected to.



Estuarine ecological zones
Catchments, Floodplains, Mangrove swamps, Tidal mud and sand flats, Dunes

1. Estuaries are the end beneficiaries of **river catchments** and they thrive on a "normal" diet of freshwater,silt, sediment and nutrient input. It is essential that sound land-use management is practised throughout the river basin as any significant increase or decrease of these products has a high potential to create adverse effects in the estuary.
2. **The floodplain wetlands** should be exempt from development and zoned as special buffer areas, assimilating and purifying contaminants from land and storm run-off, trapping sediment, and providing food and refuge as a vital wildlife area.
3. **The mangrove swamps and tidal sand and mudflats** are the most productive areas of the estuary. These "aquatic compost heaps" settle as a rich soup of mud, sand and organic matter which forms the base of the food-web and mainstay of life in the estuary.

   Many fish species grub in the sediment for mud prawns, sand prawns, bloodworms, razor clams, snails and mussels - whilst at low tide mud banks in the southern hemisphere are the feeding ground for many birds including waders which breed in the arctic regions.
4. Because of the importance of these habitats, **bait collection zones** should be allocated and despite the high production and sustainability of bait species, exploitation should be restricted to using the correct implements, adhering to bait limits and minimizing damage to bait beds.

   Dredging - if absolutely necessary - must be strictly controlled as it can have disastrous biological impacts on these sand and mud habitats.
5. **Foredunes** should be protected from development or disturbance and access to beaches should be carefully sited, aligned and constructed.

Fixed Structures and Agricultural development
Transport routes, bridges, jetties, slipways, buildings, riverbanks, caravanning and camping

Water is the key ecological factor in an estuarine basin. The natural rhythm of flushing, salinity control, shifting sediments and nutrient transport to which the flora and fauna have adjusted themselves can be adversely influenced by artificial breaching or the construction of weirs, barrages, jetties, groins, slipways, bridges and embankments. Any such proposed interference should be subjected to prior professional assessment.

6. **Main communication routes** such as **roads, highways and railway lines** should avoid estuarine areas. They should be located inland of estuaries with access roads to the sea aligned perpendicular to the coast.
7. **Bridges** should be elevated over water areas, with open span designs instead of solid-fill embankments; and bridge piers orientated according to the direction of the water flow, and not necessarily at right angles to the deck of the bridge.
8. **Housing, permanent structures, caravanning and camping (and Agriculture)** should only be established on old land surfaces.
9. Where possible development should be restricted to one bank and always set back from the river and estuary to make provision for a vegetated buffer strip protecting the shore against erosion and maintaining bank stability whilst enhancing the aesthetic quality of the estuarine environment.
10. No development should be established on areas subjected to normal and/or exceptional 1:50 to 1:100 year floods or on unstable or low lying areas as they often dictate protection by manipulating water levels at the expense of the wetlands ecology.

Zoning of Recreational areas
Speedboating and water-skiing, canoeing, sailing and wind surfing, fishing, hiking and bird watching

Estuaries can be used and enjoyed by man, but care must be taken not to destroy the natural assets which attracted us there in the first place. Estuaries need to be zoned as each asset has it's own potential use and carrying capacity for a particular activity.

11. **Speedboating and water-skiing** can cause user conflict and should therefore be confined to limited areas. Sites selected for power boat use must be able to withstand bank-erosion from wave action and should have tidal flush to remove exhaust fumes and oil and fuel wastes. Activities should be further restricted so as not to disturb wildlife activities on sand or mud flats at low tide.
12. **Canoeing** is not destructive but should avoid strong wave and tidal wash areas at the estuary mouth and speedboating zones.
13. **Sailing and windsurfing** should be zoned so as to capitalize on wind in relatively open areas but should be kept clear of sensitive wetlands.
14. **Fishing, hiking and birdwatching** are popular but should be restricted to provided access points, trails, viewing sites and hides. These should be carefully sited, constructed and maintained to avoid trampling damage to sensitive estuarine areas.

COASTAL DUNE REHABILITATION

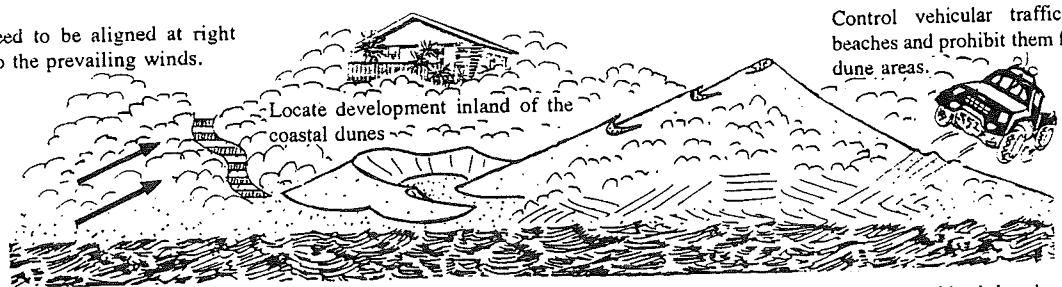
The stabilization and rehabilitation of dunes and sandspits adjacent to River mouths

NB: Bare dunes should not be stabilized merely because they are bare - they must be threatening an ecological function or something of value that cannot be located elsewhere.

Dunes and sandspits are mounds or ridges of loose wind-blown or water deposited sand which may or may not be covered by vegetation. A false impression of stability is imparted where they are bush clad as this tenuous cover merely attests to an extended temporary balance in dune dynamics.

There is a tireless battle being waged between beaches, dunes, river mouths and the surf zone (called the "littoral active zone") where this "bank" of sand is eroded back into circulation by the sea and used in times of sand shortage and restored where an excess of sand occurs. Transfer of sand from dune to beach is thus a self-regulating form of coastal protection.

The "littoral active zone" is tough and effective as long as it is free to alter within it's natural boundaries ie where it's malleability and plant fixing responses are unrestrained by the intrusion of immobile man-made structures, or damaged by excessive trampling and vehicle traffic.

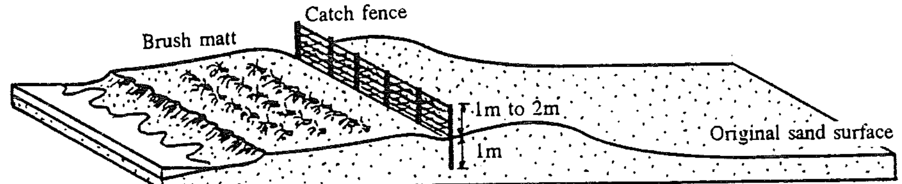


The golden rule for development on soft coasts is to avoid the "littoral active zone", especially the frontal dunes and back-beach which acts as the country's coastal buffer against:

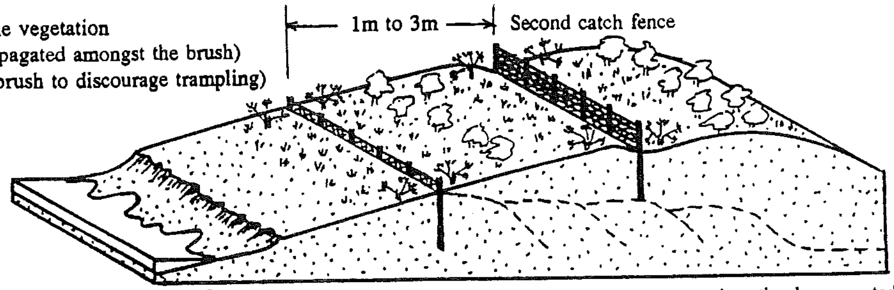
1. Invasion of wind blown sand onto roads, houses and agricultural land
2. Wave damage, salt water intrusion during storms or high tides and corrosion from sea spray
3. Beach erosion, serious damage to property, loss of coastal scenery and wildlife habitats.
4. Untimely or incorrect placement of breaching of estuary sandspits.

Stabilization and Reclamation if deemed necessary should ideally attempt to recreate dunes or sandspits by using the wind as the main formative agent together with strategically placed "catch fences", brushwood matts and plants.

Dune forming "catch fences" are used to repair gaps in dunes or to initiate rebuilding an eroded or damaged dune or sandspit. Semi-permeable (40% to 60% porosity) fence traps made of slats, saplings, and/or shade cloth and/or brush collect wind blown or collapsing sand.

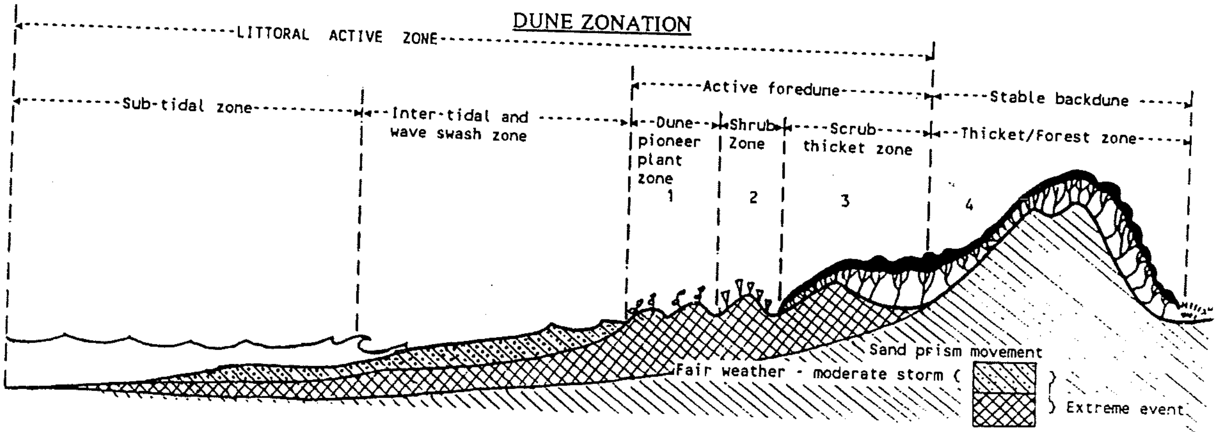


Temporary stabilization and shallow sand accumulation may be obtained by placing a brush matt on the sand surface. The butts of the branches are buried facing into the wind with the branches overlapping each other slightly. More brush can be added to that previously covered and so on.



Fences can be used in sequence to build the dune. Each new fence is placed 1m to 3m behind the previous one and on the dune created by it.

Following temporary stabilization, indigenous dune vegetation may be planted to improve the "permanence" of the stabilized sand. Planting should only be attempted on rain soaked dunes but avoiding the extremely hot or cold periods. Replantings will probably be required annually for about four years in order to gap mortalities.



COASTAL DUNE KEY PIONEER PLANTS

Tree No.	PLANT SPECIES	COMMON NAME	PLANT METHOD	DUNE ZONE	COAST SECTOR T	N	TK	EC	SC	SW	W
	GRASSES										
	Agropyron distichum	Seawheat	S:P	1					+	+	
	Ammophila arenaria	Marram	P	2-4					+	+	
	Dactyloctenium australe	Dune kweek	S:P	1-4	+	+					
	Digitaria macroglossa	Finger grass	S:P	3-4	+	+					
	Ehrharta villosa	Pypgras	S:P	3-4				+	+	-	
	Eragrostis cyperoides	Steekriet	S:P	1-2							-
	Imperata cylindrica	Lalang, cotton-wool grass	S:P	2-4	+	+	+	+	+		
	Sporobolus virginicus	Beach dropseed	S:P	1	+	+	+	+	+	-	-
	SEDGES										
	Cyperus maritimus	Dune sedge	P	1-4	+	+	+	+	+		
	Scirpus nodosus	Dune slack sedge	S	2	+	+	+	+	+	-	+
	RESTIOS										
	Restio eleocharis	Katstertriet	P	2-4					+	+	
	R.leptocladus	Besemriet	P	2-4					+	-	
	HERBS & SHRUBLETS										
	Arctotheca populifolia	Dune cabbage	S:P	1-2	+	+	+	-	+	-	
	Canavalia maritima	Creeping bean	S:P	1	+	+					
	Carpobrotus spp	Hotnotvye	C	3	+	+	+	-	+	-	-
	Chironia bacifera	Christmas berry	S	2	+	+	+	-	+	-	-
	Gazania rigens	Goushlom	S:P	1-4	+	+	+	+	+		
	Hydrophylax carnosa			1	+	+	+				
	Ipomoea brasiliensis	Dune morning-glory	S:P	1-2	+	+	+	-			
	Launaea sarmentosa			1-2	+	+					
	Psoralea repens		S:P	1-3					+		
	Scaevola thunbergii	Seëplakkie, scaevola	P	1	+	+	+	+			
	Stoebe plumosa	Slangbos	S	1-4	+	+	+	+	+	+	+
	Tetragonia decumbens	Klappiesbrak	P	1-2				+	+	+	+
	SCRUB										
172	Acacia karroo	Sweet-thorn, soetdoring	P	3-4	+	+					
724	Brachylaena discolor	Dune silverleaf	P:C	2-4	+	+	+	+			
410	Cassine aethiopica	Kuduberry	P	4	+	+	+	+	+		
736.1	Chrysanthemoides monilifera	Bitou, tickberry	S	2-4	+	+	+	+	+	-	-
652	Cordia caffra	Septee	P	4	+	+	+	-			
608	Diospyros rotundifolia	Dune jackal-berry	S:P	2-3	+						
599	Euclea racemosa	Dune ghwarrie	P	2-4				+	+	+	-
553.1	Eugenia capensis	Dune myrtle	P	2-4	+	+	+	+	+		
	Helichrysum kraussi	Sand helichrysum	S	2-4	+	+					
401.1	Maytenus procumbens	Dune kokoboom	P	2-3	+	+	+	+	+	+	
736.4	Metalasia muricata	Blombos	S	2-4				+	+	+	
583	Mimusops caffra	Dune milkwood	P	2-4	+	+	+	+			
	Mundia spinosa	Skilpadbessie	S	1-3				+	+		
	Myrica cordifolia	Wasbessie, waxberry	S	2-4				+	+	+	
	M. quercifolia	Oakleaved waxberry	S	2-4					+	-	
619	Olea exasperata	Sand olive	P	2-4				+	+	+	
520.2	Passerina rigida	Dune gonna	S	2-4	+	+	+	+	+	+	
409	Pterocelastrus tricuspidatus	Kershout	P	2-4					+	+	+
380.1	Rhus crenata	Duinekraaibessie	S:P:C	2-4				+	+	+	
383.2	R. glauca	Bloukoenibos	P	3-4				-	+	+	+
385.2	R. laevigata	Duintaaibos	P	2-4				+	+	+	
390	R. natalensis	Natal karee	P	3-4	+	+	+	+			
	R. nebulosa	Sandtaaibos	P	3-4	+	+	+				
	Salacia kraussii	Ibonsi		3-4	+	+					
103.1	Salsola arborea			2-3							+
451	Scutia myrtina	Drogie, cats claw	P	3-4	+	+	+	+	+		
579	Sideroxylon inerme	White milkwood	P	4	+	+	+	-	+	+	+
733	Tarchonanthus camphoratus	Camphor bush	P	3-4		+	+	+	+	+	

PLANT METHOD: S = Seed, P = Plant, C = Cutting
T = TONGALAND; N = NATAL; TK = TRANSKEI; EC = EAST CAPE; SC = SOUTH CAPE;
SW = SOUTHWEST CAPE; W = WEST COAST

Adapted from "Coastal Dunes of South Africa" by K.L. Tinley (1985)

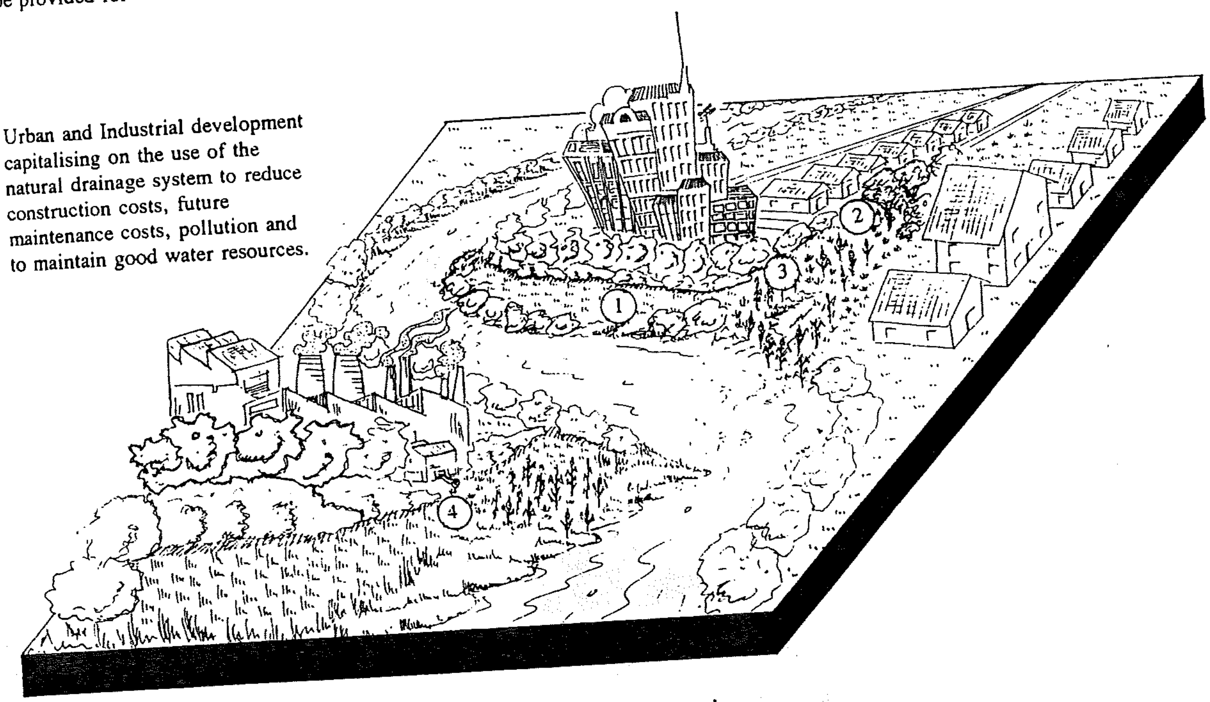
Urban and Industrial Wetlands - The Urban outdoors

The "Urban Outdoors" differs from the rural setting in that it is concerned with the survival of small "islands" of parks in a sea of concrete buildings. The need to provide these parks as recreation and "green lung" facilities in urban and industrial areas is recognised as desirable for the maintenance of human health and social needs.

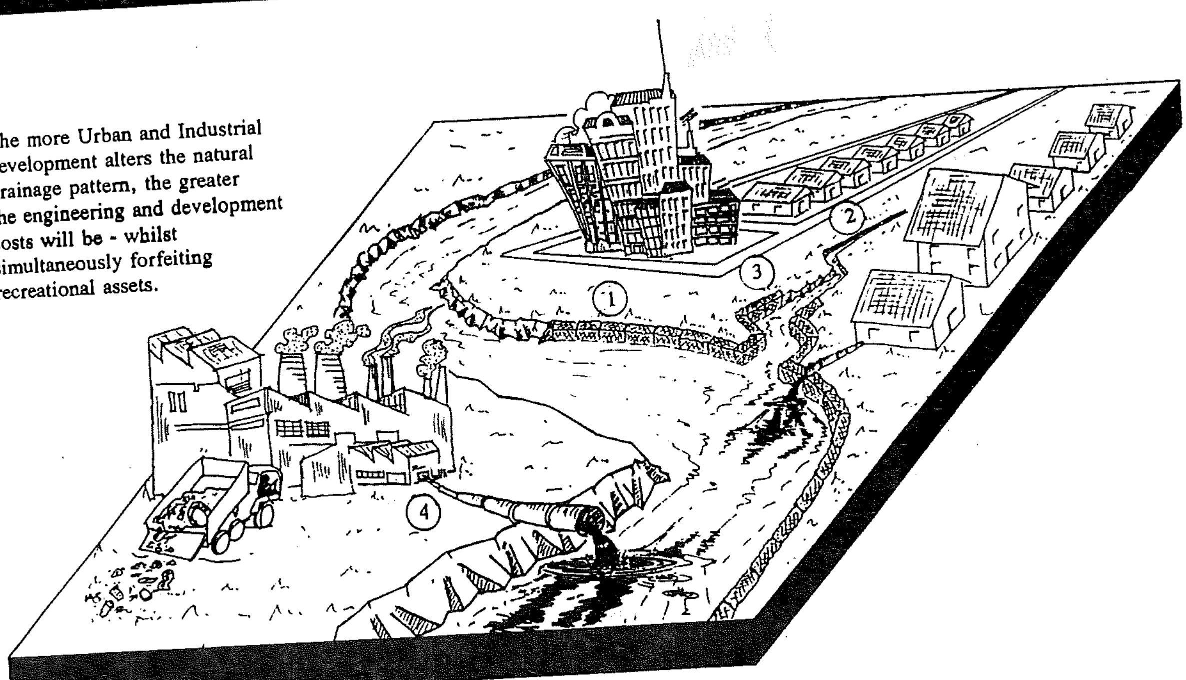
River valleys form a network of interconnected streambanks and wetlands that may be used as corridors and merging nodes of parks and nature conservation areas. Because of the networks linear design it offers ample opportunity for walking or cycling trails; various uses can be integrated - allowing parks, sportsfields, forests, marshes and picnic areas to blend - whilst invisible to the user, the wetlands and riparian zones enhance water purification, flood attenuation and wildlife corridor habitats.

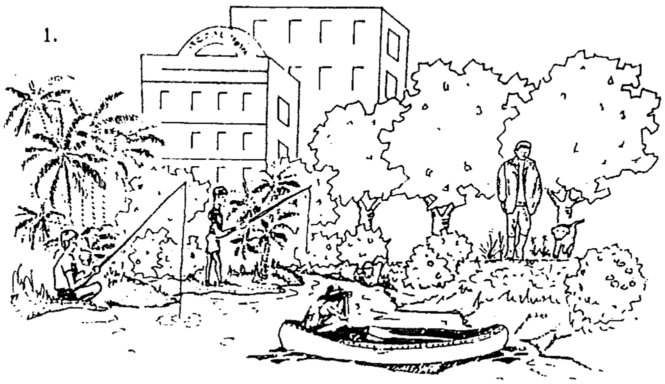
At present, economic realities make it abundantly clear that expensive formally manicured and maintained parks can simply no longer be provided for - whereas on the contrary, wetlands thrive on minimal maintenance.

Urban and Industrial development capitalising on the use of the natural drainage system to reduce construction costs, future maintenance costs, pollution and to maintain good water resources.



The more Urban and Industrial development alters the natural drainage pattern, the greater the engineering and development costs will be - whilst simultaneously forfeiting recreational assets.





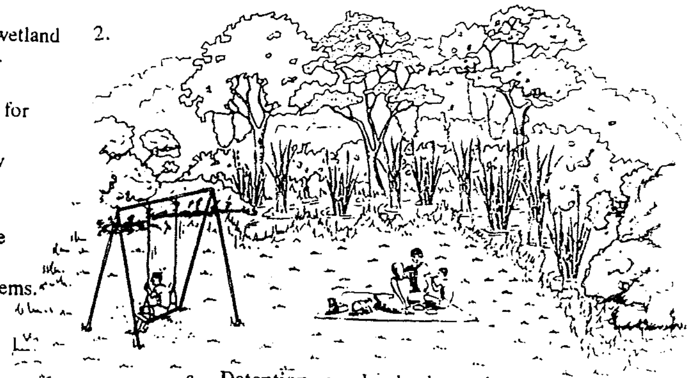
1.

a. **Riparian or streambank trees** provide a vegetative buffer strip protecting the bank against erosion whilst maintaining bank cohesion, stability and wildlife value.
b. **Natural vegetation as an aesthetic amenity** contribute to the visual attractiveness of the city by providing scenic variety and visual relief.
c. **Fishing;** active recreation as a social need
d. **Canoeing;** active recreation whilst the city reduces capital costs by developing natural solutions for stormwater management
e. **Hiking, bird-watching;** outdoor recreation and education of the public through direct contact with nature within the urban environment.

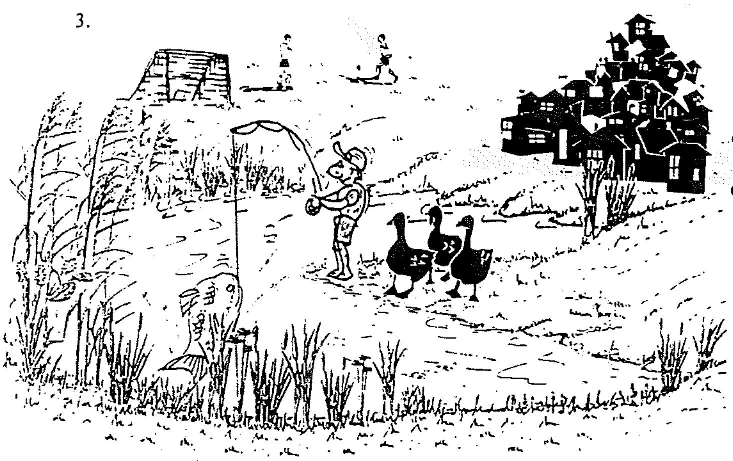
a. **A swamp forest** - an ecologically rich but rare wetland type that is recognised as a high quality but cost-effective natural water treatment system.
b. **The "wetland" with subtle manicuring** allows for minimal maintenance and low cost parks
c&d **Picnicking and playground** activities are easily blended into the natural environment.

Draining or damming of swamp forests can eliminate ecological assets and the beneficial effects on water quality whilst contributing directly to flooding problems.

2.



3.



a. **Detention ponds;** landscaped as part of the wetland and park - designed to dampen floods and regulate streamflow.
b. **The ponds allow for wetland habitat** development but need a drainage system to prevent stagnant water.
c. **Deep ponds** or pans that support the correct fish species need not be mosquito havens.
d. **Sportsfields** blended into or adjacent to the wetland environment.

The construction or dredging of drains and canals must be carried out with minimum degradation to the wetland and functions.
Roads need to be elevated above wetland surfaces or culvert pipes must be sufficiently large and spread to cause the least disruption to the natural waterflow.

4.

a. **Artificial wetlands;** based on the principles of natural wetlands can be constructed to improve waste water quality from domestic, agricultural urban or industrial sources.
They are ideal for small communities such as leisure resorts, camping sites, rural schools, informal settlements, small industry and even individual home-owners with no access to municipal sewerage systems.
b&c. **Riparian vegetation** whilst stabilising the banks also performs as a screen against stark industrial development.
d **The "Industrial Park"** is useful in maintaining the health, moral and productivity of local staff.

Alien Plant Control Guide

The intensity of alien plant invasions is usually greatest in the wetter areas along water courses and wetlands. The indigenous plants and habitats are smothered, the intensity of fires increased, streambanks eroded, channels choked and streamflow is reduced.

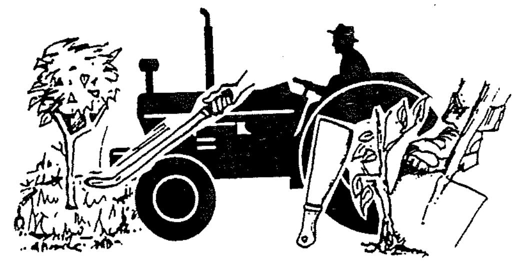
Control strategy
The general principles of control are to remove the alien invasive plants in planned phases, starting upstream on all light infestations first, and to maintain control via follow-up programmes before tackling heavier infestations.

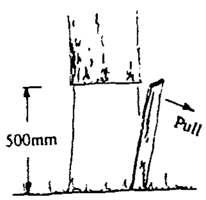
Control methods

1. Mechanical control

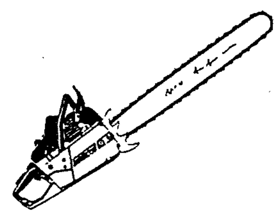
Handpulling.
An effective control for seedlings or shallow rooted plants, especially in soft or moist soil conditions.

Cutting
A method of exhausting a plant's root reserves until it dies by repeatedly cutting it down during the growing season.
If the terrain allows, then mowers (including tractor drawn) can deal with large areas.





Ringbarking
Useful where one does not wish to cause damage by felling large trees. Strip off all the bark (including the cambiam layer) from the lower 50cm of the trunk.



Felling
This usually has to be combined with ringbarking, cut-stump treatment or stacking and burning stumps to prevent coppicing.

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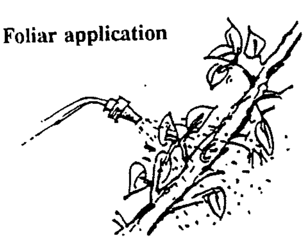
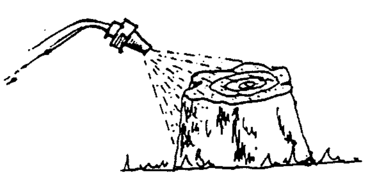
2. Chemical control
Determine the toxicity, volatility, soil persistancy and economics of the chemical used when selecting a suitable herbicide. Always read the label instructions and ensure that the necessary staff training and safety precautions are taken prior to the use of herbicides.

Foliar application

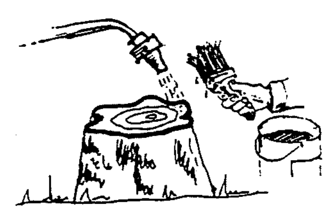


Spray the herbicide directly onto actively growing plants with full leaf cover.
Do not apply to wet foliage or when rain is imminent
Use a solid cone nozzle that ensures an even coverage of spray to all leaves and stems - to the point of run-off.

Cut stump treatment Spray with a solid cone nozzle or brush herbicide directly onto freshly cut stump surface - avoiding excessive run-off onto the soil.
Treat each stem surface on a multi-stem plant.
Very effective for killing mature woody alien plants and for use in more sensitive areas.

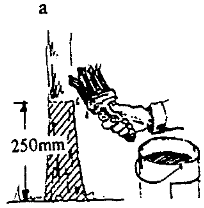


Where bark is thin apply herbicide to whole stem.

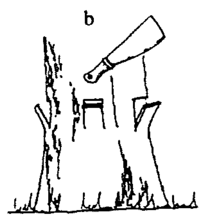


Where bark is thick apply herbicide to the exposed freshly cut bark only.

a



b



a. **Basal bark treatment** (for plants with stem diameter up to 100mm)
Apply by paintbursh or spray onto the lower 250mm of stem of standing plant; - including any exposed roots.
Treat each stem on a multi-stem plant
Use a low pressure spray and narrow angle cone nozzle.

b. **Frilling** (nicking the basal part of the stem with an axe or cane knife) to allow for herbicide application or stem injection.

Soil applied herbicides are placed in granular form on the soil surface within the dripline of the tree canopy. It is then dissolved and transported into the soil by rain where it is taken up by the roots of plants. Soil applied herbicides may also effect non-target plants.

Table of Wetland and Water course weeds and some control methods

Alien plant species	Mechanical Control					Chemical Control					Bio Control
	Hand pulling	Cutting	Ringbark	Felling	Burning	Foliar spray	Cut stump	Basal bark or frilling	Injection	Soil treatment	
Acacia cyclops Rooikrans or Redeye						Garlon				Reclaim/ Graslan	
Acacia dealbata Silver wattle			✓	✓		Garlon	Garlon Tordon s	Tordon s			
Acacia longifolia Longleaved wattle			✓								
Acacia mearnsii Black wattle	✓		✓	✓		Garlon Roundup	Tordon s	Garlon Tordon s		Reclaim/ Graslan	
Acacia melanoxylon Blackwood	✓		✓	✓							
Acacia saligna Port Jackson willow						Garlon Roundup				Reclaim/ Graslan	
Arundo donax Spanish weed											
Caesalpinia decapetala Mauritius thorn	✓					Garlon Roundup					
Cestrum laevigatum Inkberry	✓		✓								
Chromolaena odorata Triffid weed	✓					Garlon Roundup Brush off/ Estcort	Garlon Chopper/ Arsenal			Reclaim/ Graslan	
Eichhornia crassipes Water hyacinth						Roundup Igran					
Eucalyptus grandis Saligna gum			✓	✓		Garlon Chopper/ Arsenal Estcort	Garlon Chopper/ Arsenal			Reclaim/ Graslan	
Lantana camara Lantana	✓					Roundup Chopper/ Arsenal	Chopper/ Arsenal Tordon s			Reclaim/ Graslan	
Melia azedarach Syringa	✓		✓					Garlon			
Myriophyllum aquaticum Parrots feather											
Nicotiana glauca Wild tobacco											
Opuntia ficus-indica Sweet prickly pear						Roundup			Masmar		Cochineal or Cactoblastis
Pereskia aculeata Barbados gooseberry					Burn heaped material	Garlon					
Pinus spp Pine	✓		✓	✓	✓					Reclaim/ Graslan	
Pistia stratoites Water lettuce											
Populus canescens Grey poplar											
Psidium guajava Guava											
Rubus cuneifolius Bramble		✓				Garlon Roundup Brush off/ Escort				Reclaim/ Graslan	
Salix babylonica Weeping willow											
Salix fragilis Basket willow											
Salvinia molesta Kariba weed						Igran					Beetle - Cyrtobogous salviniae
Schinus terebinthifolius Brazil pepper	✓				✓						
Sesbania punicea Red sesbania	✓					Garlon Roundup	Garlon			Reclaim/ Graslan	
Solanum mauritianum Bugweed	✓					Garlon Roundup Chopper Starane	Chopper/ Arsenal	Garlon Starane		Reclaim/ Graslan	

GLOSSARY OF TERMS

Alien: Plants or animals introduced from one environment to another, where they had not occurred previously.
Breaching: Making a gap or breaking through (a sandbar)
Bioclimatic region: Broad areas characterised by distinctive ecological responses to climate and landform as expressed by vegetation and reflected in soils, fauna and water.
Catchment area: A basin-shaped area from which rainfall is collected and concentrated into stream flow
Channel flow: Water flow confined between the banks of a river or stream
Conservation: The act of planning and managing natural or man-made resources (eg Wetlands) with the object of securing their optimal use without degrading their quality, value and diversity
Decomposition: The breakdown of non-living organic matter, and it's conversion into simpler substances.
Detritus: Organic debris from decomposing plants and animals
Ecotone: A boundary zone between two plant communities containing elements of both and often it's own characteristic components, consequently an area of high biotic diversity (the edge effect), the zone may be sharp (narrow) or gently intergraded (wide)
Ecology: The science that deals with the relationship between plants and animals, (including man) and their environment
Ecosystem: The system of inter-relationships within and between a biological community and it's physical environment
Environment: The sum of all the external conditions and influences which affect the development and life of organisms
Estuary: Estuaries are the tidal portion of river mouths, bays and coastal lagoons, irrespective of whether they are dominated by marine, hypersaline or fresh water.
Eutrophication: The process by which a body of water is greatly enriched by the natural or artificial addition of nutrients such as nitrogen and phosphorous. This may result in both beneficial (increased productivity) and adverse effects, (often used to describe polluted waters) where this is smothering by dominant plant types
Evaporation: The process by which water is withdrawn by radiation from a moist land area, or water surface, and passes into the atmosphere as vapour.
Evapotranspiration: The process by which water is withdrawn from a land area by both transpiration and evaporation
Extant wetlands: Existing wetlands, which in their present condition perform functions such as stream flow regulation, flood damage protection, water purification, wildlife and soil erosion protection
Fauna: The animal life characteristic of a particular region or environment
Flood attenuation: The capacity of a wetland to slow run-off velocity and thus reduce downstream flooding.
Floodplain: An area adjacent to rivers and streams which is periodically inundated by flood flows. Floodplain ecosystems develop in response to the flooding patterns generated.
Flora: A collective term for the plant life characteristic of a particular region or environment.
Foodweb: A "Chain" of organisms through which energy is transferred. Each link feeds on and obtains energy from the one preceding it. The various components of one link collectively form a trophic level.
Habitat: The locality, or niche (ie living place) of a plant or animal and normally within a particular kind of environment
Heavy metal: A metal of high density
Hydrology: The study of water, particulary the factors affecting its movement on land
Hydromorphic soil: Soils in which water logging becomes the dominant factor determining its physio-chemical characteristics
Hygrophilous plants: Moisture loving plants which can live where there is an abundant supply of available water
Indigenous: Species that have originated naturally in a particular region or environment; not imported.
Infiltration: The passage of water through the surface of the soil via pores or small openings. It is governed by the permeability of the soil profile, and non-capillary porosity of the soil surface.
Intertidal: Generally the area which is inundated during high tides and exposed during low tides.
Inventory (of Wetlands): A country-wide "stock-taking"/ mapping exercise designed to generate information on the location and characteristics of all areas designated as wetlands.
Keypoint: A natural obstruction that restricts downward erosion of the river channel. Frequently the "keypoint" is a hard stratum of rock (such as a dolorite dyke or sill), but can also occur laterally in the form of alluvial ridges.
Leachate: A toxic solution produced by the movement of groundwater or infiltrating surface water through landfill sites containing solid waste.
Levees: Man-made ridges of soil (technically "dykes") that are formed on either side of a river channel to protect the surrounding land from flooding. Levee formation is also a natural phenomenon.
Mottling: A mottled or variegated pattern of colours is common in many soil horizon where hydropmorphy is responsible, the colour pattern is formed by the reduction of iron compounds. The colour of the mottles normally varies from red to yellowish brown, on a grey matrix
Mulch: Organic material found on the surface of soil, such as grass or forest litter that protects the soil from the sun and rain.
Natural resource: Any raw material, either living or non-living, renewable or non-renewable, obtained from nature
Nutrient: An element or compound that is an essential raw material for organism growth and reproduction
Optimum yield: The amount of material that can be removed from a population or given area that will maximise growth on a sustained basis.
Organic matter: Carbon containing matter, usually derived from living organisms
Pan: A permanent or semi-permanent lake that is fringed by wetland - associated plants. The outlet is generally blocked by sediment.
Pesticide: Any chemical designed to kill animals or plants that humans consider to be undesirable
Pollution: Destruction or impairment of the purity of the environment
Priority wetland: Wetlands that have a high priority for attention as far as management and policy formulation is concerned
Restoration (of wetlands): The act of enhancing the condition of degraded wetlands to a level whereby certain of the functions which the system formerly provided become replaced - successful restoration means the replacement of lost functional values.
Ridge and Furrow: The result of a prescribed system of repetitive ploughings in a wetland which cause soil to be thrown into a series of parallel cambered beds that ensures controlled drainage through the excavated furrows
Riparian: Occurring on the banks of rivers, streams, dams lakes or pans
Seepage area: An area commonly found at a change of slope and at the head of drainage lines (often in association with dolorite and shales) in which there is a high. incidence of springs.
Siltation: Sand or soil deposition that occurs when water speed slows down
Stream ordering: A means of comparing rivers of different sizes in a catchment. The smallest streams, which have no tributaries are called first order streams - when two of these coalesce they form second order streams, and when two second order streams join they form third order streams, and so on
Transpiration: The process by which water in plants is transferred to the atmosphere as water vapour
Watershed: The divide separating one drainage basin from another
Wetland: *"Those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions."*
The internationally accepted definition of a wetland includes - "areas or marsh, fen peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water, the depth of which at low tide does not exceed six metres" (Ramsar Bureau, 1971)

REFERENCES

Allan, D., Types of Pans in South Africa. African Wildlife. 41 (5): 230-235.
Begg, G.W., 1979. Policy proposals for the Estuaries of Natal. Natal Town & Regional Planning Report, 43: 1-39.
Begg, G.W., 1984(a). The Estuaries of Natal (Part II). Natal Town & Regional Planning Main Series Report, 55: 1 - 631
Begg, G.W., 1984(b). The Comparative Ecology of Natal's smaller Estuaries. Natal Town & Regional Planning Report, 62: 1-182
Begg, G.W., 1986. The Wetlands of Natal (Part 1): An overview of their extent, role and present status. Natal Town & Regional Planning Report, 68: 1- 114
Begg, G.W., 1988. The Wetlands of Natal (Part 2): The distribution, extent and status of wetlands in the Mfolozi catchment. Natal Town & Regional Planning report, 71: 1 - 278
Begg, G.W., 1989. The Wetlands of Natal (Part 3): The location, status and function of the priority wetlands of Natal. Natal town & Regional Planning report, 73: 1 - 256
Begg, G.W., 1990. The Wetlands of Natal (Part 4): Policy Proposals for the Wetlands of Natal and Kwa Zulu. Natal Town & Regional Planning Report, 75: 1-86
Berjak, P., Campbell, G.K., Huckett, B.I., and Pammenter, N.W., 1977. In the Mangroves of Southern Africa. Durban, Wildlife Society of Southern Africa (Natal Branch), 1 - 72
Berold, R., and Caine, C., (eds). Peoples Workbook. Environmental and Development Agency (E.D.A.) Johannesburg. 256- 261
Branch, M., and Branch, G., 1981. The Living Shores of Southern Africa. C.Struik Publishers, Cape Town, 1 - 271
Breen, C.M., 1991. Wetlands - the will to find a way? Conserva 6(3), Department of Environment Affairs. Government Printer, Pretoria 8-11
Breen, C.M., and Begg, G.W., 1987. Wetlands - a valuable natural resource. African Wildlife, 41(5): 219 - 221
Coates Palgrave, K., 1977. Trees of Southern Africa. C.Struik Publishers, Cape Town: 1-959
Cooper, K.H., and Duthie, A., 1992. MOSS soothes city nerves. Muniviro Newsletter for Local and Regional Authorities, 9(1). Department of Environment Affairs. Government Printer, Pretoria: 4.
Council for the Environment, 1989. A Policy for Coastal Zone Management in the Republic of South Africa: Part 1 - Principles and objectives. Government Printer, Pretoria: 1 - 11
Council for the Environment, 1991. A policy for Coastal Zone Management in the Republic of South Africa: Part 2 - Guidelines for coastal land-use. Government Printer, Pretoria: 1 - 95
Crook, B.J.S., 1986. Southbroom: Guidelines pertaining to the natural environment. Environmental Planning division, Natal Provincial Administration: 1-53
Davies Lynn & Partners, 1988. Spring Types. Feasibility report for the proposed Inanda Spring Development Programme. Durban: 1 - 38
Denny, R.P., 1992. Personal communication, Cedara Weeds Laboratory, Plant Protection Research Institute, Agricultural Research Council.
Dungan, P.J., (ed). 1990. Wetland conservation: A review of Current Issues and required action. IUCN., Gland, Switzerland: 1 - 96
Durban, Director Parks, Recreation and Beaches Department, 1989. D'MOSS. Durban Metropolitan Open Space System: 1 - 96
Gaigher, C. Wetlands. Cape Department of Nature and Environmental conservation. Cape Conservation Series 6: 1 - 24
Guthrie, I., and Wyatt, J., 1992. Catchment Action: Riverine vegetation in Natal - A species guide. A Share-net resource, Howick: 1-41
Henderson, L., 1992. Invasive Alien Woody Plants of the Eastern Cape. Plant Protection Research Institute, Pretoria. Bothalia 22, 1: 119-143
Heydorn, A.E.F., and Tinley, K.L., 1980. Estuaries of the Cape. (Part 1): Synopsis of the Cape Coast - Natural features, dynamics and utilization. National Research Institute for Oceanology, C.S.I.R., Stellenbosch: 1-96
Hill, P.R., Scotney, D.M., and Wilby, A.F., 1977. Wetland Development: Ridge and Furrow system. (Draft Report). Department Agricultural Technical Services, Natal Region: 1-45
Johnson, D.N., 1985. Alien Plant invaders and their control. Natal Parks Board, Wildlife Management - Technical Guide for farmers. No.11
Kok, D.J., 1987. Invertebrate inhabitants of temporary pans. African Wildlife 41(5): 239
Kotze, D.C., 1991. The functional values of wetlands and the impact of Agricultural land-uses on these values. Unpublished report, Natal Town and Regional Planning commission: 1 -53
Kotze, D.C., 1993. Wetland-use: A decision support model for managing wetlands. Unpublished report, Water Research Commission: 1-73
Lambiris, A.J.L., 1992. Personal communication, Natal Parks Board, P.O. Box 662, Pietermaritzburg, 3200.
Le Roux, N.P., 1991. Selection of Herbicides for invader weed control. Natal Parks Board, Wildlife Management - Technical guide for farmers. No.26
Lubke, R.A., and Avis, A.M., 1986. Stabilization and Management of Coastal Sand dunes. Department of Plant Sciences, Rhodes University. Coastal Information Pamphlet. No.1: 1-9
Macdonald, I.A.W., Jarman, M.L., and Beeston, P., (eds) 1985. Management of invasive alien plants in the Fynbos Boime. South African National Scientific Programmes Report (III). C.S.I.R., Pretoria: 1-40
Mann, C., 1985. The Valley Trust. Water and Sanitation Projects: 1-47
Markham, R.W., 1984 (a). Vlei Management. Upper Mvoti Conservancy Management Guidelines. Pietermaritzburg, Natal Parks Board.
Mitsch, W.J., (Editor-in-chief) 1992. Ecological Engineering. The Journal of Ecotechnology: 1-171
Moll, E., 1981. Trees of Natal. Published by the University of Cape Town. Eco-lah Trust Fund: 1-572
Morant, P.D., 1981. Wetland Classification: A review of existing wetland classification systems and their applicability in Southern Africa. University of Cape Town: 1-180.
Palmer, E., and Pitman, N., 1972. Trees of Southern Africa. A.A.Balkema, Cape Town. Vols. 1,2 & 3: 1 - 2234.
Rowntree, K., 1991. An assessment of the potential impact of alien invasive vegetation on the geomorphology of river channels in South Africa. Southern African Journal of Aquatic Sciences, 17(1/2): 28-43.
Rowe-Rowe, D.T., and Lowry, P.B., 1982. Influence of fire on small-mammal populations in the Natal Drakensberg. South African Journal Wildlife Research, 12: 130-139.
Seaman, M.T., Pans of the Orange Free State. African Wildlife, 41(5): 237-238.
Silberbauer, M.J., and King, J.W., 1991. The distribution of Wetlands in the South-Western Cape Province, South Africa. Southern African Journal of Aquatic Sciences, 17(1/2): 65-81
Smithers, R.H.N., 1983. The Mammals of the Southern African Subregion. University of Pretoria: 1-736.
South Africa (Republic), 1983. Conservation of Agricultural Resources Act 43 of 1983. Pretoria, Government Printer.
South Africa (Republic). 1984. Forest Act 122 of 1984. Pretoria, Government Printer.
Taylor, R.H., 1991. The Greater St. Lucia Wetland Park. Published by Parke-Davis for the Natal Parks Board: 1-48.
Thibodeau, F.R., and Nickerson, N.H., 1985. Changes in a Wetland Plant Association Induced by Impoundment and Draining. Biological Conservation. 33: 269-279
Tinley, K.L., 1985. Coastal Dunes of South Africa. South African National Scientific Programmes report No. 109: 1-300
Walmsley, R.D., and Boomker, E.A., (eds) 1988. Inventory and Classification of Wetlands in South Africa. Proceedings of a Workshop. Occasional Report No.34. Ecosystem Programmes, Foundation for Research Development, C.S.I.R., Pretoria: 1-92
Wyatt, J., 1990. Indigenous afforestation of degraded watercourses. Natal Parks Board - Wildlife Management, Technical Guides for Farmers. No.24.
Zaloumis, E.A., 1987. Guest Editorial - Don't pull the plug! African Wildlife 41(5): 216-217.

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WETLAND-USE, A WETLAND MANAGEMENT DECISION SUPPORT SYSTEM FOR NATAL, SOUTH AFRICA, DESIGNED TO ACCOUNT FOR WETLAND FUNCTIONAL VALUES[1]

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ABSTRACT

Despite legislation directed at wetland conservation, up to 58% of the wetlands in certain Natal catchments have been lost due to wetland development and poor land use practices. WETLAND-USE, a wetland management decision support system, is currently being developed to rationalize management and land use allocation decisions within wetlands. The system attempts to ensure that appropriate information concerning the wetland and its surrounding landscape is collected and the likely impacts of different uses of the land are predicted. Three wetlands, Mgeni vlei, Ntabamhlope vlei and Wakkerstroom vlei, served as case studies for developing the model. Results gained from these wetlands, together with information derived from extensive literature reviews and consultation with various experts, was used to produce the prototype system. This paper describes the overall system, focusing particularly on the components dealing with burning of wetlands and the impact of these practices on wetland dependent species, such as Wattled Cranes and Grass Owls.

INTRODUCTION

Despite legislation directed at wetland conservation, up to 58% of the wetlands in certain of South Africa's major catchments have been lost, primarily due to agricultural development and poor land use practices (Begg 1988). Wetland use is presently planned from the restricted perspectives of individual users with specific interests (e.g., livestock grazing) and with little attention being given to the effects on wetland functional values, which benefit society at large. A decision support system (WETLAND-USE) is being developed in an attempt to ensure that wetland functional values are adequately accounted for when planning for the use of wetlands. Its primary aim is to assist in making tradeoffs between benefits derived by the individual and those derived by society at large. The study area chosen for developing the model is in Natal (Figure 1).

The aim of this paper is to present the system used for stratifying wetlands into management zones and describe selected sub-components of WETLAND-USE in order to demonstrate how the system operates.

THE CONCEPTUAL DESIGN OF THE MODEL

WETLAND-USE is a simple rule-based model with a conceptual design having three main components (Figure 2).

INFO-COLLECT prompts the user to collect and input the appropriate site and regional information, delineate the wetland zones, and input the proposed land use information.

LAND USE-ASSESS assists in selecting an appropriate land use alternative for a given wetland area by predicting the likely impacts of the proposed land use (e.g., pasture production) on the functional values for that area (e.g., flood attenuation).

LAND USE-RECOMMEND recommends how the wetland in question should be managed for the chosen land use. For example, if the chosen land use is stock production off a natural (undeveloped) wetland, then the model provides information concerning stocking rate and grazing systems.

Wetland management zones used by WETLAND-USE

In order to make informed wetland management decisions it is important to zone wetlands into homogeneous management units. Consequently, a system has been developed for categorizing the wetland zones in the study area (Figure 3).

[1]This paper was presented in part at INTECOL's IV International Wetlands Conference, October 1992.

Although dominant vegetation types provide a convenient means of stratifying wetlands into agro-ecological zones (Table 1), they cannot be relied on solely for the purposes of land use assessment. Ideally, long-term hydrological data should also be obtained, but these are lacking for South African wetlands. Consequently the best surrogate measure possible, soil morphology, is used, combined with additional observations of features such as drainage channels and flood lines. A provisional three class system for determining the degree of wetness of wetland soils using soil morphology has been developed (Table 2). Considering that the characterization of soils is the basis for land use planning and that the degree of wetness is the most important factor giving rise to local soil differences in wetlands, then the potential usefulness of this system can be appreciated.

A geomorphological classification of wetlands was included in WETLAND-USE because of the important influence geomorphology has on local surface and groundwater movement patterns (factors which have an important influence on the response of wetlands to management actions). The geomorphological classification system has two parameters: (1) landform setting, based partly on the system of Semenuik (1987) (Table 3); and (2) terrain type (e.g., crest, midslope, or valley bottom).

INFO-COLLECT (Information concerning the wetland site, wetland catchment, downstream service area, impact area, and proposed land use)

General questions are first posed by the three subcomponents: WETSITE-INFO, CATCHMENT-INFO, and DOWNSTREAM-INFO. These concern the entire wetland, its catchment, and potential downstream significance, respectively. More specific questions are then posed by IMPACTSITE-INFO concerning the impact site (that part of the wetland site to which the proposed land use will be applied).

Information requested by WETSITE-INFO and CATCHMENT-INFO includes, *inter alia*: wetland surface area, surface flow characteristics, wetland-dependent rare and endangered species, and current and past use of the wetland and its catchment. The purpose of DOWNSTREAM-INFO is to establish the current levels of benefit that would be derived if the wetland were effectively attenuating floods and purifying water. For example, if many people were dependent on potable water from the downstream area, the potential benefit would be very high.

IMPACTSITE-INFO requires additional information such as soil type and soil *n* value (the relationship between the percentage of water under field conditions and the percentages of inorganic clay and humus) (Soil Survey Staff 1990).

LAND USE-ASSESS (Predicted impact of the chosen land use)

In order to explain the model process, use is made of a single land use: planted pastures. This is dealt with by PASTURE-ASSESS (Figure 4).

PASTURE-ASSESS begins by determining what agro-ecological zone comprises the impact area. If it is open water or marsh the user is informed that pasture production is unacceptable because the hydrological and ecological impact is likely to be unacceptably high. If the zone is wet meadow then pasture production is considered acceptable provided that all the conditions specific to the zone are met (e.g., no rare or endangered species breeding in the impact area). If all of the conditions are met then the user is informed that the proposed land use is acceptable, otherwise the user is informed that the land use is unacceptable.

LAND USE-RECOMMEND (Management recommendations concerning the chosen land use)

In order to illustrate this component, recommendations concerning the burning of undeveloped wetlands used for stock grazing are described (Figure 5). The model begins by determining whether annual early winter burning is required by the manager because of the fire risk that the wetland poses. From an environmental impact point of view, burning at this time is not considered ideal. Thus, recommendations are made to minimize this impact. One of the species that appears to be most severely affected by this practice is the Grass Owl (*Tyto capensis*), an autumn to early winter breeder. Specific recommendations are made to account for this species.

If burning is required to enhance grazing potential or control alien plants then the recommendation is made that this be done every second year in early spring, as this is likely to have the least impact. However, it may result in the mortality of Wattled Crane (*Bugeranus carunculatus*) chicks or eggs, as the Wattled Crane is a winter to early spring breeder. Again, specific recommendations are made to minimize impact on this particular species. Finally, generally applicable recommendations are made, aimed at reducing the extent and intensity of fire. In essence, all these burning recommendations attempt to minimize the hydrological and ecological impacts, while at the same time maximizing the land user's benefit.

DISCUSSION AND CONCLUSIONS

WETLAND-USE is a prototype decision support model, designed to assist in allocating appropriate land uses to different wetland zones and to make ongoing management decisions for different land uses.

Criticisms of WETLAND-USE are that:

- the knowledge base which it uses has too many gaps to predict even highly coupled and immediate impacts on wetland values;
- it uses arbitrary cutoff points and qualitative reasoning;
- it fails to consider spatial and temporal cumulative effects;
- it is a gross oversimplification of the field situation;
- it applies to a limited geographical area.

While all these criticisms are valid, wetland management decisions are presently being made with little or no consideration for loss of wetland functional values. Any improvement, therefore, will be beneficial. Optimal use needs to be made of the best currently available information, even if this is only qualitative and arbitrary cutoffs are chosen. The structure of the model is open and can be refined at a later date by incorporating more detailed information, as it becomes available, and/or supplementing the model with new components.

The primary user groups of the model will be extension personnel with general biological or agricultural training, but lacking specialized wetland expertise and without the time to collect detailed data. Thus, the model needs to be simple.

One of the biggest pitfalls in decision support model building is choosing a problem that is too broad to handle adequately (Waterman 1986). The problem of wetland management is extremely broad. Consequently, it calls for a narrowing of the model's focus. This has been done by:

- restricting the geographical area over which the model is valid;
- limiting the land uses considered to those which are most common in the study area;
- limiting the hydrological and ecological values considered.

In South Africa, and in many other countries for that matter, there is growing dissatisfaction among resource managers concerning the contribution that research is making toward the enhancement of resource management. Thus, with the objective of identifying the key management issues and characterizing the decision-making process in wetlands, resource managers and extension personnel have been involved in the development of WETLAND-USE. In characterizing the decision-making process and synthesizing current knowledge, it is hoped that WETLAND-USE will not only contribute towards improving the current management of wetlands but will also assist in identifying the most important wetland management assumptions and information needs. This will then assist in designing research programs that satisfactorily enhance resource management.

ACKNOWLEDGMENTS

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REFERENCES CITED

Acocks, J. P. 1953. Veld types of South Africa. Memoirs of the botanical survey of South Africa 28: 1-128.

Begg, G. W. 1988. Wetlands of Natal (part 2): An overview of their extent, role and present status. Natal Town and Regional Planning Commission report 71.

Breen, C. M. and G. W. Begg. 1989. Conservation status of southern African wetlands. Pages 254-263 *in* B. J. Huntley, ed., Biotic diversity in southern Africa: concepts of conservation. Oxford University Press, Cape Town, South Africa.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. Laroc. 1979. Classification of wetlands and deepwater habitats of the United States. FWS/OBS-79/31. United States Fish and Wildlife Service, Biological Services Program, Washington, D. C., USA.

Phillips, J. 1973. The agricultural and related development of the Tugela Basin and its influent surrounds. Natal Town and Regional Planning Commission Report, Vol. 19.

Soil Classification Working Group. 1991. Soil classification: a taxonomic system for South Africa. Memoirs on the Agricultural Natural Resources of South Africa No. 15. SIRI, D.A.T.S., Pretoria, South Africa.

Soil Survey Staff. 1990. Keys to soil taxonomy, 4th ed. SMSS technical monograph no. 6. Blacksburg, Virginia, USA.

Semenuik, C. A. 1987. Wetlands of the Darling System:

A geomorphic approach to habitat classification. Journal of the Royal Society of Western Australia 69(3): 95-112.

Waterman, D. A. 1986. A guide to expert systems. Adison-Wesley, Menlo Park, California, USA.

Wetland Training Institute. 1989. Field guide for delineating wetlands: unified federal method. Wetland Training Institute, Tacoma, Washington, USA.

Table 1. Agro-ecological zones used by WETLAND-USE for land use planning.

The open water zone is characterized by the absence of tall emergent plants, and is permanently or semi-permanently flooded. It consists of two dominance types: vegetated open water and non-vegetated open water. In vegetated open water, plants that grow principally on or below the surface of the water cover more than 30% of the substrate. In non-vegetated open water, vegetation covers less than 30% of the substrate. From a land use point of view it is not necessary to distinguish between these two dominance types.

The marsh zone is dominated by tall (usually > 1 m) emergent herbaceous vegetation. It includes four dominance types, reed marsh dominated by *Phragmites australis*, *Carex* marsh, *Typha* marsh, and mixed sedge marsh dominated by sedges (e.g., *Cyperus* spp.), rushes (*Juncus*), and/or hydrophytic grasses (e.g., *Leersia hexandra*). Some marsh areas are seasonally wet but most are permanently or semi-permanently wet.

The wet meadow zone is dominated by short (usually < 1 m) hydrophytic sedges and grasses restricted to temporarily or seasonally wet areas. It includes two vegetation dominance types, hummocked sedge meadow which is characterized by hummocks (vegetation-covered earth hummocks over 20 cm high and 50 cm in diameter) and non-hummocked sedge meadow. Most sedge meadow areas are seasonally wet.

The wet grassland zone supports a mixture of hydrophytic plants found in the wet meadow zone and dryland species and is usually temporarily wet. It comprises a single vegetation dominance type, wet grassland.

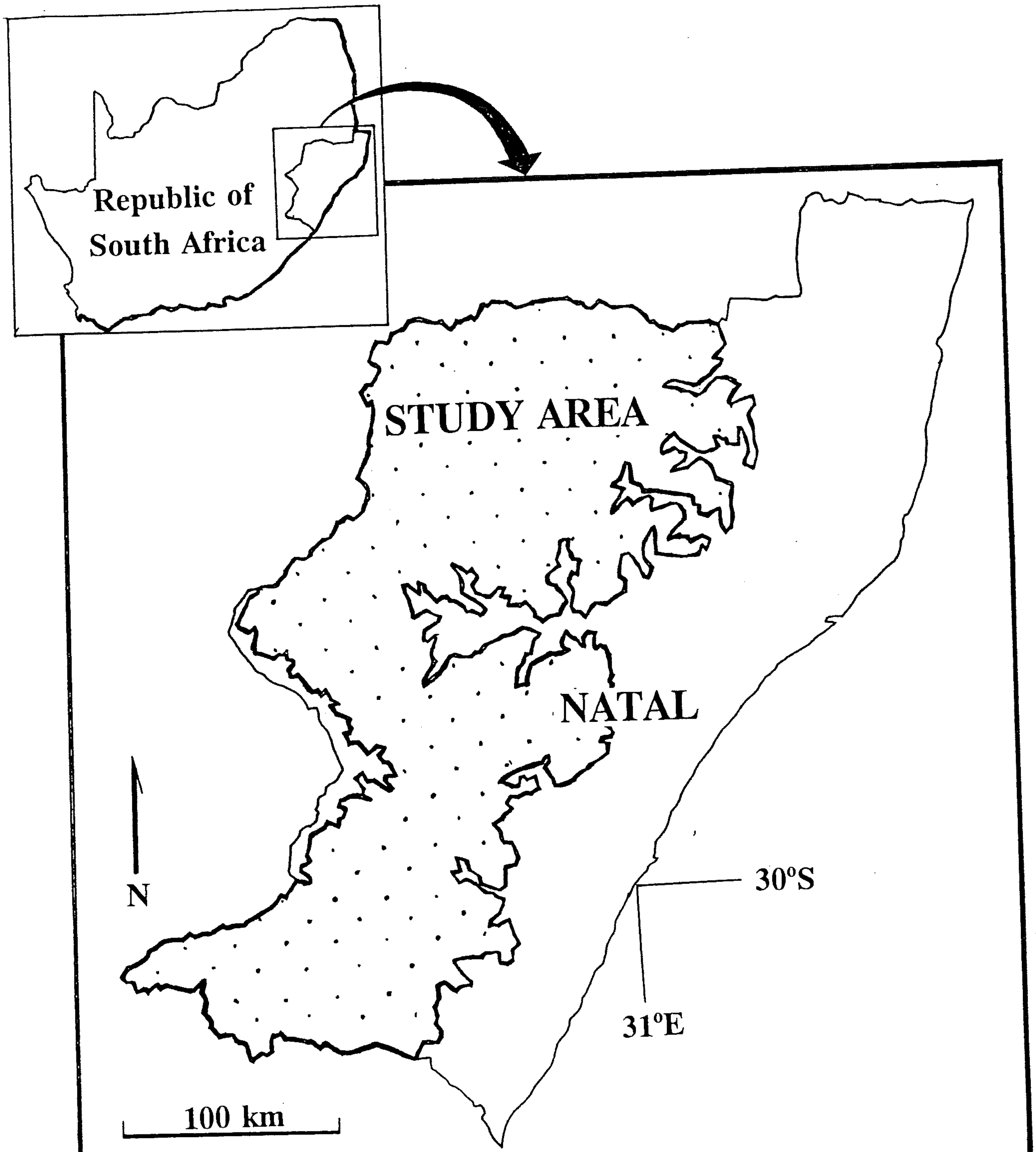


Figure 1. Study area location.

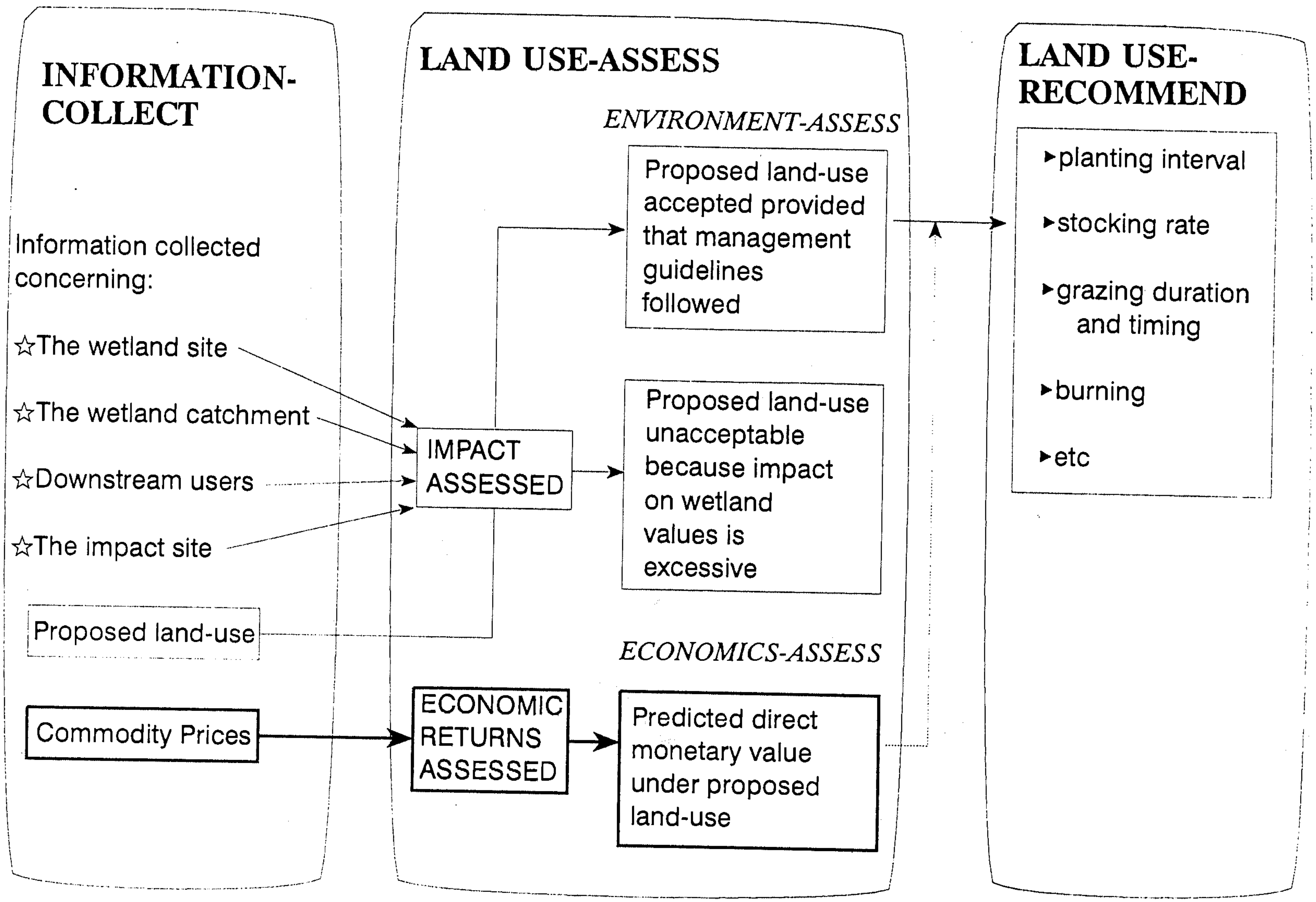


Figure 2. The conceptual design of the model.

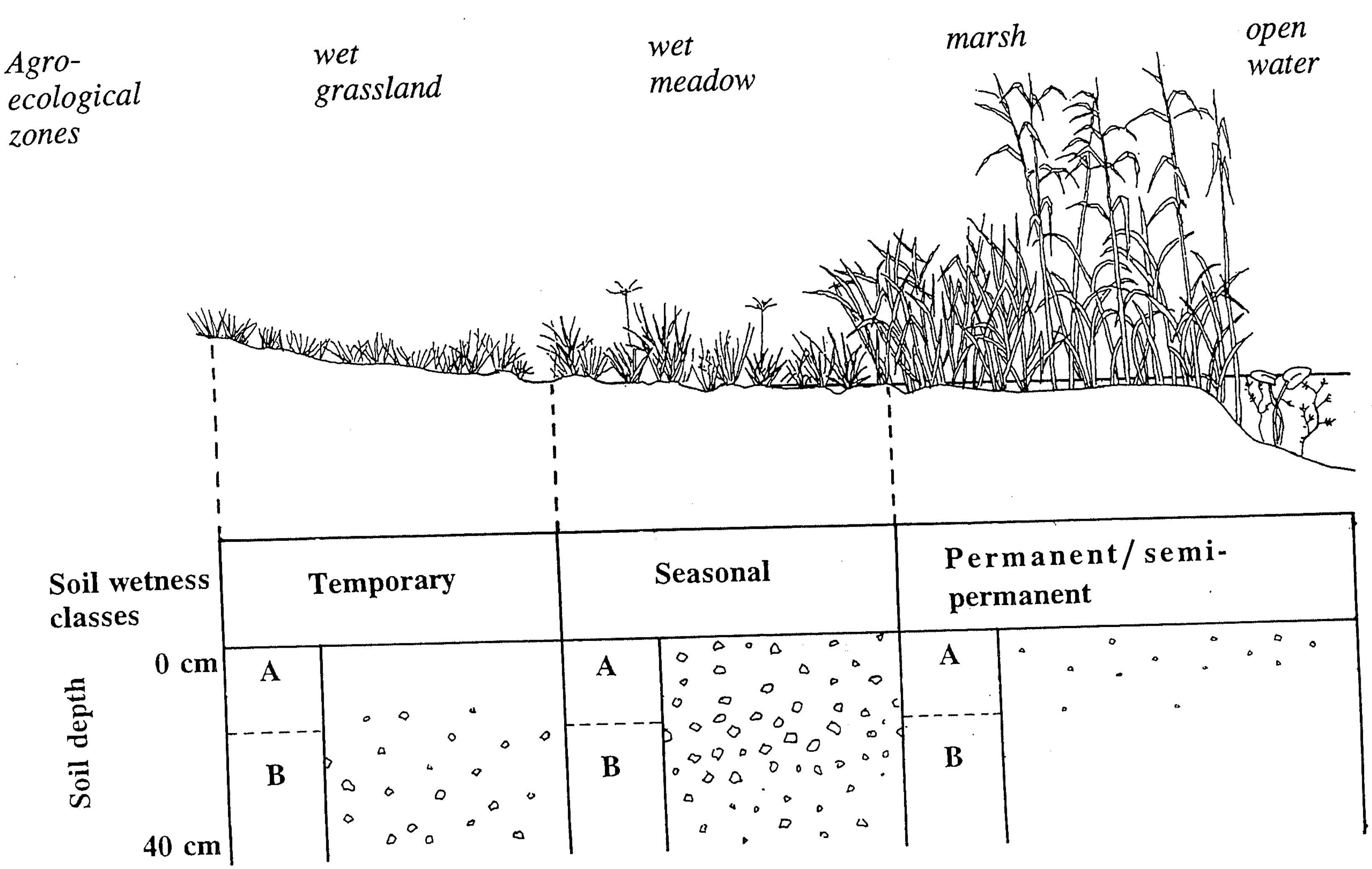


Figure 3. The agro-ecological zones and soil wetness classes used by WETLAND-USE.

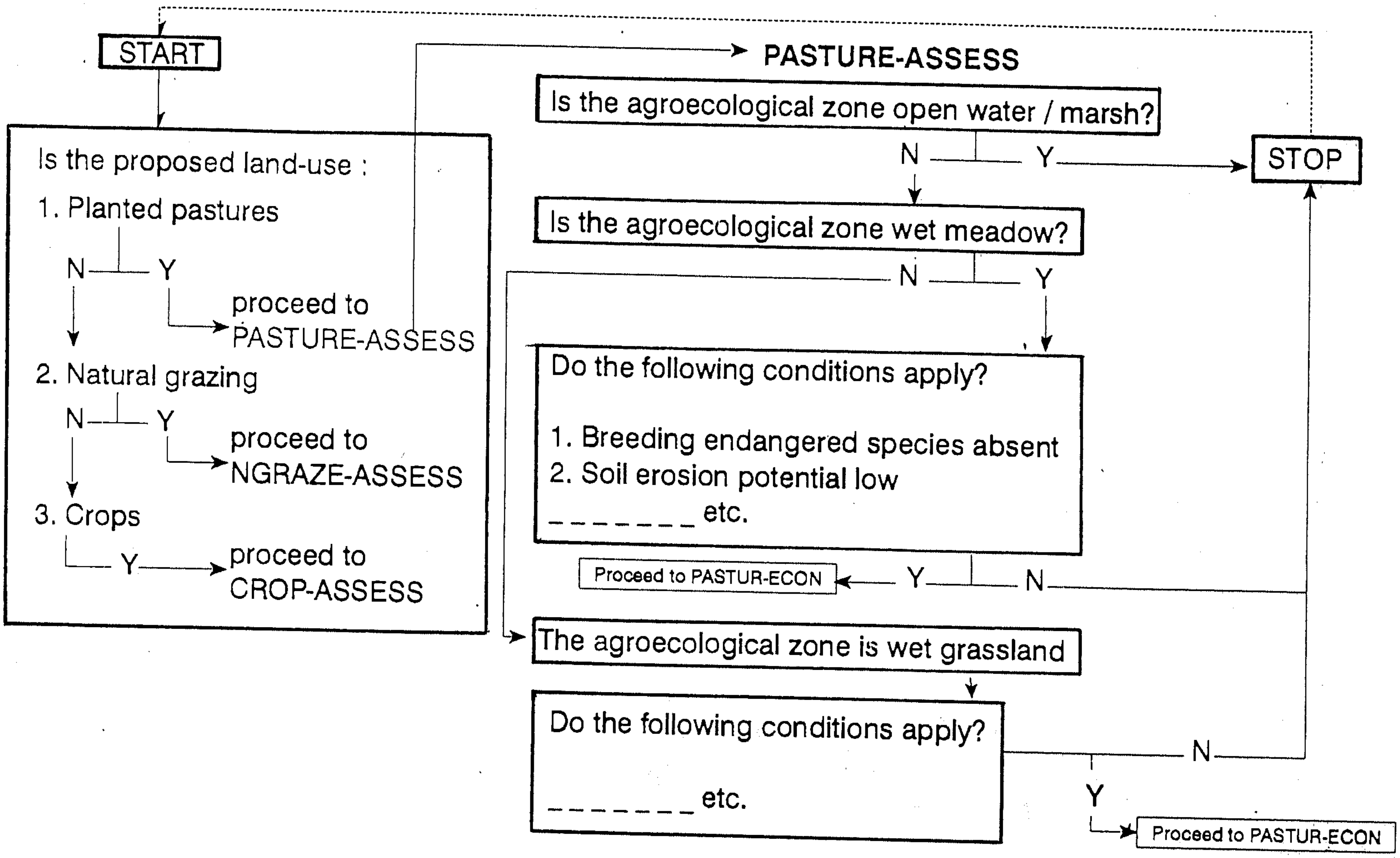


Figure 4. An algorithm illustrating the interrogation process of WETLAND-USE.

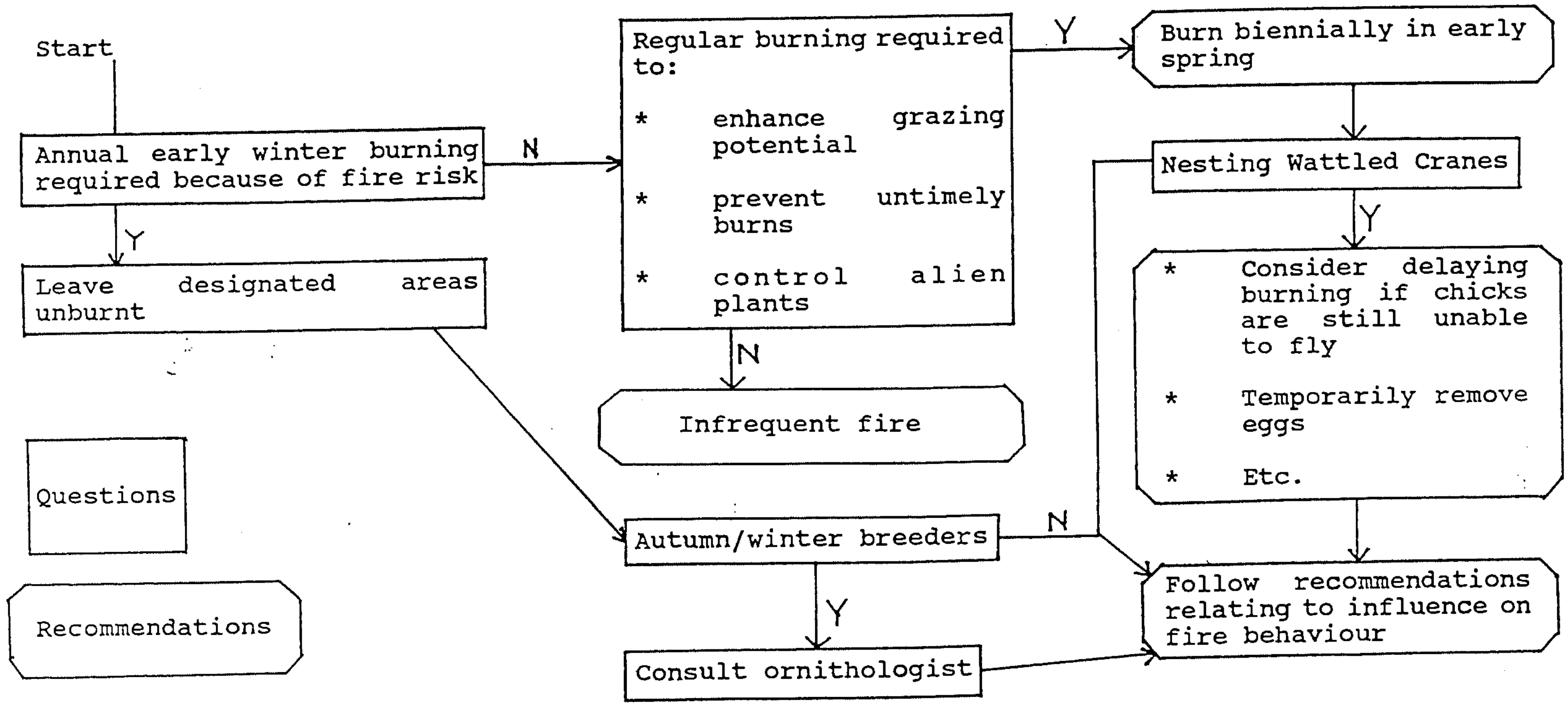


Figure 5. An algorithm illustrating wetland burning frequency and timing recommendations given by WETLAND-USE.

Table 2: A provisional three class system for determining the degree of wetness of wetland soils based on soil morphology. Wetland plant classes from Wetland Training Institute (1989).

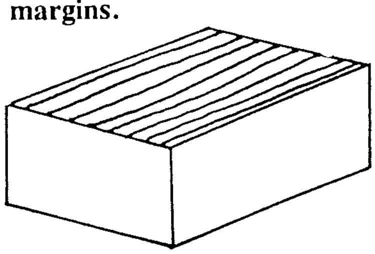
Parameter	Temporary	Degree of wetness Seasonal	Permanent/Semi-permanent
Soil depth 0-10 cm	Matrix chroma: 1-3 Few/no mottles Few roots Nonsulphidic*	Matrix chroma: 0-2 Many mottles Many roots Seldom sulphidic*	Matrix chroma: 0-1 Few/no mottles Many roots Often sulphidic*
Soil depth 30-40 cm	Matrix chroma: 0-2 Few/many mottles	Matrix chroma: 0-2 Many mottles	Matrix chroma: 0-1 No/few mottles
Vegetation class+	Predominantly FACW, FAC, and FACN grass species	Predominantly FACW and OBL sedges and grasses	Predominantly OBL reeds, sedges, and/or bulrushes

* Sulphidic soil material has sulphides present which give it a characteristic "rotten egg smell"

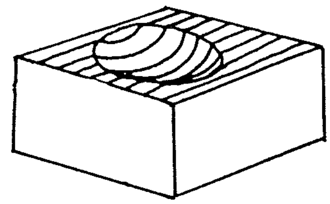
+ Obligate wetland plants (OBL) occur almost always (estimated probability > 99%) in wetlands under natural conditions; Facultative wetland plants (FACW) usually occur in wetlands (estimated probability 67-99%), but occasionally are found in non-wetlands; Facultative plants (FAC) are equally likely to occur in wetlands or non-wetlands (estimated probability 34-66%); Facultative non-wetland plants (FACN) usually occur in non-wetlands (estimated probability 67-99%), but occasionally are found in non-wetlands

Table 3: Primary and commonly occurring secondary landform settings.

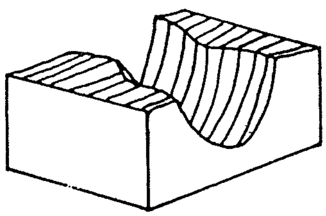
Flats have a slope of <2%,little or no relief and diffuse margins.



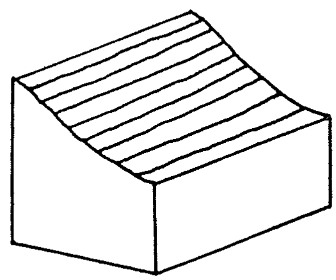
Depressions are depressed basin-shaped areas in the landscape with no external drainage. Depressions may be shallow or deep and may have flat or concave bottoms. They usually do not have clearly defined margins.



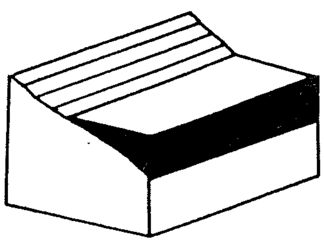
Channels refer to any incised water course. Channels may be shallow or deep but always have clearly defined margins.



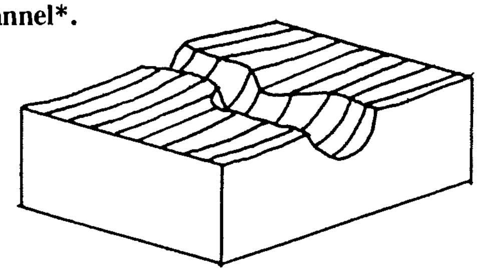
Slopes are areas with a gradient of greater than 2 %, which may be concave or convex.



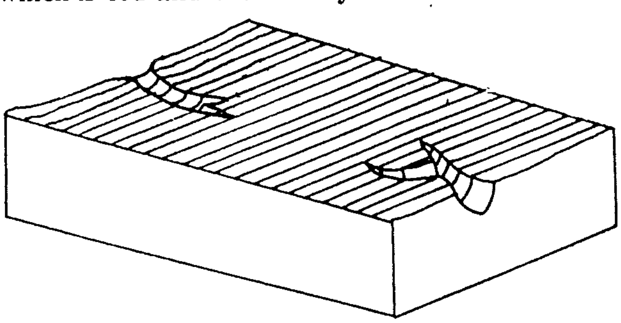
Fringes refer to areas on the edges of open water, such as that provided by lakes or dams.



Channelled flats comprise a flat incised by a channel*.



Channel-disrupting flats comprise a flat which is fed and drained by a channel*.



* Secondary landform settings

INTEGRATED RESERVE MANAGEMENT AT THE VERLOREN VALLEI NATURE RESERVE, EASTERN TRANSVAAL, SOUTH AFRICA

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ABSTRACT

The Verloren Vallei Nature Reserve, on the Steenkampsberg, was acquired in 1983, with the conservation of grassland and Wattled Cranes (*Bugeranus carunculatus*) as the major priorities. The reserve is regarded as a conservation nucleus for the surrounding plateau. Wattled Cranes are wary, and desert their nests for the duration of human disturbance. The average daily minimum temperatures are low, and disturbances of more than two hours might terminate breeding attempts. Grazing by domestic stock at low stocking rates was allowed, and a controlled burning program with biannual burns was implemented. The general veld condition improved, and species requiring taller grass conditions increased in numbers. In future point ignitions will be used when blocks are burned, and the low stocking rates will be maintained. The crane numbers on the reserve reflected the overall pattern for Transvaal, which decreased since 1983. Several cases of poisoning of cranes were reported. In some cases cranes were deliberately poisoned, but accidental poisonings also occurred. Feeding areas will be established on the reserve and other suitable areas in an effort to attract cranes to the reserve during the critical period in spring. In a special effort to increase the general awareness of the public towards cranes, the farmers and schools in the area will be informed about conservation.

INTRODUCTION

The Verloren Vallei Nature Reserve is situated about 40 km north of Dullstroom on the Steenkampsberg, and covers an area of 5,891 hectares. The reserve is regarded as a conservation nucleus for the surrounding area. The Steenkampsberg is an elevated plateau-like region of about 50 by 20 kilometers in extent, at an altitude of between 1,850 and 2,300 m. The low dip of geological strata, the high annual rainfall and poor surface drainage has resulted in the formation of numerous permanently wet marshy areas or sponges ranging from between 2 and 293 hectares in size. These wetlands are ecologically and hydrologically very important in the catchment areas of the Crocodile and Steelpoort Rivers.

The plateau, lying only two degrees south of the Tropic of the Capricorn, experiences a subalpine climate. The area has very cold winters and mild summers that can be wet and misty.

The climate on the plateau, combined with an annual rainfall of 820 mm, produces an abundant and varied number of flowering plants. In an independent study by Bloem (1988) a total of 453 plant species were identified on the reserve, of which at least 18 were regarded as threatened. Botanists are of the opinion that many new plant species could still occur in the area.

Thirteen bird species which occur on the plateau are endemic to southern Africa. Ten threatened bird species occur on the plateau. These are:

- Bald Ibis (*Geronticus calvus*)
- Stanley's Bustard (*Neotis denhami*)
- Wattled Crane (*Bugeranus carunculatus*)
- Grey Crowned Crane (*Balearica regulorum*)
- Blue Crane (*Anthropoides paradiseus*)
- Cape Vulture (*Gyps coprotheres*)
- Yellowbreasted Pipit (*Anthus chloris*)
- Grass Owl (*Tyto capensis*)
- Rudd's Lark (*Heteromirafra ruddi*)
- African Marsh Harrier (*Circus ranivorus*)

The following five threatened mammal species also occur on the plateau:

- Rough-haired golden mole (*Chrysopalex villosus rufus*)
- African wild cat (*Felis lybica*)
- Antbear (*Orycteropus afer*)
- Oribi (*Ourebia ourebi*)
- Aardwolf (*Proteles cristatus*)

CRANES ON THE STEENKAMPSBERG

This area is unique as three crane species occur and nest side by side (Tarboton 1984b). These crane species are Wattled Crane, nesting in open wetlands; Grey Crowned Crane, nesting in screened wetlands; and Blue Crane, nesting in wetlands or grassveld.

The Wattled Crane population on this plateau occurs at least 600 km from the next most southerly occurrence of the species, which is in Botswana and Zimbabwe. The climatic conditions on this plateau differ greatly from the areas to the north, with average temperatures being at least 7° C lower (Table 1).

Wattled Cranes are very wary and the mere presence of humans in the vicinity of nesting sites is enough to cause desertion of the nest for the duration of the disturbance. The vegetation around the nest sites offers little screening and nest desertions have been observed with human presence at distances of between 400 and 1,000 meters from nest sites. These cranes have no fixed breeding season, and they nest at any time of the year (Tarboton, Barnes, and Johnson 1987), even in the coldest months when average temperatures are near freezing. A disturbance of more than one to two hours during a 42-day nesting period in winter is enough to terminate a breeding attempt (Batchelor 1984a). Indirect human disturbance has made many potentially attractive breeding sites unsuitable for Wattled Cranes (Tarboton 1984a).

RECENT LAND USE AND CONSERVATION PROBLEMS IN THE AREA

Climatic conditions on the Steenkampsberg largely determine the type of farming, which primarily consists of cattle and sheep farming. The pasture is considered to be "sour", meaning that the grass in its mature state is unpalatable. New growth after burning is rapid, however, and recently burned veld is considered to be excellent for sheep during the summer months. As soon as the green flush appears after the spring burns sheep are moved onto the plateau, and are kept there until late autumn when no regrowth occurs. It often happens that an area is burned two or three times in a year. There is no doubt that the viability and quality of the grassland deteriorate from this practice. The frequent use of fires and the subsequent overgrazing of the veld cause an increase in surface runoff, with less moisture being absorbed by the soil. This is accompanied by an increase in soil erosion and a lowering of the water table, causing wetland areas to decrease in size.

In an attempt to produce some winter feed during the summer months, lands are prepared and planted on some farms. Several cases have been observed where wetlands were drained to establish these lands, causing permanent damage to those wetlands.

Much of the eastern escarpment of the Transvaal is ideally suited for commercial timber production. Fortunately the Steenkampsberg is considered marginal for forestry purposes on account of generally shallow and leached soils. Nevertheless many plantations have been established, and many examples of plantations encroaching on wetlands can be seen on the plateau. These plantations also change the highly variable and species-rich grassveld vegetation into an alien species monoculture. Plantations have a marked effect on soil/moisture relationships, tending to dry out the soil and lower the water table.

The cool summer climate and high rainfall on the Steenkampsberg, combined with cold winters and favorable topography make the area most suitable for trout angling. Since most streams are too small to support viable populations of this sought-after alien fish, many have been impounded and the trend is accelerating. Unfortunately, many wetlands are potential dam sites, and may be flooded as water accumulates behind dam walls. The remaining nest sites might be rendered unsuitable by visits of anglers to the trout dams.

Like the Wattled Cranes, Stanley's Bustards are very wary and the presence of a human in the vicinity (even at distances of 400-1,000 m) is enough to cause nest desertion. Prolonged periods of disturbance may terminate the breeding attempts.

Cranes eat a wide range of foods, including insects, frogs, grass seed, grain, bulbs, and corms. The Wattled Crane is the most aquatic of the three crane species and spends most of its foraging time on the edges of wetlands (Tarboton 1984a). Blue Cranes often feed on dry land and at certain times of the year large flocks may become a nuisance to crop farmers. Blue Cranes are sometimes also joined by Grey Crowned Cranes and Wattled Cranes. The critical time is a period of two to three weeks in spring when maize plants, just emerging from the ground, are exploited. Deliberate efforts to poison Blue Cranes sometimes also affect the other crane species. Accidental poisoning occurs when cranes ingest seeds treated with pesticides to control other pests.

ESTABLISHMENT OF THE VERLOREN VALLEI NATURE RESERVE

The grassveld biome was not well conserved in South Africa. Most of the species in this biome that are considered to be threatened are in this position because of loss of habitat. During 1980, the plateau was identified as an ideal place to establish a grassveld biome nature reserve. Compared to other grassveld areas, the Steenkampsberg plateau was considered to be the least disturbed area as no major sections were developed or changed into agricultural lands or plantations.

Initially the landowners showed some opposition to the expropriation of their land. In meetings between what was then TPA Nature Conservation, the Department of Agriculture, and the local farmers a compromise was reached under which no farmer would be forced to sell his farm; and grazing would be permitted on the reserve as long as it did not conflict with the primary conservation goals.

All the landowners of the proposed nature reserve area voluntarily sold their farms and the Verloren Vallei Nature Reserve, established in 1983, is currently regarded as an ecologically important reserve.

GOALS OF VERLOREN VALLEI NATURE RESERVE

As already stated, the Verloren Vallei Nature Reserve is regarded as a conservation nucleus for species in the plateau system. The following goals were identified in 1985.

1. Promote conservation of threatened avifauna (principally Wattled Cranes).

2. Conserve unique habitats within the reserve (wetlands, quartzite and dolemite outcrops).

3. Promote conservation of wetlands on the greater plateau.

4. Promote conservation of a representative example of the North-Eastern Sandy Highveld Veldtype (Acocks 1953).

5. Promote conservation of threatened and localized plant species on the reserve.

6. Promote conservation of threatened animal species on the reserve.

7. Promote environmental awareness through low key nature-oriented outdoor recreation.

8. Undertake and promote management-oriented research.

MANAGEMENT OF THE VERLOREN VALLEI NATURE RESERVE

Grassland management

Indigenous grass species were established on the few lands that existed on the reserve. The plantations of alien species that existed on the reserve were systematically removed.

Burning regime

Since fires are part of the ecosystem on the plateau, a burning program was developed to simulate the effect of the natural fires. The burning program on the reserve involved the division of the reserve into burning blocks that were burned every second to third year during spring. Burning blocks must comply with certain conditions (e.g., good grass species composition and sufficient fuel load). The burning blocks were separated with firebreaks in order to facilitate control of fires on the reserve.

Grazing regime

The internal fences that existed were removed to allow free movement of game on the reserve. Since the establishment of the reserve the initial low numbers of most game species steadily increased. Between 1983 and 1986 cattle and sheep were allowed to graze at moderate stocking rates on the burned blocks during the summer months. During 1986 it was decided that the highly selective grazing of sheep was in conflict with the conservation goals, and since 1987 only cattle have been allowed to graze on the reserve with the game species.

Wetland management

No specific management strategies have been formulated for the wetland areas on the reserve.

Monitoring

Some plant, bird, and mammal species are regularly monitored. The numbers of cranes on the reserve reflect the overall pattern for cranes in the Eastern Transvaal, i.e., a declining population since 1983.

Since the sheep were removed from the reserve, the general veld condition has improved and the numbers of birds and mammals that require taller grass conditions (Yellowbreasted Pipit and oribi, in particular) have increased significantly.

Contact with surrounding communities

As the human presence can cause disturbance at nesting sites of high priority species, the reserve has not been open to the public. The few attempts to promote conservation on the plateau were not well received by the community there. Although all the landowners voluntarily sold their land prior to the proclamation of the reserve, the members of the community still bear some resentment towards Nature Conservation.

PROPOSED FUTURE MANAGEMENT OF THE VERLOREN VALLEI NATURE RESERVE

Grassland management

The removal of alien plantation species and other exotic plant species will continue.

Burning regime

The current burning program, with a biannual burn for those blocks that fulfill all the burn conditions will be maintained, as the veld constantly improved under this regime. In the future these blocks will not be ignited on one front; rather, point ignition will be used to simulate the natural fires more accurately.

Grazing regime

The numbers of the game species will be allowed to increase. As the three major game species are selective tallgrass grazers, the chances of over-utilization of the available grazing is slim. However, it will be closely monitored to guard against over-utilization. Cattle will be allowed to graze on the reserve at controlled moderate stocking rates. It is hoped that this will work towards improving the relations between Nature Conservation and the surrounding farmers. The smaller wetlands that show signs of trampling by cattle will be temporarily fenced with an electric fence.

Wetland management

Proper wetland management and monitoring actions will be implemented on the reserve and surrounding areas as more information becomes available.

Crane management

The cranes on the reserve, and where possible outside the reserve, will be monitored on a regular basis.

Crane poisoning

In an attempt to reduce the numbers of cranes that are poisoned during the critical three weeks in spring, feeding areas will be established on the reserve and on other suitable properties where grain will be supplied. We hope that these feeding areas will draw the birds away from the agricultural lands. If the feeding areas prove to be successful, indigenous natural crane feeds will gradually be introduced to try to replace the grain.

Crane rehabilitation

The need for the establishment of a crane rehabilitation area on the reserve will be investigated. Injured cranes or those hand reared in zoos and in other enclosed areas will be rehabilitated here, with the aim to release them into their natural habitat.

Monitoring

The threatened plant, bird, and mammal species will continue to be monitored. Where possible these actions will be expanded to the greater plateau as well. The effects of the grassland management practices will also be monitored. The use of grassland condition assessment techniques using species composition and grass fuel load determination is proposed.

Contact with the community

As the reserve is regarded as the nucleus for conservation on the plateau, the general cooperation of the public on the plateau must be improved. Through cooperation with other conservation organizations, actions will be launched to make contact with the general public where conservation issues will be discussed with them. In this way, the public's understanding of the conservation issues in their area may be improved; at the same time, more support for conservation in the area will be generated. These actions will involve contact with landowners, farmers associations, schools, clubs, etc. Visits to the reserve will still be controlled, and "open days" will be encouraged.

REFERENCES CITED

Acocks, J. P. H. 1953. Veld types of South Africa. Memoirs of the Botanical Survey of South Africa 28: 1-192.

Bloem, K. J. 1988. Plantsosiologiese studie van die Verlorenvalei-natuurreservaat, Transvaal. Unpubl. M.S. Thesis. University of Pretoria, South Africa.

Batchelor, G. 1984. Current land use and conservation problems. Fauna & Flora 41: 28-32.

Tarboton, W. R. 1984a. The status and conservation of the Wattled Crane in the Transvaal. Pages 665-678 *in* J. A. Ledger, ed., Proceedings of the Fifth Pan-African Ornithological Congress. Southern African Ornithological Society, Johannesburg, South Africa.

Tarboton, W. R. 1984b. Cranes on the Berg. Fauna & Flora 41: 17-19.

Tarboton, W. R., P. R. Barnes, and D. N. Johnson. 1987. The Wattled Crane in South Africa during 1978-1982. Pages 353-361 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Table 1. Comparison of temperatures between Maun, Botswana and the Steenkampsberg Plateau, South Africa (Belfast).

Month	Mean Daily Temperature (°C)		Mean Daily Minimum Temperature (°C)	
	Maun	Belfast	Maun	Belfast
January	25.5	17.4	18.9	11.9
February	25.3	17.3	18.7	11.8
March	24.2	16.1	17.5	10.1
April	22.5	13.6	14.1	7.5
May	18.7	11.0	9.6	4.1
June	15.3	8.1	5.7	1.1
July	15.3	8.5	5.6	1.4
August	18.5	10.7	8.6	3.2
September	22.8	13.7	13.0	6.2
October	26.3	15.1	17.6	8.3
November	26.5	15.8	18.9	10.0
December	25.7	16.8	18.9	11.2
Average	22.2	13.7	13.9	7.2

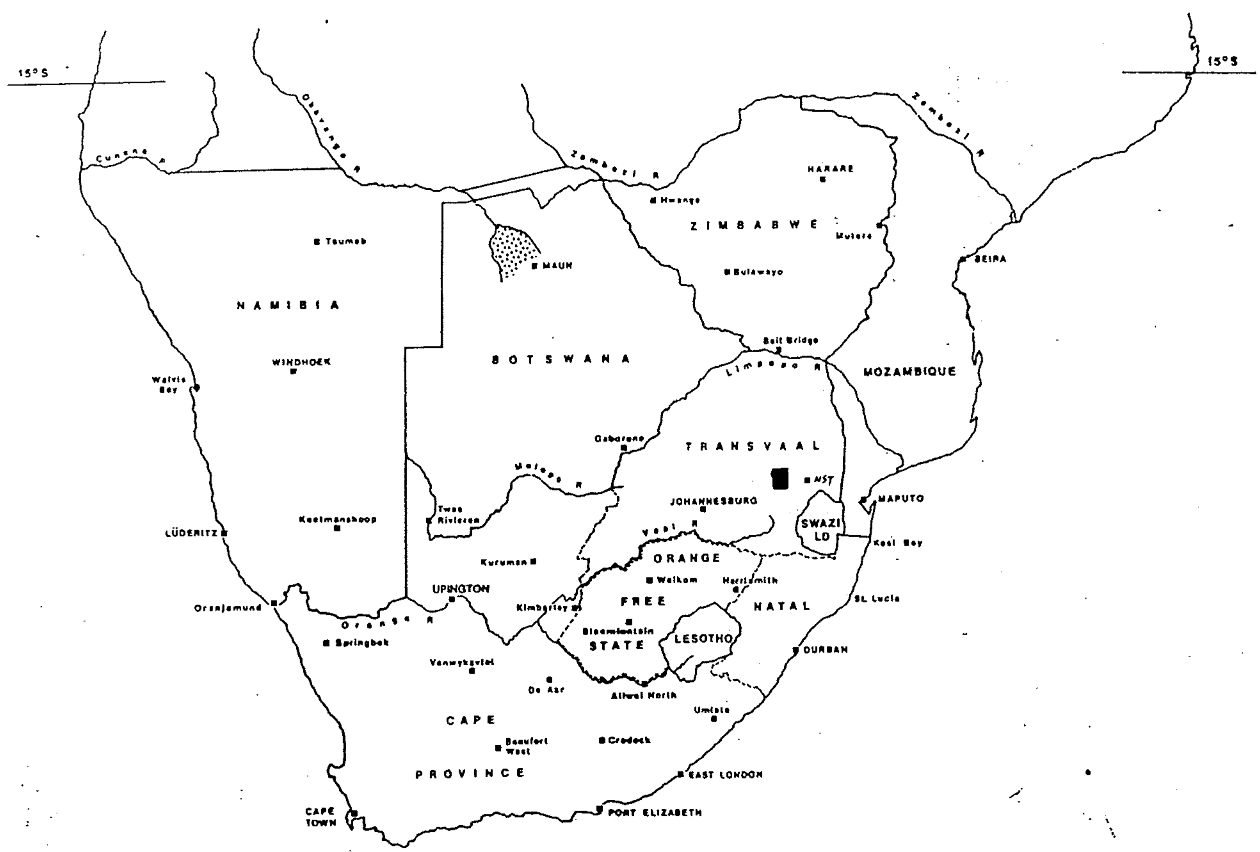

Figure 1. Steenkampsberg plateau (■) in South Africa.

THE CHALLENGE OF CONSERVING WAKKERSTROOM WETLAND

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INTRODUCTION

Wakkerstroom is a very small town in the Eastern Transvaal Province of South Africa, lying between Volksrust and Piet Retief, and 280 km south-east of Johannesburg. The Wakkerstroom district is a major mountain catchment area as three large rivers have their sources here and it receives between 800-1,200 mm of rain per annum. It is mountain sour-grassland, lying at an altitude between 1,600-2,250 m above sea-level. The site chosen to become the town of Wakkerstroom 150 years ago was totally dictated by the magnificent wetland, so much so that from the town's founding to the present day the wetland in its entirety has lain within the municipal boundaries. The main body of the wetland is some 500 ha. in extent and 9 km long, and with the surrounding land that has been included, the Wetland Reserve and Crane Sanctuary is 650 ha. (Figure 1). This makes it the largest protected wetland its kind in the Eastern Transvaal. It provides breeding habitat for at least 13 pairs of Grey Crowned Cranes and supports many other wetland bird species. If managed effectively the wetland could offer habitat for many rare or endemic plant species. The wetland belongs to the Town Council and for 150 years it was used as a commonage for grazing (mainly cattle). The wetland was severely overgrazed and burned annually in its entirety, with a resultant lack of mosaic in the habitat.

Time has passed the village by. Wakkerstroom has a population of a couple hundred whites, a few Indians (traders), and about 4,000 blacks. The black community, Zulu, displays high social discipline. There is a great lack of awareness among all sections of the population regarding the environment. There is poaching as a result of economic factors. The farming community is mostly old (third generation) land-owning Afrikaans- and English-speaking families. The area is relatively pristine, a fact that can be attributed to cattle and sheep farming being the main agricultural activity. There is no industry and no pollution, and a low population density.

The farmers are reasonably successful financially, but are subject to ever-increasing pressures on the economic viability of agriculture. This could result in altered land use such as overgrazing, tilling more land for crops, afforestation, etc.

As this is sourveld and really only suitable for summer grazing, annual burns are perceived by the farmers as necessary management of the grasslands in the catchment.

Some 14 endangered and/or endemic bird species are associated with the area, including three species of cranes.

There is an ever present threat of afforestation, of irresponsible mining of the large underlying coal deposits, and other activities that either have destroyed or threaten far too many of our wetlands and mountain catchment areas. A new political dispensation may introduce a land policy that would increase the population density to unsustainable levels or drastically alter the present agricultural usage of the catchment.

THE WAKKERSTROOM NATURAL HERITAGE ASSOCIATION

Recognizing the uniqueness of the area and the fact that responsibility for the area rests with local people, a group of residents formed a conservation association, known as the Wakkerstroom Natural Heritage Association (WNHA). The WNHA has the objective of "identifying, conserving, utilizing, and enjoying the sites of natural heritage in the Wakkerstroom district".

WHY NOT ONLY CRANES AND WETLANDS?

The reasons for the WNHA not focusing its objectives only on wetlands and cranes, although these had been the origin of concern, include the following.

1. The realization that the future of the wetland was as much, if not more, dependent on the sound management of the catchment as on management of the wetland alone.

2. The fact that the district is home to three crane species (Blue *Anthropoides paradiseus*, Grey Crowned *Balearica regulorum*, and Wattled *Bugeranus carunculatus*) with many other wetlands in the area, while Wakkerstroom Wetland houses only Grey Crowned Cranes.

3. The importance of grasslands as habitat for all three crane species, and thus the need to include conservation of grasslands as part of the objectives. Utilizing the Natural Heritage Site Program of the Department of Environment Affairs seemed the logical way to address the situation.

4. The fact that the economics of the town dictated a plan of action that would also inject some vigor into the economy through ecotourism.

5. The fact that action on a broader front, though progress

may seem slower, would be more valid and sustainable as all conservation and socioeconomic issues are taken into consideration in an integrated and coordinated plan.

SCIENTIFIC RESEARCH

Soon after the WNHA began its drive to have the wetland declared a reserve, they realized that it was not going to be an easy or simple task. The greatest need--for research and establishment of norms--was brought home very sharply when a problem with coal loading at the Wakkerstroom Station developed. Not having any norms made it more difficult to allocate blame. It was also very clear that before the WNHA understood the present "management policy" and functioning of the wetland it could make no informed decisions about what, if any, changes had to be brought about, and why. Any changes have to be soundly motivated if it is to succeed in persuading the community to support the venture. After all, a number of community members could be adversely affected by the loss of land or cattle grazing rights. As the WNHA firmly hold the view that no sustainable conservation can be achieved without including the human element in the equation, it also has to accommodate our community's reasonable needs and perceived rights to the wetland. This includes cattle grazing (and the fire policy dictated by this need), the gathering of dung, reeds, and other materials, and finding an answer to the socio-economic situation giving rise to poaching.

Gaining a mentor/advisor in the person of Dr. Warwick Tarboton (specialist scientist and chief ornithologist of the Directorate of Nature Conservation, Transvaal Provincial Administration), now president of the WNHA, was the key to any successes the WNHA have had. I know that if it were not for the clear and very patient guidance that the Association received from Dr. Tarboton it would definitely have failed, not because it lacked commitment or enthusiasm or hard work, but because it lacked wisdom and insight. The end objective must always be clear in one's mind and the end objective MUST be sustainable.

The WNHA also consulted the Wetlands Awareness Campaign in the person of Jon Wyatt who was instrumental in involving the Institute of Natural Resources and the Grassland Sciences Department of the University of Natal in the person of Don Kotze (MSc student).

The combined research of these three people formed the basis of the management plan for the Wakkerstroom wetland which was identified as the first project to be undertaken.

WETLAND RESERVE AND CRANE SANCTUARY

The WNHA succeeded in gaining a 10 year lease of the wetland from the town council. The objectives in taking on such a large financial responsibility as the lease of the wetland from the council was to attain management control in order to address the problems facing the wetland. Of these problems, the historical grazing and fire policy was the main issue which motivated the Association's concern and which had to be addressed first. The research and three independent scientific surveys all indicated that the grazing pressure was far too high and no proper grazing policy had been followed in the past. Annual burns of the total wetland area were also considered to be highly irresponsible.

The council had previously had an annual income of some R 1,300 per annum out of the wetland. By making it financially attractive to lease the wetland to the Association, the council found the offer difficult to refuse and easier to use to motivate the community. A council with extremely limited income has now realized that in their wetland lies an economical potential they had overlooked.

MANAGEMENT PLAN IMPLEMENTATION AND PROBLEMS ENCOUNTERED

Division into areas of priority use

The primary objective in leasing the site from the town council and creating this reserve is to restore conditions so that the diversity of plants, animals, and birds that formerly occurred in the wetland will re-establish themselves and thereby be conserved more effectively. This will be achieved by managing fire in the systems, by reducing or modifying the grazing pressure and by grazing judiciously to create a mosaic of microhabitats, by creating more open water areas in the system (by the judicious use of herbicides), and by excluding marauding dogs and poachers that enter the area from the adjacent townlands.

As many conservation issues are more easily solved in a positive economic environment, a secondary objective is to develop facilities here for ecotourism (trails, catwalks, hides, interpretive boards) and promote Wakkerstroom as a place that offers this form of recreation.

Dr. Warwick Tarboton identified the key ornithological areas, Jon Wyatt and Don Kotze identified the key hydrological areas, consultation with the community has helped to identify the key grazing and haymaking areas, and various birdwatchers experience identified the key birding and recreation areas. With this information, the WNHA succeeded in arriving at a management policy aimed at being acceptable to all. By leasing certain sections of the reserve to adjoining farmers, the WNHA not only recover some of their expenditure, but retain the trust and cooperation of the leasees, while achieving a high degree of awareness because of the conditions (and reasons therefore) contained in their leases. The farmers are accountable for the conservation principles to be applied on these sections and utilizing cattle in a specific way can help the WNHA achieve the mosaic effect in habitat being aimed for. What has also been achieved is that the hands-on management has now been partially delegated. The task of the management committee (all who are busy people volunteering their services) has been made both practical and attainable. We would rather have a simple system that WORKS than a brilliant concept on paper with no man-power (full time staff is costly) to implement it.

While the dream of an inviolate wilderness area may appeal to many people, it is, by virtue of the history and indivisibility of town and wetland, not an attainable (nor necessarily a desirable) goal. The WNHA's goal here had to be the multifunctional use of the same system within conservation-conscious parameters.

Fire and grazing

The new management policy has as its objective the conservation of the wetland system; grazing and fire play an important role, but they have to be used judiciously. The cattle play an important role in veld management as does the cutting of hay as, among other reasons, they both cater to a certain spectrum of birds, and so does fire. If a greater mosaic within the system is to be created, all these tools have to be used in different measure in different areas. The total banning of all or some of these tools in certain areas, particularly at certain times, is also indicated. The WNHA has monitored this system for the past three to four years by using one of the barometers available, i.e., the birds. In this kind of monitoring it is extremely important to realize that high numbers of birds only indicate certain positive aspects; of greater importance is the variety of birds and the absence of birds that should be in the system, and most important is the breeding success of birds that use wetland habitats for breeding. It was particularly in this last test that the wetland performed badly. The Grey Crowned Cranes try their best, with up to thirteen pairs using the wetland, but the lack of suitable cover for the chicks to "escape" to when threatened means no young were successfully raised. This lack of cover is directly the result of the historic grazing policy. This is but one example and many more can be cited.

Fencing

To implement the new management policy, specifically pertaining to grazing control, it was necessary to fence the entire wetland. Fencing would also start addressing the poaching problem and the uncontrolled access of cattle and unauthorized entry by people, often with dogs, creating disturbances, robbing nests, and so on. To simultaneously reduce the grazing pressure and generate some income to offset against the lease it was decided to bring the grazing fees nearer to the market price.

FIRST PROBLEM

Ironically, but not entirely unexpectedly, after the euphoria following the very successful opening weekend on 17 December 1992, all sorts of problems with the Wakkerstroom Town Council and some residents cropped up. The changes in management led to all the problems.

The WNHA's homework had not been complete on the local perceptions and attitudes, overlooking the small but very important contingent of people who had traditionally used the wetland as common grazing for their cattle. They paid the council R16 per head per year for this right. The WNHA felt strongly that the low fee of R16 per head per annum (when the market figure was upwards of R60 per head per annum) contributed greatly to grazing abuse in the wetland, and they raised the fee to R48 per head per annum. Furthermore, grazing fees were to be paid monthly with no leasee having tenure beyond three months, in order to give flexibility to the grazing system.

These changes affect a few people "adversely." Historically they had been able to utilize the grazing with little effective control, with some paying for 16 head but actually pushing as many as 40 head into the wetland, and some had unrestricted access. The Town Council (and particularly a few individuals on the council) resisted these changes and attempted to stop the fencing program and keep the grazing fee at R16.

In all cases it simply boiled down to perceptions (and realities) of vested interests (particularly grazing) being threatened. This seems to be the essence of all conservation issues. The answer lies in finding the balance between accommodating reasonable requests and perceived rights and standing firm on that which is non-negotiable. As all the management decisions were based on thorough research and would eventually benefit the whole community and not just a handful with vested interests, we decided that the time had arrived to take a hard line. If certain basic issues and principles were not sorted out once and for all with the residents in general and the council in particular, even though we could in the process lose the reserve, the wetland in any case had a tenuous future at best. The council had to make a simple choice. Either it accepted the lease and its financial benefits to the community as a whole (not to mention the positive effect of the reserve on Wakkerstroom as a town), and therewith also accept and abide by the management guidelines of which they had had a copy since the inception of the lease, or the WNHA would consider them in breach of contract and pull out. Good sense prevailed and the situation is now that the council officially accepts the management guidelines. Agreement has been reached individually with all affected parties regarding the fencing and boundaries and grazing will be available at a cost, for a time span and in the area indicated by the management committee.

This does not mean that we are out of the woods--we expect the next year to be difficult. Those residents who are "negatively" affected in comparison to what they were used to in the past may take a while to adjust to and accept the changes.

An interesting development has been the eagerness from certain black community members to pay the higher grazing fee. Previously they had been limited to the eastern third which was extremely overgrazed. Now that there is good grass cover and grazing is limited, they seem to understand and appreciate the underlying philosophy and are eager to participate. As one old gentleman put it: "R16 a year for bare veld is too much, but R48 a year for good grazing is cheap."

PROBLEMS WITH GETTING THINGS DONE

Getting people to really become involved and help with fencing, building hides, making firebreaks, and so on is very difficult. Although the community is starting to perceive the reserve as an asset they still do not perceive it as *belonging* to them. Therefore they do not think this will change until the management of the reserve returns to the community. Whether this is desirable and practical remains a matter of great debate.

CONTROLLING FIRE

As the main reason for burning the wetland annually in July or August is the "benefit" of early green grazing in September and October, the adopted strategy includes:

- burning firebreaks around the perimeter to control fire entering the wetland from runaway fires (it also makes opportunistic arson slightly more difficult);
- burning firebreaks around the hides to protect them in the case of any fire.

Informing everyone that in the event of any fire that was not part of the management plan, grazing on such a section would be prohibited until January. The hope is that with the benefit removed and actual grazing loss suffered through fire, those with grazing rights will become monitors guarding against fire rather than the instigators of fire. We will have to see whether this has the desired effect.

HIDES AND OTHER VISITOR FACILITIES

It was decided to use wood and reeds as these materials are readily obtainable, not as expensive as bricks and mortar, blend with the environment, and are easier to erect in the unstable conditions of the wetland than more permanent structures.

Getting sponsorship for the three hides was easier than getting them physically erected. The task fell to the overworked committee. Other visitor facilities will be tackled as and when finances are available.

COAL LOADING AT WAKKERSTROOM SIDING

The necessity of having a watchdog in any community was stressed by this whole development. Until the station was suddenly transformed, without any prior consultation with *any* section of the community, into a coal-loading siding, no one would have foreseen such a scenario or the dangers resulting from it. Massive amounts of storm water flowed through the facility, being contaminated there with coal dust and then flowing into the wetland. Luckily agreement was reached with Transnet (the parastatal railway corporation) about the need for proper precautions and facilities for contaminated water management at the siding and together with the two mining companies the situation was eventually addressed. This was an ongoing battle with some successes and some setbacks. In the end it took two years to solve. Keeping the media out of the fight, sound scientific data, constant pressure, and reasonable demands were the reasons for eventual satisfactory resolution of the problem.

RESULTS

The wetland reserve project is possibly unique in the country in that it aims, initially, to conserve and manage optimally a large wetland that lies within townlands, and in the longer term, to develop a small rural town into a center for ecotourism.

Although the benefits of properly managing and utilizing the wetland are far reaching and of national impact, the people living in Wakkerstroom are the ones who have already derived the immediate and direct benefits resulting therefrom. Land prices have increased by up to 400% in two years, vacant houses have been bought and restored, town pride has returned, and the economy has taken a definite upswing. Unemployment, which would have soared, has been contained to a large extent.

The economic difference that the wetland has made to Wakkerstroom has been the single most persuasive argument in favor of its conservation.

ENVIRONMENTAL EDUCATION CENTER

There is a dire need for an environmental education center through which to address the lack of environmental awareness.

First attempt failure

The WNHA secured the use of a small hall in the town at a nominal R50 per month rental to use as an environmental education center, but it proved impossible to man on a reasonably full-time basis. No finances and few volunteers, most untrained, soon made the Association realize that in this instance the cart had been put before the horse--a clear case of not listening to sound advice, but being carried away by enthusiasm. The decision to close the facility was taken for the WNHA when the building became needed as an extension to the school.

New plan

The WNHA then opted for an ad hoc system in the interim; groups that are interested are accommodated on a day when someone is available and the wetland itself is used as a classroom.

The Kotzes have nearly completed a little hall at their guest house which will serve the interim purpose of housing illustrative and reference materials, providing a venue for meetings, lectures, slide shows, etc. Being at the guest house it can be opened and staffed by one of the Kotzes whenever required. Volunteers can man the facility when they are available.

Teachers from schools in the village and surrounding towns can themselves be presenters of relevant programs, following up with fieldwork in the vicinity.

The lesson here is that in order to be viable it was necessary to scale down, start small, and network with needs of and expertise available in programs launched by other established groups, including Field Service, Scouts, Guides, Voortrekkers, and teachers at primary and secondary schools.

The ultimate aim would still be to eventually have an integrated environmental education and community development center.

SOUTH AFRICAN NATURAL HERITAGE PROGRAMME

The WNHA decided on making use of a national environmental program run by the Department of Environment Affairs (the South African Natural Heritage Programme) to promote conservation awareness among farmers in the district. In this program, landowners that have unique or unusual natural history features on their properties can register their land as a 'natural heritage site', being awarded a certificate for this and being given a bronze plaque that can be erected at the entrance to their property. Dr. Tarboton has guided this program, and a number of applications from surrounding farmers are currently being processed. In this process the farmer is made aware of special aspects of his farm and an opportunity is created for discussing problems and solutions. Most farmers become proud and therefore protective of the special features that qualify their recognition.

RESEARCH AND LIAISON WITH RELEVANT ORGANIZATIONS

The WNHA believes in networking and learning from others. It cannot show any progress without the help, advice, and assistance (financial, research, and otherwise) of related organizations. The organizations that close links are maintained with are:

- International Crane Foundation, USA;
- Southern African Crane Foundation;
- Directorate Nature Conservation, Transvaal Provincial Administration;
- South African Nature Foundation;
- Wetlands Awareness Campaign;
- Department of Grasslands Sciences, University of Natal;
- Wetland Link International, United Kingdom;
- Wildlife Society of Southern Africa;
- Botanical Society of Southern Africa;
- African Gamebird Research, Education, and Development Trust;
- Animal Rehabilitation Centre, Pretoria; and
- Poison Working Group, Pretoria.

CONCLUSION

As the WNHA has progressed over the past two and a half years it has been amazed at the difference between its original and present perceptions, accepting that there will be as much of a difference between these present perceptions and the realities of two or four years hence. Maintaining flexibility and fluidity without compromising the bottom line is important. Finances have played the deciding factor in changing attitudes, viability of projects and the overall success. Valid contributions to conservation can be made by ordinary people. The important factors in deciding success or failure are good liaison, research communication, a lot of perseverance, and patience. Flexibility, an open mind, the realization that answers and solutions have to be found, and that the WNHA's own perceptions cannot be forced on anyone are essential ingredients to success. Everybody, seen from their specific circumstances, influences and norms, has a valid point of view. Nobody can claim high moral ground, as a commitment to conservation is very often dependent on the degree of affordability. People, including those associated with the WNHA, must be persuaded, convinced, informed, and educated.

Community conservation is a coordination where ingredients supplied by specialist scientists, government organizations (conservation and others), NGOs, conservation issues, local needs and perceptions, and economic factors are brought together. Whether this results in a witches' brew or tasty stew depends on how the community reacts. It is not static but very vibrant - ever-changing and extremely volatile.

SEVEN GOLDEN RULES FOR ORDINARY PEOPLE

1. If you do not know where to start, start anywhere, but just start.

2. Be prepared for a steep learning curve. Ask questions, read, enlist help--you'll find that people are more than willing to assist.

3. Keep a broad view. Wetland conservation is often also mountain catchment conservation and/or grassland conservation.

4. Do not despair. It will often seem as if things are in a bigger mess than when you started, but that is normal. Just keep going.

5. Opposition, enmity, and misunderstandings will surely arise. See them as challenges and react positively. Measure your reaction against the effect on the end objective.

6. Do not neglect public relations, communications, and consultations. The involvement of the local community is vital.

7. Finances will trip you. Do not give up on your objective but be enterprising, scale down, start smaller, rethink if necessary, but just keep going. Slowing down isn't a sin but stopping is.

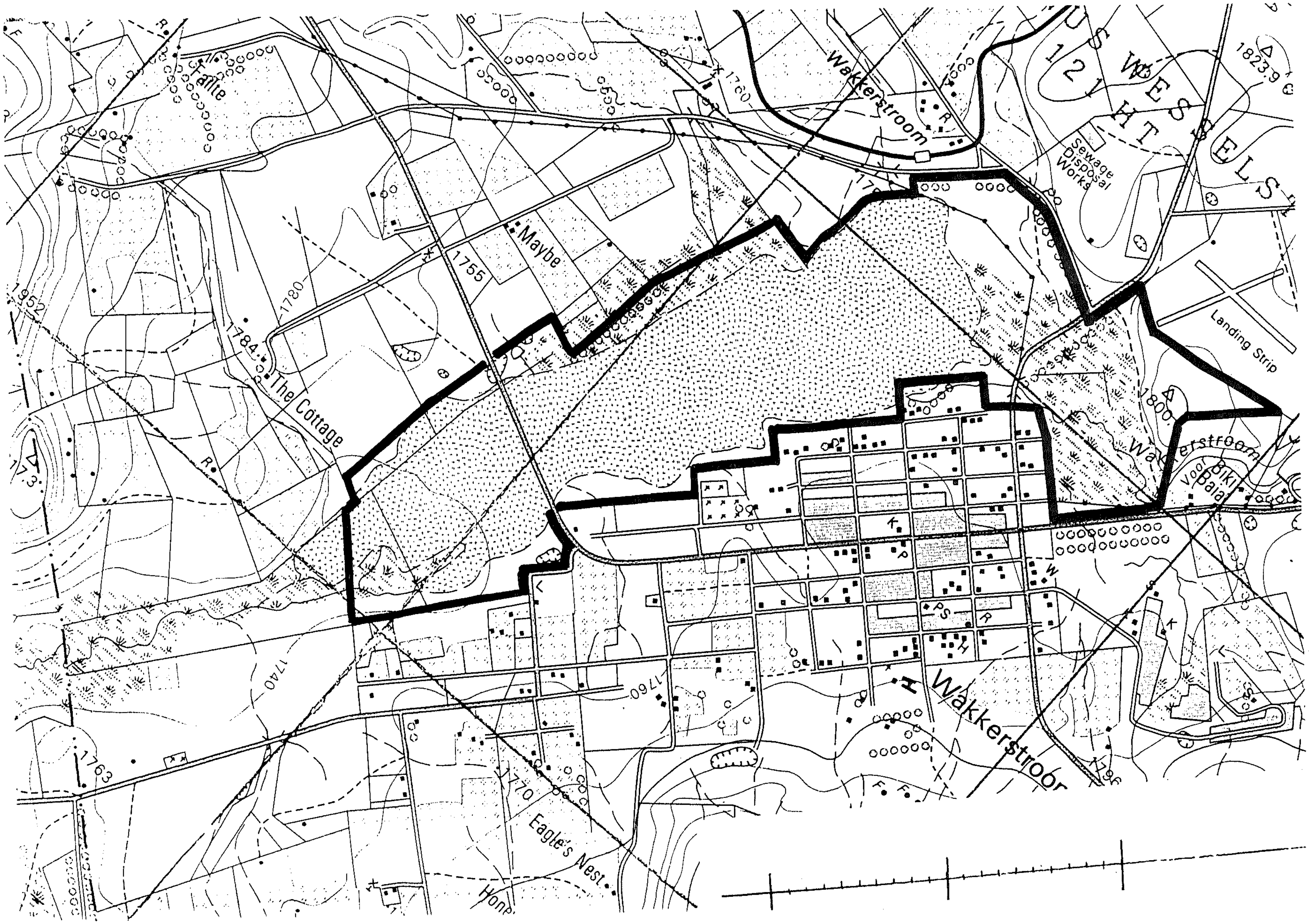

Figure 1. Wakkerstroom wetland reserve and crane sanctuary.

THE O.P.M. PROZESKY BIRD SANCTUARY AS AN EDUCATIONAL RESOURCE AREA

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ABSTRACT

The O.P.M. Prozesky Bird Sanctuary near Potchefstroom, South Africa, forms part of a wetland which is maintained by water from a neighboring sewage plant. The bird sanctuary and wetlands are extensively used in educational and community programs. Involvement of the Potchefstroom University for Christian Higher Education (CHE) in this sanctuary proved to be extremely valuable in pre- and postgraduate programs and also for the management and maintenance of the bird sanctuary. This paper reports on the educational projects in the sanctuary and the importance of the development and use of these wetlands.

INTRODUCTION

There is an increasing need for involvement in the preservation and protection of the environment and especially of wetlands. Universities and other educational institutions have also become involved in their immediate surroundings through their research and graduate curricula. This paper describes how the Potchefstroom University for CHE and the Potchefstroom community have benefited from the utilization of an important wetland conservation area near Potchefstroom as an educational resource area.

Many towns and cities in South Africa have sewage works in which a series of maturation ponds were used in the past as part of the sewage treatment. In Potchefstroom, the water from the treated sewage is channeled through three maturation ponds, which are lined with dense reeds, to a series of old maturation ponds and ultimately into the Mooi River. This whole complex of pans represents a small artificial wetland which is visited by a large diversity of water-associated bird species and is also inhabited by smaller vertebrates such as otters, rats, and mongoose. The Potchefstroom area was famous for its marshes in the past, but since the draining and reclamation of these areas, few habitat sites for waterbirds remain (Tarboton 1993). Therefore, the wetland created by the sewage works constitutes an important habitat and breeding site for these birds in the western Transvaal. The importance of this wetland area has recently been realized and in 1987 the O.P.M. Prozesky Bird Sanctuary was proclaimed in order to protect the diverse bird population in this area. The sanctuary is managed by the Wesvaal Bird Club and the Potchefstroom Wildlife Society and is maintained by the Potchefstroom City Council (Myburg 1987).

The Mooi River is another important natural resource for the Potchefstroom area. This river originates from two fountains, Bovenste Oog and Gerhard Minnebron north of Potchefstroom. It flows into the Boskop Dam, Potchefstroom Town Dam, through the Potchefstroom Municipal area and ultimately into the Vaal River. The river is an important lifeline in this area, offering potable and irrigation water and recreation, and carrying away such wastes as the end products of the sewage works and industrial waste water.

A survey was launched to investigate the possibilities of utilizing both the wetlands in the O.P.M. Prozesky Bird Sanctuary and the Mooi River for educational purposes while contributing to the well-being of these natural areas. The use of both these areas for academic purposes became quite obvious. Wetlands are known for their high rate of productivity which support a wide diversity of animal life (Begg 1990). Two projects were identified by the Department of Zoology at the Potchefstroom University for CHE, as part of the graduate curriculum, with the objective to apply basic ecological principles in practice and to contribute significantly to research and management of the environment.

The first project concerned the factors governing the distribution of waterbirds in the O.P.M. Prozesky Bird Sanctuary. Habitat diversity influences waterbird diversity (Bibby *et al.* 1992; Bernstein *et al.* 1991). A number of habitats can be identified in the O.P.M. Prozesky Bird Sanctuary, according to structural and vegetational diversity. Information about their influence on the bird species diversity is important for the management of the sanctuary.

The second project concerned the effect of the release of the treated water from the sewage works into the Mooi River on the species diversity of aquatic fauna. Treated sewage water has a high nutrient and organic material content which stimulates the activity of micro-organisms which results in the deoxygenation of water. The species composition and species diversity of aquatic organisms are affected by this change in water quality, but these usually recover to their original state further down the river (Davies and Day 1986).

The Department of Communication Sciences is involved in the O.P.M. Prozesky Sanctuary through student projects with the aim of producing a video for use on television.

The O.P.M.. Prozesky Bird Sanctuary is also used informally for important bird ringing and birdwatching activities by the Wesvaal Bird Club and other bird lovers, and bird census activities. Bird identification courses are given and the sanctuary has become increasingly popular for visits by school groups and groups of elderly people.

EDUCATIONAL OPPORTUNITIES IN THE O.P.M. PROZESKY BIRD SANCTUARY

University projects

Project 1: An investigation into the effect of habitat diversity on the species diversity of waterbirds in the O.P.M. Prozesky Bird Sanctuary.

Three habitat types were identified in the wetland area of the bird sanctuary. The three habitat types (pan types) are shown in Figure 1. The first habitat type consisted of three active pans which receive the output from the sewage works directly. The surface area was relatively large and deep (0.5-1.5 m) with clear water. There were no islands in these pans where thick riparian reed vegetation is found. One of these pans was used as representative for this habitat type.

The second habitat type consisted of a large shallow pan. Water seeped into this pan from the three maturation ponds. The pan was relatively shallow (0-1 m) and largely covered by water fern (*Azolla filiculoides*). A large number of reed islands were found in this pan, a relatively thin riparian reedbed with a network of bays providing an edge effect for nesting sites. The water was muddier than that in the first habitat.

The third habitat consisted of a long shallow pan that received flowing water from a number of other pans such as that described in habitat 2. This pan had clear water of about 1 m deep, several reed islands, a shallow mud bank (0-5 cm), and very thick riparian reed growth with deep canals and flowing water.

These three habitat types provided an ideal situation for comparative studies. During February and March, six surveys were made. Each survey consisted of three point counts, made between 6:20 and 7:20 am, 2:00 and 3:00 pm, and 5:30 and 6:30 pm. The surveys at the three pans (habitat types) were done simultaneously. Each hour count implies a point count of all the waterbirds (species and numbers per species) every ten minutes for a total of six point counts per hour. Counts were done with binoculars from fixed observation points, where the whole pan could be observed and care could be taken to minimize any form of disturbance. Shannon indices were calculated for each hour count (Ludwig and Reynolds 1988) and an analysis of variance was carried out on the data to determine if there was a significant difference between the mean diversity index at the habitat types and at different times of the day. All students were therefore required to be able to identify the waterbirds, to calculate diversity indices, to apply the relevant statistical analysis, to interpret the results, and to make management recommendations for the possible maintenance and improvement of the species diversity in the bird sanctuary. The results were given in a full report and presented as a seminar to which staff members, fellow students, the press, city council representatives, and bird club members were invited.

The results of the 1993 survey are used in this paper to demonstrate the results obtained in this project. The mean Shannon indices for the three pans were calculated; Pan 3 had the highest mean Shannon index ($H=1.6341$), followed by the deep Pan 1 ($H=1.3203$) and the shallow Pan 2 ($H=0.9298$). An analysis of variance showed that all three of the means differed significantly at $P<0.05$. The mean Shannon index for the three pans with the 95% confidence levels is summarized in Figure 2. The species diversity index during the evening was significantly higher then during the afternoon but did not differ from the morning index. These data are summarized in Figure 3. The relative frequency of observation for each of the 33 species monitored for each of the habitats, can also be presented as shown in Figure 4. The percentage frequency for each species, in each habitat, is calculated as a fraction of a third of the total frequency and gives an indication of the importance of each species. The species are indicated as numbers according to the numbers in Maclean (1984). The species can easily be divided into groups according to importance from Figure 4. The actual percentage distribution of each species between the three pans can also be calculated as shown in Figure 5. It is clear from Figure 5 that some species were found only at one pan and that there seems to be a preference of some species to certain habitat types.

Students were able to make management recommendations from the results regarding the maintenance of habitat diversity, water level in some pans, and the management of vegetation and predators.

Project 2: An investigation into the effect of the inflow of end-products of sewage works into the Mooi River on species diversity of aquatic fauna.

Water from the sewage system flows ultimately into the Mooi River system at a point situated within the Prozesky Bird Sanctuary. The study of the effect of sewage release on aquatic species diversity provides a unique opportunity for teaching students a variety of ecological principles and techniques. The inflow is rich in organic material and nutrients and the oxygen content of water immediately after the inlet is usually very low because of the activity of micro-organisms that are adapted to utilize the high levels of organic material. Under these circumstances animals adapted for low oxygen concentrations, such as a variety of annelid worms (family Tubificidae) and Diptera larvae (family Chironomidae) become very abundant. The conductivity of water which is a measure of dissolved material is usually higher after the sewage inlet. However, rivers can recover downstream (Davies and Day 1986). Species composition, for example, the presence of Odonata and Ephemeroptera larvae, can also be used to indicate clean water.

Four sites were identified. Locality A was about 500 m before the sewage inlet, locality B at the inlet, locality C just after the inlet, and locality D about 500 m after the sewage inlet. Each of the sites was stratified into homogeneous subsites, relating to microhabitats such as under trees, reedbeds, in the middle of the river, and the sediment. The students used various sampling techniques to determine species diversity, including water nets for sampling flowing water, dredges to sample sediment, and snailnets to sample epibioton. The aquatic fauna was identified with the use of keys and diversity indices were calculated. Water quality was measured at the different localities using techniques to measure oxygen content, conductivity, and pH.

The educational value of this project is obvious. Students had to learn to use identification keys to identify aquatic fauna, to use various sampling techniques, to determine water quality, to calculate diversity indices, to apply the relevant statistical analysis, to interpret the results, and to make management recommendations for the conservation of the Mooi River and species diversity. The results were given in a full report and presented as a seminar attended by staff members, fellow students, the press, and city council representatives.

The results of the 1993 survey are used in this paper to demonstrate the results obtained in this project. The mean oxygen tension and conductivity of water at the three localities is given in Figure 6. This figure clearly shows that oxygen tension of water before the release point of the sewage water (locality A) is significantly higher than the oxygen tension at the other three localities below the release point (Localities B, C, and D). An analysis of variance confirmed that oxygen content at Locality A was significantly higher than at B, C, and D and that oxygen tension at C was significantly lower than that at B and C. Conductivity was significantly lower before the release point (Locality A) than at the other three points below the sewage release point. This confirms the negative impact of treated sewage water on water quality. The Shannon index for species diversity at the four localities was calculated and is shown in Figure 7. Species diversity tended to decrease immediately after the inflow point but seemed to recover further down the river. This project gave the opportunity to study the changes in animal communities with changes in water quality. Food chains could also be identified.

Recommendations regarding the future monitoring of the Mooi River with the use indicator organisms could be made on the basis of this study.

Communication project

The O.P.M. Prozesky Bird Sanctuary also provides educational opportunities for other disciplines such as the communication sciences. Students from this department made a scientific study of all the possible features of this area with the aim to produce a video for television. This constructive involvement could have an important positive impact on this wetland area and should make people more aware of the importance of such areas.

Other informal educational activities

The O.P.M. Prozesky Bird Sanctuary is used informally for important bird ringing and birdwatching activities by the Wesvaal Bird Club and other bird lovers. A total of 431 birds were ringed since the beginning of 1992 (Figure 8), an activity that plays an important role in the monitoring of bird populations. Four students have already obtained A-permits for ringing. The Department of Zoology at the Potchefstroom University for CHE supports the students with equipment and transport to obtain ringing permits. These activities create the infrastructure for students and members of the public to become involved in the study of birds and birdwatching. Bird identification courses are often given at the sanctuary and school groups visit it on educational excursions. The sanctuary has become a popular site for elderly people as well. Important waterbird census activities, which contribute to an international census network, are carried out at the bird sanctuary. This is coordinated by the Zoology Department through senior post- graduate students. These students gain experience and training in these activities. Experienced birdwatchers are also involved and give assistance with the training of students in bird identification.

DISCUSSION

This paper demonstrates how artificial wetlands such as municipal sewage works can become a valuable asset for any town. The development of these areas into bird sanctuaries creates a wide spectrum of educational and recreational facilities which can be used very effectively by universities, schools and the general public. Involvement of educational institutions in these wetlands could contribute with research inputs and management recommendations. The development and maintenance of such facilities also provide much needed habitat for waterbirds and should contribute significantly to the protection and conservation of them. These wetlands are ideally suited for many educational levels and for demonstrating a large variety of ecological principles and techniques.

ACKNOWLEDGMENTS

We acknowledge with thanks the following students who assisted with the execution of the projects: L. Beyl, J. Breytenbach, A. du Buys, L. Els, G.P.J. Grobler, L. Griessel, A. Jacobs, T. L. Klerck, J. Kotze, L. Lötter, E. Louw, H. Mulder, N. Portwig, A. J. Pretorius, J. Stassen, and S. Voster. We thank Mr. K. le Roux for the preparation of the figures. We also thank Mr. S. de Beer, W. Scott, S. W. Evans, and K. le Roux for assistance with projects, and Mr. A. Gerber for information on projects in communication sciences.

REFERENCES CITED

Begg, G. 1990. Policy proposals for the wetlands of Natal and Kwazulu. Natal Town and Regional Planning Report 75: 8-9.

Bernstein, C., J. R. Krebs, and A. Kacelnik. 1991. Distribution of birds amongst habitats: theory and relevance to conservation. Pages 317-345 *in* C. M. Perrins, J. D. Lebreton, and G.J.M. Hirons, eds., Bird population studies. Oxford University Press, Oxford, UK.

Bibby, C. J., N. D. Burgess, and D. A. Hill. 1992. Bird census techniques. Academic Press, London, UK.

Davies, B. R. and J. A. Day. 1986. The biology of conservation of South Africa's vanishing waters. Centre for Extra-Mural Studies, University of Cape Town, South Africa.

Ludwig, J. A. and J. F. Reynolds. 1988. Statistical ecology. John Wiley and Sons, New York, USA.

Maclean, G. L. 1984. Roberts' birds of Southern Africa. John Voelcker Bird Book Fund, Cape Town, South Africa.

Myburg, P. 1987. Die Prozesky Voëlreservaat. Hoephoep 9: 3.

Tarboton, W. 1993. Ambassadors of the wetlands. Africa environment and wildlife 1(2): 65-74.

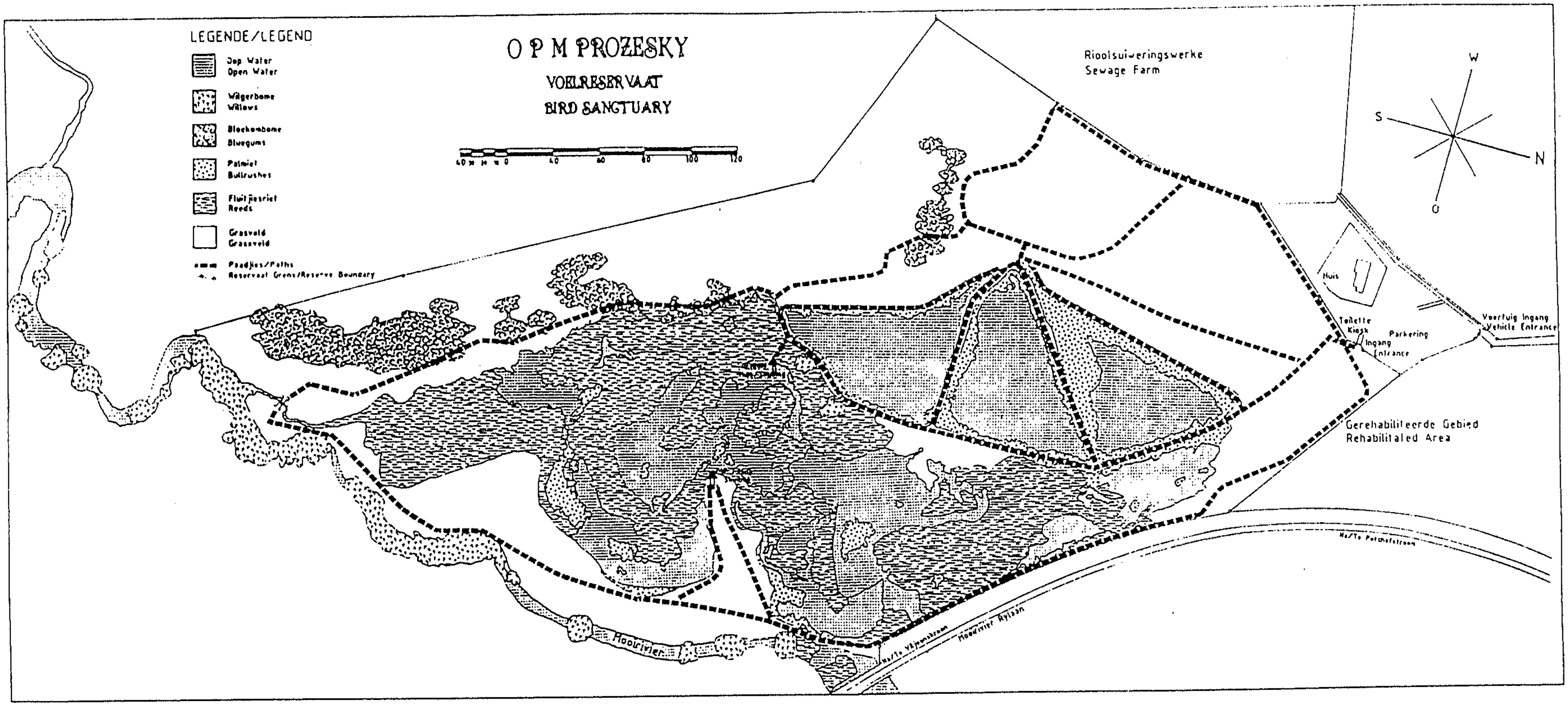

Figure 1. Map of the O.P.M. Prozesky Bird Sanctuary at Potchefstroom.

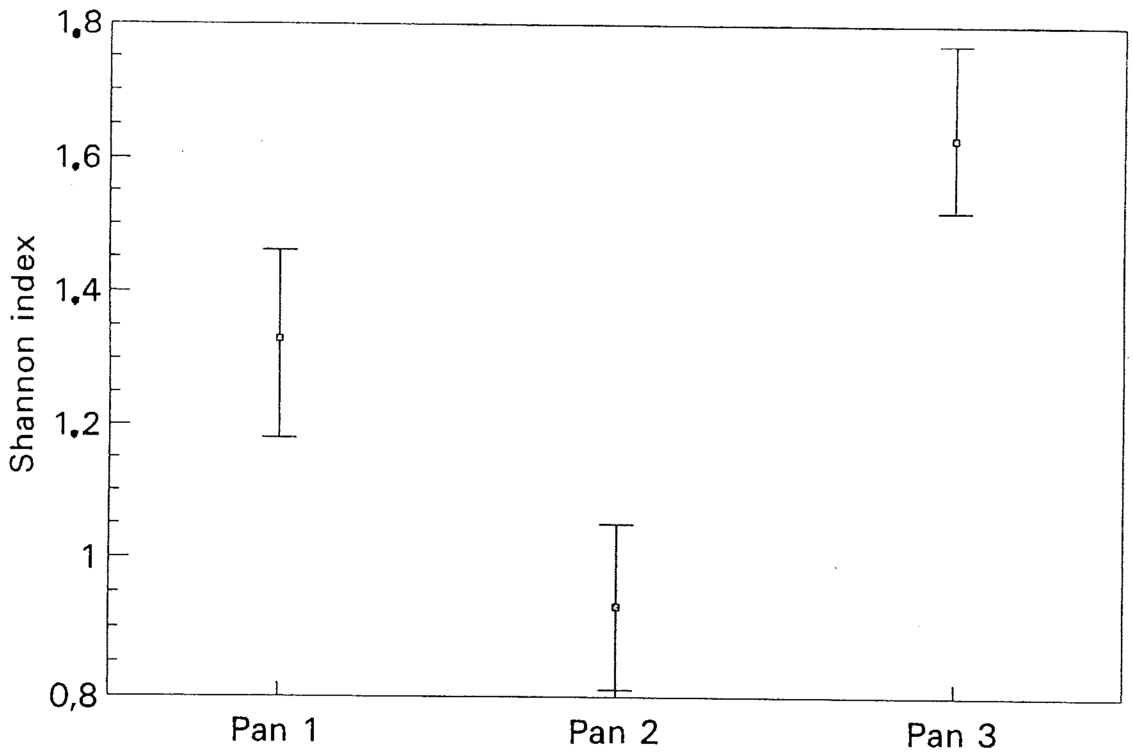

Figure 2. Species diversity (mean with 95% confidence intervals) of waterbirds at three pans in the O.P.M. Prozesky Bird Sanctuary.

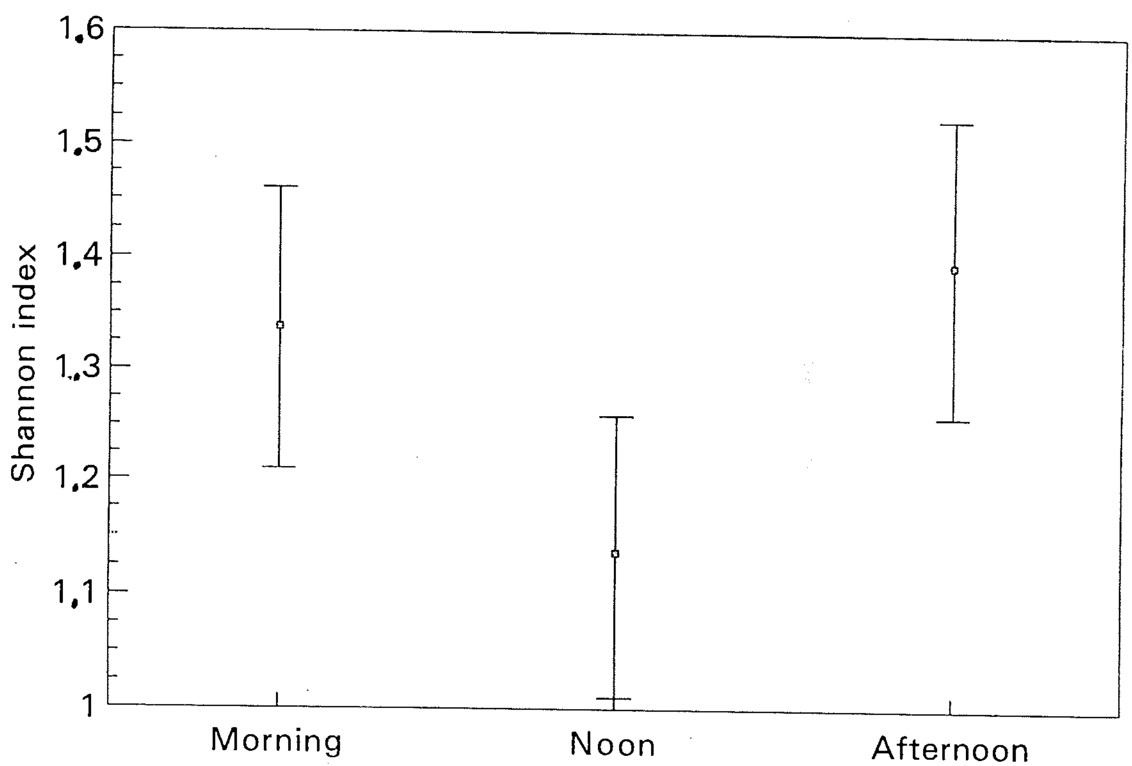

Figure 3. Species diversity (mean with 95% confidence intervals) of waterbirds at different times of day in the O.P.M. Prozesky Bird Sanctuary.

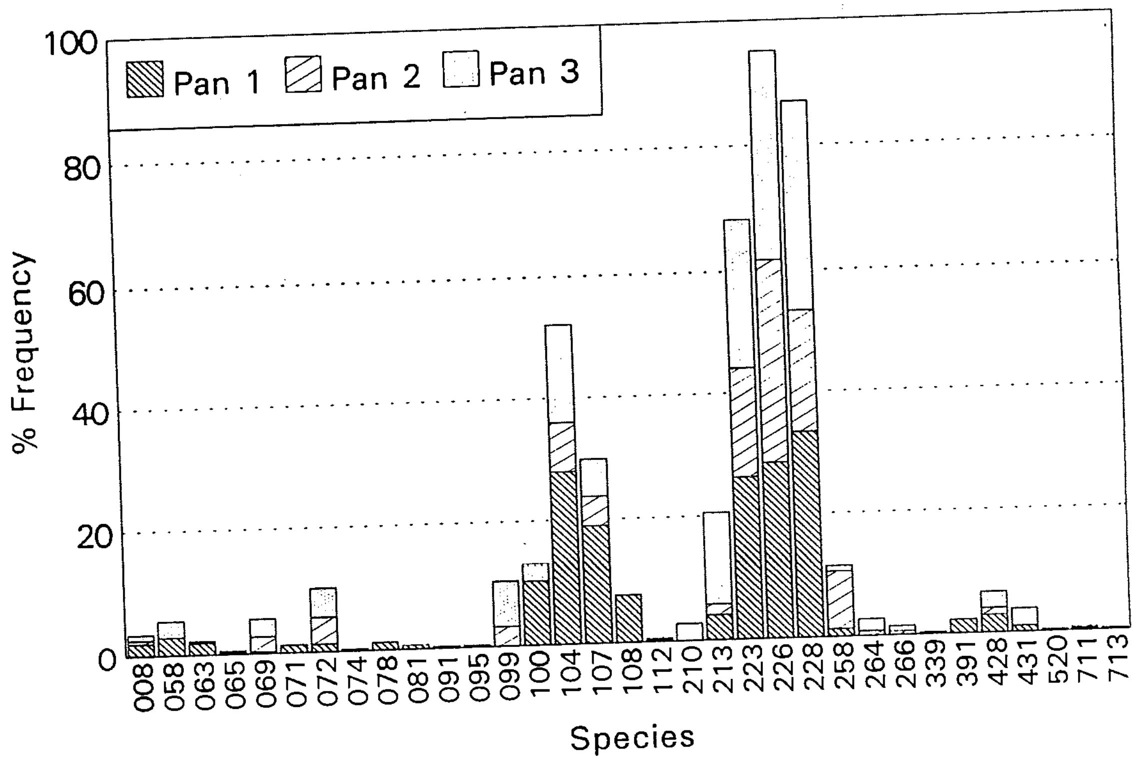

Figure 4. Frequency of 33 waterbird species observed at three pans in the O.P.M. Prozesky Bird Sanctuary (numbers according to Maclean 1984).

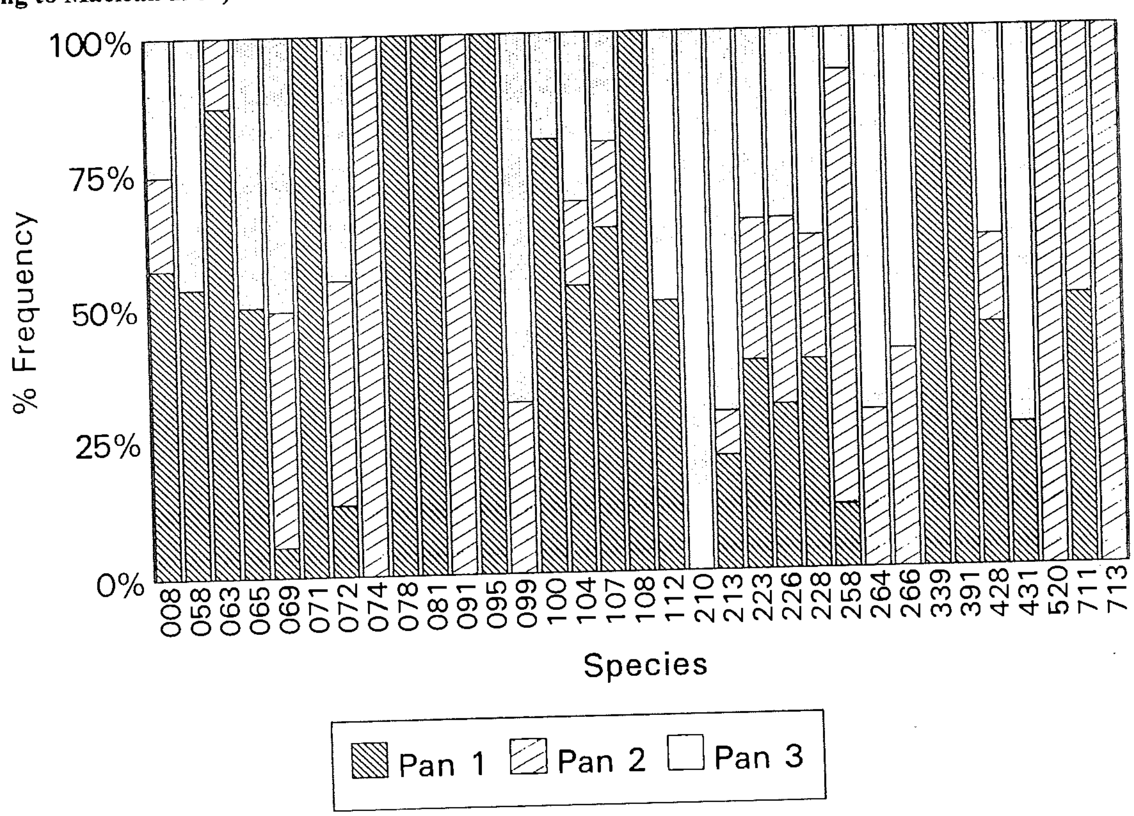

Figure 5. Percentage frequency distribution of 33 waterbird species at three pans in the O.P.M. Prozesky Bird Sanctuary (numbers according to Maclean 1984).

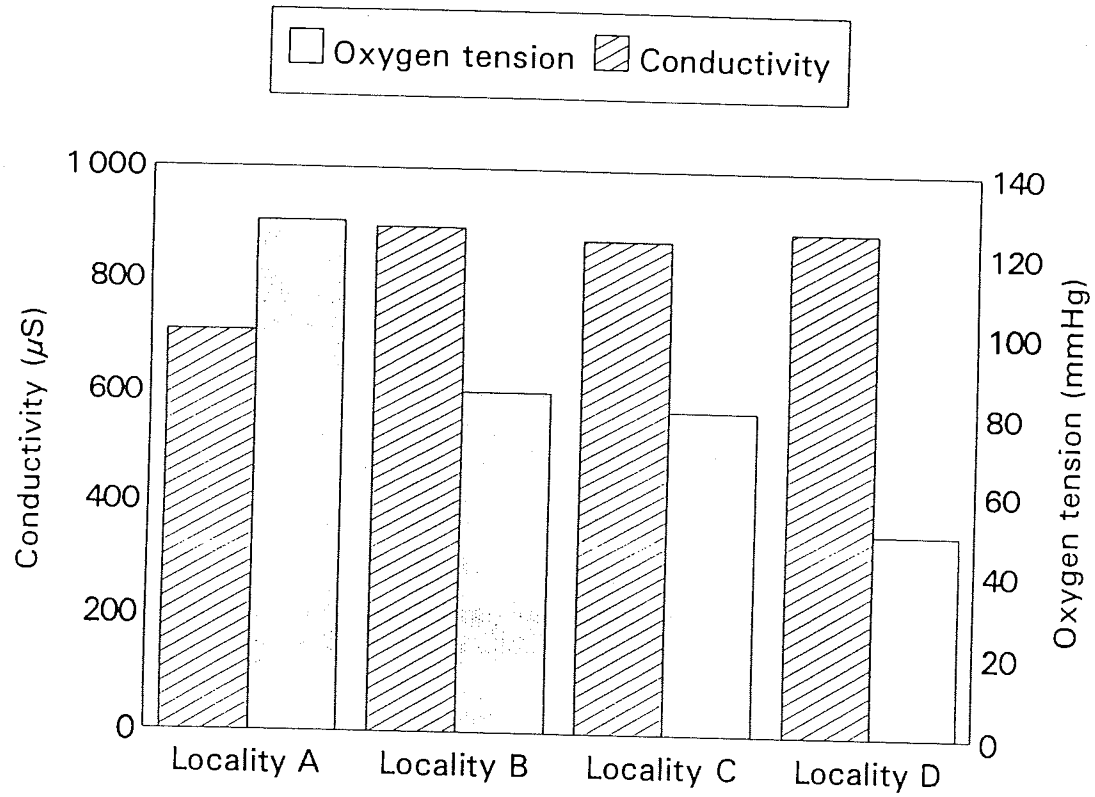

Figure 6. Oxygen tension and conductivity of water measured at different localities in the Mooi River.

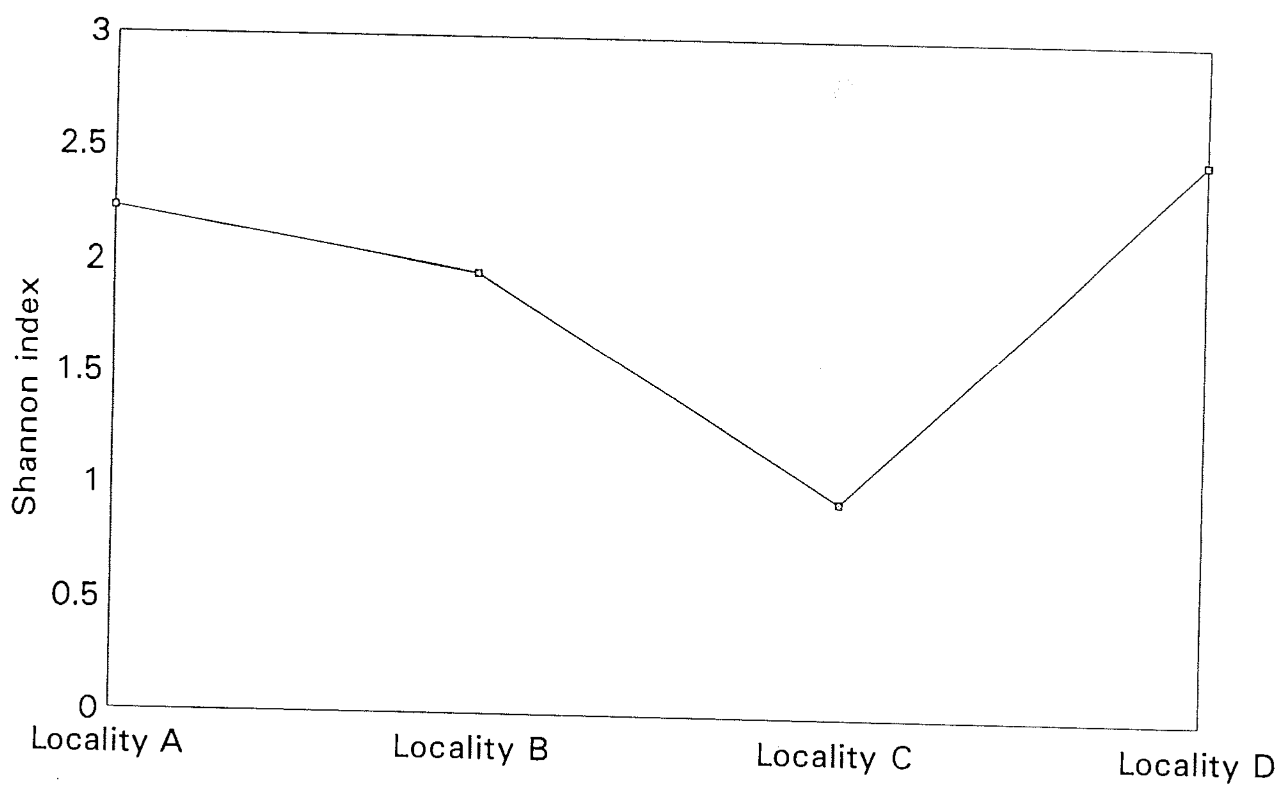

Figure 7. Species diversity of aquatic fauna at different localities in the Mooi River.

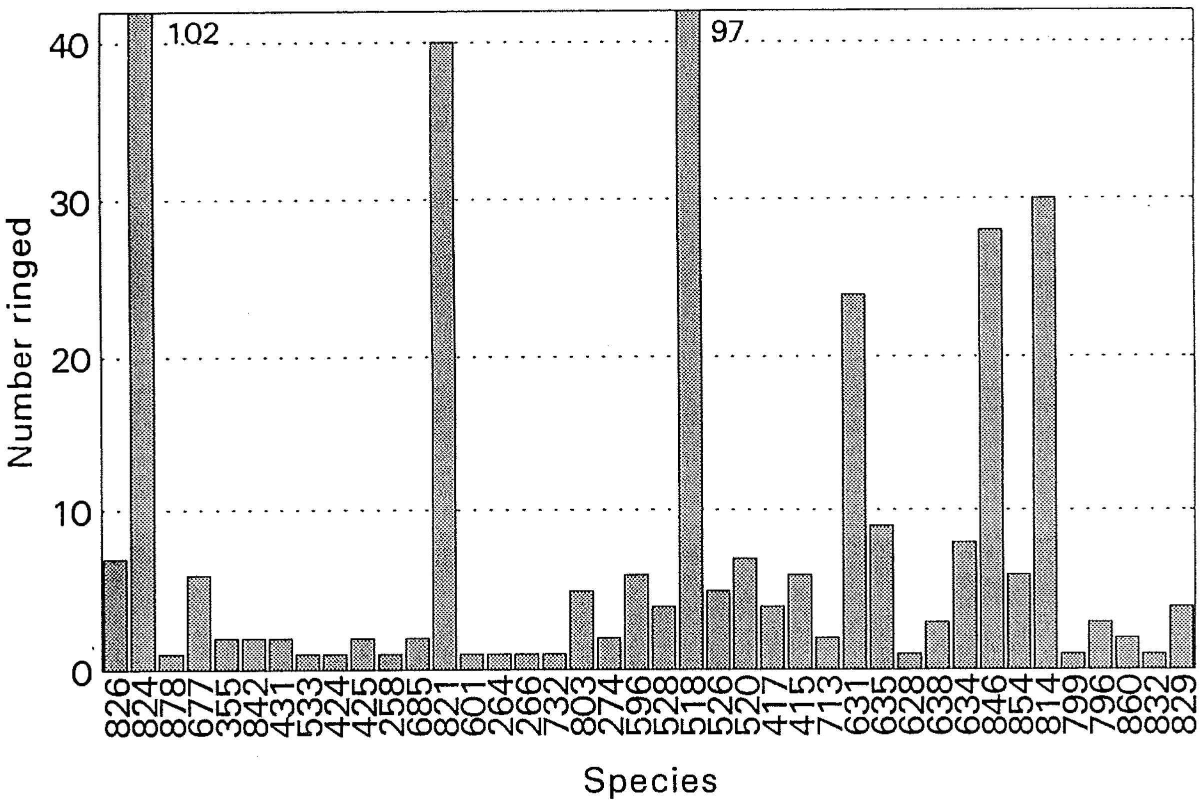

Figure 8. Birds ringed by students at the O.P.M. Prozesky Bird Sanctuary (numbers according to Maclean 1984).

SECTION 6

INTERNATIONAL PERSPECTIVES ON CRANE AND WETLAND CONSERVATION

ENVIRONMENTAL PROBLEMS, CONSERVATION, AND RATIONAL MANAGEMENT OF TROPICAL AFRICAN SHALLOW LAKES AND RESERVOIRS

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ABSTRACT

Tropical African lakes and reservoirs support diverse wildlife and many livestock on their marginal and perennial wetlands and pastures. The lakes are used for fisheries, domestic water supply, irrigation, tourism, and navigation. The reservoirs are primarily used for hydroelectric power supply and tourism. The main problem associated with the lakes and reservoirs are water-related diseases (especially bilharzia and malaria), siltation, and agrochemical pollution. Occasional massive fish kills are particularly problematic in the large lakes. There are serious population resettlement problems and loss of fertile agricultural floodplains with the construction of large dams across the large tropical African rivers. Apart from a few traditional management practices, the basic modern management techniques for lakes and reservoirs include catchment rehabilitation and conservation through reforestation and modern agricultural practices.

INTRODUCTION

Some of the largest lakes as well as some of the smallest lakes in the world are found in tropical Africa. Indeed three of the world's largest lakes, Victoria (68,800 km²), Tanganyika (13,500 km²), and Turkana (7,560 km²) are found in tropical East Africa. In addition to these large lakes (more than 2,000 km²), many more small ones are found dotted all over central and eastern Africa. These include among others Lake Chad in central-west Africa, Lakes George, Albert, Edward, and Kivu on the western arm of the Great Rift Valley; Lake Kioga on the Victorian central plateau in Uganda; and the lakes of the eastern Rift Valley, such as Baringo, Nakuru, and Naivasha in Kenya (Table 1).

USES OF LAKES AND RESERVOIRS

During the last 30 years dams, large and small, have been constructed at a very speedy pace in tropical Africa. Most of the dams have been built across the major rivers in arid or semi-arid tropical climates. The large reservoirs and man-made lakes include the Akasombo in the Volta River in Ghana, the Kainji on River Niger in Nigeria, the Kariba and Cabora Bassa on the River Zambezi in southern Africa, the Nyumba ya Mungu in Tanzania, and the Tana River cascades in Kenya. The Owen Falls dam on the outflow of River Nile is essentially part of Lake Victoria. The other important dam is the Aswan dam which forms the Nasser reservoir on the River Nile in Egypt. Table 2 gives some important characteristics of some of the important tropical African reservoirs.

Lakes

The main uses of lakes in tropical Africa are fisheries, domestic water supply for both rural and urban needs, livestock watering, navigation, and tourism/wildlife conservation (in that order of importance). Lake Chad is intensively fished for its rich ichthyo-fauna which comprise about 140 species. The main species of fish exploited are *Lates niloticus*, *Oreochromis* spp., and *Heterotis niloticus* to mention but a few (Leveque 1983). In addition to the fisheries potential, Lake Chad is also the major water resource for the people of northern Nigeria, northern Cameroon, and the Republics of Chad and Niger. The lake's littoral wetlands serve as dry season grazing areas for the many livestock and wildlife. The wetlands also conserve water in the dry season which supply domestic needs.

Lake Tanganyika and Kivu are used mainly for fishing and navigation. There is a thriving fishery in Lake Tanganyika based on the *Limnothrissa* spp. At the moment ecological studies of the lake are being undertaken by Japanese scientists in collaboration with local African scientists (H. Kawanabe *pers. comm.*). Similarly the lakes of the western Rift Valley are used for fishing mainly *Lates niloticus* and tilapia species especially *Oreochromis niloticus*.

Most important are the lakes in the eastern arm of the Rift Valley particularly Lakes Turkana, Baringo, Nakuru, and Naivasha in Kenya. Lake Turkana is famous for its Nile perch *L. niloticus* and tilapia *O. niloticus* fishery. At the southern shore of the lake is a lucrative fish filleting factory which produces substantial amount of fillet and canned fish for local consumption and export. Lake Baringo contains only a few species of fish, *Labeo*, *Barbus*, *Clarias*, and *O. niloticus* which form the mainstay of the lake's fishery. Lake Nakuru is a saline lake (20,000 µs/cm²) with high densities of blue-green algae *Spirulina platensis*. As a result of this dense alga food, the lake is usually inhabited by more than one million flamingos at a time, both Lesser Flamingo (*Phoeniconais minor*) and Greater Flamingo (*Phoenicop-*

terus ruber). Indeed Lake Nakuru has been described as the greatest bird spectacle in the world because of its pink flamingos and fish-eating pelicans. The Lake Nakuru National Park contributes significantly to the tourism industry in Kenya. The park is one of the efficiently conserved areas in Africa today, where a great variety of wildlife co-exist.

Lake Naivasha deserves special mention as it is the only freshwater lake in the Rift Valley in Kenya. Its conductivity is relatively low (350 $\mu s/cm^2$) for an endoerrheic system. As such the lake contains characteristic freshwater fauna and flora. The main uses of the lake are fishing, irrigation, domestic water supply, and tourism based on its abundant bird life. Before 1925 there were no indigenous fish species in the lake except for a small minor *Aplocheilychthyes antenorii*. Today the mainstay of the lakes fishery are the introduced tilapia species, *O. leucostictus, O. zillii,* and the largemouth black bass (*Micropterus salmoides*). Lake Naivasha water is intensively abstracted for the riparian agriculture, domestic water supply, and livestock watering. About 1-2% of the water loss is through abstraction, and 95% through seepage out and evaporation.

The lake of prime importance in tropical Africa is Lake Victoria. Lake Victoria lies astride three territories Uganda, Kenya, and Tanzania (Figure 1). Forty percent of the lake water comes from the surrounding catchment and about 60% from direct rainfall (Beadle 1981). The only outlet of Lake Victoria is River Nile. The regional importance of Lake Victoria as fishery, and urban and rural water resource cannot be overemphasized. The Nile, and therefore the Lake Victoria, is the lifeline of Sudan and Egypt. The Nile flows out of the lake at the Owen Falls dam in Uganda. The river traverses through several shallow lakes including Kioga and Albert before it enters into the Sudd wetlands in Sudan. In Egypt the river is dammed at Aswan to form Lake Nasser and thereafter flows into the Mediterranean Sea through several deltaic wetlands, supplying water to thousands of irrigated farmlands as well as the city of Cairo among others in Egypt.

Domestic and industrial water for the lake towns, Kisumu, Homa Bay, Jinja, Kampala, Entebbe, Mwanza, and Bukoba is obtained solely from the lake. Sewage disposal is in turn emptied into the lake after poor biological treatment. The riparian rural communities in Kenya, Uganda, and Tanzania depend on the lake for their domestic water and livestock watering. There is a regular steamer service currently navigating between the major towns in Kenya and Tanzania.

Dams and reservoirs

The man-made lakes and reservoirs have been constructed at a very increased rate in order to store water for domestic use, hydroelectric power generation, and irrigation. Recently the value of hydropower potential has been emphasized by the world energy crisis. According to Szesztay (1973), 10% of the stream flow in the world was regulated by dams in the 1960s and the proportion is expected to reach 66% by the year 2000.

Dams and reservoirs have produced great benefits to the many African developing nations where they are built. They supply the energy required for heavy industries (e.g., aluminum refining in Ghana, and copper smelting in Zambia and Zimbabwe); for light industries (e.g., textile, cotton, coffee, tea, and sugar processing in Kenya); and for urban and rural electrification. Water stored behind the dams is used for irrigated agriculture (especially in Egypt from the Lake Nasser) and helps to realize the promise of high yielding grains by providing the controlled water supply essential for their successful cultivation. Large dams have become symbols of modernization and a powerful force for political unification (Freeman 1974).

PROBLEMS OF TROPICAL AFRICAN LAKES AND RESERVOIRS

Tropical African lakes have problems which are unique to the climatic conditions and life styles in the region. The tropical Africa belt (between 20°S and 20°N) has two major climatic seasons, dry and wet seasons, with little variation in local daily temperatures, usually about 20-50 °C. The high temperatures and the alternating dry and wet seasons influence the prevailing environmental conditions.

The major problems of the tropical lakes and reservoirs are drought and floods resulting in fluctuating water levels, siltation, agrochemical and industrial pollutants, water weeds and other floating hydrophytes, fish kills and overfishing, and water-borne and water-related diseases.

Foreign fish introduction in some lakes and reservoirs have caused scientific and political controversy as regards their ecological merits. The following sections will review, though not exhaustively, some of the major problems encountered in some of the lakes and reservoirs in tropical Africa.

Lakes

Problems associated with fluctuating water levels

The problem of drought can be appreciated by looking at the conditions in Lake Chad and the Rift Valley lakes in Kenya, especially during the past five or so years. Unreliable weather patterns resulted in prolonged drought and subsequent drop in lake levels. It has been reported recently (H. Mustafa *pers. comm.*) that Lake Chad has had insufficient rain for the past 10 years. The inflowing river, the Chari, has also been excessively abstracted for water upstream, thus reducing the amount reaching the lake. The situation is currently very critical.

In almost all the Rift Valley lakes, the lake water levels have been gradually, dropping since 1981. Figure 2 shows the trend of lake level changes in some Kenyan Rift Valley lakes. The causes of the lake water level decline has not been adequately explained apart from the belief that poor rainfall in the region was partly responsible. It has been suggested by some geologists (Nyambok *pers. comm.*) that the Rift Valley floor cracks increase by more that 1 cm annually due to volcanic and other tectonic activities. These activities could easily open up fissures in the valley floor and lake basins from which water may continue to seep out. Coupled with poor replenishment from the catchment, seepage may explain some of the water level decline. Lake Nakuru almost dried up completely in 1986/87 (Figure 2) resulting in the temporary loss of millions of flamingos that are characteristic of the lake.

Similarly, water levels in Lakes Turkana and Naivasha decreased significantly resulting in decreased fish yield in those years. In Lake Naivasha, the problem of declining water level from climatic changes is made worse by water abstraction by the hundreds of riparian farmers, who use the fresh lake water for sprinkler irrigation of flowers, lucerne, grapes, and grain crops. The impact of these agricultural practices has not yet been assessed.

By way of the Nile outflow, Lake Victoria presents unique and special environmental and economic problems along with its many uses and benefits. The Owen Falls dam was constructed in the 1950s at the very outflow of the River Nile. The main purpose of the dam was to provide hydroelectric power to Kenya and Uganda. The creation of the Owen Falls dam, however, has since created major lake problems with secondary impacts in Uganda, Kenya, and Tanzania. In 1961/64, exceptionally high rainfall was experienced with a subsequent rise in the water levels of Lake Victoria (Figure 3). Water levels rose by about 3 m (cf. normal seasonal water level increases previously of 0.2 to 0.4 m) and subsequently large areas around the lake were submerged. Large shoreline areas of wetlands were created by the inundation around the lake. Many people in Uganda, Kenya, and Tanzania living on the shores of the lake lost their farmlands without any form of compensation. One particularly disturbing example was the permanent inundation of the seasonal floodplains of the Yala River basin in Kenya which resulted from the rise in the lake level. To date an area of 170 km² is a swamp at the delta of the Yala River. Nearly 1,000 people lost their land to the swamp. Of this submerged swamp land ca. 40 km² remains about 3 m below the present lake level (1,140 m above sea level. While efforts are currently underway to reclaim ca. 120 km² of the swamp for agricultural use, the area below 3 m cannot be reclaimed.

Although the new swamps and littoral wetlands may have increased the breeding and nursery grounds for fish, especially the tilapia and lung fish, many human health problems accompanied the submergence. There was a drastic increase in the density of aquatic snails, particularly the bilharzia disease vectors *Bulinus sudanica* and *Biomphaleria pfeiferi*. An increase in cases of bilharziasis was also reported 1 to 2 years after the submergence of new areas all around the lake (P. Olindo *pers. comm.*).

Although most people attribute the rise in Lake Victoria water level to climatic changes alone, it is doubtful as to whether the engineers who regulate the Nile River outflow at the Owen Falls dam did not intentionally take advantage of the abnormally wet season and raised the outflow gates at the dam (in order to increase water storage capacity of the lake) by 3 m. If this were not the case, by the dry season in 1986/87 (see Figure 2), the lake water would have dropped down to its previous level prior to 1961.

A special problem associated with changes in water level in the whole of Lake Victoria is floating and drifting papyrus, *Cyperus papyrus*, islands. These islands are occasionally a major nuisance not only in Lake Victoria, but also in Lakes Kioga and Naivasha. In northern Lake Victoria at the Owen Falls hydroelectric dam the floating vegetation islands are common. These are also a nuisance in the Winnam gulf where they destroy fishing nets and hamper navigation. In Lake Naivasha, the water fern *Salvinia molesta* was accidentally introduced in the 1960s. To date the weed is still a problem in the lake and it covers relatively large areas of the lake surface, especially during high water levels. Thus it interferes with sailing, navigation, boating, and fishing activities in the lake. It also clogs water pumps and depletes dissolved oxygen in its undergrowth areas. Salvania, however, causes little problem when the water level declines. Most of the salvania mass is left stranded on the drawdown area and backwaters with the receding water level.

Problems of declining fisheries

Another specific problem of tropical African lakes is declining fisheries. In about 1955 the colonial British government in Uganda introduced the predatory Nile perch (*Lates niloticus*) into Lake Victoria through Uganda water at Jinja (Greenwood *pers. comm.*) The Nile perch is a fast growing fish and usually attains a length of ca. 2 m and weighs ca. 100 kg. Nile perch is indigenous to Lakes Albert, Kioga, and Turkana where, through the course of time, it has evolved along with other fish communities into stable ecological balance.

The introduction of the Nile perch into Lake Victoria was one of the world's biggest ecological mistakes. Since its introduction, the fish has grown fast and spread in the Lake. The perch has in fewer than 30 years preyed on, foraged, and nearly eaten out most of the smaller fish species, especially *Haplochromis* spp. and Tilapia *Oreochromis* spp., to a very low level. As a result of predation from the Nile perch, there is very little Tilapia fish available for the riparian tribes who depend on fish as their main food source.

The problem of declining fisheries from the Nile perch predation has been made more serious by overfishing by the local people. Human population around Lake Victoria has nearly trebled in 20 years, putting added pressure on already diminishing fisheries. Fishing gear includes gill nets, seine nets, and mosquito nets. The increasing use of mosquito nets in tropical African lakes has been detrimental since the nets catch small fish. Fish data from the Kenya waters of Lake Victoria show that the percentage of fish by weight are 54% *Lates niloticus* (Nile perch), 17% *Engraulicyris* (omena), 4% *Orechromis niloticus*, 4% *Mormyrus* sp., and 4% *Bargus* (Burgis and Mavuti 1987). Trawling in the gulf in 1985 gave 98% of the fish caught as Nile perch and the rest as other fish with only a few tilapia. Nile perch is increasingly becoming a food acceptable to the local people as tilapia becomes scarce from predation and overfishing.

In recent times, there have reportedly been frequent and massive fish kills in Lake Victoria and Lake Chad (Beadle 1981). The fish species that have been most affected are the Nile perch and Tilapia species. The problem of fish mortalities in the lake subsequently caused great concern to the people and government of the riparian countries. In Kenya, a task force of environmental scientists was commissioned in 1985 by the Kenya National Academy of Sciences to investigate the problem of the frequent mass deaths of fish in the lake. This group of scientists reported, after exhaustive research, that the fish kills were caused not by environmental pollution but mainly by natural limnological phenomena, in particular, oxygen depletion in the water mass after storms and turnover of the lake. Because of oxygen depletion and possibly other associated and synergistic factors, the fish become stressed, vulnerable and eventually die of asphyxia. The problem is still being investigated further.

Water quality problems

In tropical Africa today, modern agricultural enterprises and urbanization have rapidly developed with the thrust of international modernization, industrialization, and economic development. These development activities have had major impact on the water quality of the lakes in tropical Africa.

The water quality of Lake Victoria is currently threatened by, among the many agricultural activities in the catchment, agrochemicals, waste water, and agro-industrial effluents. This problem is particularly serious in the Kenya catchment of Lake Victoria (Machooka *et al.* 1988). The catchment of Winnam gulf is intensively farmed and numerous processing factories for agricultural products have developed very rapidly in recent years. The factories include coffee, tea, and sugar processing factories and paper and pulp processing industries. The semi-treated effluents from these factories are discharged into the rivers and down into the lake. The impact of these agro-industrial effluents is presently not known but is being investigated (Machooka *pers. comm.*). In addition to the effluents, silt loads washed down the major rivers into the lake from the tea and sugar farmland causes great concern. Siltation and nutrient load into Lake Victoria is currently showing signs of eutrophication and increased conductivity (cf. main lake at 120 μs/cm and Winnam gulf at 150 μs/cm).

In Tanzania the majority of pollutants into Lake Victoria are urban industrial effluents from soap, tannery, textile, coffee, and sugar factories, as well as municipal sewage. However, most of the industries have facilities for treatment of their effluents before discharging them into the lake (Madati *et al.* 1982). Residual runoff of pesticide pollutants from the cotton and coffee growing riparian areas is also common. Most of the Lake Victoria waters are relatively unpolluted although water quality data in that region are very scarce.

From the Uganda side major pollution problems come from sewage from urban centers, organic effluents from agro-based industries, heavy metal pollution from light urban industries, and agrochemical pollutants, especially pesticides and fertilizers, from agriculture and public health projects (Bungenyi 1982).

These pollutants flow into Lake Victoria through Rivers Kagera and Katonga and also from the lake shore runoff and town effluents; otherwise there are few rivers draining into the lake from the Uganda catchment. It is especially notable that in most of the lake cities, e.g., Kampala (1 million people), Jinja (500,000 people), and Entebbe (400,000 people), there is partial treatment of sewage effluents through an aeration-activated sludge process and biological oxidation ponds. In some lake towns, however, e.g., Majanji and Bikakate, raw sewage empties directly into lake bays (Okedi 1982), posing serious health hazards to the local people. The environmental effects and problems from draining sewage directly into Lake Victoria would include deoxygenation from increased BOD of the water, eutrophication from the rich nutrient water, leading to explosive growth of algae, and introduction of pathogens arising from untreated human excreta and wastewater, which could cause gastroenteritis and other diarrheal diseases.

Organic and inorganic poisons are a major problem in Uganda lakes but their effect is not yet known. For instance, in Jinja, pollution has serious effects on the lake's water quality. The organic and inorganic poisons come from several industries, particularly a copper smelting factory producing copper, cadmium, and cobalt poisonous wastes. Toxicity levels of these poisons, however, tend to vary depending on whether they impact on plankton, microinvertebrates, fish or man. Their effects are usually cumulative up the trophic levels and may reach lethal concentration in some cases.

Aquatic problems caused by extensive use of pesticides on agricultural crops in the northern portion of the Lake Victoria basin, especially on coffee and cotton, have not been assessed. The pesticides include DDT, Lindane, Malathion, endosulfan, dieldrin, Bayluscide, and frescon among others. The pesticide residues finally end up in Lake Victoria waters where their effect tends to be cumulative.

Lakes George and Edward in northern Uganda have special problems from copper waste products which find their way into the lakes' water systems. The wastes, carried down to the lakes by River Nyamwamba (Bungenyi 1979, 1982), are mainly from Kilembe Copper Mines and include cobalt and cadmium. Investigations carried out in Tanzania waters show that pesticide pollution is a major environmental problem. Appreciable levels of DDT, DDE, endosulfan, dieldrin, and lindane have been found in fish oils and lake water (Madati *et al.* 1984) although the problems are localized around Mwanza on Lake Victoria.

PROBLEMS OF DAMS AND RESERVOIRS

Man-made lakes and reservoirs in tropical Africa have created many environmental and human problems which are unique to the region and which must be weighed against their benefits. Water weeds have affected tropical reservoirs with varying degrees of severity. In the Kariba dam on the Zimbabwe/Zambia border, infestation with water fern *Salvenia molesta*, has interfered with smooth utilization of the reservoir. The weeds obstruct navigation and fishing activities, clog penstock intakes to the turbines, and provide habitats for a number of vectors of water-related diseases, especially malaria and schistosomiasis. The alarming spread of schistosomiasis among the populations in tropical Africa has been a consequence of the spread of the intermediate snail host in man-made lakes and downstream irrigation schemes. This has been particularly serious among the people around Volta and Kainji dams in West Africa, Kariba and Cabora Bassa in Southern Africa, and Nyumba ya Mungu in Tanzania. Around the populations in the vicinity of the Tana River dams in Kenya the problem of water-related diseases is not yet severe. This could be attributed to the poor soils and subsequent lack of irrigation activities downstream of the Tana River Cascades. The problem of siltation in these African dams is severe, especially in Kariba and Masinga dams, as well as the West African reservoirs.

Another major and relatively unique problem of dams and reservoirs in tropical Africa is resettlement of the great numbers of people who must be moved from the reservoir areas (see Table 2). From the West African reservoir areas (Volta and Kainji) and the Kariba reservoir area, an average number of 65,000 people from an average area of 8,843 km² were moved and resettled elsewhere. From nearly 1,800 km² in the Ivory Coast, 100,000 people had to be resettled to find room for the construction of the Akasombo dam. The Aswan High Dam for Lake Nasser in Egypt saw the displacement of more that 120,000 people from 5,000 km². Another 1,500 people were displaced by the Masinga dam and reservoir on the Tana River.

Resettlement of people is a very costly problem both socially and economically. Most African people live in culturally defined families and tribal set-ups which are dismantled when people are moved and resettled in new areas. In tropical Africa most people live in the fertile river valleys and depend on the rich alluvial floodplains for subsistence agriculture and water supply. The people have to be moved out of these rich farmlands when reservoir areas are inundated, regardless of the huge resettlement costs.

Most of the dams in tropical Africa are constructed in arid or semi-arid climatic zones. The potential for evaporation in these areas is very high. Consequently the tropical African reservoirs suffer from loss of water and reservoir capacity through increased evaporation. Other ecological problems are mainly sedimentation, obstruction of fish immigrations, and disruption of the downstream hydrology and aquatic systems especially floodplains and estuaries (Freeman 1974).

The problem of sedimentation and therefore loss of reservoir capacity is particularly serious. The Tana River cascades in Kenya comprise five dams and reservoirs, namely Masinga, Kamburu, Gitaru, Kindaruma, and Kiambere in that order downstream. Kindaruma and Kiamburu were the first to be constructed in the 1970s. Later in 1981 the Masinga dam came as a major relief to the Kamburu dam which was for 10 years chocked with silt from the vast catchment on Mt. Kenya and Aberdares Mountains. Masinga Dam currently acts as a silt check dam reducing siltation problems in the downstream dams. The problem of water-borne and related diseases is not very severe in the Tana reservoirs but it is ever present. Malaria and bilharzia however are prevalent in the population near the cascades.

MANAGEMENT AND CONSERVATION

Lakes

In a broad sense there are two main strategies for the management of lakes and reservoirs: management of the catchment of lakes and reservoirs, and management of the lakes and reservoirs themselves. In practice and for successful management, the two go hand in hand.

Management of the catchment of lake reservoirs

Across tropical Africa, most of the traditional and modern management practices are geared toward rehabilitation and conservation of the watershed, lake or reservoir basin, and catchment.

Lake Chad has been faced with great management paradoxes in recent times. As the lake water level declines, the need to conserve the upstream rivers and regulate their flow in order to recharge the lake becomes more important. Water abstraction from the feeder rivers is now controlled by Lake Chad Development Authority. Water usage is well monitored in the catchment. Recently there have been suggestions and proposals for interbasin water transfer. The proposals have been that, in order to maintain water levels in Lake Chad, from water from the Oubangi River on the border of

Central African Republic and Zaire at just above Bangui could be siphoned into River Chari by its southwestern tributary just above Bouca, a distance of 150 km. The feasibility of this proposal remains to be assessed. Similarly, in Kenya, the possibility of transferring water from the Athi River to the Tana River system to increase water capacity in the cascades has been considered by the Tana and Athi River Development Authority. While interbasin water transfers are feasible in wetter temperate climates, they may not be practicable in tropical arid areas where every single sub-catchment needs the available water.

Another management practice for the catchments is soil conservation by afforestation and modern agricultural practices. These are essential management actions which are widely practiced today across tropical Africa in order to reduce soil erosion and siltation into the lakes and reservoirs. In Lake Victoria catchment, particularly in the agricultural Kenya watershed and Burundi subcatchments, afforestation and bench terraces are common management techniques. Proper use of fertilizers and biocides is also controlled by the relevant authorities to protect the lakes from eutrophication. Sewage and waste water from the major towns around Lake Victoria are treated before discharge into the lake, most commonly through open biological activated sludge and oxidation ponds. These are rather efficient in the hot tropical climate, and are very easy to construct and manage. Sewage in some cities, e.g., Kampala, is not effectively treated but does pass through papyrus swamps before entering Lake Victoria. Other catchment management practices include water rights apportionment and regulation; silt check dam construction on rivers with excessive silt and sediment; and enforcement of water quality standards regarding industrial effluent disposal into the rivers. This is particularly so in Kenya where the number of agrochemical industries has increased recently with the increase in agricultural output especially in tea, coffee, sugar, textile and paper processing. These management strategies are practiced to protect reservoirs and lakes alike from siltation and cultural and agrochemical pollution.

The second type of management strategy are those practiced for specific problems of water bodies, although most are common. The problem of fish kills on most tropical lakes is a common natural limnological phenomenon that is a consequence of oxygen depletion, alga toxicity and asphyxia. There is little that can be done about natural catastrophes like these. Occasional deaths of large numbers of fish have been reported widely in tropical African lakes, especially in Lake Chad, Lake George, Lake Albert, and Lake Victoria (Beadles 1981). In all these lakes, the fish kills are directly associated with abnormally prolonged calm and stratified lake conditions followed by sudden violent stormy or windy conditions that mix the lake water mass to the bottom of the lake, bringing into suspension oxygen-consuming organic matter. The depletion of dissolved oxygen conditions that follow then result in massive and widespread fish kills in these lakes. Fish kills are uncommon in reservoirs.

The problem of declining fisheries through overfishing in most of tropical Africa's lakes and reservoirs has prompted stringent management actions. The most common of these is regulation of fishing gear, especially the mesh size of gill nets, to a size that does not capture the breeding stocks. This is the case in Lakes Victoria, Turkana, Naivasha, and Chad. The implementation of fisheries policies and regulations in Africa today is not easy because it is too expensive to enforce. The use of mosquito nets is currently banned in most lakes as the nets catch small juvenile fish and destroy fisheries. On Lake Naivasha and Lake Victoria, certain littoral areas are conserved as breeding and nursery grounds and are protected from any form of fishing. Punitive legal measures are taken against those who defy the regulation.

Another example of management efforts has been introduction of foreign species of fish to improve fishery resources. In Lake Kariba, the Clupeiid fish 'ndagaa' *Limnolhrisa miodon* was introduced from Lake Tanganyika. To date the mainstay of the lake's fishery (about 35,000-40,000 metric tons annually) is from this fish. Over one thousand people are employed in this lucrative fishery. According to C. Magadza (*pers. comm.*) the management of the fisheries resources of Lake Kariba has been by trial and error. The gill net fishery has decreased and the pelagic fishery is effectively monitored and controlled by a licensing system and compulsory returns of all fishermen. Still, policing of illegal fishing and collection of management data from the fishery are difficult because of the distances involved and because the peasant fishermen do not appreciate the need for conservation.

Introductions of Tilapia *Oreochromis leucostictus* and largemouth black bass (*Micropterus salmoides*) into Lake Naivasha in 1925 and the 1950s respectively, have been a major success. To date the lake's fishery is based solely on these two species.

Not all fish introductions are such great success stories. The introduction of the Nile perch (*Lates niloticus*) into Lake Victoria in 1955 has caused great controversy and unknown ecological imbalance especially in relation to the indigenous tilapia fishery. It is claimed that the predacious Nile perch has almost wiped out the tilapia *Oreochromis* spp. and *Haplochromis* spp. from the lake. While this may be so, these assertions must be weighed against the contribution of overfishing to the decline of the tilapia. Nile perch today provide an important alternative fishery resource for the lake although its impact is still a subject for debate. Introductions have, however, been one of the better ways of improving reservoir fisheries and may be recommended only for reservoirs but not for natural lakes.

Control and eradication of water weeds has been another key issue in lake and reservoir management in tropical Africa. A good example of this is the case of the common water fern weed *Salvinia molesta* in Lake Kariba and Lake

Naivasha. *Salvinia* was accidentally introduced into Lake Kariba from the upper catchment during the feeding phase of the dam. By 1969, the weed covered 25% of the reservoir choking fisheries and obstructing navigation. As a management action, a South American grasshopper *Paulinia* sp. was introduced as a biological control, but its effect on the *Salvinia* weed has been negligible. *Salvinia* has however declined in Lake Kariba because the fluctuating water levels leave a large and dying biomass of *Salvinia* in the drawdown area.

In Lake Naivasha, chemical control of *Salvinia* was tried several times in the 1970s but without success. Although aerial spraying with paraquat herbicide was recommended, it was later abandoned because paraquat is lethal to other aquatic life especially fish. With the lake's fluctuating water level, however, the Lake Naivasha *Salvinia* problem seems to be reduced and regulated, and only becomes problematic during periods of high lake water levels. The management of Lake Naivasha has been recently reviewed by Harper *et al.* (1990).

CONCLUSION

The uses and problems of lakes and reservoirs in tropical Africa are many and varied. The deteriorating climatic conditions, increasing human population, and subsequent pressure on land for agriculture and industrialization pose a great threat. There is a great need for environmentally sound management of the aquatic resources for sustainable development in tropical Africa today.

REFERENCES CITED

Beadle, L. C. 1981. The inland waters of tropical Africa: an introduction to tropical limnology. Longman Publishers, London, UK.

Bungenyi, F.W.B. 1979. Copper ion distribution in the surface waters of the Lakes George and Idi Amin (Edward). Hydrobiologia 64: 9-15.

Bungenyi, F.W.B. 1982. Copper pollution studies in the Lakes George and Edward, Uganda: the distribution of Cu, Cd and Fe in water and sediments. Environmental Pollution 3(2): 129-138.

Burgis, M. J. and K. M. Mavuti. 1987. The Gregory rift. Pages 77-80 *in* M. J. Burgis and J. J. Symeons, eds., African wetlands and shallow waterbodies. Editions de l'OSTROM, Paris, France.

Freeman, P. H. 1974. The environmental impact of a large tropical reservoir. International Environmental Programs, Washington, D. C.

Harper, D. M., K. M. Mavuti, and S. M. Muchiri. 1990. Ecology and management of Lake Naivasha, Kenya, in relation to climatic change: alien species introductions and agricultural development. Environmental Conservation 17: 328-335.

Leveque, C. 1983. The ecology of Lake Chad. Unpubl. mimeograph.

Machooka, S. M., M. Omondi, D. Mshila, and L. Nyongesa. 1988. The water quality of Lake Victoria (Kenya portion) in relation to industrial location. Workshop Report, UNCRD/UNEP/ILEC. Nagoya, Japan.

Madati, P. J., E. Begere, D. Mosha, A. Moshi, H. Mongi, and E. Shikony. 1982. The current situation on water quality and pollution problems in Tanzania. Pages 33-35 *in* C. O. Okidi and P. M. Olindo, eds., The quality of water and its impact on the living resources of the Lake Victoria basin. A Workshop Report.

Okedi, J. 1982. Current threats of aquatic pollution in the Uganda sector of Lake Victoria basin. Pages 41-44 *in* C. O. Okidi and P. M. Olindo, eds., The quality of water and its impact on the living resources of the Lake Victoria basin. A Workshop Report.

Szesztay, K. 1973. Hydrology and man-made lakes. Pages 259-263 *in* W. C. Ackerman, G. F. White, and F. B. Worthington, eds., Man-made lakes: their problems and environmental effects. American Geophysical Union, Washington, D. C.

Talling, J. F. 1963. Origin of stratification in an African rift lake. Limnology and Oceanography 8: 68-78.

Table 1. Some important tropical African lakes. Main uses include: 1 = fisheries; 2 = domestic water; 3 = irrigation; 4 = tourism; 5 = navigation. Main problems include: a = fish kills; b = siltation; c = droughts and water level; d = municipal and agrochemical pollution; e = water related diseases; f = aquatic weeds and flooding.

Lake	Country	Area (km^2)	Conductivity (µs/cm)	Main uses	Main problems
Victoria	Kenya, Uganda, Tanzania	68,800	110	1245	abdef
Tanganyika	Tanzania, Zaire	13,500	600	1245	bcd
Turkana	Kenya	7,560	3,300	1245	c
Chad	Chad, Nigeria, Cameroon, Niger	8,000	180	125	abc
Kivu	Zaire	3,000	1,500	1245	e
Edward	Uganda	-	925	1245	abef
Albert	Uganda	5,250	735	1245	abef
Kioga	Uganda	200	200	1245	abef
Naivasha	Kenya	160	300	12345	bcdf
Nakuru	Kenya	42	20,000	4	bcd
Baringo	Kenya	45	900	1245	bc

Table 2. The major large reservoirs in tropical Africa. Main uses include: 1 = hydroelectric power generation; 2 = fisheries; 3 = domestic water supply; 4 = tourism and navigation; 5 = irrigation. Main problems include a = siltation; b = water weeds; c = water related diseases; d = agrochemical pollution; e = high water level fluctuations.

Reservoir date of closure	River	Country	Area (km^2) and Drawdown	Volume (km^3) and Fish capacity	Hydropower	No. of people resettled	Uses	Problems
Volta* (Akasombo) (1964)	Volta	Ghana	8,730 3m	14-165 40 mt	768	88,000	12345	ac
Kainji* (1966)	Niger	Nigeria	1,250 10m	11.5 10,000 mt	960	50,000	12345	abcde
Nasser *(Aswan) (1964)	Nile	Egypt	5,000 20m	132 10,000 mt	10^7/4r	120,000	12345	abcde
Kossou* (1971)	Bandama	Cote d'Ivoire	1,600 3m	20 16,000 mt	175	100,000	1234	bcd
Kariba* (1958)	Zambezi	Zambia Zimbabwe	4,300 13m	147 20,000 mt	800	57,000	12345	abcde
Cahora Bassa (1975)	Zambezi	Mozambique	2,700 32m	127 mt ?	4,000	?	12345	bcde
Masinga (1981)	Tana	Kenya	160 3m	2 1,500 mt	140	3,500	123	ade
Nyumba ya Mungu (1965)	Pangani	Tanzania	180 ?	2.5 ?	?	?	12345	c

*Sources: Freeman (1974) and Beadle (1981)

THE NEED FOR ENVIRONMENTAL IMPACT ASSESSMENT OF WETLAND PROJECTS IN AFRICA

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ABSTRACT

Of central importance is the question of whether environmental impact assessment is really an effective tool today in the third world. Does it effectively deal with the problems arising from management and development of wetlands? The cost of environmental impact assessment is normally a small percentage, about 1.5%, of the total cost of a project. The extent of the assessment, however, should be established relative to the economic status of individual countries under consideration and in line with prevailing local conditions. In practice there is little room for public confidence in the way most African wetlands are utilized and managed. To be effective, environmental impact assessment of projects must essentially be built early in the project so as to have effect at the stage when the design of the project is still open to change. This paper will take up several questions relating to the management of wetlands. Examples of projects in four African tropical wetland ecosystems are discussed.

INTRODUCTION

That we are dealing with an important development issue is no longer in doubt. Wetlands in the broad sense constitute many of the important rural regions slated for various types of future developments. Other development areas, especially urban regions, often include or border on wetlands. Almost all of the new major development schemes in Africa are located in river basins where the ultimate goal is to achieve control over the natural wetlands. Floodplains, marshes, swamps, bogs, and shallow lakes are to be regulated so as to create such artificial wetlands as reservoirs, rice plantations, irrigation canals, and sumps. Few people now question the concept of prior analysis--"examine before deciding"--and most large bilateral or multilateral projects include environmental assessment. What has increasingly come into question is not the assessment but the method (Printz 1981). Some common factors involved in methodology are cost, scope, expectations, and effectiveness; unfortunately these are often taken at face value. Given the present state of wetlands development, the following factors demand detailed consideration.

COST

The actual cost of impact assessment and environmental safeguards is generally a small proportion of the total cost of any development project, seldom exceeding 3% (World Bank estimate based on a review of 1,500 projects (Anon 1978)).

One of the more important aspects of cost is the fact that the elaborately detailed impact assessment required by law in developed countries (such as the United States) may be so expensive to undertake in a lesser-developed country that the project would be set aside as not being cost effective. The assessment usually done in such cases is often toned down to be more in line with "local conditions." This seems like a reasonable approach and it will succeed in many cases, but it does put a great deal of faith in the good judgment of policy makers, politicians, and developers. We now know that, at least in some cases, they are not worthy of such trust.

SCOPE

How far afield should any assessment go? In some developing countries where environmental nightmares may be the order of the day, even if a given assessment mitigates or reverses a very small portion of the overall environmental degradation, is this enough? What is to be done with the more pervasive environmental problems which often reverse what little good is accomplished by small local efforts? Some environmentalists recommend that after a particular assessment has addressed the immediate impacts (in terms that are easily translated into design modifications), it must then address secondary and long range effects and, in addition, must include some general actions which will raise the environmental consciousness of the general public. The present authors have seen assessments in which this is done, and in which each step toward immediate, secondary, long range and general action is accorded a priority, usually diminishing. This more intensive approach has two advantages: (1) it does allow for raising environmental consciousness and (2) it provides a means by which developers, engineers, and environmentalists can at least trade off options and come to some agreement on long term effects. As Ashby (1980) said, these issues are "conflicts between one kind of good and another kind of good; they are not simple duets between good and bad."

EXPECTATIONS

The general public often assumes that because environmental impacts are being considered during the design of a project, that this will lead to structural changes which will bring benefits to people living in the project area. Little do they know that the impact assessment may be brushed aside in the haste to complete a design already set in its final stage, perhaps even before the assessment is commissioned. Common sense tells us that if an impact assessment is implemented only after a project is started (even while the concrete is being poured!) its effect will be minimal. To be effective an environmental impact assessment must be pre-designed so as to have an effect on a project at a phase when the design is still open to change. Otherwise there can be nothing but false expectations.

EFFECTIVENESS

How effective have environmental assessments of wetlands been in the past? We would like to devote the remainder of this paper to this point. In particular we will use four environmental assessments of African wetlands to illustrate that there is little room for public confidence in the way these wetlands are generally being managed.

As examples we have chosen four cases: (1) a large development project (the Jonglei Canal) which was designed specifically to divert water from Africa's largest wetlands; (2) an intermediate size development project (the Kafue Gorge Dam) where a large, important river floodplain system was altered; (3) a smaller project (the Burundi Peat Bogs) where a small, very old wetland system is being managed; and (4) a medium project (the Yala Swamp) where reclamation through drainage has been ongoing for 20 years now.

The Jonglei Canal Project

The main channel of the White Nile at Juba (Figure 1) delivers 80 million cubic meters of water a day. The original "Equatorial Nile Project" submitted to the government of the Sudan in 1938 consisted of a complex series of dams and canals to allow an increase in river flow during peak rainy seasons. It was felt that the increased flow would be needed for irrigated agriculture as development proceeded. In 1952, a less complex, but still ambitious scheme was outlined, consisting of a canal which would divert flow from the channel before it reached the Sudd swamps (Figure 1) where 48% of the water enters. This diversion canal (referred to as the "Jonglei Canal") was the subject of an agreement by the governments of the Sudan and Egypt in which the Jonglei Canal Project was proposed in 1967 and approved in 1976. Moghraby (1982) summarized the goals of this two-phase project, with phase one to consist of the following.

1. Excavating a 369 km canal with a discharge capacity of 20 million m^3/day (slope of 7-9 cm/km, width 54 m, depth 4 m average).
2. Equipping the canal with a head regulator to be located at Bor and a tail regulator at the exit close to Malakal, both incorporating navigation locks.
3. Dredging and raising banks of River Atem (a subsidiary river close to the White Nile), and equipping it with a regulator.
4. Excavating a second canal with discharge capacity of 5 million m^3/day.

Phase one was completed in 1983 and 280 km of the main canal had been dug (A. Moghraby *pers. comm.*). The second phase was to include the following.

1. Increasing the capacity of the main canal to discharge 43 million m^3/day.
2. Using the equatorial Great Lakes (Victoria, Edward, and Albert) for long-term storage to equalize natural flow in the White Nile.
3. Improving the carrying capacity of all major channels (e.g., Bahr el Jebel and Bahr el Zeraf) to allow a flow of 75 million m^3/day.

Moghraby (1982) advocated the continuation of phase two. He reasoned that a large amount of time and effort had already gone into this project and would increase the amount of water available for agriculture, but also pointed out that the project "aims at developing the economy and way of life in an area that had been suffering from primitiveness and an almost non-existent infrastructure." The proposed phase two of the project, however, had enormous effects on the whole central portion of the southern Sudan. The Nile floodplain varies from 6,000 to 100,000 km wide and provides a home to about one-half million people and seasonal access routes for large additional numbers of people and livestock. Moghraby felt that future needs and the present state of knowledge of the region did not justify undertaking phase two of the project.

This project was and still is one of the largest undertakings of its kind in the Third World. Its ultimate goal was the complete control over one of the world's largest wetlands. Because of local civil war in the Sudan, however, phase two has never taken off and the project has since stopped.

The question is, what was done prior to implementation in the way of environmental assessment? The first comprehensive report on the project appeared in 1956 as a large (861-page) document (Anon. 1954). This has been said to be the first "environmental assessment" of a development project. It was certainly a landmark document in setting out baseline information. In turn, it has been cited many times over as the most reliable account of the ecology of the Sudd region (Rzoska 1976). It certainly was an ambitious undertaking for the time and place. In fact, prior to the actual construction of the canal more details were felt to be needed about livestock and game animal migration in the region. With this in mind a "range ecology survey" in 1978 and a "swamp ecology survey" in 1980 (Meffitt-Babtie 1978, 1980) were conducted in the Sudd well after the start of the project.

The first of these surveys included baseline data on present livestock abundance and distribution of people and livestock during wet and dry seasons. It also included sections on: veterinary aspects (growth, production, quality and diseases of animals); rangeland production (distribution of grasses, nutrient value, etc.); water supply (location, distribution, yield, and frequency of existing and potential sites); and range ecology (burning, succession, etc.). Because the earlier study in 1954 contained much background information, the 1978 study was easier to devise. It concentrated more on the actual canal region and therefore seemed to be a more typical assessment of present conditions. Also because impacts on migration routes, game animal habitats, and human settlements are always more dramatic, it was easier for this survey to predict short and long term effects. There was some earlier information on which to build a time frame. Nevertheless, the survey still, by necessity, left out many details of the design and interventions which in the future could create important adverse impacts.

The second survey in 1980 proved to be of a completely different nature. First, it could not rely on earlier ecological work because detailed quantitative studies did not exist. Second, most of the information to be collected was basic ecological data on tropical wetland ecosystems, that is, primary data. Given the enormous geographical area to be dealt with, it was only possible to concentrate initially on a transect starting just east of the canal survey line at Kongor village and proceeding to a Nile river channel, the Bahr el Zeraf (Figure 1).

Both of the surveys were completed by 1983 and were subsequently considered by government policy makers. Information from the 1978 survey was used to modify the canal design somewhat. Both surveys must really be considered in the future as baseline surveys, because they do not constitute an assessment in themselves and can not be used to modify the original project design. What of the earlier 1956 comprehensive study? This study was also necessarily concerned with collection and analysis of baseline data. Thus, none of the studies or surveys really constitute an "environmental assessment" as we commonly use this term today.

A proper environmental assessment would have been carried out after the project activities had been identified, but prior to the final design. The output of such an assessment should be of immediate benefit in terms of the engineering design. It should also apply generally to long term planning about such topics as control of aquatic weeds, development of national parks, planning and management of wildlife reserves, pilot projects in community water supply and sanitation, watershed management, and management of expected changes in the social and physical environment when the project proceeds. For example, all of these environmental considerations were incorporated into the development plan for the Mahaweli River Basin in Sri Lanka (Printz 1981) and were included in the environmental assessment carried out there. This basin is much smaller in area (4,000 km²) than the region to be affected by the Jonglei Canal (50,000 km²).

Aside from the lack of long-term environmental analysis, this project lacked an assessment that could have considered the immediate impacts, especially; (1) an impact matrix; (2) an international documentation and information survey for the basin; (3) assessment of existing institutional capacity for monitoring and mitigating the impacts; (4) a comprehensive statement of the existing environmental problems facing the region; (5) a review of the pre-feasibility design in relation to existing baseline environmental data; (6) an environmental risk/benefit analysis; and (7) proposed modifications in the project design.

Given the fact that this approach was not used and that the canal would have been completed without adequate environmental assessment, we could only hope that the wetlands involved would be stable enough to survive, but the civil war took its toll on the project. So what next?

Kafue Flats

The Kafue Flats are typical of East African wetlands found along river courses, where the floodplain contains ponds, pools, swamps, and seasonally-flooded grasslands. Prior to the construction of the dam at Kafue Gorge below the flats, several studies and assessments were carried out. The result was a predictive model (White 1973) designed to show how the river and floodplain would react once the dam was closed. The general prognosis was good. After dam closure there would be a certain degree of inundation of the floodplain but with construction of the second dam (at Meshi Teshi above the flats) virtually complete control of the basin would be achieved. A regular seasonal flooding of the flats would allow the wetland ecosystem to continue functioning as before. In this case, however, a series of natural and technical problems arose that overrode these careful plans. First, the rains expected during normal years failed for some time, forcing the managers to hold back river water for power generation over the long dry period expected to follow. This resulted in an excessively long period of inundation of the flats. Subsequently, the Meshi Teshi Dam developed structural faults because of unexpected ground movement activity and had to be drained. The flats, rather than remaining as a seasonally-inundated wetland system, became a permanent sump for emergency water storage.

Obviously the events and technical difficulties that occurred were beyond anyone's control, and in this case careful prior analysis was carried out after an environmental assessment. A development project has adversely affected a natural wetland system; can this be avoided in the future? If so, what is to be done? Ashby (1980) would have the engineers build in fail safe protection. As he points out, natural ecosystems are products of millions of years of evolution. They have symbiotic networks, food chains, recycling pathways, and so on, all of which result in a natural homeostasis. Man-made systems often lack the fundamental quality seen in natural systems, a built-in stability. Using Ashby's reasoning, we would advocate that in the initial design, environmental engineers should have used a more open model, one with a larger degree of flexibility even though it might have allowed a larger loss in the degree of management. In tropical developing countries there is often a lack of the available machinery of infrastructure; when catastrophe strikes resources can not be mobilized quickly enough to cope efficiently with the impacts. In the case of Kafue, hindsight is easy, but perhaps the most important lesson learned is that single hydrological models are not enough when Africa's large wetlands are at stake.

The Burundi Peat Bogs

The recent need to develop energy resources in developing countries has turned attention toward peat deposits. Large deposits exist in the swamp forests of Zaire, the papyrus swamps of central Africa, and the fen bogs of Rwanda and Burundi. Several peat projects have been recently started in Africa with different degrees of success. In Burundi, a large project was implemented through a parastatal body. This project involved peat extraction from six bogs ranging from 2 to 100 ha. They are high altitude sedge fen bogs (1,800-2,400 m altitude) which have been described previously by Deuse (1966). Several of the bogs have been used for peat since 1971, but the project sought to expand operations in order to provide an alternate fuel source while forestry plantation efforts were starting up. An environmental assessment was carried out in 1979 by a multidisciplinary team (Gaudet 1980) in order to consider in detail bog habitat, biota, water quality, drainage, present and projected nutrient loading, conservation aspects, socioeconomic impacts, effects on health and ground water, immediate environmental consequences of peat use on the general public, long term consequences, use of alternative fuels, and mitigation, especially bog reclamation. The design of the project incorporated almost all of the findings and recommendations for mitigation of short term effects. In this case the assessment was of use in modifying project design. It adequately predicted the project impacts and provided for mitigation.

The Yala River Swamps

In Kenya there is a great need to develop agriculture for food production from the few suitable ecosystems, in order to improve human welfare, but what policy makers seem to have forgotten is that the responsibility to safeguard and conserve animal and plant species as well as their habitat lies squarely on their shoulders. The economic justification for conservation is most easily appreciated when species have a monetary value, but this economic consideration is not always possible and careful interpretations are necessary to demonstrate value (Carpenter 1985). When landscapes and particularly swamps are disturbed by human beings, many plants, fishes, birds, insects and other animals may lose their home habitats and life support. Whatever the circumstances prompting swamp drainage and reclamation, a thorough environmental impact analysis is essential to achieve proper perspectives on the structure and function, and usefulness and advisability of such developments prior to any drainage activities. This, however, was not the case in the drainage and reclamation of the Yala Swamp. Prior to the initial drainage and partial reclamation of the swamp by canalization and diversion of the Yala river in 1970-71 (International Lake Environment Committee 1975) little or no attention was given to environmental/ecological issues and impacts of the reclamation and subsequent agricultural developments. Indeed no form of environmental impact assessment was conducted. An environmental impact assessment for the current proposal to reclaim area II still has not been undertaken even as planned, at least not to the knowledge of the authors.

The Yala Swamp is unique yet typical of tropical African floodplain wetlands. It is unique in that it combines both lacustrine and riverine characteristics by containing within it some of the most important antique lakes containing the endemic Lake Victoria fauna. It is a typical African floodplain wetland in that more than 90% of its vegetation is tall and luxuriant stands of rooted papyrus reeds (*Cyperus papyrus*). The papyrus reeds act as silt traps and as natural filters of biocides and fertilizers originating from the adjoining agricultural catchments. Thus these papyrus swamps keep at bay nutrient enrichment of the receiving lakes.

The present extent and size of the Yala Swamp on the northeastern shores of Lake Victoria is shown in Figure 3. Before its partial reclamation in 1970-71 (Area I) the Yala Swamp was almost entirely a permanent papyrus swamp covering an area of about 20 km by 8 km. The Yala River proper followed numerous courses through the swamp area before it was diverted into the present course by a channel leading to the southern extremity of Lake Kanyaboli. From there it now filters through the papyrus swamp into small channels to enter Lake Victoria near the southern end of a sand bar between the lake and the swamp.

Before the partial drainage and reclamation, the swamp covered an area of approximately 16,500 ha. excluding the open waters of Lakes Kanyaboli, Sare, and Namboyo. Since the construction of the diversion canal in 1967-70 the section of the swamp that dried out is referred to as Area I and the remainder of the swamp which is still flooded has been described as Area II and Area III.

Most of Area III reportedly lies below the current Lake Victoria water level from which it is separated by a 5 km long sand bar. This area covers about 6,000 ha. which were flooded between 1920 and 1964. The swamp vegetation and soils are therefore relatively very young. Area II is between Area I and III and covers about 9,000 ha. It is proposed to be reclaimed by gravity drainage. Area III can only be reclaimed by pumping and empoldering. A few high spots in the present swamp occur as islands and remain relatively dry during periods of low water flow into the Yala River.

Lakes Sare, Namboyo, and Kanyaboli are perhaps the only free water pressure points subject to environmental disruption in the Yala Swamp ecosystem. Except for Lake Kanyaboli which has gradually undergone dramatic environmental change all the other open water has been little influenced by the diversion of the Yala River in 1970.

The watershed of the Yala Swamp covers a catchment area of about 2,600 km². This catchment includes some of the densely populated and intensively cultivated agricultural areas of Kapsabet and Nandi Districts. The catchment also includes some of the poorly formed dry lands in Siaya Districts from which heavy loads of silt are washed down into the Yala River during the rainy seasons. Along its 200 km water course to Lake Victoria, the Yala River traverses through smaller swamps and wetlands in the upper and middle courses before discharging into the Yala Swamp.

Lake Sare is located in Area III and Lake Namboyo is in Area II (Figure 3). Lake Sare is about 4 km² in surface area and is surrounded by papyrus swamp. Water flows out into Lake Victoria through a culvert near the southern part of the Got Agutu sand bar. Ecologically this lake is influenced directly by the flow of the Yala River and Lake Victoria.

The fish fauna is similar to that found in the open water of Lake Victoria, although with some riverine species. The most dominant fish species are *Oreochromis niloticus, O. leucostictus, O. variabilis, Haplochromis* spp., *Protopterus aethiopicus, Synodontis victoriae, S. afrofischeri*, and *Clarias mossamabicus*. The local fishermen have confirmed that the lake has already been infested with the carnivorous Nile perch (*Lates niloticus*). The absence of Oreochromis esculenta from Lake Sare as well as Lake Victoria is noted with great concern.

The trend in the limnological properties of Lake Kanyaboli has been disturbing since 1981 The diversion of the Yala River and the construction of the protection dike, has gradually the salinity of the lake. In 1981 the electrical conductivity was between 60 and 600 mS/cm. In 1994, electrical conductivity values obtained by the author were between 360-520 uS/cm. This increase in conductivity clearly indicates that the lake is gradually becoming more saline due to the river diversion and separation from the main swamp.

At present Lake Kanyaboli is a very important nursery ground and refuge area for many species of fish and birds. In particular, the lake is the only water body now known to contain appreciable populations of the Lake Victoria indigenous tilapia species Oreochromis esculenta and several other Haplochromis species.

The fish and fisheries of Lake Kanyaboli are dominated by cichlids which are rarely found in the open Lake Victoria. These include *O. esculenta, O. niloticus*, and the Haplochromis species. Other important fish species are Protopterus aethiopicus (kamongo) and the catfish *Clarias mossamabicus*. The fisheries of Lake Kanyaboli are therefore unique and represent those of Lake Victoria before the introduction of the Nile perch Lates niloticus in the late 1950s by British colonial fisheries officers through Uganda waters at Jinja. The Nile perch has not yet reached Lake Kanyaboli.

One becomes weary of the environmental disruption of Lake Victoria and its wetlands in the name of development. First development of the area affected Lake Victoria tilapia fishery and secondly, the invaluable lacustrine and riverine wetlands of the lake. The need, therefore, to conserve and protect some of the swamp and lakes cannot be overemphasized. The decision to drain Area II has already been reached. It would therefore seem opportune and advisable for planners and decision makers to recognize the dire need and importance of conserving and protecting at least Area

III and the swamp lakes in, more or less, their natural state. The consequences of reclaiming all the swamp would be disastrous to the total ecology and fisheries of Lake Victoria.

With regard to the environmental aspects in relation to health and sanitation, available information and suggestions do not fully apply to the general situation in the swamp area and to the phased type of land use (rain-fed or irrigated crop production) that may be envisaged or realized. Therefore these aspects should be given due attention again in the framework of the Yala Swamp development.

It is strongly recommended even at this study stage that Area III should never be reclaimed or disturbed in any way. This area should be conserved naturally to act, as it does, as a natural silt filter and sink for the agricultural pollutants from the catchment and the reclaimed land. This would guarantee the good quality of water from the Yala Swamp entering Lake Victoria. It will also be a refuge and new habitat for the swamp birds and animals as well as swamp fish that will be displaced from the reclaimed Area II. An environmental impact assessment is therefore imperative even at this late stage.

CONCLUSIONS

In the Burundi case the assessment was adequate and timely, and was taken up seriously during project design. Even at that there were still questions raised. Of special interest is the fact that this assessment necessarily used specialists from outside the country. There was no local expertise available in Burundi at the time to carry out this kind of work. This is a problem commonly seen in many countries in Africa. What is needed now is a major effort to create an infrastructure that will insure a positive approach to environmental management. Moreover even if we are assured that adequate assessments of projects are carried out, what assurance do we have that project management will continue to mitigate environmental impacts? At present we need some way of evaluating the effects of such an approach on developments. Does environmental management pay off? If so, is it economically significant enough to impress local governments? Does it exert enough pressure to maintain interest in long term impacts? Does it generate realistic environmental guidelines or an appropriate legal framework?

Several bilateral aid agencies are now aware of the magnitude of the environmental problems associated with projects in the developing world. But they are necessarily confined to specific projects; they can make only limited progress on a regional basis and can seldom override the effects of large capital projects not contained in their portfolios. International organizations, such as the United Nations Environmental Program, are concerned with global environmental effects but are limited by mandate in their degree of project involvement. Other agencies, such as the World Bank, are in an ideal position to help coordinate, direct and take charge of the major environmental management efforts needed in developing countries.

In a news article the World Bank stresses that it is trying to build environmental concerns into given projects (Anon. 1982), including the provision of appropriate protection and/or mitigation measures. However, J. Lee in that article (*op. cit*) makes the point that no amount of surrogate activity can compensate in developing countries that lack the capacity to define, analyze, and effectively cope with environmental impacts. Until this capacity is in place wetlands will remain susceptible to the impacts of modern development.

REFERENCES CITED

Anon. 1954. The equatorial Nile project. Sudan Government, Khartoum, Sudan. 4 vols.

Anon. 1978. Environmental consideration for the industrial development sector. World Bank, Washington, D. C., USA.

Anon. 1982. The Stockholm Conference revisited. News and Views from the World Bank, July-August: 4-6.

Ashby, E. 1980. What price the furbish lousewort? Environmental Science and Technology 14 (10): 1176-1181.

Carpenter, R. A. 1985. Ecologinomics: a guide to sustainable development. Pages 497-510 *in* Environmental impact assessment of wetland resources. Proceedings of the International Seminar on sustainable development. University of Roorkee.

Deuse, P. 1966. Contribution a l'etude des tourbienes du Rwanda et Burundi. IRSAC Report 30: 53-115.

Gaudet, J. J. 1980. Environmental assessment of the Burundi peat project. Mimeographed report. U. S. Agency for International Development Regional Office, Nairobi, Kenya.

International Lake Ardit Committee (ILACO). 1975. Yala Swamp investigation project. Final report. Nairobi, Kenya.

Meffitt-Babtie, M. R. 1978. The Jonglei Canal Report. Government of the Sudan, Khartoum, Sudan.

Meffitt-Babtie, M. R. 1980. The Jonglei Canal Report. Government of the Sudan, Khartoum, Sudan.

Moghraby, A. el. 1982. The Jonglei Canal-needed development or potential ecodisaster? Environmental Conservation 9: 141-148.

Printz, Jr., A. C. 1981. Environmental assessment as a tool for system-wide cooperation. Paper presented at Conference on Environmental Practices of Consulting Firms Working on Projects, March, 1981, New York. (Text available from author, U. S. Agency for International Development, Washington, D. C. 20523.)

Rzoska, J. 1976. The Nile: biology of an ancient river. Junk, The Hague, Netherlands.

White, G. 1973. Zambia's Kafue hydroelectric scheme and its biological problems. in J. Ackerman, ed., Man-made lakes, their problems and environmental effects. Geophysical Monograph Series 17, U. S. Geophysical Union, Washington, D. C.

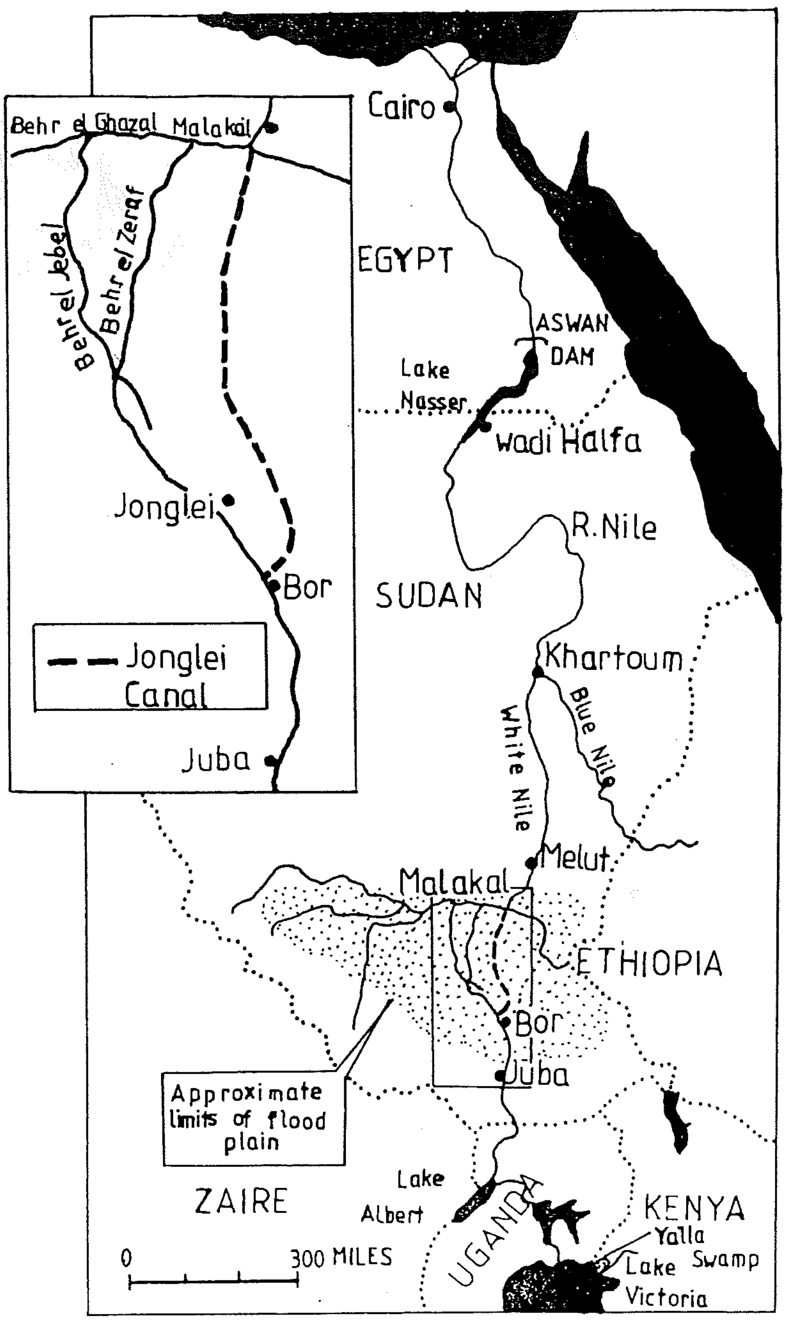

Figure 1. The Jonglei Canal Project.

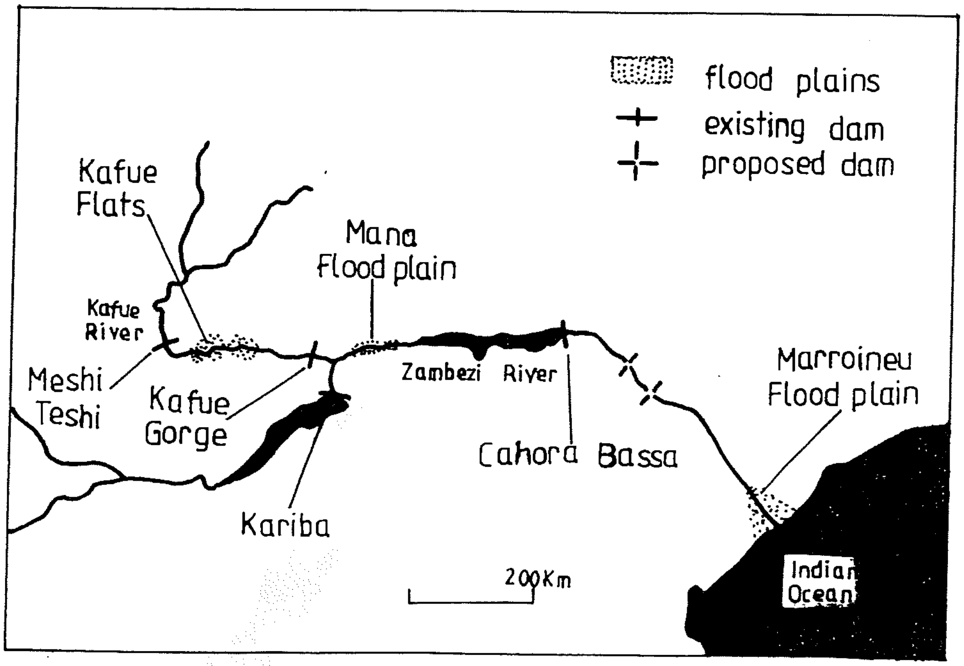

Figure 2. The Kafue Flats.

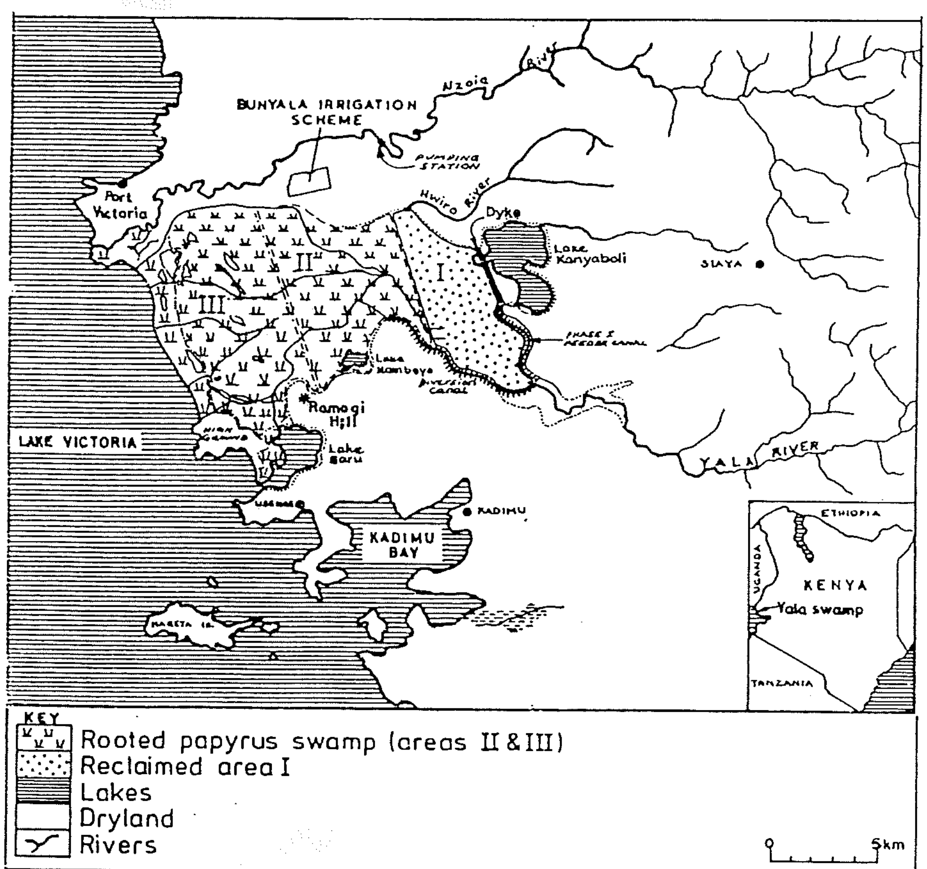

Figure 3. The location and extent of the Yala Swamp.

READING LANDSCAPES: A FIELD ASSESSMENT METHODOLOGY FOR UNDERSTANDING WETLANDS IN THEIR CATCHMENTS

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INTRODUCTION

During the past twenty-five years, much of our understanding of wetland ecosystems and their dynamics has evolved over the need for regulatory protection of (and public support for) wetlands. Increasingly, threats to wetlands from both direct impacts (e.g., draining and filling) and indirect impacts (e.g., runoff of toxicants, development in the catchment) require regulators and conservationists to articulate and quantify the unique attributes and importance of wetlands. As a result, the assessment of wetland functions and values, and the classification and delineation of wetlands and their boundaries, have become important research topics and have been the subjects of a myriad of conferences, symposia, and scientific papers. Through this process, a variety of field methods have been proposed to help regulators and conservationists find and defend answers to questions such as:

- what defines a wetland and distinguishes it from other ecosystems;
- what is the wetland type;
- what functions does a particular wetland perform and what values do humans place on those functions;
- what activities can occur in wetlands or their catchments before critical functions are lost;
- how do wetland functions change as a wetland is degraded or altered;
- can specific wetland functions be replaced through restoration or creation.

Although developed and presented in a regulatory framework, assessment methods are also of great value to field researchers and conservationists trying to better understand wetlands. Wetland science requires interdisciplinary approaches to understanding wetlands and their catchments. Often, we find ourselves as wildlife biologists trying to make management decisions that require an understanding of wetland hydrologic processes, or as water quality technicians needing to understand vegetation dynamics. Interdisciplinary teamwork is essential to addressing many wetland issues and researchers and conservationists must have some understanding of other fields. This broad-based understanding becomes crucial in cases where field researchers and conservationists do not have access to people with skills in specific areas that are needed for the project or research.

In this paper, we provide a method of field evaluation to help "guide the eyes" of field researchers and conservationists to try to understand (and document, if necessary) (1) the key processes occurring in wetlands and (2) the critical relationship between wetlands and their catchments. The method is a synthesis and simplification of previous field assessment techniques that were developed to assess the functions and values of wetlands and to delineate their boundaries.

FIELD ASSESSMENT OF WETLAND FUNCTIONS AND VALUES

The seminal work upon which most current assessment and evaluation methods are based is the Wetland Evaluation Technique (WET and WET2) developed for the U.S. Federal Highway Administration by Adamus *et al.* (1983). The WET method was developed to provide an evaluation technique that: (1) can assess most of the recognized wetland functions and values; (2) is applicable to a wide variety of wetland types; (3) is reproducible and rapid; and (4) has a sound technical basis in the scientific literature (Adamus *et al.* 1987). Drawing from the previous evaluation and classification methods of Larson (1975), Cowardin *et al.* (1979), Golet (1973), and papers from Greeson, Clark, and Clark (1979), WET provided state-of-the-art assessment techniques for 11 categories of wetland functions and values:

- groundwater recharge;
- groundwater discharge;
- floodflow alteration;
- sediment stabilization;
- sediment/toxicant retention;
- nutrient removal/transformation;
- production export;
- wildlife diversity/abundance;
- aquatic diversity/abundance;
- recreation;
- uniqueness/ heritage.

WET characterizes and evaluates wetland functions and values in terms of opportunity (whether the wetland has a chance to fulfill a given function), effectiveness (the probability that a wetland is productive in maximizing the opportunity of fulfilling a given function given its physical, chemical, and biological characteristics), and social significance (the degree to which the function performance is valued by society). WET characterizes these functions in terms of predictors, which are variables that are assumed to be correlated with the physical, chemical, and biological characteristics measured in the wetland and surrounding landscape.

WET challenges wetland investigators, most of whom have specialized training in one field, to consider the full range of processes that determine wetland functions and values. For example, a crane biologist conducting an assessment must also assess wetland hydrology, water quality, and soils, in addition to the biological aspects with which he or she is most comfortable.

Subsequent work since WET is built on the recognition that some of the goals and needs of wetland assessment were not achieved by WET. Beilfuss (1990) reviewed more than 120 such schemes, addressing wetland functions and values at local, state, regional, national, and international levels. Many methods were developed to focus the assessment procedure on specific wetland types or geographic regions. Methods modeled after WET were developed in Michigan (MDNR 1983), Wisconsin (ACOE 1983), Minnesota (ACOE 1988), New Hampshire (Ammann and Stone 1992), and elsewhere, to make the assessments specifically applicable to regional wetland types and conditions. Other methods focused on further developing the assessment of specific wetland functions (e.g., Smardon 1983; Simon *et al.* 1987; Hollands 1985; Niering 1985) rather than addressing all possible wetland functions in one technique. Still other methods ranked wetlands using significance values for wetland functions; overall "scores" for wetlands were based on a sum of the weighted values of each individual function (Ammann *et al.* 1985; Barnard 1985). Others called for abandoning the ranking system after research showed that the ranking of wetland functions inadvertently targeted "low" function wetlands for development (Piel 1985).

Most recently, the Hydrogeomorphic (HGM) approach, developed by Brinson (1993) and others, is becoming the established method for wetland assessment in the United States. Building on a decade of lessons learned from WET and its spin-offs, the HGM method was developed to (1) classify wetlands based on their difference in functions, position in landscape, dominant sources of water, and flow and fluctuation of water once in the wetland, (2) articulate functions in a way that is not value-dependent, and (3) use reference wetlands as standards of comparison for evaluating wetland functions. It aims to accurately assess the net changes in wetland functions resulting from both degradation and restoration (Brinson 1993; Brinson *et al.* 1994).

It is apparent that there is a real need to develop assessments that are more rapid and user-friendly in the field than HGM and WET. Many questions in WET require detailed laboratory analysis (e.g., "Does analysis indicate that the soil types present in the [wetland] contain more than 4,000 mg/kg (dry weight) of amorphous extractable aluminum in the upper 8 inches?") or extensive, repeated field sampling (e.g., "Does most runoff or surface water entering the [wetland] have a concentration of suspended solids (preferably inorganic suspended solids) regularly exceeding 80 mg/l for prolonged periods, or exceeding 200 mg/l at least once annually, or a secchi disc reading consistently less than 2 meters?"). Detailed questions such as these, while illustrating the complexity inherent to wetland research, are nonetheless impractical in most regulatory situations where a field reviewer may have to make decisions on impacts to wetland functions and values after a single site visit. Similarly, the dependence of the HGM method on reference wetlands more than doubles the work of the investigator.

The more rapid methods have focused on distilling the evaluation process down to a few key questions that can help the evaluator gain a general impression about the hydrologic and ecological functioning of the wetland. This general understanding of the system provides support for regulatory decisions to deny or grant permission to impact a wetland. The Wetland Evaluation Questionnaire (Simon 1988), Wetland Evaluation Checklist (MDNR 1988), Urban Wetlands Evaluation Checklist (Beilfuss *et al.* 1990), and most recently Rapid Assessment Methodology for Evaluating Wetland Functional Values (Siebert 1992) and Minnesota Routine Assessment Method for Evaluating Wetland Functions (MIWG 1995), are based on this concept. Questions are designed to elicit simple yes or no answers, which guide the assessor through key issues or parameters that determine the ability of the wetland to perform a particular function. These methods also focus on quick field observations that can help the assessor draw conclusions about the hydrological and ecological dynamics of the wetland throughout the year. The evaluator must have the expertise to interpret the implications of his or her answers to the questions.

While these methods cannot replace the comprehensive nature of the WET and HGM methods, they may better meet the need for rapid assessment in situations where detailed or long-term research is not feasible. Because there is the issue of accuracy and repeatability inherent to all methodologies, the main challenge to these methods is whether they adequately represent the scientific integrity of the more comprehensive methods.

FIELD ASSESSMENT OF WETLAND CHARACTERISTICS

A second area of emphasis in wetland science that contributes to our ability to rapidly assess wetland characteristics is wetland delineation.

Regulators must determine if a given area meets the technical criteria that defines it as a wetland, and, if so, must delineate the boundaries of the wetland based on the three fixed criteria of hydric soils, hydrophytic vegetation, and wetland hydrology. Furthermore, regulators must be able to determine these three characteristics during the course of a single site visit.

The Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987), Federal Manual for Identifying and Delineating Jurisdictional Wetlands (FICWD 1989), and subsequent proposed revisions (see especially Committee on Characterization of Wetlands 1995), were developed to provide guidelines for defining and identifying wetlands.

The hydric soils criterion requires field determination of soil texture and color, including gleying and mottling. The analysis also includes characterizing the amount of organic soils, hydric mineral soils, and hydric spodosols relative to non-wetland soils. Vepraskas (1992) describes a variety of techniques for recognizing hydric soils.

The hydrophytic vegetation criterion identifies dominant plants species within the plant communities, and determines whether they occur predominately in wetland or upland settings. Tiner (1991) describes the use of hydrophytes (those plants that need or tolerate wet conditions) in wetland delineation.

The wetland hydrology criterion utilizes visual signs of surface inundation, the water table, soil saturation, oxidized channels associated with rhizomes, watermarks, drift lines, waterborne sediment deposits, surface scoured areas, wetland drainage patterns, and morphological plant adaptations such as buttressed tree trunks and adventitious roots. Hydrology is the most difficult criterion to assess in one site visit because of temporal changes in wetlands.

The science of wetland delineation is confounded by questions as to whether it is ecologically, hydrologically, or even socially meaningful to determine the artificial boundary between ecosystems that occur along a gradient. Is it wise to identify unregulated "non-wetland" areas for development when wetlands themselves are dependent on the integrity of their upland surrounding? Nonetheless, the process of determining key field indicators to assess wetland soils, vegetation, and hydrology has yielded an excellent framework for determining wetland characteristics in the field.

LESSONS FOR FIELD INVESTIGATORS

In a sense, all wetland assessment and delineation schemes are an effort to standardize "best scientific judgment." They aim to translate a thought (or decision-making) process formed from the collective experiences and intuitions of wetland scientists into a step-by-step process so that other evaluators can reach these same conclusions in a timely manner. They require reliable, repeatable evaluations without sophisticated equipment or detailed desktop analysis.

In many cases, rapid assessment methods cannot replace long-term field research. The influence of groundwater on a system (e.g., flow directions and fluctuations), the breeding success of certain species, or changes in water quality over time cannot be ascertained during one-day field visits. Furthermore, little is gained by having the evaluator spend several days trying to qualitatively arrive at a judgment about these functions that really require quantitative field data. Nonetheless, a great deal of knowledge can be gained during a brief site visit that can help the wetland researcher or conservationist gain an understanding of the key wetland characteristics and functions.

THE FIELD ASSESSMENT METHODOLOGY

An annotated version of the field assessment methodology is given in the Appendix. The **bold** type face is the actual assessment form generally used in the field. The *italic* type face provides explanation to help clarify the purpose or intent of some of the questions. Literature citations are provided so readers can obtain additional background information regarding a question, particularly where "rules-of-thumb" guidelines are offered.

Wetlands are complex systems that defy rigid classification, so not all of the function predictors are necessarily present or reliable in every situation. Certain questions or sets of questions may not pertain to certain wetland types. The evaluation should also not be limited to the questions provided where additional observations and/or further in-depth research is required to adequately understand some features or functions of the wetland system.

The goals of this field assessment methodology are to help the field researcher and conservationist:

- gain a practical field understanding of the wetland's hydrology, soils, and vegetation;
- make field judgments about natural temporal changes that occur in the wetland (i.e., how is the wetland likely to appear during the rainy or dry season, during peak flooding, during a drought year, etc.);
- identify visual evidence regarding the use of the wetland by different fish and wildlife species;
- understand the important functions of the wetland relative to its catchment;
- determine whether a proposed impact is likely to significantly alter the wetland's functions;
- evaluate floral diversity of the wetland and invasion by aggressive exotic species;
- distinguish between functions that enhance and degrade wetland quality.

Most of the questions were developed through repeated field application and training courses offered by the International Crane Foundation and the Wisconsin Department of Natural Resources. Field researchers and conservationists working through the assessment scheme will likely find portions of the assessment obvious and straightforward, and other parts unfamiliar and challenging. However, efforts to work through the questions presented, understand the meaning behind the questions, and develop the observational skills necessary to answer the questions in the field, will result in a great deal of understanding about the defining characteristics and processes of wetlands and their catchments.

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REFERENCES CITED

Adams, L. W. and L. E. Dove. 1989. Wildlife reserves and corridors in the urban environment: a guide to ecological landscape planning and resource conservation. National Institute for Urban Wildlife, Columbia, Maryland, USA. 91 p.

Adamus, P. R. 1983. A method for wetland functional assessment, vol. 1. Critical review and evaluation concepts, and vol. 2 Federal Highway Administration assessment method. U.S. Department of Transportation, Federal Highway Administration reports FHWA-IP-82-23 and FHWA-IP-82-24. Washington, D.C., USA. 176 p. and 134 p.

Adamus, P. R., E. J. Clairain, Jr., R. D. Smith, and R. E. Young. 1987. Wetland evaluation technique (WET), Vol. 2 methodology. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, USA. Technical Report Y-87. 206 p.

Ammann, A. P. and A. L. Stone. 1992. Method for the comparative evaluation of non-tidal wetlands in New Hampshire. New Hampshire Department of Environmental Services, Concord, NH, USA. 72 p.

Ammann, A. P., R. W. Franzen, and J. L. Johnson. 1985. Connecticut's wetland evaluation method designed for town and officials and other non-specialists. Pages 98-102 *in* J. A. Kusler and P. Riexinger, eds., Proceedings of the national wetlands assessment symposium. Association of State Wetland Managers, Berne, New York, USA.

Ashton, R. 1991. Defining the ecotourist based on site needs. Pages 91-98 *in* J. Kusler, compiler, Ecotourism and resource conservation: a collection of papers. Ecotourism and Resource Conservation Project, Madison, Wisconsin, USA.

Barbour, C. D. and J. H. Brown. 1974. Fish species diversity in lakes. American Naturalist 108(962): 473-488.

Barnard, W. D. 1985. The need for ranking wetlands. Pages 232-234 *in* J. A. Kusler and P. Riexinger, eds., Proceedings of the national wetlands assessment symposium. Association of State Wetland Managers, Berne, New York, USA.

Beilfuss, R. 1990. Appendix 5: Annotated functional classification bibliography. Pages 197-255 *in* Water Resources Management Program, eds., Urban wetlands in the Yahara-Monona watershed: functional classification and management alternatives. University of Wisconsin, Madison, Wisconsin, USA.

Beilfuss, R. D., D. R. Siebert, and P. Rossa. 1990. Urban wetland evaluation checklist. Pages 13-33 *in* Water Resources Management Program, eds., Urban wetlands in the Yahara-Monona watershed: functional classification and management alternatives. University of Wisconsin, Madison, Wisconsin, USA.

Brinson, M. M., W. Kruczynski, L. C. Lee, W. Nutter, R. D. Smith, and D. Whigham. 1994. Developing an approach for assessing the functions of wetlands. Pages 615-624 *in* W. J. Mitsch, ed., Global wetlands: old world and new. Elsevier Science B. V., Amsterdam, The Netherlands.

Brinson, M. M. 1993. A hydrogeomorphic classification for wetlands. Technical Report WRP-DE-4. U. S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, USA.

Committee on Characterization of Wetlands. 1995. Wetlands: characteristics and boundaries. National Research Council, Washington, D.C., USA.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetland and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, FWS/OBS-79-31.

Cuplin, P. 1986. Fish. Pages 257-266 *in* A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, eds., Inventory and monitoring of wildlife habitat. U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., USA.

Diamond, J. M. 1976. Island biogeography and conservation: strategy and limitations. Science 193: 1027-1029.

Elder, J. F. 1987. Factors affecting wetland retention of nutrients, metals, and organic materials. Pages 178-184 *in* J. Kusler and G. Brooks, eds., Proceedings of the national wetland symposium: wetland hydrology. Association of State Wetland Managers, Berne, New York, USA.

Eng, R. L. Waterfowl. Pages 371-386 *in* A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, eds., Inventory and monitoring of wildlife habitat. U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., USA.

Environmental Laboratory. 1987. Corps of Engineers wetland delineation manual. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, USA. Technical Report Y-87-1.

Federal Interagency Committee for Wetland Delineation (FICWD). 1989. Federal manual for identifying and delineating jurisdictional wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service, Washington, D.C., USA. Cooperative Technical Publication.

Golet, F. C. 1973. Classification and evaluation of freshwater wetlands as wildlife habitat in the glaciated northeast. Transactions of the Northeast Fish and Wildlife Conference 30: 257-79.

Greeson, P. E., J. R. Clark, and J. E. Clark, eds. 1979. Wetland functions and values: the state of our understanding. Proceedings of the National Symposium on Wetlands. American Water Resources Association, Minneapolis, Minnesota, USA.

Hall, H. D. and V. W. Lambou. 1989. Determining the value of bottomland hardwood riverine wetlands to fisheries. Pages 132-137 *in* J. Kusler and S. Daly, eds., Proceedings of an intentional symposium: wetlands and river corridor management. Association of Wetland Managers, Berne, New York, USA.

Hay, R. W. In press. Supplement to Wisconsin Department of Natural Resources rapid assessment methodology for evaluating wetland functional values: amphibian habitat. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

Hollands, G. G. 1985. Assessing the relationship of groundwater and wetlands. Pages 240-242 *in* J. A. Kusler and G. Brooks, eds., Proceedings of the national symposium: wetland hydrology. Association of Wetland Managers, Berne, New York, USA.

Howes, J. R. 1987. Rapid assessment techniques for coastal wetland evaluation. Results of a workshop held in Selangor, West Malaysia. 1-7 March 1987. Interwader Publication No. 24. Kuala Lumpur, Malaysia.

Jones, K. B. 1986. Amphibians and reptiles. Pages 267-290 *in* A. Y. Cooperrider, R. J. Boyd, and H. R. Stuart, eds., Inventory and monitoring of wildlife habitat. U.S. Department of the Interior, Bureau of Land Management, Washington, D.C., USA.

Kusler, J. A. and P. Riexinger, eds. 1985. Proceedings of the national wetlands assessment symposium. Association of State Wetland Managers, Berne, New York, USA.

Larson, J. S., ed. 1975. Models for assessment of freshwater wetlands. Publication no. 32. University of Massachusetts Water Resources Research Center, Amherst, Massachusetts, USA.

Larson, J. S., P. R. Adamus, and E. J. Clairain, Jr. 1989. Functional assessment of freshwater wetlands: a manual and training outline. Publication no. 89-6. University of Massachusetts, Amherst, Massachusetts, USA. 62 p.

MacArthur, R. H. and E. O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey, USA. 203 p.

Michigan Department of Natural Resources (MDNR). Date Unknown. Wetland evaluation checklist technique. Operational draft. Lansing, Michigan, USA.

Michigan Department of Natural Resources (MDNR). 1983. Manual for wetland evaluation techniques. Division of Land Resources Programs, Lansing, Michigan, USA.

Minnesota Interagency Wetland Group (MIWG). 1995. Minnesota routine assessment method for evaluating wetland functions. Operational draft. Minnesota Board of Water and Soil Resources, St. Paul, Minnesota, USA.

Mitsch, W. J. and J. G. Gosselink. 1993. Wetlands. 2nd ed. Van Norstrand Reinhold, New York, USA.

Moyle, P. B. and J. J. Cech, Jr. Fishes: an introduction to ichthyology. 2nd ed. Prentice Hall, Englewood Cliffs, New Jersey, USA.

Niering, W. A. 1985. Scenic, cultural (heritage), and educational values of wetlands. Pages 58-64 *in* J. A. Kusler and P. Riexinger, eds., Proceedings of the national wetlands assessment symposium. Association of State Wetland Managers, Berne, New York, USA.

Noss, R. F. 1987. Corridors in real landscapes: a reply to Simberloff and Cox. Conservation Biology 1:159-164.

Piel, R. 1985. An evaluation of the ranking system, for coastal wetlands in New Jersey. Pages 244-247 *in* J. A. Kusler and P. Riexinger, eds., Proceedings of the national wetlands assessment symposium. Association of State Wetland Managers, Berne, New York, USA.

Siebert, D. R. 1992. Rapid assessment methodology for evaluating wetland functional values. Operational draft. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA. 9 p.

Simon, B. D. 1988. Wetland evaluation questionnaire. Operational draft. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA. 3 p.

Simon, B. D., L. J. Stoerzer, and R. W. Watson. 1987. Evaluating wetlands for flood storage. Pages 104-109 *in* J. A. Kusler and G. Brooks, eds., Proceedings of the national symposium: wetland hydrology. Association of State Wetland Managers, Berne, New York, USA.

Smardon, R. C. 1983. The future of wetlands: assessing visual cultural values. Allanheld, Osmun, and Company Publishers, Totawa, New Jersey, USA.

Smith, R. D., A. Ammann, C. Bartoldus, and M. M. Brinson. 1995. An approach for assessing wetland functions using hydrogeomorphic classification, reference wetlands, and functional indices. Operational draft. U.S. Army Corps of Engineers Waterways Experiment Station, Technical Report TR-WRP-DE-10. Vicksburg, Mississippi, USA.

Stewart, R. E. and H. A. Kantrud. 1973. Ecological distribution of breeding waterfowl populations in North Dakota. Journal of Wildlife Management 37: 39-50.

Tiner, R. W. 1991. The concept of a hydrophyte for wetland identification. Bioscience 41:236-247.

U.S. Fish and Wildlife Service. 1980. Habitat evaluation procedures (HEP). U.S. Fish and Wildlife Service. Division of Ecological Services. ESM 102. Washington, D.C., USA.

U.S. Army Corps of Engineers (ACOE). 1983. Wetland Evaluation Methodology. Wisconsin Department of Natural Resources, Madison, Wisconsin, USA.

U.S. Army Corps of Engineers (ACOE). 1988. Minnesota Wetland Evaluation Methodology for the Northcentral United States. Minnesota Department of Natural Resources, St. Paul, Minnesota, USA.

Vepraskas, M. J. 1992. Redoximorphic features for identifying aquic conditions. Technical Bulletin 301. North Carolina Agricultural Research Service, North Carolina State University, Raleigh, North Carolina, USA. 33 p.

Weller, M. W. and C. E. Spatcher. 1965. Role of habitat in the distribution and abundance of marsh birds. Iowa State University Agriculture and Home Economics Experimental Station, Special Report 43. 31 p.

APPENDIX

FIELD ASSESSMENT METHODOLOGY FOR UNDERSTANDING WETLANDS IN THEIR CATCHMENTS

PART ONE: GENERAL INFORMATION

Site name:	**Site ownership:**
Country:	**State/District/Province:**
Latitude/Longitude:	**Altitude:**
Name/distance of nearest town/city:	
Protection status:	
Evaluators:	**Date of visit(s):**

Wetland type(s):
Estimated size of wetland (ha.):
Estimated size of wetland's catchment (ha.):

⇒The wetland type is typically based on the dominant plant community present. Some of the recognized wetland types include: shallow open water (including oxbow lake or billabong, freshwater lagoon); deep marsh (including reed swamp, papyrus swamp, littoral zone of lake); shallow marsh; sedge meadow; fresh (wet) meadow; low prairie or grassland; calcareous fen; open bog; coniferous bog; extensive peatland; shrub-carr; alder thicket; lowland hardwood swamp; coniferous swamp; floodplain and gallery forest; seasonally flooded basins (including dambos, vernal pools); blanket bog; pocosin; montane sponge or vlei; alkaline grassland; pans, playas, or mudflats; estuary. Some human-made systems are also sometimes classified as wetland types, including the margins of impoundments or reservoirs, aquaculture ponds, reclaimed swamps, and rice paddies. Larger wetland systems with various wetland types within them might include floodplains, inland deltas, and coastal deltas. The catchment (also known as the watershed) can be defined as the region or area surrounding the wetland that is bounded peripherally upstream by a water divide or downstream parting such that water drains to a single outlet, such as a wetland, lake, river, or ocean. A catchment can also be defined in terms of groundwater divides rather than surface water divides, if they are known. The size of the catchment depends entirely on what scale the evaluator is interested in. An evaluator interested in a small depressional wetland in an agricultural setting might view the wetland catchment as the portion of surrounding farmlands providing water to that system. An evaluator interested in the Zambezi Delta might view its catchment as all areas contributing water to the entire Zambezi River system and all of its tributaries. The size of the wetland and its supporting catchment can be best estimated using maps or aerial photographs, if available.

Describe any seasonality limitations of this site visit due to time of year of the evaluation and/or current hydrologic and climatic conditions; include climatic conditions during period of site visit (e.g., cloud cover, air temperature, precipitation, tidal cycle):

⇒It is important to consider any annual or seasonal climatic/hydrological factors (e.g., monsoon wet or dry season, drought conditions, spring flooding, peak bird migration) and current climatic factors (e.g., unusual temperatures, recent heavy rainstorms) that may be significantly influencing the condition of the wetland at the time of the assessment.

PART TWO: SITE CHARACTERISTICS

⇒In order to assess a wetland system, it is important to have a good understanding of the site hydrology, soil characteristics, plant and animal communities, and the characteristics of surrounding lands (both natural conditions and human land uses). In addition, regulatory programs may require documentation of hydrology, soils and vegetation in order to establish jurisdiction over an area.

I. WETLAND HYDROLOGY

⇒To understand the hydrology of a wetland it is important to determine the setting in the landscape, key components of the water budget (the summation of hydrologic inputs and outputs), and the impacts humans have had, or may be having, on the natural conditions.

A. Describe the geomorphic setting of the wetland:
___ **Depressional (e.g., prairie pothole marshes; dambos; vleis; bogs; vernal pools)**
___ **Riverine (e.g., gallery forests, lowland hardwood swamp)**
___ **Lacustrine fringe (e.g., littoral zone of lakes)**
___ **Organic soil flats (e.g., extensive peatland)**
___ **Mineral soil flats (e.g., pans, playas, mudflats)**
___ **Estuarine fringe (e.g., tidal marshes)**
___ **Slope (e.g., calcareous fens)**
⇒*The terminology used here is from Brinson (1993), which is the basis for the hydrogeomorphic classification approach (HGM) currently being refined by the United States Army Corps of Engineers-Waterways Experiment Station for wetland functional assessment* (Smith *et al.* 1995). *The geomorphic setting of the wetland determines water flow dynamics, water sources, and thus plant and animal communities that are found in the system.*

B. Describe the important water inflows and outflows of the wetland (including seasonal):
___ **Precipitation (e.g., rainfall, snowfall)**
___ **Overland surface water inflow (e.g., sheetflow, runoff, overbank flow)**
___ **Channelized surface water inflow (e.g., riverine, canal, culvert)**
___ **Groundwater inflow (e.g., water table aquifer or groundwater flow-through, artesian or groundwater discharge)**
___ **Open water evaporation**
___ **Vegetative transpiration**
___ **Overland surface water outflow**
___ **Channelized surface water outflow**
___ **Groundwater outflow (recharge to aquifer below)**
⇒*The water budget of a wetland is made up of inflow and outflow of surface and groundwater, precipitation, and evaporation and transpiration (evapotranspiration). Evapotranspiration is almost always an important source of water loss from wetlands. The variation in the water levels in a wetland (either above or near surface) over time is called the hydroperiod. The source and variability of water levels can greatly influence the biota that are found in and near the wetland. Though fully understanding the hydrology may be impossible without long-term instrumentation, the evaluator should at least try to determine the dominant water source(s) for the wetland.*

C. Describe any indicators of wetland hydrologic conditions such as standing water, buttressed tree trunks, adventitious roots, surface scoured areas, waterborne sediment deposits, drainage patterns, drift lines, water marks, water stained leaves, soil saturation, soil mottling/gleying, organic soils, or oxidized rhizopheres.
⇒*The hydroperiod of a wetland can vary season to season, as well as from year to year. As a general rule, the hydrologic conditions observed during a site visit or series of visits, are not representative of conditions in other time periods. Evidence of past conditions should be noted to gain insight into the temporal nature of wetland hydrology. Field indicators can reveal information such as previous standing water elevations over the short-term (e.g., drift lines, watermarks, thin waterborne sediments) and fairly long-term (e.g., morphological adaptations of plants such as buttressed or multiple tree trunks, adventitious roots, pneumataphores, and shallow roots), long-term high water tables (e.g., soil gleying, oxidized channels associated with living roots or rhizomes) or fluctuations (e.g., soil mottling). Many useful references and training courses are available to illustrate some of these field indicators (Environmental Laboratory 1987; Tiner 1985; FICWD 1989).*

D. Describe any human alterations to the wetland hydrology such as ditching, drainage tiles, culverts, well pumping, diversion of surface flow, upstream dams, and changes to runoff within the catchment which could affect the magnitude, timing, duration, or source of water inflows or outflows.
⇒*Often, what we assume to be "natural" hydrologic conditions have actually been established over time through human influence. It is useful to walk the periphery of the wetland area and look for hidden indicators of disturbance, especially old drainage channels and tiles. Might the wetland watertable have been lowered by local irrigation withdrawals? The presence of culverts may indicate changes to inflows and outflows to the wetland. Water diversion structures and upstream dams may also be identified using aerial photos and maps.*

II. WETLAND SOILS

⇒*Wetland soils are excellent integrators of hydrologic conditions past and present. Long-term saturation slows plant matter decomposition which allows the accumulation of organic materials called peats and mucks. Sites with greater fluctuating* *water levels can lead to differential oxidation and reduction in the soil, leaving behind tell-tale morphologic conditions in mineral soils.*

A. Is the soil a histosol (organic soil), and if so, is it a peat or a muck?

⇒*Histosols range from the drier, more fibric peats (where actual plant parts can be discerned from among the decomposing material), to sapric peats or mucks which have little to no identifiable plant parts. Peats and mucks tend to have high water-holding capacities that reduce wetland subsurface water movement and maintain conditions suitable for hydrophytic vegetation.*

B. Is the soil a mineral soil, and if so, is there evidence of mottling, gleying, sulfidic materials, iron or manganese concretions, organic streaking, or an underlying impervious layer? Describe the soil texture (e.g., sand, silt, clay, loam, gravel):

⇒*Because mineral soils range from well-drained sands to nearly impervious clays, a rough understanding of the soil color and texture can reveal a great deal of information about wetland hydrology (Tiner 1985). Observations such as soil mottling (spots or blotches of color from oxidized iron and manganese interspersed with the dominant soil color) and gleying (neutral gray soil color), or the presence of hydrogen sulfide ("rotten eggs" smell), reveal prolonged anaerobic (saturated) conditions in the wetland.*

III. WETLAND VEGETATION AND FLORAL DIVERSITY

A. Identify the percentage of the wetland covered by the any of the following plant communities, and the dominant species:

	floating (non-rooted) community dominated by:⇒*e.g., Lemna, Spirodela*
	floating mat community dominated by:⇒*e.g., Cyperus papyrus*
	floating-leaved community dominated by:⇒*e.g., Potamogeton, Nymphaea*
	submerged community dominated by: ⇒*e.g., Utricularia, Ceratophyllum*
	emergent community dominated by:⇒*e.g., Typha, Papyrus, Scirpus, Phragmites*
	sedge meadow/wet grassland community dominated by:⇒*e.g., Eleocharis, Carex, Juncus, Calamagrostis*
	shrub community dominated by:⇒*e.g., Alnus, Cornus, Salix*
	deciduous broad-leaved community dominated by: ⇒*e.g., Acer, Fraxinus, Populus deltoides*
	coniferous tree community dominated by:⇒e.g., *Larix laricina, Thuja occidentalis*
	open sphagnum mat or bog community dominated by:⇒*e.g., Vaccinium, Andromeda*
	mudflat annual community dominated by:⇒*e.g., Polygonum, Bidens, Echinochloa*
	other (explain):⇒*including upland vegetation communities that occur in a complex with wetland communities*

⇒*The dominant vegetation species should be considered within each distinct community in the wetland, and within each stratum, including mature trees, saplings, shrubs, grasses, sedges, and forbs (non-grasslike herbaceous plants). If necessary, these community types can be further subdivided. Emergent vegetation, for example, might include robust emergents (e.g., Typha* spp.*), narrow-leaved emergents (e.g., Sparganium* spp.*), broad-leaved emergents (e.g., Pontedaria* spp.*), tall meadow emergents(e.g., Zizania* spp., *Leersia* spp.*), short meadow emergents (e.g., Carex* spp., *Juncus* spp.*), and so forth.*

B. Are any of the plant communities in the wetland regionally scarce or rare?

⇒*In landscapes that still support a number of undegraded wetlands, unique wetland types or individual wetlands with unique hydroperiods or other physical features may provide an important and unique niche for certain vegetation associations that are not found in disturbed wetlands.*

C. List other plant species identified during the site visit. Indicate those plant species or genotypes in the wetland or adjacent lands that are rare, endangered, or threatened. Does the wetland support a variety of native plant species?

⇒*This list is not intended to generate an exhaustive inventory of the site. Rather, it should serve as a guideline for consideration of the overall floral diversity of the wetland. Consider the wetland relative to others in the area with respect to the presence of non-native and/or aggressive "weed" species that can form monotypic stands and reduce the diversity, structure, and interspersion of vegetation in the wetland. Many assessment methodologies fail to recognize the value of floral diversity, even though a diverse plant community is normally a good indicator of high quality wildlife habitat as well.*

D. Describe any disturbances affecting floral diversity in the wetland, such as exotic or aggressive plant species, artificial drainage or flooding, water diversion, frequent or suppressed wildfires, excavation, filling, devegetation, trampling, sedimentation, fertilizer/herbicide/pesticide usage, and urban or industrial pollution.

⇒*Disturbances of the plant community include both invasions of exotic species that displace native species, such as water hyacinth (Eicchornia crassipes), purple loosestrife (Lythrum salicaria), or reed canary grass (Phalaris arundinacea) outside of their native range, and changes in physical conditions and processes (e.g., natural flooding, grazing, or burning regime) that alter or destroy natural vegetation communities.*

IV. CATCHMENT LAND USES

⇒*In order to understand the natural processes and human activities affecting a wetland, it is critical to assess not only the wetland itself, but also the surrounding landscape. As discussed above, the evaluator should be careful to address issues of scale in defining the wetland catchment. The surrounding land uses may have significance for the "Human Values" part later in the assessment.*

A. Which of the following land uses occur in the catchment of the wetland:

___ Agricultural/cropland
___ Agricultural/grazing
___ Aquaculture
___ Industrial/mining
___ Commercial/residential
___ Grassland/old field
___ Forested
___ Barren land
___ Roads/parking
___ Other (specify)

⇒*Use maps and aerial photos, if available, as a supplement to site reconnaissance to try to estimate the percentage of the immediate catchment that is in each of the identified land uses.*

B. Describe any natural ecological communities supported by the catchment of the wetland.

⇒*The ecological importance of a wetland may depend highly on its relationship with surrounding wetlands and uplands. Corridors of connected "wild" areas can form a mosaic of habitat, important to humans and wildlife. The concept of corridors and connectivity is echoed throughout this assessment.*

C. Is the wetland or its surrounding catchment legally protected in any way?

⇒*It is also useful to note if the legal protection is enforced through legal or social controls.*

D. Estimate the population density within the larger catchment in which the wetland occurs (e.g., none, 1-20, 21-100, 101-1,000, 1,001-10,000, 10,000+). Is the number of people in the catchment increasing rapidly, increasing slowly, remaining stable, decreasing slowly, or decreasing rapidly?

⇒*Understanding human population dynamics near the wetland provides insight as to the importance of the site for raw materials, food consumption, recreation, and other uses, as well as the potential for abuses due to encroaching development and/or over-use.*

V. FISH AND WILDLIFE HABITAT

⇒*This section guides the evaluator through habitat features that are critical to fish and wildlife. Although rapid assessments cannot and should not replace solid baseline research on animal biology and ecology, they can provide considerable insight into the likelihood that a given site can provide quality breeding, feeding, staging, or roosting habitat for a diversity of species.*

A. List the species observed, evidenced, or known to utilize the wetland:

mammals	
birds	
reptiles	
amphibians	
fish	
invertebrates	

⇒*The names of any animal species observed (dead or alive), evidenced (through observation of nests, tracks, scat, feathers, skins, suspended sediments, etc.), or known to utilize the wetland (recent observations by others) should be listed. These lists are not intended to generate an exhaustive inventory of the site. Rather, they should serve as a guideline for consideration of the overall faunal, floral, and habitat diversity of the wetland.*

B. Are there any rare, endangered, or threatened fish or wildlife species in the wetland or its surrounding catchment?
⇒*This may require checking with occurrence lists such as the IUCN Redbook, Natural Heritage Inventory maintained by The Nature Conservancy, and national or state records.*

C. Is the wetland community providing fish or wildlife habitat that is regionally scarce or rare?
⇒*In landscapes that still support a number of undegraded wetlands, unique wetland types or individual wetlands with unique hydroperiods or other habitat features may provide an important and unique niche for certain fish and wildlife species. For example, groundwater discharge wetlands often support rare and unique vegetation communities and can be important fish spawning grounds, particularly in areas where other wetlands undergo seasonal drawdowns. Small wetlands may provide fragments of "wild" habitat in a human-dominated catchments.*

D. Is the catchment and/or the wetland itself a relatively large tract of undeveloped land important for wildlife that require large home ranges or upland breeding grounds?
⇒*The wetland may be a large tract or may be part of a mosaic of natural landscape features that form a large tract or corridor, effectively increasing the size of the "island" of habitat that is undisturbed. Many wildlife species, ranging from invertebrates to birds and mammals, show a strong relationship between species richness and habitat size (Diamond 1976). Fish also show a strong relationship between surface area and species diversity, although fish diversity tends to decrease with mean depth of water (Barbour and Brown 1974). Further, many species of geese and ducks require upland breeding sites that are near or adjacent to wetlands. Other species spend much of their lifecycle in uplands, but depend on wetlands for food, water, or cover.*

E. Does the catchment contain other wetland areas that provide potential wildlife habitat?
⇒*In addition to the size of the wetland "island", the proximity of the wetland to other wetland areas is a major determinant of animal species richness (MacArthur and Wilson 1967). Especially important is the proximity of the wetland to other wetlands with differing hydroperiods. Different animals require different hydrologic conditions (water depths, fluctuations, etc.) at different times of the year, so hydrologic conditions in one wetland provide adequate habitat for some species but not for others. Wetlands with different hydroperiods in close proximity also help buffer against years of extreme drought or flood. Many animals evolved to take advantage of a diversity of wetlands in the landscape to meet different parts of their lifecycles.*

F. Is the wetland connected to other natural areas or wetlands via a wildlife corridor that may be significant for mammal, bird, reptile, amphibian, fish, or invertebrate migration?
⇒A *wildlife corridor between the wetland and other natural communities in human-dominated catchments help restore the connectivity of the original landscapes. Different animal species have widely varying abilities to disperse and utilize different areas. Many amphibian and reptile species, for example, breed in wetlands but require non-developed upland areas for other aspects of the lifecycle, and require undisturbed corridors to pass between these areas. Corridors may help prevent genetic isolation of a species, buffer against degradation of an individual wetland site, or allow access to additional resources. The significance of the corridor may depend on the width of the corridor, habitat structure and quality within the corridor, the nature of the surrounding habitat, human use patterns in the catchment, and the particular species using the corridor (Noss 1987). As a general rule, the corridor should be at least 100 m wide to be considered significant for terrestrial wildlife. Corridors for fish must include a stream or seasonally flooded area that connects the wetland to permanent water.*

G. Is the wetland buffered by a strip of native vegetation of at least 30m width on all sides?
⇒*Buffer areas of natural vegetation around wetlands in human-dominated catchments help preserve water quality, minimize runoff impacts, control erosion, and maintain undisturbed habitat. Although the necessary size of the buffer area varies depending on the wetland type, research suggests that a width of at least 30 m is ideal for these functions (Adams and Dove 1989).*

H. Does the wetland contain a number of diverse vegetative cover types, relatively high structural (vertical) diversity, and a high degree of interspersion of those vegetation types?
⇒*Most wildlife species require more than one structural type of vegetation to meet their needs for food and cover, and therefore depend on the presence and extent of edge within the wetland. Diverse vegetation types of different heights and densities provide habitat for a greater diversity of species than monotypic stands of vegetation. High interspersion of vegetation occurs where edge is abundant and consists of many different species, life forms (e.g., trees, shrubs, emergents, surface vegetation, submergent vegetation, etc.) are broken into segments of variable size and shape, and community sub-forms (e.g., narrow-leaved emergents, broad-leaved emergents, robust emergents, etc.) are small and scattered (Golet 1973). Qualitative differences among individual vegetation species can also be significant for successful brood rearing. For example, Typha provides cover but not food, and is generally of less value than species such as Polygonum, Scirpus, and Sagittaria, which provide both food and cover.*

I. Is the estimated ratio of open water to vegetative cover between 30 and 70 percent which is critical to supporting breeding waterfowl?
⇒*In addition to vegetation diversity and interspersion, the relative proportion of vegetative cover and open water is a critical consideration in assessing the value of a wetland to wildlife (Stewart and Kantrud 1971). Wetland cover can range from complete open water to 95-100% of the wetland being covered by vegetation. Wetlands can provide breeding, staging, wintering, and molting grounds for a variety of waterfowl, including swans, geese, dabbling ducks, bay ducks, and sea ducks. Although individual species have their own specialized habitat needs (e.g., many geese species prefer dense nesting cover whereas many dabbling ducks prefer breeding habitat with an abundance of water areas of varying size, depth, and configurations to provide a diversity of aquatic vegetation structure), a general rule of thumb from waterfowl research suggests that a moderate degree of vegetation cover (30-70%) provides habitat for the highest overall diversity of waterfowl species (Weller and Spatcher 1965). Of course, where a particular species is of concern more specific habitat needs must be investigated.*

J. Does the wetland contain any islands for waterfowl or colonial waterbird nesting that are adequately protected from predators (separated from land by water that is at least 2 m deep and 100 m wide)?
⇒*Many geese and ducks prefer islands for nest sites, especially in areas with high densities of mammalian predators or human disturbance (Eng 1986). Many species of colonial waterbirds require suitable nest sites that are free from predators, sheltered from adverse environmental conditions, and close to wetland food sources.*

K. Does the wetland contain standing dead trees (snags) important for cavity nesting birds?
⇒*Waterfowl species such as tree nesting ducks (e.g., Aix* sp., *Dendrocygna* sp.*) require tree cavities.*

L. Does the wetland contain exposed soft mud, consolidated mud, dry/ cracked mud, or muddy sand for shorebird feeding?
⇒*Individual migrant shorebird species vary in their habitat preferences, but generally require shoreline habitat that is open and free of much vegetation structure and topographic relief and has a high density of prey. More detailed assessment techniques for shorebirds and their coastal habitats are provided in Howes (1987).*

M. Does the wetland and/or adjacent lands provide microhabitat important for amphibians, reptiles, and small mammals such as litter (fallen logs, trees), moist clay soils, unsaturated well-drained soils, extensive plant root systems, or dense horizontal vegetation cover?
⇒*A wide variety of habitat components help determine the diversity and abundance of amphibians and reptiles. Amphibian and reptile defense, escape cover, feeding substrate, food or prey, nest substrate, physiology, reproduction, and thermoregulation are all related to microhabitat features such as water permanence, vegetation litter, vegetation horizontal and vertical structure (live and dead), and soil depth and moisture holding capacity (Jones 1986). Some small mammal species use similar microhabitat.*

N. Does the wetland support surface water for enough of the year to allow for lifecycle completion for most amphibian species that are likely to breed in the wetland?
⇒Most amphibian species require standing water to complete their lifecycles. The timing and duration of standing water required varies by latitude and climate and among different amphibian species. Wetlands that provide several months or more of standing water during most years are more likely to provide significant breeding grounds for amphibians than wetlands with shorter hydroperiods. For example, in the northern United States and Canada, wetlands that provide standing water until late July are most likely to support significant breeding habitat for amphibians (Hay in press).

O. Is the wetland free of predatory fish that prey on amphibians?
⇒Predatory fish such as bass (Micropterus spp., *Morone* spp.*), perch (Lates* spp., *Perca* spp.*), and bluegill (Lepomis* spp.*) that feed on amphibians and their eggs can reduce the potential of a wetland for amphibian recruitment (Hay in press).*

P. Do large natural fluctuations occur seasonally such that the surface water area of the wetland expands greatly during the wet periods?
⇒Water level fluctuations that create prolonged flooding over large areas are extremely important to fish communities, expanding habitat and food resources, and provide important cues for reproduction and growth (Moyle and Cech 1988). Artificial fluctuations such a rapid reservoir releases, however, can expose or inundate nesting sites and alter or destroy natural vegetation cover. In these systems, a wetland substrate must be sufficiently uneven and pocketed such that fish can concentrate and survive in pools when water levels are low. Dry season fish concentrations may also provide an important food resource for piscivorous birds and mammals.

Q. Is the wetland pH fairly neutral?
⇒Most freshwater fish species can accommodate pH ranging from 5.0 to 8.5, although some species are adapted to highly acidic or basic conditions (Moyle and Cech 1988). "Black water" wetlands that are transparent but dark brown in color because of dissolved organic humic matter tend to be extremely acidic and inhospitable to most fish species. Surface water pH can be easily obtained in the field with a Hach kit or pH strips.

R. Does the wetland surface water remain sufficiently oxygenated throughout the year (e.g., no hydrogen sulfide odor when sediment is stirred, large open water fetch for wind mixing, rapid water movement through wetland)?
⇒Most warmwater fish require a dissolved oxygen concentration of 5 mg/l or greater. Cold-water fishes require dissolved oxygen to be at saturation. The critical period for dissolved oxygen is during late summer and during long periods of ice and snow cover (in cold climates) (Cuplin 1986).

S. Is sufficient cover for fish refugia, spawning grounds, or nursery habitat available in the wetland such as undercut stream banks, submerged log piles, grass islands, submerged aquatic plants, shaded areas, or boulders?
⇒Many species of spawning fish require submerged vegetation and other substrates for egg deposition sites and nest building. Fish require submerged refugia or shade from overhanging vegetation to escape or hide from predators. In general, wetlands with a high percentage of submerged cover (70-100%) provide the best fish habitat (Hall and Lambou 1989).

T. In temperate climates, is 50% or more of the wetland standing water shaded by trees or grasses, and does the wetland have sufficient depth or groundwater inflow to maintain open water conditions throughout the year?
⇒The fish fauna in temperate climates is largely determined by water temperature. Riparian vegetation is extremely important for shading smaller water bodies and streams and moderating summer water temperatures. Shrubs, trees, and other woody vegetation provide the best shading. To withstand bottom freeze, wetlands must be of sufficient depth, or must have a constant source of groundwater discharge.

U. Does the wetland provide significant food base for fish and wildlife such as detritus, algae, zooplankton, aquatic insects, benthic invertebrates, forage fish, amphibians, reptiles, small mammals, seed-producing plants (e.g., *Ceratophyllum*, *Polygonum*, *Zizania*, *Sparganium*, *Scirpus*), tuber-producing plants (e.g., *Sagittaria*, *Potamogeton*, *Eleocharis*, *Vallisineria*), foliage-producing plants (e.g., *Lemna*, *Wolffia*), fruit-producing plants, or nut-producing trees?
⇒Consider the overall diversity of vegetation species and lifeforms, vegetation cover and water quality, sources for leaf litter and detritus, and the availability of microhabitat for species at the base of the food chain. The evaluator may want to compare the wetland to more or less degraded wetlands elsewhere in the catchment or region.

V. Do any perturbations occur in the wetland and catchment that enhance or maintain fish and wildlife habitat, such as lightning fires, anthropogenic fires, managed fires, natural or managed grazing, water level manipulations, fencing, shoreline revegetation, exotic fish removal, or deposition of snags, nesting boxes, or platforms?
⇒*Often the frequency and intensity of natural fire, grazing, and water level fluctuations on wetlands are greatly altered by human settlement. Some management practices are used or may be necessary to maintain wildlife habitat values in the wetland and/or surrounding catchment.*

W. Describe any disturbances with potential to negatively affect fish and wildlife diversity in the wetland, such as exotic or aggressive plant species, exotic or aggressive animal species, hunting/trapping/fishing, artificial drainage or flooding, water diversion, frequent or suppressed wildfires, excavation, filling, devegetation, trampling, sedimentation, fertilizer/herbicide/pesticide usage, and urban or industrial pollution.
⇒*Disturbances to the animal community include both biotic factors (e.g., invasions of exotic species that displace native species, changes in grazing patterns) and abiotic conditions and processes (e.g., changes in the natural flooding or burning regime, water quality) that alter or destroy necessary habitat conditions.*

PART THREE: HUMAN USES AND VALUES

⇒*The physical and biological characteristics of a wetland can yield important values (often referred to as "functional values") for humans. Often human uses of a wetland and its surrounding catchment can be interpreted as "human abuses", as some land use practices in and near the wetland can have significant adverse affects on the natural functioning of the wetland. The following sections guide the evaluator through the assessment of flood storage and attenuation, shoreline stabilization, sediment retention and sedimentation impacts, nutrient/toxicant retention, removal, and transformation, groundwater recharge, and sustainable utilization. Questions address (1) the importance of the function to the human and ecological community, (2) the wetland and/or catchment characteristics that may create conditions required for the function to occur, and (3) the effectiveness of the wetland in performing the function.*

I. FLOOD STORAGE AND ATTENUATION

⇒*One the major values attributed to wetlands is the capacity to store floodwaters and/or attenuate flood peaks. The position of the wetland within the catchment is often the most important consideration for this function. Wetlands that have significant flood attenuation capabilities reduce flood peak discharge by altering the timing and magnitude of the flood (extending the duration of flooding through storing water while the flood peak passes and then later releasing water downstream). When wetlands are altered to increase flood storage or attenuation, other functions we value, such as fish and wildlife habitat, may be diminished.*

A. Is the wetland located upstream, upslope, or in conjunction with a human settlement, land use practice, or ecological community that is dependent upon some degree of flood storage or attenuation?
⇒*The assessor must first establish if flood storage or attenuation is of significant value to the human or ecological community, regardless of the effectiveness of the wetland or catchment in performing this function. If the wetland is the closest wetland upstream from a village, floodprone property, or habitat, it has a higher likelihood of providing significant flood protection value.*

B. Is the wetland located in the mid or lower reaches of the catchment or fed by a relatively high-order stream?
⇒*Wetlands located in the lower portions of a catchment, especially floodplains connected with higher order streams (streams that are fed by a number of upstream tributaries), tend to be more important for flood storage/attenuation because they generally receive a more significant proportion of the total floodwaters than upper catchment areas.*

C. Is the wetland part of a series of wetlands in the catchment (e.g., prairie potholes, oxbow lakes, seasonal flooded basins) that have the potential to contribute cumulative flood storage?
⇒*Wetlands located in the upper portions of the catchment may contribute to flood storage or attenuation through cumulative storage effects. A mosaic of smaller wetlands, especially seasonally flooded basins, may attenuate the movement of substantial volumes of rainfall runoff to the lower catchment, and the greater the ratio of wetlands to the total watershed area, the greater the reduction in flooding.*

D. Does the wetland receive direct discharge of stormwater as a major water input?
⇒*Many wetlands are valued as stormwater detention basins. Open channels or pipes may connect the wetland to sources of*

stormwater in the catchment. As discussed in Sections III and IV below, such conditions can also lead to significant degradation of wetland quality.

E. Are there large impervious areas, steep slopes, moderate slopes with row cropping, or areas with severe overgrazing or devegetation within the catchment that may lead to significant runoff problems?
⇒Pervious soils, shallow to moderate slopes, and thick vegetation cover with minimal exposed ground all tend to increase the percentage of rainfall that infiltrates to the subsurface or groundwater. As the proportion of surface water run-off increases relative to infiltration, floodwaters tend to become more concentrated downstream and result in shorter-duration floods with higher peaks. In general, significant runoff problems occur in many settings when more than 50% of the catchment is characterized by these high runoff conditions.

F. Do major flooding or rainfall events occur at a time when the volume of water stored in the wetland is small relative to the maximum storage capacity of the wetland?
⇒Consideration the ratio of the wetland's seasonally flooded area to its permanently flooded area. The storage capacity of a wetland during a particular rainfall or flooding event depends on the antecedent water conditions in the wetland before flooding occurs. A wetland may have a large capacity to store floodwaters, but annual heavy rainfall may occur in a concentrated time period such that the wetland rapidly utilizes its excess capacity and has no further flood storage value during the flooding season. Wetlands generally have greater impacts on smaller floods.

G. Is there a natural feature or human-made structure impeding drainage from the wetland (e.g., no surface water outlet, dammed or plugged outlet, constricted outlet, outlet with less capacity than inlet) that causes backwater conditions and thus allows for storage of water?
⇒Wetlands with little or no outlet capacity can be effective at retaining floodwaters. The capacity of a wetland to store floodwaters may be enhanced by artificial outflow restrictions, although these conditions can create conflicts between the value of a wetland for flood storage and its value for maintaining flora and fauna diversity. Preserving the natural flood storage and attenuation function of a wetland often prevents the need for dams and impoundments.

H. Does the wetland show evidence of water level responses to storm events (debris marks, erosion lines, stormwater inputs)?
⇒Watermarks and debris marks around the wetland (Part Two, Section I) can reveal that water levels in the wetland may appear to increase (from a given rainfall or flooding event) or decrease (through evapotranspiration and seepage) by a magnitude or rate much greater than expected. These observations suggest the potential for significant flood storage or attenuation function.

I. Considering the size of the wetland area in relation to the size of its catchment, at any time during the year is water likely to reach the wetland storage capacity (i.e., the level of observable wetland vegetation or soils)?
⇒The total runoff from the catchment can be roughly estimated by multiplying the area of the catchment by the depth of rainfall occurring in a fixed period of time (e.g., the amount of rainfall in a 24 hour storm that is great enough to have a probability of occurring only once every two years). The volume of the wetland storage capacity is then approximated by multiplying the area of the wetland by the flood storage depth (the maximum storage area extends only to the edge of the wetland vegetation, to limit analysis to the wetland and not the landscape in general). The percentage of the total storm event that can be stored in the wetland can be determined by dividing the volume of wetland storage by the total runoff from the catchment. In general, wetlands with a maximum flood storage to runoff ratio of less than 25% do not perform significant flood storage function. Wetlands that capture more than 25% of runoff may be significant in catchments where flood storage is important for protecting downstream property (Simon et al. 1987).

J. Considering the wetland size, configuration, sinuous or braided flow patterns, bottom surface roughness, and presence of any dense stands of macrophyte vegetation, is the wetland likely to significantly reduce the velocity of surface water inflow?
⇒In addition to reducing peak flood elevations by slowing the movement of floodwaters downstream, a wetland can also reduce damage caused by high velocity water movement. Observations of dense emergent or woody vegetation in the line of the flow path (e.g., a vegetated zone of at least 3 m width), long flow paths (e.g., a length of flow path at least 15 times the average width), and complex flow patterns (e.g., highly winding channels, shallow elevation gradient) suggest significant flood attenuation function through a reduction in flow velocity (Larson et al. 1989).

K. Describe any disturbances affecting flood storage and attenuation in the wetland such as artificial drainage and flooding, water diversion, excavation, filling, grazing, devegetation/deforestation, and sedimentation.

⇒*Human disruption of the natural flood storage and attenuation function of a wetland may limit its ability to store or detain floodwaters or reduce flow velocities. Extensive draining or ditching of wetlands can reverse the process of flood storage and attenuation by accelerating the movement of floodwaters downstream. Deliberate wetland filling and sedimentation from runoff can reduce the wetland storage capacity relative to the size of the catchment. Overgrazing and deforestation can facilitate rapid water movement through the wetland.*

II. SHORELINE STABILIZATION

⇒*Wetland vegetation is valued for its capacity to anchor and stabilize shorelines. Although the presence of wetland plants generally indicates stable geomorphology that is not prone to erosion, wetland vegetation can retard erosion in unstable lake fringe or riparian systems to a certain degree. Removal of wetland vegetation along stream banks can trigger stream channel instability, resulting in increased streambank erosion. If the geomorphic setting of the wetland (Part Two, Section I) is depressional, organic or mineral soil flats, or slope, shoreline stabilization is not a relevant consideration and this part of the assessment should be skipped.*

A. Is the wetland located adjacent to human settlements, agricultural fields, or ecological communities that are prone to the potential effects of erosion?

⇒*The assessor must first establish if shoreline stabilization is of significant value to the human or ecological community, regardless of the effectiveness of the wetland or catchment in performing this function. If the wetland stabilizes a shoreline that would otherwise result in the degradation of properties or habitat, it has a higher likelihood of providing significant shoreline stabilization value.*

B. Is the wetland shoreline exposed to potentially erosive wave action caused by a long, unvegetated (open water) fetch, rapid water currents, or boat traffic?

⇒*Shoreline erosion in lakes and wide rivers is highly correlated to wave action, especially if the unvegetated distance from the nearest shoreline is more than 2 km or the waterbody has high speed boat traffic (Larson et al. 1989). Most of the scouring of sediment in riparian systems occurs at the outer edge of river meanders. Channelized riverflow may lead to high flow velocities with strong erosive energy during storm events.*

C. Is the shoreline area vegetated with any of the following: thick swaths (greater than 3 m width) of submerged or emergent vegetation in the wave zone that decrease wave energy; perennial wetland species that form dense root mats; wetland species that have long stems that are resistant to erosive forces; or densely rooted wetland shrubs that provide upper bank stability?

⇒*Many of the intrinsic characteristics of wetland vegetation help reduce shoreline erosion through breaking up the kinetic energy of erosive forces. Where non-native vegetation species are used to stabilize wetland shorelines, however, trade-offs may occur between shoreline anchoring values and flora and fauna values. In addition, an evaluation of the geomorphology of the stream or coastline may be needed to determine if the erosive forces at work are likely to overwhelm the resistance offered by wetland vegetation. Often wetland vegetation is more of an indicator of stable streams and coastlines than of active shoreline stabilization.*

III. SEDIMENTATION IMPACTS AND SEDIMENT RETENTION

⇒*A major attribute of wetlands is their value in retaining sediment from rainfall runoff and flooding events. A wetland in any geomorphic setting (Part Two, Section I) has the potential for sediment retention. In catchments where the sediment transport is highest and the opportunity for sediment retention in wetlands is of greatest value, however, the impact of sedimentation on other wetland functions (e.g., vegetation diversity, fish and wildlife habitat) and human values (e.g., flood storage, groundwater recharge, recreation) may be serious. Evaluators must consider the relative value of the wetland and the downstream lake, stream, or coastal ecosystems that the wetland is buffering from the impact of sedimentation. In many cases, measures to control the sources of sedimentation are best for the overall health of the catchment.*

A. Is the wetland located upstream, upslope, or in conjunction with fish spawning habitat, navigation channels, drinking water supplies, flood control reservoirs, groundwater recharge sites, or ecological communities negatively impacted by sedimentation?

⇒*The assessor must first establish if sediment retention is of significant value to the human or ecological community, regardless of the effectiveness of the wetland or catchment in performing this function. If the wetland is a short distance upstream from drinking water supplies, open water lakes or reservoirs used for recreation, or sensitive habitat, for example, it has a higher likelihood of providing significant sediment retention value.*

B. Do land uses in the catchment include tillage on steep slopes or intrinsically erodable soils, row cropping on moderate slopes, deforestation, or severe overgrazing which can lead to erosion and sedimentation?

⇒*Most sedimentation problems are related to poor land use practices in the catchment.*

C. Is the local climate characterized by intense precipitation or wind events that break-up and transport sediment in the catchment?

⇒*Arid regions are especially vulnerable to erosion from the kinetic energy of rainfall and wind, because antecedent soil moisture is often low. Frequent high intensity rainfall can produce considerable erosion in any climate, however.*

D. Does the wetland provide significant retention time for particle settling by storing floodwaters or reducing run-off velocities?

⇒*Floodwater retention time can be estimated as the time it takes for sediment to travel through the wetland. Depressional wetlands generally have no outlets and provide long-term permanent sediment retention and accumulation. Riverine, lacustrine, and estuarine wetlands and organic and mineral soil flats may retain some fraction of the sediment influx, depending on their ability to reduce flow velocities as described in Part Three, Section I above. There is a strong correlation between the significance of flood water attenuation and sediment retention.*

E. Does the wetland vegetation prevent open water wave action and currents from stirring-up sediment from the wetland substrate?

⇒*Sediment that is retained by wetland vegetation may be resuspended in the water column through the kinetic energy of waves and currents. Thin bands of vegetation perpendicular to direction of water flow (less than 3 m width) may only temporarily retain sediments before they are resuspended and carried further downstream.*

F. Is fine mud observable on and beneath wetland plant stems?

⇒*The presence of fine sediment films on vegetation may indicate that the wetland has received sediment loads in the past. If the wetland is clouded by suspended sediment after several days have has passed since the last storm event, this may further indicate that the ability of the system to absorb such influxes is being taxed.*

IV. NUTRIENT/TOXICANT IMPACTS AND RETENTION/REMOVAL AND TRANSFORMATION

⇒*Wetlands are highly valued for their capacity to improve water quality through the retention, removal, and/or transformation of nutrients, metals, organic contaminants, and natural organic detritus. There is widespread interest in using natural and created wetlands for wastewater treatment and water quality improvement. Lacustrine fringe, estuarine fringe, and riverine wetlands and organic and mineral soil flats all have the potential to retain or remove nutrients such as nitrogen and phosphorus from flowing waters. However, a wetland may act as either a sink, transformer, or source for water-borne chemicals depending on hydrologic characteristics (e.g., slope, velocity, seepage, drainage, retention time), vegetation (e.g., nutrient uptake and organic production rates), sediment characteristics (e.g., capacity for adsorption and precipitation of metals and organic compounds, accretion to the wetland substrate), and microbial activity (e.g., sulfate reduction, denitrification through biotransformation)(Elder 1987). In catchments where nutrient or toxicant transport is highest and the opportunity for chemical retention in wetlands is of greatest value, however, the impact of excessive nutrient or toxicant loading on other wetland functions (e.g., vegetation diversity, fish and wildlife habitat) and human values (e.g., water supply, aesthetics, recreation) may be serious. Evaluators must consider the relative value of the wetland and the downstream lake, stream, or coastal ecosystems that the wetland is buffering from the impact of nutrient or toxicant loading. In many cases, measures to control the sources of nutrients and contaminants are best for the overall health of the catchment.*

A. Is the wetland located upstream, upslope, or in conjunction with drinking water supplies, groundwater supplies, shallow lakes or ponds, or ecological communities negatively impacted by toxic runoff or excess nutrient loading?
⇒*The assessor must first establish if nutrient retention, removal, and/or transformation is of significant value to the human or ecological community, regardless of the effectiveness of the wetland or catchment in performing this function. If the wetland is a short distance upstream from drinking water supplies, open water lakes or reservoirs used for recreation, or sensitive habitat, for example, it has a higher likelihood of providing significant water quality value.*

B. Does the catchment have the potential to deliver significant runoff to the wetland?
⇒*Wetlands that are located in the mid- to lower reaches of the catchment generally receive a greater percentage of rainfall runoff and floodwaters than wetlands further upstream in the catchment. Large impervious areas, steep slopes, moderate slopes with row cropping, and areas with severe overgrazing or devegetation within the catchment may contribute to significant runoff (Part Three, Section I).*

C. Does the wetland receive overland flow or direct discharge of stormwater or wastewater as a primary source of water?
⇒*Drainage tiles or ditch outlets in the wetland suggest significant stormwater discharge. Evidence of rapid water level responses to storm events (e.g., debris marks, erosion lines, stormwater inputs) may also indicate significant overland stormwater discharge to the wetland.*

D. Do catchment land use practices include fertilizer, manure, herbicide, or pesticide applications, or urban/industrial pollution?
⇒*Catchments with a large percentage of agricultural, commercial, residential, or industrial land use are generally significant sources for nutrient and pollutant runoff (Part Two, Section IV).*

E. Is the wetland of sufficient size to effectively treat domestic wastewater?
⇒*Wetlands with approximately 1 ha. open water per population of 30 people could effectively treat wastewater in most settings (Larson et al. 1989).*

F. Does the wetland provide significant sediment retention?
⇒*Many nutrients and contaminants enter the wetland via suspended sediment. This is a particularly important pathway for phosphorus, which is adsorbed onto clay particles. Refer to Part Three, Section III to answer this question.*

G. Is water passing through the wetland filtered through dense macrophyte stands that can provide nutrient or metal uptake (e.g., *Scirpus, Eleocharis, Papyrus, Phragmites, Typha*)?
⇒*Different species of aquatic macrophytes vary in their ability to retain and uptake nutrients. The high stem density of species like rushes (e.g., Scirpus, Eleocharis) increase resistance to flow and improve contact time for uptake. As water moves through the wetland, the composition of the nutrient load tends to shift from forms used by vegetation to forms released by vegetation. Nutrient uptake also varies depending on the season when growth and primary productivity are highest, especially in temperate areas where seasonal plant dehiscence occurs. The permanent removal of chemical constituents occurs when sediments are buried below the root uptake zone of the wetland vegetation. Toxicants are generally not taken up by wetland vegetation, but some metal uptake may occur (Elder 1987).*

H. Is the wetland sufficiently shallow along its flow path (less than 1 m depth) to facilitate chemical exchange between inflowing water and the wetland substrate?
⇒*Shallower wetlands are more effective at nutrient removal because they provide a greater degree of contact between inflowing water and the wetland substrate. The removal of metals and organic compounds occurs primarily through adsorption to sediments and subsequent accretion (burial) in the wetland substrate (Elder 1987).*

I. Does the wetland have an accumulation of organic matter (e.g., peat, muck, sphagnum moss) for the permanent removal of nutrients?
⇒*Refer to Part Two, Section II. Sediment with high organic matter content also provides strong a high cation exchange capacity, further increasing nutrient removal.*

J. Is the wetland substrate characterized by predominant anaerobic conditions that facilitate nutrient retention and transformation processes (e.g., semi-permanently to permanently flooded, seasonally flooded with drawdown periods of very short duration, strong hydrogen sulfide odor in sediments)?
⇒*The presence of both aerobic and anaerobic conditions in wetlands facilitates processes such as denitrification, sulfate reduction, and iron and manganese transformation to more soluble forms for plant uptake. Anaerobic conditions can be observed directly (e.g., hydrogen sulfide odor) or inferred from the wetland hydroperiod.*

K. Are algal blooms, duckweed blooms (e.g., *Lemna, Azolla*), water hyacinth (*Eicchornia*) blooms, dense macrophyte growth, or other signs of excess nutrient loading to the wetland apparent or historically reported?
⇒*Highly eutrophic conditions in the wetland suggest that the ecosystem is at or near its capacity for nutrient uptake and water quality maintenance.*

L. Are there extensive beds of clams, mussels, or other filter-feeding organisms present?
⇒*The presence of such species indicates algae and waterborne sediments are being filtered and removed from the water column, improving water clarity.*

V. GROUNDWATER RECHARGE

⇒*Wetlands are often credited with recharging subsurface aquifers for maintaining groundwater supplies for drinking water and irrigation. However, most wetlands probably do not contribute significant groundwater recharge, because most wetlands are underlain by impermeable soils. Groundwater recharge occurring through wetlands located at or near the top of a hill with permeable soils are a function of the landscape rather than the particular wetland. Small depressional wetlands, such as dambos and prairie pothole wetlands, may provide the best opportunity for cumulative groundwater recharge function. Vegetated upland areas with more pervious soils are typically much more significant sources for infiltration and groundwater recharge. Groundwater discharge is also sometimes considered as a wetland function, although this process is a function of the landscape rather than the wetland itself. Groundwater discharge through wetlands can be very important for maintaining floral diversity, wildlife habitat, fish spawning grounds, and baseflow in headwater streams, but is considered within the discussions in Part Two on wetland hydrology, wetland vegetation, and fish and wildlife habitat. Finally, it should be noted that it is very difficult to fully understand groundwater dynamics in wetlands within a rapid assessment framework.*

A. Does the wetland occur upslope from wells for water supply or irrigation or ecological communities that depend on groundwater?
⇒*The assessor must first establish if groundwater recharge is of significant value to the human or ecological community, regardless of the effectiveness of the wetland or catchment in performing this function. If the wetland is a located within 5-10 km upstream from drinking water, irrigation supplies, or sensitive habitat, for example, it has a higher likelihood of providing significant groundwater recharge value.*

B. Is the wetland part of a floodplain system with shallow unconfined aquifers that provide groundwater for drinking water, irrigation, or the maintenance of ecological communities?
⇒*Wetland floodplain systems may store infiltrated floodwaters as subsurface water, which can be significant for flood recession agriculture or maintaining mudflat conditions. These shallow aquifers are generally not connected with local or regional groundwater systems, however, and therefore do not provide significant groundwater recharge for water supplies in areas that are outside of the immediate floodplain.*

C. Is the wetland located in a highly impervious catchment where upland recharge has been reduced or eliminated?
⇒*Groundwater recharge is most likely to be significant in more urban watersheds where most of the natural recharge areas have been eliminated. The relative percentage of groundwater contributed by the wetland may increase substantially in these settings.*

D. Does the wetland occur in a stepped topographical sequence within the watershed?
⇒*Both groundwater recharge and discharge can be significant in stepped topographic sequences, where upslope wetlands recharge groundwater that discharges in downslope wetlands. This type of groundwater recharge is important for maintaining the hydroperiod of other wetlands, but may not be significant in terms of human water supply.*

E. Is the wetland underlain by relatively pervious soils such as well-sorted glacial sediment or alluvial sediment, rather than thick clay, unfractured bedrock, shale, or siltstone?
⇒*Some wetlands have relatively pervious soils and may contribute meaningful groundwater recharge if they receive significant rainfall runoff or floodwaters.*

F. Is the wetland one of several wetlands in the catchment (e.g., prairie potholes, dambos, other seasonal flooded basins) that have the potential to contribute cumulative groundwater recharge?
⇒*The best opportunity for groundwater recharge probably occurs in conjunction with the cumulative flood storage value of depressional wetlands in the catchment (Part Three, Section I). Recharge occurs most frequently around the edges of wetlands with impermeable substrates after floodwaters are captured, and is relatively highest in small wetlands with a high edge to volume ratio (Mitsch and Gosselink 1993).*

G. Describe any disturbances affecting groundwater recharge from the wetland such as artificial drainage, excavation/ filling, agricultural development, or sedimentation.
⇒*Groundwater recharge function is degraded when wetland edges or substrates become less permeable through sedimentation, filling, or agricultural compaction. The cumulative groundwater recharge value (as well as flood storage value) of some depressional wetlands in the catchment is destroyed by drainage tiles and channels.*

VI. SUSTAINABLE WETLAND UTILIZATION

⇒*Wetlands are also valued for a variety of consumptive and non-consumptive uses, many of which are compatible with the ecological integrity of the wetland and other important human values. Many of these values are best assessed through discussions with people living in the immediate catchment of the wetland. Unsustainable forms of wetland use, such as agricultural development, overgrazing, dredging, filling, and impounding waters, are addressed throughout the assessment as impacts and disturbances to particular wetland functions.*

A. Describe any of the following non-consumptive uses observed, evidenced, or known to occur in the wetland or its immediate catchment:

Ecotourism	
Education activities	
Scientific research	
Nature observation/art/photography	
Recreational boating/canoeing	
Hiking/exploration	

⇒*Although difficult to quantify, values such as ecotourism, education, scientific research, aesthetics, and recreation can be very important to the human community even in low-income areas.*

B. Ecotourism potential: Does the wetland site or immediate catchment offer one or two outstanding wildlife or cultural experiences and an infrastructure that can support ecotourists?
⇒*A well-managed ecotourism program can generate substantial income and provide strong incentives for the wise-use and protection of a wetland. The wetland site may have ecotourism potential if it offers unique or spectacular wildlife experiences (e.g., endemic species, large or unusual species, concentrated waterfowl flocks, feeding activities, nesting colonies, seasonal migrations) that one has a good chance of observing, interspersed with other interesting points, such as good birding areas or impressive scenery. Successful ecotourism at a wetland requires people-management as well as "watchable wildlife". Important infrastructure includes availability of land transport, trails and footpaths, boats, housing, and well-trained guides or visitor centers. Wetlands located in remote areas should offer enough to keep an ecotourist happy for at least three days, unless other environmental, social, or architectural features of significance are located nearby (Ashton 1991).*

C. Education potential: Is the wetland located in close proximity to schools, universities, or other education centers, and have direct public access via public roads, dikes, lands, or waterways?
⇒*Wetlands are educationally rich environments because of their ecological diversity and complexity. They are field laboratories where students can learn about natural history and cultural heritage. Wetlands are especially valuable for education in more urban settings where access to natural areas may be limited. For the site to have good potential for a wetland*

education program, students must have direct hands-on access to the wetland soils, water, and vegetation, and some of its animal life.

D. Scientific research potential: Does the wetland contain any rare or endemic species or other species or site characteristics of public or scientific interest?

⇒*The complexity of wetlands makes them ideal sites for scientific research. The presence of rare or endemic species or species of special cultural value may encourage scientific exploration. Scientific research may draw attention to wetlands that may otherwise receive little conservation support.*

E. Aesthetics and recreation potential: Does the wetland encourage exploration by providing long views within the wetland, long views into the adjacent catchment, convoluted edges within and/or around the wetland border, different (and perhaps more natural/complex) environments from the catchment land cover, or valuable greenspace in an urban area?

⇒*The wetland may have strong aesthetic value, encouraging non-consumptive uses such as nature observation, hiking, biking, catch-and-release fishing, and canoeing or providing inspiration for art and literature. Wetlands that create a sense of "mystery" by preventing the observer from seeing more than 50% of the wetland from a particular vantage point, or add to the variety of visibly separate areas of similar vegetation, color, or texture within the catchment as a whole, are especially important for encouraging aesthetic and recreational usage (Smardon 1983). In urban areas, the presence of greenspace provided by a wetland may be significant if it provides a contrast to the surrounding land uses. Unpleasant odors, litter, or noises will greatly detract from the aesthetic and recreational value of a wetland. Although it is often very difficult to put an economic value on aesthetic and recreational uses of wetlands, especially in low income areas, these values are often expressed by strong community or regional support for protecting a threatened wetland.*

F. Renewable resources: Does the wetland support stable harvests of vegetation or animal species that have important edible, medicinal, material, or naturally pest-resistant value?

⇒*Wetlands may provide a wealth of renewable resources for cultural and religious practices, sport, and subsistence needs. Wetlands that are managed wisely may provide sustainable harvests of traditional medicines, construction materials, fuelwood, crafts, skins, pelts, shellfish, fish, and waterfowl. For some resources, especially migratory wildlife and slow-growing perennial vegetation, it may be difficult to determine whether a population is remaining stable without more extensive scientific study.*

TAXONOMY AND ECOLOGY AS BASIC TOOLS IN WETLAND CONSERVATION

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ABSTRACT

This paper addresses the significance of academic research for the conservation and management of wetlands. Two studies, one on shorebirds and their intertidal invertebrate prey in the northwest European Wadden Sea and the other on fish and their avian predators in East African Lake Victoria, are used as examples. These studies have demonstrated how a combination of taxonomy and ecology may provide results which are directly applicable to nature management. Detailed investigation of the prey fraction harvestable to the birds has revealed that traditional prey stock assessment largely overestimates the food supply. Since the resources discussed are partly shared with man, stock assessment may lead to high catch quotas for fishermen and, consequently, to direct competition between human and avian users of wetlands.

INTRODUCTION

The need for scientific research in nature conservation has since long been disputed. Classical conservationists were primarily concerned with the preservation of natural wildlife areas (Sheail 1987). They tried to keep all human activities, including research, out of the conservation areas. However, people apparently have influenced their environment all over the world over thousands of years to such a degree that real "virgin" habitats have vanished (Golley 1991). In recent years, the key issue in wildlife conservation has changed from preservation to management (e.g., Homewood and Rodgers 1991). Nature managers try to balance the resilience of an ecosystem and the impact of socioeconomic demands. To do their work properly, they should at least have a basic knowledge of the biological processes working in the area they have to manage. Therefore, scientific research in nature reserves is often stimulated nowadays.

Wetlands are very fragile ecosystems because they contain several natural resources (Howard 1993). Many wetlands are exploited as fisheries. Although artisanal fisheries do not normally deplete the stocks completely, the effects can be large (Barel *et al.* 1991). Commercial fishing does not usually start before some stock assessment has been conducted, but still it may result in strongly declining fish populations (Barel *et al.* 1991). Conservation organizations have tried to assess the value of wetlands for wildlife, often using birds as key species (Howard 1993). The choice of birds as indicator species may have resulted from personal "birding" traditions of conservationists, but seems to be relevant, since it has been found that no less than 12% of the African bird species are associated with lakes and swamps (Tyler 1993). Most research has been restricted to counting the numbers of birds using a wetland for feeding, molting, wintering, etc. Combination of fish stock assessment and bird counts forms a base for "wise use" of wetlands (Carp 1972). It provides a first estimate of the amount of resources, the potential exploitation by birds, and the fraction which might be harvested by people. However, management based only on this information will be very poor. In this paper I will give a few examples of the potential contribution of academic research to a better assessment of resource utilization.

Taxonomy and ecology are two disciplines in biology which can be of crucial importance to the management of an ecosystem. The role of taxonomy is obvious; before one can make any statement on the functioning of a system, one should be able to distinguish the species involved. Next, ecological investigations should unravel the food web--the crux in studies on resource utilization. Recent studies on avian foraging ecology have addressed the important problem of prey availability (see Wiens 1991). These revealed that often only a small part of the standing stock of prey can actually be harvested by predators (Reading and McGrorty 1978; Myers *et al.* 1980; Zwarts and Wanink 1984, 1989, 1991, 1993; Richardson 1985; Wanink and Zwarts 1985; Zwarts and Esselink 1989; Wanink 1992; Zwarts and Blomert 1992; Zwarts *et al.* 1992; Wanink *et al.* 1993). Here I will review some results of two studies in which I participated, to demonstrate the relevance of taxonomy and ecology for wetland conservation. The ecological part of both studies mainly dealt with foraging. To date, this is probably one of the issues most relevant to nature conservation (Newton 1991; Howard 1993).

STUDY AREAS

The first study was done in the marine intertidal environment of the Wadden Sea, the largest estuarine area in Europe with a surface area of 10,000 km^2, which is shared by The Netherlands, Germany, and Denmark. The Wadden Sea is the principal staging and wintering area in Europe for millions of migrating ducks, geese, shorebirds, gulls, and terns (Smit 1981). Up to 2 million shorebirds may simultaneously exploit the 4,000 km² of tidal flats exposed during low tide, aiming for invertebrates living in and on the sediment. The Wadden Sea is also the most important nursery area for many fish species of the North Sea. Man has long since exploited stocks of shrimp and flatfish. Recently, large modern vessels aiming for cockles and mussels have exerted severe pressure on the populations. The combination of an extensive fishery and a few successive years with poor spatfall of cockles and mussels has resulted in a total destruction of the stocks and a dramatic decline in molluscivorous birds (Beukema 1992; Swennen and Duiven 1992). The data presented in the current paper result from a study on the relationships between shorebirds and their infaunal prey, conducted along the Frisian coast in the Dutch part of the Wadden Sea, between 1977 and 1986 (see Zwarts and Wanink 1993).

The second study area was situated in the southern part of Lake Victoria, the largest tropical lake in the world with a surface area of 69,000 km², which is shared by the East African countries of Tanzania, Uganda, and Kenya. A large part of the 3,300 km long, extremely irregular shoreline, with many shallow bays, is fringed by vast papyrus swamps (Greenwood 1974). The swamps and the adjacent shallow lake waters may be regarded as one of the larger African wetlands (Tyler 1993; P. Mafabi *pers. comm.*; Mavuti *this proceedings*). In the 1970s the development of a commercial fishery for haplochromine cichlids locally resulted in a serious decline in the populations of these endemic fishes (Witte and Goudswaard 1985), which used to form over 80% of the lake's demersal fish biomass (Kudhongania and Cordone 1974). In the early 1980s the explosive population increase of an introduced large predator, the Nile perch (*Lates* sp.) (Harrison 1991), resulted in an even more dramatic destruction of the haplochromines; approximately 200 of the 300+ species of the cichlid flock were eradicated (Ogutu-Ohwayo 1990; Barel *et al.* 1991; Witte *et al.* 1992a, 1992b). The food web in the lake changed significantly (Ligtvoet and Witte 1991) and non-piscine species were also affected (Goldschmidt *et al.* 1993; Witte *et al.* 1995). Although the most severe effects of the Nile perch explosion occurred in the open waters, changes in the fringing wetland areas have been observed (Kruuk and Goudswaard 1990; Goudswaard and Wanink 1993; Wanink and Goudswaard 1994; Wanink *et al.* 1993). The data presented in the current paper result from a project on taxonomy, morphology, and ecology of fishes from the Mwanza region (Tanzania) of the lake, conducted by the Haplochromis Ecology Survey Team (HEST) between 1977 and 1990 (van Oijen *et al.* 1981). During the latter half of this period applied fishery biology and relationships between fish and their avian predators were incorporated into the project (HEST 1988; Wanink *et al.* 1988, 1989).

MATERIALS AND METHODS

Detailed information on all techniques used is given in the cited papers. Here I will describe some simple but crucial techniques used to study foraging ecology, which will be discussed in this paper.

For the Wadden Sea study, foraging shorebirds were observed from hides using a zoom-telescope (15-60×). The hides were erected on the mudflats, in the center of an area where 73 plots of 0.1 ha. were pegged out. These plots were sampled monthly to determine the biomass of the benthic prey species. Sampling was done by pushing a core sampler (ø 15 cm) 40 cm into the sediment, taking it out, and sieving the contents through a 1-mm sieve. The invertebrates were stored in fresh seawater and brought to the laboratory for analysis (see Esselink and Zwarts 1989; Zwarts 1991; Wanink and Zwarts 1993).

This classical approach results in knowledge of the total biomass of potential prey, but it gives no information on the fraction which may actually be taken by the birds. For a shorebird feeding on buried invertebrates, the accessibility of the prey will be determined by the length of the bird's bill and the depth in the sediment at which the invertebrate is staying (Myers *et al.* 1980). Therefore, shorebirds were caught, their bills were measured, and their legs were marked with color rings. When observing them afterwards, the depth from which they took their prey could be estimated. To be able to compare this to the depth distribution of the invertebrates, a different sampling method was developed. The core was not sieved, but laid down horizontally and broken open carefully after which the living depth of bivalves and the burrow depth of worms was measured. All animals were individually measured, weighed, etc., so depth could be related to, for example, size and condition. This sampling program was conducted fortnightly during 1980-86 to be able to analyze seasonal and annual trends (see Zwarts 1986; Esselink and Zwarts 1989; Zwarts and Wanink 1989, 1993).

For the Lake Victoria study, the fraction of the fish stocks in Lake Victoria accessible to foraging Pied Kingfishers (*Ceryle rudis*) had to be estimated from their depth distribution in the water column because the birds can only reach surface dwellers. Depth distribution was estimated by setting gill nets reaching from the water surface to the bottom and emptying the nets every 2 or 4 hours over a 24-hour cycle. Markers were attached to the nets at regular depth intervals (0.5 or 1 m), so the fraction of the total prey population present at a given depth class, and its fluctuations in time, could be determined (see Goldschmidt *et al.* 1990; Wanink 1992; Wanink *et al.* 1993).

Although very small mesh sizes were used (the minimum size was 8 mm stretched mesh), juveniles of the cyprinid *Rastrineobola argentea* (kiswahili: dagaa), the most important prey for Pied Kingfishers after the Nile perch boom, could not be sampled with this material. Most length classes could be caught in two small trawl nets (cod end 5 mm stretched mesh) which were operated from a small boat using a 25 hp outboard engine. One of these nets could sample the surface and the other the bottom layer (see Witte 1981; Witte *et al.* 1992b).

TAXONOMY AS A TOOL FOR MANAGEMENT

The Wadden Sea is an area characterized by high numbers of relatively few species all of which can easily be identified from taxonomic tables. Almost the reverse was found in Lake Victoria, however. When in 1976 a commercial trawl fishery for haplochromines was started in the Mwanza region, fishery managers only knew that they were going to exploit a massive stock (Kudhongania and Cordone 1974) consisting of many species (Greenwood 1974). Although 40 species could be caught in one haul and the catch composition varied with area and depth (Witte and van Oijen 1990), the 250+ species which formed the base of this multi-species fishery were regarded as a single ecological unit (Witte 1981). At the time 75% of the species in the research area were undescribed (van Oijen *et al.* 1981) and identification of species appeared to be extremely difficult due to the overall morphological similarity (Barel *et al.* 1977). Therefore, HEST decided to follow Greenwood (1974) and split the fish into trophic groups (van Oijen *et al.* 1981). In this way the system was simplified, but still important ecological conclusions could be made and passed on to the fishery management. This was also the best solution for the fishery authorities, since management at the species level would not have been feasible (Pauly 1980). One of the major conclusions from the research was that the distinguished groups were not evenly distributed over the area, but very habitat-restricted (Witte 1981). Thus, local overfishing may lead to a stock depletion which will not be replenished by immigration from neighboring habitats.

The use of trophic groups appears to speed up the process of understanding the functioning of an ecosystem, which makes it an important tool for nature management. Bellan (1991), reaching the same conclusion, further points to a similar use of "functional groups," which are distinguished according to their foraging mode. Functional groups have been successfully used in the Wadden Sea research. Invertebrates were split into suspension- and deposit feeders on the basis of morphological features, and relationships between foraging mode, distribution, growth, and burying depth--all very relevant to foraging shorebirds--have been established (Zwarts and Wanink 1989; Wanink and Zwarts 1993). There seems to be some danger in this approach, however. The bivalve *Macoma balthica* has been classified as a deposit feeder according to its morphology, but ecological research revealed that it may take most of its food by suspension feeding (Hummel 1985). A similar contradiction between classification on the basis of either morphology or diet has been observed in the cichlid flock from Lake Victoria (van Oijen *et al.* 1981). This brings me to the point which should always be stressed by ecologists: the need for ecological research.

ECOLOGY AS A TOOL FOR MANAGEMENT

Seasonal patterns in growth and mortality of the intertidal invertebrates from the Wadden Sea result in large fluctuations in overall biomass, with winter values reaching only 50% of those for summer (Beukema 1974; Zwarts and Wanink 1993). The average standing stock of 25 g ash-free dry weight (AFDW) per m² (Beukema 1976) and the production of 25 g AFDW per m² per year (Beukema 1981) seem to guarantee a fair supply for shorebirds as well as for human exploitation (Wolff and Smit 1984). However, most birds leave the Wadden Sea after a short staging period in autumn and fly to tropical Africa, to find a standing stock of only 9 g AFDW per m² in the most important wintering area along the East Atlantic Flyway: Mauritanian Banc d'Arguin (Zwarts 1988; Wolff and Smit 1990; Zwarts *et al.* 1990). The relatively stable environment and high production of the Banc d'Arguin have been mentioned as factors attracting wintering shorebirds (Wolff and Smit 1990). Mass departure from the Wadden Sea by the birds, in spite of the high prey densities present, supports the idea that density of available prey rather than absolute density determines the quality of feeding grounds (see Evans 1976; Wiens 1989).

Prey availability has been the subject of extensive studies on the foraging ecology of shorebirds in the Dutch part of the Wadden Sea (reviewed in Zwarts and Wanink 1993). Total prey population has been divided into various fractions, which were defined as follows (Zwarts and Blomert 1992; Zwarts *et al.* 1992; Zwarts and Wanink 1993).

1. **Detectable prey**. Touch-feeding shorebirds like Oystercatcher (*Haematopus ostralegus*) and Knot (*Calidris canutus*) randomly probe their bills into the substrate, so the probability of detecting a prey may be estimated from the surface "touch area" of the invertebrate (Hulscher 1976, 1982; Zwarts and Blomert 1992). Visually hunting birds like Curlew (*Numenius arquata*) need clues like siphon holes of bivalves, which may decay over the low water period, leaving a very small detectable prey fraction (Zwarts and Wanink 1984).

2. **Accessible prey**. Invertebrates living in the sediment at depths surpassing the bill length of their predators are inaccessible by definition. Prey buried within the range of the bill may not always be classified as accessible, however, since actual probing depth of a bird depends on prey density and is adjusted to maximize intake rate (Wanink and Zwarts 1985).

3. **Ingestible prey**. Oystercatchers have developed techniques to remove the flesh from their bivalve prey (Hul-

scher 1982; Wanink and Zwarts 1985), which makes all sizes ingestible. Species like Knot, which eat their prey whole, cannot swallow shells being larger than the size of their gape (Zwarts and Blomert 1992).

4. **Available prey**. Prey which are detectable, accessible, and ingestible form the available fraction. Shorebirds usually do not take the full size range of available prey, however, but reject the smaller size classes (Zwarts and Wanink 1984; Piersma 1987).

5. **Profitable prey**. Prey are unprofitable and should be rejected when energy yield during the time needed to handle them is below the mean intake rate during feeding (searching + handling), in order to maximize intake rate (Hughes 1980). Profitability usually increases with prey size, because energy content increases exponentially with size, while handling time increases less (Zwarts and Wanink 1984).

6. **Harvestable prey**. Prey are harvestable when they are available as well as profitable. The harvestable fraction of a prey population determines the importance of an area as a feeding site for their predators. Harvestability of intertidal invertebrates by shorebirds may show large seasonal and annual fluctuations (Zwarts and Wanink 1993).

Using the harvestable fraction in our analyses instead of total prey density strongly influenced the estimated food supply for Oystercatchers in the Wadden Sea and for Pied Kingfishers in Lake Victoria (Figures 1 and 2). The clam *Scrobicularia plana* is one of several prey species taken by Oystercatchers. Although *S. plana* normally is rare in the Dutch Wadden Sea, the species was abundant in our study area, reaching biomass values of 40-70 g AFDW per m² during 1979-82 (Zwarts and Wanink 1993). The strong year class of 1976 contributed to almost 100% of the standing stock and hardly any recruitment occurred during the period of investigation (1977-86). Mortality and growth resulted in an increase of biomass during 1976-79, constant levels (except from seasonal changes) during 1979-82, and a decline during the following years.

Figure 1 shows total biomass and the fraction harvestable by Oystercatchers for 2 sampling dates in 1978, when mean shell length amounted to 30 mm, and for 2 sampling dates in 1982, when clams had reached a size of 40 mm on average. Total biomass was high in 1978 (both dates: 33 g/m²) as well as in 1982 (both dates: 36 g/m²). Clams smaller than 20 mm, which are not profitable to Oystercatchers and thus should be ignored (Zwarts *et al.* 1994), contributed 0.5-1.5% only to total biomass in 1978 and were completely absent in 1982. Since prey size has a higher impact on shorebird intake rate than prey density (Zwarts *et al.* 1994), the increase in mean length (33%) and total biomass (9%) between 1978 and 1982 may, in spite of the population decline, have allowed for higher intake rates of Oystercatchers in 1982. This was counteracted, however, by a change in availability of the clams. As mentioned before, the fraction available to Oystercatchers solely depends on accessibility and is, thus, set by depth distribution.

Two trends in burying depth have shaped the harvestability curves in Figure 1. First, depth increases with size (Zwarts and Wanink 1989). Assuming that the birds take their prey from the upper 6 cm of the sediment only (Wanink and Zwarts 1985; Zwarts and Wanink 1991), the available fraction for each size class has been estimated from Figure 5 in Zwarts and Wanink (1989). The upper panels in Figure 1 clearly show the decreasing availability with increasing size. Harvestable biomass in August amounted to 20 g/m² (61% of total biomass) in 1978 and to 15 g/m² (42%) in 1982. Second, clams of a given size bury shallower in summer than in winter (Zwarts and Wanink 1989). Burying depth increases strongly between August and November (Zwarts and Wanink 1993). This is reflected in Figure 1, which shows that the harvestable fraction in November dropped to 2 g/m² (6%) in 1978 and to 1 g/m² (3%) in 1982. Therefore, in spite of a large stock of *S. plana*, clam-feeding Oystercatchers may face very poor foraging conditions in winter.

Detectability of dagaa to hunting Pied Kingfishers is hard to measure. Therefore, the available fraction in Figure 2 represents a maximum estimate, assuming all accessible fish to be detectable. Since the birds can swallow all size classes (Wanink *et al.* 1993), the available prey fraction solely depends on accessibility, just like in clam-feeding Oystercatchers. Plunging kingfishers can take fish from the upper 30 cm of the water column (Whitfield and Blaber 1978). The gear used to sample dagaa distribution could distinguish depth classes of 50 cm only, so the accessible fraction may be overestimated. The threshold size of dagaa profitable to Pied Kingfishers was determined from pellet analysis (Wanink *et al.* 1993). Figure 2 shows that 71 g DW per area covered by 10 minutes of trawling (51% of total biomass) was available during August-October, when most fish were relatively small. In fact, many were too small to be profitable prey, and only 43 g/10 min (30%) was harvestable. Eight months later, most fish had passed the profitability threshold and not more than 1 g/10 min (0.2%) were ignored by the birds (lower panel in Figure 2). By this time total biomass had increased to 480 g/10 min, but the harvestable fraction still amounted to 45 g/10 min (9%) only. Low harvestability is caused by daily vertical migration patterns of dagaa. Large fish spend the day near the bottom and move to the surface around sunset, while small fish occupy the surface layer by day and settle at intermediate depths at night (Wanink 1992).

With the examples depicted in Figures 1 and 2, I have tried to demonstrate how the simple use of some basic principles from academic research in the field of foraging ecology may provide more reliable estimates of the food supply for wetland birds. In both cases, more detailed studies have further refined the picture.

Oystercatchers were found to take shallow living prey from the accessible fraction (Wanink and Zwarts 1985). Body condition of *S. plana* and of four other prey species appeared to increase with depth, so the birds were actually selecting marginal prey (Zwarts and Wanink 1991). Oystercatchers feeding on the clam *Macoma balthica* often encountered prey infested by a parasitic trematode. The percentage of clams being infested decreased with depth (Zwarts and Wanink 1991). The birds were able to identify parasitized clams after opening them and they would normally reject the flesh (Hulscher 1982). Time spent on handling infested prey lowered the intake rate of Oystercatchers, while prey rejection reduced the harvestable fraction of clams.

Pied Kingfishers also encountered parasitized prey regularly. Most dagaa over 35 mm long present at the surface during daytime were carrying tapeworms which reduced their body weight by 20% on average (Wanink 1992). Infested fish were actually eaten by the birds. The worms were regurgitated together with fish bones in pellets. Pied Kingfishers have reduced the impact of parasites on their diet by concentrating their hunting effort in the hour before sunset, when unparasitized adult dagaa start their daily migration from the bottom area to the surface (Wanink *et al.* 1993). This recent habit of twilight feeding has increased the availability of large dagaa to the birds.

CONCLUDING REMARKS

During this workshop different opinions about the role of research in wetland conservation have been expressed. I support the idea that knowledge of the functioning of ecosystems is essential in their conservation (Gichuki *this proceedings*). Two strong arguments against the use of research as a base for all management have been put forward, however. First, wetlands may have disappeared by the time researchers have completed their analysis (P. Mafabi *pers. comm.*). Second, the costs of specialized research may be a problem, especially in developing countries (Kotze *et al. this proceedings*). In this paper I have tried to show how the time constraint of ecological research may be reduced by using taxonomical units other than the species. Moreover, the use of some basic ideas, like dividing a potential prey stock into the categories discussed, may quickly provide the most relevant information for management. Finally, the use of expensive and sophisticated equipment is not always necessary. A pair of binoculars, a simple core sampler, some gill nets, a ruler, and a balance would be enough to produce the main results presented above.

In both the Wadden Sea and Lake Victoria, birds and people share the resources, a potentially dangerous situation. As mentioned, the clam *S. plana* is rather uncommon outside our study area. Apart from *S. plana* the clams *Macoma balthica* and *Mya arenaria*, mussels *Mytilus edulis*, and cockles *Cerastoderma edule* are important as food for Oystercatchers. Although the Wadden Sea has the status of a nature reserve, fishing for mussels and cockles is allowed in the Dutch part. Fishing was not even banned when in 1990 stocks had declined after some years of failing recruitment, and the remaining banks were depleted by human use (Beukema 1993). One could argue that mussel- and cockle-feeding birds could switch to other prey species which were still abundant, but these alternatives were, in contrast to mussels and cockles, all burying deeply and only small fractions were harvestable. As a result, many birds left the area and higher numbers than normal were found dead (Beukema 1993).

By a combination of overfishing and predation by the introduced Nile perch, the stocks of haplochromine cichlids in the Mwanza Gulf of Lake Victoria severely declined during the 1980s (Witte and Goudswaard 1985; Witte *et al.* 1992a, 1992b). Although Pied Kingfishers also used to feed on dagaa before the decline of the haplochromines, the relatively large cichlids were more important in those days (Goudswaard and Wanink 1993; Wanink and Goudswaard 1993). The change to a diet of almost exclusively dagaa has dramatically increased the number of fish needed daily. This has resulted in a change of the foraging behavior. Kingfishers used to exploit the inshore areas only, but are now flying out very far to meet the largest prey available (Wanink *et al.* 1993). Dagaa stock has increased after the disappearance of the haplochromines (Wanink 1991; Witte *et al.* 1992a), but the low harvestability (Figure 2) leaves the birds with a relatively poor food supply. Therefore, the recent increase in fishing effort for dagaa by man should be watched carefully.

Both wetlands discussed are shared by three countries, which inhibits the implementation of proper management for the integral system. Cooperation at the government level seems to be very difficult. It is my experience, however, that researchers from different countries easily combine their efforts and share their knowledge to achieve a common goal. Thus, apart from using the basic tools, researchers could play a basic role in the conservation and wise use of wetlands by bringing home the message from an inspiring meeting like the workshop in Maun.

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REFERENCES CITED

Barel, C.D.N., M.J.P. van Oijen, F. Witte, and E.L.M. Witte-Maas. 1977. An introduction to the taxonomy and morphology of the haplochromine Cichlidae from Lake Victoria. Netherlands Journal of Zoology 27: 333-389.

Barel, C.D.N., W. Ligtvoet, T. Goldschmidt, F. Witte, and P. C. Goudswaard. 1991. The haplochromine cichlids in Lake Victoria: an assessment of biological and fisheries interests. Pages 258-279 *in* M.H.H. Keenleyside, ed., Cichlid fishes: behaviour, ecology and evolution. Chapman and Hall, London, UK.

Bellan, G. 1991. Characteristic, indicative and sentinel species: from the conception to the utilization. Pages 95-100 *in* O. Ravera, ed., Terrestrial and aquatic ecosystems: perturbation and recovery. Ellis Horwood Ltd., Chichester, UK.

Beukema, J. J. 1974. Seasonal changes in the biomass of the macro-benthos of a tidal flat area in the Dutch Wadden Sea. Netherlands Journal of Sea Research 8: 94-107.

Beukema, J. J. 1976. Biomass and species richness of the macrobenthic animals living on tidal flats of the Dutch Wadden Sea. Netherlands Journal of Sea Research 10: 236-261.

Beukema, J. J. 1981. Quantitative data on the benthos of the Wadden Sea proper. Pages 134-142 *in* N. Dankers, H. Kühl, and W. J. Wolff, eds., Invertebrates of the Wadden Sea. Balkema, Rotterdam, The Netherlands.

Beukema, J. J. 1992. Long-term and recent changes in the benthic macrofauna living on tidal flats in the western part of the Wadden Sea. Pages 135-141 *in* N. Dankers, C. J. Smit, and M. Scholl, eds., Proceedings of the 7th International Wadden Sea Symposium, Ameland 1990. Netherlands Institute for Sea Research, Publication series no. 20.

Beukema, J. J. 1993. Increased mortality in alternative bivalve prey during a period when the tidal flats of the Dutch Wadden Sea were devoid of mussels. Netherlands Journal of Sea Research 31: 395-406.

Carp, E. 1972. Proceedings of the International Conference on the Conservation of Wetlands and Waterfowl, Ramsar, Iran. International Waterfowl and Wetlands Research Bureau, Slimbridge, UK.

Esselink, P. and L. Zwarts. 1989. Seasonal trend in burrow depth and tidal variation in feeding activity of *Nereis diversicolor*. Marine Ecology Progress Series 56: 243-254.

Evans, P. R. 1976. Energy balance and optimal foraging strategies for shorebirds: some implications for their distributions and movements in the non-breeding season. Ardea 64: 117-139.

Goldschmidt, T., F. Witte, and J. de Visser. 1990. Ecological segregation in zooplanktivorous haplochromine species (Pisces: Cichlidae) from Lake Victoria. Oikos 58: 343-355.

Goldschmidt, T., F. Witte, and J. Wanink. 1993. Cascading effects of the introduced Nile perch on the detritivorous/phytoplanktivorous species in the sublittoral areas of Lake Victoria. Conservation Biology 7: 686-700.

Golley, G. B. 1991. Transferring theoretical knowledge to application in understanding the response of ecosystems to perturbation. Pages 41-46 *in* O. Ravera, ed., Terrestrial and aquatic ecosystems: perturbation and recovery. Ellis Horwood Ltd., Chichester, UK.

Goudswaard, P. C. and J. H. Wanink. 1993. Anthropogenic perturbation in Lake Victoria: effects of fish introductions and fisheries on fish eating birds. Pages 312-318 *in* R. T. Wilson, ed., Proceedings of the Eighth Pan-African Ornithological Congress. Annales Musée Royal de l'Afrique Centrale (Zoologie) 268.

Greenwood, P. H. 1974. The cichlid fishes of Lake Victoria, East Africa: the biology and evolution of a species flock. Bulletin of the British Museum (Natural History). Zoology series, Supplement 6: 1-13.

Harrison, K. 1991. The taxonomy of East African Nile perch, *Lates* spp. (Perciformes, Centropomidae). Journal of Fish Biology 38: 175-186.

HEST. 1988. Haplochromis Ecology Survey Team: progress report 1987. HEST/TAFIRI Report 44. Rijksuniversiteit Leiden, Leiden, The Netherlands.

Homewood, K. M. and W. A. Rodgers. 1991. Maasailand ecology: pastoralist development and wildlife conservation in Ngorongoro, Tanzania. Cambridge University Press, Cambridge, UK.

Howard, G. W. 1993. Issues in wetland and waterbird conservation in Africa. Pages 483-487 *in* R. T. Wilson, ed., Proceedings of the Eighth Pan-African Ornithological Congress. Annales Musée Royal de l'Afrique Centrale (Zoologie) 268.

Hughes, R. N. 1980. Optimal foraging theory in the marine context. Oceanography and Marine Biology Annual Review 18: 423-481.

Hulscher, J. B. 1976. Localisation of cockles (*Cardium edule* L.) in darkness and daylight. Ardea 64: 292-310.

Hulscher, J. B. 1982. The Oystercatcher (*Haematopus ostralegus*) as a predator of the bivalve *Macoma balthica* in the Dutch Wadden Sea. Ardea 70: 89-152.

Hummel, H. 1985. Food intake of *Macoma balthica* (Mollusca) in relation to seasonal changws in its potential food on a tidal flat in the Dutch Wadden Sea. Netherlands Journal of Sea Research 19: 52-76.

Kudhongania, A. W. and A. J. Cordone. 1974. Batho-spatial distribution patterns and biomass estimates of the major demersal fishes in Lake Victoria. African Journal for Tropical Hydrobiology and Fisheries 3: 15-31.

Kruuk, H. and P. C. Goudswaard. 1990. Effects of changes in fish populations in Lake Victoria on the food of otters (*Lutra maculicollis* Schinz and *Aonyx capensis* Lichtenstein). African Journal of Ecology 28: 322-329.

Ligtvoet, W. and F. Witte. 1991. Perturbation through predator introduction: effects on the food web and fish yields in Lake Victoria (East Africa). Pages 263-268 *in* O. Ravera, ed., Terrestrial and aquatic ecosystems: perturbation and recovery. Ellis Horwood Ltd., Chichester, UK.

Myers, J. P., S. L. Williams, and F. A. Pitelka. 1980. An experimental analysis of prey availability for sanderlings (Aves: Scolopacidae) feeding on sandy beach crustaceans. Canadian Journal of Zoology 58: 1564-1574.

Newton, I. 1991. Concluding remarks. Pages 637-654 *in* C. M. Perrins, J.-D. Lebreton, and G.J.M. Hirons, eds., Bird population studies: relevance to conservation and management. Oxford University Press, Oxford, UK.

Ogutu-Ohwayo, R. 1990. The decline of the native fishes of Lakes Victoria and Kyoga (East Africa) and the impact of introduced species, especially the Nile perch, *Lates niloticus* and the Nile tilapia, *Oreochromis niloticus*. Environmental Biology of Fishes 27: 81-96.

Oijen, M.J.P. van, F. Witte, and E.L.M. Witte-Maas. 1981. An introduction to ecological and taxonomic investigations on the haplochromine cichlids from the Mwanza Gulf of Lake Victoria. Netherlands Journal of Zoology 31: 149-174.

Pauly, D. 1980. A selection of simple methods for the assessment of tropical fish stocks. FAO Fish Circular 729: 1-54.

Piersma, T. 1987. Production by intertidal benthic animals and limits to their predation by shorebirds: a heuristic model. Marine Ecology Progress Series 38: 187-196.

Reading, C. J. and S. McGrorty. 1978. Seasonal variations in the burying depth of *Macoma balthica* (L.) and its accessibility to wading birds. Estuarine and Coastal Marine Science 6: 135-144.

Richardson, H. 1985. Availability of buried littleneck clams (*Venerupis japonica*) to Northwestern Crows (*Corvus caurinus*). Journal of Animal Ecology 54: 443-457.

Sheail, J. 1987. Seventy-five years in ecology: the British Ecological Society. Blackwell Scientific Publications, Oxford, UK.

Smit, C. J. 1981. The importance of the Wadden Sea for estuarine birds. Pages 280-289 *in* C. J. Smit and W. J. Wolff, eds., Birds of the Wadden Sea. Final report of the section 'Birds' of the Wadden Sea Working Group. Balkema, Rotterdam, The Netherlands.

Swennen, C. and P. Duiven. 1992. Dynamics and feeding of sea-birds in the Wadden Sea and tropical tidal-flat areas. Pages 65-66 *in* Annual report 1991. Netherlands Institute for Sea Research (NIOZ). Netherlands Institute for Sea Research, Publication series no. 19.

Tyler, S. J. 1993. The importance of swamps to birds in Africa. Pages 523-526 *in* R. T. Wilson, ed., Proceedings of the Eighth Pan-African Ornithological Congress. Annales Museé Royal de l'Afrique Centrale (Zoologie) 268.

Wanink, J. H. 1991. Survival in a perturbed environment: the effects of Nile perch introduction on the zooplanktivorous fish community of Lake Victoria. Pages 269-275 *in* O. Ravera, ed., Terrestrial and aquatic ecosystems: perturbation and recovery. Ellis Horwood Ltd., Chichester, UK.

Wanink, J. H. 1992. The Pied Kingfisher *Ceryle rudis* and dagaa *Rastrineobola argentea*: estimating the food-intake of a prudent predator. Pages 403-411 *in* L. Bennun, ed., Proceedings of the Seventh Pan-African Ornithological Congress. Nairobi, Kenya.

Wanink, J. H. and P. C. Goudswaard. 1994. Effects of Nile perch (*Lates niloticus*) introduction into Lake Victoria, East Africa, on the diet of Pied Kingfishers (*Ceryle rudis*). Hydrobiologia 279/280: 367-376.

Wanink, J. and L. Zwarts. 1985. Does an optimally foraging Oystercatcher obey the functional response? Oecologia (Berl.) 67: 98-106.

Wanink, J. H. and L. Zwarts. 1993. Environmental effects on the growth rate of intertidal invertebrates and some implications for foraging waders. Netherlands Journal of Sea Research 31: 407-418.

Wanink, J. H., T. Goldschmidt, and F. Witte. 1989. Recent changes in the zooplanktivorous/insectivorous fish community from the Mwanza gulf of Lake Victoria. Pages 22-28 *in* WOTRO Report for the year 1988. Netherlands Foundation for the Advancement of Tropical Research, The Hague, The Netherlands.

Wanink, J. H., M. R. Berger, and F. Witte. 1993. Kingfishers at Fishburger Queens: eating Victorian fast food on the wing. Pages 319-326 *in* R. T. Wilson, ed., Proceedings of the Eighth Pan-African Ornithological Congress. Annales Musée Royal de l'Afrique Centrale (Zoologie) 268.

Wanink, J. H., W. Ligtvoet, A. I. Chande, P. C. Goudswaard, J. Kashindye, E.F.B. Katunzi, O.I.I. W. Mkumbo, B. Msuku, and F. Witte. 1988. HEST/TAFIRI research in Lake Victoria: some preliminary results and their relevance for fishery management. HEST/TAFIRI Report 44. Rijksuniversiteit Leiden, Leiden, The Netherlands.

Whitfield, A. K. and S.J.M. Blaber. 1978. Feeding ecology of piscivorous birds at Lake St Lucia, part 1: diving birds. Ostrich 49: 185-198.

Wiens, J. A. 1989. The ecology of bird communities. Vol. 1: Foundations and patterns. Cambridge University Press, Cambridge, UK.

Witte, F. 1981. Initial results of the ecological survey of the haplochromine cichlid fishes from the Mwanza Gulf of Lake Victoria, Tanzania: breeding patterns, trophic and species distribution. Netherlands Journal of Zoology 31: 175-202.

Witte, F. and P. C. Goudswaard. 1985. Aspects of haplochromine fishery in southern Lake Victoria. FAO Fisheries Report 335: 81-88.

Witte, F. and M.J.P. van Oijen. 1990. Taxonomy, ecology and fishery of Lake Victoria haplochromine trophic groups. Zoologische Verhandelingen Leiden 262: 1-47.

Witte, F., T. Goldschmidt, and J. H. Wanink. 1995. Dynamics of the haplochromine cichlid fauna and other ecological changes in the Mwanza Gulf of Lake Victoria. Pages 83-110 *in* T. J. Pitcher and P.J.B. Hart, eds., The impact of species changes in African lakes. Chapman and Hall, London, UK.

Witte, F., T. Goldschmidt, P. C. Goudswaard, W. Ligtvoet, M.J.P. van Oijen, and J. H. Wanink. 1992a. Species extinction and concomitant ecological changes in Lake Victoria. Netherlands Journal of Zoology 42: 214-232.

Witte, F., T. Goldschmidt, J. Wanink, M. van Oijen, K. Goudswaard, E. Witte-Maas, and N. Bouton. 1992b. The destruction of an endemic species flock: quantitative data on the decline of the haplochromine cichlids of Lake Victoria. Environmental Biology of Fishes 34: 1-28.

Wolff, W. J. and C. J. Smit. 1984. The Dutch Wadden Sea. Pages 238-252 *in* P. R. Evans, J. D. Goss-Custard, and W. G. Hale, eds., Coastal waders and wildfowl in winter. Cambridge University Press, Cambridge, UK.

Wolff, W. J. and C. J. Smit. 1990. The Banc d'Arguin, Mauritania, as an environment for coastal birds. Ardea 78: 17-38.

Zwarts, L. 1986. Burying depth of the benthic bivalve *Scrobicularia plana* (da Costa) in relation to siphon-cropping. Journal of Experimental Marine Biology and Ecology 101: 25-39.

Zwarts, L. 1988. Numbers and distribution of coastal waders in Guinea-Bissau. Ardea 76: 42-55.

Zwarts, L. 1991. Seasonal variation in body weight of the bivalves *Macoma balthica*, *Scrobicularia plana*, *Mya arenaria*, and *Cerastoderma edule* in the Dutch Wadden Sea. Netherlands Journal of Sea Research 28: 231-245.

Zwarts, L. and A.-M. Blomert. 1992. Why Knot *Calidris canutus* take medium-sized *Macoma balthica* when six prey species are available. Marine Ecology Progress Series 83: 113-128.

Zwarts, L. and P. Esselink. 1989. Versatility of male Curlews *Numenius arquata* preying upon *Nereis diversicolor*: deploying contrasting capture modes dependent on prey availability. Marine Ecology Progress Series 56: 255-269.

Zwarts, L. and J. Wanink. 1984. How Oystercatchers and Curlews successively deplete clams. Pages 69-83 *in* P. R. Evans, J. D. Goss-Custard, and W. G. Hale, eds., Coastal waders and wildfowl in winter. Cambridge University Press, Cambridge, UK.

Zwarts, L. and J. H. Wanink. 1989. Siphon size and burying depth in deposit- and suspension-feeding benthic bivalves. Marine Biology 100: 227-240.

Zwarts, L. and J. H. Wanink. 1991. The macrobenthos fraction accessible to waders may represent marginal prey. Oecologia 87: 581-587.

Zwarts, L. and J. H. Wanink. 1993. How the food supply harvestable by waders in the Wadden Sea depends on the variation in energy density, body weight, biomass, burying depth and behaviour of tidal-flat invertebrates. Netherlands Journal of Sea Research 31: 441-476.

Zwarts, L., A.-M. Blomert and J. H. Wanink. 1992. Annual and seasonal variation in the food supply harvestable by Knot *Calidris canutus* staging in the Wadden Sea in late summer. Marine Ecology Progress Series 83: 129-139.

Zwarts, L., A.-M. Blomert, B. J. Ens, R. Hupkes, and T. M. van Spanje. 1990. Why do waders reach high feeding densities on the intertidal flats of the Banc d'Arguin, Mauritania? Ardea 78: 39-52.

Zwarts, L., J. T. Cayford, J. B. Hulscher, M. Kersten, P. M. Meire, and P. Triplet. In press. *In* J. D. Goss-Custard, ed., The behavioural ecology of the oystercatcher. Oxford University Press, Oxford, UK.

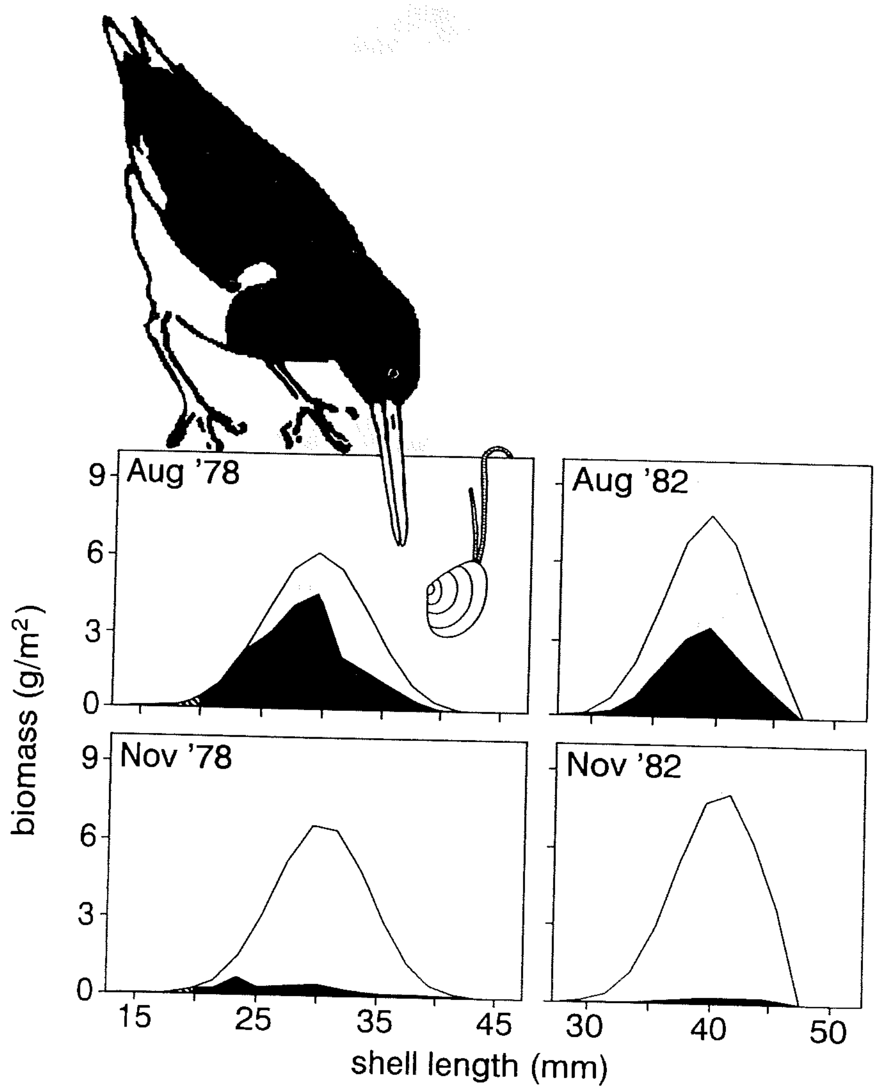

Figure 1. Biomass of *Scrobicularia plana* (cohort 1976) after 3 and 7 growing seasons. Open areas depict total biomass (AFDW). Filled areas represent clams available to Oystercatchers, split in an unprofitable (hatched) and a harvestable (black) fraction.

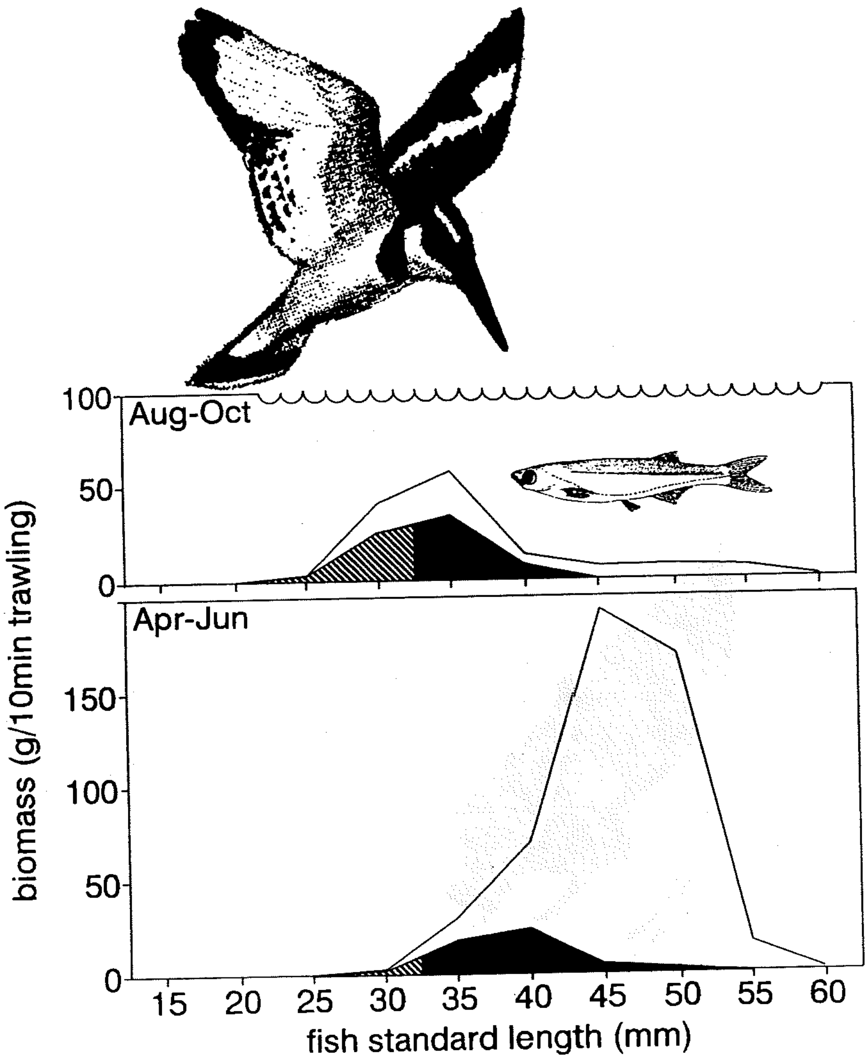

Figure 2. Biomass of *Rastrineobola argentea* determined half a year (Aug.-Oct.) and just over one year (Apr.-June) after the annual breeding peak (Feb.-Mar). Open areas depict total biomass (DW) of specimens larger than 15 mm standard length. Filled areas represent fish available to Pied Kingfishers, split in an unprofitable (hatched) and a harvestable (black) fraction.

CRANE CONSERVATION, AERIAL VIDEOGRAPHY, AND GLOBAL POSITIONING SYSTEM

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ABSTRACT

The Global Positioning System (GPS), a constellation of 24 navigational orbiting satellites, is an excellent tool for crane surveys and other field work. GPS provides precise position location whether on foot, in an aircraft, or in a ground vehicle. A small hand-held receiver gives instant location, speed, and other navigational data which can be stored, downloaded to a computer, or captioned to videography. In the Platte River valley, Nebraska, where 480,000 Sandhill Cranes roost for 6 to 8 weeks during their northward migration, the U. S. Fish and Wildlife Service conducts aerial surveys of crane populations and assessments of crane roosting habitat. Observers in low-flying aircraft count cranes and record GPS positions of diurnal feeding and loafing cranes in wet meadows and croplands along the river. These points are later plotted on maps by hand or by computer. Since crane roosting habitat has declined because of water storage and diversion projects, the Platte River is videotaped from an aircraft for later analysis of channel width and other roosting habitat features. The videotape is captioned by a GPS caption generator sending the GPS signal to the videotape. This procedure allows the rapid location of video frames. One standard videotape, costing only $7, can record over 400 kilometers of river, making such remote sensing an inexpensive undertaking. Suitable GPS receivers to work with a video camera cost about $3,000. Video camera system prices vary widely, but most systems are priced within the budgets of natural resource agencies. Video technology gives instant turn around time and would be very useful in Africa, where color and black and white photographic processing is difficult to obtain.

INTRODUCTION

The purpose of this paper is to introduce two technologies, global positioning system (GPS) and aerial videography, which can improve your field work on cranes, wetlands, and other aspects of conservation-related tasks. Aerial videography is simply mounting a video camera in an aircraft and recording the terrain beneath the aircraft for later viewing or computer analysis in your office. GPS is a constellation of orbiting satellites which nearly precisely give your position on earth. You just press a few buttons on a hand-held receiver to get position and navigation information.

Having spent most of my professional career in the field, including managing a national wildlife refuge, and working in Africa, I am mindful of the need to be practical and cost-conscious when recommending new gadgets for wildlife-related work. Therefore, I shall not dwell on deluxe expensive video cameras and GPS receivers. I believe that just about all who attended the African Crane and Wetland Training Workshop in Maun, Botswana in August, 1993 are interested in low-cost and practical options for wildlife managers. The average wildlife manager in the U. S. or Africa simply cannot afford the latest and most costly technology. Do you want a sophisticated research-generated multi-spectral and multi-camera system costing $85,000+ or a simpler camera ($1,500-3,000) from a catalog or store?

It is very important to have goals in mind when you are considering the purchase of new field equipment. Some people buy things just because their colleagues have those things. They believe that they will sooner or later find a use for the equipment. They probably will find a use but the equipment, rather than management goals and objectives, is creating the need. You don't buy a machete and then wonder what you are going to do with it. Perhaps I can illustrate this point from my own experiences with aerial videography and GPS.

Why did I become interested in aerial videography and GPS? My interest was not academic but quite practical and driven by the environmental and regulatory responsibilities, which my employer, the U. S. Fish and Wildlife Service (USFWS), has along the Platte River, Nebraska, located in the center of the United States. The Platte River has been affected by numerous water projects, including dams and diversions. Water depletions have dramatically affected habitats and species abundance. A tremendous amount of Sandhill Crane (*Grus canadensis*) and endangered Whooping Crane (*Grus americana*) roosting and feeding habitat has been destroyed. Other species of birds listed as endangered or threatened under the Endangered Species Act of 1973, as amended, are also affected.

Currently, some water projects are under review for re-regulation in accordance with recent laws giving equal weight to environmental considerations alongside irrigation and power. The USFWS is commenting on the need to provide appropriate instream flows for endangered and threatened species as well as other fish and wildlife resources. I had the responsibility for assessing the existing habitat conditions for the endangered Least Tern (*Sterna antillarum*), threatened Piping Plover (*Charadrius melodus*), and Sandhill Crane.

The Sandhill Crane, Least Tern, and Piping Plover depend on wide unvegetated channels for roosting and nesting. The Sandhill Cranes typically roost in an undisturbed channel with good horizontal visibility and near adjacent wetland meadows (Sidle *et al.* 1993). Least Terns and Piping Plovers nest on bare to sparsely vegetated sandbars in the river channel. The availability of channel habitats changes depending upon the flow of water. Beginning in 1987, I assessed habitat conditions weekly and at different flows during the April to August breeding season of the Least Tern and Piping Plover using aerial videography along 400 km of river. I needed frequent aerial images of the river in order to draw a picture of Platte River sandbars and other river channel habitat features. Satellite imagery would have been too costly, not always available due to cloud cover, and would not have had the required resolution. Conventional aerial photography would have cost tens of thousands of dollars more than repetitive satellite imagery. Videography, whose resolution lies somewhere between a satellite image and a photograph, seemed like a cost-effective technology. I was also hoping that there was a way to freeze selected video frames and make measurements of the river channel on a computer screen. I was as new to computers as I was to videography.

Two colleagues of mine at the Northern Prairie Wildlife Research Center in North Dakota had just rented a video camera from a local camera store and were going to record hundreds of wetland plots in North Dakota from a light aircraft. This tedious work used to be done by aerial photography. I borrowed their camera, mounted it in the hole of the fuselage of a single-engine fixed-wing aircraft, and flew along the Platte River. I viewed the videotape and I could easily detect sandbars and other channel features. It seemed like it was going to work.

Meanwhile, remote sensing specialists at the University of Nebraska had developed a simple but crude piece of software to grab video frames and make measurements. I could now play the $7 video tape of 400 km of river, freeze selected scenes (e.g., scenes of nesting sites, and a systematic sample of scenes of the river), and make measurements of sandbars, channel area, channel width, and vegetation coverage. When portable hand-held GPS receivers became popular in the early 1990s, I was able to add GPS data to the videotape. That is, the latitude, longitude, time, speed, and aircraft track are imprinted on the videotape. When you look at the tape you know exactly (±100 m) where any video scene is. A $7 videotape and 3.5 hours of flying ($55 per hour) gave me good remotely sensed data of 400 km of river. So, my use of video and GPS was cost-effective and productive, and I continue to use these tools for various conservation projects.

I'll have more to say about practical applications of video and GPS as we go along, but I would first like to describe in general terms GPS and aerial videography. As you read this paper reflect upon your current responsibilities and how videography and GPS could lead to more efficient crane, wetland, and other conservation work.

AERIAL VIDEOGRAPHY

The basic aerial videography system is a video camera, video recorder (VCR), video monitor, and power supply. If you plan to process video scenes with a computer, a camera/VCR with red-green-blue band (RGB) outputs is useful. RGB gives excellent color separation. You can use a camcorder which is a video camera and video recorder packaged into one unit, however, the recorder segment of a typical camcorder may not record the high resolution which a separate VCR can record. A good super VHS (S-VHS) or Hi-8 system will record 400+ lines of video. There are, however, camcorders now available with 400+ lines of resolution (Sony CCD VX3). Using a camcorder means fewer cables and equipment in the aircraft than required with a separate VCR. However, it is not possible to use a GPS caption generator with a camcorder.

I started with and often still use a standard VHS camera and 240-line VCR. It still gives an adequate image of the Platte River from several thousand feet of altitude. So, you don't necessarily have to buy the best. It depends on what you are trying to resolve with videography. I recommend that potential users of aerial video first borrow and test video equipment to determine if intentions will be met.

As I mentioned above there is costly video equipment and relatively inexpensive cameras and VCRs. There are $40,000 color-infrared cameras, and expensive multispectral black and white video, black and white mid-infrared, and thermal infrared. All of these cameras serve an important purpose, for example, assessing heavy grazing, soil salinity, burned areas, phytomass levels, and much more. They are expensive, complicated and occupy a lot of aircraft cabin space. I believe that for the average manager a common commercially available S-VHS camera of just about any make and model is sufficient for recording surface conditions of interest to wildlife conservationists. Therefore I will not discuss the complicated and expensive systems. If anyone is interested in advanced airborne video systems, please contact me and I can steer you in the right direction.

I typically pilot a single engine Cessna 172 or 182 fixed-wing aircraft. One of the planes has a hole in the fuselage through which I mount the video camera in a custom-made metal camera mount. On the other plane I use a home-made heavy wood and steel mount which slides over the window ledge of the right front window and screws tightly against the door. The camera rides on the mount outside the fuselage and is accessible for adjustments by the person occupying the right front seat. The window flies up and latches onto the bottom of the wing or remains up in the slipstream. The window mount is very useful because most planes do not have a convenient hole in the fuselage much less a hole which will accommodate the specially built mount for the specific camera you use. However, the open window makes for a noisy flight.

The video monitor gives me a live picture of the Platte River below and allows me to keep the aircraft centered over the river to capture the entire width of the river and a narrow strip of both river banks for reference. Without the monitor it would not be possible to track a ground feature of interest. If you are simply recording random transects you just need the monitor to check whether or not your VCR and camera are still recording and whether or not GPS data is still being received and imprinted on the video. For example, if you undertake a random transect survey of cranes over a large wetland such as the one in southern Sudan you might want to record habitat conditions with a video camera as you are counting the cranes. You could mount the camera vertically looking straight down or use two cameras pointing obliquely on both sides of the aircraft and recording the transect width. I'll discuss the details of linking GPS and video later on.

Video equipment can be powered with the provided rechargeable batteries but they only last about one hour. One of the aircraft I use has a twelve volt electrical system and I can plug the video equipment, including the 13-cm monitor, into the cigarette lighter receptacle. However, most aircraft have 24-28 volt systems and you will need a converter between the cigarette lighter receptacle and the equipment. Another alternative is to use 12-volt sealed, rechargeable, gel batteries such as those manufactured by Power-Sonic Corporation (Redwood City, California) for use in motor bikes. They are very compact and will power your equipment for many hours. The biggest drain on batteries is the monitor. However, there are now available small hand-held LCD monitors, such as those manufactured by Sony, costing less, and consuming less power and less space in the aircraft than typical 13-cm monitors.

You can equip yourself with the above items for about $5,000, perhaps less because prices and equipment are constantly evolving and improving. Remember, you can also utilize the video equipment for a variety of work on the ground. It is not restricted to use in an aircraft. Furthermore, some managers are avoiding the high cost of conventional aircraft and using balloons and small remote controlled aircraft into which they place still and video cameras. These techniques are well-suited to small, discrete, study areas. Other managers are loading cameras onto ultra-lite aircraft which don't normally require a pilot's license but still offer adequate range for many projects. So, don't despair if you don't have a Cessna.

There are other considerations in aerial videography but not enough space here to discuss all of them. Dick Myhre and his colleagues at the U. S. Forest Service have written an excellent manual entitled *Airborne video system users guide* (1992) which discusses the equipment and planning necessary for video missions. Although it describes an airborne video system which is best suited for a multi-engine aircraft, the principles of aerial videography, which they discuss, remain the same for smaller video equipment and smaller aircraft. Don't be intimidated by all of the extra equipment in the *Guide*. Concentrate on the principles and procedures. I have listed Dick's address and telephone number in the Appendix to this paper. Contact him or me if you want a copy of the guide. I have also listed the names, addresses, and telephone numbers of other individuals whom I believe are the most experienced in aerial videography, GPS link to aerial videography, and the computer processing of aerial videography.

VIDEO VIEWING AND PROCESSING

The aircraft is now on the ground and we have our videotape of cranes, wetlands, or other habitats. What do we do with the tape? Many will simply want to view the videotape on a television set or monitor, and count or qualitatively assess what they see. For example, we often videotape Sandhill Cranes feeding on wetland meadows along the Platte River simply to document their occurrence. Aerial videography of the rare Whooping Crane roosting on the river is printed on a standard color printer. The print later guides biologists to the roosting spot, after the cranes have left, in order to run a transect across the river and take instream flow measurements to assess Whooping Crane roosting habitat.

More sophisticated analyses of videography require a computer and software to make measurements. I mentioned earlier that I will run the videotape on a computer monitor and measure the area of Platte River channel, sandbars, vegetation, and other features. If you have a computer you need to add an image capture board. Your camcorder or VCR will plug into the board and you are ready to measure. Software packages for image analysis range in price from free public domain software (e.g., U. S. government software) to over $8,000. It's difficult to keep track of the latest software developments. Specialists in Geographic Information Systems (GIS) may be able to help you. Some GIS packages can now grab video images and incorporate the video with other map data. I have listed various experts at the end of this paper. As you explore this field and define your needs, the correct software should become apparent. I would go slowly at first. Borrow a camera, test it out on a variety of wildlife and habitats, get comfortable with aerial videography, try some simple image analysis on someone else's computer and software, and then sit back and reassess your needs before spending a lot of money. Make sure you have a rigorous application for this equipment in the air and on the ground.

I currently use Map and Image Processing System (MicroImages, Lincoln, Nebraska, USA) but there are cheaper systems. MIPS has a convenient system to organize during such aerial surveys. If you are on the ground and want to record the position of a flock of Black Crowned Cranes (*Balearica pavonina*), for example, 100 m accuracy is again acceptable and suitable for plotting wildlife locations on maps.

A simple and legal process known as differential GPS will remove the effects of selective availability. Post-processed differential and real-time differential are two methods to overcome selective availability. Differential works like this: one receiver records data on a known point (control), while a field unit (you and your hand-held receiver on the Serengeti plains) obtains fixes. Each unit acquires data concurrently from the same multi-satellite constellation. Selective-availability-induced variations are eliminated by calculating how far a received position is from the control point and applying these latitude, longitude, and altitude corrections to data collected at the remote site. Because each received fix is time-stamped, fixes obtained on the control point are easily matched to the data file collected at the remote location. Post-processed differential means going back to your office and comparing your hand-held GPS receiver data with data collected by a base station GPS which can be located several hundred km from your field GPS receiver. For example, I collect GPS data along the Platte River and compare the data with data collected by a GPS base station 100 miles away in Lincoln, Nebraska. You could also buy two GPS receivers and set up your own base station. There are a growing number of base stations in Africa.

A few people use real-time differential GPS (DGPS), a process which requires GPS receivers with advanced processing features and a GPS base station with a VHF radio transmitter. It's a bit complicated but essentially the transmitter sends a correction message to the remote unit. The U. S. Forest Service has had some success with this technique, combining DGPS data and large-scale aerial videography to get precise positioning and good georeferencing of video frames covering only a small field of view. The drawbacks to real-time GPS are the extra equipment, restricted range of VHF transmitters (50 miles), and the complexities and cost of the system. Autonomous GPS giving a nominal registration of aerial video scenes is probably good enough for most applications.

GPS receivers vary in price from about $1,000 to $20,000 for a complex surveying GPS unit. GPS receivers for aircraft instrument panels are usually expensive because they are going into an aircraft and anything that goes into an aircraft has to be expensive. I use the Magellan NAV PRO 5000 receiver, a hand-held receiver that I can use in a vehicle, aircraft, boat, or on foot. I have also used the Trimble Pathfinder.

GPS AND AERIAL VIDEOGRAPHY

When I fly along the Platte River on aerial videography missions, I am not flying over an uncharted or poorly mapped part of the world. During the viewing of any Platte River videotape, I have a convenient atlas of aerial photographs which I follow and compare with the video to ascertain what part of the river I am viewing. Still, the inclusion of GPS data on the tape is useful for archival and other purposes. In more remote areas it is simply not possible to discern your position by looking at the video, and so linking GPS to video becomes essential. For example, supposing you wanted to videotape the aerial transects you were flying to census cranes. Without GPS it would be almost impossible to pinpoint the location of any video scene. You may want to use a video camera on the ground to record crane habitat features. A link to GPS data would allow you to return to that location in the future and accurately store video data.

I am familiar with two ways to incorporate GPS data onto video. The first method is to use a video character generator between the camera and the video recorder to record in a small window on the screen the latitude, longitude, and other GPS data. The GPS data are permanently on the videotape. (For more information on character generators contact Compix, Inc., Tigard, Oregon, USA, at 503-639-8496.) The second method is to time tag the video image with GPS time while saving time and position in a GPS receiver or data collector. (For more information on time tagging contact Horita Co., Mission Viejo, California, USA at 714-364-1143 or Fast Forward Video, Irving, California, USA at 714-852-8404).

The advantage of the character generator is that the link between the GPS position and video image cannot be lost and no special playback equipment is required because the GPS data are part of the video image. The disadvantage is that the GPS data are not machine readable and a separate camera and recorder are required. You can't use a camcorder. Because the GPS data on the videotape are not machine readable, the GPS data are not differentially correctable in a post-processing manner. You could, however, use a real-time differential GPS setup as described above but there are inherent limitations and costs there.

The advantage of the time code generator is that the video image is GPS time tagged and GPS information is recorded separately. This allows for differential GPS with a base station. Fast Forward Video makes a time tagger that can be used with a camcorder thus making a more portable field system. You will, however, need a time decoder during the playing of the video tape.

DISCUSSION

Aerial videography and GPS are but tools for crane conservationists. Aerial videography gives real time imagery. You can look at it right away and you can become somewhat self-sufficient in remote sensing. It allows you to "get down dirty" and examine what you think is on a much smaller scale satellite image. It gives real time imagery allowing you to be independent of distant and inaccessible photographic development laboratories. GPS further enhances your independence, productivity, and scientific accuracy.

I hope this paper has served its stated purpose. Sure, there are a lot of details I couldn't get in here, and there is probably some new toy out there to make video and GPS even more productive. But if I got you to think about this technology and its application for crane and wetland conservation then it has served a purpose. Settle back and reflect on your everyday professional responsibilities and how these devices can help. Remember to keep it cheap and efficient, and productive for crane conservation.

REFERENCES

Alban, J., P. Ishikawa, and M. Hoppus. 1992. Light aircraft airborne video system with real-time differential global positioning system. Unpublished report. Nationwide Forestry Applications Program, U. S. Department of Agriculture, Forest Service, Salt Lake City, Utah, USA.

Bobbe, T. 1992. Real-time differential GPS for aerial surveying and remote sensing. GPS World (July, 1992): 18-22.

Braam, B. 1992. CIR video: an operational tool for environmental monitoring. Unpublished report. Karelsilva Oy, Savitaipale, Finland.

Eustis, M. T. 1992. The NAV PRO 5000 GPS receiver: basic differential procedures. Field Notes no. 402. Magellan Systems Corporation, San Dimas, California, USA.

Everitt, J. H. 1990. Aerospace video imaging systems for rangeland management. Journal of Photogrammetric Engineering and Remote Sensing 56: 343-349.

Grahman, L. A. and M. L. Scott. 1990. Evaluations and testing of airborne video and in-house software for aquatic and terrestrial habitat analysis. Unpublished report. National Ecology Research Center, Fort Collins, Colorado, USA.

Hurn, J. 1989. GPS: a guide to the next utility. Trimble Navigation, Sunnyvale, California, USA.

Jennings, C. A., P. A. Vohs, and M. R. Dewey. 1992. Classification of a wetland area along the upper Mississippi River with aerial videography. Wetlands 12: 163-170.

Lange, A. F. 1992. Geographic video system. Unpublished report. Trimble Navigation, Ltd., Sunnyvale, California, USA.

Long, D. S., J. E. Taylor, and J. McCarthy. 1986. Cessna aircraft cabin door mount for photographic and videographic cameras. Journal of Photogrammetric Engineering and Remote Sensing 52: 1753-1755.

Meisner, D. E. 1985. Fundamentals of airborne video remote sensing. Research report 85-2, Remote Sensing Laboratory, University of Minnesota, St. Paul, Minnesota, USA.

Myhre, D., B. Russell, and C. Sumpter. 1992. Airborne video system users guide. U. S. Department of Agriculture, Forest Service, Forest Pest Management Methods Applications Group, Fort Collins, Colorado, USA.

Nichols, F. E. 1991. Videography vs. photography in remote piloted vehicles. Small Systems Remote Sensing News 2(2): 10-14.

Nichols, F. E. and P. Veisze. 1991. Small systems and rapid environmental assessment. Small Systems Remote Sensing News 2(3): 17-21.

Nichols, F. E. 1993. Low-altitude wetland and watershed monitoring. Small Systems Remote Sensing News 4(1): 1-7.

Peralta, R., J. Aperalta, J. Prado, M. Navarrete, and W. Martinez. 1993. The development of a digital videogrammetric airborne system. Unpublished report. Laboratorio de Ingenieria Aeroespacial, Universidad Nacional Autonoma de Mexico.

Pierce, R. N. 1986. Airborne video: applied to route location studies for electrical power transmission facilities. Pages 1-10 *in* M. D. Thompson and R. J. Brown, eds., Proceedings of the 10th Canadian Symposium on Remote Sensing, Edmonton, Alberta, Canada.

Pryjomko, R. 1993. African wildlife management challenges GIS. GIS World (August 1993): 42-47.

Rich, P. M., D. M. Ranken, and J. S. George. 1989. A manual for microcomputer image analysis. LA-11732-M manual. Los Alamos National Laboratory, Los Alamos, New Mexico, USA.

Sidle, J. G. and J. W. Ziewitz. 1990. Use of aerial videography in wildlife habitat studies. Wildlife Society Bulletin 18: 56-62.

Sidle, J. G., H. Nagel, R. Clark, C. Gilbert, D. Stuart, K. Wilburn, and M. Orr. 1993. Aerial thermal infrared imaging of Sandhill Cranes on the Platte River, Nebraska. Remote Sensing of Environment 43: 333-342.

APPENDIX

Other sources of information on GPS and aerial videography

Name	Expertise
Tom Bobbe U. S. Forest Service Nationwide Forestry Applications Program 2222 West 2300 South Salt Lake City, UT 84119 USA Tel: (801) 975-3663	GPS, airborne video GPS linked to video
Roger Cooper MetRoaTech, Ltd. The Hollies, Naseby Road Clipston, Market Harborough Leicester, LE16 9RZ UK	GPS linked to video
Mark Eustis Magellan Systems Corporation 115 Archwood Ave. Annapolis, MD 21401 USA Tel: (410) 626-1312	GPS
Lee Graham School of Renewable Natural Resources 325 Biosciences East University of Arizona Tucson, AZ 85271 USA Tel: (602) 621-7270	GPS, airborne video, GPS linked to video, computer processing of video
Mickey Henry Sky Vision, Inc. 5858 Westheimer, Suite 703 Houston, TX 77057 USA Tel: (713) 784-7727	GPS linked to video
Lee Miller MicroImages, Inc. 201 North 8th, Suite 15 Lincoln, NE 68508-1347 USA Tel: (402) 477-9554	Computer processing of video
Dick Myhre U. S. Forest Service 3825 East Mulberry St. Fort Collins, CO 80524 USA Tel: (303) 498-1778	Airborne video, airborne operations
Frederic Nichols Small Systems Remote Sensing Remote Sensing Research, Inc. P.O. Box 1949 Fort Collins, CO 80522 USA	Remote controlled aircraft and video

Ross Pywell
U. S. Forest Service
3825 East Mulberry St.
Fort Collins, CO 80524 USA
Tel: (303) 498-1778

GPS linked to video, computer processing of video

John Sidle
U. S. Fish and Wildlife Service
203 West 2nd St.
Grand Island, NE 68801 USA
Tel: (308) 382-6468
E-mail: jsidle@unlinfo.unl.edu

Airborne video, aircraft operations

Thomas Sklebar
National Biological Survey
Northern Prairie Wildlife Research Center
Rt. 1, Box 96C
Jamestown, ND 58402 USA
Tel: (701) 252-5363

Airborne video, aircraft operations, computer processing of video

CROP DEPREDATION BY SANDHILL CRANES

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ABSTRACT

Three components, large numbers of cranes, vulnerable crops, and nearby roost sites, are necessary for significant crop depredation to occur. There are 500,000 - 600,000 Sandhill Cranes (*Grus canadensis*) in North America. The strong seasonality in North America forces most cranes to migrate. Migration requires high energy expenditures. Cranes respond to the energy demands of migration with hyperphagia and flocking behavior. These behaviors, coupled with the large number of birds involved present the potential for major crop depredations, especially in the fall when more crops are at risk. A wide variety of crops are eaten by cranes, but maize and small grains are preferred. Cranes will not forage far from their roost, concentrating depredations around wetlands suitable for roosting. The damage potential is reduced by the Sandhill Crane's preference to feed in harvested fields. Overall in North America more crop depredation is caused by ducks and geese, but cranes are more destructive per individual than waterfowl. During the breeding season when cranes are dispersed depredation problems are minor. Control can be aimed at the cranes, the roost sites, or the crops. Because of the rarity of most crane species and past losses of wetlands, methods of control which affect crane populations, or result in additional wetland destruction, can seldom be justified. Methods which reduce vulnerability of crops, use scare techniques, or use lure crops tend to be the most effective. No method works in all circumstances and the most effective control programs use a combination of methods. Since wildlife is protected by governments, governments should have some responsibility to control wildlife damage. However, effective control programs cannot be accomplished by government actions alone; cooperative effort by the farmer is necessary. The farmers must detect and report the problem promptly and take an active part in the control activities. Governments should provide assistance with equipment and activities in the control program and should furnish lure crops where needed. In lieu of, or in addition to control programs, compensation for damage has been used. Compensation is usually more expensive and does not address the root of the problem. Although there are some differences in the behavior and feeding ecology between the African cranes and Sandhill Cranes, many of the techniques used for control of crop depredations by Sandhill Cranes should be applicable in Africa.

INTRODUCTION

Crop depredation by Sandhill Cranes (*Grus canadensis*) has been a problem in North America since the advent of modern agriculture. The conversion of wetlands to crops has likely been a contributing factor in depredation problems. Natural feeding areas have been destroyed and were replaced with vulnerable crops, often near roost sites. Cranes cause more damage per individual than either ducks or geese (Knittle and Porter 1988), but in North America damage to crops by ducks and geese exceeds that caused by cranes, because waterfowl are far more abundant. Potential for damage can be great, especially when staging, or migrating flocks of cranes occur near vulnerable, unharvested crops. Three ingredients are necessary for crop depredation by cranes to be significant. First, there must be large numbers of cranes. Second, vulnerable crops must be present. Third, adequate roost sites near the crops must be available.

This paper will review the problem of crop de-predation by Sandhill Cranes in North America. Factors affecting depredation problems will be discussed. The advantages and disadvantages of various control methods will be discussed. The applicability of this review to the cranes of Africa will be addressed.

SANDHILL CRANE FEEDING ECOLOGY AND PHYSIOLOGY

Sandhill Cranes will feed on a wide variety of agricultural crops, maize or corn, sorghum, lucerne or alfalfa, oats, wheat, lettuce, cabbage, barley, milo, rye, groundnuts or peanuts, and potatoes (Melvin 1978; Iverson *et al.* 1982; Mickelson 1987; Walker and Schemnitz 1987; Werner and Nesbitt 1987; Sugden *et al.* 1988). Most of the crane foraging is in harvested fields, which causes no damage. Most damage to unharvested crops occurs early in the fall, or when harvest is delayed by weather. Sprouting grains and leafy vegetables have been damaged throughout the year; these are damaged less frequently.

Climatic patterns and physiological constraints of breeding and migration underlie the foraging behavior, and the quality and quantity of food items eaten by Sandhill Cranes. The strong seasonality in the Northern Hemisphere compresses the breeding season and requires cranes to migrate south prior to winter. During the breeding season most Sandhill Cranes are dispersed into pairs and small flocks of nonbreeders. During the rest of the year cranes gather in large flocks. Physiological needs and consequently, feeding behavior and diet differ between these two periods.

Cranes nest early during a relatively short time period. Nesting begins soon after the cranes arrive on the nesting areas and the snow has melted. At Grays Lake National Wildlife Refuge (NWR) nesting begins in late April to early May and incubation extends through late June to early July (Drewien 1973). Young fledge in August to early September in 67-75 days (Drewien 1973). Incubating pairs seldom leave their territory (Littlefield and Ryder 1968); pairs with young also tend to remain on their territories until their young fledge. Rapidly growing young need high levels of protein in their diets. Grain crops supply little protein, while invertebrates contain a high percentage of protein. Pairs with young are more likely to feed in wet meadows and shallow marshes where invertebrates are more abundant. Mullins and Bizeau (1978) found timothy (*Phleum pratense*) corms and invertebrates were the most important food items in Sandhill Crane diets in Idaho during the summer. Nonbreeders and failed breeders usually join into small flocks. Melvin (1978) recorded depredation on sprouting maize by flocks of nonbreeders in Wisconsin, but no breeding pairs were seen in crops during the breeding season.

Migration is energetically expensive; cranes alter their feeding behavior and increase their foraging rates to store fat to fuel the flight. At Last Mountain Lake in Saskatchewan, Canada, fall staging cranes, feeding mostly on wheat, added 9 g of fat per day to their body mass. Percent fat in the body rose from 12% in mid-August to 37% in late September (Tacha *et al.* 1985). Similar trends were seen during the spring migration. On the wintering grounds in Texas, Sandhill Cranes were 8% fat in mid-winter. Between early March when cranes arrived on the Platte River staging area and late April before leaving Last Mountain Lake in Saskatchewan, male Sandhill Cranes gained 1,129 g (34%) in body mass. Females gained 953 g (30%). This was a daily gain of 25 g/day for males and 18 g/day for females. By the time they reached the breeding grounds on the Yukon/ Kuskokwim Delta they had lost 46% of their fat reserves (Krapu *et al.* 1985; Krapu 1987). These weight gains were based on increased intake of grains, primarily waste grains remaining from the fall harvest. Carbohydrates in grain can be easily converted to fats, an efficient way to store energy for migration.

Efficient acquisition of food to meet seasonal energy demands during migration and winter necessitates flocking behavior. Large flocks correlate with the presence of food, reducing search costs (Alonso and Alonso 1991). Flocking behavior of migrants and nonbreeding cranes allows a reduction of an individual's time investment in vigilance activities, allowing more time for foraging and resting. Cranes prefer to feed in harvested fields, or short vegetation, because it offers better visual detection of predators (Munro 1950; Littlefield 1986; Werner and Nesbitt 1987; Sugden *et al.* 1988) allowing greater time allocation to foraging. Cranes also prefer to feed in fields where they had fed previously (Lovvorn and Kirkpatrick 1982); this reduces search time, since the presence of food resources is already known. Cranes prefer to feed near roost sites; reported distances from roost sites to feeding areas ranged from 2.2 km to 10.8 km (Iverson *et al.* 1985; Littlefield 1986; Sugden *et al.* 1988). Limiting local flights to relatively short distances conserves energy for migration.

These foraging patterns create a tremendous potential for crop depredations by Sandhill Cranes. There are 500,000 to 600,000 Sandhill Cranes migrating in North America each year. About 500,000 cranes stop along the Platte River in Nebraska in a one-month period each spring. In western Texas up to 450,000 cranes winter each year. Flocks of this size coupled with increased foraging rates pose the potential for tremendous depredation problems. Fortunately, most of these cranes feed in harvested fields. Much of the crop depredation by these large flocks occurs in fall in the prairie provinces of Canada and prairie states of the U. S. A. Elsewhere in North America depredations are more localized and affect unharvested crops early in the fall as cranes stage near their breeding areas. Some damage to sprouting grain also occurs in the spring and fall.

DEPREDATION CONTROL

Responsibility for control

Cranes in North America are protected by international treaties, and federal and state or provincial laws. Farmers have insisted that compensation or control of damage caused by wildlife protected by law should be the responsibility of those governments. The Canadian Government provides some compensation in the form of subsidized crop insurance and other control measures, such as lure crops. The United States government does not provide compensation, but does provide assistance in control measures and lure crops. The U. S. Fish and Wildlife Service used to loan propane exploders and provide other noise-making devices to farmers requesting assistance with bird depredation problems. The farmer was responsible for replenishing the propane and for placing and moving the devices in the field. Farmers were also responsible for detecting the problem and requesting assistance. The U. S. Fish and Wildlife Service has issued pamphlets to help people with depredation problems (U. S. Fish and Wildlife Service no date, 1985).

Governmental responsibility in the United States was moved to the Animal Plant Health Inspection Service of the U. S. Department of Agriculture in 1986. The U. S. Fish and Wildlife Service now has no wildlife damage control responsibility, although some crops are still planted for wildlife on national wildlife refuges. Some state and provincial governments also provide assistance with control and/or compensation. Assistance and compensation usually do not cover the full value of the depredations. Effective depredation control cannot be done by the government alone; farmers must detect the problem early on and be willing to expend time and effort aiding in the control process.

Compensation

There are 2 types of compensation, insurance and depredation payments. Insurance can be provided by a government agency or through a fund created by the agricultural industry through self taxes. Depredation payments are payments made directly to farmers to compensate for wildlife depredations. Knittle and Porter (1988) say that compensation is the most expensive approach. Compensation does not address the problem. Payments may increase annually while the depredation problem increases. Melvin (1978) said that the compensation program encouraged fraud. Some farmers delayed claims for depredations until it was so late in the season that evaluation of actual damage could not be done, and that this led to some overpayments.

Control Techniques

Numerous techniques have been used to control crop depredations by Sandhill Cranes, some with more success than others. No method was successful all of the time, and most successful control programs used a combination of techniques. Control can be aimed at any of the 3 components (cranes, roosts, and crops) of a depredation problem, or a combination of these components.

Hunting

Sport hunting has been used in several places to reduce crop depredations. The response to hunting disturbance seems to be variable; effective in some circumstances and ineffective in others. In Saskatchewan, Canada hunting was initiated to reduce crop depredation by staging and migrant Sandhill Cranes (Stephen 1967). However, Stephen (1967) thought that hunting would not control crop depredation. Sugden *et al.* (1988) confirmed this suspicion; they found that hunting did not affect depredation at Last Mountain Lake in Saskatchewan, because hunters did not hunt in grain fields where the cranes fed, but concentrated along the flyways between the roost and feeding fields. Lockman *et al.* (1987) found that hunting in Wyoming was successful in reducing crop depredation. In this case, the hunt was early in the fall and was confined to a small area where local birds were staging prior to migration. Compensation, scare methods, and lure crops had all been used previously, but depredation problems by Canada Geese (*Branta canadensis*) and Sandhill Cranes continued to increase. The hunt caused a decline in the local crop depredations; the hunt disturbed the birds on the roosts and the feeding areas. The Wyoming hunt was more successful at moving geese than cranes out of the hunt area. Hunting for other species, such as waterfowl, may cause enough disturbance to cause cranes to leave roost and feeding areas (R. Drewien *pers. comm.*; Lovvorn and Kirkpatrick 1981, 1982). R. Drewien (*pers. comm.*) stated that disturbance from waterfowl hunting was likely to cause birds to migrate early if there was little food available locally, but there was no inclination by Sandhill Cranes to migrate early when hunted in Wyoming (Lockman *et al.* 1987). No other lethal control of cranes has been legal in North America, although some illegal shooting has probably taken place. Dyer and Ward (1977) state that lethal control of depredating birds is usually the first technique attempted, usually with no consideration of other possible techniques. Lethal control using poisoned grain and by shooting has occurred with Blue Cranes (*Anthropoides paradiseus*) in South Africa (Van Ee 1981). Hunting or other lethal methods to control crop depredation by cranes should be unacceptable for most crane species, since they are all less abundant than Sandhill Cranes, and some species are endangered.

Roost Management

Because cranes feed near roost sites, changing the pattern of use at roost sites can affect crop depredations in the surrounding area. Disturbance at roosts by hunters (R. Drewien *pers. comm.*; Lovvorn and Kirkpatrick 1981, 1982), or by propane guns (Stephen 1967) caused birds to abandon roost sites. Cranes may remain in the area if alternate roosts are available (Stephen 1967). Changes in vegetation or water levels in managed marshes could be used to attract or discourage cranes from roosting in an area. Methods that force cranes to move roosts can shift depredations to other areas. In some cases cranes can be attracted to new roosts to ease depredation pressure on other areas. In Sweden, Swanberg (1987) created openings in reeds (*Phragmites* sp.) that attracted Eurasian Cranes (*Grus grus*) to roost in the openings. Permanent destruction of wetlands as a method to control crop depredations by elimination of crane roosting sites cannot be justified. Wetlands are too valuable ecologically and too many wetlands have already been lost. In the lower 48 states of the United States over half of all wetlands have already been lost, primarily from conversion to agricultural land (Dahl 1990). The history of wetland conservation in most other countries is no better.

Agricultural Methods

Changing local agricultural practices can reduce crop depredations. There are several options to reduce crop depredation problems in early ripening grain in the fall. Earlier maturing varieties of grain that are harvested before depredations normally begin can be planted (Mickelson 1987; Knittle and Porter 1988). In northern areas grain is often swathed to help dry the grain kernels faster; swathed grain is more susceptible to depredation. Depredation can be reduced by harvesting standing grain and drying the kernels in grain dryers if necessary (Knittle and Porter 1988; Sugden *et al.* 1988). Crops can be changed to species that cranes do not prefer (Knittle and Porter 1988). Stubble fields should not be plowed until all vulnerable crops in the area have been harvested. Cranes prefer to feed in the harvested fields; if harvested fields are available cranes may not be attracted to unharvested fields (Lovvorn and Kirkpatrick 1982; Walker and Schemnitz 1987; Knittle and Porter 1988). Burning or grazing on native grasslands may improve the availability of natural foods for cranes during the winter and spring migration by removing tall rank vegetation. Werner and Nesbitt (1987) found that the number of cranes using an area in Florida increased after burning. Bulbs and rhizomes were more accessible to cranes after burning. Cattle grazing produced similar effects. Reinecke and Krapu (1986) stated that burning, grazing and haying of grasslands benefited cranes during spring migration by shortening the vegetative cover and stimulating invertebrate numbers.

Chemical Methods

Methiocarb has been shown to reduce damage to sprouting maize from Redwing Blackbirds (*Agelaius phoeniceus*), Common Grackles (*Quiscalus quiscula*), and American Crows (*Corvus brachyrhynchos*) (Stickley and Guarino 1972). The method may be useful to reduce damage by cranes to sprouting grain, but it has not been adequately field tested for cranes. Melvin (1978) said that methiocarb did not deter depredation on maize by Sandhill Cranes, but no adhesive agent was used in the field test. Successful applications of the technique with passerine birds used an adhesive agent to stick the methiocarb to the seed (Stickley and Guarino 1972). Tests by Schafer *et al.* (1977 as cited in Knittle and Porter 1978) suggest that methiocarb (at 100 ppm) and thiram (at 500 ppm) may be effective in repelling cranes from grain (also see Appendix).

Scare Techniques

Scare techniques can be used to move cranes and other birds out of crops. Scare techniques include all types of visual and audible disturbance. Visual devices include human activity, human effigies, balloons, ribbons, flashing lights, plastic sheets attached to poles, vehicles parked in fields, dogs, etc. Audible techniques include gunshots, propane exploders, rockets, shell crackers, etc.; propane exploders are the most common method used. Melvin (1978) and Sugden *et al.* (1988) stated that scare devices were ineffective. Other authors disagree. Scare techniques work best when both visual and audible cues are given, especially when the visual cue includes human activity. Scare techniques are often used in conjunction with lure crops (Fairaizl and Pfeifer 1988; Knittle and Porter 1988). Stephen (1967) found that propane exploders were a cost effective way to reduce crop depredations. The noise and human activity associated with hunting of cranes (Lockman *et al.* 1987) and waterfowl (R. Drewien *pers. comm.*; Lovvorn and Kirkpatrick 1981, 1982) reduced depredations or caused cranes to leave an area. It is important that the propane exploders be moved every few days, otherwise cranes quickly learn to ignore the noise and will not leave the area. Cranes develop high fidelity to previously used fields (Lovvorn and Kirkpatrick 1982), so scare techniques work best if initiated as soon as cranes begin using a field. Once a feeding pattern becomes established it is much more difficult to move the birds off the field (Knittle and Porter 1988). If the depredations are discovered as soon as the cranes start using the field and prompt action is taken, cranes can be scared out much more easily. This is why the role of the farmer in early detection of the depredation problem is so important.

Improperly used scare techniques can increase the amount of crop damage. Several times more grain is damaged than is consumed. If allowed to continue to use a field cranes will eventually consume the grain knocked to the ground. If scared to other unharvested fields, cranes will continue to do more damage (Fairaizl and Pfeifer 1988). Overall damage can increase when cranes are scared from unharvested field to unharvested field, although damage to an individual field might be reduced. Where there are no harvested fields or no government lure crops nearby it may be best not to harass cranes to other fields and to pay compensation or to purchase the standing grain in private fields as a lure crop (Fairaizl and Pfeifer 1988). If adequate roost sites and food are nearby, scare techniques are unlikely to force migrants to keep migrating (Stephen 1967). If undisturbed harvested fields or lure crops are available scaring birds out of unharvested fields can reduce overall crop damage (Knittle and Porter 1988).

Lure Crops

Lure crops can be effective in controlling crop depredation by cranes, especially when used in conjunction with scare techniques. Knittle and Porter (1988) suggest that lure crops can be used where there are large numbers of birds, birds can be hazed from nearby fields, there are many vulnerable crops nearby, there is a long damage season (> 30 days), and damage is greater than the amount of grain consumed. All these conditions occur with cranes during fall staging and migration.

Lure crops can be on private or government lands. On many state, provincial, and federal wildlife areas in North America crops are grown for waterfowl and cranes. Often private individuals are allowed to sharecrop on government lands, with the government share of the crop being left in the fields as a lure crop for wildlife. In other cases the government agencies grow the crop themselves. Lure crops are useful in the breeding areas of cranes and waterfowl. Once geese fledge in July and cranes in September, they start to flock and increase foraging rates to store energy before migration. Lure crops provide food until the local crops can be harvested and stubble fields become available for feeding. On many wintering areas, where local grain crops have already been harvested, lure crops may reduce depredations on lucerne, or on fall planted grains. Lure crops may also serve as an enticement to keep cranes on refuges where they are safer.

In central Canada and north-central United States lure crops can reduce depredations by migrating cranes and waterfowl. The potential for widespread depredation is higher since larger numbers of birds are involved and much of the grain is not yet harvested. Fairaizl and Pfeifer (1988) stated that lure crops can be cost effective. They were concerned primarily with damage by ducks, but their results are also applicable to cranes. They purchased crops standing in farmers' fields for lure crops after damage had begun, and substantial numbers of ducks used the field regularly. Farmers were not allowed to disturb ducks from these fields and scare devices were used in surrounding fields to move ducks to the lure crops.

Placement and management of lure crops can improve their efficacy. Since staging and wintering cranes prefer to feed in short cover, the lure crops should be mowed or knocked down to encourage crane use. Ideally, lure crops would be planted nearer the roost than the crops at risk. If the lure crop is eaten before the end of the depredation season, grain can be spread in the lure crop fields to keep cranes from depredating unharvested fields (Knittle and Porter 1988). Cranes should not be disturbed from the lure crop fields or from the nearby roost; this may encourage them to move to other fields, increasing the damage. In North America spread grain must be managed to prevent problems with waterfowl hunting. Hunting near bait is illegal; spread grain is considered bait. Hunters can be fined whether they know the area has been baited or not. The problem can be solved by removing the grain by harvesting, disking, or plowing 10 days prior to the hunting season, or by closure to all hunting of a sufficient area around the grain. Unconsumed grain from baiting or harvest waste can cause other problems. During wet periods the grain can become moldy. Mycotoxins can develop in these moldy grains and kill all birds which eat it. In 1979 aflatoxin poisoning was confirmed in Sandhill Cranes from eating moldy maize (Windingstad 1988). Moldy groundnuts were suspected in another crane die-off involving 450+ Sandhill Cranes, and over 5,000 Sandhill Cranes died in 1985 from suspected mycotoxin poisoning (Windingstad 1988). Disking or plowing the moldy grain under can reduce mycotoxin poisoning problems.

Cranes can develop long term fidelity to certain fields (Lovvorn and Kirkpatrick 1982). Because of site fidelity, lure crop fields should be in the same area each year. Cranes will be more likely to return to the lure crop field than to depredate other fields. Safe refuges and reliable food supplies can form new, long-lasting migratory traditions for cranes. At Jasper-Pulaski Fish and Wildlife Area in Indiana the number of migrant cranes rose from very few in the 1930's to over 13,000 in 1978 (Lovvorn and Kirkpatrick 1981). There can be negative effects to large crane concentrations attracted to lure crops. The depredation problem may shift from lighter damage spread over a wider area to heavier damage confined to a more concentrated area. The potential for disease outbreaks increases with increasing bird density.

CROP DEPREDATION BY OTHER CRANE SPECIES

Similarities in feeding patterns and dietary preferences suggest that depredation control methods used for Sandhill Cranes may be applicable to African cranes, even though most African cranes are less migratory. Conversion of wetlands to croplands has exacerbated the problem in Africa, as in other countries, by removal of natural crane feeding areas and by placing crops adjacent to roost sites (Johnson and Barnes 1991; Mafabi 1991). The Eurasian and Demoiselle Cranes (*Anthropoides virgo*) that winter in northern Africa are most similar to Sandhill Cranes in life history. Both are migratory. Both species feed in harvested fields when available, but also depredate on a wide variety of unharvested and sprouting crops on the wintering areas (Alonso *et al.* 1984; Alonso *et al.* 1987; Alonso and Alonso 1991; Khachar *et al.* 1991; Wang F. 1991; Wang Y. 1991). The Wattled Crane (*Bugeranus carunculatus*), which feeds primarily on aquatic plants (Konrad 1981), may be less likely to damage crops than the other resident species. The four resident crane species in Africa are less migratory. There may be regional movements, but no long range migration as in most Sandhill Cranes. Their breeding seasons are less compressed than in the Sandhill Crane, so they will spend more time on breeding territories and less time in flocks than Sandhill Cranes. They exhibit flocking during the nonbreeding season, but should not need to store energy for migration, and should not exhibit hyperphagia. They prefer to feed near roosts and in short vegetation, and except for the Wattled Crane readily feed on crops. Crop damage may also occur during the breeding periods;

Mafabi (1991) recorded crop depredation during incubation by Grey Crowned Cranes (*Balearica regulorum*).

These observations suggest a different pattern to depredation problems, less intense, but longer in duration. The longer duration ensures that cranes will be present at times when crops will be vulnerable. The longer duration will require effort by federal, and state officials, and by farmers over a longer period of time, and will increase the likelihood of cranes habituating to scare control measures. As a result damage control efforts may be more expensive and perhaps less effective than similar efforts for Sandhill Cranes. Control efforts may be more complicated on small subsistence farms, because there are more farmers to deal with and depredation will have a relatively greater impact on the farmer.

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REFERENCES CITED

Alonso, J. C. , J. A. Alonso, and J. P. Veiga. 1984. Winter feeding ecology of the crane in cereal farmland at Gallocanta, Spain. Wildfowl 35:119-131.

Alonso, J. C., J. P. Veiga, and J. A. Alonso. 1987. Possible effects of recent agricultural development on the wintering and migrating pattern of Common Cranes in Iberia: a study of winter ecology in a suitable locality. Pages 277-299 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Alonso, J. C. and J. A. Alonso. 1991. Costs and benefits of flocking in wintering Common Cranes. Pages 271-276 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Dahl, T. E. 1990. Wetland losses in the United States 1780's to 1980's. U. S. Department of the Interior, Fish and Wildlife Service, Washington, D. C., USA.

Drewien. R. C. 1973. Ecology of Rocky Mountain greater Sandhill Cranes. Ph.D. Dissertation. University of Idaho, Moscow, Russia.

Dyer, M. I. and P. Ward. 1977. Management of pest situations. Pages 267-300 *in* J. Pinowski and S. C. Kendeigh, eds., Granivorous birds in ecosystems. Cambridge University Press, Cambridge, UK.

Fairaizl, S. D. and W. K. Pfeifer. 1988. The lure crop alternative. Pages 163-168 *in* D. W. Uresk, G. L. Schenbeck, and R. Cefkin, eds., Eighth Great Plains wildlife damage control workshop proceedings. U. S. Department of Agriculture, Forest Service, General Technical Report RM-154.

Iverson, G. C., T. C. Tacha, and P. A. Vohs. 1982. Food contents of Sandhill Cranes during winter and spring. Pages 95-98 *in* J. C. Lewis, ed., Proceedings 1981 Crane Workshop. National Audubon Society, Tavernier, Florida, USA.

Iverson, G. C., P. A. Vohs, and T. C. Tacha. 1985. Habitat use by Sandhill Cranes wintering in western Texas. Journal of Wildlife Management 49:1074-1083.

Johnson, D. N. and P. R. Barnes. 1991. The breeding biology of the Wattled Crane in Natal. Pages 377-386 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Khachar, S., H. R. Patanka, A. Gaekwad, T. Mundkur, R. Pravez, and R. M. Naik. 1991. Wintering cranes in Gujarat State, India. Pages 327-333 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Knittle, C. E. and R. D. Porter. 1988. Waterfowl damage and control methods in ripening grain: an overview. U. S. Fish and Wildlife Service, Technical Report 14.

Konrad, P. M. 1981. Status and ecology of Wattled Cranes in Africa. Pages 220-237 *in* J. C. Lewis and H. Masatomi, eds., Crane Research Around the World. International Crane Foundation, Baraboo, Wisconsin, USA.

Krapu, G. L. 1987. Use of staging areas by Sandhill Cranes in the midcontinent region of North America. Pages 451-462 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Krapu, G. L., G. C. Iverson, K. J. Reinecke, and C. M. Boise. 1985. Fat deposition and usage by arctic-nesting

Sandhill Cranes during spring. Auk 102:362-368.

Littlefield, C. D. 1986. Autumn Sandhill Crane habitat use in southeast Oregon. Wilson Bulletin 98:131-137.

Littlefield, C. D. and R. A. Ryder. 1968. Breeding biology of the greater Sandhill Cranes on Malheur National Wildlife Refuge, Oregon. Transactions of the North American Wildlife and Natural Resources Conference 33:444-454.

Lockman, D. C., L. Serdiuk, and R. Drewien. 1987. An experimental greater Sandhill Crane and Canada goose hunt in Wyoming. Pages 47-57 *in* J. C. Lewis, ed., Proceedings 1985 Crane Workshop. Platte River Whooping Crane Habitat Maintenance Trust and U. S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

Lovvorn, J. R. and C. M. Kirkpatrick. 1981. Roosting behavior and habitat of migrant greater Sandhill Cranes. Journal of Wildlife Management 45:842-857.

Lovvorn, J. R. and C. M. Kirkpatrick. 1982. Field use by staging eastern greater Sandhill Cranes. Journal of Wildlife Management 46:99-108.

Mafabi, P. G. 1991. The ecology and conservation of the Gray Crowned Crane in Uganda. Pages 363-367 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Melvin, S. M. 1978. Ecology of non-breeding Wisconsin Sandhill Cranes, with emphasis on crop damage and migration. M.S. Thesis. University of Wisconsin, Stevens Point, Wisconsin, USA.

Mickelson, G. 1987. Management of lesser Sandhill Cranes staging in Alaska. Pages 264-275 *in* J. C. Lewis, ed., Proceedings 1985 Crane Workshop. Platte River Whooping Crane Habitat Maintenance Trust and U. S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

Mullins, W. H. and E. G. Bizeau. 1978. Summer foods of Sandhill Cranes in Idaho. Auk 95:175-178.

Munro, D. A. 1950. Economic status of the Sandhill Crane in Saskatchewan. Journal of Wildlife Management 14:276-284.

Reinecke, K. J., and G. L. Krapu. 1986. Feeding ecology of Sandhill Cranes during spring migration in Nebraska. Journal of Wildlife Management 50:71-79.

Schafer, E. W., Jr., R. B. Brunton, D. J. Cunningham, and E. C. Schafer. 1977. The repellency of methiocarb to Sandhill Cranes. U. S. Fish and Wildlife Service, Denver Wildlife Research Center, Unpublished Bird Damage Research Report 56. 6 pages.

Stephen, W. J. D. 1967. Bionomics of the Sandhill Crane. Canadian Wildlife Service, Report Series - Number 2.

Stickley, A. R., Jr. and J. L. Guarino. 1972. A repellent for protecting corn seed from blackbirds and crows. Journal of Wildlife Management 36:150-152.

Sugden, L. G., R. G. Clark, E. J. Woodsworth, and H. Greenwood. 1988. Use of cereal fields by foraging Sandhill Cranes in Saskatchewan. Journal of Applied Ecology 25:111-124.

Swanberg, O. 1987. Migrating Common Cranes in Sweden: experiments in farming for cranes and vegetation control in wetlands. Pages 225-229 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings of the 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Tacha, T. C., C. Jorgenson, and P. S. Taylor. 1985. Harvest, migration, and condition of Sandhill Cranes in Saskatchewan. Journal of Wildlife Management 49:476-480.

U. S. Fish and Wildlife Service. No date. Control of migratory game bird depredations. U. S. Fish and Wildlife Service, Washington, D. C., USA.

U. S. Fish and Wildlife Service. 1985. ADC 106: controlling migratory waterfowl depredations. U. S. Fish and Wildlife Service, Washington, D. C., USA.

Van Ee, C. A. 1981. Status of the Blue Crane in South and Southwest Africa. Page 259 *in* J. C. Lewis and H. Masatomi, eds., Crane Research Around the World. International Crane Foundation, Baraboo, Wisconsin, USA.

Walker, D. L. and S. D. Schemnitz. 1987. Food habits of Sandhill Cranes in relation to agriculture in central and southwestern New Mexico. Pages 201-212 *in* J. C. Lewis, ed., Proceedings 1985 Crane Workshop. Platte River Whooping Crane Habitat Maintenance Trust and U. S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

Wang F. 1991. The distribution of cranes in Shanxi and their relation to the ecological environment. Pages 91-94 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Wang Y. 1991. A preliminary study on the winter ecology of cranes at Caohai. Pages 119-121 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Werner, A. S. and S. A. Nesbitt. 1987. Wintering of greater Sandhill Cranes in Florida. Pages 196-200 *in* J. C. Lewis, ed., Proceedings 1985 Crane Workshop. Platte River Whooping Crane Habitat Maintenance Trust and U. S. Fish and Wildlife Service, Grand Island, Nebraska, USA.

Windingstad, R. M. 1988. Nonhunting mortality in Sandhill Cranes. Journal of Wildlife Management 52:260-263.

APPENDIX

Vertebrate damage control research is being done by the Denver Wildlife Research Center, and several cooperating universities.

For more information on current programs and past work contact:

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IMPORTANCE OF COLOR BANDING FOR MIGRATION AND POPULATION STUDIES ON CRANES

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Numbered plastic color bands were first used in Japan on swans, and have succeeded in generating a lot of information about local movement and long distance migration. Similar color banding research was started for cranes in 1979 at the crane wintering site in Izumi, Japan. As of spring 1993, 181 Hooded Cranes (*Grus monacha*) and 68 Whitenaped Cranes (*G. vipio*) had been banded. Each bird has been fitted with a numbered plastic color band (orange or yellow) and a numbered metal band on the tibia. It is possible to read the numbered color bands even from a distance of 500 m using a telescope.

We have made and sent several hundred color bands to crane researchers in Russia, China, and Mongolia with the support of the Wild Bird Society of Japan. In those countries, 12 Hooded Cranes and 64 Whitenaped Cranes have been banded, using mainly these bands, on the breeding or staging sites.

Of the total 193 banded Hooded Cranes, 13 individuals were either recovered (found dead) or sighted outside of their original banding sites, a recovery rate of 6.7%. Among the birds banded in Japan, two were found dead in the central-western part of the Korean Peninsula during the spring migration period in March, and two were resighted at Taegu, which is a newly discovered wintering site in South Korea. Those two birds wintered there for only one season and returned to Izumi the following winter. Nine of the twelve birds banded in Russia were sighted in Japan. The birds (5 individuals) who bred along the Bikin River and the Marevka River in the Premorsk region wintered at Izumi. Four birds from Daursky Reserve in the Chita region, which is known as a staging site for this species, were resighted at Izumi also.

Forty-seven recoveries or sightings of Whitenaped Cranes have been reported of the total 132 banded, a recovery rate of 35%. Among the birds banded in Japan, nine were reported from South Korea during the December and February/March migration periods. Most birds were found at the mouth of the Han River, and one at the center of the Korean Peninsula. Fifteen other birds were reported in Japan at sites such as Tsushima Island on the Sea of Japan and Nagasaki Prefecture. A pair was found nesting at the Zhalong Nature Reserve in the Heilongjiang Province of China. A total of 54 birds were banded at five different breeding sites in Russia. At Khingansky Reserve, Amursk Reserve and near Blagoveshchensk, 35 birds were banded. Sixteen of them were observed at Izumi, and one was found dead in South Korea. From Lake Khanka, two of three were reported at Izumi. However, there are no recovery records between the Daursky Reserve in Russia and Japan, even though sixteen birds have been banded around that area.

Annual rates of return to the wintering site for banded individuals were calculated. In Hooded Cranes, about 54% of birds which were banded as juveniles returned the following year. The return rate for adults (more than 2 years old) in the first year following banding was about 77%, and in subsequent years was 87% on the average. In Whitenaped Cranes, about 73% of birds which were banded as juveniles returned the following year. The return rates both of first year and subsequent years of adults was about 83%.

The age of first breeding and longevity records are also important knowledge that can be estimated only by banding research. One female Hooded Crane started to breed at two years old, and another bird is still alive after 13 years. Three Whitenaped Cranes (two males and a female) started to breed at 2 years old, and another is still alive after more than 11 years.

RELEASE AS A CONSERVATION STRATEGY FOR NON-MIGRATORY SPECIES OF CRANES

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INTRODUCTION

Conservation strategies for threatened cranes require the selection of management techniques that will resolve or correct the causes of population decline. Causes of endangerment to wild cranes include loss of habitat, human interference or disturbance, hunting for food or other purposes, climatic changes, disease, fire, genetic problems including inbreeding, hybridization, predation, pesticides, powerlines, poisoning, pollution, catastrophic events, and trade for the live animal market (Mirande *et al.* 1992). Passage and enforcement of national legislation or international treaties and the establishment of parks or reserves to protect species and habitat are effective measures (King 1977). At the same time, management may need to include manipulative techniques which address specific problems confronting a species. This can include predator control, control of factors having detrimental impacts on habitat (i.e., grazing, wildfire, or invasion of exotic plants), provision of artificial feeding stations, or captive breeding and subsequent release programs to bolster or re-establish wild populations.

The first efforts to establish viable wild populations of avian species centered on: (1) restocking programs for game birds such as Ringnecked Pheasant (*Phasianus colchicus*), Wild Turkey (*Meleagris gallopavo*), and Canada Goose (*Branta candensis*); and (2) introduction of exotic species such as European Starling (*Sturnus vulgaris*), House Sparrow (*Passer domesticus*), and Rock Dove (*Columba livia*) (Laycock 1966; Fyfe 1977; Long 1981). Fyfe (1977) stated that successful programs exhibited a number of similarities. First, repeated introductions of relatively large numbers of birds were usually necessary to build up initial populations. Second, the environments in which they became established usually contained few effective predators or competitors so there was little resistance to population growth. Age and experience of released stock affected survival rates. Habitat improvement and protection measures needed to occur simultaneously. Lastly, the species involved usually had high reproductive rates, were ecological generalists, and were gregarious (flock forming) so that they did not have difficulty finding mates (Fyfe 1977).

Endangered species of cranes, in contrast, have low reproductive rates. The most endangered cranes have highly specialized ecological requirements, and cranes are only seasonally gregarious. While most successful re-introductions involve releasing large numbers of birds, most endangered wild crane populations are not large or prolific enough to provide abundant stock for release. These factors combine to make the reintroduction of endangered cranes a more complicated task. A variety of studies have been or are currently being conducted to develop techniques for establishing or bolstering endangered crane populations. To date, no self-sustaining population of wild cranes has resulted from re-introduction attempts. However, there are several examples of release programs that have successfully added captive-bred individuals to existing migratory and non-migratory populations of conspecifics.

Following is a review of these programs with a focus on non-migratory populations, since these techniques are most applicable to African cranes. The criteria for evaluating the feasibility of a release program, and the guidelines used in planning and conducting a release are discussed.

These criteria and guidelines have been developed by the Re-introduction Specialist Group (RSG) of the World Conservation Union (IUCN) (Appendix 1). As the world rapidly develops release methods for threatened and endangered species, RSG works to assemble information on all re-introduction projects, coordinate communication between researchers, and to develop guidelines for the use of release programs as part of overall conservation strategies. Release programs have been divided into 4 main categories.

1. **Reintroduction.** An attempt to establish a species in an area which was once part of its historical range, but from which it has become extinct. A re-introduction should aim to establish a viable, free-ranging population in the wild which requires minimal long-term management.

2. **Translocation.** Deliberate and mediated movement of wild individuals or populations from one part of their range to another.

3. **Reinforcement/Supplementation.** Addition of individuals to an existing population of conspecifics.

4. **Conservation/Benign Introductions.** An attempt to establish a species for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area.

Release programs are undertaken for many reasons, including: (1) enhancing the long term survival of a species; (2) increasing biodiversity; (3) re-establishing a key species in an ecosystem; (4) providing long-term economic benefits to a local or national economy; or (5) promoting conservation awareness (RSG 1995). It is extremely important to fully evaluate release programs before initiating them because they are expensive and labor intensive.

REVIEW OF RELEASE PROGRAMS FOR CRANES

To date, little work has been done on translocation of cranes. Nesbitt and Williams (1973) reported that over a 3 year period, 26 wild, sub-adult Florida Sandhill Cranes (*Grus canadensis pratensis*) were trapped, banded, and relocated a distance of 152 miles to suitable habitat. After 20 months, dispersal had been minimal in these translocated birds.

Two techniques have been developed for the reinforcement/supplementation of pre-existing wild populations. Both techniques involve the release of captive reared individuals. Release stock have been produced by multiple clutching of genetically well-represented captive pairs, or through the removal of wild eggs. If it is necessary to collect wild eggs, impact on the productivity of the wild birds should be minimized by: (1) removing eggs early to promote renesting; (2) removing the second egg from nests known to have 2 late-term viable eggs in species which generally only rear 1 chick; or (3) replacing wild eggs with captive produced eggs.

The first technique involves rearing and release of semi-wild birds which pair and produce offspring with wild mates. This has been successful with Redcrowned Cranes (*Grus japonensis*) and Whitenaped Cranes (*Grus vipio*) at the Zha Long Nature Reserve in China, the Khinganski Nature Reserve in Russia, and the Kushira Marsh in Japan. Birds hand reared by humans, are allowed to roam freely in the protected marshes of a nature reserve. In the spring, they pair with each other or wild birds. Over the winter months, these semi-wild birds and their families are placed into holding pens. The following spring, the families are released into the marsh, and the young generally join the wild birds and migrate their second fall. Offspring resulting from these matings are reportedly much more tolerant of human approach than wild birds, and consequently better adjusted to human disturbance. Additionally, wild pairs have increased their usage of the protected reserves, due to the presence of these semi-wild birds (Jie *et al.* 1991).

In Hokkaido, Japan, flightless male Redcrowned Cranes have been placed into enclosures within the reserve and have lured in and mated with wild females. The resulting offspring are free to join the wild flock (Konrad 1976).

Isolation rearing is a second technique which allows a large number of crane chicks to be hand reared which are imprinted on their own species and fearful of humans. The technique limits the amount of human exposure the chicks receive by using a number of props including: (1) tape recordings of adult cranes vocalizations which are played to both hatching eggs and chicks; (2) taxidermic mounts and live role models in addition to exposure of chicks to one another; (3) puppets or taxidermic heads used for feeding the chicks; and (4) negative conditioning to humans, also called fear training (Horwich 1989).

A variation of the technique is called costume rearing. Costume rearing imprints the chicks on a crane puppet head and costumed human "parent". The costume serves to mask human facial features during feeding and exercise sessions. The costume is then used at the release site to acclimate the birds to wild conditions, including foraging and selection of food items and roost site selection (Horwich 1989; Horwich *et al.* 1992; Nagendran 1992; Urbanek and Bookhout 1992).

The program to reinforce/supplement the existing population of non-migratory Mississippi Sandhill Cranes (*Grus candensis pulla*) uses a combination of these two release techniques (Ellis *et al.* 1992). This program is the most successful release of a non-migratory species of crane to date. The release provides clear examples of the RSG's guidelines for pre-project activities, planning, preparation and release stages, and post release activities.

The Mississippi Sandhill Crane was once found in 3 states in the southern United States. Over the past thirty years, the population has declined and is now only found in Jackson County, Mississippi (Aldrich 1972).

From 1965-82, eggs were collected from the wild to establish a captive breeding program. In 1973, the crane was listed as endangered under the Endangered Species Act. Federal listing of a species legally protects the species and its habitat. In 1974, the Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR) was established to protect important breeding and wintering areas. In 1976, a Recovery Plan was approved by the U. S. Fish and Wildlife Service (Valentine *et al.* 1976). A Recovery Plan includes a series of measurable objectives and time frames aimed at ensuring the long-term survival of the species. As part of this plan, research was continued to learn more about the species critical needs such as, habitat preferences, food requirements, and breeding behavior.

According to Valentine (1983), Mississippi Sandhill Cranes rely on savanna habitat (open grasslands with scattered pine trees) and farmland. During the 1950's, much of the savannas were destroyed and converted to pine plantations. To restore and improve the savanna areas, refuge staff harvested pine plantations and then maintained the grasslands using prescribed fires. The cranes also rely on grazed pastures and harvested crop lands for food during the winter. The refuge plants portions of the refuge in corn, ryegrass, and sorghum every year. Roosting areas were improved using water control structures (Valentine 1983).

The Mississippi Sandhill Recovery Plan also suggested bolstering the wild population with the release of captive reared birds (Valentine *et al.* 1979). By 1981, the captive breeding program at the Patuxent Wildlife Research Center was ready to support a release. It contained genetically well-represented pairs, and was able to produce birds for release on a regular and sustainable basis.

From 1981-88, all release birds were parent reared. In 1989, parent and isolation reared birds were reared. When the parent reared birds reached 4.5 months of age, and the isolation reared birds reached 55-60 days of age, they were separated into cohorts. Cohorts were composed of parent reared birds, isolation reared birds, or a mix of isolation and parent reared birds. This was done so that differences in breeding, survival rates, and movement patterns could be assessed after release (Ellis *et al.* 1992).

After extensive health monitoring, they are placed in crates and transferred by airplane to release pens at the MSCNWR. The birds are brailed (rendered temporarily flightless by fastening a plastic strap around one wing) and the cohorts are placed in one of three release pens.

The pens are approximately 2 ha. in size and contain marsh and grassland areas and artificial feeding stations. Through temporary confinement in pens, the birds are safe from predators, and can gradually acclimate to wild conditions. This technique of gentle release has been found to result in higher survival rates than abrupt release (Zwank and Derrickson 1981).

After 4 weeks, health and behavior of each chick is assessed. Chicks suitable for release are fitted with plastic color bands and radio transmitters mounted on leg bands. Brails are removed, and the birds are allowed to fly in and out of the release pen. Chicks normally return to the pen in the evenings to feed, and this reduces the risk of predation. In time, they gradually stop utilizing the release pen (Zwank and Derrickson 1981).

Radio tagging allows the birds to be closely monitored after release. Information is collected about each bird's, behavior and movements. The radio transmitters can be equipped with a mortality switch, which triggers a signal when the bird has not moved in several hours. Attempts are made to locate carcasses. Cause of death is determined through necropsy at the National Wildlife Health Laboratory (an agency administered by the U. S. Fish and Wildlife Service).

Success of the release is measured in survival rates and breeding success. Coyotes, bobcats and feral dogs, cause the highest mortality, so predator control and habitat improvement continue to be high priorities. The release birds have significantly bolstered the wild population. One hundred nineteen of the 142 birds in the current population are release birds. However, the entire population only fledges one chick per year. Therefore, research into and the control of the factors contributing to this poor breeding success is a high priority.

EVALUATING AND DEVELOPING RELEASE PROGRAMS

Identification of management priorities is essential in the development of species conservation programs. Based on these priorities, managers must evaluate the need for specific management options and evaluate their feasibility. Once a management option is selected and implemented, it must be monitored and its success evaluated. The RSG Draft Guidelines for Re-introduction help managers answer the following questions: (1) Should a release be conducted? (2) How should a release be conducted? (3) How successful was the release? and (4) What improvements can be made?

Using specific examples from various crane breeding and release programs, the following discussion elaborates upon selected items from the guidelines. The complete guidelines are provided in Appendix 1.

Should a release be conducted?

Is there a need to assess the taxonomic status of individuals to be re-introduced? For example, ICF believed that the wild Eastern Sarus Crane (*Grus antigone antigone*) population in Southeast Asia was extinct. In an effort to start a captive breeding program to support a reintroduction program in Thailand, ICF collected Australian Sarus Crane (*Grus antigone gilli*) eggs. After these birds were breeding, and conditions for a release established, a population of Eastern Sarus was discovered in Vietnam. Behavioral and morphological characteristics indicate that the two populations are distinct from each other. DNA studies are also being conducted to evaluate convergence (G. Archibald *pers. comm.*). The Australian birds are no longer being considered for release, and efforts have focused on the captive breeding of the native Eastern Sarus.

Detailed study of wild populations need to be conducted. The biology of the species needs to be understood, along with a thorough understanding of what caused the population's decline or extinction (Beck 1991; Chivers 1991; Price 1991; Kleiman *et al.* 1994). Once these factors are understood and most importantly, eliminated, then a release program can be considered. One tool that may be very useful in assessing the status of a population and deciding upon specific conservation actions, is the Population and Habitat Viability Analysis (PHVA). A PHVA has 4 main goals: (1) to assess the main threats faced by a population; (2) to look at the species biology and then use computers test the probability of survival or extinction based on knowledge of the species and its habitats; (3) to examine the different management options and test what would happen if they were successfully implemented; and (4) to bring the people together who can contribute to the success of these programs, such as field managers, captive specialists, government officials, educators, and researchers.

A good quality, protected release site should be available. It should be within the historical range of the species. It is suggested that the site have few, or no resident wild population (to prevent the spread of disease and social disruption). However, it is much easier to release birds to supplement a population, than to try and restore an extinct population. Pre-release health screening protocols have been officially established for the Whooping Crane (*Grus americana*) and Siberian Crane (*Grus leucogeranus*) to minimize the risk of introducing a disease to the wild population (Langenberg

1992).

Release programs must also take place with permission from all relevant government agencies, local landowners, and local communities, so that there is long term protection for the species. The attitudes of the local people must be thoroughly assessed, in conjunction with development of environmental education and public relations programs.

Captive stock is needed that is as closely genetically related to the native stock as possible. The captive population needs to be self sustaining and reliably produce large number of animals for release. Several taxa of cranes have self propagating captive populations including the Whooping Crane, Siberian Crane, Mississippi Sandhill Crane, and Whitenaped Crane. Releases should not be conducted just because there are surplus birds being produced in captivity.

How should a release be conducted?

Proper networking with persons/agencies with relevant experience and expertise (e.g., ICF, RSG, USFWS) is important. Releases can be modeled after programs like the Mississippi Sandhill project with modifications to fit local conditions.

Adequate funding must be secured for all program phases. Funding sources include non-profit organizations, governmental agencies, airlines, equipment manufactures, and private individuals. Recovery projects can be expensive. For example, the annual federal budget for Endangered Species in the U. S. is $60-80 million/yr. The Whooping Crane recovery program budget is $2 million/yr. Captive propagation of the Whooping Crane is $500,000/yr. The Florida Whooping Crane Reintroduction Project has a $225,000/yr. budget (J. Lewis *pers. comm.*).

How successful was the release and what can we do to improve?

Post release monitoring needs to be conducted. This can be accomplished through tagging, radio telemetry, or through the use of local volunteers who have been trained to report on the birds locations and behavior.

It is important to develop a clearly defined method of evaluating post release results. The 'success' of the effort must be evaluated to determine if changes or improvements need to be made in methodology. This might include using formal experimental design and statistical analysis of relative survival rates (Kleiman *et al.* 1994). Current crane release programs are reviewed annually by a multidisciplinary team. Techniques, objectives, rearing and release methods are discussed and modifications implemented as needed.

CONCLUSION

Captive breeding and release are expensive and labor intensive. They are not a magical solution to saving endangered species. The primary focus should be on protecting cranes in the wild and allowing populations to recover naturally whenever possible. However, there are cases where captive breeding and release are necessary components of strategies to insure long-term, viable, wild populations.

A decision to release should be made as part of an overall conservation strategy for the species. If a release is identified as a priority activity, managers should carefully review the guidelines established by RSG for application to their situation. Literature on release should also be studied. Training in release techniques by study visits to release sites should be considered.

REFERENCES CITED

Aldrich, J. 1972. A new subspecies of sandhill crane from Mississippi. Proc. Biol. Soc. Wash. 85:63-70.

Beck, B. B. 1991. Managing zoo environments for reintroduction. Pages 436-440 *in* Proc. Ann. Meet. Am. Assoc. Zool. Parks and Aquariums.

Chivers, D. J. 1991. Guidelines for reintroductions: procedures and problems. Pages 89-99 *in* J. W. Gipps, ed. Beyond captive breeding: reintroducing endangered mammals to the wild. Clarendon Press, Oxford, UK. 248pp.

Ellis, D. H., G. H. Olsen, G. F. Gee, J. M. Nicolich, K. E. O'Malley, M. Nagendran, S. G. Hereford, P. Range, W. T. Harper, R. P. Ingram, and D. G. Smith. 1992. Techniques for rearing and releasing nonmigratory cranes: lessons form the Mississippi sandhill crane program. Pages 135-141 *in* D. W. Stahlecker, ed., Proceedings of the Sixth North American Crane Workshop. Regina, Saskatchewon, Canada.

Fyfe, A. 1977. Reintroducing endangered birds to the wild: a review. Pages 323-329 *in* S. A. Temple, ed., Endangered birds: management techniques for preserving threatened species. University of Wisconsin Press, Madison, Wisconsin, USA.

Horwich, R. H. 1989. Use of surrogate parental models and age periods in a successful release of hand-reared sandhill cranes. Zoo Biol. 8:379-390.

Horwich, R., J. Wood, and R. Anderson. 1992. Release of sandhill crane chicks hand-reared with artificial stimuli. Pages 255- 261 *in* D. A. Wood, ed., Proceedings 1988 North American Crane Workshop. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, USA.

Jie, X., S. Liying, and J. Xingxing. 1991. A way of expediting the recovery of the red-crowned crane. Pages 47-50 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

King, W. B. 1977. Endangered birds of the world and current efforts towards managing them. Pages 9-17 *in* S. A. Temple, ed., Endangered birds: management techniques for preserving threatened species. University of Wisconsin Press, Madison, Wisconsin, USA.

Kleiman, D. G., M. S. Price, and B. B. Beck. 1994. Criteria for reintroductions. Pages 287-303 *in* P. J. S. Olney, G. M. Mace, and A.T.C. Feistner, eds., Creative conservation: interactive management of wild and captive animals. Chapman and Hall, New York, New York, USA. 517pp.

Konrad, P. M. 1976. Potential for reintroduction of cranes into areas of former habitation. Pages 317-325 *in* J. C. Lewis, ed., Proceedings of the International Crane Workshop. Oklahoma State University, Stillwater, Oklahoma, USA.

Langenberg, J., ed. 1992. Whooping Crane Health Management Workshop. Madison, Wisconsin. 69pp.

Laycock, G. 1966. The alien animals: the story of imported wildlife. Natural History Press, Garden City, New York, USA. 240 pp.

Long, J. L. 1981. Introduced birds of the world. Universe Books, New York, New York, USA. 528pp.

Mirande, C., S. Ellis, and U. Seal, eds. 1992. Crane Conservation Assessment and Management Plan. Captive Breeding Spec. Group. Apple Valley, Minnesota, USA. 157 pp.

Nagendran, M. 1992. Winter release of isolation-reared sandhill cranes in south Texas. Pages 131-134 *in* D. W. Stahlecker, ed., Proceedings of the Sixth North American Crane Workshop, Regina, Saskatchewan, Canada.

Nesbitt, S. A. and L. Williams. 1973. A trial translocation of sandhill cranes. Pages 332-335 *in* Proc. 27th Ann. Conf. Southeastern Assoc. Game and Fish Comm.

Price, M. S. 1991. Draft guidelines for reintroductions. Unpubl. memo. to members of the IUCN/SSC Reintroduction Spec. Group.

Reintroduction Specialist Group of the International Union for the Conservation of Nature/Species Survival Commission. 1995. IUCN/SSC guidelines for reintroductions. Nairobi, Kenya. 7pp.

Urbanek, R. P. and T. A. Bookhout. 1992. Development of an isolation-rearing/gentle release procedure for reintroducing migratory cranes. Pages 120-130 *in* D. W. Stahlecker, ed., Proceedings of the Sixth North American Crane Workshop. Regina, Saskatchewan, Canada.

Valentine, J. M. 1983. Management of the Mississippi sandhill crane. Pages 387-397 *in* G. W. Archibald and R. F. Pasquier, eds., Proceedings 1983 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Valentine, J. M., R. E. Noble, B. Quisenberry, W. A. Swanson, and W. H. Turcotte. 1976. Mississippi sandhill crane recovery plan. U. S. Fish and Wildlife Service, Atlanta, Georgia, USA.

Valentine, J. M., R. E. Noble, B. Quisenberry, W. A. Swanson, and W. H. Turcotte. 1979. Mississippi sandhill crane recovery plan. U. S. Fish and Wildlife Service, Atlanta, Georgia, USA.

Zwank, P. J. and S. R. Derrickson. 1981. Gentle of release captive, parent reared sandhill cranes into the wild. Pages 112-116 *in* J. C. Lewis, ed., Proceedings 1981 Crane Workshop. Grand Teton Natl. Park, Wyoming, USA.

APPENDIX 1

IUCN/SSC GUIDELINES FOR REINTRODUCTIONS

INTRODUCTION

These policy guidelines have been drafted by the Reintroduction Specialist Group of the IUCN's Species Survival Commission, in response to the increasing occurrence of reintroduction projects world-wide, and consequently, to the growing need for specific policy guidelines to help ensure that the reintroductions achieve their intended conservation benefit, and do not cause adverse side-effects of greater impact. Although the IUCN developed a Position Statement on the Translocation of Living Organisms in 1987, more detailed guidelines were felt to be essential in providing more comprehensive coverage of the various factors involved in reintroduction exercises.

These guidelines are intended to act as a guide for procedures useful to reintroduction programs and do not represent an inflexible code of conduct. Many of the points are more relevant to reintroductions using captive-bred individuals than to translocations of wild species. Others are especially relevant to globally endangered species with limited numbers of founders. Each reintroduction proposal should be rigorously reviewed on its individual merits. It should be noted that reintroduction is always a very lengthy, complex and expensive process.

Reintroductions or translocations of species for short-term, sporting or commercial purposes - where there is no intention to establish a viable population - are a different issue and beyond the scope of these guidelines. These include fishing and hunting activities.

This document has been written to encompass the full range of plant and animal taxa and is therefore general. It will be regularly revised. Handbooks for reintroducing individual groups of animals and plants will be developed in the future.

CONTEXT

The increasing number of reintroductions and translocations led to the establishment of the IUCN/SSC Species Survival Commission's Reintroduction Specialist Group. A priority of the Group has been to update IUCN's 1987 Position Statement on the Translocation of Living Organisms, in consultation with IUCN's other commissions.

It is important that the Guidelines are implemented in the context of IUCN's broader policies pertaining to biodiversity conservation and sustainable management of natural resources. The philosophy for environmental conservation and management of IUCN and other conservation bodies is stated in key documents such as "Caring for the Earth" and "Global Biodiversity Strategy" which cover the broad themes of the need for approaches with community involvement and participation in sustainable natural resource conservation, an overall enhanced quality of human life and the need to conserve and, where necessary, to restore ecosystems. With regards to the latter, the reintroduction of a species is one specific instance of restoration where, in general, only this species is missing. Full restoration of an array of plant and animal species has rarely been tried to date.

Restoration of single species of plants and animals is becoming more frequent around the world. Some succeed, many fail. As this form of ecological management is increasingly common, it is a priority for the Species Survival Commission's Reintroduction Specialist Group to develop guidelines so that reintroductions are both justifiable and likely to succeed, and that the conservation world can learn from each initiative, whether successful or not. It is hoped that these Guidelines, based on extensive review of case histories and wide consultation across a range of disciplines will introduce more rigor into the concepts, design, feasibility and implementation of reintroductions despite the wide diversity of species and conditions involved.

Thus the priority has been to develop guidelines that are of direct, practical assistance to those planning, approving or carrying out reintroductions. The primary audience of these guidelines is, therefore, the practitioners (usually managers or scientists), rather than decision makers in governments. Guidelines directed towards the latter group would inevitably have to go into greater depth on legal and policy issues.

1. DEFINITION OF TERMS

a. **"Reintroduction"**: an attempt to establish a species in an area which was once part of its historical range, but from which it has been extirpated or become extinct. ("Re-establishment" is a synonym, but implies that the reintroduction has been successful).

b. **"Translocation"**: deliberate and mediated movement of wild individuals or populations from one part of their range to another.

c. **"Reinforcement/Supplementation"**: addition of individuals to an existing population of conspecifics.

d. **"Conservation/Benign Introductions"**: an attempt to establish a species, for the purpose of conservation, outside its recorded distribution but within an appropriate habitat and eco-geographical area. This is a feasible conservation tool only when there is no remaining area left within a species' historic range.

2. AIMS AND OBJECTIVES OF REINTRODUCTION

a. Aims:

The principle aim of any reintroduction should be to establish a viable, free-ranging population in the wild, of a species, subspecies or race, which has become globally or locally extinct or extirpated, in the wild. It should be reintroduced within the species' former natural habitat and range and should require minimal long-term management.

b. Objectives:

The objectives of a reintroduction may include: to enhance the long term survival of a species; to re-establish a keystone species (in the ecological or cultural sense) in an ecosystem; to maintain and/or restore natural biodiversity; to provide long-term economic benefits to the local and/or national economy; to promote conservation awareness; or a combination of these.

3. MULTIDISCIPLINARY APPROACH

A reintroduction requires a multidisciplinary approach involving a team of persons drawn from a variety of backgrounds. As well as government personnel, they may include persons from governmental natural resource management agencies; non-governmental organizations; funding bodies; universities; veterinary institutions; zoos (and private animal breeders) and/or botanic gardens, with a full range of suitable expertise. Team leaders should be responsible for coordination between the various bodies and provision should be made for publicity and public education about the project.

4. PRE-PROJECT ACTIVITIES

4a. BIOLOGICAL

(i) Feasibility study and background research

- An assessment should be made of the taxonomic status of individuals to be reintroduced. They should preferably be of the same subspecies or race as those which were extirpated, unless adequate numbers are not available. An investigation of historical information about the loss and fate of individuals from the reintroduction area, as well as molecular genetic studies, should be undertaken in case of doubt as to individuals' taxonomic status. A study of genetic variation within and between populations of this and related taxa can also be helpful. Special care is needed when the population has long been extinct.
- Detailed studies should be made of the status and biology of wild populations (if they exist) to determine the species' critical needs. For animals, this would include descriptions of habitat preferences, intraspecific variation and adaptations to local ecological conditions, social behaviour, group composition, home range size, shelter and food requirements, foraging and feeding behaviour, predators and diseases. For migratory species, studies should include the potential migratory areas. For plants, it would include biotic and abiotic habitat requirements, dispersal mechanisms, reproductive biology, symbiotic relationships (e.g., with mycorrhizae, pollinators), insect pests and diseases. Overall, a firm knowledge of the natural history of the species in question is crucial to the entire reintroduction scheme.
- The species, if any, that has filled the void created by the loss of the species concerned, should be determined; an understanding of the effect the reintroduced species will have on the ecosystem is important for ascertaining the success of the reintroduced population.
- The build-up of the released population should be modeled under various sets of conditions, in order to specify the optimal number and composition of individuals to be released per year and the numbers of years necessary to promote establishment of a viable population.
- A Population and Habitat Viability Analysis will aid in identifying significant environmental and population variables and assessing their potential interactions, which would guide long-term population management.

(ii) Previous Reintroductions

Thorough research into previous reintroductions of the same or similar species and wide-ranging contacts with persons having relevant expertise should be conducted prior to and while developing reintroduction protocol.

(iii) Choice of release site and type

- Site should be within the historic range of the species. For an initial reinforcement there should be few remnant wild individuals. For a reintroduction, there should be no remnant population to prevent disease spread, social disruption and introduction of alien genes. In some circumstances, a reintroduction or reinforcement may have to be made into an area which is fenced or otherwise delimited, but it should be within the species' former natural habitat and range.
- A conservation/benign introduction should be undertaken only as a last resort when no opportunities for reintroduction into the original site or range exist and only when a significant contribution to the conservation of the species will result.

- The reintroduction area should have assured, long-term protection (whether formal or otherwise).

(iv) Evaluation of reintroduction site

- Availability of suitable habitat: reintroductions should only take place where the habitat and landscape requirements of the species are satisfied, and likely to be sustained for the foreseeable future. The possibility of natural habitat change since extirpation must be considered. Likewise, a change in the legal/political or cultural environment since species extirpation needs to be ascertained and evaluated as a possible constraint. The area should have sufficient carrying capacity to sustain growth of the reintroduced population and support a viable (self-sustaining) population in the long run.
- Identification and elimination, or reduction to a sufficient level, of previous causes of decline: could include disease; over-hunting; over-collection; pollution; poisoning; competition with or predation by introduced species; habitat loss; adverse effects of earlier research or management programs; competition with domestic livestock, which may be seasonal.
- Where the release site has undergone substantial degradation caused by human activity, a habitat restoration program should be initiated before the reintroduction is carried out.

(v) Availability of suitable release stock

- It is desirable that source animals come from wild populations. If there is a choice of wild populations to supply founder stock for translocation, the source population should ideally be closely-related genetically to the original native stock and show similar ecological characteristics (morphology, physiology, behaviour, habitat preferences) to the original sub-population.
- Removal of individuals for reintroduction must not endanger the captive stock population or the wild source population. Stock must be guaranteed available on a regular and predictable basis, meeting specifications of the project protocol.
- Individuals should only be removed from a wild population after the effects of translocation on the donor population have been assessed, and after it is guaranteed that these effects will not be negative.
- If captive or artificially propagated stock is to be used, it must be from a population which has been soundly managed both demographically and genetically, according to the principles of contemporary conservation biology.
- Reintroductions should be not carried out merely because captive stocks exist, nor should they be a means of disposing of surplus stock.
- Prospective release stock, including stock that is a gift between governments, must be subjected to a thorough veterinary screening process before shipment from original source. Any animals found to be infected or which test positive for non-endemic or contagious pathogens with a potential impact on population levels, must be removed from the consignment, and the uninfected, negative remainder must be placed in strict quarantine for a suitable period before retest. If clear after retesting, the animals may be placed for shipment.
- Since infection with serious disease can be acquired during shipment, especially if this is intercontinental, great care must be taken to minimize this risk.
- Stock must meet all health regulations prescribed by the veterinary authorities of the recipient country and adequate provisions must be made for quarantine if necessary.

(vi) Release of captive stock

- Most species of mammal and birds rely heavily on individual experience and learning as juveniles for their survival; they should be given the opportunity to acquire the necessary information to enable survival in the wild, through training in their captive environment; a captive bred individual's probability of survival should approximate that of a wild counterpart.
- Care should be taken to ensure that potentially dangerous captive bred animals (such as large carnivores or primates) are not so confident in the presence of humans that they might be a danger to local inhabitants and/or their livestock.

4b. SOCIO-ECONOMIC AND LEGAL REQUIREMENTS

- Reintroductions are generally long-term projects that require the commitment of long-term financial and political support.
- Socio-economic studies should be made to assess impacts, costs and benefits of the reintroduction program to local human populations.
- A thorough assessment of attitudes of local people to the proposed project is necessary to ensure long term protection of the reintroduced population, especially if the cause of species' decline was due to human factors (e.g., over-hunting, over-collection, loss or alteration of habitat). The program should be fully understood, accepted and supported by local communities.
- Where the security of the reintroduced population is at risk from human activities, measures should be taken to minimize these in the reintroduction area. If these measures are inadequate, the reintroduction should be abandoned or alternative release areas sought.
- The policy of the country to reintroductions and to the species concerned should be assessed. This might in-

clude checking existing provincial, national and international legislation and regulations, and provision of new measures and required permits as necessary.

- Reintroduction must take place with the full permission and involvement of all relevant government agencies of the recipient or host country. This is particularly important in reintroductions in border areas, or involving more than one state or when a reintroduced population can expand into other states, provinces or territories.
- If the species poses potential risk to life or property, these risks should be minimized and adequate provision made for compensation where necessary; where all other solutions fail, removal or destruction of the released individual should be considered. In the case of migratory/mobile species, provisions should be made for crossing of international/state boundaries.

5. PLANNING, PREPARATION AND RELEASE STAGES

- Approval of relevant government agencies and land owners, and coordination with national and international conservation organizations.
- Construction of a multidisciplinary team with access to expert technical advice for all phases of the program.
- Identification of short and long-term success indicators and prediction of program duration, in context of agreed aims and objectives.
- Securing adequate funding for all program phases.
- Design of pre- and post- release monitoring program so that each reintroduction is a carefully designed experiment, with the capability to test methodology with scientifically collected data.
- Monitoring the health of individuals, as well as the survival, is important; intervention may be necessary if the situation proves unforeseeably favorable.
- Appropriate health and genetic screening of release stock, including stock that is a gift between governments. Health screening of closely related species in the reintroduction area.
- If release stock is wild-caught, care must be taken to ensure that: a) the stock is free from infectious or contagious pathogens and parasites before shipment and b) the stock will not be exposed to vectors of disease agents which may be present at the release site (and absent at the source site) and to which it may have no acquired immunity.
- If vaccination prior to release, against local endemic or epidemic diseases of wild stock or domestic livestock at the release site, is deemed appropriate, this must be carried out during the "Preparation Stage" so as to allow sufficient time for the development of the required immunity.
- Appropriate veterinary or horticultural measures as required to ensure health of released stock throughout the program. This is to include adequate quarantine arrangements, especially where founder stock travels far or crosses international boundaries to the release site.
- Development of transport plans for delivery of stock to the country and site of reintroduction, with special emphasis on ways to minimize stress on the individuals during transport.
- Determination of release strategy (acclimatization of release stock to release area; behavioural training - including hunting and feeding; group composition, number, release patterns and techniques; timing).
- Establishment of policies on interventions (see below).
- Development of conservation education for long-term support; professional training of individuals involved in the long-term program, public relations through the mass media and in the local community; involvement where possible of local people in the program.
- The welfare of animals for release is of paramount concern through all these stages.

6. POST-RELEASE ACTIVITIES

- Post release monitoring is required of all (or sample of) individuals. This most vital aspect may be by direct (e.g., tagging, telemetry) or indirect (e.g., spoor, informants) methods as suitable.
- Demographic, ecological and behavioural studies of released stock must be undertaken.
- Study of processes of long term adaptation by individuals and the population.
- Collection and investigation of mortalities.
- Interventions (e.g., supplemental feeding, veterinary aid, horticultural aid) when necessary.
- Decisions for revision, rescheduling, or discontinuation of program where necessary.
- Habitat protection or restoration to continue where necessary.
- Continuing public relations activities, including education and mass media coverage.
- Evaluation of cost-effectiveness and success of reintroduction techniques.
- Regular publications in scientific and popular literature.

CAPTIVE STATUS AND MANAGEMENT OF THE BLACK CROWNED CRANE IN NORTH AMERICA FOR CONSERVATION

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ABSTRACT

Cranes in North American zoos have been displayed in mixed species exhibits for a number of years, with little emphasis on reproduction. This report will include a census of the Black Crowned Crane in the North American region. We would like to stress the importance of supporting programs in the field, and applying captive husbandry to assist in field work. The failure to recognize the importance of reproducing these cranes has left the population small, but relatively clean genetically. Most birds are founders. Efforts are now being made to breed pairs in their winter holding quarters, as well as giving them a private enclosure to breed in. The Grey Crowned Crane has reproduced well in the last 10 years, and can serve as a model for the Black Crowned Crane. There is a surplus of Grey Crowned Cranes and the method used to breed them is being tried on the Black Crowned Cranes. This makes the Grey Crowned Crane an ideal test species. Husbandry, photoperiod, and techniques are being developed. To supply a surplus of Black Crowned Cranes for a release program there needs to be a studbook of the population. Facial patterns, measurements, and DNA study should be done. Also a complete bibliography needs to be compiled. Possibly genetic work can be done on museum specimens that have been collected in Nigeria. I also recommend a husbandry manual which would be helpful for any new institutions getting involved in this program.

INTRODUCTION

Crowned cranes have been displayed in mixed species exhibits in North America for a number of years, with little emphasis on reproduction. Until recently, no distinction was made between Black and Grey Crowned Cranes and both species were often kept together. All birds were recognized as one species, *Balearica regulorum*. With closer attention to morphological differences, as well as DNA and egg white protein analyses, taxonomists and geneticists have suggested that the crowned crane populations represent two species, each with two distinct subspecies.

Although both species were often kept together in the past, very few, if any, hybrids have been produced. The Grey Crowned Crane (*Balearica regulorum*) has adapted very well to captivity and has bred in mixed exhibits. This species has actually produced a surplus in the last ten years from approximately 100 to 400 specimens, and may serve as a model for the rarer Black Crowned Crane (*Balearica pavonina*).

CENSUS

The reported Black Crowned Crane population peaked in 1992 at 166 (52 male, 66 female, and 48 unknown sex). Most of these birds are believed to be West African Crowned Cranes (*Balearica pavonina pavonina*), although misidentification has been a problem due to the inability of importers to supply collection locality data. A study is underway to classify the birds whose taxonomic status is unclear. There are more of the Sudan subspecies (*Balearica pavonina ceciliae*), in Europe, where keepers appear to have better collection data. They have assisted in preparing a photographic brochure of facial patterns and are working on creating a norm for measurements for the different subspecies. An evaluation of each specimen must be done to determine precise subspecific ranking. If this program becomes international, those birds would also have to be studied.

Until recently, only one institution was raising offspring consistently. This has left us with a captive population composed primarily of founders, which will be advantageous once propagation techniques become standardized.

There have been several photographs submitted for the studbook demonstrating that some institutions believing they hold the Black Crowned Crane actually possess the Grey Crowned Crane.

HUSBANDRY EFFORTS

Crowned cranes have long been used to enhance hoofed animal enclosures, with reproductive considerations being secondary to exhibition. Black Crowned Cranes that have been provided with privacy, and housed outdoors year round have begun to reproduce. Birds in the Northern climates that must winter in shelters or barns, off display, are occasionally attempting reproduction when the environment is adequately controlled.

Using techniques that have proven successful with the Grey Crowned Crane, nests and chicks were reported this past winter from Black Crowned Cranes. These included providing sufficient space, at least a 4 m^3 space in a stall, with access to outside runs on warmer days. This amount of space seemed to be especially important to bring the male into breeding condition; the females tend to lay eggs when proper nest material and photoperiod are provided. Photoperiods of 17 hours of daylight seemed important, even for species naturally occurring along the equator. In addition, a month prior to these increasing photoperiods, breeder diets with a higher protein level were provided.

With the reproduction of birds in their off exhibit seasonal quarters, individuals can still be exhibited in the warm months, possibly with their offspring. As mentioned before, the Grey Crowned Cranes have proven easier to manipulate but similar methods, with further refinement, show promise for use with Black Crowned Cranes.

THE FUTURE

Reproduction techniques need to continue to be developed in order to create a self-sustaining captive population capable of generating a surplus of birds that could be available for a release program. It is theoretically possible that we may able to undertake a major project in restocking former crane habitat areas of Nigeria. However, we must first continue our offensive on this problem in three areas.

1. Field work in Nigeria needs to be completed to identify and prepare a suitable release site.

2. Husbandry techniques must be perfected and standardized to produce a self-sustaining captive population with a significant number of surplus birds. A husbandry manual should be developed for institutions new to the program.

3. Genetic and taxonomic work must be coordinated to insure that the stocks of birds used to repopulate the areas in Nigeria are the same subspecies or populations as those originally existing there. This would include DNA studies to identify potential pairs used to produce offspring. The scientific expertise for this technical work is now currently available to establish baseline data, and I believe funding may be possible for such a project.

CONCLUSION

I think an international effort could be very successful, if all aspects of the problem are recognized and pursued. The completion of the "North American Studbook," the demographics of the population, the recent reproductive successes in the United States, and the large number of founder birds as potential breeding nucleus are all encouraging signs that this project might eventually be successful.

There is an increasing emphasis on conservation efforts by world zoos and private institutions. If suitable habitat in the wild is established, and resources to continue development of this reintroduction project are forthcoming, the Black Crowned Crane can once again return to Nigeria.

ACKNOWLEDGEMENTS

I would like to thank the staff of the Denver Zoo for their assistance in preparing this report. I would also like to thank Susie Kasielke from the Los Angeles Zoo for reviewing this paper.

CAPTIVE STATUS AND MANAGEMENT OF WATTLED CRANES FOR CONSERVATION

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In order to understand the current status of the captive population of the Wattled Crane (*Bugeranus carunculatus*), it is helpful to review its past history. Based on the data provided to the international studbook keeper, Wattled Cranes were held as early as 1873, when the Berlin Zoological Garden and Aquarium had a pair. The life expectancy, in these early years, was rarely beyond five years. Over the next century, the world captive population remained low.

It was during the mid- to late-1960s that exports began, and they continued at a steady rate over the next twenty-five years. Table 1 shows that 163 birds were exported between 1965 and 1989. The European and American markets were the largest consumers, and accounted for nearly 76% of all the exports, with 68 and 54 birds respectively.

Studbook records document the first successful breeding for the species by the New York Zoological Park in 1944. This was repeated annually until 1947. The pair ceased breeding until 1963; thereafter, they bred sporadically for the next nine years. The male of this pair last sired an offspring in 1984, and still survives today at 45 years in captivity. Female Studbook #12, now 36, is the oldest living female. The studbook data identify male #29 and female #21 as the oldest successfully reproducing birds. Their ages are 22 and 25 years, respectively.

Reproduction from the exported birds of the late 1960s and early 1970s was not realized until 1977, when a pair bred successfully at the Zoological Society of London, Whipsnade Park. Table 2 shows that 221 captive hatches occurred over a 13-year period from 1980 to 1992. Both the European and American facilities appear to have constructively used the wild-caught birds, as they were also the largest producers. The European facilities have hatched 66, while the American facilities have hatched 101 Wattled Cranes. Asia, more specifically Japan, is close behind, having produced 54 birds. Unfortunately the Japanese population is derived from only four founders. Japan has recently established a regional studbook for its Wattled Crane population.

The American Association of Zoological Parks and Aquariums, in late 1989, approved the establishment of a Species Survival Plan (SSP) for several crane species in North America. The Wattled Crane was among those approved. The goals targeted maintaining 90% heterozygosity over 150 years, and put the number of founders at 20. There were some 39 potential founders at that time, of whom 36 now survive. Fifteen of the thirty-six have living descendants. The North American carrying capacity was estimated at 120 birds for each of the four crane SSP programs. The first SSP Master Plan for Wattled Cranes in North America recommended that four of the five breeding pairs not be allowed to produce any additional offspring. Efforts were turned to the remaining potential founders. Table 2 reflects these efforts in the low number of hatchings since 1989.

It is clear from the available data that once a bonded pair commences breeding and success is achieved, these pairs will consistently produce offspring. On a worldwide basis, there are some sixteen breeding pairs in thirteen institutions. Egg production can be expected during any month of the year. Birds in northern hemisphere facilities tend to lay between the months of October and June, while those of the southern hemisphere tend to lay from July to October.

The major obstacle facing the captive breeding program lies primarily with the fertility rate. On a worldwide basis, the fertility rate for all eggs produced during 1991 was 28.7% and only 19.4% for 1992. This is typical of the annual fertility rate. Given that most wild-caught females are egg producers, one should give serious consideration to maintaining all males, especially wild-caught males, as full-winged birds. Efforts to correct the infertility problem through established semen collection techniques have not been fruitful. Wild-caught males do not perform well following manual manipulation, although captive-hatched males seem to have adapted well.

In the United States there has been some concern over the number of broken and smashed eggs. The annual percentage of broken eggs varies from year to year. This phenomenon does not have as significant an impact on the infertility rate as does the infertility rate on the potential population growth, but it is an area which warrants investigation. Breakage rates as high as 12.5% have been documented, but the norm seems to be in the 5% range.

The percentage of known fertile eggs which hatch tends to be high, usually above 75 percent. Likewise, the survival rate of chicks to four months was 73 percent. There were a total of 221 hatches from 1980 to 1992, of which 162 survived to four months. The number that survived to one year was 146, or 88% of the four-month-old cranes. Over 66% of all hatches thus survived to one year. As expected, natural incubation yields a higher hatch rate than artificial incubation; we have much to learn in our efforts to fine tune artificial incubation parameters.

At the Crane Conservation Assessment and Management Plan (CAMP) meeting held in Calgary, Alberta in August 1992, recommendations were made on some 30 distinct crane taxa. Using the Mace/Lande criteria for assessing extinction threats, the Wattled Crane was classed as vulnerable. Under the captive program recommendation, it was pledged as I-1 (Intensive-1), with the recommendation that an organized global captive action plan be developed within three years. The program is considered one of emergency based on the present availability of genetically diverse founders.

Europe, North America, and Asia all have or are developing regional survival plans. The next logical step is to unite on a global scale. A crucial first step toward this endeavor was addressed at a meeting in Antwerp, Belgium in September 1993. The Captive Breeding Specialist Group prepared a Global Captive Action Plan for all cranes and discussed the formation of Global Animal Survival Plans (GASP) for some crane species. By utilizing the current living founders and potential founders, now numbering 84 and representing 40% of the living captive population, along with their descendants (another 124 cranes), an effective GASP for the Wattled Crane would appear to be achievable.

Given the resources available through the captive population, the international community could assist African nations that identify captive breeding or release programs as part of their conservation efforts for the Wattled Crane. Although this presents some challenges, they are not insurmountable. For example, it would be easy to provide either eggs or birds from the North American SSP program. These eggs or birds could be provided from the founders who as a result of their genetic contribution are not currently being allowed to produce additional offspring. Other regional programs would likely participate in such a worthy endeavor, one which would maximize the value of these captive birds, thereby minimizing the need to remove additional birds from the wild.

All considered, we have a strong foundation on which to build effective captive conservation programs for the Wattled Crane. Placing a concerted effort on securing the wetlands should be one of our top priorities. Captive programs are also essential to secure the future of Wattled Cranes should the populations in the wild be devastated.

Table 1. Number of Wattled Cranes exported by continents during five-year intervals, 1965-89.

Continent	1965-1969	1970-1974	1975-1979	1980-1984	1985-1989	Total
Africa	11	2	4	0	13	30
Americas	8	19	12	13	2	54
Asia	2	3	4	2	0	11
Europe		29	24	11	4	0
Totals	50	48	31	19	15	163

Table 2. Number of captive hatched Wattled Cranes by continent during the periods 1980-84, 1985-89, and 1990-92, and number of captive hatched chicks surviving to 4 months and to 1 year.

Continent	1980-1984	1985-1989	1990-1992	Total hatch at 4 months	Total surviving	Total surviving at 1 year
Africa	0	9*	7*	16*	13	13
Americas	38	54	9	101	67	60
Asia	13	29	12	54	44	40
Europe	16	22	28	66	51	46
Totals	67	105	49	221	162	146

*Eggs collected from wild, not included in totals

Table 3. Number of wild caught and captive hatched Wattled Cranes living in captivity, 31 December 1992.

Continent	Total no. wild caught living	Total no. captive hatched living	Total no. living in captivity
Africa	18	1	19
Americas	36	52	88
Asia	6	29	35
Europe	24	42	66
Totals	84	124	208

BEHAVIORAL REPERTOIRE OF CAPTIVE WATTLED CRANES

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ABSTRACT

This paper presents a behavioral repertoire for captive Wattled Cranes kept at the Wildlife Survival Center of the New York Zoological Society on St. Catherines Island on the coast of Georgia, USA, 1989 to 1991. General categories of individual (non-social) behavior include: (1) general postures; (2) sleep-related postures; (3) sensory-related behavior; (4) maintenance, including care of body surface and comfort movements; (5) thermoregulatory and respiratory movements; (6) terrestrial locomotion; (7) ingestion and egestion, including foraging, swallowing, and defecating. General categories of social behavior include: (1) agonistic displays; (2) attack; (3) defense; (4) concordant behavior; (5) pair-related behavior; (6) parental behavior including nest building, nest defense, and incubation.

INTRODUCTION

Despite its large size and large numbers in certain parts of Africa, the Wattled Crane (*Bugeranus carunculatus*) has been little studied (Urban 1988; Urban *et al.* 1986). During the 1987 International Crane Workshop the Working Group on African Cranes established several priorities for studies on cranes of Africa, especially species such as the Wattled Crane that are threatened or endangered in parts of their ranges (Urban and Gichuki 1991). One of the studies desired was a detailed description of the Wattled Crane's general and breeding behaviors. In this paper we present a behavioral repertoire for captive Wattled Cranes kept at the New York Zoological Society's Wildlife Survival Center on St. Catherines Island, a barrier island on the coast of Georgia, USA.

In describing the individual (non-social) behaviors of this species we have followed the terminology of Ellis *et al.* (1991). To reduce both the work required of the reader and the possibility of ambiguity we have briefly re-described each behavior which we list, making a serious (we hope successful) effort to avoid plagiarizing their work. However, there is a practical limit to the number of ways to say essentially the same things, especially when closely following the lead of others. Where we do not list a behavior which they described, we did not see it in the birds that we watched.

At present there is no similar compendium of social behaviors of cranes. We have, therefore, followed the terminology sent to us by D. H. Ellis (*pers. comm.*) and that published by Archibald (1976), Masatomi and Kitagawa (1975), and Voss (1976).

We have included as figures illustrations of some of the behaviors we recorded. These were drawn from our videos and 2x2 slides of the cranes that we studied.

We conducted our study in the years 1989 to 1991, inclusive, observing six pairs of cranes. The pairs are kept in enclosures 90 by 150 feet (27 by 45 meters) in size. Two pairs of the same species are not placed in adjacent enclosures, eliminating intraspecific interaction other than what occurs between the members of a pair. These large enclosures provide an environment in which the cranes can conduct most normal activities, including breeding, except that they cannot fly. They are not disturbed by people other than at feeding time twice each day. We made our observations from a blind some three meters above the ground. outside the enclosure at one corner. During the three years we studied the cranes we were able to watch them in all 24 hours of the day and in all months of the year.

BEHAVIOR OF THE WATTLED CRANE

I. General postures

A. Stand: The crane stands with both feet on the ground, legs straight, the body with the anterior-posterior axis at an angle of about 45 degrees above horizontal, wings folded on the back, neck extended forward then up (Figure 1). It usually holds its head with the beak declined below horizontal and pointed ahead within an angle of about 60 degrees left or right of directly forward. The two-legged stand is the most frequently observed posture.

B. Stand, one leg: The bird lifts one foot off the ground. It may be raised to the abdomen or the leg may be held loosely with the foot from one to about 15 cm from the ground.

C. Sit: The tarsometatarsi are parallel to and resting on the ground. The tibiotarsi are vertical. The general body posture is that of the two-leg stand.

Figure 1. Stand.

D. Lie: The crane rests its belly on the substrate. In most of the few instances observed the bird held its head and neck upright, not extended on the ground, and continued to rummage in the vegetation in front of it.

II. Sleep related positions

If the crane under observation had its eyes closed, we considered it to be asleep. Wattled Cranes usually sleep standing on one or both legs. One was seen one time sleeping while sitting.

A. Head-droop Sleep: The neck is deeply curved and head bowed. The bill may rest on the front of the neck or may be held one or two centimeters from it.

B. Head-tuck Sleep: The head and neck may be turned to either side and the bill tucked under the wing on that side (Figure 2). Usually the outwardly directed eye is not covered.

III. Sensory related behavior

A. Binocular Gaze: The bird faces the object of its attention directly, watching it with both eyes.

B. Monocular Gaze: The bird turns the side of its head and the eye on that side toward the object under observation.

C. Head-tuck Watch: After tucking its bill under a wing a crane may stand with the observable eye open, apparently keeping watch.

Figure 2. Head-tuck Sleep.

D. Blink: The crane flicks the nictitating membrane rapidly across the eye. Apparently this serves to moisten the eyeball and/or remove foreign objects from its surface.

E. Listen: The bird cocks its head in response to sound. This action is so similar to monocular gaze that it cannot be distinguished unless there is some sound which the human observer can also hear.

IV. Maintenance

A. Care of Body Surface

1. Preen

a. Dig-in: Rapid, short movements of the bill push aside feathers and allow the tips of the mandibles to reach the body surface, which is then nibbled.

b. Nibble: Rapid, short, open-close movements of the tips of the mandibles in contact with the integument or plumage scratch the surface and/or dislodge such items as ectoparasites and dirt.

c. Comb-out: The crane sweeps its bill along a feather from proximal to distal portion with the feather between the tips of the mandibles.

d. Stroke: The bird sweeps its bill back and forth over the feathers, not always in contact with the surface.

e. Head Rub: The inverted head (crown, face, or bill) is rubbed slowly to rapidly on the lower nape, back, or wing, smoothing feathers, dislodging debris, and/or distributing uropygial oil.

2. Oil: Head rub or nibble of the uropygial tuft obtains oil on the head and/or bill, which is then applied to the feathers by head rub, stroke, and/or nibble.

3. Scratch: The crane flicks its foot against its head or

upper neck with the nail or pad of the middle toe scratching the skin or feathers.

4. Bill Flick: A quick sideways flip of the bill dislodges material from the surface of or from between the mandibles. This may be done once, in rapid series, or at intervals.

5. Leg Flick: The crane jerks its foot and lower leg quickly to one side, apparently to dislodge adherent material. It may be done once, in rapid series, or at intervals. This description differs from the "leg flick" of Ellis *et al.* (1991) in which "the tarsus and dorsal surface of the foot slap one to several times upward and sometimes against the abdomen". We have called that behavior "leg pump" (IV-B-3-d, below).

6. Bill Wipe: The bird rubs or strokes the bill against vegetation or substrate to remove clinging material.

7. Fluff: The crane raises the feathers of one area or of its entire body (Figure 3).

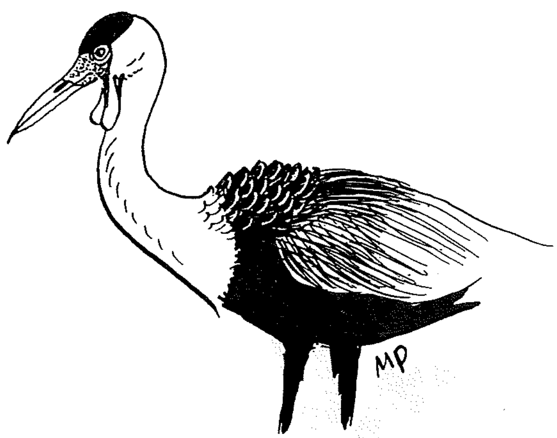

Figure 3. Fluff (feathers of anterior dorsum).

8. Sleek: Depression of the feathers tightly to the surface in one zone or over the entire body gives a very smooth appearance.

9. Bathe

a. Bill Slosh: The crane slashes its bill from side to side under water.

b. Head-neck Dip: The bird thrusts its head and neck quickly into and out of the water. This is sometimes done in rapid sequences and sometimes one dip at a time. In either case dipping is usually followed by head shaking.

c. Belly Slosh: Standing in water, the crane leans forward and thrusts most of its body belly first into the water without immersing the head and upper neck, then returns to the original position. Usually this is done several times in sequence and there may be several such sequences separated by bouts of preening. While its body is immersed and/or while emerging from the water the bird may flap its wings vigorously.

B. Comfort Movements

1. Shaking

a. Head-shake: The crane extends its head and neck and rotates them rapidly back and forth on the axis. This is often done in conjunction with b, c, and d, below.

b. Ruffle-shake: The bird simultaneously fluffs its feathers and pivots its body rapidly back and forth on its axis. Usually it lowers its head and allows its wings to flop loosely at its sides, thus tending to shake them alternately rather than simultaneously.

c. Shiver-shake: This is very like the ruffleshake, but is done more rapidly, with less rotation, and without fluffing. The wings move relatively little. (See also VIII-C-3, Defensive Displays.)

d. Wing-shake: The loosely folded wings are simultaneously flopped vigorously at the sides.

e. Tail-shake: Rapid side-to-side movement of the pygostyle briefly rustles the rectrices.

f. Tail Wag: Slower movement of the pygostyle produces a distinct side-to-side sweeping of the rectrices.

2. Stretching

a. Yawn: The mandibles are involuntarily stretched wide apart with a brief straining period before they are closed.

b. One-leg Stretch: The crane extends and stretches one leg behind it.

c. Side Stretch: The wing and leg of one side are simultaneously extended back and/or down with a brief strain at maximal extension.

d. Two-wing-spread Stretch: The bird spreads both wings as far as possible and strains briefly.

e. Bow Stretch: The crane bends forward, lowering the anterior end of its body, curves its neck deeply, arches its half-folded wings toward the midline above its back, and strains briefly.

3. Other

a. Rise-flap: The bird raises its anterior end until the body axis is approximately vertical and sweeps its wings back and forth strongly.

b. Wing Fold: The crane moves a drooping or extended wing quickly into the folded position at the side of the body.

c. Leg Flick: See IV-A-5. Though probably used primarily to dislodge adherent material, this is also a comfort movement.

d. Leg Pump: When a crane lifts one leg toward its abdomen it sometimes raises and lowers it one to several times in what appear to be involuntary movements reminiscent of the motions of a dog's hind leg when its ribs are gently tickled. Ellis *et al.* (1991) called this "leg flick".

e. Wattle Retract: Wattled Cranes when probing often retract their wattles enough to avoid contact with the substrate. They can be contracted into small mounds that are not readily apparent.

V. Thermoregulatory and respiratory movements

A. Fluff and Sleek: See IV-A-7,8. A combination of these actions, usually fluff followed by sleek, particularly in the anterior region of the back (Figure 3), occurs frequently in hot weather, especially if the bird is standing in the sun.

B. Ruffle: In very warm weather a crane may hyperelevate the feathers over most of its body, probably increasing heat loss by convection from exposed areas of the skin.

C. Pant: The bird breathes rapidly with its bill open.

D. Orientation to Sun: On several occasions on one hot day we saw two incubating cranes (male and female) align their bodies with the anterior end toward the sun, minimizing insolation.

VI. Locomotion

A. Walk: The crane moves its feet alternately one ahead of the other in the standing posture, always keeping at least one foot on the ground as it progresses (Figure 4). Wattled Cranes frequently give an impression of sedate composure, stalking with measured tread, but they can also walk quite rapidly (5-6 km/hr) without apparent effort. Walking is the usual form of locomotion for cranes on the ground.

Figure 4. Walk.

B. Run: The crane moves its feet much more rapidly in running than in walking and takes substantially longer, springier strides, often having both feet off the ground at once (Figure 5). Wing extension usually accompanies running, helping to maintain balance. Frequently the wings are flapped, perhaps to help propel the bird forward as well as to maintain balance.

C. Hop: A bird standing on one leg may move short distances by hopping on that leg. We have seen this only a few times and have not seen two-legged hopping.

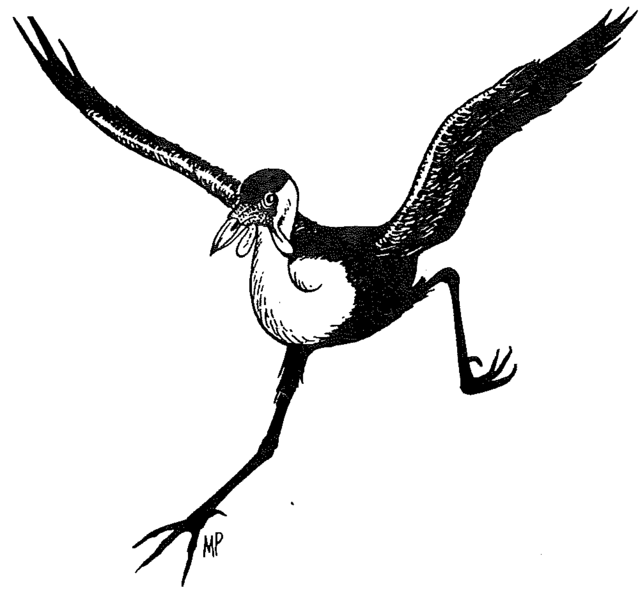

Figure 5. Run.

D. Leap: Cranes frequently jump vertically when dancing (Figure 6; See VIII-A-4).

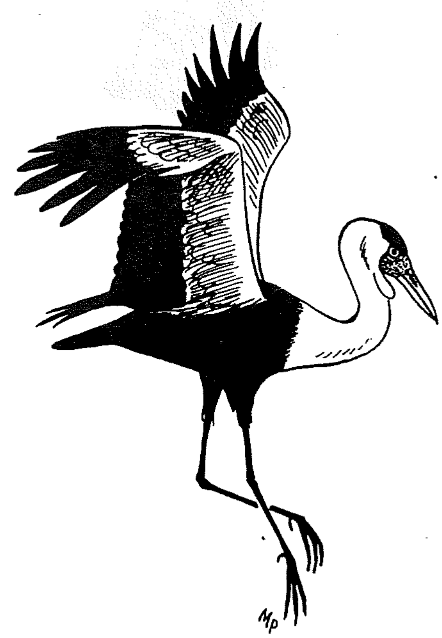

Figure 6. Leap.

E. Waddle: A sitting bird may move a short distance by shuffling its tarsometatarsi over the ground.

VII. Ingestion, egestion

A. Foraging: Although they are amply provisioned by zoo staff, the Wattled Cranes on St. Catherines Island engage extensively in wandering about their enclosures, scrutinizing land surfaces, rummaging in vegetation, and probing in water to obtain natural foods in addition to what is provided in feeders. We have seen the following actions as components of foraging.

1. Stab: A hard, forward thrust of the head drives the beak at prospective prey or into vegetation or mud to reach for some potentially edible item which the crane has located.

2. Probe: Probing employs a less vigorous thrust than stabbing and usually consists of a series of low-amplitude jabs into earth, mud, or water. This is an investigating or seeking action.

3. Peck: A crane employs this moderately vigorous, short thrust of the beak usually to grasp a small object (less than a centimeter in greatest dimension).

4. Nibble: The bird uses short, quick, relatively gentle open-shut motions of its bill to explore, break off, or pick up small pieces of some substance.

5. Bite: The crane grasps an object firmly between its mandibles, usually in one vigorous movement.

6. Twist: With an object firmly held in its bill the bird moves its head repeatedly side-to-side with a rotating motion to free the thing from attachment.

7. Tug: The crane employs a backward movement of the head and neck to pull on something clamped between its mandibles.

8. Thrash: The bird holds an item in its bill and shakes it vigorously with rapid side-to-side motions.

9. Bash: The bird grips something firmly with its bill and flails it against the ground or some stout object.

10. Bill-side-push: The crane pushes left or right with its bill against vegetation or against the side of a hole which it has dug in seeking food.

11. Bill-push-open: The bird forces its mandibles apart while its bill is inserted into the ground, enlarging the hole which it is making.

12. Bill Wipe: Rubbing its bill against some object removes materials which may cling to the bill when it is thrust into vegetation, earth, or water in search of food.

B. Swallowing:

1. Nibble-swallow: The crane takes a small object (ca. 0.5 cm or less in greatest dimension) in its bill and moves it to the pharynx by rapid, short, open-close movements of the mandibles.

2. Toss-swallow: The crane grasps a moderate to large sized (ca. 0.5 cm or more in greatest dimension) object between its mandibles, then moves it toward the pharynx by relaxing its grasp and making a quick, forward motion of its head, immediately reclamping it firmly. These actions are repeated until the object is in position to swallow.

3. Drink (scoop-swallow): The bird scoops water into its bill, raises its head until the bill is above horizontal, then rapidly opens and closes the bill while swallowing. The sequence is usually repeated several times.

C. Egestion

1. Bill-shake: Rotating the head and neck rapidly and strongly side-to-side about 60 degrees, usually with the bill open, the crane throws an object or fluids from the pharynx and/or bill.

2. Defecate: Wattled Cranes usually eject feces directly downward in a quick jet without detectable prior indication. The action takes no more than a second.

VIII. Social behavior

A. Agonistic Display

1. Alert Posture: The basic posture is a tense, two-legged stand with the neck extended and held straight at about 45 degrees above horizontal and the bill held parallel or just above parallel to the ground (Figure 7). Frequently a crane will maintain this posture while stalking slowly forward, one sedate step at a time.

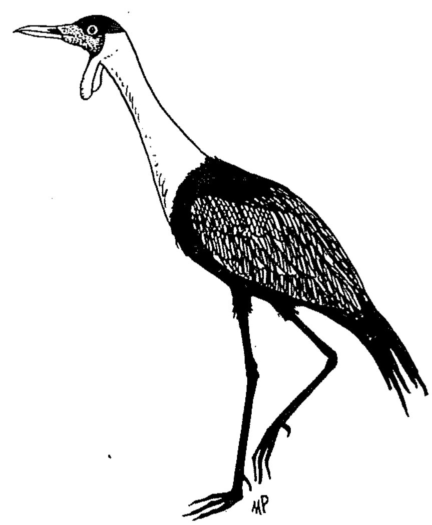

Figure 7. Alert Posture.

2. Calls

a. Purr Call: On several occasions the members of a pair seemed to maintain contact with each other by making a low sound much like the purring of a very large cat.

b. Purrp Call: Very occasionally either member of a pair would give a "purrp" like an abruptly truncated purr, which we interpret also as a contact call. Sometimes a bird would give a "purr" between two "purrps", and rarely five or more "purrps" per second.

c. Guard Call: Several times we heard a single, loud "ker-arck" call which we think to be a guard-type call.

d. Unison Call: The female initiates the unison call, throwing her head back almost to her back with her beak pointing straight up, then immediately extending her head and neck vertically with her beak still pointing up. The first note of the call is begun with her head and neck drawn fully backward and completed as they remain vertical. This first high-pitched, squeaky note lasts about one second and is followed by eight to ten short notes of approximately the same pitch. Her entire call lasts approximately 4.0 seconds.

The male responds almost instantly. He was out of sight behind a tree on both occasions when we were able to videotape unison calls, so we cannot make a precise association between the position of his head and the notes of his call. His first note is at almost the same pitch as the female's. His second note begins at that pitch, descends noticeably, and is followed by five to seven short notes at the lower pitch, then two more, both beginning at the pitch of the short notes, then descending. The calls of the two birds end together.

Wattled Cranes have been observed to be less vocal than other crane species (G. Archibald *pers. comm.*; Walkinshaw 1965). Those at St. Catherines seldom called. The unison calls that we taped were made during nest exchanges and were the only ones we heard in association with that activity. This call seems to be used largely in courtship, but also in defending the pair's territory (=enclosure).

3. Ritualized Preen: On the few occasions on which we saw this behavior, the crane moved its bill just above the surface of the feathers on the back and/or wings, not making contact, and using movements essentially the same as those for nibble and stroke, all the while watching closely (monocular gaze) with the visible eye.

4. Dancing: While dancing is certainly a part of the courtship ritual of Wattled Cranes, it also occurs in other contexts, often involving only one bird. There appears to be no specific, essential movement to initiate dancing, nor is there any particular sequence for the actions involved. Bowing, leaping, running, wing-flapping, spread-hold, tuck-and-bob, and stick tossing (Figures 5, 6, 8, 9, and 10) may all be components, though often one or more of these may be missing. For example, a sequence might begin with spread-hold posture, followed by bow, leap, bow, leap, running with wing flapping, bow, leap, bow, then a ruffle-shake and preening, the last sometimes real and sometimes ritualized. However, those same components might be combined in any of several other possible sequences. Most of the time the male of a pair would be the instigator. Sometimes the female then joined him, but often she did not. When she was the instigator, he might or might not join her.

B. Attack

1. Charge: During incubation one male would react to any person, vehicle, or other large bird by running hard with wings outspread (Figure 5) to the fence of his enclosure at the nearest point to the object of his attention. As he ended his charge it was possible to see that the feathers of his back extending posteriorly from his nape were elevated. Walking away he would perform two or three shiver-shakes.

2. Stab: A hard, forward thrust of the head drives the beak at the object of the crane's hostility.

C. Defensive Displays

1. Wing-flare-face: The crane raises its body and neck into a near-vertical position and spreads its wings wide apart, facing the object of its attention directly (Figure 8). This appears to be a warning gesture, but it may quickly flow into a balancing mechanism as the crane performs a stab.

2. Directed Walk: The bird assumes the alert stance, then paces with measured tread with one side turned toward whatever it perceives as a threat (Figure 7).

3. Shiver-shake: See IV-B-1-c. This may be done with the directed walk.

D. Concordant Behavior

1. Follow: In moving about within the enclosure the two cranes of the pairs we watched tended to stay together most of the time. If one began moving away, usually the other followed. We saw no distinctive behaviors associated with this.

2. Allopreen: We recorded this once, when a female briefly performed dig-in and nibble on a male's back and side. He showed no response.

E. Pair-Related Behavior

1. Purr Call: See VIII-A-2-a.
2. Purrp Call: See VIII-A-2-b.
3. Unison Call: See VIII-A-2-d.
4. Ritualized Preen: See VIII-A-3.
5. Dancing: See also VIII-A-4. Wattled Cranes tend to be relatively less active than other crane species (Walkinshaw 1965) and confinement, even in fairly large enclosures, may deter them further. Their dance sequences vary both in content and in duration, but each contains at least some of the elements below; some may contain all.

a. Spread-hold: The crane raises its body to a near-vertical position, spreads its wings widely, and holds this posture for at least several seconds (Figure 8).

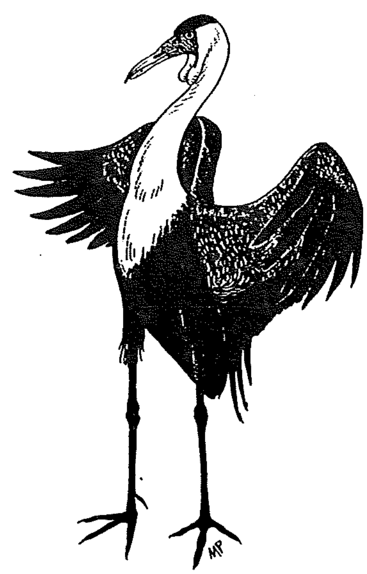

Figure 8. Wing-flare Face.

b. Run-flap: This is essentially similar to VII-B, but the wings are flapped continuously and vigorously, not just extended and waved to maintain balance. The running pattern is likely to be erratic, zigzagging and circling, rather than unidirectional.

c. Run-leap: The bird jumps vertically or horizontally, often repeatedly, in mid-career.

d. Bow: The crane appears to lean forward, bending its ankles and knees, and lowering its head, neck, and thorax below horizontal (Figure 9). It may bend its neck backward, lifting its head, or it may extend the neck, holding the head near the ground, or move the head back and forth between the two positions. It may keep its wings folded or extend them to the side. This may be done once or several to many times.

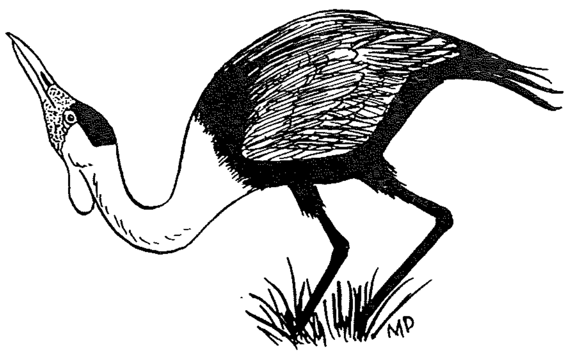

Figure 9. Bow.

e. Tuck-and-bob: Extending its humeri and arching the distal parts of its wings, the crane bends its ankles and knees and lowers the anterior part of its body below horizontal, arching its neck backward while holding its bill against the front of its neck, then quickly returns to the posture of the two-legged stand while keeping its wings in the spread position (Figure 10). This may be done once or several times in quick succession.

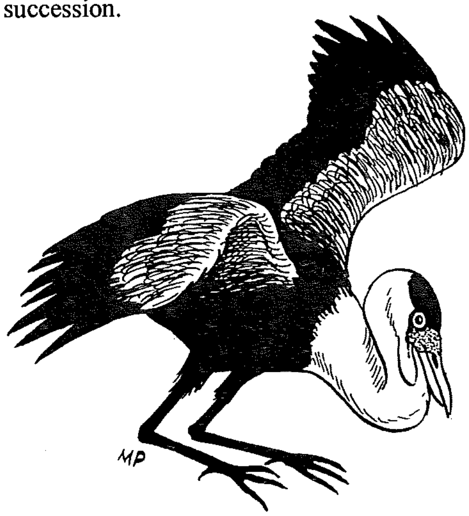

Figure 10. Tuck-and-bob.

f. Gape: The bird holds its mandibles wide apart.

g. Peck: See VII-A-3.

h. Toss-object: The crane grips an object firmly in its mandibles and throws it vigorously up into the air or to the side.

4. Pre-copulatory display

a. Parade March: Both cranes assume the Alert Posture (VIII-A-l; Figure 7) and walk side-by-side for a short distance, in some cases turning tightly, pivoting on the female.

b. Receptive Posture (female): The female bends forward, extending her humeri while allowing the more distal parts of her wings to hang relaxed (Figure 11).

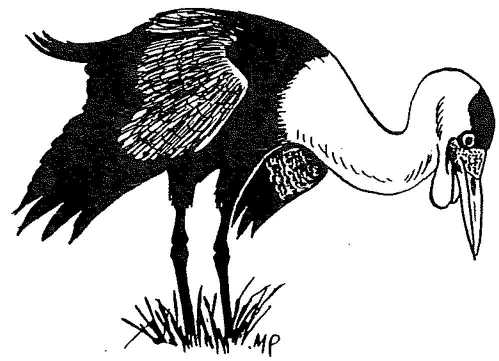

Figure 11. Receptive Posture (female)

5. Copulation: With the female in receptive posture, the male steps from behind onto the her back and appears to grasp the proximal ends of her wings with his feet (Figure 12). The female elevates her tail as he flexes his abdomen ventrally to effect cloacal apposition. The effort to do this lasts three to five seconds. During copulation both birds hold their wings partially extended.

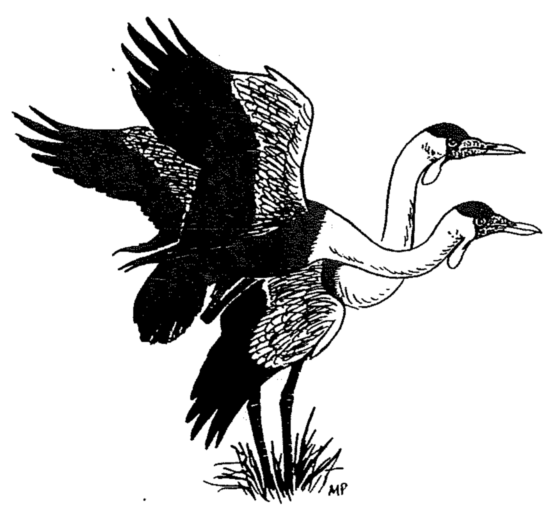

Figure 12. Copulation.

6. Post-copulatory Behavior: In the instances which we have observed, immediately after copulation both birds made a slight bow, then the female walked two or three meters away, did a ruffle-shake, and began preening. The male danced 20-30 seconds on several occasions, about 80 seconds on one, then did a ruffle-shake and began preening. The 80-second episode included several rushes to and from the nearest fence.

F. Parental, Nest-Related

1. Bite: See VII-A-5.

2. Carry: The crane transports an object (stick, vegetation, etc.) held in the bill to the nest.

3. Side-toss Object: The bird throws an object which it is carrying sideways onto the nest.

4. Drop Object: The bird opens its mandibles and allows an object being carried to drop onto the nest.

5. Push: The crane uses its bill to shove something from one place to another on the nest.

G. Parental, Incubation-Related

1. Rock-down: The parent bird stands with its feet naturally apart with the eggs between them, then lowers its breast to the eggs, rocking from side to side as it alternately adjusts its feet and legs four or five times each until it is comfortably ensconced (Figure 13).

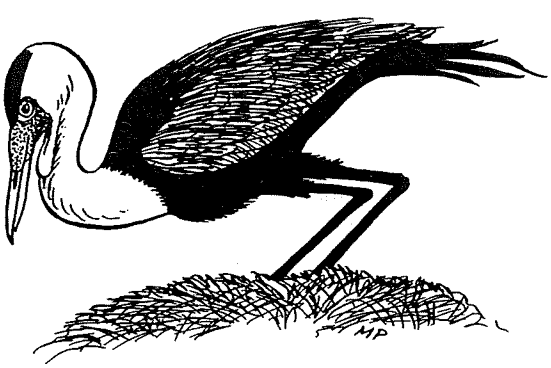

Figure 13. Rock-down.

2. Incubate: The crane on the nest may remain there from a few minutes to several hours. During longer periods it may stand from time to time and rearrange the eggs in the nest, change its orientation, stretch, and/or walk a few steps.

3. Egg Turn: With its bill the incubating parent pushes gently at the eggs, turning them and/or reorienting them in the nest.

4. Nest Exchange: When the incubating parent is ready to be relieved it stands and walks a short distance away. Usually at that time the other parent walks to the nest, investigates and adjusts the eggs, then rocks down into the incubating position. On some occasions the bird not incubating may approach the nest, whereupon the incubating bird may stand and move away. Occasionally they may give a unison call, but most of the exchanges which we have seen were accomplished silently.

H. Parental, Hatching and Rearing: In the program at St. Catherines eggs are removed from the nests to an incubator shortly after they are laid and dummy eggs substituted. We have not observed hatching or any aspects of rearing except a call. Parents occasionally produce a "purr-rup" call when they have young. We have interpreted this as a warning note.

I. Parental, Nest Defense

1. Distraction Display: In the one instance in which we have seen a distraction display the female bent her knees and ankles; crouched, with humeri spread and the remainder of the wings relaxed and drooping, appearing to be damaged; and lowered her anterior body and head below horizontal. She moved slowly forward, limping, with her wings trailing alongside, then sat and leaned forward until the base of her neck almost touched the ground. In this posture she snapped up a couple of insects, then stood and walked away, appearing to have lost interest.

2. Wing-flare-face: See VIII-C-1.

3. Charge: See VIII-B-2. We have seen this performed by the male, but not the female.

COMMENT

Many of the postures and activities of Wattled Cranes appear in more than one behavior. For example, Spread-hold and Wing-flare-face appear identical, and the initial postures of Rise-flap and of Two-wing-spread Stretch also look much like these. Run and Run-flap may be used for rapid locomotion alone, or may be components of Dance or Charge. The context determines what it is that one is viewing.

ACKNOWLEDGEMENTS

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REFERENCES CITED

Archibald, G. W. 1976. The unison call of cranes as a useful taxonomic tool. Ph.D. Thesis. Cornell University, Ithaca, New York, USA.

Beall, F. B. C. 1990. International studbook for the Wattled Crane *Bugeranus carunculatus*. Baltimore Zoo, Baltimore, Maryland, USA. Mimeo.

Ellis, D. H., G. W. Archibald, S. R. Swengel, and C. B. Kepler. 1991. Compendium of crane behavior. Part I: Individual (non-sexual) behavior. Pages 225-234 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Masatomi, H. and T. Kitagawa. 1975. Bionomics and sociology of Tancho or the Japanese Crane, *Grus japonensis*. II: Ethogram. Journal of the Faculty of Science, Hokkaido University, Ser. VI, Zoology 19(4): 834-878.

Urban, E. K. 1988. Status of cranes in Africa. Pages 315-329 *in* Proceedings of the Sixth Pan-African Ornithological Congress. Nairobi, Kenya.

Urban, E. K., C. H. Fry, and S. Keith. 1986. The birds of Africa, Vol. 2. Academic Press, London, UK.

Urban, E. K. and N. Gichuki. 1991. Recent research and conservation activities with cranes in Africa. Pages 351-355 *in* J. Harris, ed., Proceedings 1987 International Crane Workshop. International Crane Foundation, Baraboo, Wisconsin, USA.

Voss, K. 1976. Behavior of the Greater Sandhill Crane. M.S. Thesis. University of Wisconsin, Madison, Wisconsin, USA.

Walkinshaw, L. H. 1965. The Wattled Crane *Bugeranus carunculatus* (Gmelin). Ostrich 36: 73-81.

THE AFRICAN WATERFOWL CENSUS

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The International Waterfowl Census (IWC) is coordinated worldwide by Wetlands International (formerly the International Waterfowl and Wetlands Research Bureau or IWRB). The IWC works through a network of national coordinators to collect data on waterfowl populations, which can then be used to monitor and conserve those populations. The IWC has shown that by establishing a series of annual counts, it is possible to monitor the long-term trends of waterfowl populations, and changes at individual sites. The African Waterfowl Census is the latest extension of the IWC.

The African Waterfowl Census was started in 1991. Since then over 200 wetlands in 27 African countries have been counted. The IWC worldwide takes place in January. A second census takes place in April or July in Southern Africa, and in July in Kenya and Uganda. No census takes place in Western Africa yet. It is expected that with increased African coverage in the future, the data will prove a valuable tool for monitoring wetland habitats and waterbird distribution, providing data to identify conservation priorities, and promoting the awareness of wetland issues.

Because many waterfowl species migrate seasonally between numerous countries, international cooperation is required to monitor their populations effectively. Wetlands International aims to stimulate the international monitoring of waterbird species utilizing African wetlands, and to encourage cooperation among countries sharing common flyways which encompass networks of wetland habitats.

The disturbance, degradation, and loss of wetland habitats caused by human activities are a major threat to the migratory waterfowl that rely on the wetlands during their annual cycle. In addition, many waterbirds are hunted throughout their flyways. Addressing these pressures can only be achieved by international cooperation in research, monitoring, and conservation action. The destruction of habitat or unregulated hunting in a single range state may influence the entire population throughout the flyway. Therefore, it is essential to design and implement integrated conservation plans at flyway level. Such conservation plans must take account of the institutional capacity and expertise within different range states and should cover diverse topics including monitoring, research, habitat conservation and management, hunting regulation, training, education, and awareness. This will require a coordinated approach by governments and non-governmental organizations, scientists, and administrators working in partnership for a common goal.

Wetlands International provides technical support to international conventions such as Ramsar and Bonn. As an integral component of wetlands, waterbirds can be used to identify wetlands of international importance using the Ramsar criteria. The IWC data have been used as a base to review the status of migratory waterfowl in order to draft the African/Eurasian waterfowl agreement, under the Bonn convention. The agreement will form the necessary framework to implement conservation measures through action and management plans.

During the 1993-95 triennium, Wetlands International aimed to develop its program in Africa, and to integrate it with regional, national, and local program and projects focusing on the conservation and wise use of wetlands and waterbirds. The conservation activities are planned in cooperation with various international organizations and in relation to the international conventions.

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BIRDLIFE INTERNATIONAL: IMPORTANT BIRD AREAS OF AFRICA PROJECT SUMMARY

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ABSTRACT

In collaboration with concerned organizations and individuals, BirdLife International seeks to compile and publish a comprehensive directory of sites critical for birds in Africa, in order to promote their lasting conservation. These sites are termed Important Bird Areas or IBAs. Protection of these sites would, because of the way many endemic plant and animal species are concentrated together in relatively small areas, also conserve much of the terrestrial biodiversity of Africa, to the continuing benefit of the human population in the vicinity of these sites. The international cooperation, institution building, and training necessary for the compilation of national IBA inventories is seen as essential to the project's success.

The bird fauna of Africa is extremely rich with some 2,200 species occurring on the continent and associated islands, including Madagascar. This reflects the huge environmental diversity of Africa which ranges, for example, from desert to rainforest and from mangrove swamp to alpine moorland. Some of the largest and/or most diverse wetland, forest, woodland, savanna, and desert ecosystems in the world are found in Africa. Hundreds of millions of birds depend on these ecosystems for all or large parts of their lives.

The impact of humans is seen in all these habitats through increases in human population and associated agricultural intensification and industrialization. These result in greater levels of forest and woodland clearance, wetland drainage and pollution, grazing pressure, and coastal land-claim. All ecosystems in Africa are affected and some are becoming severely threatened. The rainforests of Africa, for example, which contain over half the biota of the continent, have been reduced by two-thirds of their historical extent. Moreover, both the montane and eastern coastal forests are particularly at risk.

As a result of such threats, 212 species of birds in Africa and its islands are considered to be under threat of global extinction. With another 117 species classified as near-threatened, over 15% of Africa's birds are at risk.

Birds have proven to be excellent indicators of biodiversity and flagships for conservation because they are relatively well known and can carry popular support. They have been used effectively in developing wetland evaluation and conservation (e.g., the Ramsar Convention) and, more recently, in identifying major centers of terrestrial endemism where unique wildlife concentrates in some very restricted areas (BirdLife Biodiversity Project). In both cases, the distribution of birds has been used to identify areas of global importance, not only for birds, but for other life forms as well. There is, at present, no comparable way of identifying sites at a global level by other means since adequate data are not available for other animal groups or for plants.

Decision makers urgently need up-to-date information on the most critical areas for conserving birds and habitat. It is essential that the conservation community speak clearly to people in authority from international to local levels. Sites will not be protected unless biologists can explain which are the most important and why.

BirdLife International started a program to identify and promote the conservation of the most important places for birds in Europe in 1985. The resulting publication (Grimmett and Jones 1989) has been influential in promoting the development of conservation initiatives and collaboration among organizations across Europe. It has proven to be uniquely valuable in presenting decision makers with clear statements about the need for conservation and has guided conservation efforts towards filling gaps both in knowledge and in the degree of site protection. A similar IBA program for the Middle East was finished in 1994 and already the benefits are beginning to be seen.

From this experience BirdLife is convinced that it can make a major contribution to biodiversity conservation by developing such a program in Africa, through both the review and publication of data and the strengthening of national organizations. Thus, BirdLife seeks to produce, with financial support from the Royal Society for the Protection of Birds, BirdLife's UK partner, the first comprehensive directory of the Important Bird Areas in Africa. This is to include not only all countries on the African mainland, but also adjacent and outlying islands in the Atlantic Ocean on or east of the Mid-Atlantic Ridge (Cape Verde, Ascension Island, St. Helena and the Tristan da Cunha group), and equivalent islands in the Indian Ocean (Madagascar, the Seychelles, the Comores, the Mascarenes). Omitted, however, are the Azores, the Canaries, and Madeira as these were included in the IBAs of Europe. Socotra is covered by the Middle East IBA program.

There are eight main objectives of the program.

1. To identify and document globally important placesfor bird conservation in Africa based on inclusion of endemic avifauna, threatened species, concentrations of numbers of

individuals or species, and representation of regionally characteristic bird assemblages.

2. To promote, develop and involve national organizations and contributors, as far as possible, in achieving the main aim.

3. To further national contributions to the main aim through the promotion of institution building, network development, and training as appropriate.

4. To publish and distribute widely a continental directory of sites.

5. To promote the publication of national site directories in appropriate languages.

6. To establish a database containing the critical information in a way which can be maintained, updated, and made available in individual countries and to the wider conservation community.

7. To inform relevant national authorities, where appropriate, of the program and to seek their acceptance of its concept, aims, and progress at the national level.

8. To inform decision makers at all levels of the existence and significance of IBAs.

To oversee the African IBA program, a steering committee has been established with francophone and anglophone members and representatives from five African countries. Wherever possible, the project coordinator will work through national coordinators in each country to whom all necessary training in IBA methodologies will be provided. Fostering this collaborative approach, which has already been highly successful in Europe and the Middle East, is seen as an important ancillary aim to preparing the directories. Information for the IBA site accounts will be gathered from all available sources, including members of the local population, local governmental and non-governmental environmental organizations, individual experts and scientists, protected areas staff, natural history museums, research institutions, universities, and cartographic centers. An IBA data-sheet has been produced to facilitate the compilation of data and distributed to potential contributors throughout Africa. The criteria used in the selection of lists for inclusion in the directories have been developed as a result of extensive consultation with African wildlife conservation organizations and ornithologists.

The national directories will consist of a general introduction to the country itself, its ornithological importance, the national conservation infrastructure, a map showing the location of the Important Bird Areas, and a series of detailed site accounts. All proposed Important Bird Areas will be considered and their value taken into account as lists of candidate sites are drawn up and assessed for inclusion in the final directory.

All organizations and individuals with an interest in bird conservation in Africa and who would like further information are invited to contact the Project Coordinator, Dr. L. Fishpool, from whom the names and addresses of national coordinators can be obtained.

REFERENCE CITED

Grimmett, R.F.A. and T. A. Jones. 1989. Important bird areas in Europe. International Council for Bird Preservation, Cambridge, UK.

SECTION 7

NATIONAL CRANE AND WETLAND ACTION PLANS

PREPARING NATIONAL CRANE AND WETLAND ACTION PLANS

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There are many advantages to preparing national action plans for cranes. National action plans can provide more detailed information on the status, threats to, and conservation needs of a nation's cranes and their wetland and grassland habitats. They allow this information to be conveyed to other parts of the country (where such information may be unavailable), as well as neighboring nations and the world at large. National action plans help to identify the gaps in our knowledge of cranes and their habitats. They provide researchers and conservationists (especially those working under isolated conditions) with direction by prioritizing research and conservation activities. These priorities also aid scientists, resource managers, agency officials, funding organizations, and political leaders in allocating available resources.

Most national action plans will contain the following elements.

INTRODUCTION

The action plan should begin with a brief discussion of the species of cranes present in the country and their importance. On the latter point, topics that might be covered include: cranes as symbols of a nation; cranes as part of a nation's natural and cultural heritage; cranes and ecotourism; cranes as objects of biological research; cranes as creatures of beauty; and cranes as indicators of ecosystem health. The introduction should lay out the need for, and rationale behind, a national-level plan. It is important that the crane conservation be discussed within the broader context of biodiversity conservation efforts within the country.

The introduction should also provide basic information on the nation's wetlands (and grasslands in countries where these habitats are important): the types present and their location. Wetlands, in this context, are defined broadly, and include areas of land that are permanently or periodically inundated: lake shores, ponds, swamps, marshes, bogs, riparian or lacustrine flood plains, pans and wadis, coastal salt marshes, mangrove swamps, and artificial impoundments. The key wetlands that cranes inhabit (and the periods when they are present) should be identified. The importance of wetlands should be discussed, including their value as a source of food, forage, and fiber; as a source of money through tourism; as a source of water for fish ponds and other agricultural activities; as a means of controlling flooding and regulating other ecosystem functions; and as a natural water purification mechanism.

Finally, the introduction should include a discussion of the goals and organization of the action plan.

SPECIES ACCOUNTS

The plan should provide species accounts of the cranes (including subspecies) that occur within the country, with comments on range (including maps), historical and present status and distribution, population numbers and trends, habitat and ecology, and official conservation status (following the revised IUCN (1994) criteria).

CRITICAL WETLAND ACCOUNTS

The plan should describe critical wetlands: their location, extent, climate, topography, flora and fauna, hydrology, ecology, human impact and utilization, and conservation status. In those nations or regions where grassland ecosystems also provide important crane habitat, a critical account of grasslands should also be provided

PRINCIPLE THREATS TO CRANES AND THEIR HABITATS

The plan should provide comments on the principal threats to cranes and their habitats. Possible threats include agricultural expansion, use of pesticides and fertilizers, overgrazing and degradation of wetlands, construction of dams, afforestation of grasslands, pollution, utility lines, hunting, live trapping for commercial trade and domestication, poisoning, and disturbance by people and warfare.

RECOMMENDED PROJECTS AT THE NATIONAL LEVEL

The plan should review current conservation measures and recommend projects at the national level. Focus areas may include censusing and monitoring, habitat protection and management, research (for example, on food habits, behavior, reproduction and field ecology, migration, and the effects of pesticides and poisons), captive propagation, reintroduction, and education and training.

Where possible, the action plan should specify project timelines and estimated budgets as a prelude to preparing full project proposals.

RECOMMENDED PROJECTS AT THE REGIONAL LEVEL

The action plan should identify projects that need to be pursued at the regional and continental scales. This section should specify the species and wetlands involved and the objectives, description, and justification. Focus areas may include: coordinated watershed planning; migration studies; international agreements; collaborative research projects; and international protected area networks.

SECURING SUPPORT FOR CRANE AND WETLAND CONSERVATION PROJECTS

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INTRODUCTION

In most cases, securing financial support is the limiting factor in implementing recommended actions. Financial resources are available, but it is sometimes a problem to identify these resources, and then to secure a grant. To overcome these obstacles, the following tips are offered.

IDENTIFYING SOURCES OF FINANCIAL SUPPORT

In securing financial support for a project, it is crucial to identify funders interested in supporting projects involving wildlife research, conservation, and sustainable development. Grantors seldom support programs that fall beyond their carefully defined criteria. Thus, the first step in seeking support is to learn about the particular concerns of different funding organizations. Funders usually have published material about their areas of interest. Representatives of funding organizations often attend conservation meetings and publish announcements in newsletters and journals. If a project fits within a funder's area of interest, it is usually helpful to establish personal contact with the funder (or a member of the staff if the funder is an organization). It helps if someone within the organization can answer your questions or critique your proposal before it is formally submitted. Inviting the funder(s) to your project site is an excellent way to gain advice and cultivate interest among potential funders.

THE LETTER OF INQUIRY

Having selected the seemingly most appropriate sources, the applicant should write a letter of inquiry to each grantor to secure additional information. This provides an opportunity to cultivate the interest of the grantor without asking for support. Knowing more about the grantor will also facilitate developing a comprehensive proposal. A two-page letter should ask for information about the types of projects the grantor supports and the level of funding. The letter should summarize the importance of the proposed program, the achievable objectives, the methods to be applied, and the qualifications of the applicant. The inquiry letter should not actually request funds but should indicate the level of funding required. The actual amount requested should be determined after the grantor indicates the range of grant sizes. If the grantor asks for a formal proposal, the amount requested should fall within this range.

THE FORMAL PROPOSAL

If the potential grantor expresses interest in the proposed project, the next step is to prepare a formal proposal. This is often the most important step in any conservation effort. The proposal should be clear, concise, and well written to reflect the importance of the project and the motivation and ability of the applicant. A neat, preferably typewritten, proposal is crucial to developing the interest of the grantor; misspellings and typographical errors do not give a favorable impression.

The proposal should include a summary, a statement of the project's rationale and objectives, a description of the problem, an outline of the study methods and activities, and a specific timeline and budget. Literature sources that support statements in the proposal should be listed in alphabetical order by the author's last name at the end of the proposal. Three well respected people who know you and who are familiar with your work should be listed as personal references. Include their names, addresses, and telephone and fax numbers. References should provide their consent before you include them in your proposal. The budget should fit within the range of giving of the funder. Deadlines for submitting proposals and grant reports should be observed closely.

SECURING AND MANAGING A GRANT

If a grant proposal is accepted, thank-you letters should be sent to funders and references after the grant has been approved and after funds have been received. If a grant is provided through a supporting institution, the accountants of that institution should be advised in advance so that they are prepared to receive and manage the grant. If funds are sent directly to the grantee, the funds should be placed in a special bank account independent of all other accounts. This facilitates accounting. Funds from the account should only be used for items listed in the proposal to the grantor. Receipts should be received for all funds spent.

Well written and concise project reports and accounting reports should be submitted to the funder midway through, and upon completion of, a project. Receipts for all funds used should be kept, and a complete financial report including receipts should be submitted upon completion of the project. Unused funds should be returned to the funder.

COMMUNICATIONS

Written and verbal communication with grantors is vital in developing a productive relationship. Grantors are people too, and their lives are devoted to providing effective, constructive grants. They appreciate being appreciated. Sometimes grantees feel grantors owe them support and after a grant is received, the grantor is forgotten. Such behavior is a prescription for reducing the possibility of grant renewal.

PERSONAL CONTACT

Receiving a grant is often based on personal contact between the grantee and grantor. If a grantor lives in or is visiting the grantee's region, the grantee should try to establish personal contact with the grantor. A 15-minute visit to the office of the grantor can be very productive and provide an opportunity to invite the grantor to visit project sites. Grantors of wildlife research and conservation projects are usually keenly interested in the natural world and welcome the opportunity to learn from specialists and to travel with them in the field.

CULTIVATING SUPPORT

In many cases, cultivation of the grantor leads to additional support, both through the grantor and through other funders with whom the grantor has contact. This usually depends upon direct personal communication between the grantee and the grantor. A grantee should be creative in cultivating this expanded support. For example, grantees should invite grantors on expeditions or short field trips, keep grantors informed about the progress and problems of the work, and seek the advice of grantors in areas where the grantor may have expertise. In short, grantors usually give to people rather than projects. Personal contact is therefore vital.

PERSEVERING

Not all grant proposals can or will be funded, especially in the initial effort to gain support. You should not be discouraged by such results, but should look for opportunities to refine and improve the proposal, to identify more promising sources of support, and to learn from the process. In some cases, it may be necessary to redefine the focus, breadth, or organization of the project. In other cases, it may be useful to work with other individuals or non-profit organizations in your region on joint projects that offer different funding possibilities and that convey multiple benefits. In any case, it is important to continue to seek out information and contacts, and to communicate your enthusiasm for the project.

BOTSWANA CRANE AND WETLAND ACTION PLAN[1]

INTRODUCTION

Botswana holds the second largest population of Wattled Cranes (*Bugeranus carunculatus*) after Zambia (Urban *this proceedings*). It is estimated that 2,000-3,000 birds, of which 700-1,000 are breeding pairs, live in the Okavango Delta and flock in the adjacent Makgadikgadi Pans and Lake Ngami in wet years. Elsewhere in its range the Wattled Crane is endangered (Konrad 1981; Collar and Stuart 1985; Urban 1988), leading to regional and international concerns about the status of the species.

Very limited research has been conducted on the ecology of Wattled Crane in Botswana. However, there are speculations that the population status and breeding success of this species as well as that of the Slaty Egret (*Egretta vinaceigula*) could be used to indicate the ecological health of the Okavango Delta. In view of this, the ecology of the Wattled Crane is the focus of the Crane Action Plan of Botswana.

The Action Plan seeks to undertake the following activities in order to develop an effective conservation policy for the Wattled Crane and the management of its habitats in Botswana.

1. Determine the exact number of resident breeding pairs of Wattled Crane. This knowledge would be an important pre-requisition for drafting effective conservation plans for the species in the country.

2. Determine the numbers and distribution of breeding and non-breeding populations and their trends in the country. This would reveal the status of Wattled Crane in the country, an important pre-requisite to effective management of Wattled Crane.

3. Identify prime breeding and roosting areas the Wattled Crane occupies in Botswana. This effort would facilitate mapping important habitats to effect survival and reproductive success of the species.

4. Study and understand the population dynamics and breeding biology and success of Wattled Crane. Knowledge of the factors that influence survival and reproductive success of this species would help to develop effective polices and management treatment to conserve the species in the country.

5. Understand the life history and adaptive strategies of Wattled Crane. Knowledge of feeding requirements, seasonal variations in food availability (quality and quantity), consumption and impact of these on the energy budgets of the species would promote human understanding of the ecological needs for the survival and reproduction of Wattled Cranes in Botswana.

6. Understand migration patterns of Wattled Cranes. Research on the origin of non-breeding birds utilizing the Okavango Delta and factors attracting the species to the Delta would facilitate efforts to secure the population of Wattled Cranes in its range.

SPECIES ACCOUNT

Wattled Cranes occur in the Okavango Delta in two socially distinct categories: (1) pairs and family flocks; and (2) larger flocks (up to 200 or more birds). The origin of the larger flocks is not certain, but could be either: (1) non-breeding adults, the breeding sites of which are (temporarily) unsuitable; (2) sub-adult birds; and (3) migrants, either within the Okavango system or from abroad (e.g., Namibia, Zambia, Angola).

The Okavango Delta is identified as the core area for this Action Plan because it is the main habitat where Wattled Cranes are found in the country. Understanding the ecology of Wattled Crane in the Okavango Delta would help to develop an effective conservation policy for this species in Botswana and also would guide the formulation of appropriate policy and management programs for the species in its key habitats.

There seem to be no comprehensive study reports available from research on Wattled Cranes in the Okavango Delta. Most people interested in cranes in the area, however, have a certain (sometimes strong) opinion on the number of Wattled Cranes in the delta (and on other aspects of its biology), but even though several of these views are congruent within certain limits (Mangabuli *this proceedings*) most are based on limited and generally opportunistically collected field evidence. It is, therefore, very well possible that even the most widely accepted rough estimate of the number of Wattled Cranes in the delta (1,500-3,000 birds), as the most basic aspect of crane knowledge, is quite wrong.

CRITICAL WETLAND ACCOUNT

The Okavango Delta, the world's largest inland delta, is the most important wetland system in Botswana. It consists of a mosaic of wetlands, drylands, and intermittently flooded

[1] Prepared by the Botswana delegation to the African Crane and Wetland Training Workshop: M. Herremans, J. Mangabuli, and S. Motaloate. Compiled by R. Beilfuss.

lands. It has a diversity of habitats in the form of perennial swamps (4,887 km^2), seasonal swamps (3,855 km^2), intermittently flooded land (2,502 km^2), and dry land (1,842 km^2) (Scudder *et al.* 1992). Apart from enhancing human life, the 15,846 km^2 Okavango Delta is home to a myriad of aquatic and terrestrial species including the Wattled Crane.

PRINCIPLE THREATS TO CRANES AND THEIR HABITATS

The Wattled Crane is a protected species in Botswana. Principle threats are as discussed in Meine and Archibald (1996).

RECOMMENDED PROJECTS AT THE NATIONAL LEVEL

Four research priorities for Wattled Cranes in the Okavango are ordered below by decreasing importance/ increasing complexity.

Project: Wattled Crane breeding ecology

Determine: (1) the size of the Wattled Crane breeding population; (2) the number of breeding pairs; and (3) the location of their breeding territories in relation to yearly variations and longer term changes in flood levels. Discussions during the African Crane and Wetland Training Workshop suggested that an extrapolation of inventory data, whether from strip counts by boat or from the air, would be inappropriate to make a population estimate (either total or only breeding) because of the extreme heterogeneity and complex mosaic of habitats in the delta. The only reasonably accurate approach for an inventory of the breeding population seems therefore to be an aerial survey of the "full count" type (or anything that comes close). Information on the location of breeding territories can also be compiled from incidental observations by the general public, and a questionnaire addressing the collection of such information is to be organized by the Botswana Department of Wildlife and National Parks (DWNP).

Project: Wattled Crane population dynamics

Determine aspects of Wattled Crane population dynamics, including: (1) breeding success; (2) age at first breeding and recruitment into the breeding population; and (3) self sustainability of the population. Information pertinent to population dynamics can be collected once a sufficient number of accessible breeding sites have been located. A color ringing scheme for chicks could also contribute to this study and could reveal aspects of migrations.

Project: Wattled Crane movements

Determine Wattled Crane movements, including: (1) regular migratory movements within the system related to arrival or recession of the floods; and (2) migratory movements between wetlands in southern Africa. For the study of seasonal movements, the possibility of using satellite tracking should be investigated and appropriate funding should be secured.

Project: Wattled Crane population size and trends

Determine the overall Wattled Crane population size and its longer term trends. This would involve understanding the dynamics of the flocking process.

Implementation of projects

All the above prioritized projects could best become a full time effort for a sufficiently qualified person. Since it is impossible at the moment to provide such a person from the other assignments (with higher overall priority for the country) within the ornithology research unit in DWNP, it is advisable to have such a project and position sponsored externally.

REFERENCES CITED

Collar, N. J. and S. N. Stuart. 1985. Threatened birds of Africa and related islands: the ICBP/IUCN red data book, part I. ICBP and IUCN, Cambridge, UK.

Konrad, P. M. 1981. Status and ecology of Wattled Crane in Africa. Pages 220-237 *in* J. C. Lewis and H. Masatomi, eds., Crane research around the world. International Crane Foundation, Baraboo, Wisconsin, USA.

Meine, C. M. and G. W. Archibald, compilers. 1996. The cranes: status survey and conservation action plan. The World Conservation Union, Species Survival Commission, Gland, Switzerland and Cambridge, UK.

Scudder, T., R. E. Manley, R. W. Coley, R. K. Davis, J. Green, G. W. Howard, S. W. Lawry, D. Martz, P. P. Rogers, A. R. D. Taylor, S. D. Turner, G. F. White, and E. P. White. 1993. The IUCN review of the Southern Okavango Integrated Water Development Project. IUCN, Gland, Switzerland.

Urban, E. K. 1988. Status of cranes in Africa. Pages 315-329 *in* G. C. Backhurst, ed., Proceedings of the Sixth Pan-African Ornithological Congress. Nairobi, Kenya.

BURKINA FASO CRANE AND WETLAND ACTION PLAN[1]

INTRODUCTION

General

The survival and development of human populations in Burkina Faso is highly dependant upon local biological resources such as traditional medicines, food, housing, and cultural needs. However, the wildlife and wetlands of Burkina Faso are undergoing serious degradation due to a combination of climatic factors (e.g., drought, desertification) and socio-economic factors (e.g., forest depletion, engineering works, wood cutting, grazing, bush fires).

Immediate action is necessary to resolve this problem. In response, the Nature's Friends' Foundation (NATURAMA) and WWF-USA are currently developing a cooperative project in the region of the Kabore Tambi National Park, in Burkina Faso. NATURAMA is also in partnership with International Crane Foundation, for crane and wetlands conservation.

NATURAMA is a NGO grouping together about 500 members from most of west African countries, mainly Burkina Faso. It is accredited to the United Nations as a NGO concerned about environment and development. NATURAMA is preoccupied with the management of natural resources relating to heritage without boundaries (wildlife, plant life, and hydrosystems). NATURAMA's main objective is the conservation of biological diversity, through education, field projects, research, and circulation of research findings.

This Action Plan, focusing on cranes and wetlands, aims to contribute to national efforts for biodiversity preservation. But, what is the importance of cranes and wetlands?

Cranes

Of the 6 species of cranes that occur Africa, we have one species, the Black Crowned Crane (*Balearica pavonina*), in West Africa, which may be found in many provinces of Burkina Faso. The Black Crowned Crane is a big beautiful bird, historically considered by all the ethnic groups as a symbol of good life and plenty. In the eastern Burkina, the region where the biggest national parks of West Africa (3,000,000 ha.) are found, the local ethnic group, the Gourmantche, has imitated the nuptial dance of cranes in their own dances. For this effort, the group has won the national festival of dance in Burkina Faso three times.

Black Crowned Cranes live near water and contribute to the ecological balance of wetlands. They eat many pests in farmers fields. When praying to the gods to send good rains, the tribal wise men call upon the intercession of cranes to transmit their wishes.

Cranes are an indicator of healthy wetland conditions because they are unable to live in polluted wetlands. Cranes always lay their eggs near water, and their chicks need undisturbed conditions to develop. We can consider the quality of water in a wetland to be acceptable if cranes occur there.

Wetlands

The wetlands of Burkina Faso are permanently or periodically inundated: ponds, swamps, marshes, bogs, riverine or lacustrine floodplains, dams, artificial impoundments, and the lakeshores of the two hydroelectric dams. The key wetlands in Burkina that cranes inhabit include:

- the Kompienga Lake, and the seven ponds and riverine floodplains of the W, Arly, and Pama National Parks in the east;
- the Oursi pond and the "forage christine", in the north;
- the hippopotamus pond of Balla and the 2 Bales National Park, in the West;
- the Kabore Tambi National Park with the adjacent Bagre Lake, and the Nazinga Game Ranch, in the south.

These wetlands are of great value for the economy and ecology of Burkina Faso:

- they are a cradle for biodiversity and productivity;
- they trap sediments, detoxify heavy metals, and remove excess nutrients;
- they reduce soil erosion and storm damage;
- they absorb heavy rains and prevent flooding;
- they are rich sources of plant and insect life for freshwater fish;
- they are the sources of permanent water;
- they recharge groundwater systems;
- they provide consumptive uses such as recreation;
- they are of economic use to local people (e.g., vegetation, wildlife) if managed and used in a sustainable manner.

Goals of the Action Plan

The main goals of this **Action Plan** are:

- to review the current status of, threats to, and conservation needs of the nation's cranes and wetlands;
- to provide direction to the people of Burkina Faso that deal with cranes and wetlands, and to outline actions they can undertake;
- to provide information to scientists, resource managers, agency officials, and political leaders, so that they can

[1] Prepared by the Burkina Faso delegate to the African Crane and Wetland Training Workshop: S. Zeba.

establish international research, conservation, and educational programs on cranes and their wetlands;
- to describe cranes conservation projects that require financial and institutional support at national and international levels;
- to prioritize the projects on cranes and their wetlands in Burkina Faso.

SPECIES ACCOUNT

Range of cranes

The range of the West African Crowned Crane *(B. p. pavonina)* in Burkina Faso includes the wetlands of four regions: the ponds of the north; the wetlands of eastern protected areas; the artificial dams and natural rivers of the south; and the hippopotamus pond in the west. The cranes are historically protected by the customs of local hunters in all of the ethnic groups of Burkina Faso.

Population including trends

There has not been a national census of cranes in Burkina Faso since 1982. At that time, cranes number were estimated to be 2,500-3,000. But today it is thought that the number has declined to between 1,000-1,500.

Habitat

Crane habitat has been much modified in northern Burkina, by drought and anthropogenic pressures. In the East, South, and West, however, crane habitat remains largely unchanged. However, these areas can quickly deteriorate because since 1988-90 there has been a large population resettlement from the north into these three regions.

Official conservation status

Since the December 1979 law on wildlife conservation in Burkina Faso, cranes have been classified in Appendix I as protected birds and cannot be lawfully hunted or exploited.

CRITICAL WETLAND ACCOUNTS

The critical wetlands of northern Burkina Faso

Critical wetlands in northern Burkina Faso are located in the Sahelian biogeographical district, where the rainy season is about 3 months per year (300-500 mm), with temperatures between 12-45 °C. It is a very degraded region where erosion (by wind and rain) has severely depleted the soils. Much of the vegetation has disappeared, and the groundwater systems are not being recharged adequately.

The fauna consists of arid land species such as gazelle, ostrich, and many birds species, augmented in the winter by the arrival of many migratory species. The common tree species of the area include *Balanites* spp., *Boscia senegalensis, Combretum micranthum*, and *Acacia* spp. Human impact on the natural resources of the region is significant, particularly due to cattle herding.

The conservation status of this region was strengthened in 1976 by the creation of the Sahel game reserve (1,600 ha.) which includes the main wetlands. But the Government has no means to protect this area, and it is overexploited without restriction by the local population.

There are also differing opinions between government departments as to the best method of regional development. Hence, the intervention of an NGO such as NATURAMA can promote the participation of local communities in the sustainable use of these wetlands, and help provide solutions to the problems.

The critical wetlands of southern Burkina Faso

These wetlands comprise the ponds of the Kabora Tambi National Park. These are fed by the Nazinon river in rainy season (May-October, 700-850 mm). The temperatures vary between 15-35 °C.

The flora is very diverse. The main species of trees include *Adansonia digitata, Butyrospermum parkii, Parkia biglobosa, Anogeissus leiocarpus*, and *Lannea microcarpa*. The fauna is also diverse, Elephant, many antelope species, buffalo, hippopotamus, crocodile, and many bird species occur there.

The area (155,000 ha.) is protected by a law passed in 1976, declaring it as a National Park.

The critical wetlands of eastern Burkina Faso

These comprise eight ponds located among W National Park (3), the Arly National Park (3), and the Pama Game Reserve (2), which are fed during the rainy season by the Niger River, the Arly and Pendjari Rivers, and the Doubodo River. These wetlands occur near the Gobnangou mountains, in wide plains that are periodically inundated by the rains during the months of May to November (800-900 mm). Temperatures vary between 15-34 °C. It is the most important region for tourism in West Africa because it constitutes, with the neighboring protected areas in Benin and Niger, the biggest wildlife reserve of this region.

The flora is dominated by many big trees such as *Daniella oliveri, Khaya senegalensis, Parkia biglobosa, Acacia* spp., *Lannea* spp., and *Combretum glutinosum*. The fauna is very diverse, and includes 31 big mammal species such as elephants, lions, antelopes, and buffaloes, and more than 300 species of birds including cranes.

These wetlands are located in areas under protection since 1974, but they have been subjected to droughts during the last two decades such that some of these wetlands have become temporary rather than permanent.

The critical wetlands of western Burkina Faso

There are two critical wetlands in western Burkina: the Mouhoun river and the Hippopotamus pond at Balla. The region receives 900-1,000 mm of rain per year, with a temperature of 12-32 °C. Human impact is increasing rapidly in the area, because there is competition for the utilization of these wetlands for farming, livestock, and mineral exploitation. There is also a large scale migration of people from the North into these areas. Consequently, soil erosion is increasing, and it is becoming evident that the capacity of these wetlands to support people and wildlife is decreasing.

Balla pond is located in a Biosphere Reserve recognized by UNESCO since 1987, while the Mouhoun river is mostly included in the four protected forests of Tisse, Baporo, Sourou, and 2 Bales. However, this level of protection does not prevent local people and immigrants from clearing fields and farming near the wetlands. There is also no strategy for the education of neighboring communities.

PRINCIPAL THREATS TO CRANES AND THEIR HABITATS

The principal threats to cranes and their wetlands in Burkina Faso are:

- the loss of wetlands in protected areas due to drought and desertification, including thirteen ponds in national parks of East, South, and West Burkina Faso;
- agricultural expansion;
- overgrazing and degradation of wetlands;
- hunting (for commercial purposes);
- poisons and toxins, used by some poachers to catch fishes in natural ponds.

RECOMMENDED PROJECT AT THE NATIONAL LEVEL

The NATURAMA Foundation would like to prioritize only one Phase One project, because not all problems can be solved at the same time due to the lack of human and material resources.

Project: Basis of support for the conservation of cranes and wetlands in Burkina Faso

Target species and wetlands

Black Crowned Cranes, in the following wetlands:

- 3 ponds in the Kabore Tambi National Park;
- 5 ponds in W and Arly National Parks and Pama Game Reserve;
- 2 ponds in the 2 Bales National Park;
- 2 ponds in the protected forests of Diefoula and Koflande.

These twelve ponds must be improved by dredging the mud or sand that have reduced the capacities of these waterbodies. The other wetlands of the Northern, Western, and Central regions will be addressed by censusing, monitoring, training, and public education exercises.

Project objectives

The main objective is to promote the conservation or wetlands in Burkina Faso. For this, detailed objectives include:

- to identify information needed to reinforce and finalize this Action Plan (censusing cranes and critical wetlands);
- to save the threatened wetlands through the rehabilitation of the main crane habitats;
- to prepare all future program partners through a program of training and public education;
- to start a captive breeding program for reintroduction of cranes to the main wetlands;
- to prepare individual strategies for the involvement of local communities in the management of each wetland.

Project description and justification

For this phase of crane and wetland conservation in Burkina Faso, the following activities are the most urgent and relevant.

<u>Censusing and monitoring</u>
We need to know the current crane population sizes and the trends. Only in this way, will it be possible to develop an adequate policy for the preservation of cranes, with the participation of local communities. We also need to know how to rehabilitate the ponds and the costs required.

<u>Habitat protection and management</u>
It is urgent to rehabilitate these twelve natural ponds (see above) that are currently disappearing due to the effects of drought. These ponds are habitats of cranes, and are vital for all wildlife that depend on them.

<u>Studies</u>
These concern feeding habits, behavior, reproductive and field ecology, crane migration studies, monitoring of populations and wetlands, and effects of pesticides and poisons. These activities will also lead to strategies for the involvement of local communities in the management of each wetland.

Captive breeding and reintroduction

It is necessary to undertake a captive breeding program, in order to regenerate the population of cranes. So, they will return to the wetlands once their management has been improved, through this Action Plan. The captive breeding will be done in the Kabore Tambi National Park. It can also serve to provide cranes for the wetlands of neighboring countries (Niger, Benin, Togo, Mali, and Ivory Coast).

Education and training

The conservation of cranes and wetlands necessitates a process of public education and the training of the technicians in charge of this Action Plan. For that, the NATURAMA Foundation will focus on activities that produce concrete results for modest costs.

The program of public education will be made through the publication of a specialized bulletin, to be regularly sent to all the national and international institutions involved in crane and wetlands conservation. NATURAMA will also use radio, television, and newspapers to disseminate information to the public, in all the main languages.

The training of technicians will involve 4 persons initially (these persons will train local people and other technicians from the institutions involved):

- one for coordinating the censusing, monitoring, and research activities;
- one for the coordination of education and training;
- one for the captive breeding program and reintroduction of cranes;
- one for the coordination of habitat protection and management activities.

Project timetable

This first phase of the project will take 2 years, and NATURAMA wishes to start it as soon as possible.

Institutional arrangements

It is necessary to involve the government in the process of this Action Plan. However, there are many advantages to this initiative being led by the NGO NATURAMA, because it is a flexible organization, able to ensure an equitable participation of all the ministries and neighboring communities. As an environmental NGO, NATURAMA will also be able to highlight the ecological aspects of wetlands, often neglected.

Project budget ($US)

Aerial counting ($300/hour x 15 hours)	$ 4,500
Equipment (binoculars, camera and film, etc.)	2,000
Field trips by car	2,500
Food for the counters (5 pers. x 20 days x 20 $/day)	2,000
Preparatory studies for the rehabilitation of ponds	3,000
Administration	2,000
Total	$16,000

RECOMMENDED PROJECT AT THE REGIONAL LEVEL

Project: Census, monitoring, and captive breeding center for crane conservation in West Africa

Project location

Kabore Tambi National Park (Burkina Faso)

Countries involved

Burkina Faso, Niger, Benin, Togo, Ghana, Ivory Coast, Mali, Gambia, Senegal, and Mauritania.

Project objectives

1. To coordinate the census and monitoring of the Black Crowned Cranes in West Africa.

2. To undertake the captive breeding of cranes in order to reintroduce them in wetlands of West Africa.

3. To build up expertise for supporting the conservation of cranes in West Africa.

4. To support ornithology in general in West Africa.

Institutional arrangements

Implemented by the International Crane Foundation (ICF) and NATURAMA. The geographical location of Burkina Faso is in the heart of West Africa, and NATURAMA has five ornithologists available for the project.

Project budget (6 month preparatory phase, $US)

Formation of sub-regional network	$ 3,000
Field studies for the captive breeding center	3,000
Training of an expert at ICF center	6,000
Reporting	1,000
Administration	2,000
Total	$15,000

KENYA CRANE AND WETLAND ACTION PLAN[1]

INTRODUCTION

The Grey Crowned Crane (*Balearica regulorum*) is common in Kenya, and has the following values:

- it is part of the culture of the past-folklore;
- it is a symbol used by local institutions (such as logos);
- its beauty offers aesthetic value;
- it is a good biological indication of the health of wetlands.

The definition of wetlands in Kenya varies but the important attributes are that the area must be flooded temporary or permanently, it must have characteristic hydrophytes (macrophytes) and the presence of hydric (wet) soils. The population of cranes in Kenya are distributed over a range in the Central Park of Kenya, the Rift valley areas, and the western parts of Kenya. Cranes are becoming an agricultural pest species in some of these areas - mainly in grain growing fields. A captive breeding project at the coast (Bambiom in Mombasa Town) is also ongoing. Critical wetlands include Saiwa Swamp, Lake Ol'bolosat, Yala Swamp, Kabianga Swamps, and various dams and pools scattered over the range discussed above.

Grasslands in the vicinity of wetlands should be properly managed. This includes assessing the carrying capacity of livestock (grazers) in this grasslands.

The goals for this Action Plan follow those discussed in Urban and Meine (*this proceedings*), as well as setting up of a database and training local people to empower the communities on wise use.

SPECIES ACCOUNTS

The Grey Crowned Crane has no official conservation status in Kenya. Its current status indicates a decline compared to past estimates (Urban *this proceedings*), however, there is no data to confirm this. Population estimates, including trends, need further attention (N. Gichuki *this proceedings*). Habitats for Grey Crowned Cranes include:

- the swamps, which are critical breeding habitats;
- the grassland fringing swamps, which are foraging habitats;
- agricultural grain fields, which are also feeding areas.

The Black Crowned Crane (*Balearica pavonina*) occurs at the edge of its southern range in far northern Kenya, with numbers in the low 100s.

PRINCIPLE THREATS TO CRANES AND THEIR HABITATS

Major threats include those outlined in Urban and Meine (*this proceedings*), especially:

- loss of breeding sites through drainage of wetland for agricultural expansion and other developments;
- damming of rivers which reduces amount of water reaching downstream wetlands.

RECOMMENDED PROJECT AT THE NATIONAL LEVEL

Project: Crane research, monitoring and education program

Target species and wetlands

Grey Crowned Crane, in all crane habitats in Kenya.

Project goals and objectives

The goals of the project are as follows.

1. To gather more information on the ecology and socio-economic aspects of the cranes.

2. To train two people at graduate level on management and research of cranes and crane habitats.

Specific objectives include the following.

1. (a) Survey all existing and potential crane habitats.
   (b) Start an annual crane census and mapping program to monitor local and regional movements of cranes.

2. (a) Study all existing and potential crane habitats.
   (b) Identify existing and potential threats to cranes and their habitats.

3. (a) Collect and document the existing information on the values of cranes and their habitats through community participation and education;
   (b) Formulate a management model that incorporates local communities in the conservation of cranes and their habitats.

[1] Prepared by the Kenya delegation to the African Crane and Wetland Training Workshop: C. Gichuki, N. Gichuki, P. Gitahi, J. Keter, P. Kuria, K. Mavuti, P. Micheni, O. Nasirwa, E. Ojoo, P. Raburu, D. Rotich, M. Wanjala. Compiled by C. Gichuki.

MALAWI CRANE AND WETLAND ACTION PLAN[1]

PREAMBLE

The Malawi National Wetland Action Plan already exists (wetlands: a conservation programme for Southern Africa: Report document Vol. II. November 1991. SADC funded by NORA). The said document has been approved by the government and covers relevant areas in wetland conservation. Issues pertaining to crane conservation in Malawi are outlined below. The goals and objectives of the Malawi National Wetland Action Plan are included under the *Recommended Projects at the National Level* section below.

INTRODUCTION

There are 2 species of cranes which occur in Malawi, the Wattled Crane *(Bugeranus carunculatus)* ("Ngwahe" in Chickewa) and the Grey Crowned Crane *(Balearica regulorum)* ("Ngwaru" in Chickewa). They have aesthetic and biological values and are indicators of the well-being of wetlands. These cranes were once widely distributed. However to date, the Wattled Cranes are restricted to Nyika National Parks and Rwaza Wildlife Reserve. The latter species is found in Nyika National Park, Rwaza Reserve, and in isolated dambos throughout Malawi.

Goals for the Action Plan include:

- to review the current status of, threats to, and conservation needs of Malawi's cranes and wetlands;
- to sensitize the local people in crane areas, as well as the nation at large on conservation status of cranes;
- to describe and prioritize crane conservation projects that require financial assistance and institutional support at the national and international levels.

SPECIES ACCOUNTS

There are approximately 50 Wattled Cranes in Malawi. They were historically common, but now have very restricted range. They are protected by national law. Wattled Cranes occur in wetlands in Nyika and Kasund Parks and Rwaza Reserve (Banda *this proceedings*; Nhlane *this proceedings*).

There are approximately 50-100 Grey Crowned Cranes in Malawi. They were common in the past, but their current status in is unknown. The are considered to be threatened in Malawi. Grey Crowned Cranes occur in dambos and other wetlands.

CRITICAL WETLAND ACCOUNTS

In preparation.

PRINCIPAL THREATS TO CRANES AND THEIR HABITATS

The threats to cranes outside protected areas are the destruction and loss of their habitat due to agricultural encroachment, the use of agricultural chemicals, and overgrazing of the wetlands. Deforestation both in the catchment and around the wetlands also encourages soil erosion, and results in high sediment loads in rivers which feed the wetlands. In protected crane areas, the principal threats to their habitats are uncontrolled fires and human disturbance (tourists), especially in their breeding areas.

RECOMMENDED PROJECTS AT THE NATIONAL LEVEL

Projects need to address the following broad areas:

- information and research;
- policy and legislation;
- planning and management;
- awareness, education, and training;
- organization and institutional arrangement.

Specific project needs for crane conservation include:

- carry out censuses and monitor population of cranes in key wetlands;
- carry out research on the biology of the cranes including food habits, behavior, reproduction, and field ecology;
- access the conservation status of crane habitats;
- carry out public awareness on conservation of cranes and wetlands.

The following detailed program of action, adopted from the Malawi National Wetland Action Plan, is recommended. This Action Plan is general, and obviously some ideas which are being proposed here may have already been dealt with. While the implementation of this Action Plan should take into account the existence of these activities, it should further observe the constraints of regional and national origin.

[1] Prepared by the Malawi delegation to the African Crane and Wetland Training Workshop: H. Banda, D. Kamundi, and M. Nhlane.

Project: Develop a well-established system of information on wetlands conservation in Malawi with emphasis on ecological, socio-economic, and cultural values.

Project Objective 1

Organize and establish systems of information on wetland conservation in Malawi.

Activities

1. Carry out a general wetland inventory of all wetland areas. This is important for setting up priority areas for both short term or long term purposes.

2. Carry out detailed assessment of the values and functions of selected areas.

3. Conduct detailed research programs on the management of wetland resources (e.g., fisheries, wildlife, forage, forest, soils, water, agriculture), and control of pollution, sedimentation, fires, and other threats.

4. Establish a program to disseminate information on values, threats, and conservation plans to all technical professional, policy makers, politicians, and relevant institutions.

5. Make this information readily available to planners, decision makers, and relevant institutions.

Project objective 2

Establish a system of national assessment which will allow for the short and long term monitoring evaluation of the effectiveness of wetland development and research programs.

Activities

1. Enhance the capacity of national research institutions to survey and monitor wetlands and the impact of developments upon them. This should be supported by seminars and workshops to exchange information;

2. Develop an appropriate wetlands assessment methodology at a national level;

3. Conduct Environmental Impact Assessments for development projects which may affect wetland ecosystems;

Project: Ensure policy reforms towards sustainable utilization of national resources.

Project objective

Develop policy reforms to encourage wise use of wetlands for sustainable development, that take into account their values, functions, vulnerabilities, and conservation.

Activities

1. Review current policies that may be effective for wetland conservation initiatives and, if any exist, they should be used for developing the wetland program. If none are effective, then consideration should be given to establishing a new policy.

2. Work with already established institutions or establish new institutions to create suitable policies which provide a supportive working environment for conservation, and to make reviews on controversial policies on land, grazing, resource sharing, and chemical application.

3. Work with local communities particularly those living in and around the wetland areas to develop appropriate policy reforms which would enhance their participation in resource administration, sustainable utilization, and management.

4. Strengthen international cooperation with the neighboring countries and where appropriate ensure joint conservation, management, and sustainable utilization of shared wetlands.

Project: Develop and apply national legislation linking conservation to sustainable use.

Project objective

Develop appropriate legislation to support the implementation of the wetland policy.

Activities

1. Review and create legislation relevant to wetland conservation and suggest improvement, including repeal of legislation which would negatively affect implementation of the program.

2. On the basis of this, work with appropriate authorities for legal change to create a supportive environment for implementation of the program.

3. Conduct periodic seminars or workshops to review progress and effectiveness of both policy and legislation.

Project: Incorporate wetland concerns into national conservation strategies, national environmental policies, and national development plans for effective implementation of the program.

Project objective 1

Incorporate wetland conservation policies and guidelines into national economic development plans.

Activities

1. Identify specific national development goals whose pursuit can be assisted through the application of wetland policies and guidelines.

2. Work with appropriate institutions to facilitate the integration of the wetland policies into the national planning system.

Project objective 2

Strengthen the capacity of planning institutions, and promote coordination in the planning process.

Activities

1. Provide, where necessary, manpower, equipment, and funds to planning units to facilitate the planning procedures;

2. Conduct training seminars and workshops with course emphasis on sustainable development;

3. Encourage institutional and sectoral contact to share knowledge and exchange views on planning matters.

Project: Formulate plans for conservation of wetlands

Project objective

Develop and promote planning techniques and processes which should help planners to identify priorities.

Activities

1. Develop technical guidelines and planning manuals for planning as well as for field operations. These guidelines should cover fields such as:
   - community participation;
   - river basin planning and management;
   - dambo management;
   - weed control;
   - habitat improvement;
   - range management.

2. Organize training seminars and workshops on how to implement guidelines and the use of manuals at all user levels.

Project: Attain a stronger linkage between wetland conservation and sustainable development.

Project objective 1

Promote principles of sustainable utilization of wetland resources.

Activities

1. Provide planners of the institutions and sectors with the necessary information on wise use of wetlands and attempt to link this to the objectives of the development plans of other sectors.

2. Provide necessary demonstrations (through field trials) of possible wetland development output (increased socio-economic output) and increased productivity of wetlands. This should provide a forum for using cost-benefit principles to determine why wetlands should be conserved.

3. Work with local communities to demonstrate methods for harvesting resources, and mechanisms through which these can generate cash for local purposes.

Project objective 2

Promote non-consumptive uses of wetland resources such as recreation and tourism, which raises revenue for local communities.

Activity

Establish activities such as field projects which demonstrate how wetland resources could be used for tourism and non-consumptive uses.

Project: Promote rehabilitation of degraded wetland areas in Malawi.

Project objective

Develop techniques for habitat restoration and species population management.

Activities

1. Conduct trial projects on habitat rehabilitation.

2. Carry out field projects on animal translocation (wildlife and fish) to replenish depleted areas.

3. Conduct training seminars and workshops on habitat management and restocking methods with emphasis on benefits of wetland conservation.

Project: Encourage the public to value wetlands and to recognize the need for their conservation.

Project objective 1

Improve understanding of the importance of the wise use of wetlands for sustainable development.

Activities

1. Develop courses on wetlands for community leaders and extension workers.

2. Develop courses on wetlands for teachers in primary, secondary, and tertiary education, and promote the incorporation of wetland conservation issues into school curricula.

3. Work in close collaboration with NGOs and media (radio, television, newspaper). in order to ensure widespread coverage of wetlands conservation and in particular to communicate information to users groups.

4. Exhibit education materials in various forms such as shows; exhibitions, books, magazines, and pamphlets.

5. Conduct education seminars and outreach programs for various categories and where possible include field trips to wetland sites.

6. Develop educational units for conservation of wetlands.

Project objective 2

Foster greater understanding and acceptance of the need for wetlands conservation by decision makers in the public and private sectors.

Activities

1. Conduct seminars and field trips on wetland conservation for decision makers.

2. Produce audio-visual materials on wetlands with emphasis on the environmental benefits of wetland conservation.

Project: Ensure that Malawi has the necessary trained manpower in wetlands conservation.

Project objective

Increase opportunities for training of field staff in various fields of wetland conservation primarily at technical level with Diploma or Certificate, graduate and post-graduate studies in wetlands ecology or any related field.

Activities

1. Identify institutions and national organizations such as a university and colleges which could serve as training centers in wetland conservation and assist them to develop appropriate courses.

2. Encourage member states to incorporate training on wetland conservation issues into the curricula of educational institutions.

3. Prepare and update training materials and programs on wetland conservation.

Project: Promote, coordinate, and implement effectively the wetland conservation action plan.

Project objective 1

Provide effective coordination of the wetland conservation action plan both at national and regional levels.

Activity

Establish mechanisms for improved regional coordination which can help promote and coordinate the implementation of the action plan.

Project objective 2

Provide effective coordination of activities related to the conservation of wetlands at the national level.

Project activities

1. Establish wetland conservation units or coordinating committees.

2. Advise on and coordinate all functions including those of research, education, legislation, policy formulation, planning, management, and training.

3. Conduct periodic seminars or workshops for various institutions so as to improve contact and sharing of experiences in wetland conservation.

Project: Foster and ensure local community participation in the implementation of the wetland conservation program.

Project objective

Establish mechanisms effective for ensuring the participation of local communities in the management of wetland resources.

Activity

Work with appropriate authorities to facilitate the above.

MOZAMBIQUE CRANE AND WETLAND ACTION PLAN[1]

INTRODUCTION

Mozambique has undergone fundamental political and economic changes which will have a profound effect on the future development of this country. The cease fire and signing of the Peace Accord in October, 1992, and subsequent peaceful elections bring high prospects for peace. These changes are helping to create the necessary conditions for integrated development and sustainable use of wetlands in Mozambique, and the possibility of Mozambique becoming a member of the Ramsar Convention.

General

The total area of Mozambique is approximately 800,000 km^2 and comprises a great variety of habitats, including wetland areas such as Rovuma floodplain in the extreme north, Gorongosa area in the great Rift valley, and Maputo Elephant Reserve in the south.

Cranes

Mozambique has two species of cranes:
- Wattled Crane (*Bugeranus carunculatus);*
- Grey Crowned Crane (*Balearica regulorum)*

The ecology and conservation of cranes in Mozambique has not been investigated. The main economic value of cranes is probably their potential for eco-tourism.

Wetlands

Wetland areas in Mozambique include marshes, fens, peatlands, riverine and lacustrine systems, floodplains, mangroves, swamps, pans, springs, vleis, and coastal salt marshes. Key wetlands areas in Mozambique, that cranes inhabit, include:
- Marromeu wetland (Zambezi Delta);
- Gorongosa National Park (Vrema floodplain and lakes);
- Lake Niassa (Chiuta and Chilwa).

Wetlands have many values in Mozambique. Wetlands provide natural resources that may be used sustainably for rural development. Wetland areas are important for waterbird habitat, especially waterfowl and cranes. Wetlands are a rich source of plants and insect life for supporting freshwater fishes, which subsequently provide a source of vitamins and protein for people. With proper management and policy guidelines, people near wetlands can derive income from freshwater fisheries and local tourism. These wetlands areas provide grassland for livestock and ungulate grazing, rich soils for agriculture, water supply to local communities for irrigation and drinking, and forest resources such as fuelwood and timber.

Grasslands

Important grasslands include Rovuma floodplain, Marromeu floodplain, Gorongosa National Park (Vrema floodplain), and Maputo Elephant Reserve floodplain. The grassland areas are very important for livestock and ungulate grazing, soil stability, and building materials, and also provide roosting and breeding sites for many species of birds.

Goals of the Action Plan

1. Review the current status of threats and conservation needs of Mozambique's cranes and wetlands.

2. Provide planning and management direction to the personnel in Mozambique that deal with cranes and wetlands, and outline actions to be undertaken.

3. Provide information to scientists, resource managers, agency officials, and political leaders, so as to establish international research, conservation, and education programs on cranes and their wetlands.

4. Describe and prioritize crane and wetland conservation projects that require financial and institutional support at the national and international levels.

SPECIES ACCOUNTS

The Wattled Crane mainly occurs in central Mozambique. No field research has been done on the ecology of Wattled Cranes, although observers counted over 2,500 Wattled Cranes and many breeding pairs during aerial surveys over the Marromeu floodplain in 1990 (Singini *this proceedings*). The Wattled Crane is a globally endangered species.

The Grey Crowned Crane population is scattered from southcentral Mozambique (including Gorongosa National Park) to the north. Little information is known, although both the northern and southern subspecies may occur in Mozambique. The Grey Crowned Crane is officially considered to be a threatened species in Mozambique, but so far no management or conservation work has been

[1] Prepared by the Mozambique delegate to the African Crane and Wetland Training Workshop: P. J. Tomas Singini; with assistance from R. Beilfuss, N. Coulthard, L. Fishpool, and P. Dutton

done.

CRITICAL WETLAND ACCOUNT

Marromeu wetland (approximately 360 km^2) occurs off the south bank in the delta of the lower Zambezi River. The Marromeu complex includes extensive floodplains (comprising swamp forest, papyrus swamp, oxbow lakes, and seasonally inundated grassland), acacia savanna, palm savanna, and mangrove estuaries. Marromeu supports a diverse flora and fauna, including large numbers of ungulates and waterbirds. The upstream dam development at Cahora Bassa and Kariba have caused the severe degradation of the floodplain (Beilfuss and Allan *this proceedings*). Marromeu is a game reserve but due to the recent civil war, no management has been carried out in the area and at present moment the area is abandoned. The climate of Marromeu is mostly humid tropical, with annual rainfall varying from 300-1,000 mm, the average annual temperature is about 24 °C.

PRINCIPAL THREATS TO CRANES AND THEIR HABITATS

1. Upstream dam development has caused major drainage lines and floodplain habitats to dry up, and facilitated the uncontrolled burning of grasslands and loss of wetland vegetation.

2. Warfare has lead to habitat changes by concentrating most of the human population in confined areas, resulting in habitat destruction. Military poaching has greatly reduced the wildlife population.

3. The dry floodplain vegetation is not recovering from grazing and agricultural expansion, negatively affecting the nesting and roosting site for cranes and other birdlife in the area.

4. Pollution, chemicals, and poisoning are not well controlled, and may be impacting birdlife and other living organisms.

RECOMMENDED PROJECT AT THE NATIONAL LEVEL

Censusing and monitoring are very important to obtain updated information on the range and status of the cranes and other important waterbird species in Mozambique. However, to meet this goal requires the protection and management of wetland habitats. We especially need to educate and train local people to expand conservation activities.

Project: Surveys, ecology, and breeding biology of the Wattled Crane in the Marromeu wetland complex, Zambezi Delta, Mozambique.

Target species and wetlands

Wattled Cranes in the Marromeu Complex of the Zambezi Delta.

Project objectives

1. To assess the population, distribution, habitat use, conservation status, and basic breeding biology of Wattled Cranes in and around Marromeu game reserve;

2. To use this research to develop management strategies for protecting cranes and other birdlife in the Marromeu complex that will benefit the people and wildlife of Mozambique.

Project justification

The largest concentration of Wattled Cranes in Mozambique is known to occur in the Marromeu wetlands, but nothing is known of their current conservation status and needs. Only a small part of the wetland has any legal protection (designated as a Game Reserve) and this has no management or law enforcement. With the onset of peace it is likely that human populations will move out of the wetland area, but the threats to cranes from hunting and new land use pressures are unknown.

The Wattled Crane is listed as a species of special concern in the ICBP/IUCN Red Data Book. There is an urgent need to assess the Mozambique population of this threatened species as part of a wider national strategy for wetland conservation.

Project methods

1. Establish a regular system of crane counts at Marromeu, using aerial surveys or ground surveys (if feasible).

2. Locate feeding, roosting and breeding sites within the wetland area.

3. Carry out detailed studies and time budgets of habitat use by cranes within and outside Marromeu Game Reserve.

4. Investigate current and possible future threats to cranes in the Marromeu wetlands in light of currently changing land uses and practices in the Game Reserve and surrounding hunting areas.

5. Train Mozambican staff (wardens and research scien-

tists) in appropriate census techniques for on-going monitoring of the crane population.

6. Investigate past records of Wattled Cranes in other areas of Mozambique and carry out surveys in these areas to assess the total Mozambique population of Wattled Cranes.

7. Count Grey Crowned Cranes and other important waterbirds in all areas surveyed for Wattled Cranes in order to assess the total Mozambique population of these species.

Project timetable

A two year research program, based in Marromeu, including a full time expatriate research biologist will probably be needed to manage the research program and train a Mozambican counterpart and wildlife department staff in appropriate census and research techniques.

Project budget (in $US)

A detailed budget is in preparation, but total cost including salaries, transport, air fares, and local expenses will be approximately $50-100,000.