CRANES, AGRICULTURE, AND CLIMATE CHANGE James Harris International Crane Foundation

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Proceedings of a workshop organized by the International Crane Foundation and Muraviovka Park for Sustainable Land Use

On behalf of Wetlands International – IUCN SSC Crane Specialist Group

May 28 – June 3, 2010

Edited by James Harris

International Crane Foundation
Baraboo, Wisconsin, USA

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Front cover photo: Hooded Cranes in corn stubble, Heilongjiang Province, China.
Photo by Wu Haifeng.

Back cover photo: Black-necked Cranes in winter at Dashanbao National Nature Reserve, Yunnan Province, China. Photo by Wang Keju.

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INTRODUCTION: CRANES, AGRICULTURE AND CLIMATE CHANGE

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These proceedings include papers and abstracts from a workshop on cranes, agriculture and climate change held in early June 2010 at Muraviovka Park close by the Amur River in far eastern Russia. In large part, this workshop was designed to enhance interactions and activities among members of the Wetlands International – IUCN Species Survival Commission Crane Specialist Group. Among the primary mandates for the Specialist Groups is to assess threats to species and to develop and disseminate effective conservation responses. We chose agriculture and climate change as themes because both processes affect cranes significantly, in complex ways, throughout the world.

The papers in this collection, prepared by workshop participants, serve as an introduction to these topics. The workshop was the first step in a longer term effort by the Crane Specialist Group to understand how agriculture and climate change affect cranes, to identify and implement research to fill gaps in our understanding, and to promote ways to avoid conflicts between people and cranes that arise as agricultural landscapes and climates change. We hope reading these papers will lead to more discussions among specialists, to better understanding, and to more effective conservation action.

Because of the small size of this workshop – 30 participants from 14 countries – many relevant projects and investigations were not included in the workshop program, or in these proceedings. With this introduction, I wish to present some of the major themes that ran through our discussions at Muraviovka, drawing upon what we are learning from the varied situations around the world where cranes are responding to agricultural change, climate change, or frequently both. For the most part, this introduction supplements rather than summarizes what the papers in these proceedings provide.

Muraviovka Park was an ideal setting for the dual themes of the workshop. Muraviovka protects a former channel of the Amur River, the world's third longest river without a dam on its main course. The Amur forms the border between Russia and China for over a thousand miles. Being privately managed by a non-governmental organization, the park stands in contrast to the magnificent governmental system of zapovedniks, or strictly protected areas, where the impacts of people have been minimal and human access is carefully minimized and controlled. Muraviovka Park was established in the early 1990s to protect valuable wildlife habitat where cranes live in close proximity to people; in fact, the great density of nesting cranes and storks is the result of the benefits that the agricultural landscape provides to wildlife using the adjacent wetlands. The park has essentially been an experiment in how to devise conservation programs that preserve and enhance this positive relationship between cranes and people (Smirenski 1998, Nosatchenko and Smirenski 2007, Smirenski and Smirenski 2010, Smirenski et al., abstract in these proceedings).

Yet at the time of our workshop, Muraviovka and most areas of the mid and upper Amur Basin were experiencing a severe, multi-year drought so that large parts of the wetlands were dry and other parts had far less water than normal. Numbers of nesting cranes and storks had declined, and a fire had burned 80% of the park less than a month before the workshop, in the midst of the egg incubation season for cranes and many other waterbirds. As with most local and short-term events, it would be misleading to draw definitive links between spring fires or breeding failures for cranes and global climate change, yet the condition of the wetlands certainly demonstrated what drier and hotter climates could do to habitat for cranes.

The basin of the Amur River (called the Heilongjiang in China) has the greatest diversity of cranes on earth (six species, four of them threatened) and provides many examples of the challenges posed by agriculture and climate change to cranes. What was formerly the largest wetland in China, the Sanjiang or Three Rivers Plain, is so-named because it lies where the Ussuri and Songhua Rivers flow into the Heilongjiang. Major, sustained efforts at wetland drainage have destroyed the vast majority of wetlands while creating highly productive agricultural landscapes of national importance to China – for example, more than 75% of wetlands have been lost in both the Naoli and Bielahong River Basins (Liu et al. 2005). Wetland fragments, some of them sizable by North American or European standards, still support cranes although their quality and productivity are impacted by agricultural practices that do not sustain the value of those remaining wetlands for wildlife or for people.

The Amur Basin coincides with a gradient of declining rainfall from east to west. And as is often the case in arid regions, the drier (upper) parts of the basin have more variable rainfall with periodic cycles of drought. Human demand for water in the north of China, where population growth and development have been rapid, strains available water resources. During dry years there simply isn't enough water. Irrigated agriculture has been essential in sustaining growth in national crop production, but multiple drivers are generating immense pressure on water resources and water supply for irrigation, especially in northern China. This demand has greatly promoted groundwater abstraction, which has increased from roughly 10 km^3/yr during the 1950s to more than 100 km^3/yr in the 2000s (Wang et al. 2007). Today, roughly 70% of the irrigated area in northern China is groundwater-fed (Wang et al. 2009), and irrigation produces approximately 70% of total grain production (Amarasinghe et al. 2005). As croplands increasingly rely on groundwater supplies, the water table is declining which in turn affects those wetlands fed by groundwater discharge (see Sinclair Knight Merz 2001).

The same prolonged drought period that degraded crane habitat at Muraviovka left most wetlands of the middle and upper Amur/Heilong Basin without water, including in particular the Daurian steppe (see Andronov et al. 2008, Parilov et al. 2008, Simonov and Dahmer 2008, and www.dauriarivers.org) Herdsmen were forced drastically to reduce their herds, and the animals remaining still overgrazed the parched steppe. Cranes, Swan Geese (*Anser cygnoides*) and other waterbirds crowded into the last wetlands. Livestock also concentrated for water, and the resultant disturbances prevented successful breeding by waterbirds. While a causal connection cannot be proven, during this same drought period the population of White-naped Cranes (*Grus vipio*) wintering at Poyang Lake declined from roughly 3,000 in the mid 1990s to 1,000-1,500 today (see Li et al. in preparation).

Benefits from Agriculture and Climate Change

The 15 crane species can be roughly sorted by how aquatic their habitat requirements are, with the most threatened of cranes tending to be those most completely reliant on wetland habitats. The Critically Endangered Siberian Crane (*Grus leucogeranus*) is the most thoroughly aquatic of all crane species, while the Endangered Whooping (*G. americana*) and Red-crowned Cranes (*G. japonensis*) likewise depend on water more than their close relatives (Meine and Archibald 1996). Most cranes do show adaptability in the face of landscape change, and also respond to changes in human behavior. Sandhill Cranes (*G. canadensis*) in the 1930s, for example, survived in Wisconsin only in the largest and most remote wetlands. Wetland restoration in the 1940s and 1950s provided more extensive breeding habitats, but the species (now strictly protected from hunting) began to use smaller wetlands for nesting (Hunt and Gluesing 1976). This process has continued, in part due to a growing crane population that now occupies all larger suitable wetlands; pairs now nest in wetlands just one or several hectares in size (ICF unpublished data). Even the Red-crowned Crane has shown significant adaptability. Pairs of the mainland population, where birds are still afraid of people, nest only in large, undisturbed wetlands. But on Hokkaido, Japan where the species is a National Monument and protection very strict, the growing crane population uses almost all available wetlands and still grows, although the species now must often forage in pastures and even roadsides (Meine and Archibald 1996; Yulia Momose, personal comm. 2012).

The most historically successful crane species formerly used grasslands and other uplands for foraging for part or all of the year, and have learned to use croplands in much the same way. Several papers in these proceedings (see, for example, Nowald et al. 2012, Salvi 2012a) document the close association between cranes and agriculture in Europe, and attribute the dramatic recovery and spread of Eurasian Cranes (*G. grus*), sometimes into landscapes where they have not bred for centuries, to the abundant food provided by farming. In the same way, the recovery of Sandhill Cranes in Wisconsin is attributed in part to their adaptation to foraging on corn (maize) fields and other croplands. Cranes are not most abundant in the northern parts of Wisconsin which have the most wetlands, but in the central and southeast parts which have many wetlands among abundant farmlands (Su 2003).

While many ecosystems and the birds that inhabit them face severe threat from climate change, some of the cranes appear to have benefitted in the short term. Eurasian Cranes in Central Europe now migrate and begin breeding earlier (Mewes and Rauch 2012), a change that provides cranes with the opportunity to lay a second clutch of eggs should the first clutch fail. Migrations are shorter, and presumably involve less energy expenditure and hazard, with a substantial part of the population that uses the western European flyway no longer traveling as far south as Spain but stopping for winter in France or even, for a few birds, in Germany (see Salvi 2012b, Prange 2012).

The Black-necked Crane (*G. nigricollis*) inhabits high altitude wetlands of the Tibetan-Qinghai Plateau, migrating relatively short distances to lower elevations in winter. Black-necked Cranes at Cao Hai National Nature Reserve in western Guizhou Province of China prefer sedge meadows and other wetlands, but also forage on croplands (Li and Barzen 2000). In south-central Tibet where wetlands are scarce, Black-necked Cranes roost in shallow side channels of rivers or sandbars and forage on wheat and barley fields (Meine and Archibald 1996). In 1990, the world population of Black-necked Cranes, based on counts at all the major wintering areas, was about 5,600. By the early 2000s, the number had grown to about 11,000 birds – a remarkable increase at a time when most waterbirds in Asia were declining (Bishop and Tsamchu 2007). While the species has benefitted from better protection from hunting, the high altitudes of central Asia have exhibited some of the most dramatic temperature increases on earth (for example, see Shen 2004, Wang et al. 2008), and the milder conditions are presumed to have resulted in higher reproductive success and lower mortality of older birds. In addition, glacial melt may have resulted in more available water in some areas, providing better breeding habitat.

While the Black-necked Crane population has definitely increased, the long-term impacts of climate change may reverse this short-term period of growth. Reduction of permafrost has caused many lakes at high altitudes to dry out, while as glaciers retreat, spring runoff will eventually experience major reductions (Farrington 2009). Yet changing climates are extremely complex across the plateau, with increases of precipitation in some areas that may expand wetlands. An increase in severe weather events, with short periods of very cold temperatures, even if overall temperatures are rising, could lead to mortality among cranes – as has already been documented at Dashanbao National Nature Reserve (Kong Dejun, personal comm. 2012).

Conflicts

Given the extent to which cranes have adapted to foraging on farmlands, it is almost surprising that conflicts with farmers have not been more intense. While cranes use corn fields extensively, and have appeared to expand their distribution in both Europe and North America due to foraging opportunities provided by corn, they do not like to walk among tall plants and thus do not damage standing corn in summer or during the period before harvest. After harvest, they quickly turn to corn stubble for waste grain. Yet cranes do feed on corn immediately after planting in spring and in the early growth period until the food contained in the seed has been used up by the emerging plant (Su 2003).

Tolerance for damage depends to some extent on the farmer. The International Crane Foundation (ICF) has worked with over 50 farming families in Wisconsin and found that attitudes toward the cranes, and crane damage, depends as much on the outlook of the farmer as on what the cranes have done. Farmers live close to wildlife, and have developed varied relationships with their wildlife companions. Su Liying remembers one farmer who complained to her energetically about a hectare of corn seedlings lost to crane damage. This corn had been planted especially to feed the White-tailed Deer (*Odocoileus virginianus*)!

But damage can be great, especially in fields near crane roosting areas and especially close to those wetlands with flocks of non-breeding cranes (see Goroshko these proceedings). When those vulnerable croplands are isolated from farmsteads or roads so that the cranes can feed undisturbed, entire fields of 15 ha or more can be consumed in a few days (Su Liying, personal comm.).

At ICF’s study area in central Wisconsin, the farmer who most disliked the cranes happened to have more cranes on his land than anyone in the area. But he suffered no crop damage because he had learned to coat the corn seedlings just before planting with a fungicide that the cranes found distasteful. They would not eat those seeds but turned to other food sources. Over the next decade, ICF worked with farmers and a manufacturer to develop a non-toxic chemical that tasted bad to the cranes, would remain on the seeds long enough to provide protection for the 2-3 weeks needed, was compatible with the farming machinery in use, and inexpensive enough that farmers would use it (Schramm et al. 2010). As a result of this work, the biopesticide 9, 10 anthraquinone is now being commercially produced as "Avipel," with a general license pending from the U. S. Environmental Protection Agency. Already plans are underway to introduce this repellent for corn fields in South Africa (Kerryn Morrison, personal comm. 2012).

Yet what is economical for farmers in Wisconsin is not for those in East Africa, where the endangered Grey Crowned Cranes (*Balearica regulorum*) likewise cause damage to seedling corn (Jimmy Muheebwa, personal comm. 2012). One of the reasons the species is endangered is poisoning by angry, perhaps desperate, farmers who cannot afford such losses. In addressing crane damage to corn, ICF researchers have believed that farmers should not bear the costs of having cranes on their land. Crane conservationists need to include within their agendas protecting the welfare of those living with the cranes (Harris and Archibald 1999).

Different parts of the world have different opportunities and approaches to prevent crop damage. Lure crops have been effective at Muraviovka Park (Smirenski et al., in preparation) and on the Daurian steppe (see Goroshko 2012). In northern Germany, large flocks of migrating cranes damaged crops. The Germans developed artificial feeding stations that effectively concentrated the cranes away from croplands. As an added benefit, these crane flocks provided spectacular viewing opportunities for tourists. The cranes found substantial natural roosting areas in the nearby shallow lagoon landscape "Vorpommersche Boddenlandschaft" (Nowald 2012).

At the same time, in Japan artificial feeding has meant that crane protection can be achieved without protecting the natural ecosystems on which cranes normally depend. The extreme example is Izumi, where up to 90% of the world's Hooded Cranes (*G. monacha,* a Vulnerable species) and as much as 40% of the world's White-naped Cranes (also Vulnerable) roost within several acres of artificially flooded rice paddy and eat grain and fish put out for them each morning (Amano 2009). Intense concentrations of cranes without natural habitat leads to conflicts with local farmers and potential risks from catastrophic weather or disease events (Meine and Archibald 1996). This situation is in contrast to other areas including nearby China and far eastern Russia, where crane protection has led to the establishment of dozens of nature reserves aimed to protect complex wetland ecosystems and landscapes, with highly valuable ecosystem services benefitting humans as well as a broad array of biodiversity (see Ma and Li 1994, Harris 2009). Artificial feeding here would disrupt the ecology of cranes and risk the loss of globally important wetlands that are currently protected in large part because the cranes depend upon them.

These crane management efforts can also lead to conflicts among crane conservationists. At the Muraviovka workshop, Itai Shanni of Israel suggested to the Germans, who are proud of the spectacular growth in crane numbers, that Europe's cranes have outgrown the capacity of places to the south to support cranes, in particular the Hula Valley in Israel, where too many cranes have led to strong conflict between bird enthusiasts and farmers (Shanni 2012).

Back in Wisconsin, the growth in crane numbers has led to calls for a legalized crane hunt (Beilfuss 2012b). Claims that a hunt would help reduce crop damage are misleading, as the significant damage occurs in spring, and an autumn hunt would not influence crop damage by cranes in May or June unless numbers of cranes were dramatically reduced. Yet the sportsmen, many of them farmers who support crane wetlands on their land, see the growing numbers of cranes as a highly attractive opportunity for a new recreational hunting experience. This dispute may lead to a growing divide between two important conservation constituencies.

The greatest impacts of climate change on cranes and people concern changes in water availability. Wetland ecology is closely tied to the quantity, timing, and quality of water. For discussion of these issues, and case studies that serve to highlight the sensitivity of wetlands and their biodiversity to changes in water supply, see Finlayson and D'Cruz 2005, MA 2005, WWF-UK 2008, Le Quesne et al. 2010, Ramsar Convention Secretariat 2010.

With growing human populations and growing demand for water, conflicts over water have become increasingly severe at local, regional, and national levels (Chellaney 2011, Cooley et al. 2012). Climate change is expected to result in changes in annual precipitation, seasonality of rainfall, evapo-transpiration (in part a reflection of temperature), and increased variability where more extreme events will cause water to rapidly run off the lands during heavy rains while droughts become more frequent and severe, with water shortages affecting growing portions of the human population.

Already across northeast China, the response to rainfall variability and water scarcity has led to large numbers of dams and water diversions. These engineering approaches do not utilize the natural resilience of wetlands, and often directly and seriously impact the “natural infrastructure” and many of the ecosystem services of wetlands that become increasingly important with extreme events and less predictable water flows.

As one example, a system of canals now totally encircles Zhalong National Nature Reserve. These canals are 50 meters wide and have dikes on both sides, completely eliminating overland flows and direct inflow from the Wuyuer River that formerly fed the wetland. Thus this 200,000-hectare wetland has been gradually drying out during the past 15 years. A dramatic fire that burned for months beginning in fall 2001, and a fire that swept across the wetland during the 2005 breeding season for cranes, drew national attention and helped convince government authorities to undertake development of a water management plan for the reserve. This plan led to budget allocations from provincial and city governments to pay for water used for annual releases to maintain wetland function (Harris 2009).

Similarly, construction of upriver dams and canals serving human needs severely reduced the water supply for Keerqin and Xianghai National Nature Reserves so that Red-crowned and White-naped Cranes stopped breeding there – even though the reserves had been established in large part to safeguard breeding cranes. As at Zhalong, ICF supported development of water management plans for these reserves (Harris 2009). There appears to be no immediate mechanism to restore wetlands at Keerqin, so the reserve is likely to support only migrating cranes – with no successful breeding of these threatened species possible. At Xianghai, in 2012, water from the reservoir in the middle of the reserve (which is managed for fish production by another agency) was released into the marshes, benefitting cranes and other waterbirds; this release happened because of abundant water supply, and doesn’t necessarily mean releases will occur in future dry years when releases are most needed.

Mitigation of climate change necessitates expanding development of energy sources that do not release greenhouse gases into the atmosphere. However, as described in a later section of this paper, the Three Gorges Dam on the Yangtze River – developed in good part for hydropower – is having significant impact on water levels downriver, including Poyang Lake that is the only winter home for 98% of the world population of the Siberian Crane (Hua et al. 2012).

Muraviovka Park itself appears to be significantly affected by the construction of the Zeya Dam for hydropower (Sergei Smirenski, personal comm. 2012). The Zeya River enters the Amur a short distance upriver from Muraviovka. Since the dam was constructed in 1975, the Amur River has not experienced the large floods that formerly flowed across the Amur lowlands and scoured the channels and small lakes at Muraviovka and other wetlands (Kazachinskaya 2012). As a result, gradually the wetlands are changing due to accumulations of sediments and vegetation. At present (2011-2012) when rainfall has been relatively good, numbers of White-naped Cranes nesting at the park are higher than ever but nesting Red-crowned Cranes are reduced from a decade ago (Tamaki Kitagawa, personal comm. 2012). White-naped Cranes are less aquatic than Red-crowned Cranes (Su 1993, Meine and Archibald 1996) and can breed in the drier conditions that may represent the future for these wetlands.

While these dams were not built in response to climate change, the need for renewable energy pushes energy development toward hydropower, wind power, and solar. Dams alter natural flows, movements of sediments, and water temperatures, placing further stress on riverine and wetland ecosystems already affected by changes in watersheds, local climates, and human use of fish and plant resources. All these factors make aquatic systems less resilient to impacts of climate change (see Tubbs 2012a, 2012b). Wind farms, with their associated power lines, have been constructed by wetlands at Momoge, Xianghai, and Yanchang National Nature Reserves in China. Power lines associated with the cascade of dams in the Lena River headwaters now run along the Siberian Crane migration corridor up the Aldan Valley in Russia. In the United States, efforts to streamline approval of wind farms on the central plains – the migration corridor for the only naturally occurring flock of Whooping Cranes – raise concerns that placement of wind farms, and the approval process, will not adequately protect the cranes (Stehn 2009).

Over the past 15 years, ICF has been closely involved in efforts to restore environmental flows to the Zambezi Delta, working with dam operators and several agencies of the Government of Mozambique as well as industry and local communities. Construction of the Cahora Bassa Dam ended the seasonal pulse of floods, with significant negative impacts on biodiversity including the loss of breeding Wattled Cranes (*Bugeranus carunculatus*) from much of the delta because its primary food plant *Eleocharis* could not tolerate new conditions across most of the wetlands (Bento 2002). Economic impacts on human communities far exceeded the value of electricity generated by holding back the floodwaters – fisheries declined as did farming on the floodplain (Beilfuss and Brown 2010). There were huge losses to one of the last great wild prawn industries (Gammelsrod 1996), and even sugar cane production was affected. Modeling has indicated that water releases to mimic natural flooding, although not at the scale of historic norms, could provide substantial economic benefits in the delta – for example, mean monthly outflows of 5000 m3 s-1 in December could be achieved in over 90% of years and would only reduce power generation at Cahora Bassa by <3% (Beilfuss 2010). After over a decade of dialogue, the highly diverse range of stakeholders and partners agree that natural flood pulses should be restored to the extent practical, and the project is now expanding in scope to middle and upper parts of the Zambezi, home to most of the world's Wattled Cranes (Beilfuss 2009).

Climate change scenarios predict greatly reduced rainfall and, using a moderate scenario, an increase in average annual temperature of close to 4o C for the Zambezi Basin, leading to a reduction in water availability of 26-40% by 2050 (Beilfuss 2012a). Given the critical importance of the Zambezi to millions of people, a growing human population, and the expected growth in water demand, water management and planning must take into account this grim future. Fortunately, the current work on environmental flows has helped develop the trust and working relations that may make radical rethinking of water use possible, thinking that emphasizes equity in use of shared water and wetland resources, rather than an outdated conceptual framework of people vs. wetlands.

Difficulties of Separating Multiple Causal Factors

As in the examples of the Sandhill and Black-necked Cranes discussed above, multiple factors contribute to growth or decrease of crane populations. In Western Europe the effects of the increase in corn production – that favors Eurasian Cranes – and the warming conditions happening over the same period have not been separated analytically.

Migration and wintering behavior of Sandhill Cranes has also changed. While Robbins (1991) could find only six records as early as 2 March in Wisconsin, with first arrivals usually between 10 and 15 March, a few cranes have wintered in recent years, with earliest migrants arriving from February 14 to 3 March in the last five spring seasons (Kavanagh 2008, 2009, 2011, David 2009, Szymczak 2011, Jeb Barzen, personal comm. 2012). Down Shady Lane Road from ICF headquarters, Sandhill Cranes linger in late autumn in years without snows, as late as December and in 2006 over a thousand birds remained until mid January (Harris 2008). While formerly the eastern population of Sandhills wintered in Florida and adjacent parts of southern Georgia, now a major part of this population – over 10,000 birds – winters at Hiwassee National Wildlife Refuge in Tennessee (Aborn 2010; roughly half way between Wisconsin breeding grounds and Florida). Yet these changes in behavior have also happened over a period of sustained growth for the population – there are simply more cranes in the flyway. While development within interior Florida has left less wintering habitat for cranes, the adaptation of cranes to feeding on corn means that abundant waste grain exists as far north as the fields are free of snow. Thus far, the combination of agriculture practice and warming conditions has brought substantial benefit to the eastern population.

Setting Priorities for Conservation Needs

Professor Zhang Chengyi of the National Climate Center of China studies impacts of climate change on ecosystems. Yet he has advised that the immediate threats to cranes and wetlands from wetland reclamation, water diversions, and other human activities on the land are much greater than the long term threat of climate change. Where multiple threats greatly exceed the people or resources to address them, it might be best to focus on short-term threats. Analyzing an eight-year data set for 253 territorial pairs of

Sarus Cranes (*Grus antigone*) in Uttar Pradesh, India, Gopi Sundar (2011) found that changes in land use and wetland loss posed a far greater threat to breeding Sarus than changes in rainfall patterns.

Agriculture, despite the benefits it has brought to cranes, is a prime example of how the underlying drivers of ecosystem degradation or loss – human population growth and economic development – stress the global environment. In many regions, the human pressures on wetlands are intense and in good part manifested through the diverse forms of agriculture – including cropland development, livestock grazing, and, increasingly, aquaculture.

While conceptually one can try to separate immediate impacts of human activities from the long-term impacts of climate change, the papers in these proceedings indicate how difficult that is to do in practice. Moreover, many impacts of climate change are indirect and magnify the severity of current threats. For example, variability in rainfall and scarcity of water is already a problem for wildlife and for people in the middle and upper parts of the Amur/Heilong Basin. While major uncertainties exist in modeling future climate change scenarios at the regional level, variability in rainfall and extremes of flood and drought are likely to become more frequent, with water supply for human needs less predictable (for example, see Piao et al. 2010). Water shortages may lead to additional attempts to divert water from the rivers and wetlands for urban and agriculture uses, intensifying what is already the main threat to breeding cranes in this region.

As habitat destruction continues, fewer and fewer areas may be available for wildlife, so that cranes and other species lack alternatives when variability in rainfall or other short-term conditions make individual wetlands unsuitable as habitat for cranes. In the early 1980s, for example, Red-crowned Cranes occurred at 28 sites along the coast of Jiangsu Province in winter; in winter 2008-09, the species occurred only at 7 sites (Su et al. 2008, Su in preparation). Reduction and fragmentation of wildlife habitat will become more severe under the increasingly variable conditions of global climate change.

The only naturally occurring Whooping Crane population winters in a limited part of the central Texas coast in and around Aransas National Wildlife Refuge (Meine and Archibald 1996). Whooping Cranes depend for their main winter food on blue crabs that live in the salt marshes, where water is brackish as the Guadalupe River enters the bay and mixes with seawater. When inflows are high, crab populations increase and Whooping Crane mortality is low. During times of drought, freshwater inflows decrease, salinity rises in the shallow marshes, and numbers of blue crabs plummet in areas accessible to the cranes (Chavez-Ramirez 1996, Westwood and Chavez-Ramirez 2005). High winter mortalities of Whooping Cranes have been associated with low blue crab availability (Chavez-Ramirez and Slack 1999, Pugesek et al. 2008).

Impacts of drought are now far more severe than in the past because the growing human population and demand for water have resulted in more water being allocated for human use than flows in the Guadalupe during dry years. In 2008, a drought year, the river almost went dry, the blue crabs became unavailable, and Whooping Cranes lacked food. That winter 23 cranes disappeared, 8.5% of the population (Stehn 2009). While the species can recover from an occasional bad season, climate change is expected to make drought in south Texas more frequent. Conflicts will arise more frequently between human uses of water and the environmental flows needed to sustain estuarine ecosystems, the cranes, and the humans who depend on crabbing or tourism for their livelihoods.

The Whooping Crane Recovery Plan has set a target of 1,000 Whooping Cranes for the flock that winters in Texas, if efforts are unsuccessful at establishing one or two other self-sustaining populations; only with this target achieved would the species be considered secure enough to be reclassified from endangered to threatened (Canadian Wildlife Service and U.S. Fish & Wildlife Service 2007). Given the development pressures on the Texas coast, efforts are needed now to protect sufficient habitat for 1,000 Whooping Cranes in the future. Yet this effort would be futile if it disregarded sea level rise predicted from global climate change (Chavez-Ramirez and Wehtje 2012). Rising sea waters would submerge much currently available crane habitat while creating new habitat inland if those areas could be protected from building construction and other incompatible development (Montagna et al. 2007). Thus land protection strategies need to target lands that currently are not suited to cranes.

Poyang Lake in China provides another example of the interaction of long-term climate change with short-term threats. Poyang is the winter home for almost all the world's Siberian Cranes, and there appears to be no other suitable habitat in the Yangtze Basin that could replace Poyang's shallow wetlands as crane habitat (Barzen et al. 2009).

As a response to floods and growing energy needs, and as a source of clean energy, China is constructing a series of dams on the Yangtze River and its tributaries (Gleick 2012). Already the Three Gorges Dam has had significant impact on downriver stretches of the Yangtze, including lowering water levels in winter (Hua et al. 2012). Accompanying these changes, Poyang Lake, which empties into the Yangtze, has suffered severe winter drought in three of the past five years, all during the short period that the Three Gorges Dam has been operating (Jiangxi Water Bureau, unpublished data). While wintering cranes and other waterbirds appear to have adjusted and found food within the lake basin (Barzen et al. 2011, ICF unpublished data), human activities have been severely affected, including fisheries, navigation, irrigation of rice paddies in autumn, and the general water supply. During these winter droughts, earth moving equipment can operate in normally inaccessible edges of the lake basin, so that new dikes are being built that reduce the lake area and wetland habitats for waterbirds (Ji Weitao, personal comm. 2012). A multiplicity of factors seems to be involved in these unusually low winter water levels (Harris and Zhuang 2010), including Three Gorges Dam, sand dredging that potentially could be increasing the width and depth of the outflow channel (de Leeuw et al. 2010), operation of thousands of dams on the five rivers that feed into Poyang Lake and more extreme weather – for example, severe flooding in summer 2010 followed months later by severe drought, then another drought in fall 2011, which ended during three weeks from late February to mid March 2012, when the lake waters rose nearly five meters due to intense rain (Jiangxi Water Bureau, unpublished data).

Water officials maintain that the only way to correct these changes and threats to Poyang Lake ecology and provincial economic interests is to build sluice gates across the outlet to Poyang in order to prevent excessive lowering of water in winter. The future of the lake, its wetlands, and the Siberian Crane depends on decisions regarding these sluice gates, and how they are operated if constructed (Finlayson et al. 2010). Climate change appears to be one significant element in this situation, given the unusual number of floods, droughts and other extreme weather in recent years, and the urgency it has lent to hydropower development as a clean energy source.

The Way Forward

Participants in the 2010 workshop at Muraviovka Park daily saw White-naped Cranes fly out from the wetland to forage on the farmlands. They also saw that the park has an active farm program on 800 hectares of prime cropland on the terrace that overlooks the wetlands below, lying within the ancient river channel. For the past fifteen years, the park has been practicing agriculture methods that serve to protect the wetlands as waterbird habitat (Smirenski et al. in preparation). Protected wetlands throughout the world occur adjacent to productive farmlands, so that management of wetlands by necessity needs to include promoting agriculture practices that enhance ecosystem health. Fortunately clean water supply and reduction in chemical use are important to people as well. At the same time, protection of wetlands helps stabilize water supply for surrounding areas, reducing variability in river flows and the impacts of floods and droughts.

The Anbyon project in the Democratic People's Republic of Korea (DPRK) exemplifies the advantages of integrating needs of people with wildlife when developing conservation strategies (Healy 2011). Anbyon lies not far northeast from the Choelwon Basin, now a globally important wintering area with two-thirds of the mainland population of Red-crowned Cranes (Lee and Yoo 2010) and roughly a third of the world's White-naped Cranes (Lee Kisup, personal comms, 2009-12). Crane numbers at Choelwon have increased due to human hardship in DPRK, where hungry people gleaned the waste grain from the fields in autumn, leaving no food for cranes. Anbyon, once supporting over 200 wintering Red-crowned Cranes, was abandoned by the cranes. Yet Choelwon does not have a secure future, as it lies along the Demilitarized Zone and is only protected due to the tense relations on the divided peninsula. Should the two Koreas reunite, many people hope to build a city where the cranes now find a winter home at Choelwon. A conservation priority for East Asia is to restore additional wintering areas for cranes. A warming climate would increase the suitability of northern parts of the peninsula for cranes.

The lands at Anbyon, that formerly served the cranes, now support Pisan Cooperative Farm. In developing a crane project, ICF, BirdLife International, and partners within DPRK integrated measures to restore crane habitat and food sources with assistance to Pisan Cooperative Farm in mechanizing its farming operations while minimizing on-going costs through organic farming. The result was better crop yields without chemical inputs, and a healthier environment for people and cranes.

Minimizing use of pesticides and fertilizers on farmlands adjacent to protected wetlands will help improve water quality for the benefit of wildlife and people, especially when coupled with practices such as the provision of buffers of natural vegetation to intercept runoff from fields before it can enter wetlands. As at Muraviovka Park, demonstrating sustainable agriculture adjacent to protected wetlands can help to influence farming practices in other areas.

As for the concern that impacts of climate change are less immediate, and conservation responses less urgently needed than for threats such as habitat destruction and human disturbance, we have seen that climate change interacts with and often intensifies these immediate threats. Adaptation to climate change involves increasing the resilience, whether of natural systems or of human communities, to increased variability and decreased predictability of environmental conditions. Resilient ecosystems are more likely to function and provide benefits despite changes in water supply either short-term or long-term. Adaptation measures should be flexible (helping prepare for different future scenarios) and adaptable (ready to adjust to impacts of earlier actions or changes in water supply or other external factors). For further information on climate change impacts and on adaptation, see the two articles by N. Tubbs in these proceedings, as well as online knowledge exchange platforms such as: Climate Adaptation Knowledge Exchange www.cakex.org; Adaptation Learning Mechanism http://www.adaptationlearning.net/; the European Climate Adaptation Platform http://climate-adapt.eea.europa.eu/; the Climate Change Knowledge Portal http://sdwebx.worldbank.org/climateportal/index.cfm; and the Ecosystems and Livelihoods Adaptation Network http://www.elanadapt.net/.

Thus climate change adaptation favors an ecosystem approach to wetland management, an approach that considers the system as a whole as well as the processes that drive the system, and attempts to maintain or restore those balances. An ecosystem approach increases resiliency, flexibility, and adaptability – in contrast to engineering approaches that typically attempt to regulate systems through dikes, dams, and other infrastructure that generally lack such qualities.

Climate change adaptation is best integrated as an essential component of conservation strategies addressing immediate threats, so that today's solutions will serve us well into the unpredictable future (see Glick et al. 2011). Climate change adaptation also is most effective when integrating management of natural systems with measures to increase resilience and flexibility for human communities nearby (for example, see Girot et al. 2012). In April 2012, ICF together with Chinese partners initiated such a demonstration project at two national nature reserves in northeast China – Momoge, where most of the world's Siberian Cranes rest on both spring and fall migration, and nearby Tumuji. These areas suffer from over-grazing as livestock degrade grasslands even though herd sizes have been greatly reduced, while some government policies have encouraged irrigated crops that increase dependence on groundwater so that the constraints of rainfall and limited surface water supply are effectively postponed. This project will assess the vulnerability of a pilot community to climate variability and explore solutions that protect water and other local resources while enhancing livelihoods in a sustainable manner. Water conservation, wetland protection, and the already growing tourism for viewing cranes and wetlands provide communities with more livelihood options and resilience to the impacts of climate change, while providing common purpose with the conservation objectives of the nature reserves.

Follow Up to the Muraviovka Workshop

The workshop participants agreed upon several activities to be undertaken by participants and other members of the Crane Specialist Group. As water is the most crucial resource in terms of impacts and conservation response to climate change, we wish to develop a booklet or manual that can help guide crane specialists and wetland managers as they manage water to sustain crane habitats. In addition, we plan to develop a series of factsheets that assembles what is known about direct and indirect impacts of climate change on the different crane species. This effort will begin with Eurasian and Sandhill Cranes.

We also are preparing a booklet or manual that reviews issues related to agriculture and crane conservation, presenting our experience to date, lessons learned and guidance for how to minimize conflicts while maximizing benefits for cranes and farmers. A workshop on crane conservation and sustainable agriculture is planned for late 2012 in China, as an opportunity to review draft materials in preparation for the cranes and agriculture publication, and to think together about agriculture issues as they relate to cranes of North East Asia.

Finally, the Crane Specialist Group is developing a Crane Conservation Plan that will provide an overview of the status, threats, and priority conservation needs for all 15 of the world's crane species, thus updating the IUCN Crane Action Plan (Meine and Archibald 1996). Issues related to agriculture and climate change will receive significant attention, together with other threats and the most strategic conservation responses.

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IMPACTS OF CLIMATE CHANGE ON PEOPLE AND WETLAND ECOSYSTEMS

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Abstract: Climate change is unequivocal and widely covered in the media globally. The media often debate the credibility of scientific evidence but that in no way affects the validity of climate change. Changes in climate are being observed across each continent and consequences are already being felt. Climate change will not affect all places, ecosystems and people equally; some ecosystems are more vulnerable than others. In particular, systems with low levels of flexibility, robustness and resilience could be near passing ecological tipping points. If so, the services provided by these ecosystems will be lost. Climate change comes on top of other drivers of change, and should not be considered in isolation. Other such drivers or pressures of change are human population growth and economic development or poverty alleviation in developing countries. Impacts of these other drivers of change and the need for conservation response are generally considered as a priority above climate change. Climate change is not sector-specific and is cross-cutting to many disciplines, including nature conservation and health. Global policy response to the pressures posed by population growth and the need for poverty alleviation and economic development are known as the Millennium Development Goals. One of these goals is to maintain the integrity of natural resources, but adapting to climate change is not yet included. This paper addresses the diverse impacts of climate change and what the often misunderstood terms of vulnerability, flexibility and robustness entail. It also examines effects of climate change on ecosystem services, which have critical relevance to the future for nature and people.

Keywords: Climate change, ecosystem services, natural resources, poverty alleviation, tipping point

Numerous examples of changes in climate can already be found across continents and are affecting ecosystems and people. Considering that the world population today is of six billion and estimated to reach nine billion by 2050, one can only anticipate further changes in climate and increasing pressures on ecosystems and livelihoods.

Such changes require adaptation strategies from both communities and ecosystems to avoid unmanageable impacts and manage the unavoidable ones. Climate change adaptation relies on the thorough understanding of the terms 'flexibility,' 'resilience', and 'robustness' properties for species, ecosystems, and communities:

- *Robustness* is the resistance and persistence (e.g., of an ecosystem) to changing conditions. For example, keystone species may go extinct because of an increase in temperature while other species can compensate over various time scales (e.g., demographic or evolutionary; see Lenski et al. 2006) and hence have higher robustness capacity.
- An ecosystem's *resilience* refers to its ability to recover from perturbations and damaging events, whether these are drastic or gradual changes. Resilience relates to the return to a stable state.
- Flexibility is the capacity of a system to respond or adjust to changes in parameters, both internal and external.

Resilience can be illustrated by a wetland, which returns to its normal water chemistry after acidic rains. This wetland's fauna and flora adjust to changes in pH levels and are therefore flexible.

The greatest implication of population growth is that of water demand, whether for drinking or agricultural purposes. Water is *the* common factor across ecosystems, and freshwater ecosystems are

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intimately connected with the surrounding marine, estuarine and terrestrial biomes. Freshwater ecosystems are embedded in a human matrix. Therefore, human wellbeing will rely increasingly on climate information necessary for efficient management of the hydrological cycle (water resources and water services).
Changes in climate follow three main scenarios, each impacting ecosystems (Fig.1):

- Gradual changes in the 'mean' climate, to which the ecosystem matches and adapts (a rarely occurring scenario).
- Changes in climate variability resulting in an increase in number and intensity of extreme events (e.g., droughts and floods), having significant impacts on ecosystems and livelihoods (common scenario).
- State level or stepwise climate change pushing ecosystems to pass their tipping points (common scenario).

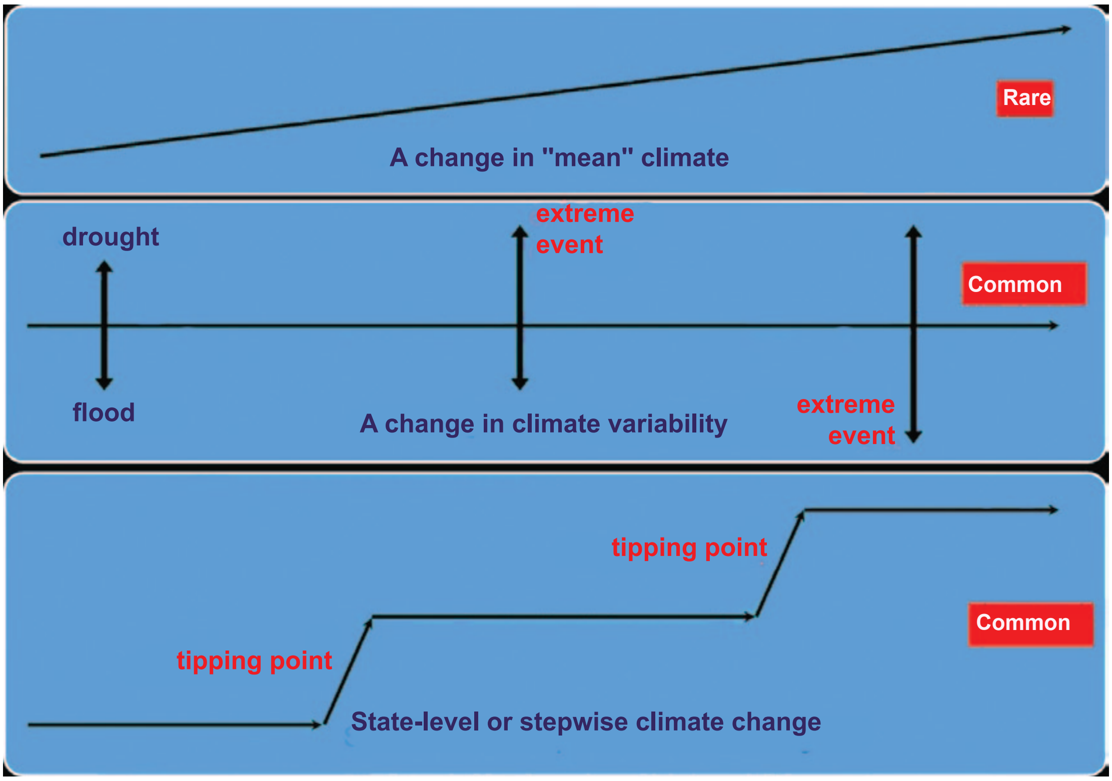

Fig. 1. The three different scenarios of climate change (Source: WWF)

The worst effects of climate change come from synergies between impacts and human activities. Ecosystems respond to changes in 'mean' climate, changes in climate variability, and to state-level or stepwise climate change. Water timing or water seasonality is the normal annual pattern of high and low water. For wetlands and lakes, this is called hydroperiod and is probably the most climate-sensitive aspect of freshwater ecosystems related to shifts in precipitation patterns. Many species are very sensitive to changes in water timing, and freshwater ecologists call water timing the master variable for wetland ecosystems.

Evidence of impacts of climate change come from three principal sources: (1) direct observation of changes (both recently and in the distant past) that can be clearly linked to climatic variables; (2) experimental studies (using manipulations to increase CO_2 or temperature for example) and (3) modelling studies. Modelling is currently the most popular since it is based on our current understanding of specific requirements and constraints (e.g., on the distributions of species and ecosystems) combined with climatic variables; modelling projects the impacts of changes in the climate and predicts changes (e.g., in populations and future distributions). A wide range of modelling techniques is being used, each with its advantages and constraints.

The impacts of climate change can be observed globally and are already affecting people and ecosystems. The direct changes in the climate system are temperatures, precipitation patterns and wind velocity. In addition, geo-physical impacts include sea-level rise, saltwater intrusion, and changes in soil and water chemistry, discharge patterns, and evaporation.

It is commonly accepted that global human activities have had a significant influence on these variables. Considerable information is currently available, although regional changes remain subject to high uncertainties due to a number of other factors (adaptation, non-climatic drivers).

Below are several examples of such changes.

RAINFALL AND TEMPERATURE (VARIABILITY)

Global average temperatures have risen by 0.7ºC over the last century and are predicted to continue rising, with increases ranging from 1.1ºC to 6.4 ºC by the end of the 21st century relative to the 1980-1999 baseline (Fronzek and Carter 2007). Current climate change scenarios predict an increase of two degrees Celsius globally (Fig. 2). The magnitudes of impact can therefore be estimated more systematically based on these ranges and possible scenarios.

Predictions for precipitation, however, are less confident due to the influence of regional processes (Fig. 3). A distinction is then required between annual and intra-annual scale of resolutions and projections. Rainfall may be projected to increase, decrease and/or change in seasonal distribution pending on the region even though uncertainty about climate projections persists. The most relevant for planning conservation and development actions at the local level is obviously the shift in seasons, which is particularly crucial to freshwater ecosystems (Poff and Zimmerman 2010). For example, there has been a fourfold increase in permanently dry ponds in Yellowstone over the last 16 years, directly linked to dramatic declines in amphibian populations and diversity (McMenamin et al. 2008).

An example of direct impact of the variability of rainfall and temperature is glacial melt.

Among the most vulnerable regions are those where water comes mainly in the form of winter snowfall and stream-flow, largely from spring and summer snowmelt. In such areas, a temperature increase is likely to induce an increased winter runoff and a reduced spring and summer flow. For some of these areas, this shift would alter flooding patterns with increased risk for late winter flooding and the likelihood of reduced availability of irrigation water during periods of high demand. The changes in runoff would, however, not only depend on changes in precipitation, but also on the physical and biological conditions within the catchment.

WATER LEVELS – SEA LEVEL RISE

Sea levels are estimated to rise between 1, 5, and 9 meters in the coming decades due to thermal expansion of ocean water and melting of glaciers and ice caps. Already, since pre-industrial times, sea levels have risen globally between 1, 2, and 5 meters. Increased sea levels will likely force coastal ecosystems to migrate inland. However, this migration path could be obstructed by inland land uses or by the ability of these systems and their components to migrate. For example, many coastal and estuarine wetlands will be unable to migrate inland due to the presence of dikes, levees or specific human land uses close to the coastal area (Kusler et al. 1999).

Higher sea levels and increased storm surges could also adversely affect freshwater supplies available from coastal wetlands due to salt-water intrusion (Frederick and Major 1997). Salt water in delta systems would advance inland affecting the water quality available for agricultural and domestic and industrial use. In many delta and coastal areas the reduction of sedimentation due to sea level rise, dam construction and ground subsidence are already a threat to the livelihoods of coastal communities. Sea level rise would double the global population at risk from storm surges (from around 45 million up to 90 million). Examples of particularly sensitive areas include small island states, Bangladesh and other states in Southeast Asia, north-western Europe, the southern Atlantic coast and the Gulf of Mexico in the United States. Coastal erosion is considered one of the main impacts of sea level rise (Parry et al. 2007). Increased coastal flooding, loss of habitats, an increase in the salinity of estuaries and freshwater aquifers, and changed tidal ranges in rivers and bays, transport of sediments and nutrients, patterns of contamination in coastal areas are among the main effects of coastal erosion. Accelerated rates in sea level rise will likely result in shifts in species compositions, together with a reduction in productivity and function (Warren and Niering 1993).

These changes will affect both surface and groundwater systems (e.g., recharge and flow) and impact ecosystem requirements, domestic water supply, irrigation, hydropower generation, industrial use, navigation and water based tourism. Major impacts on regional and temporal water distribution and availability are therefore to be considered.

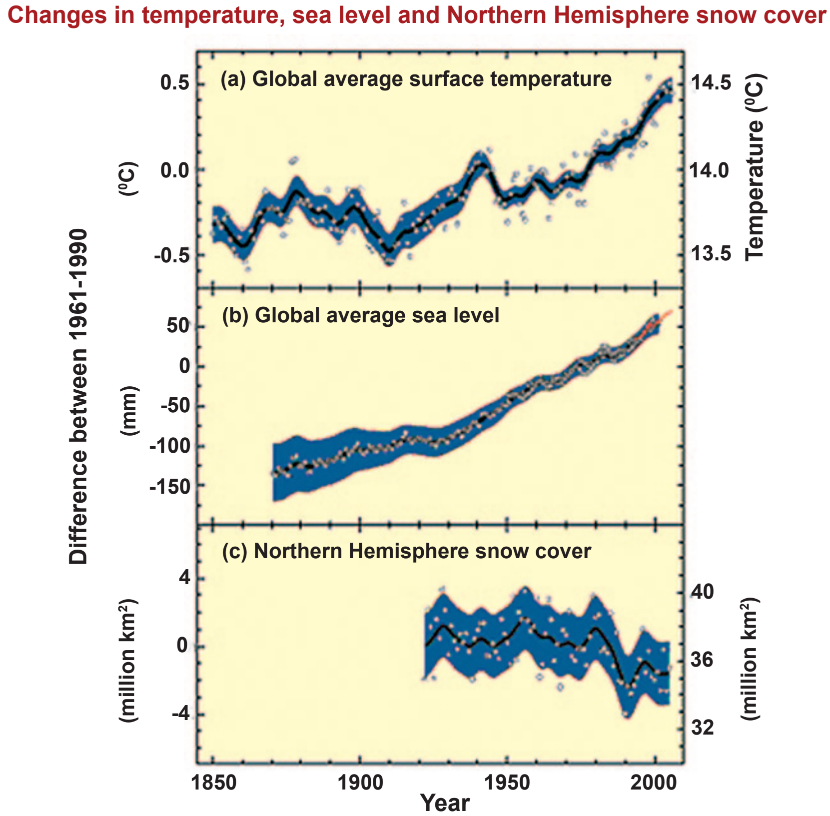

Fig. 2. Observed changes in (a) global average surface temperature; (b) global average sea level from tide gauge (blue) and satellite (red) data; and (c) Northern Hemisphere snow cover for March-April. All differences are relative to corresponding averages for the period 1961-1990. Smoothed curves represent decadal averaged values while circles show yearly values. The shaded areas are the uncertainty intervals estimated from a comprehensive analysis of known uncertainties (a and b) and from the time series (c). Source: IPCC

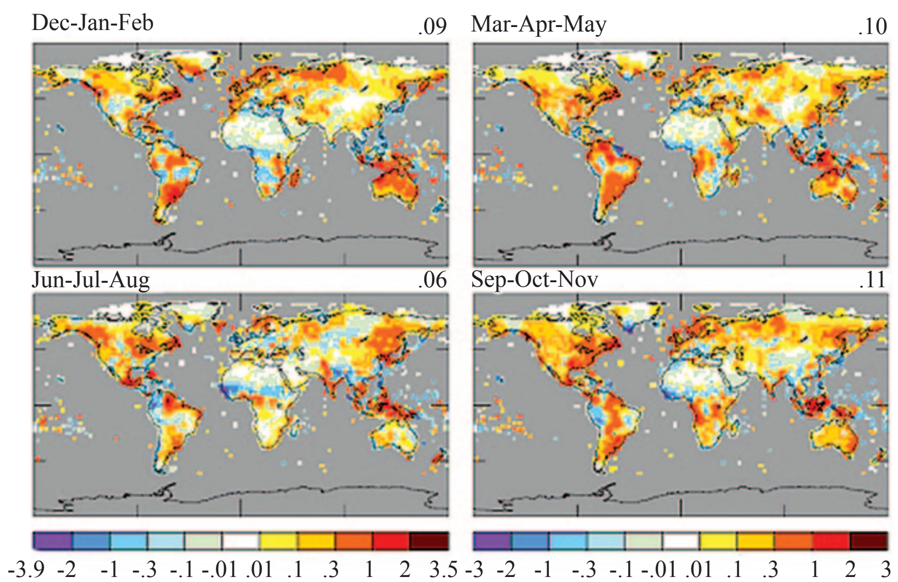

Fig. 3. Changes in precipitation (1901-2000) in mm/day based on local linear trends. Source: NASA

An example of direct impact of sea level rise is erosion. Throughout the 20th century, the global rise of sea level contributed to increased coastal inundation, erosion and ecosystem losses, but the precise role of sea-level rise is difficult to determine due to considerable regional and local variation from other factors. In the late 20th century effects of rising temperature include loss of sea ice, thawing of permafrost and associated coastal retreat at high latitudes, and more frequent coral bleaching and mortality at low latitudes.

CHEMISTRY OF SOIL AND WATERS

Changes in climate will affect soils in terms of acidification, eutrophication, and land cover change (Fig. 4), including change in composition of terrestrial systems and agricultural expansion. Also, a number of factors are affecting Arctic soils: (1) reduced ice-cover duration on lakes (in the northern Arctic areas especially), (2) the increased and more rapid stratification, (3) earlier and increased primary production, and (4) decreased oxygenation at depth (Chapin et al. 2005, Conlan et al. 2007, Durance and Ormerod 2007). Acidification is an increasing threat to oceans also because of their uptake in anthropogenic carbon dioxide. The decrease in pH is already being observed, especially at the surface of oceans.

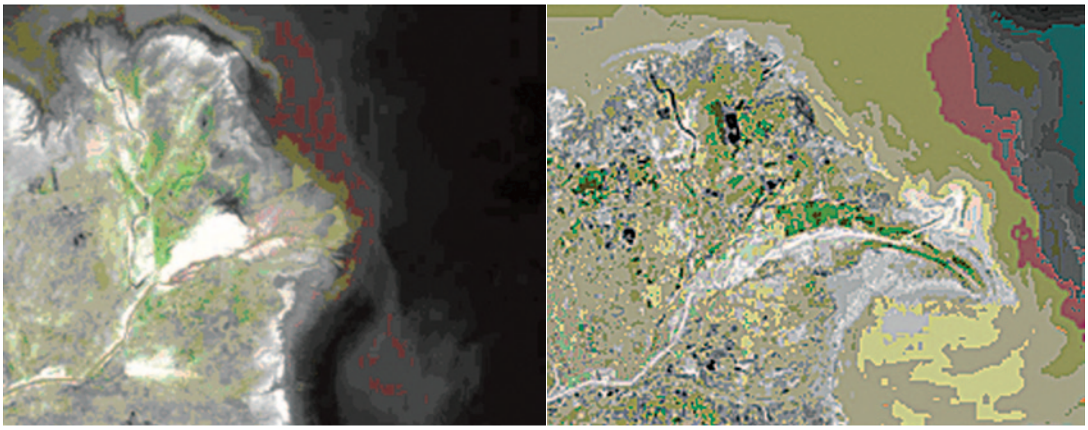

Fig. 4. Illustration of agricultural expansion in Huang He Delta, China. 1979 (left): Agricultural lands were few until land reclamation efforts began in the 1950s. Only thirty years ago, this place was a vast expanse of saline alkaline soil with limited agriculture. 2000 (right): Between 1979 and 2000, the delta tip grew nearly 100 square km. Aquaculture has expanded along much of the coast and agriculture overall is better developed. Source: UNEP (2003), "Selected Satellite Images of Our Changing Environment"

WEATHER EVENTS (STORM INTENSITY)

An increase in the frequency and the severity of extreme events is likely in reference to hurricanes, tornadoes, catastrophic rainfall and drought (Fig. 5). This trend is of particular importance when linking ecosystem services to climate change, but also for adaptation and mitigation strategies. Worth noting here is that the increase in number and intensity of extreme events will first affect local communities (e.g., smallholder and subsistence farmers, artisanal fisher folk) whose adaptive capacity is constrained. In the longer term, there are likely to be additional negative impacts of other climate-related processes such as snowpack decrease especially as it affects the Indo-Gangetic Plain, sea-level rise, and a spread in the prevalence of human diseases affecting agricultural labour supply. Coasts are highly vulnerable to extreme events, such as storms, which impose substantial costs on coastal societies. Annually, about 120 million people are exposed to tropical cyclone hazards that killed 250,000 people from 1980 to 2000.

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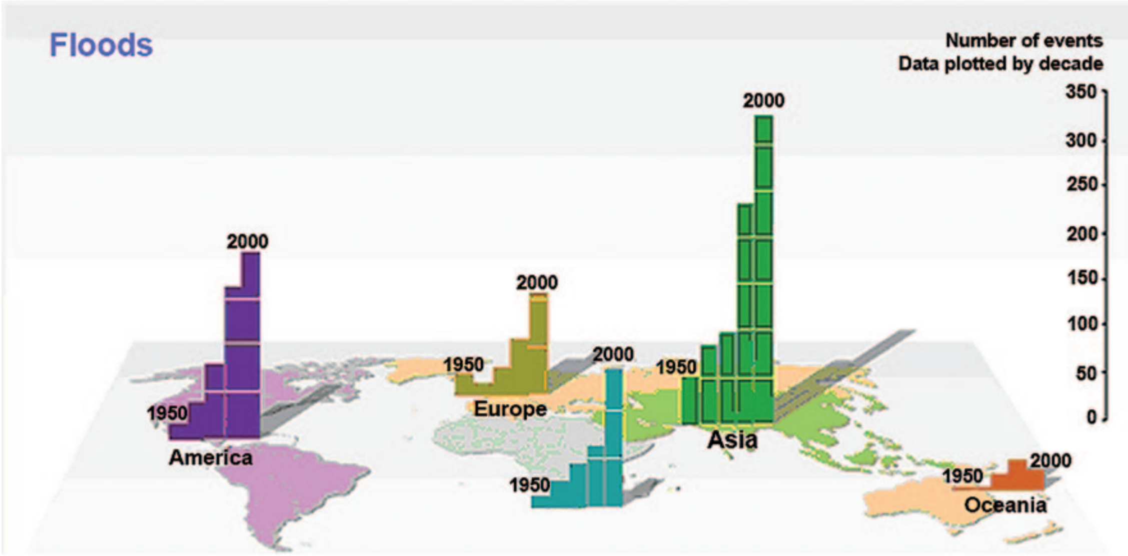

Fig. 5. Number of flood events by continent and decade since 1950. Source: Millennium Ecosystem Assessment

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ADAPTATION STRATEGIES FOR PEOPLE AND WETLAND ECOSYSTEMS

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Abstract: Climate change is a major global threat that impacts ecosystems and the services they provide. The most effective approach to adapting to changes in climate is focusing on water. Adaptation is necessary to address impacts resulting from changes in climate and to reduce our vulnerability to future climate change; yet these actions are seldom undertaken in response to climate change alone. Pressure is growing on the cities to change their approach to planning and growth as the current simple supply/demand approach will be catastrophic. There is increasing recognition that climate change is as much a development problem as it is an environmental one and adaptation strategies can prove to be highly cost-effective, although comprehensive estimates of adaptation costs and benefits need to be taken into account. In addition, adaptive capacity is uneven across and within societies. Flexibility is perhaps the clearest and simplest message for adaptation. Effective policy needs to involve a portfolio of diverse adaptation and mitigation actions to avoid conflicts during implementation.

Keywords: Climate change adaptation; cost-effectiveness; ecosystem-based approaches; ecosystem services

ECOSYSTEM SERVICES

Ecosystem services provide significant social, economic and ecological benefits. Wetlands capture and bridge issues relating to water, yet the vast majority of what we know about wetlands is valid for all other ecosystems. Ecosystem services provided by wetland ecosystems and coastal areas are estimated to be 15.5 trillion USD a year, which represents 46% of the total value of services provided by ecosystems globally (Reist et al. 2006, Wrona et al. 2006a, Wrona et al. 2006b).

Wetland ecosystems provide fundamental ecological functions including the regulation of water regimes as well as providing habitats for flora and fauna. Human populations also benefit from these ecosystems’ invaluable services such as their regulatory role of global and local climates. Wetland functions can generally be grouped into three types: (1) regulation, (2) provision of habitats, and (3) production. Wetland ecosystems provide globally significant benefits, whether it is socially, economically or environmentally.

However, changes in climate (both those forecast and the ones already observed) pose a serious threat to the ecosystem services provided by wetlands, thus adding to other major threats (e.g., (1) increased demand for agricultural land associated with population growth; (2) infrastructure development and river flow regulation; and (3) the invasion of non-native species and pollution) and further contributing to changes in the climate.

Wetlands regulate both water quantity and quality (Anisimov et al. 2007, Dudgeon 2007, Berry 2008). Several types of wetlands are known to act as hydrological buffers such as floodplain wetlands, which store water when rivers come out of their banks and therefore reduce flood risk downstream. Such services are often of considerable value, especially when infrastructure alternatives to regulate the quantity of flow are much more expensive. Wetland plants (e.g., reed beds) are known to be important regulators and biofilters due to their capacity to remove toxins and excessive nutrients from the water. The maintenance of many complex biological processes involving soils, water, plants, animals, and micro-organisms is necessary to sustain these ecosystem services.

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Ecosystem services provided by wetlands also include provision of resources for direct human consumption such as drinking water, fish and fruit, reeds and timber for construction and finally peat and wood as a fuel source (Reist et al. 2006, Wrona et al. 2006a, Wrona et al. 2006b, Anisimov et al. 2007, Dudgeon 2007, Berry 2008). Wetland ecosystems also provide opportunities for recreation, aesthetic experience and reflection (e.g., fishing, sport hunting, bird watching, photography, and water sports). Such activities are of tremendous economic value considering tourism is one of the leading income generating industries globally.

Gradual changes in the services provided by an ecosystem may be hard to detect, but then the ecosystem passes a certain threshold or tipping point and transitions into a new ecosystem state. These ecosystem transitions often happen quite rapidly, in less than a decade. For instance, wetlands that are only occasionally eutrophic in summer may, with warmer water temperatures, become eutrophic during other seasons, perhaps even reaching a third stage where they are eutrophic in part of winter.

The first impacts and changes are to be expected at the boundaries between ecosystem types. Large changes in ecosystem distribution are expected in the tropics due to the effects of rising temperatures and reduced precipitation. Such changes are exacerbated by the effects of land-use change, which also impacts on biodiversity by reducing the ability of organisms to adjust in response to a changing climate.

Rare and endangered plant and animal species with sensitivity to small temperature changes often have no alternative habitat, especially in isolated areas such as those in mountainous and alpine wetlands. Coastal wetland flora and fauna generally respond to small, permanent changes in water levels. However, the degree to which they are able to adapt to these changes will depend to a great extent on the ability for species to 'migrate' to alternative areas.

Many species will have difficulty responding to extreme events even if mean climate variables stay roughly the same. The overall stress on species will increase significantly.

The responses by species to climate change are complex and each species is different, so that generalized "rules" cannot describe how all species are reacting. However, the following responses can be distinguished:

- Species respond to climate change by changes in range (e.g., pole-ward shifts and upward shifts in mountainous systems) (see Figs. 1 and 2).
- Species respond to climate change by changes in the timing of biological events such as migration or breeding (as one example, however, decreased water flow in summer is likely to decrease habitat availability and may prevent seasonal habitat shifts of migrating fish) (Reist et al. 2006, Wrona et al. 2006a, Wrona et al. 2006b).
- Species respond to climate change by changes in species composition and abundance. Species less tolerant of new conditions give way and/or are replaced by others, for example, by those with greater tolerance for warmer and drier conditions (Xenopoulos et al. 2005, Gopal and Chauhan 2006, Xenopoulos and Lodge 2006).
- Climate changes affect species genetic diversity. This impact has so far not been the subject of much research, yet it is highly probable that impacts on genes will be a direct consequence from fragmented habitats and hence fragmented populations, both at a microevolution (generations) and at macroevolution levels in the course of thousands of years. Competition, as well as interactions between diseases and hosts-parasites, will be affected among plants and animals, including human beings. The various impacts combined are expected to lead to changes in pollination, predator-prey interactions, and human health.

The interaction between climate change and land cover is likely to lead to reduced discharge from many rivers that will in turn lead to significant loss of freshwater fish species. Climate change can also facilitate the spread and establishment of invasive species impacting ecosystem composition and eventually the services it provides. Changes in climate can even trigger native species to become invasive. Compositional changes in fish communities have already been observed, such as increases in species richness, proportions of warm water species and total abundance. Climate change will also influence invasive establishment by increasing the virulence of some diseases.

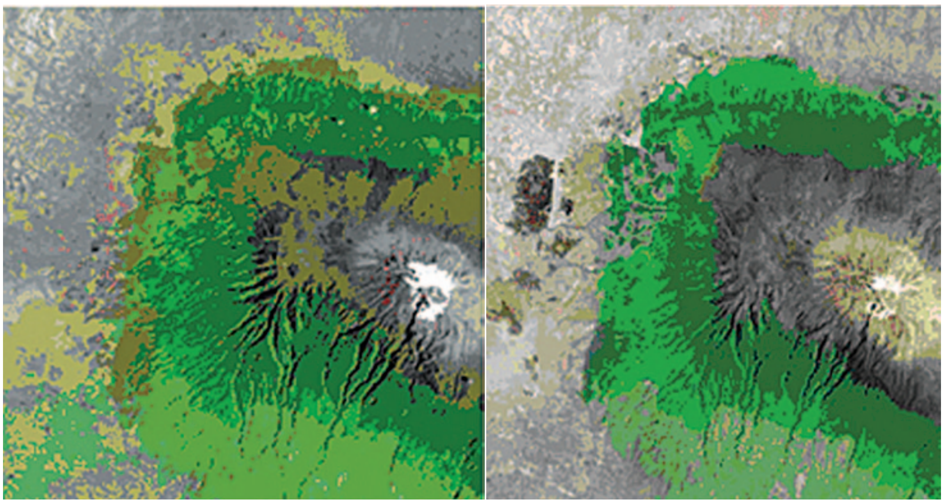

Fig. 1. Illustration of a mountainous ecosystem particularly affected, Mt Kilimanjaro. 1976 (left): A forest belt spans altitudes between 1,600 and 3,100 meters surrounding Mt. Kilimanjaro. Green shows natural vegetation and brown shows desert areas. 2000 (right): This image shows large tracts of indigenous forest that have been converted into other land uses, representing about 12 percent of the Kilimanjaro Forest Reserve. Source: UNEP (2003), "Selected Satellite Images of Our Changing Environment"

LIVELIHOODS

The quantity and quality of water supplies already represent a serious problem today in many regions, including some low-lying coastal areas and small islands, that become particularly vulnerable to reduction of local water resources. For example, recharge of aquifers through seasonal inundations of floodplain areas represents an important process for the maintenance of these water resources, upon which many human communities in these arid and semi-arid regions depend (see Fig. 3). Also, it is worth considering community heterogeneity since not all within a community will be affected equally by changes in climate, whether it is women or minorities for example, each having different adaptive strategies.

Changes in flow regimes and water levels, for instance, impact largely on the status of inland wetlands. The impacts of climate change on the ability of mountainous (and coastal) ecosystems to regulate water flows are of great concern, since it critically reduces the ability of communities to access drinking water.

A key consideration for food security is that of fisheries. Fisheries may improve in the short term in boreal regions though decline is to be expected elsewhere. Due to increased flooding and the degradation of freshwater, fisheries decline could impact hundreds of millions of people, and socio economic costs for coasts are virtually certain to escalate as a result of climate change. Sea-water intrusion could increase the habitat of brackish-water fisheries but significantly damage the aquaculture industry. Overall, sea level rise is expected to exacerbate already declining fish productivity in Asia. Arctic marine fisheries would be greatly influenced by climate change, with some species, such as cod and herring, benefiting at least from modest temperature increases, and others, such as the northern shrimp, suffering declining productivity. Warming of areas of the northern polar oceans has had a negative impact on community composition, biomass and distribution of phytoplankton and zooplankton. The impact of present and future changes on higher predators, fish and fisheries will be regionally specific, with some beneficial and some detrimental effects (Xenopoulos and Lodge 2006). Fisheries make an important contribution to the GDP of many island states. Impacts on commercial and artisanal fisheries will directly affect local, national, and eventually international economies.

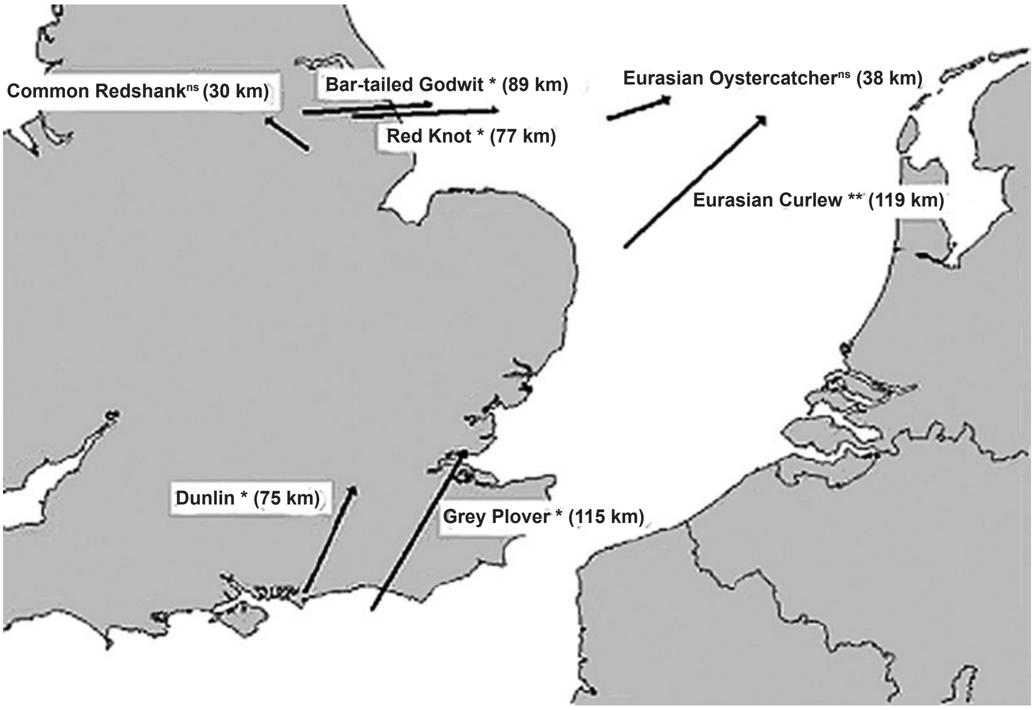

Fig. 2. Climate change and bird redistribution. Direction and magnitude of shifts in the weighted centroids of populations of seven species of waders between January 1981 and January 2000. The vectors are derived by fitting a straight line through the location of the centroid of the wintering population each year, calculated using geographical locations of each site, and weighting the calculation by the number of individuals occurring on that site. The arrows are plotted in such a way that the start and end points correspond to the actual locations of the weighted centroids as predicted by the line of best fit. Significance of these relationships is also indicated as: ns (not significant); * (Po0.05); and ** (Po0.01). Source: Maclean et al. 2008

At this early stage the health effects related to changes in climate are small, but are projected to progressively increase in all countries and regions. Projected climate change-related exposures are likely to affect the health status of millions of people, particularly those with low adaptive capacity, through:

- increases in malnutrition and consequent disorders, with implications for child growth and development;
- increased deaths, disease and injury due to heat waves, floods, storms, fires and droughts;
- the increased burden of diarrheal disease;
- mixed effects on the range (increases and decreases) and transmission potential of malaria in Africa;
- increased frequency of cardio-respiratory diseases due to higher concentrations of ground-level ozone related to climate change; and
- altered spatial distribution of some infectious disease vectors.

Those at greater risk include, in all countries, the urban poor, the elderly and children and women, traditional societies, subsistence farmers, and coastal populations.

ADAPTATION

Adaptation in the context of climate change can be defined as a deliberate management strategy to minimise the adverse effects of climate change, to enhance the resilience of vulnerable systems, and to reduce the risk of damage to human and ecological systems from changes in climate. "Climate change preparation" is probably a more accurate description than the somewhat confusing term "adaptation," especially to the general public.

Adaptations vary according to the system in which they occur, who undertakes them, the climatic stimuli that prompts them, and their timing, functions, forms, and effects. In unmanaged natural systems, adaptation is autonomous and reactive; it is the process, by which species and ecosystems respond to changed conditions.

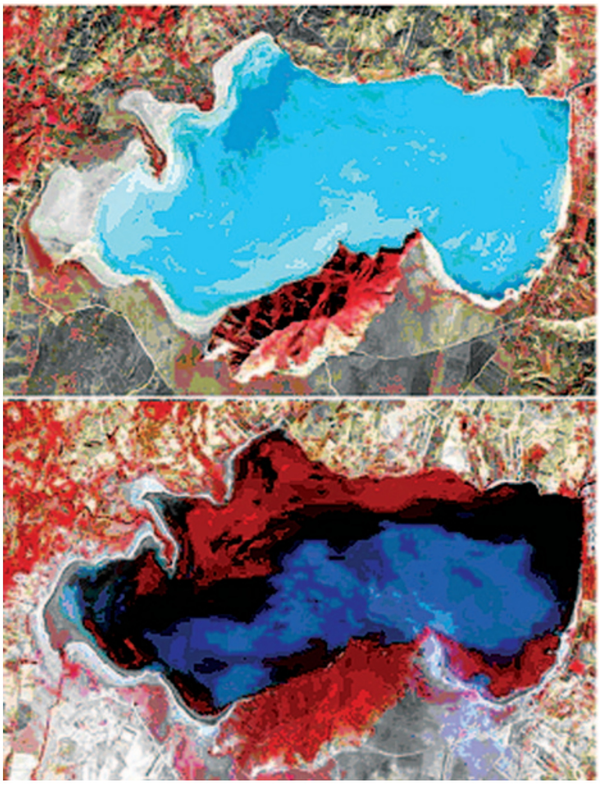

Fig. 3. Example of an infrastructure causing additional water stress in Ichkeul Lake in Northern Tunisia in November 2001 (top) and 2005 (bottom). Land and water vegetation is indicated by shades of red as infrared reflectance is passed through a red color filter within an image processor. Dam construction in the region has drastically reduced the inflow of freshwater to the lake causing an increase in salinity. Vegetation was replaced by salt-loving plants, thereby diminishing critical stopover habitat for migrating birds. Source NASA/GSFC/METI/ERSDAC/JAROS and U.S./Japan Aster Science Team

Humans have adapted to the climate for centuries by gradually modifying their behaviour to adjust to such changes. Today, however, we are facing geological scale changes in the climate within the span of one or two human lives. Changes in behaviour can no longer be as gradual as they have been in the past.

A very wide range of adaptation strategies have been developed to address these different changes, focusing on ecosystems, communities, engineering/infrastructure or prediction tools. Ecosystem and community based approaches are until now under-rated and under-represented, hence these approaches need to further demonstrate their benefits and cost-effectiveness.

Decision makers at many levels are frequently unaware of the connection between wetland condition and the provision of wetland services and the consequent benefits for people. Consequently, in very few cases are decisions made taking into account the total economic value of marketed and non-marketed services provided by wetlands. This lack of understanding and recognition is contributing to the continued rapid loss, conversion and degradation of wetlands, despite the fact that the total economic value of unconverted wetlands is often greater than that of converted wetlands. The Millennium Ecosystem Assessments and other assessments (e.g., the ongoing Comprehensive Assessment of Water Management and Agriculture, or CA) and policy documents have recognized that the full range of benefits and values provided by wetland ecosystem services should be considered in decision-making that affect wetlands, and that economic valuation provides a powerful tool for placing wetlands on the agenda of conservation and development decision-makers.

Based on de Groot (2006), a framework for wetland valuation has been designed. The main steps are: Step 1, analysis of policy processes and management objectives; Step 2, stakeholder analysis and involvement; Step 3, function analysis (identification and quantification of services); Step 4, valuation of services; and Step 5, trade-off analysis and communicating wetland values.

Enhanced protection and management of biological resources can mitigate the impacts of climate change and contribute to solutions as nations and communities strive to adapt to climate change. Such ecosystem-based strategies can offer cost-effective, proven and sustainable solutions to climate change, contributing to and complementing other national and regional adaptation strategies. One cannot stress enough the crucial role of water in all ecosystems and how climate plays a central role in determining key qualities for any body of water. Protecting forests, wetlands, coastal habitats and other natural ecosystem can provide social, economic, and environmental benefits, both directly through more sustainable management of biological resources and indirectly through protection of ecosystem services. Better protection and management of key habitats and natural resources can benefit poor, marginalized and indigenous communities by maintaining ecosystem services as well as access to resources during times of drought.

The biggest challenge with adaptation is uncertainty for planning, policy, management, and implementation. Science can help but only to a certain extent because stakeholders and policy makers are the ones who prioritise and make the final decisions. Science can help by informing decision makers about adaptation and presenting choices and options. Resource managers are the ones dealing with the practical impacts of climate change and they will recommend practical solutions.

Ultimately, adaptation is about making choices, bearing in mind that adaptation is to be a win-win solution: invest in climate adaptation now to profit from ecosystem services today and multiply your profit by several fold tomorrow.

Water demand is projected to increase steadily during the coming decades. Climate change, however, is expected to lead to decrease in water availability, especially in arid and semi-arid areas. To address this problem, many countries will need to continue efforts to increase reservoir storage capacity to meet the increasing demands for irrigation. Response measures to address climate change by utilising hydropower (and constructing dams) as an alternative to fossil fuel power plants will put additional stress on ecosystems by increasing habitat fragmentation. In China, dam construction is already expected to increase by 6% annually (Fulton 1999), and this rate will increase due to pressure to expand water storage capacity through dam construction, causing further coastal area and delta erosion. Gradual compaction of delta peatland soils and delta wetlands drainage will induce land subsidence, causing deltas and island to fall below sea levels. The combination of sea-level rise and land subsidence could place human populations in the deltas and the coastal zone at additional risk.

Finally, the three key words when developing a plan of action for climate change adaptation are (1) robust (not event-driven but involving cross-sectoral integration of development policy goals for current and future needs); (2) flexible (not based on one scenario only, but mixing measures responsive to different scenarios) to avoid missing opportunities especially in the longer term and (3) adaptive (able to function under uncertainty and adjust the management approach based on the outcomes of implemented strategies and taking into account new realities). An important adaptation strategy is the prevention of additional stresses other than climate change that can reduce the ability of ecosystems to respond to climate change. Reducing pollution, avoiding vegetation removal, and protecting biological diversity and integrity are, therefore, viable activities to maintain and improve the resiliency of ecosystems so that they continue to provide important services under changed climatic conditions (Erwin 2009).

The consensus is growing that ecosystem services for wetlands in particular can effectively guide and inspire conservation action due to the deepening recognition of ecosystems’ significant values globally. Conservation and sustainable use of wetlands has direct benefits for many other types of ecosystems and provide the umbrella for both fauna and flora species conservation. Therefore, water supply and water management must be at the very core of the ecosystem solution to our environmental challenges.

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CLIMATE CHANGE, CRANES, AND TEMPERATE FLOODPLAIN ECOSYSTEMS

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Abstract: Floodplain ecosystems provide important habitat to cranes globally. Lateral, longitudinal, vertical, and temporal hydrologic connectivity in rivers is essential to maintaining the functions and values of these systems. Agricultural development, flood control, water diversions, dams, and other anthropogenic activities have greatly affected hydrologic connectivity of river systems worldwide and altered the functional capacity of these systems. Although the specific effects of climate change in any given area are unknown, increased intensity and frequency of flooding and droughts and increased air and water temperatures are among many potential effects that can act synergistically with existing human modifications in these systems to create even greater challenges in maintaining ecosystem productivity. In this paper, I review basic hydrologic and geomorphic processes of river systems and use three North American rivers (Guadalupe, Platte, and Rio Grande) that are important to cranes as case studies to illustrate the challenges facing managers tasked with balancing the needs of cranes and people in the face of an uncertain climatic future. Each river system has unique natural and anthropogenic characteristics that will affect conservation strategies. Mitigating the effects of climate change on river systems necessitates an understanding of river/floodplain/landscape linkages, which include people and their laws as well as existing floodplain ecosystem conditions.
Keywords: rivers, wetlands, dams, groundwater pumping, water rights

INTRODUCTION

Floodplain ecosystems, including rivers, floodplains, and associated wetlands provide roosting, foraging, stopover, and nesting habitats for cranes worldwide. Geomorphic, hydrologic, and biological alterations to these systems are widespread, thus challenging conservation and management efforts for cranes and other species. The objectives of this paper are to: 1) provide an overview of basic geomorphic and hydrologic processes in floodplain ecosystems, particularly as they relate to the distribution and functioning of floodplain wetlands; 2) discuss common systemic changes in temperate floodplain wetlands as a result of human activities; and 3) discuss the potential effects of climate change on floodplain ecosystems and its implications for crane conservation. I will also use three temperate North American rivers – the Rio Grande, Guadalupe, and Platte – as case studies.

Floodplains are formed by the erosion and deposition of sediments (Leopold et al. 1964). In general, floodplain ecosystems are considered to tend toward dynamic equilibrium among sediment load, water discharge, and channel geometry (Osterkamp and Hedman 1977). However, climate changes, dams, channelization, increased hydrologic inputs, excessive sediment inputs or removals, or other natural or anthropogenic alterations can result in regime shifts that create instability in the watershed as the river and its floodplain begin to adjust to the new baseline conditions. Thus, rivers and their floodplains should not be considered static, but rather are continuously responding to prevailing sediment loads, hydrologic processes, and/or climatic conditions.

The patterns of erosion and deposition greatly influence the distribution and characteristics of wetland communities on the floodplain. The rates and composition of deposited sediments are a function of sediment load (volume and composition), water velocity, and duration of flooding. Sediment-limited streams (i.e., streams that can transport greater amounts of sediment than is present in their current load) are erosive and can produce entrenchment of streams and erosion of banks. In contrast, transport-limited streams (i.e., streams where sediment load exceeds transport capacity) are often characterized by a braiding pattern. Coarser sediments require greater water velocities for transport, whereas finer sediments typically require slower water velocities and longer periods of time for deposition to occur.

Common features of many floodplains are oxbow lakes or abandoned channels, natural levees, backswamps, and ridge and swale complexes. Natural levees are formed as floodwaters leave the river and the heaviest, coarsest particles are deposited as the water encounters resistance on the floodplain and loses velocity. Backswamps tend to be flooded for the longest periods, thus facilitating the deposition of fine particles, such as silts and clays. Although current climatic conditions are responsible for current depositional regimes, these depositional processes overlay features created under past climatic conditions and surface deposits may mask important underlying features that greatly affect biotic and abiotic processes.

HYDROLOGY

Hydrologic connectivity is a concept that is helpful in understanding the hydrograph, or patterns of river discharge through time, and natural, anthropogenic, and climatic influences on the hydrograph (Ward 1989). Hydrologic connectivity ensures the water-mediated transport of matter, energy, and organisms within or between elements of the hydrologic cycle (Pringle 2003). According to Ward (1989), river systems have four dimensions: 1) the longitudinal dimension integrates upstream-downstream linkages; 2) the lateral dimension captures the connectivity between the river and its floodplain, as well as uplands in the watershed; 3) the vertical dimension captures the interaction between the channel and contiguous ground waters; and 4) the temporal dimension recognizes the temporal variation among and within the other three dimensions.

The hydrograph is a function of numerous factors including climate, watershed size, land use and soils, and previous hydrologic conditions among others. Runoff, precipitation and groundwater are the primary hydrologic inputs into river systems. The relative importance of these inputs varies among and within watersheds, years, and seasons and is dependent upon the degree of hydrologic connectivity among uplands, the river, its floodplain, and its estuaries. Longitudinally, river flows provide important freshwater inputs to estuarine systems which have a strong influence on estuarine community structure and productivity. Vertically, the river at times recharges alluvial aquifers, but during periods of low runoff or along certain stretches of the river, groundwater may discharge into the river and may make up an increased proportion of river flow. The degree of groundwater influence can also affect nutrient and chemical composition of surface and groundwater in wetlands and rivers. Lateral surface connections are important for the deposition of sediments, nutrient cycling, and for reproduction of some organisms. Temporal variability is critical in these systems; stabilization of water regimes within and among years and/or reduction or amplification in the frequency or intensity of extreme hydrologic years in rivers and wetlands can severely impede long-term productivity of these systems and alter plant and animal community structure.

Geomorphic features and soils affect surface and subsurface hydrologic processes. For example, ridges and natural levees are some of the highest points on the floodplain and are less frequently flooded by surface waters than swales and flats. Sites with coarse grained soils often have greater subsurface hydrologic connectivity or subsurface hydrologic conductivity (i.e., water moves more freely) than sites with fine textured soils. However, current depositional environments often overlay soils created by historic depositional environments resulting in complex subsurface hydrologic environments that may not be accurately interpreted from surface deposits.

VEGETATION COMMUNITIES

The hydroperiod, or the timing, depth, duration, and frequency of flooding, is the primary determinant of plant species composition on floodplains. However, the geomorphic setting and soils strongly influence the hydrologic environment by affecting frequency of flooding and the duration of surface flooding and saturation of the root zone. All phases of plant succession are affected by flooding.

Van der Valk (1981) developed a conceptual model of plant succession in prairie wetlands that is generally applicable for succession in herbaceous floodplain wetlands as well. The model is based on life history processes of dominant wetland plant species and emphasizes the role of dispersal mechanisms (i.e., seedbank versus dispersing to the site); flooding/drawdown and light availability in seed germination and establishment; and life-span of common species. Wetland plant species differ in terms of their peak time of germination and in the moisture, sunlight, and soil requirements necessary for germination. In fact, these differences have formed the basis for moist-soil management in the U.S., which is practiced by impounding an area and manipulating flooding/drawdowns and other disturbances to stimulate production of desirable plants for breeding, wintering, and/or migrating waterbirds. Of course, improper design of impoundments or inappropriate management strategies can also facilitate establishment of undesirable plants, alter nutrient cycles or salinity regimes and lead to overall reduced productivity.

In unmanaged floodplain wetlands, alteration of surface and subsurface flooding patterns and nutrient and sediment loads can produce rapid changes in plant communities. Reduced flood frequency can reduce sediment deposition and nutrient inputs and can reduce establishment of species dependent upon mineral soils for germination and allow establishment of drier site species. Reduced flood magnitudes can prevent scouring of woody vegetation and facilitate shifts in herbaceous plant communities to woody plant communities. In arid regions of the south-western United States, hydrologic alterations can enhance establishment of the invasive tamarisk (*Tamarix ramosissima)*, which some evidence suggests uses substantially more water than native species and can further exacerbate water availability issues (Lite and Stromberg 2005).

ANTHROPOGENIC EFFECTS ON FLOODPLAIN WETLANDS

Dams

As of 1998, there were over 45,000 dams in the world that exceeded 15 m in height (Avakyan and Iakovleva 1998). Large dams are still being developed throughout the world, including on rivers such as the Mekong that support large numbers of cranes and waterbirds. Dams have been constructed for many purposes including flood control, water supply, and hydropower.

Dams have substantial impacts on rivers and floodplain ecosystems both above and below the dam, with the actual effects depending upon the structure of the dam, how the dam is operated, and unique characteristics of the river basin. In general, however, above the dam floodplain ecosystems are converted to lotic systems and inundate floodplain wetlands often to great depths. Downstream of dams, sediment-starved water being released from dams often results in channel entrenchment and erosion of stream banks. Channel entrenchment can lead to drainage of floodplain water tables, less frequent overbank flooding, and colonization of the floodplain and associated wetlands by drier site species. These impacts can extend dozens of kilometers downstream. Flow releases from dams can have numerous impacts on floodplain ecosystems, including reduced peak flows, increased low flows, and altered timing of flows. Each of these can substantially affect wetland habitats used by cranes by affecting the hydroperiod of wetlands and plant community structure. Finally, dams can also affect nutrient and biogeochemical cycling in estuarine systems (Humborg et al. 1997). The magnitude of flow releases can also affect salinity levels, and thus the productivity of estuarine habitats.

Surface and Groundwater Withdrawals

Surface water is withdrawn from rivers primarily as a result of agriculture or human consumption in urban areas. The actual effects of water withdrawal on river and floodplain ecosystems depend upon the magnitude and timing of withdrawals. Globally, including the United States, water withdrawal rights are over allocated on many rivers (i.e., more water can be withdrawn from the river than available surface water in the river) and some rivers dry up for large stretches during some years. Minimum flow requirements have now been developed for some rivers, which can provide some protection to prevent them from drying up.

Groundwater pumping is also common in many regions and can adversely affect rivers and associated wetlands. Over pumping of groundwater can cause rivers to switch from recharge to discharge systems and can lower stage levels or even dry up river channels. Similarly, floodplain wetlands can switch from discharge to recharge wetlands, thus drying wetlands. Depending upon the size of the underlying aquifer, groundwater pumping may be occurring at great distances from the affected wetland (Richardson et al. 2001).

Case Studies

Platte River, Nebraska. The entire Platte River is located in Nebraska, although its two main tributaries, the North and South Platte Rivers, arise in the Rocky Mountains of Colorado and Wyoming. Historically, the river hydrograph was dominated by snowmelt patterns and high flows were present in the spring but receded to a trickle or completely dried up by June (Ghent 1929, Hadley et al. 1987). The river has high coarse sediment load (i.e., sands) and a braided channel. During March of each year, about 500,000 Sandhill Cranes (*Grus canadensis*) stop at the Platte during migration (Kinzel et al. 2006), forage in the surrounding corn fields and wet meadows, and roost in shallow, unvegetated reaches of the river.

During the mid-1800s, irrigation ditching efforts began in the Platte's tributaries and within a few years the river was over appropriated (Hadley et al. 1987). Groundwater began being pumped in the late 1800s and reservoir development began in the early 1900s. Intensification of surface and surface water uses has continued until the present day. As a result of these competing water uses, there have been several hydrologic and geomorphic changes in the river that have stimulated plant community changes in the floodplain wetlands and the river and have negatively impacted crane habitats. Specifically, groundwater withdrawals have reduced or eliminated flooding in some wet meadows (Felipe Chavez, Platte River Whooping Crane Trust, personal communication), and in the river, the occurrence of large scouring floods has been eliminated or reduced in frequency, summer (June) flows have increased due to recapture of irrigation water through subsurface river connectivity, and mean river flows have been attenuated (Hadley et al. 1987).

These hydrographic changes resulted in a rapid increase through the 1900s in colonization of unvegetated islands with *Populus* and *Salix* forests (Johnson 1994). The current hydrographs are extremely well-suited to the dispersal, germination, establishment, and survival of these species. Receding June flows allow for germination and establishment of these species, and higher but not extreme summer flows enhance survival by protecting seedlings from drought. Furthermore, lower winter flows, particularly during cold winters with large ice packs, have also reduced the scouring effect of ice on seedling mortality and further enhanced the survival of these species. As a result, woody islands proliferated during the 1900s. In the last few decades, total area in corn production and the amount of waste grain has decreased and Sandhill Crane foraging flights have increased in distance. Thus, forest eradication efforts are ongoing to improve crane roosting conditions, as cranes will not roost in vegetated reaches, and to reduce the distances of foraging flights to corn fields (Pearse et al. 2010). It is believed that woodland extent and active channel area were always quite dynamic and their relative proportions through time reflected changing climatic cycles and the sensitivity of these dynamics to small changes in flow. Johnson (1994) argues that the woodland/channel dynamic has now reached a new equilibrium and no drastic changes will occur unless climate and flow patterns change, which is, of course, a strong possibility.

Guadalupe River, Texas. The Whooping Crane is the world's rarest crane with only about 280 birds in the wild flock. The wild flock breeds in Wood Buffalo National Park (Canada) and winters at Aransas National Wildlife Refuge in coastal Texas, within San Antonio Bay. During the winter, blue crabs can make up to 80-90% of the Whooping Cranes' diet, and in months or years with low blue crab abundance Whooping Cranes can be in an energetic deficit (Chavez-Ramirez 1996). Alternative food items such as clams and wolfberry do not have the same nutritional level as crabs (Nelson 1995). Unpublished data from Tom Stehn, the U.S. co-chair of the Whooping Crane Recovery Team, suggests that the 7 winters in the last 21 years with the highest Whooping Crane mortality were characterized by high salinities, low freshwater inputs from the Guadalupe River, and low blue crab abundance. Years of high salinities can create additional stress on Whooping Cranes because they must fly to freshwater areas to drink. Although the factors affecting blue crab abundance are complex, they are at least partially related to salinities at various points in the life cycle (Kennedy and Cronin 2007).

Freshwater flows in the Guadalupe and San Antonio Rivers, the two primary rivers providing freshwater input to San Antonio Bay, are under intense scrutiny. The city of San Antonio, the 8th largest city in the United States, lies within this region and the number of people within the watershed is expected to increase by 75% and overall water use by 29% (Texas Water Development Board 2007, Sahoo and Smith 2009). Historically, the Edwards Aquifer provided a significant portion of drinking water for San Antonio, but use of this aquifer has threatened endangered species and tight regulations are now in place to protect the aquifer. This aquifer also provides 70% or more of base flow for the Guadalupe River during dry periods (Guadalupe River Basin Authority 1988). Longley (1994) found that inflows to San Antonio Bay ranging from 1,109 million m^3 to 1,849 million m^3 were needed to maximize fisheries harvest, including blue crabs, in San Antonio Bay. A total of 58% of the inflows are a result of the Guadalupe River (Longley 1994). There is substantial concern about whether the estuarine community and wintering Whooping Cranes can be sustained by the Guadalupe

River, particularly during drought years with the large number of existing and proposed water withdrawals (Johns 2004). In fact, Longley (1994) found that during six years within the period from 1941 to 1987 the Guadalupe River failed to meet minimum flow requirements. Furthermore, currently over 123.3 million m^3 of existing water rights in the Guadalupe Basin are unexercised and the Guadalupe Basin River Authority (GBRA) has applied for an additional 233.7 million m^3 (The Aranasas Project 2010). A lawsuit was recently filed against the GBRA by The Aransas Project for the purposes of developing a Habitat Conservation Plan under the Endangered Species Act, evaluating existing and pending water rights permits, developing a plan to roll back water rights during periods of drought, and insuring freshwater inflows to San Antonio Bay.

Middle Rio Grande River: The Middle Rio Grande River south of Albuquerque, New Mexico hosts about 80% (about 17,000) of the wintering Sandhill Cranes from the Rocky Mountain population as well as cranes from the mid-continent population, 40,000-50,000 light geese (*Chen* spp.), and more than 100,000 puddle ducks. Cranes roost in natural and managed wetlands and forage in a variety of irrigated agricultural crops, managed wetlands, and floodplain habitats (Austin, these proceedings, John Vradenburg, USFWS, personal comm.). The refuge typically supports around 20,000 cranes during the winter, but during drought years when playas are dry, the number of cranes using the refuge can increase to about 50,000.

High concentrations of cranes and geese increase mortality from avian cholera. Thus, when habitat is limited, either due to water limitations or poor agricultural productivity, the risk of cholera outbreaks is high. Furthermore, during drought or low flow years, agricultural production is substantially reduced because of limited irrigation capability. Bosque del Apache National Wildlife Refuge has a senior water right, but the Refuge experiences water supply shortages, particularly during drought years, because the Middle Rio Grande Basin is both over-appropriated and unadjudicated. Since the Refuge sits at the end of the Basin, the Refuge is especially vulnerable to water supply shortages and this creates substantial concern over the refuge's ability to manage wetlands and agricultural crops. Furthermore, high population growth has stimulated many individuals to sell their water rights to urban interests, while being able to continue to farm on their land by leasing paper water rights from the local conservancy district. Projected trends in the sale of rural water rights to urban centers, increase in the intensity and duration of drought conditions due to climate change, and increased upstream water depletions due to increased groundwater pumping all raise concern over the reliability of the Refuge's water supply in the near future (Paul Tashjian, U.S. Fish and Wildlife Service, personal comm.).

Climate Change

Rivers respond to sediment and hydrologic inputs, which are highly dependent upon climatic processes. Thus, climate shifts will produce changes in river systems and there are an infinite number of possibilities that could occur, both positive and negative. Increased frequency and intensity of droughts could further stress water-stressed rivers and estuaries. Drought could also lead to reduced vegetative cover, thus when rainfall does occur in the basin, erosion of sediments could increase, which would affect rivers and their floodplains. Increased rainfall could improve conditions on water-stressed rivers, provided thresholds are not exceeded. Regardless of potential climatic scenarios, however, many river systems worldwide are immediately threatened by flood control, water development, and navigation projects, as well as urban expansion. Thus, while much attention has been placed on the impact of future climate scenarios, the integrity of many floodplain ecosystems is challenged by existing climatic conditions and human pressures. Integrated, process-based approaches that focus on the root causes of degradation and that consider both long-term ecosystem integrity and human needs may enhance restoration opportunities and minimize floodplain ecosystem changes as a result of changing climate (King et al. 2009, Beechie et al. 2010).

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EURASIAN CRANE

REASONS FOR CHANGES IN CRANE MIGRATION PATTERNS ALONG THE WEST-EUROPEAN FLYWAY

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Abstract: Since the 1980s the volume of passage of Eurasian Cranes (*Grus grus*) through Central Europe increased from ~50,000 to 250,000 birds, while the number of breeding pairs increased fivefold (growth of 6-8%/year), with much greater pair density in traditional breeding areas. This process was accompanied by the cranes spreading north, south and west in Central Europe, with more birds coming from east than north, and establishment of new resting places in inland areas in Germany. There are now about 70 such resting sites with 200-70,000 birds per site and a total number of 213,600 counted on 23 October 2008. In recent years, more cranes spend the winter farther north along the flyway up to 90,000 birds in France and up to 15,000 in Germany, with the cranes staying later until late December and even through the winter as well as returning earlier in spring. Better foraging conditions in EU countries combined with protection of cranes and milder winters are the major reasons for changes in migration and stopover patterns for the Eurasian Crane in Central and Western Europe. Damage on huge fields is lower than two percent of the grain value.
Keywords: West-European flyway, Eurasian Crane, climate, crane-agricultural management

INTRODUCTION

Between the 1980s and the end of the current decade, the migration volume of the Eurasian Crane (*Grus grus*) along the West European Flyway (WEF) has increased from about 50,000 to 250,000 birds (Prange 1989, 1999, 2000-2009, 2010a,b, Prange and Mewes 1987). This paper discusses possible causes of these changes in relation to agriculture and climate.

MATERIAL AND METHODS

Within the framework of the German Crane Working Group (GCWG) about 300 volunteers and professional ornithologists are actively working to protect and monitor breeding and resting sites of Eurasian Cranes. This work was initiated in the 1970s and at present 60 local groups are surveying 150 crane sleeping sites, which accommodate from 200 to 70,000 birds each, or over 95% of the total crane flock resting in Germany. At these sites the cranes are monitored at least every 10 days, often more frequently or even daily.

This article evaluates the data from this monitoring. In addition, systematic observation of migration in Hesse (Kraft 2004-2009) and comprehensive resting data from France and Spain are included to yield the precise and complete number of cranes on their West-European route. For example, on 23 October 2008, 213,600 birds were resting at all German sites. Before this date, 19,019 cranes had passed Hesse. An unknown number of cranes migrated more to the north or the south before this time, yielding a total of about 250,000 cranes (± 5% error) on the West-European route.

MIGRATION AND RESTING IN CENTRAL EUROPE

The gathering of indigenous cranes at local sites begins in late July with the non-breeding «summering» birds, followed by the families up to September.

Birds migrating from the north and east arrive between the end of August and the end of October. They are resting at long-term sites, many of which are identical with the gathering sites. Table 1 shows the resting and migration between the end of the 1970s and the current decade. The increase from one time period to another has several explanations.

Table 1. Resting and migration on the West European Flyway (WEF) over three decades

Years	Number of Years	Resting			Migration (WEF)
		Baltic Sea Coast	German Inland	All Germany	
1977-1984	5	18,000	7,600	25,600	~ 35,000 (25-45,000)
1985-1990	6	27,500	20,183	44,100	51,000 (38-54,000)
1991-1995	5	33,400	28,000	59,000	68,000 (49-74,000)
1996-2000	5	38,600	56,200	97,000	108,000 (>83->130,000)
2001-2005	5	44,800	95,000	140,000	184,000 (150-230,000)
2006-2010	5	62,500	158,000	190,000	237,000 (230-250,000)

Breeding in Germany

Between 1970 and 2009 the number of breeding pairs in Germany increased from ~1,000 to 7,100, i.e. by 6-8%/year, depending on the region. This population growth is the first reason for the increased migration. Greater density in the traditional breeding areas has been accompanied by the spread of cranes to the north (about 50 km), south (60 km), and west (240 km) in Central Europe (Mewes 2010).

Passage from the North and the East

Up to the middle of the 1990s, cranes arrived from the north (Scandinavia) rather than from the east; since this time many more cranes have been coming from the east than from the north (1980: 30 and 70%, 2008: 70 and 30%, respectively). This change must be the second reason for the increased migration.

More arrivals from the east imply greater migration in the central and southern parts of the flyway. It seems to result from some shifting of the dividing area east of Poland between the West-European migration route and the more eastern ones. It is known that crane food resources in the north-west of Russia decreased with the breakdown of the Soviet Union and its socialist agricultural structure (Ilyashenko and Markin 2010). This situation could be the reason why many more cranes from the east are now using the western flyway, and this change implies that more birds would be resting in the German inland than on the Baltic coast.

Increase in Number of Resting Areas

The increase in migration has resulted in the appearance of new stopover sites in the German inland (in 1980 ~32, in 2008 ~70 resting sites), with the number of cranes steadily increasing up to a peak of 70,000 birds in autumn at the Baltic Sea (Ruegen-Bock region, Figs. 1 and 2) and at Rhin-Havelluch north-west of Berlin (Figs. 3 and 4).

Fig. 1. Ruegen-Bock area at the Baltic Sea coast with roosting sites (circles) and observation points (crosses). Photo by the National Park

Fig. 2. Feeding on maize stubble fields near the isle of Bock

Fig. 3. Water reservoir of the Helme River with pre-roosting and roosting sites

Fig. 4. Cranes foraging on wheat seeds in autumn

Evolution of a new resting site – the Helme Reservoir at the southern border of the Central-European Flyway – is shown in Figs. 5 and 6.

Fig. 5. Morning before departure at flooded meadows of the Rhinluch

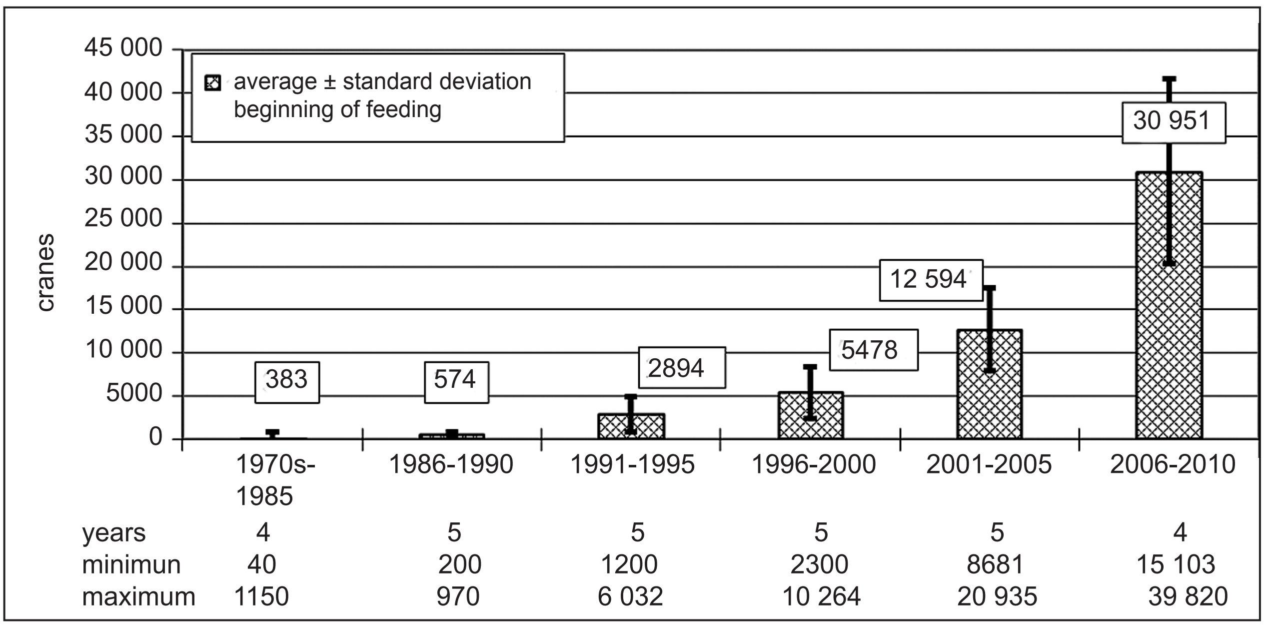

Fig. 6. Increase in number of cranes resting at the Helme River Reservoir in the most southern part of the migration route (outside of the breeding area).

Since the late 1990s, measures of habitat restoration, and the rewatering of peat moors in the north-west of Germany (Lower Saxony), in combination with intensive maize cultivation, have encouraged the cranes to stay four weeks longer in Germany. Up to 90,000 cranes were resting at 12 to 16 of these sites, with the peak reached four weeks later than in the eastern parts of the country (Niemeyer 2007-09; Figs. 7 and 8).

Fig. 7. Moorland peat production in Lower Saxonia before remoistening

Fig. 8. Moorland after remoistening in the Diepholz lowland

CHANGES IN AGRICULTURE AND DAMAGE BY CRANES

Changes in agriculture influence the duration of stopover and food consumption by cranes. Since the late 1960s, maize (corn Zea mays) cultivation has become more and more important everywhere. Maize stubble fields are now the main crane feeding areas in late autumn, winter and early spring (Fig. 9, Table 2, Figs. 10 and 11). Grain left after harvest is an important part of the crane diet in early autumn, but its consumption may have decreased due to better agricultural techniques.

Fig. 9. Cranes in a maize stubble field

Fig. 10. Wintering with food in a non-harvested maize field

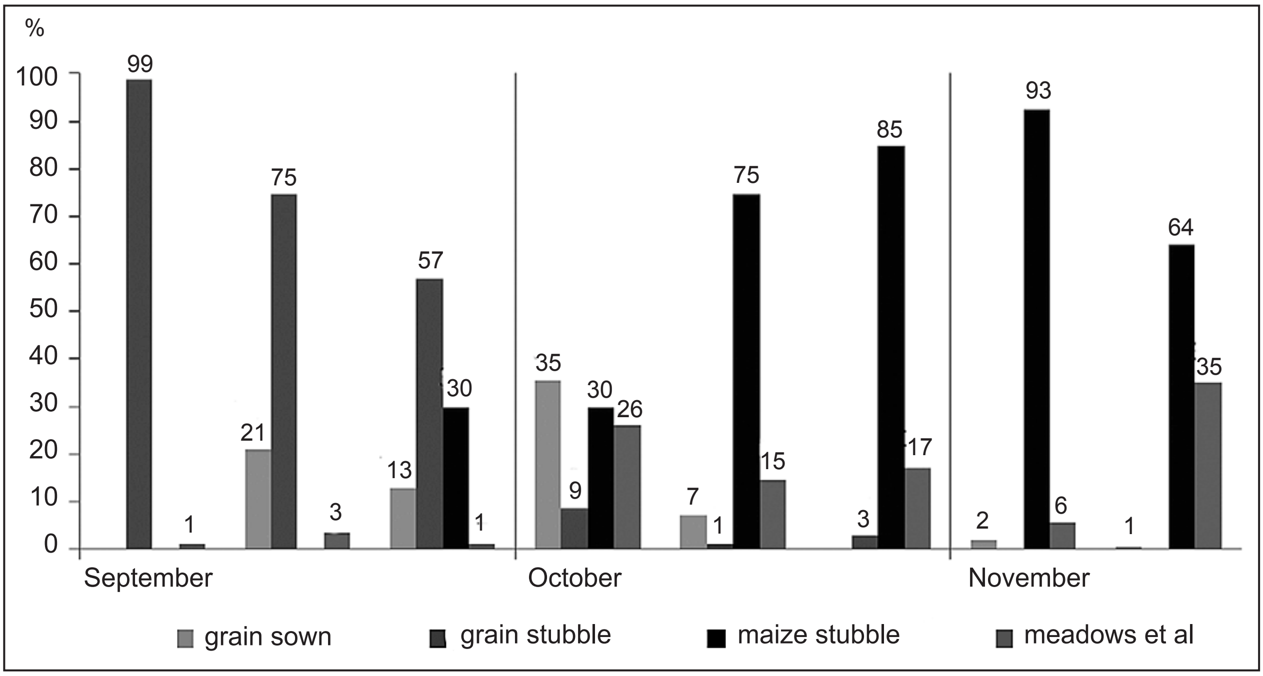

Fig. 11. Food consumption in autumn 2006 at the Isle of Ruegen (Bräse & Weiss 2006)

Table 2. Cranes counted in different crop fields at the Ruegen-Bock Region in spring (%)

Crops	% of all cranes counted in:			
	1961/68 (Grün 1968, Mansfeld 1972)	1985* (Prange 1987)	2005 (Bräse et al. 2005/06) March	April
Maize stubble	0	1	44	0
New seeds	49	33	0	85
Grain stubble	3	18 (+ clover)	0	0
Winter grain	8	3	5	5**
Fields, grass, others	40	45	51	5
Total individuals	22,590	2,400	7,028	

* Relationship between observed number of cranes and the total area of all fields (3,060 ha):

Cabbage	8:1	Winter grain in spring	1:1
Maize stubble	5:1	Rape	1:2
New harvest leftovers	3.2:1	Fields	1:4
Stubble	3:1	Grassland	1:8
Potatoes	2.5:1		

**Winter grain had grown poorly.

The enhanced maize cultivation is a main factor for the longer presence of cranes resting in autumn and for wintering farther north compared to earlier decades (Table 3).

Table 3. Cranes/observations in different crop fields at the Ruegen-Bock Region in autumn (%)

Crop Fields	% of all cranes counted in:			
	1960	1966/67	2005 Sept.-Oct.	2005 Nov.
Maize stubble	0	18	37	78
Grain stubble	33	32	41	0
New seeds	9	25	13	2
Fields, grass, rape	58	14	9	20
Total number of cranes/ observations	12,539 (cranes)	106 (observations)	80,612 (cranes)	
Authors	Mansfeld 1961	Prange 1973	Bräse et al. 2005/06	

Damage to agriculture has been under discussion as long as cranes have been feeding in cultivated fields, a behavior that sometimes caused a real problem to farmers. Most vulnerable are small recently planted grain fields as well as cabbage, peas and potatoes located near major resting sites (Fig. 12). Non-breeding groups sometimes damage maize fields in May. Table 4 presents survey data on damages.

Fig. 12. Potatoes damaged by cranes

Table 4. High and moderate damage to agriculture

High ?	In cabbage and peas plantations In newly planted small fields In maize fields in May/June (with many summering birds)
Moderate ?	In newly planted large fields In potato fields (without herbs or grasses) In meadows with “diversion feeding” (see text below)
Damage on huge fields was and is ≤ 2 % of the grain value	

Effective crane-agricultural management requires leaving the maize stubble unploughed into the winter period, early new sowing of winter crop, artificial feeding in special situations, and protection of sensitive crops such as cabbage, peas and potatoes by actively scaring the birds away. When these measures are applied, damage by cranes is low and crane stopover is compatible with intensive agriculture. One farmer who suffered a loss of his crops put it this way: “We have to live with the cranes but to prevent serious damage.”

So called “diversion feeding” can protect new crop fields partly and promotes cooperation with farmers. This artificial feeding should be applied on fields with stubble where there is no disturbance. It should not be done on meadow-land continuously because the grass-cover can be damaged (Fig. 13).

Fig. 13. A damaged meadow after a long time of artificial feeding

Changes Due to Climate

A change has occurred in the migratory behavior of cranes – the breeding birds in spring are returning four weeks earlier to Germany, southern Sweden, and Poland.

New wintering places have developed in more northern areas in Western Europe: in 1980/81 several hundreds of cranes wintered in France, whereas in 2000/01 there were about 68,000 birds and in 2009/10 up to 90,000 birds (Fig. 14; A. Salvi 2010, personal comm.).

Fig. 14. Roosting site in a wintering area

In Central Europe wintering has been increasing since the early 2000s (Figs. 15 and 16). Large differences between the years are climate-related. In the mild winter of 2005/06 about 15,000 birds remained in Germany in January. In the long winter of 2009/10 with much snow there were 1,200 birds in January (a new pattern/ tradition).

Fig. 15. Wintering cranes feeding on manure

Fig. 16. Wintering cranes feeding on silage with cattle

Cranes wintering in Germany are breeding mainly in Central Europe. About 30 banded cranes were sighted in January 2001 north of Berlin, all from the German population. The Scandinavian and East European cranes arrived in late February and March (Schreiber and Rauch 2001). This pattern confirms earlier observations that, in general, cranes from far away do migrate farther than those from nearby. It is called an «overjump» migration (Prange 1989).

It seems that populations whose habitats are most affected by climate change – in Western and Central Europe – adapt more quickly to this change. On the other hand, the peak of crane resting has not changed over decades at stopover sites where cranes from far away make their resting with a shorter time compared to the Central European population (Nowald et al. 2010).

CONCLUSIONS AND SYNOPSIS

There is a close connection between the increase of the volume of crane migration and the increase in maize production over the last four decades. Yield of wheat and some other crops per hectare increased enormously, but the overall production of all crops has increased only by ~10%.

The synopsis in Fig. 17 illustrates a complex system of factors responsible for the changes in the crane population and migration (Prange 2010). Balanced protection of the species and its habitats in the European countries serves as a background for all other factors. Seven meetings of the European Crane Working Group between 1985 and 2010, as well as many activities of the national and local crane working groups, established optimum conditions for the protection and existence of the Eurasian Crane in highly developed and industrialized countries.

These changes are related to better food, mild winters, and establishment of new roosting sites in Central and Western Europe that resulted in growth of the breeding populations, greater concentrations of cranes in more numerous stopover and wintering sites, as well as greater volume of migration, thus establishing new migratory and wintering patterns / traditions.

Sharing of such information with the public and more public involvement will attract more and more people to nature. Crane tourism will open new sources of income for local people in major stopover areas. It has to be discussed, however, how to prevent damage to crops and disturbance to cranes from the visitation by humans.

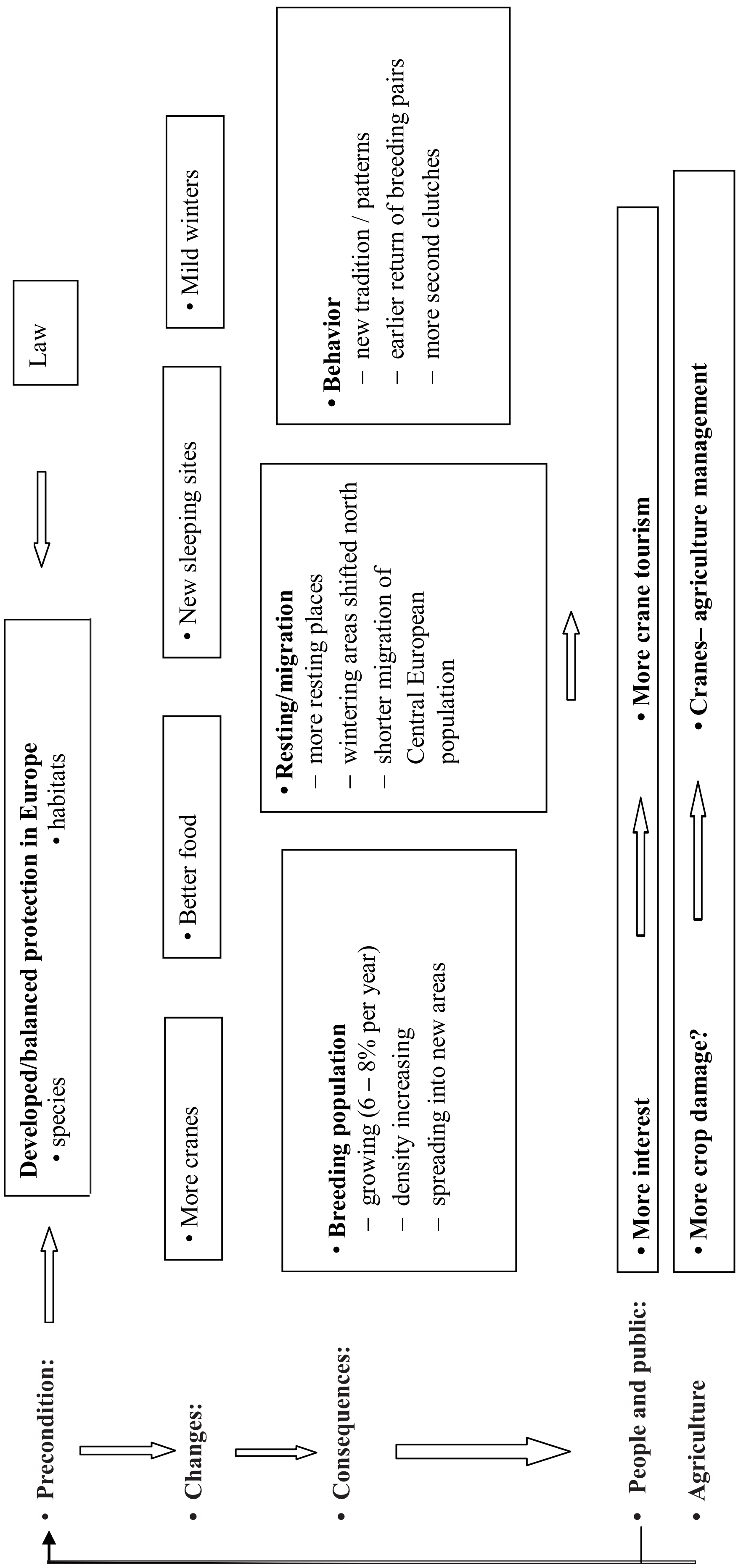

Fig. 17. A complex system of interacting factors that contribute to changes in crane breeding, migration and wintering

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CRANES AND CLIMATE CHANGE IN SWEDEN

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Abstract: Expected effects of higher temperatures and more rainfall in the future are new species invading, breeding ranges of many species moving northwards, and some species disappearing from the Swedish avifauna. Eurasian Cranes (*Grus grus*) now arrive earlier in spring and can stay for a longer period in the breeding territory; they also demonstrate positive population trends. The Swedish population is estimated at ~100,000 cranes. The future for wetlands in Sweden is relatively bright if proper action is taken. The national goal of rich biodiversity, however, seems very difficult to achieve.
Keywords: cranes, Sweden, climate, wetlands

INTRODUCTION

The Eurasian Crane (*Grus grus*) has been a well-known species in Sweden for a very long time. Several places have names referring to cranes, i.e., containing the Swedish name "*trana*." It was considered a species of the desolate mires of northern Sweden, although small numbers also bred in the southern part of the country.

As in many other parts of Europe a remarkable increase in numbers has occurred in the last decades. Based on a nation wide census in 1980, the population was estimated at 12,500 breeding pairs or close to 30,000 individuals (Bylin 1993). At the European Crane Congress at Flämsätt, Sweden in 2003, an estimate at 66,000 cranes was reported (Skyllberg et al. 2003). Yearly censuses of birds breeding in Sweden conducted by standardized methods (the Swedish Bird Survey) revealed that this increase continues (Ottvall et al. 2009, Lindström et al. 2009). Increase indices from these censuses, combined with 66,000 cranes counted in 2002, provide a rough estimate of a population of ~100,000 cranes in Sweden today. During the last 30 years there has also been an expansion of the breeding range in Sweden, and today cranes breed in all Swedish counties (Lundgren and Lundin 2003).

OBSERVED EFFECTS THAT CAN BE CAUSED BY CLIMATE CHANGE

Several migrating bird species, including the Eurasian Crane, now arrive in Sweden earlier in the year than they did a few decades ago. In the Tranemo area cranes have been arriving roughly two weeks earlier in the last decade compared to the 1980s. Accordingly, breeding also starts earlier. Experienced pairs start breeding before mid April, and there is one record from 2007 of incubation starting in late March.

The autumn migration is more dependent on favourable weather conditions. In some years cranes in the south of Sweden have started migration before mid September. The majority of the Scandinavian cranes leave Sweden in late September or October. Only a few cranes stay in Sweden during winter and even fewer survive. Probably all cranes that try to winter have some kind of injury or illness or are attached to a mate or an offspring that is not able to migrate.

Cranes now stay for a longer time on the breeding grounds, at least in southern Sweden. When studies commenced in Tranemo in the early 1990s, second clutches were not known from Sweden. Today second clutches are not infrequent, which could be attributed to an earlier onset of breeding. Second clutches laid in late May or June can produce fledged juveniles before the start of autumn migration. Although it looks possible that this trend could increase breeding success to some degree, no such increase has yet been observed. Other factors are probably more important. In the mid 1990s a tick disease caused a very strong reduction in the fox (*Vulpes vulpes*) population. During these years with very few foxes, crane breeding success was roughly 0.6 large chick/ pair. When the fox population recovered in 1998-1999, crane breeding success dropped to and still is ~0.4 chick/ pair. Without second clutches the breeding success would probably have been even lower.

CLIMATE EFFECTS ON ECOSYSTEMS

A longer vegetation period has changed farming practices to some extent. This change alters the conditions for species that use agricultural areas. Several species have undergone serious declines and some species have been able to benefit from the changes – i.e., some geese, Whooper Swans (*Cygnus cygnus*), and cranes. Changes in land use in the last 50-60 years have provided more suitable breeding places for cranes, at least in southern Sweden. In the last decades obvious changes in crane behavior have also occurred. In rural areas it is not uncommon to find nests in the proximity of human settlements. These two factors have contributed to the population increase.

The most likely scenario of increasing temperatures is that breeding ranges of many species will move northwards. New species will invade and other species, above all arctic species, will decrease in numbers or stop breeding in Sweden. In the mountains the tree line has climbed upwards, decreasing the area for the species living above. Several species, including cranes, have been observed shifting upwards to the alpine heath in recent years (Green et al. 2009).

One hypothesis put forward by Ottvall et al. (2009) is that the observed fall in rodent numbers in the north of Sweden is due to the milder climate, resulting in unfavorable winter conditions for these animals. This shift provides a link to changes in the avifauna, since rodents are the main source of food for several bird species. A lower number of rodents might force generalist predators (such as foxes and weasels) to prey on birds to a greater extent, which might impact far more species than those specifically dependent on rodents.

CLIMATE IN SWEDEN IN THE 21st CENTURY

This section is based on information from the Swedish Environmental Protection Agency www.naturvardsverket.se and Swedish Meteorological and Hydrological Institute www.smhi.se .

Temperature

Mean temperature has increased by ca. 2°C since 1860. The mean yearly temperature is expected to rise by 3-5°C by 2080 compared to the mean temperature in 1960-1990. The temperature increase is expected to be higher in the eastern parts compared to the western parts of the country, where the Atlantic Ocean will limit the rise. The most remarkable change is that the lowest winter temperatures are expected be 8-12°C higher within 100 years.

The rise in temperature will shorten the period with snow cover. It will be one to three months shorter in most of the country. At the end of this century most of southern Sweden may have winters without snow or with snow cover for less than one month.

Precipitation

Precipitation has increased in most of Sweden in the last decades, in some regions by 15-20%. Only in the easternmost parts have there been decreases. During this century days with heavy rain or snowfall will increase during winter, spring and autumn. In southern Sweden summers are expected to be warmer and dryer. The increase in rainfall may to some extent affect water quality.

To summarize, the expected changes in climate may create a mid-Swedish climate in the northern part of the country, while the central part may have a climate like Denmark or northern Germany today. The southern part would have temperatures like today's central France. However, in general precipitation is expected to increase substantially in most part of the country.

ENVIRONMENTAL GOALS IN SWEDEN

Sweden has set goals for the future state of its environment (www.naturvardsverket.se). The Swedish Parliament has adopted environmental quality objectives for 16 areas. The objectives define the quality and state of Sweden's environment and of its natural and cultural resources that are sustainable in the long term. Each year the Environmental Objectives Council reports to the Government on the progress we have made towards our environmental objectives. In the overall assessment the Environmental Objectives Council notes that a changed climate will have adverse consequences for several other objectives. The risk of sudden environmental changes increases with rising temperatures, and many such changes may prove irreversible.

What is more, the demand for renewable energy arising from the need to curb greenhouse gas emissions may conflict with other goals, for example, if there is an expansion of wind or hydroelectric power or if more timber and biofuels are extracted from forests in an unsustainable manner.

Three of the 16 environmental quality objectives are quoted here from the Summary of the Environmental Objectives Council 2009. The objectives most relevant to the issues in this paper concern climate, wetlands and biodiversity.

Reduced Climate Impact

The Council's assessment: This objective will be very difficult to achieve. The trend in the state of the environment is negative.

Levels of greenhouse gases in the atmosphere continue to rise. Global emissions grew by 25% between 1990 and 2005, and are expected to increase more rapidly over the next 20–30 years if no further action is taken to reduce them. In Sweden, greenhouse gas emissions have decreased by 9% since 1990. The Swedish interim target for 2008–2012 is for average annual emissions to be at least 4% lower than in 1990, and this will probably be achieved.

Thriving Wetlands

The Council's assessment: This objective can be achieved by 2020 if further action is taken. The trend in the state of the environment is positive.

Efforts to protect and recreate mires and other wetlands are in progress, though not quickly enough. Although key interim targets will not be met on time, the prospects for the country's wetlands look fairly promising in the somewhat longer term. Work is continuing on the Mire Protection Plan for Sweden, which identifies valuable mires requiring protection, and on action programmes for threatened species.

Conservation considerations for aquatic and wetland environments in agriculture and forestry are likely to improve with the implementation of the EU Water Framework Directive. The Government has given county administrative boards special funding to establish and restore wetland areas. Re-creation of wetlands may prove important in mitigating the effects of climate change and changed precipitation patterns.

A Rich Diversity of Plant and Animal Life

The Council's assessment: This objective will be very difficult or not possible to achieve by 2020, even if further action is taken. No clear trend in the state of the environment can be seen.

Despite action to date, the loss of biodiversity is continuing, and many species do not have viable populations. Some species may remain at a site for a long time after their habitat has lost the quality required for their reproduction and long-term survival. For other species, for example those dependent on old, hollow trees, it will take a long time to restore habitats and hence for populations to be re-established. The trend for threatened species is also negative – the threats are in fact growing. For many species it is not enough to halt the current decline; their populations need to increase.

Current use of biological resources is not sustainable, and in many cases we still lack sufficient understanding of ecosystem functions and processes. However, nature conservation and environmental protection efforts have produced some good results and biodiversity loss is now not as severe as before. But even if trends for all the interim targets were pointing in the right direction, the objective might not necessarily be met by 2020.

Under these three objectives it is quite clear that there is much to do to fulfil the goals. The tendency in birds is that in the last decade population trends are "increasingly stable," i.e., fewer species are decreasing and the number of species that show positive population trends is increasing (Ottvall et al. 2009). However, many species have a more stable population trend after a long period of decline. They have stabilized at a lower level and this includes some wetland species. In fact, for 1990-2002, 46% of the breeding bird species in Sweden have shown decreasing trends, which is the highest proportion of any country in Europe (Ullman 2006).

CONCLUSIONS

Even if Sweden belongs to a part of Europe that may expect less devastating effects than many other countries, if decisive measures are not taken, there will be drastic effects on both the climate and environment. Higher temperatures and more rainfall will cause changes in ecosystems as well as in plant and animal life. Vegetation zones will be pushed northwards and towards higher altitudes in the mountains. The Eurasian Crane has been a winner in the last decades, increasing substantially in numbers and expanding its breeding range. The breeding range expansion may increase further, this time towards higher altitudes in the Scandinavian mountains.

Increased precipitation will probably increase the wetland area in Sweden. However, decisions concerning water management, forestry, irrigation and other needs of the society will probably also play an important role in the future. To what extent conservation will be considered is yet to be seen. For example, there is a rapid increase in erecting wind mills as a renewable energy resource (wind energy). The location of windmills is of considerable concern among ornithologists. The Swedish Ornithologists Union has stated that it is essential that locations are avoided where there is a clear impact on birds and environment. Also of importance is that conservation aspects are taken into account early in the planning process. This practice is not always followed and furthermore well-based conservation assessments often need field studies in the proposed locations.

Bird species with high demands on wetland quality may have problems in the future. Cranes use a wide variety of breeding places and will probably be less affected if water quality decreases.

Increased temperatures will probably make cranes return even earlier in spring and depart later in autumn. I offer three predictions:

1. Cranes will be wintering in Sweden.
2. Migration flights will be shorter.
3. The Iberian Peninsula as an important wintering area will become history.

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INFLUENCE OF CLIMATE CHANGE ON THE BEGINNING OF BREEDING OF EURASIAN CRANES IN GERMANY

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Abstract: In1970-1980, the average return date of pairs of the Eurasian Crane (*Grus grus*) from wintering grounds to breeding areas in Mecklenburg-Western Pomerania (northeast Germany) was 13 March, with rare occasions of arrivals in February. In recent years, the arrival date has moved up to mid February. Due to mild winters over the last 20 years, some cranes now spend the winter in their breeding grounds. From 1970-1980, beginning of breeding averaged 10 April. To study changes in timing of egg-laying, selected crane pairs were observed within an area of 340 km² in Mecklenburg-Western Pomerania. This study included nest monitoring and collection of data on egg size and weight for statistical analysis. Between 1999 and 2009, beginning of incubating shifted from 2 April to 21 March. In spite of the severe and long winter of 2009/10, some cranes started breeding in March and the first chicks were seen on 23 April. Results of this study and earlier research indicated that in 2009 the beginning of breeding occurred 20 days earlier than in 1980. An early beginning of breeding is beneficial for reproduction for crane populations in Germany since chicks may successfully fledge from the second or even third clutch after the loss of the first clutch.
Keywords: Eurasian Crane, breeding dates, climate change, Mecklenburg-Western Pomerania

INTRODUCTION

The Eurasian Crane (*Grus grus*) is a common breeding bird in East Germany. Since 1980, the population has been growing steadily and expanding its breeding range to the south, north and west. Since that time dates of arrival at the breeding area and the beginning of breeding were recorded, although in early years the data were collected randomly.

Between 1970 and 1980, cranes returned from their wintering grounds to Mecklenburg-Western Pomerania (northeast Germany) around 13 March. As an exception, first arrivals were documented in February. At that time the beginning of incubation averaged 10 April (n=44). The earliest date of egg laying was recorded on 22 March 1961. Overall, eight more cases of egg-laying in March were recorded (Mewes 1987). To determine the beginning of breeding of Eurasian Cranes more precisely, more data have been collected in Mecklenburg's inland since 1990.

MATERIAL AND METHODS

The study area of ~340 km² is located in Central Mecklenburg-Western Pomerania in the administrative district Parchim. It is a home to ~100 crane pairs, which is equivalent to a population density of 30 breeding pairs per 100 km². Every year, but more intensively since 2005, egg measurements (length, diameter, and weight) have been taken from as many nests as possible. While calculating the egg volume ($V = 0.51 \times$ length $\times$ diameter^2), the weight of freshly laid (not incubated) eggs was also calculated. Knowing the actual weight at the time of data collection we could estimate the date of egg-laying. To analyze changes in timing of breeding, measurements were taken only of the first clutch of a breeding pair. A total of 450 eggs were examined between 1999 and 2009.

RESULTS

From 1999 to 2009, an earlier average beginning of breeding was documented, shifting from 2 April to 21 March (Fig. 1). Despite the prolonged and harsh winter in 2010, the first cranes were arriving as early as 19 February and the first chicks hatched on 23 April (beginning of breeding around 22 March).

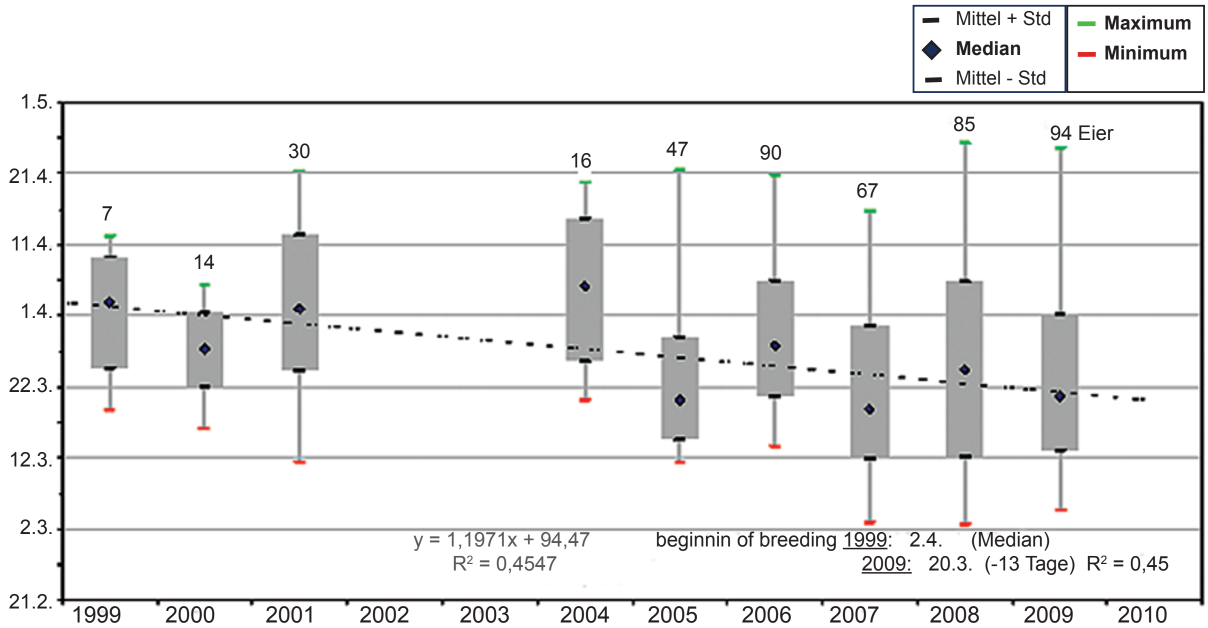

Fig. 1: Beginning of incubation in the Goldberg region of Mecklenburg-Western Pomerania in 1999-2009; first clutches only (chart by Moriz Rauch)

According to older studies (Mewes 1987) and the present results of the past 10 years in Mecklenburg-Western Pomerania, cranes start breeding 20 days earlier than the average of 1980.

DISCUSSION

Due to mild winters over the last two decades the behavior of the wintering German crane population has changed. Some cranes tend to spend winter in the breeding grounds or in small groups at stopovers along the flyway. Thus many Eurasian Cranes no longer migrate to reach distant Spain, but stay in France or in West Germany during winters (Nowald et al. 2012). In general, the cranes return in mid February to the breeding grounds and start breeding around a month later (Mewes 2006). Therefore the breeding has begun much earlier in recent years. This new trend may have positive influence on reproduction success of the German crane population. Since breeding grounds are still well-filled with water in early spring, providing safe habitat for breeding, cranes do not suffer significant losses of clutches or chicks during that time, and even if first clutches are destroyed, there is still sufficient time to rebuild nests and lay new eggs. Furthermore, there is reasonable evidence that cranes may even lay eggs for the third time after having lost their first and second clutches. Due to the early start of the breeding season chicks from subsequent clutches will have sufficient time to fledge by late summer or early autumn. That is why this new trend associated with mild winters contributes to positive population development.

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INFLUENCE OF CLIMATE CHANGE ON THE WINTERING SITE SELECTION OF EURASIAN CRANES

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Abstract: On the West European Flyway, Eurasian Cranes (*Grus grus*) migrate short and mid-range distances from the breeding grounds in northern Europe to traditional wintering grounds in Spain. Due to the global warming and mild winter temperatures, Eurasian Cranes may select wintering sites further north, thereby shortening their migration routes. From 1990 to 2009 the German Crane Working Group marked 553 Eurasian Cranes with colour rings in the breeding areas of Mecklenburg-Western Pomerania, north-eastern Germany. From 1997-2009, January sightings of 388 banded wintering cranes were recorded. The shortest distance between the banding and wintering sites was 11 km in January 2007, the longest distance of 2,380 km was documented in 2008. Since 2003, an increasing number of German cranes have spent winters in France and some birds even stayed in Germany. Between 1997 and 2007 median (mean) migration distances of cranes shortened from 2,088 km (2,041) to 320 (677) km. The results suggest a great impact of climate change and increased winter temperatures on the migration range of German crane populations. Availability of restored and artificial wetlands as well as vast cultivation of maize along the flyway also contributed to changed wintering strategies in crane populations of north-eastern Germany. Recently a controversy arose about a proposal to provide artificial feeding during severe winter conditions, supported by some NGOs and private people but opposed by "Crane Conservation Germany."

Keywords: climate change, Eurasian Cranes, migration distance, wetland restoration, wintering

INTRODUCTION

On the West European Flyway, Eurasian Cranes (*Grus grus*) migrate short and mid-range distances from the breeding grounds in northern Europe to traditional wintering grounds in Spain (Prange 1989). Shallow fresh water wetlands with 20 to 30 cm water depth are preferred roosting sites for cranes (Loworn and Kirkpatrick 1981). If roosting sites are frozen, however, cranes feel unsafe due to less protection against predators. Foraging on seeds, bulbs and other food items becomes impossible due to frozen or snow-covered grounds. Mewes (1996a) reported that successful wintering in Germany only occurred during mild winters and positive population change depends on mild winter temperatures and thin snow cover. Due to global warming and predicted mild winter temperatures, Eurasian Cranes might select wintering sites further north, thereby shortening their migration routes.

This study is a project of "Crane Conservation Germany," a working group of the German Society for Nature Conservation (NABU), the World Wide Fund for Nature Germany (WWF), and Lufthansa.

METHOD AND MATERIALS

From 1990 to 2009 the German Crane Working Group marked 553 Eurasian Cranes individually with colour rings in the breeding areas of Mecklenburg-Western Pomerania, north-eastern Germany. Banding of cranes has been standardized by the agreement of the European Crane Banding Group since the late 1980s. For individual identification cranes are banded with six colour plastic rings (black, white, red, green, blue, and yellow) placing a country code on the left leg and a three-coloured individual code on the right leg. In addition to plastic rings, any marking requires a metal ring of the responsible ornithological or banding centre. Juvenile birds are mostly banded before fledging at the age of 5-10 weeks. Adult cranes are caught occasionally, when they are moulting every third or fourth year and stay flightless over a 6-week period (Nowald et al. 1996). In addition to colour banding, radio tags were attached to 248 cranes between 1995 and 2008 (Nowald 1999).

During the months of January, from 1997-2009, sightings of 388 marked wintering cranes were recorded.

In this study the North Atlantic oscillation index (NAO) was used to describe winter conditions affecting wintering site selection of cranes. The NAO is a climatic phenomenon of the North Atlantic Ocean currents which is influenced by fluctuations of atmospheric pressure at sea level, the Icelandic low and the Azores high. In addition, strength and direction of westerly winds and storm tracks across the North Atlantic Ocean are induced by the east-west oscillation motions of the Iceland low and the Azores high. The NAO is highly correlated with the Arctic oscillation, as it is a part of the latter (http://en.wikipedia.org/wiki/North_Atlantic_oscillation 05.07.2010, 09:15 CEST). A positive NAO index indicated a mild and humid winter whereas a negative NAO represents a cold winter.

RESULTS AND DISCUSSION

The shortest distance between the ringing and recovery localities in January was 11 km, in 2007. The longest distance of 2,380 km was recorded in 2008 (Table 1). Since 2003 an increasing number of German cranes wintered in France, some birds even in Germany. Between 1997 and 2007 median (mean) migration distances of cranes decreased from 2,088 km (2041) to 320 (677) km.

Table 1: Migration distances in kilometres from 1997 to 2009

	1997	1998	1999	2000	2001	2002	2003
n:	9	14	21	24	13	15	15
Mean:	2041	2061	1824	1668	1606	1418	1292
Minimum:	1730	1979	739	743	97	741	745
25th Percentile:	2031	2019	1971	1370	1425	773	755
Median:	2088	2072	2019	1971	1773	1423	777
75th Percentile:	2108	2091	2066	2078	2075	2073	2072
Maximum:	2145	2136	2198	2123	2193	2155	2083

	2004	2005	2006	2007	2008	2009
n:	26	34	51	43	58	65
Mean:	1785	1150	1538	677	1128	1057
Minimum:	1402	111	233	11	213	106
25th Percentile:	1439	333	1375	268	265	315
Median:	1740	1415	1498	320	835	978
75th Percentile:	2086	1720	2079	985	2067	1603
Maximum:	2260	2182	2190	2210	2380	2159

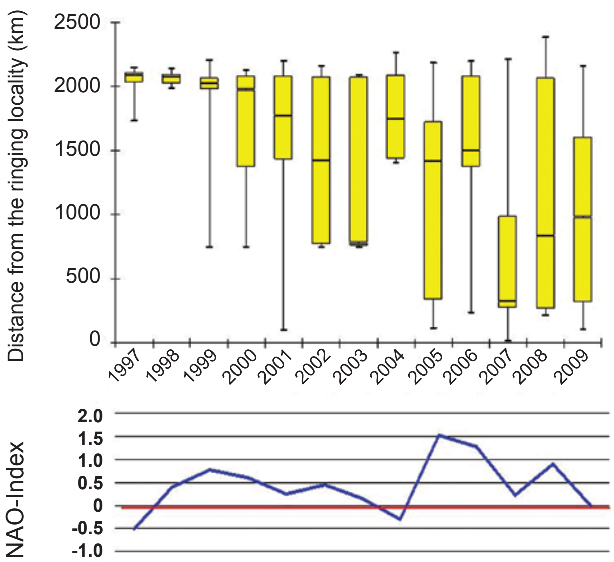

Fig. 1. Migration distances from the banding location to wintering sites

Migration distances seem to correlate with winter conditions summarised as the NAO index (Fig. 1). From 1997-2006, in years with negative or low positive NAO index, the median migration distance of German cranes was as long as 1,500 km. In the following years, however, the migration distance shortened with a higher positive NAO index. The One-Way-ANOVA test shows significant differences in the migration distances from 1997 to 2009 ($F=12.11$ with $df=12$; $p<0.0001$) whereas the BARTLETT's test revealed significant differences in the mean comparison ($chi^2 = 102.25$ with $df=12$; $p<0.0001$).

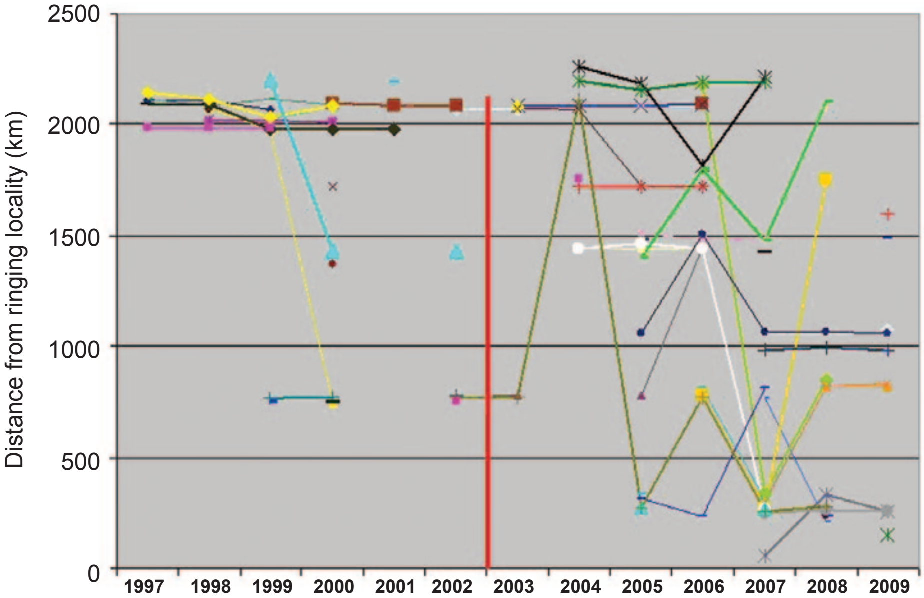

Fig. 2. Wintering site selection of individual cranes

It is assumed that in recent years most of the birds did not select other wintering sites than the ones used during the last century. Since 2003, however, migratory behaviour of individually marked birds has changed remarkably (Fig. 2; marked by red vertical line). Between 2004 and 2009, some cranes changed their migration distances by 300 km to over 2,000 km, while other birds used their traditional wintering sites in Spain. The studied German crane population shows two different migration strategies: conservative versus progressive. If birds react flexibly to quickly changing environmental conditions they benefit in terms of fitness. Birds with short migration ranges will have an advantage and may approach the breeding grounds earlier than other birds of the same population.

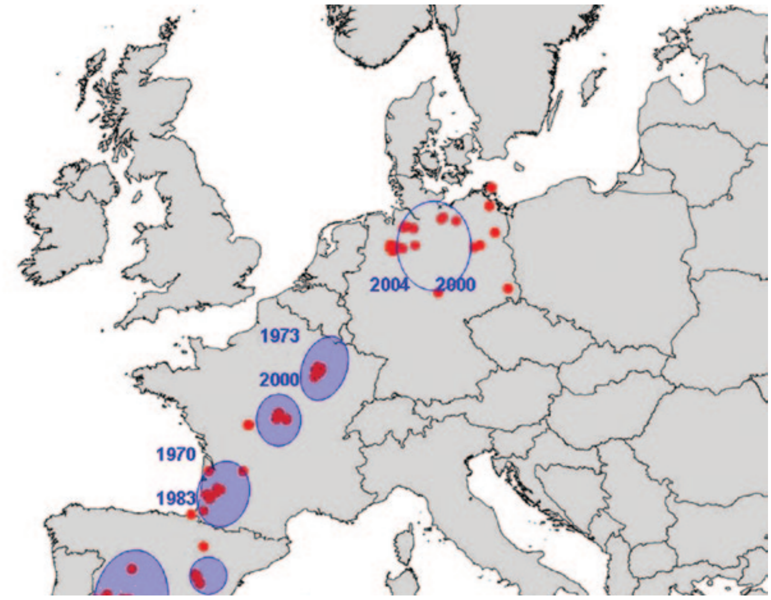

Fig. 3. January recoveries of banded cranes from the study area between 1997 and 2009.
First wintering on sites is indicated by year

Due to warm winters cranes from Germany marked in recent years spend winter not only in traditional sites in the Extremadura (Southwest Spain) or at the Laguna de Gallocanta (Northeast Spain; Alonso and Alonso 1996) but also further north in Europe, even in Germany (Fig. 3).

Availability of newly restored or artificial wetlands as secure roosting grounds also made a great impact. For example, the Lac du Der Chantecoq in north-eastern France was established in 1973 as a rainwater retention basin preventing floods in Paris. This place was immediately used for resting during migration by as many as 70,000 cranes and in recent years, specifically in January, over 5,000 cranes spent the winter here, with an exception of the colder winters of 2004 and 2005 when only 2,500-3,000 birds were observed (compare with Fig. 1 NAO index; Le Roy 2005). The new wintering site of Arjuzanx (south-western France) was an open-cast mining of lignite with industrial exploitation until 1992 (Petit and Couzi 2005). During the following years this region was restored to a National Reserve with shallow artificial lakes which are used by cranes during migration and wintering (Fig. 3). In January 2006 the maximum number reached ~20,000 cranes (Patrick Dulau personal comm.). In both regions cranes have found good nutritional resources on maize stubble fields.

Since 2004 cranes have wintered in the “Diepholzer Moorniederung” in the Lower Saxony (West Germany) (Kerrin Lehn in lit. 2009). Birds have been roosting in 15 different raised bogs, which were restored in the late 1990s after peat extraction was discontinued. On 15 January 2007 about 7,700 cranes were counted in this area. Due to a cold spell the birds disappeared and on 30 January 2007 only 2,300 cranes were sighted (Friedhelm and Niemeyer in lit. 2007).

During the last winter questions arose among NGOs and private people about a need to establish artificial feeding in staging areas during severe snow, ice and winter conditions. “Crane Conservation Germany” is against any such projects in Germany during winter, because cold spells and heavy snowfalls naturally force the birds to leave the area where otherwise they might perish even with artificial feeding (Mewes 1996a). Without the feeding the cranes migrated to France in January for only a short time, which did not affect their behavioural patterns.

Positive population development remarkably contributed to the increasing numbers of German cranes on wintering sites further north in Europe. Mewes (1996b) reported only 1,909 breeding pairs in 1992-1993 whereas in 2008 the numbers had increased to 6,700 pairs (Mewes 2010).

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CRANES AND PEOPLE: AGRICULTURE AND TOURISM

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Abstract: The Eurasian Crane (*Grus grus*) population in Europe has been increasing for more than 30 years. In 2008 about 240,000 cranes migrated through Europe on the western flyway alone, wintering mainly in France and Spain. To reduce conflicts with farmers and to protect the cranes, different administrations in Europe remitted different guidelines, ministerial acts or laws. Mostly, farmers were to receive compensation for crop damage. In Mecklenburg-Western Pomerania, however, artificial feeding is now the most successful management method to reduce conflicts, both with farmers and tourists. These feeding sites are financed by the provincial government and NGOs. Because of actual changes in agricultural cultivation (e.g., planting winter crops), fewer conflicts were observed during the spring migration in the Rügen-Bock region in NE Germany. Crane tourism is growing. In autumn thousands of tourists visit the resting site of cranes in the shallow lagoon landscape "Vorpommersche Boddenlandschaft" in NE Germany, resulting in greater level of human disturbances. Crane Rangers of the Crane Information Centre try to reduce the disturbances by directing visitors to places with fenced-off observation facilities, overlooking crane feeding places. Cranes, however, boost local tourism development; special events like the "Week of the Cranes" with slide shows and excursions, as well as boat trips to the shallow night roosting areas in the lagoons, attract many visitors.

Keywords: Eurasian Cranes, agriculture, tourism

INTRODUCTION

Europe is the homeland of the Eurasian Crane (*Grus grus*). The species' breeding territory stretches from the Weser River in Germany across Scandinavia, the Baltic States, Poland, Ukraine, Belarus and European Russia to Asia. Some isolated small populations are breeding in England, the Netherlands and France. In Europe Eurasian Cranes migrate on two main flyways (see Fig. 1). Along the routes the birds stop at different main resting areas. Cranes in the western flyway winter mainly in France and Spain.

For a number of reasons, the Eurasian Crane population in Europe has been increasing for over 30 years. According to Prange und Mitarbeiter (2009), in 2008 about 240,000 cranes migrated through Europe on the western flyway alone (see Fig. 2).

In addition to prolonged and intensified conflicts between cranes and farmers in different European regions for more than 15 years (Zimmermann et al. 1999), we have also observed an increasing number of disturbances caused by tourists in some areas of Central Europe.

This paper summarizes experiences of addressing conflicts between cranes and farmers, such as financial compensation for crop damage and management of artificial feeding sites. The paper also identifies the impacts of and opportunities for crane tourism.

RESULTS AND DISCUSSION

Cranes and Agriculture

For the growing crane population on the western flyway, numbers of individuals also increase at stopover sites, including the Rügen-Bock area with up to 70,000 cranes (see Fig. 3).

A major cause of the crane population growth is the food availability for staging and wintering cranes in intensively farmed areas – leftover grain after harvest and newly planted crops. This change was attributed to new agricultural machinery, financial aid provided by the European Union, and increased cultivation of maize, wheat, and barley.

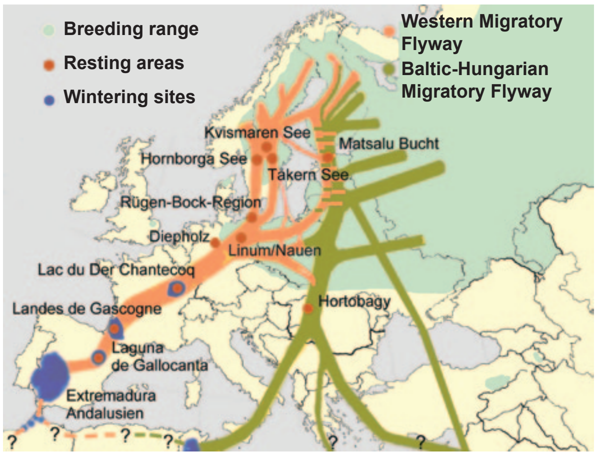

Fig. 1. Breeding range, flyways, resting areas, and wintering sites of Eurasian Cranes in Europe

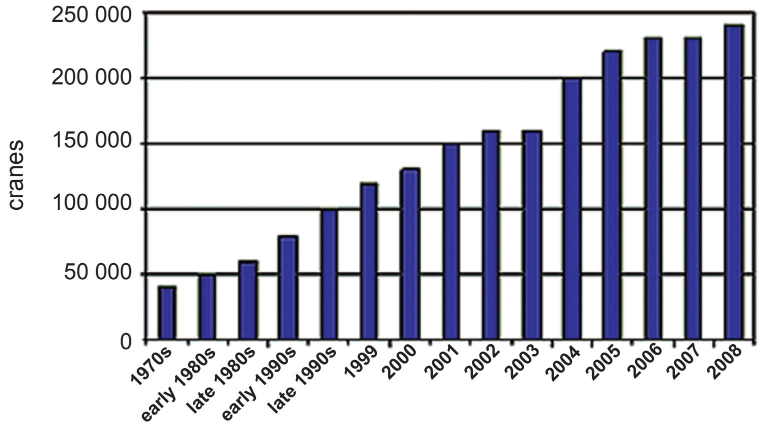

Fig. 2. Development of the Eurasian Crane population on the Western European Flyway

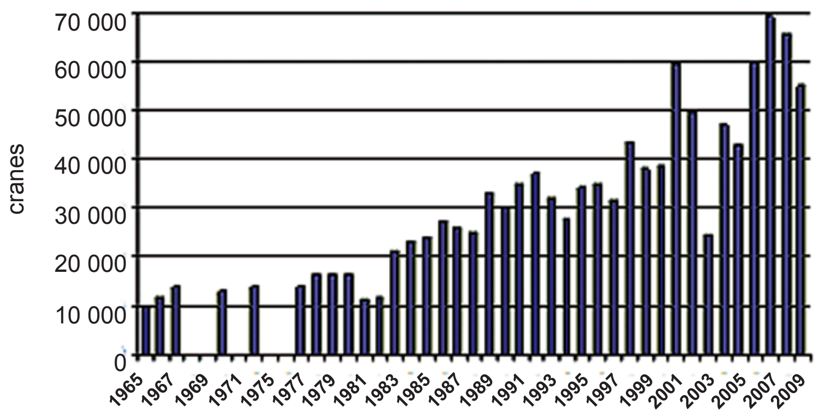

Fig. 3. Crane population development at the Rügen-Bock area in autumn, NE-Germany

Favoured food sources during autumn migration at the Rügen-Bock area are maize, followed by wheat and barley (Nowald 1996, Ulbricht 1999). In the 1970s and 1980s cranes found considerable crop remains on grain stubble fields (remains of cereal 3-5% and 5-10% of maize). But in recent years, the birds find less crop remains on cereal and maize stubble fields (1-2% remains of cereal and 0-1% of maize, in lit. 2001, B. Kopmann) due to technologically advanced harvesting machinery. On a sample surface of 25x25 cm^2 of the examined cereal stubble fields we found about 10 grains in 2000, 20 grains in 2001 and no grain in 2002 (median data, Crane Information Center Groß Mohrdorf). Crop remains on cereal stubble fields were low and non-uniformly distributed. On maize stubble fields, the remains were much more evenly distributed. But in more than 50% of the samples, we didn't find any maize seeds on a surface of 100 x 100 cm^2. The duration of cranes feeding on agricultural stubble fields was extremely short [grain or maize stubble fields only 4 days and 2.5 days (median) respectively – Nowald et al. 2001]. Cranes feed for such a short time period on the remains because stubble fields are ploughed immediately after harvesting. For this reason, cranes have to switch from harvested areas to new sown fields. But at these sites the birds are chased out by farmers because of anticipated crop damage. For more than fifteen years we have observed intensified conflicts between cranes and farmers in different regions in Europe (Zimmermann et al. 1999).

To reduce conflicts with farmers and to protect the cranes, different administrations in Europe remitted different directives, guidelines, ministerial acts or laws. Mostly, farmers were to receive compensation for crop damage as done for example by the administration of Mecklenburg-Western Pomerania.

First, the administration of Mecklenburg-Western Pomerania remitted a guideline to compensate crop damages: "Directive to negotiate applications for losses of revenue insurance in case of damage caused by protected species from 13 December 1991" (the Ministry of Agriculture and Nature Protection reimburses the costs). ["Richtlinie zur Bearbeitung von Anträgen zur Ertragsausfallminderung bei Schäden durch besonders geschützte Tiere vom 13.12.1991" (Ministerium für Landwirtschaft und Naturschutz erstattet Ertragsausfall).]

In 1995 the administration remitted a ministerial act to prevent crop damages by cranes (and other species). They financed artificial feeding sites: "Proposal to prevent freshly sown winter crops and rape seed from game damage from 15 September until 31 October 1995" (proposal from 22 August 1995). ["Erlass zur Verhinderung übermäßiger Wildschäden auf frisch eingesäten Wintergetreide- und Rapssaaten in der Zeit vom 15 September bis 31 Oktober 1995" (Erlass vom 22.08.1995)].

In 1996 the administration remitted a new guideline to compensate crop damages: "Directive for the loss of income – ErAusRL – from 8 October 1996 on the grant of loans to reducing economic burdens subsequent to damage inflicted by protected or migrating species. – Feeding supply is achieved by spreading grain fruits resp. other suitable arable crops" ["Ertragsausfallrichtlinie – ErAusRL – vom 08.10.1996 (RL über die Gewährung von Zuwendungen zur Minderung von wirtschaftlichen Belastungen infolge von Beeinträchtigungen, die durch besonders geschützte und/oder wandernde Tierarten verursacht warden)"]. As a first priority, this guideline lay down measures that aimed to prevent crop damage by using artificial feeding sites. This guideline was considered very helpful and successful since farmers have established up to 20 feeding sites in the "Rügen-Bock-area."

In 2000 the administration remitted a guideline to prevent crop damages: "Directive for the grant of loans to support extensive farming at the centre of resting areas of migrating bird species (Funding guidelines of bird resting areas – VoRastRL) from 27 November 2000" ["Richtlinie für die Gewährung von Zuwendungen zur Förderung der extensiven Ackernutzung im Bereich von Rastplatzzentren wandernder Vogelarten (Vogelrastplatzförderrichtlinie – VoRastRL) vom 27.11.2000"]. But farmers insisted on boycotting this guideline since it has been established. Farmers did not like to sign contracts with a five-year long agreement. They would have no chance to change the arable land under contract and they also had to abandon chemical fertilizers.

Compensation for Crop Damages Versus Artificial Feeding Sites?

In Mecklenburg-Western Pomerania, artificial feeding has become apparent as the most successful management strategy to reduce conflicts, both with farmers and tourists. The feeding sites are financed by the provincial government and NGOs like "Kranichschutz Deutschland," which was founded as a working group of the German Society for Nature Conservation (NABU), the World Wide Fund for Nature Germany (WWF) and Lufthansa Airlines. In this jurisdiction, there is no financial compensation for crop damage by cranes.

As to the very limited areas of wild lands emerging within agricultural environments in Germany, cranes do not distinguish between feeding on artificial feeding sites or on newly sown fields or other crops. By financial comparison, however, artificial feeding is much cheaper than paying for crop damage.

Due to the actual changes in the agricultural cultivation, we had fewer conflicts during spring migration in the Rügen-Bock region for some years. This reduction is because farmers stopped growing summer cereals and are now growing winter cereals in the fall, when most of the cranes have left the resting area (the resting period is from early September through November and December). Beside changes in the crop growing timetable, the kinds of cultivated crops have also changed (see Fig. 4). Fields cultivated with the crop most favoured by cranes – maize – have declined from ~15% to 5% of lands planted. There is also an alarming trend of reduced food availability for cranes in harvested fields. Additionally, due to EU legislation, areas of winter rapeseed have increased from 10% to over 20% of total croplands. This change is unfavorable for cranes because of low nutritious value of rapeseed and the difficulty for cranes to use this habitat because of the dense growth of these plants. Le Roy (2005) also noted the reduction in maize farming in the important staging region of Lac du Der Chantecoq (north-eastern France) in the last years, while the cultivation of wheat and barley is increasing.

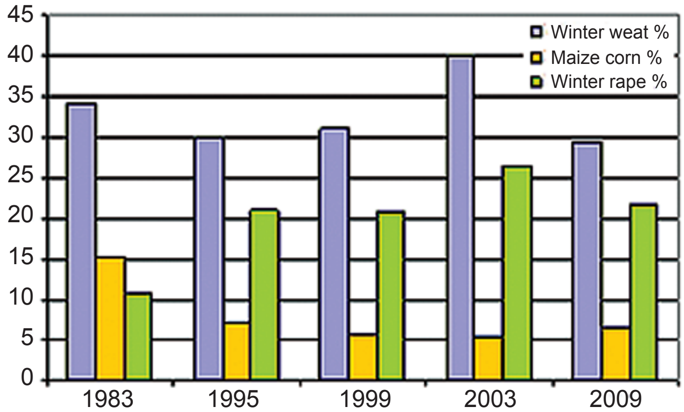

Fig. 4. Percentage of different crops on the cultivated lands in the administrative district of Nordvorpommern, NE-Germany (1983: in lit.; 2010: B. Kopmann LPG Prohn; 1995-2003: Statistisches Informationssystem http://www.mvnet.de/inmv/land-mv/stala/sis/tabelle.php?&id=344; 2009: Amt für Landwirtschaft Franzburg, Nettelbeck)

In general, the demands from the global market, financial support from the EU and biogas production have contributed to the modification of farming. This development is currently having a massive impact on food availability for cranes.

Cranes and Tourism

The crane resting area at the Baltic coast has been experiencing a real rush of visitors. Fifteen years ago, only a few birders came to see cranes flying to the roosts in the shallow lagoon landscape "Vorpommersche Boddenlandschaft" in northeast Germany. In recent years we have counted at the Rügen-Bock area alone maximum numbers of 60,000 to 70,000 cranes (see Fig. 3). Meanwhile, thousands of tourists have come to see the resting cranes in the shallow lagoons in autumn to attend this natural spectacle. Year by year about 15,000 tourists come to see the exhibition of the Crane Information Center (see Fig. 5) as single visitors, in small groups, or groups organized by travel agencies in combination with special crane-watching programs. The tourism industry is currently talking about the fifth season. A similar development is documented for other important crane resting areas in Germany as well, such as in the "Rhin-/Havelluch region" or in the "Diepholzer Moorniederung." Due to the rush of visitors during the last years, incidence of human disturbances has remarkably increased. In particular, there is a growing number of inexperienced photographers with insufficient equipment (no zoom lenses) who try to approach too close, so the birds take flight. Well trained rangers of the Crane Information Centre are dedicated to reduce disturbances by directing visitors to places with fenced-off observation facilities. On the other hand, cranes are beneficial for the development of tourism. Special events like the "Week of the Cranes" with slide shows and excursions, as well as boat trips to the shallow night roosting areas of the lagoons of the "Vorpommersche Boddenlandschaft," attract more visitors.

Proceeds from tourism do not benefit farmers but go to small businesses (tour boat owners, restaurants, hotels). On the other hand, tourists create problems to farmers by parking in the entrances of crop fields or blocking the farm tracks. Additionally, only a minor part of benefits from tourism trickles down to nature conservation organisations. Costs of rangers' labor and crane feeding are higher than support from the tourism industry or donations made by tourists.

Due to the financial benefits from tourism, the industry has to take over more responsibility for crane conservation in the future. First of all they should build more observation towers and parking sites. Operators of hotels and guest houses should provide better information to tourists about where and how to watch cranes.

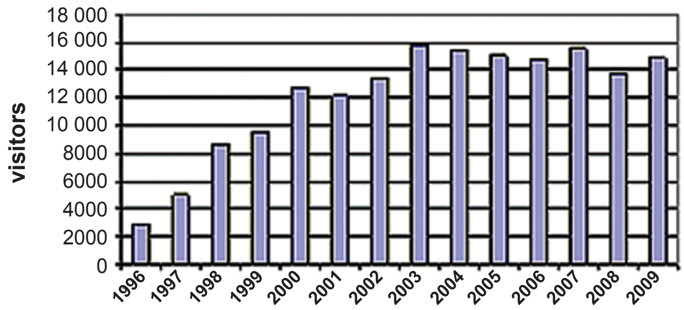

Fig. 5. Numbers of tourists attending the exhibition at the Crane Information Center in Groß Mohrdorf, NE-Germany

In conclusion, while tourism and tourists feel a strong affinity with cranes, like most of the people do who follow cranes on their migration, some farmers would prefer a world without cranes. Due to dedicated conservationists (governmental organizations and NGOs) conflicts are being resolved. Actually cranes have found, without any doubt, better conditions for breeding and resting in Germany during the few most recent years. Effects of climate change are not yet visible. In the “Climatic Atlas of European Breeding Birds” Huntley et al. (2007) predicted the extinction of the Eurasian Crane as a breeding bird in Germany. In fact, to avoid this scenario by Huntley, which we hope will never come true, we ought to maintain breeding and resting areas for European Cranes by intensifying collaboration with landowners, energy-suppliers, and the tourism industry for the cranes’ welfare.

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EURASIAN CRANE (*GRUS GRUS*) AND AGRICULTURE IN FRANCE

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Abstract: The review of the French ornithological literature since the 19th century shows that Eurasian Cranes (*Grus grus*) have always used agricultural systems as feeding places. Information remained very scarce, however, and until the 1980s conflicts with farmers were never indicated. Dramatic transformations in landscapes and in agricultural practices that began in the 1980s, linked to demographic changes in crane populations, resulted in increasing concentrations of birds at some places so that the first significant crop damage happened in March 1984 in eastern France, especially in Champagne and to a lesser extent in Lorraine. The damage occurred mostly to newly sown fields in late winter (barley, wheat, peas, etc.). Serious damage-prevention efforts have been made since 1990 using agro-environmental programs of the European Agriculture Policy. Farmers, however, were not satisfied with the results, and in 2005 a special experiment was initiated in Champagne to indemnify the damages with money. In other parts of the country (mainly in the southwest), increasing numbers of cranes also staged and spent the winter, but due to the specific variety of crops in those areas (mainly corn, no winter cereals), the risk of damage was very low. In addition, agro-environmental programs provided food for cranes during winter. More recently, changes in agricultural practices and crop varieties (increasing colza fields together with decreasing corn fields since 2005) seem to be causing negative trends in historical crane wintering sites and could also reduce growth of local breeding populations due to meadows destruction.
Keywords: Eurasian Crane, France, wintering, crop damage, agriculture

INTRODUCTION

In Europe, it appears that the encounters of cranes and farmers are part of the history as evoked, for example, in some poems of Homer in Ancient Greece (9th century B.C.). In France, like in other countries, migrating cranes are traditional users of agro-systems. When reading the available ornithological papers from the 18th and 19th centuries through to the 1980s, however, no description of significant damage to crops (and resulting conflict with farmers) is found. This lack of conflict could perhaps be explained by lower crane population numbers in those times and probably to wide dispersion of cranes during staging due to extensive agriculture practices of the past.

Since the middle of the 20th century, important transformations in agriculture have occurred in Europe and especially in France, with crop specialization in some regions and a spectacular increase of corn culture, extending from the southwest of the country to all other regions (Fig. 1).

Many studies have shown the very high importance of corn in crane diets in the United States (Fritzell et al. 1979, Loworn and Kirkpatrick 1982, Krapu et al. 1984), as well as in France (Salvi 1984, Génard et al. 1991, Riols 1997) or Germany (Nowald 1996). Thus in corn-raising areas, corn can reach up to 96% of the total food intake of cranes (Reinecke and Krapu 1979, 1986).

This paper examines the relationship between Eurasian Cranes (*Grus grus*) and agriculture in France. Throughout the migration flyway in France many areas have become very attractive for cranes due to increased corn farming, combined with favorable conditions such as climate change, modifications of landscapes, creation or restoration of large wetlands (Salvi 2012 in press). However, in some seasons, when corn resources are obviously depleted, the birds have to find other food, resulting in possible damage to other crops.

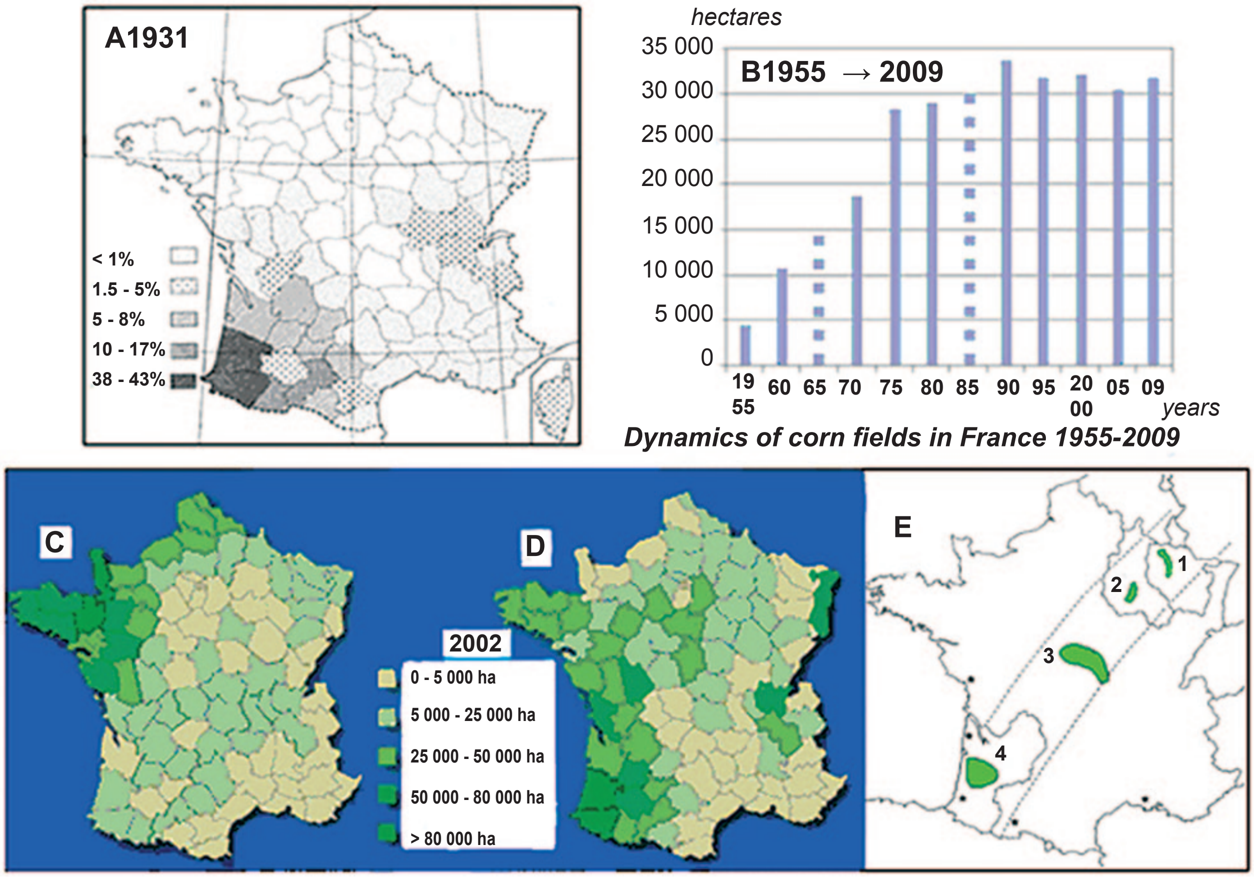

Fig. 1. Expansion of corn farming in France in the last century: A – percent of land under corn in 1931; B – changes in areas under corn from 1955-2009; C and D – areas under corn culture in France (C – for green mass, D – for grain); E – the main crane flyway with staging and wintering areas (1 – Lorraine, 2 – Champagne, 3 – Central France, 4 – Aquitaine). From: Faucher 1931, French Ministry of Agriculture, Salvi in press

METHODS

The study concerns three regions of France, that cranes use to stage yearly and to winter since the late 1970s (Fig. 1). The important wintering area in Central France is not taken into account because it was colonized by cranes only recently (Merle 2008). Data were mainly collected by ornithological organisations and crane watchers in France. Further information about different crane areas is given by Salvi et al. (1995) and Salvi (2003).

The statistical data concerning farming activities are mainly received from the French Ministry of Agriculture at national and regional levels.

RESULTS

Cranes and Agriculture in Aquitaine

This region, a former vast assemblage of wetlands, is largely covered with pine forests with some immense cleared areas (totaling several thousand hectares) cultivated mainly for corn. In autumn cranes arrive after the harvest, with up to 50,000 birds spending the winter feeding in the corn stubble and leaving the region before the next planting season. Under these conditions cranes cannot inflict any damage.

Nevertheless, the presence of cranes is intimately linked to agriculture, as it supplies the birds with their principal food. It is important to make this situation sustainable; therefore a specific program was developed to make feeding conditions better for staging and wintering cranes (Gallato 2003). From 1998 specific five-year contracts were offered to farmers for maintaining 80% of their existing corn fields and leaving corn stubble available for feeding cranes in winter. During this five-year program 1998-2003, the contracts had been accepted by 62 farms totaling 3420 ha. A good climate between conservationists and farmers allowed development of eco-tourism activities focused on crane watching.

Cranes and Agriculture in Champagne (Lake Der-Chantecoq and Surroundings)

In autumn, the cranes generally arrive in Champagne after the harvest and mainly feed in corn stubble. Some of them (up to 25,000) spend the winter here. Over time corn becomes scarce and sowing of early crops (barley, peas) begins. Starting in mid-February, thousands of migrant cranes arrive from the southwest needing plenty of food. The duration of staging depends on the weather, which can temporarily stop the migration. As crane staging numbers and duration increase, damage to crops tends to develop (Fig. 2).

In the Lake Der-Chantecoq area the first significant damages followed by farmers' complaints occurred in March 1984, mainly on freshly sown barley, peas, and bean fields (Riols 1997). From 1993 to 2003, the mean value of damage was estimated at about 40,000 €/year. An agro-environmental program has been developed to avoid damage by keeping corn stubble available for cranes as long as possible (until 15 December or even 15 March). During this five-year program 1998-2003, agreements had been established for 1030 ha (Le Roy and Mionnet 2003).

A new three-year experimental project was initiated in 2005 with financial support from the regional administration in Champagne Ardenne (Regional Council), which decided directly to compensate the farmers for crop damage caused by cranes. At the same time, some artificial feeding points were established and regular monitoring of staging cranes was conducted by local ornithologists from the French Society for the Protection of Birds (LPO Champagne Ardenne).

Considering these results and their relatively reasonable costs (Fig. 3), a new program was initiated from 2009 to 2013 for a maximum total compensation of 100,000 €/year for the entire region. During this same time an agro-environmental program is being implemented, including artificial feeding and grassland restoration and creation.

Cranes and Agriculture in Lorraine (Plain of Woëvre)

From an historical point of view, no significant problem between cranes and agriculture was known in Lorraine until the 1980s. That was probably one of the keys to the success of some crane projects in the 1990s, where, at the same time, a specific agro-environmental program was developed with the farmers for conservation of grasslands. Even in high numbers, cranes were generally dispersed at different places (five, six, and sometimes more locations scattered along this plain and extending 70 km from north to south). In addition, availability of huge grassland areas probably helped limit the damage at that time.

Some isolated complaints began to appear in 1984 and were reiterated more consistently 12 years later (in 1996). In recent years, damage is recurrent, especially on newly sown barley fields in February-March. One of the major reasons for this problem is often an unfortunate coincidence between the earlier arrival of migrating cranes and the planting of spring barley (Fig. 2). For the first time in 2004, this situation spurred the farming organizations to conduct an inquiry to estimate the damage incurred within the entire plain. At this time, no compensation is expected from the authorities, and the conflict is still recent. In addition, many are attentively watching the situation in neighboring Champagne, where the regional authority has decided to indemnify farmers since 2005.

Furthermore, at this date Lorraine is the only region of France where cranes are breeding successfully. Therefore conservationists have decided to pay attention mainly to the breeding status of cranes focusing on certain changes in agriculture in parts of the region during the last decade that produce negative effects on breeding cranes.

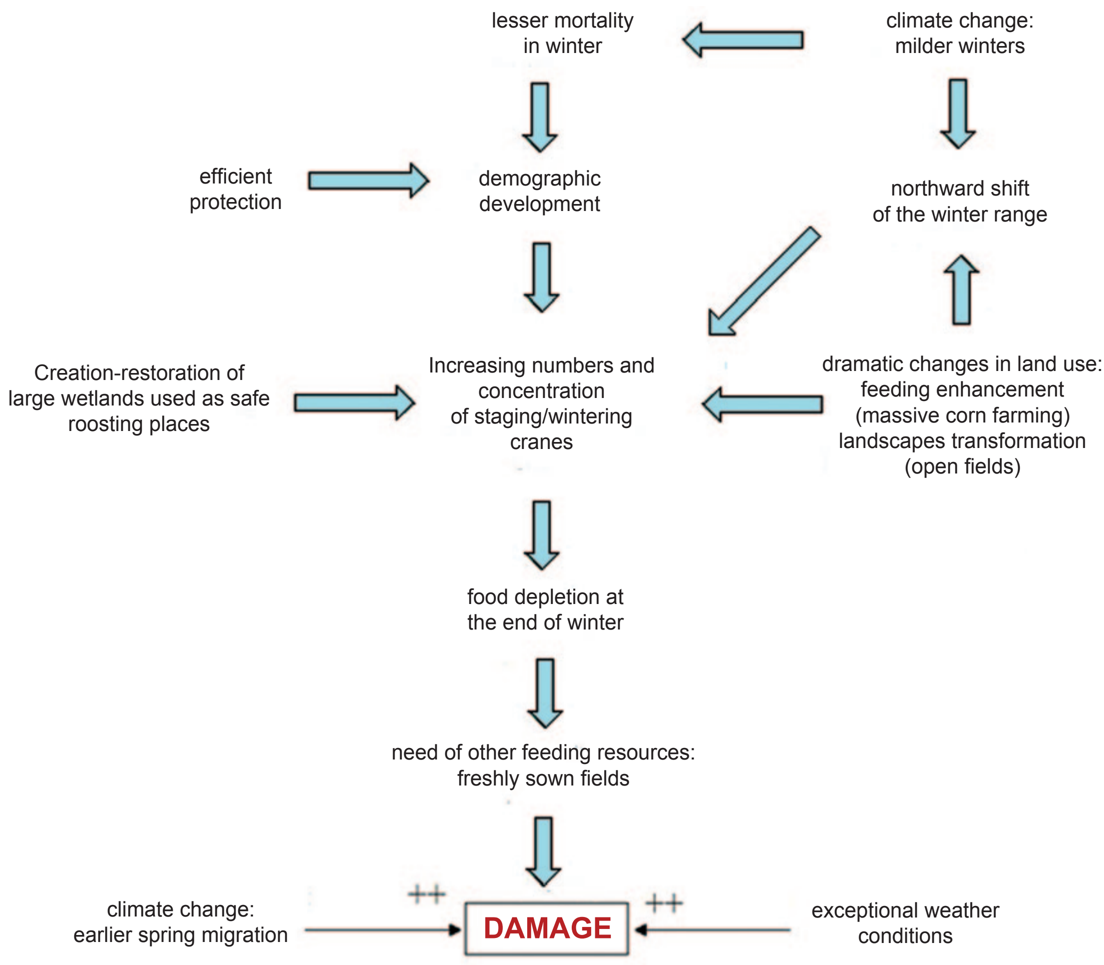

Fig. 2. Schematic mechanism for the increasing occurrence of crane damage in east France (Lorraine and Champagne)

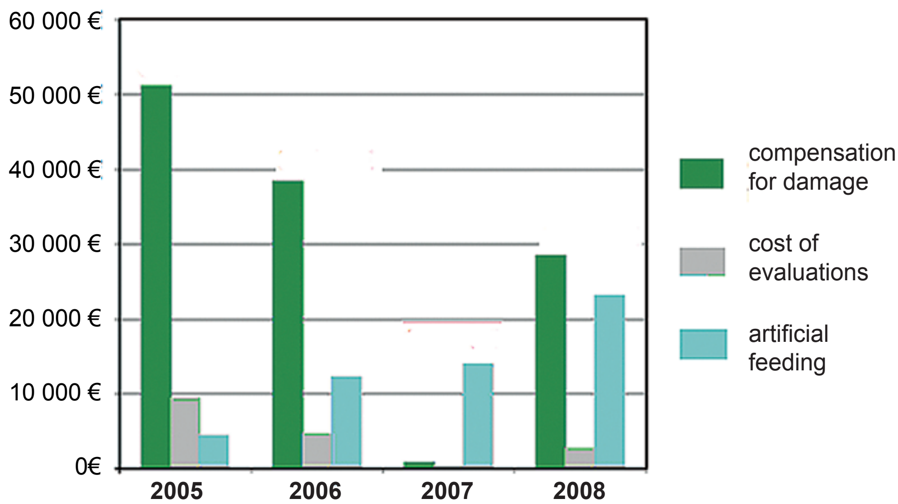

Fig. 3. Costs for management of crane damage in Lake du Der-Chantecoq area from 2005-2008. Annual total costs are in red. Source: Regional Council of Champagne-Ardenne

Thus different programs were developed to support the extensive traditional land use of grasslands, and to save meadows and wetlands (agro-environmental and conservation programs).

Other changes in farming, linked to the international economy and local opportunity, seem also to affect the wintering patterns of cranes, such as the increased culture of rape, a crop of no interest to cranes, for the production of biofuel, paired with a simultaneous decrease in corn growing (Fig. 4).

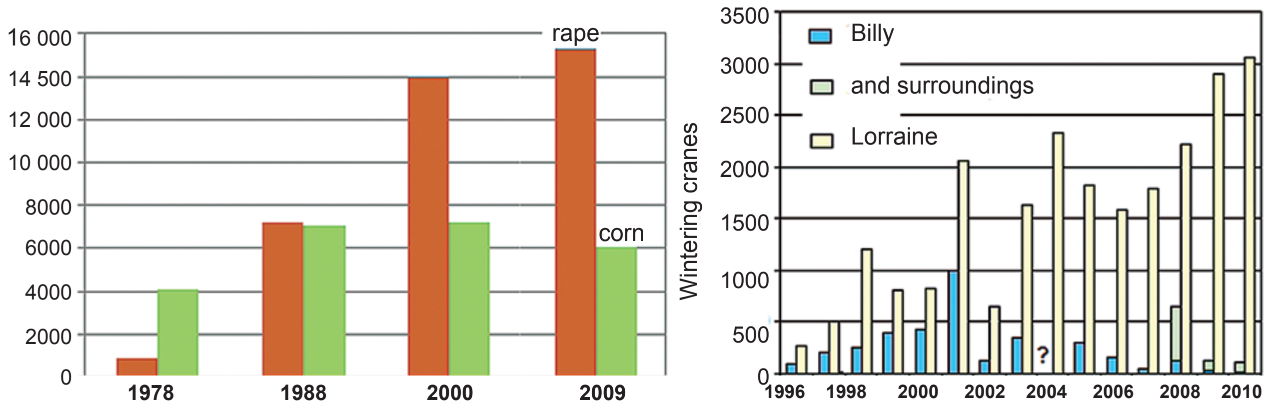

Fig. 4. Comparative dynamics of rape and corn in Woëvre (Lorraine, France) in the last 30 years (source: regional administration of the French Ministry of Agriculture) and dynamics of crane numbers wintering in the northernmost historical wintering area in France Billy-les-Mangiennes (Salvi in press)

Finally, the expansion of rape culture, together with other intensive farming practices, contributes to the reduction of feeding grounds available near the breeding places of cranes.

DISCUSSION

Like many birds the Eurasian Crane is strongly linked to agricultural conditions in France. Major changes in agricultural practices in the past five decades have strongly contributed to promote the spectacular increase in crane numbers. At the same time, concentration of so many birds in agro-systems, sometimes for long periods, obviously results in conflicts with farmers. For now, different solutions based on European regulations and financial support allow short-term solution of some problems. In the long term, only the diversity of landscapes and agricultural practices can help to reduce the pressure of cranes on agro-systems.

In the very near future cranes will certainly face new problems in France (and probably elsewhere in the European Union) because of the changes in winter farming management to reduce the contamination of ground water by nitrates. Stubble fields will thus be ploughed almost immediately after harvesting and replaced by a green cover (rape or any other winter culture), resulting in a massive decrease in the availability of corn. Thus, the local situation observed in Billy-les-Mangiennes (see Fig. 5) could be the example of what could happen in the next years on a large scale. Under these conditions the question is, where the cranes will go for feeding?

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EURASIAN CRANE (*GRUS GRUS*) AND CLIMATE CHANGE IN FRANCE

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Abstract: Since the late 1970s the study of Eurasian Crane (*Grus grus*) migration in France has gathered large amounts of data and allowed description of long term changes in behavior. During this period the convergence of favorable climatic and demographic factors, together with adaptation of the cranes' feeding ecology to intensified agricultural practices in Europe, have resulted in the emergence and expansion of crane wintering grounds in France. Wintering cranes were exceptional in France until 35 years ago. Since then they have increased considerably and the number of cranes wintering in France has now reached more than a third of the whole population using the West-European migratory flyway, from Scandinavia to the Iberian Peninsula. The main wintering areas are also staging places and lie in southwestern France as well as in the northeastern part of the country, where the climate is traditionally colder. The timing of migrations has also changed during these last decades especially in spring, when - migration begins now about two weeks earlier than in the 1980s. These changes are strongly correlated with climate change over a long term period, even though recent cold winters might have temporarily reversed these trends.
Keywords: Eurasian Crane, behavior, France, climate change

INTRODUCTION

Long-term surveys of Eurasian Cranes (*Grus grus*) in France conducted for over 30-35 years show important changes in their biology and behavior. Probably the most spectacular modification is the massive increase of crane numbers crossing Western Europe. As a result, staging areas are frequently used by huge concentrations of birds. About 35 years ago some cranes began to winter in the country. Their number increases now yearly. A recent change is observed during autumn migration which now frequently extends to mid or late December, probably in relation to attempts of some cranes to winter in the northernmost areas (Germany). In spring, the migration takes place earlier than in the past. Since the 1990s breeding pairs of cranes have been sighted, 150 years after the species had disappeared from the country (Salvi in press).

Different factors are believed to explain these changes, which probably combine with each other at various levels to produce very important and complex evolutions. Among these factors, effective measures to protect cranes in all European countries have obviously contributed to the positive dynamics of the population. This population growth, however, is also supported by important transformations both in some landscapes (i.e., creation and restoration of wide wetlands) and in farming practices (better feeding conditions for cranes due to development of maize since the middle of the 20th century). Finally, climate change may also induce modifications in behavior patterns of cranes. This paper focuses on testing this hypothesis.

METHODS

The study first of all addresses the Lorraine region in the northeast of France, traditionally known as one of the colder regions in the country (Fig. 1). In 2007-2009, a comprehensive joint study on climate change was conducted by the regional administration and the University of Metz that produced important meteorological data available upon request from the Météo France administration.

Lorraine is also an important staging and wintering area for cranes in France (Salvi 1984a, 1984b) and it is still the only region in the country where cranes are currently breeding (Salvi and Moreau 2003). Cranes have been monitored in Lorraine for about 35 years during migrations, as well as during staging, wintering and breeding. All data presented in this article are the result of the author’s personal observations, conducted with the assistance of an important network of collaborators.

RESULTS

The Reality of Climate Change in France and in Lorraine

Studies on climatic factors in France in the last century show an increase of at least 1.2°C of the mean yearly minimal temperature. The same (but rather lower) evolution is observed for the mean maximal temperature (from 0.6 to 0.8°C) with some regional variations. The main part of this increase took place in the last 3 decades of the century (Fig. 1).

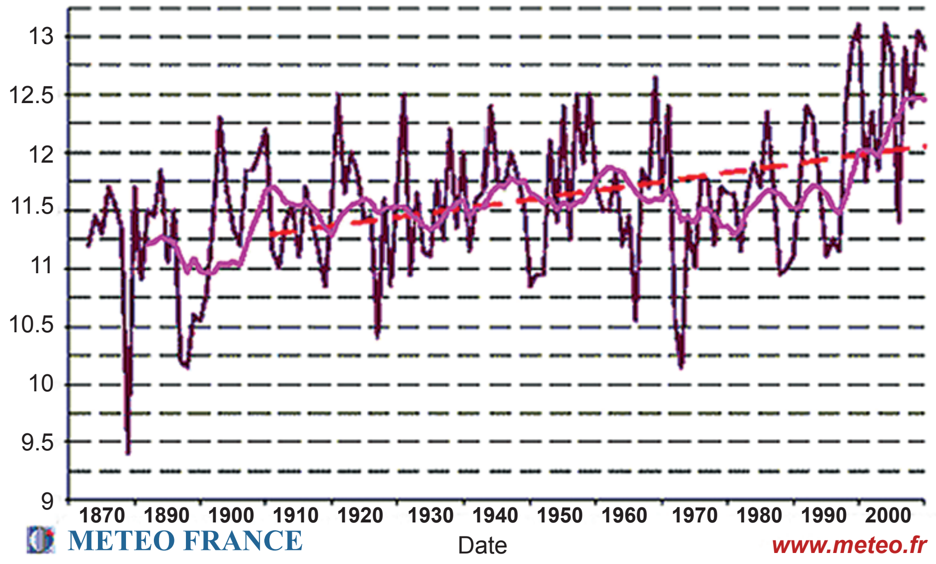

Fig. 1. Dynamics of mean yearly temperature in Paris, France. Red dashes: tendency in 1901-2000

In Lorraine, the analysis of mean yearly temperatures from 1879 to 2007 shows an estimated increase of 1.2-1.3°C (Fig. 2). This change is the equivalent of the region moving 200-300 km southwards. Warming affected maximum as well as minimum temperatures in all seasons. Snow cover in winter has been reduced both in duration and depth and snowfall is being replaced by rain.

Eurasian Cranes: New wintering patterns in France

General patterns of cranes wintering in France have been described from the beginning of the phenomenon (1974) to the late 1980s (Riols 1986-87, 1991, Salvi 1984a). In the course of the last 35 years, four different stages can be distinguished in the development of wintering in France (Fig. 3):

1. Before 1974 wintering cranes were exceptional in France; only single birds, most often young or injured adults, were observed from time to time;
2. From 1975 small flocks were discovered spending winter in three different regions of the country. During the winter of 1982/83 a sudden increase occurred (3500 wintering cranes) following an unusual western migration of November 1982 (Riols 1986-87, Salvi 1984a) and thereafter the number seemed to stabilize around 1000-1500 birds;
3. Winters 1987/88 to 1991/92: numbers of wintering cranes, 4000-5000 birds, were consistently higher than during the preceding stages;
4. From winter 1992/93 onwards there was a spectacular rise in numbers, a fourfold increase compared to previous levels, approaching 20,000 cranes in 1995/96 and more than 100,000 in 2010/11 (Salvi et al. 1996, Salvi 2012).

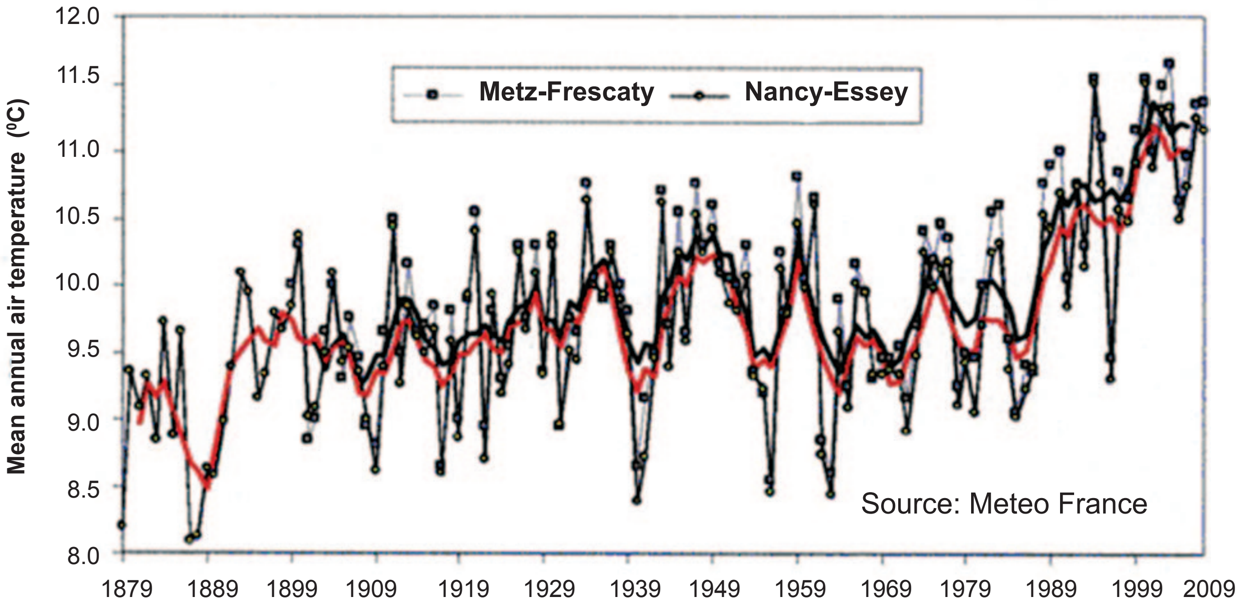

Fig. 2. Dynamics of mean yearly temperatures in Lorraine, France, 1879–2007

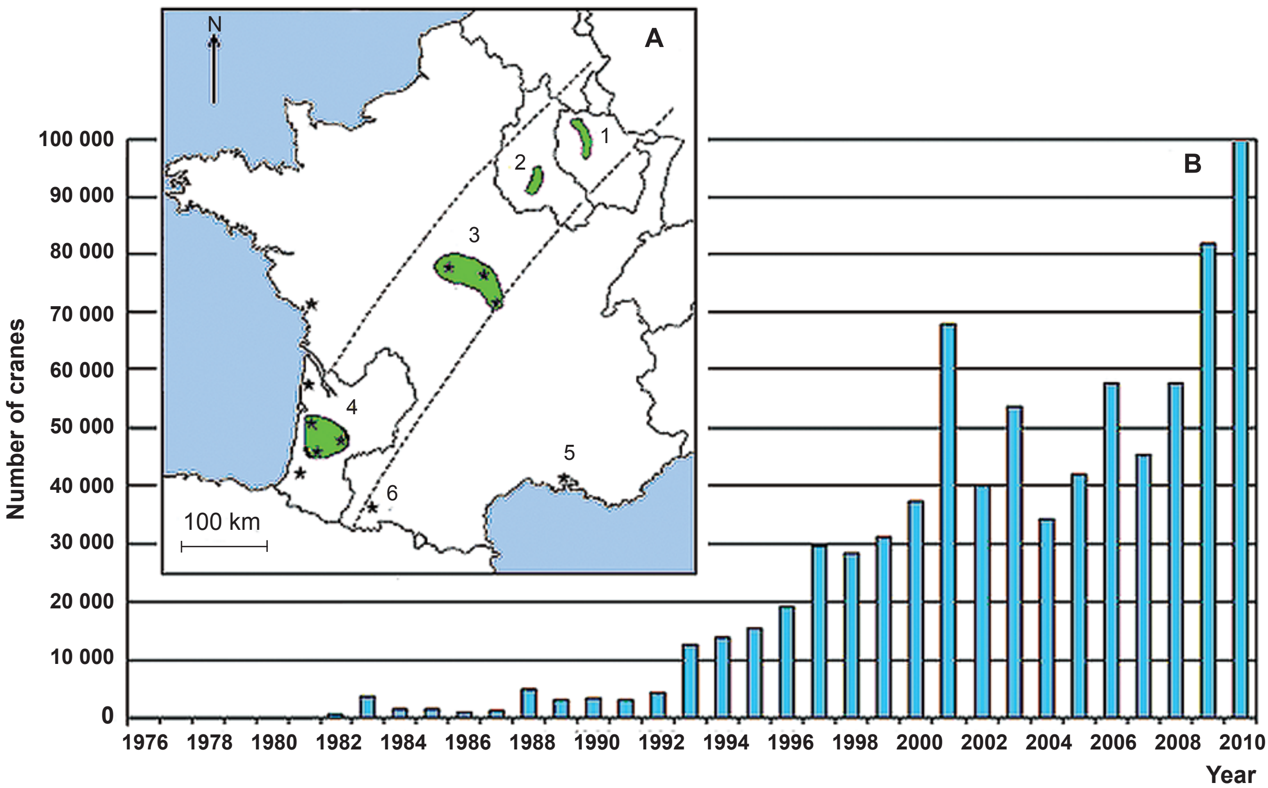

Fig. 3. Wintering cranes in France: A – main wintering areas of the Eurasian Crane in France (1 – Lorraine, 2 – Champagne, 3 – Central France, 4 – Aquitaine, 5 – Camargue, 6 – Puydarrieux). Dotted lines show the main route of cranes across the country (Salvi 2006, Merle 2008). B – dynamics of crane numbers wintering in France during the last 35 years

In addition to the traditional wintering regions of cranes in France (Lorraine, Champagne, Aquitaine and later Central France), other places have also been colonized (Table 1):

- Bay of L’Aiguillon (Atlantic coast): first wintering observed in 1982/83, from several dozens to 254 cranes in 2009/10;
- Puydarrieux Lake (southwest France): first wintering in the late 1990s, 158 cranes in 2001/02 increasing to 2,500 in 2009/10;
- Camargue (south France): outside the migratory route, wintering was unknown before the 1990s (Blondel and Isenmann 1981); then several dozens of wintering cranes were observed, followed by several hundreds (Kayser et al. 2003, 2008) and up to 2,300 in 2009/10.

Table 1. General patterns at main wintering areas for cranes in France. (For locations see Fig. 3.)

	Lorraine	Champagne	Central France	Aquitaine	Camargue	Puydarrieux
# of cranes First wintering	31 1977/78	31 1976/77	<100 1999/00	25 1977/78	67 1999/00	158 2001/02
# of cranes Max # in winter of	3,070 2009/10	24,130 2009/10	12,000 2009/10	50,500 2009/10	2,280 2009/10	2,500 2009/10
# of wintering places	At least 7	At least 3	At least 3	At least 5	2	1

Estimated total maximum number of cranes wintering in France is up to 100,000 birds. Compared to a total population on the western European flyway of about 240,000 cranes (Prange 2010), more than a third of the population wintered in France in 2009/10.

Wintering Cranes and Changes in Minimum Winter Temperatures in Lorraine

The dynamics of crane wintering in Lorraine appear strongly positively correlated to the changes in mean winter temperatures. First wintering occurred during mild winters; in the following years, when the mean temperature tended to decrease, the number of wintering cranes also decreased. Further on, from 1993, variations in winter conditions did not seem to have long-term effect on crane numbers, and a steady increase in wintering cranes has been observed.

Meteorological data are unfortunately not available for the last three years when winters were rather cold. Despite this situation, however, the number of wintering cranes in the country has shown a continued increase.

Spring Migration

A significant evolution was observed in the timing of spring migration that now begins about two weeks earlier than 30 years ago (Salvi 2006) (Fig. 5).

DISCUSSION

As expected, the climate warming has already produced evident effects on cranes in France, as was also observed in other countries of Western Europe. The main changes occurred in the phenology of migration as well as in wintering place selection by the birds.

Mean temperature increases in winter, decrease in snow cover depth and duration (without a decrease in total amount of precipitation) produced positive effects on crane staging and then wintering in France.

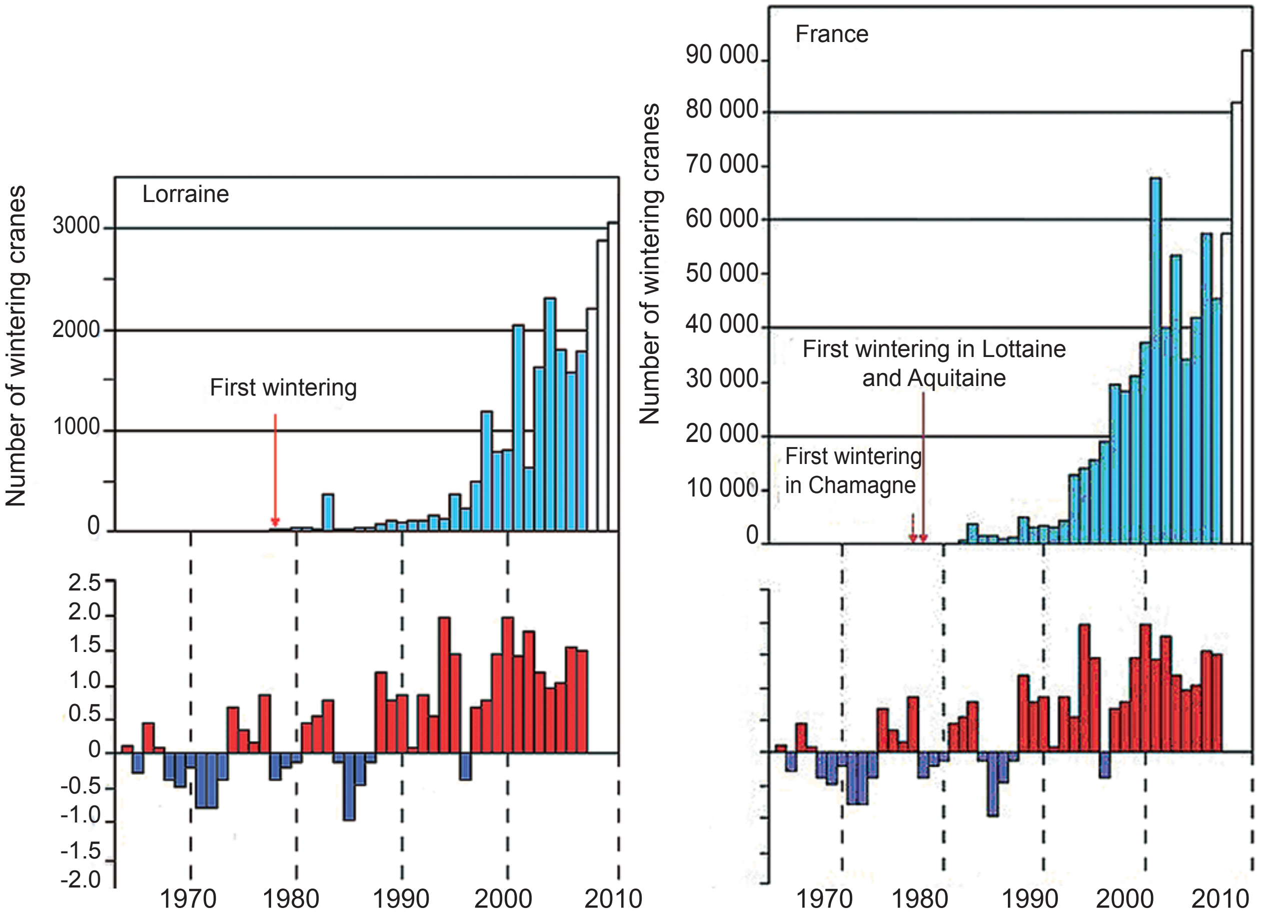

Fig. 4. Dynamics of crane wintering patterns in Lorraine and in France in relation to the difference between mean temperatures for each winter compared to mean values for the last 30 winters in Lorraine (source: Meteo France 2009)

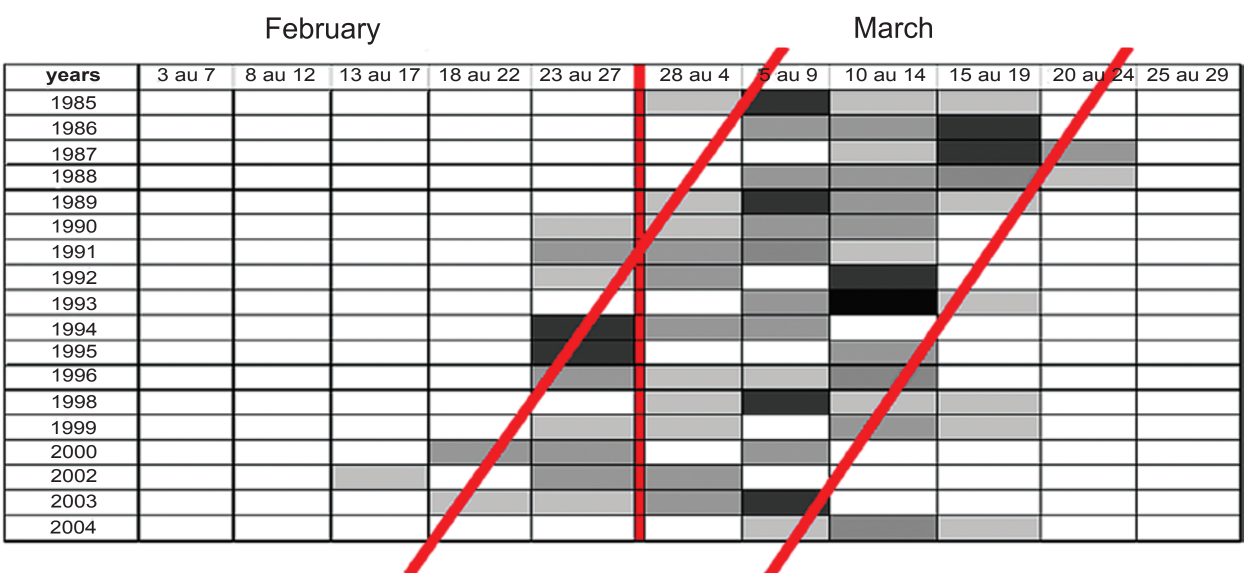

Fig. 5. Timing of spring migration in Lorraine in 1985-2004 (% of cranes observed during 5-day periods; Salvi 2006)

Combined with other factors (food availability, transformation of landscapes) climate change contributed to spectacular changes in crane numbers and seasonal patterns. Yet it is difficult to impossible to separate out the significance of individuals factors, that are themselves inter-related. For example, warming climate also affects agricultural practice.

These changes, however, can cause serious problems to farmers (Salvi 2012). Damage to the crops already inflicted in some regions suggests the potential limits of this evolution, and will probably define the status of crane conservation in the future (Salvi and Moreau 1999).

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THE HORTOBÁGY NATIONAL PARK – ONE OF THE MOST IMPORTANT STOP-OVER SITES FOR THE EURASIAN CRANE IN EUROPE: CHANGES AND THREATS

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Abstract: In the last 30 years numbers of Eurasian Cranes (*Grus grus*) staging at Hortobágy during autumn migration have been increasing steadily, with maximum numbers as high as 100,000 birds. The mosaic of fishponds, salt marshes and agricultural fields makes this area a perfect place for cranes to rest and replenish fat reserves during their migration. To identify the impacts of agricultural technology on feeding ecology of Eurasian Cranes, we studied feeding behavior of cranes in various types of fields in 1996-1998 and 2007-2008. We found that cranes prefer to feed on corn stubble, but families tend to spend more time feeding in alfalfa fields and natural grasslands. Roosting site selection in Eurasian Cranes is not limited by food availability. However, as agricultural technology is becoming more sophisticated and effective, corn may be less available in the future. It can be expected that cranes may occasionally damage newly planted wheat fields. The new system of Environmentally Sensitive Areas in the buffer zones of the National Park will provide an efficient way to subsidize farmers when cultivating crane and goose friendly fields. Specifically, farmers need to leave 20% of the corn fields unharvested and use only environmentally friendly pesticides.
Keywords: *Grus grus*, feeding ecology, agriculture, Environmentally Sensitive Areas

INTRODUCTION

Assessing habitat selection of species of conservation concern is crucial for understanding animal behavior, and accordingly for choosing appropriate conservation management measures. In Hortobágy, this question is of particular importance considering threatened migratory bird species. Many of these birds cover thousands of kilometers between biogeographically differing regions, and thus need to replenish fat reserves in an efficient way. Agricultural areas provide good feeding places that can regularly be visited by a large number of birds (Greenberg 1980, Sillett and Holmes 2002), a situation which might cause problems with the local farmers. Therefore, studies of avian behavior might help resolve conflicts between birds and people. The aim would be to protect the bird species feeding on agricultural areas, but on the other hand to keep the damage for the farmers as low as possible.

In this paper we focus on the feeding ecology of the Eurasian Crane (*Grus grus*) in its most important European staging area located in the Hortobágy National Park in Eastern Hungary. Our main objectives are to assess habitat preference patterns of the cranes and to collect information on potential conflicts between conservation management and agricultural activities.

METHODS

Study Site

Our study was conducted in the Hortobágy National Park (HNP), Eastern Hungary (47.5°N, 21.1°E). The HNP covers nearly 80,000 ha of alkaline steppes and marshes, wet meadows and fishponds (Fig. 1), 27,000 ha of which is listed as a Wetland of International Importance under the Ramsar Convention because of its significance as a breeding and stopover site for waterbirds (Ecsedi et al. 2004). Seventy-five fishponds cover altogether 6,000 ha in the HNP, ranging between 1 and 790 ha. The HNP is surrounded by extensive agricultural areas, 70% of which is covered by corn fields, providing the most important food items for the Eurasian Crane during migration. The HNP was known as the largest stopover site of the Eurasian Crane in the Baltic-Hungarian Flyway in Europe (Prange 1999), and today it can be considered as the largest stopover site in Europe, as more than 100,000 individuals can be counted during one evening roosting count (Z. Végvári unpublished data). The largest expanses of corn fields are located north

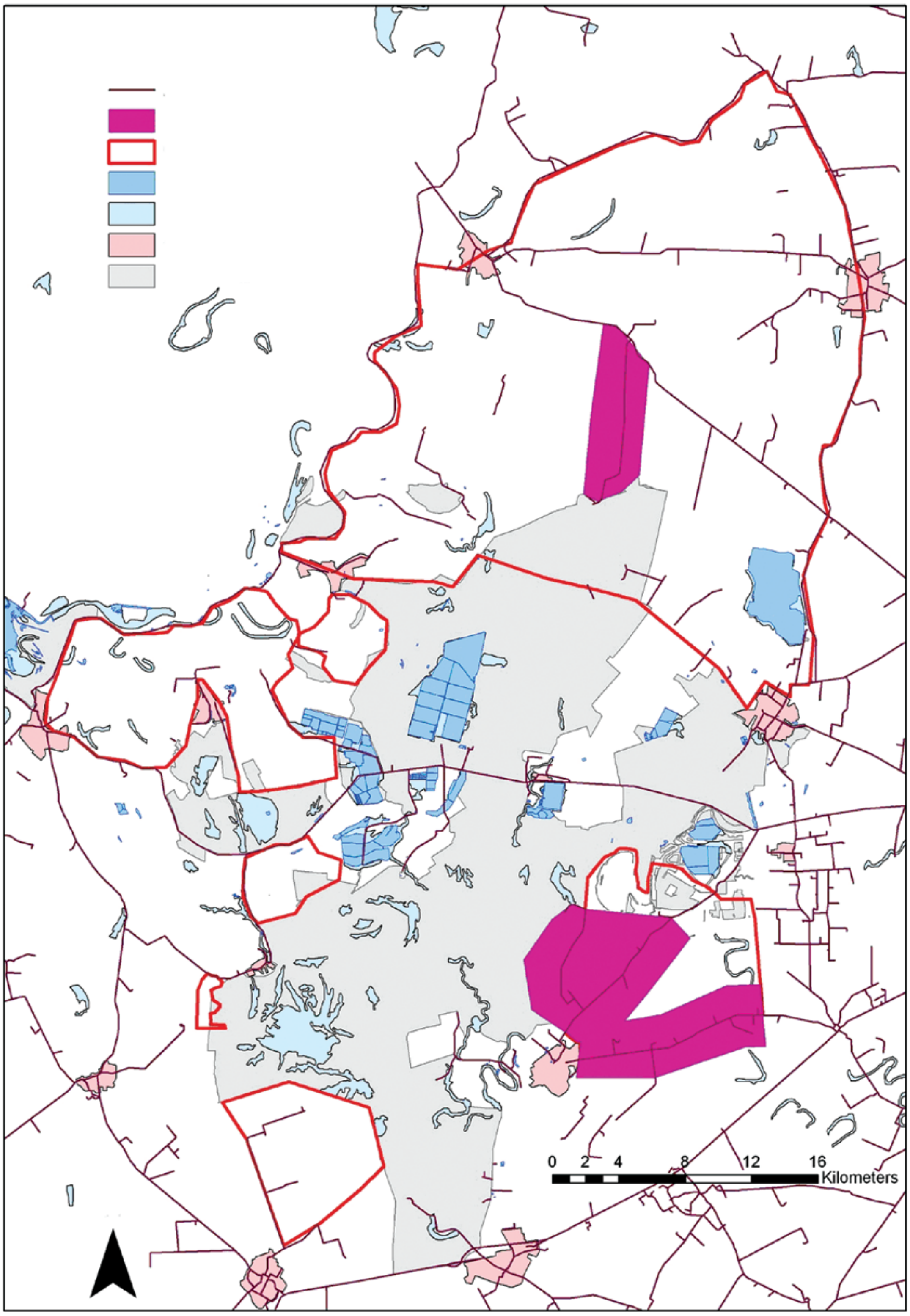

Fig. 1. Map of the Hortobágy National Park and its surroundings

and southeast of the HNP with field sizes ranging from 1 to 500 ha. Corn harvest starts usually in mid September and lasts until late October, strongly depending on weather conditions and, partly, on the economic situation.

Feeding Behavior Monitoring

Field surveys were carried out during the morning hours between mid September and late November in 1996-1998 and 2007-2008 inside the HNP and in the non-protected agricultural areas surrounding the national park. Feeding cranes were recorded 2-3 times a week in a 6,000 ha sample area (Fig. 1). We considered a flock separate if the minimum distance to the next group of birds was >100 m. During each survey in 1996-1998 we recorded the total number of cranes, number of juveniles, number of actively feeding birds (heads down, Alonso et al. 1987), the mean distance between feeding cranes, and the type of feeding area. We also recorded birds moving in or out of the field and specified their behavior. In 2007-2008 we combined habitat preference analyses with group scanning (i.e., actual behavior of each individual was recorded) and added individual-based behavior records. The selection index of feeding cranes was computed as the percentage of flocks using a given type of land cover divided by the percentage of the available area of the same type (Aebischer et al. 1993). Statistical analyses were carried out using SPSS for Windows 9.0. and the R statistical environment (R Development Core Team 2010).

RESULTS

We recorded 123 flocks in 1996-1998 on seven types of feeding habitat: (1) unharvested corn field, (2) corn stubble, (3) wheat field, (4) alfalfa field, (5) fallow land, (6) freshly ploughed area, and (7) natural grassland. Harvested and unharvested corn fields as well as natural grasslands were the most intensively used habitat types. Frequency of using different types of feeding habitats is shown in Table 1. Although 25.4% of the agricultural areas were covered by wheat fields, only 4.9% of the flocks were found feeding there. On the other hand, 5.8% of the agricultural areas were covered by corn stubble fields with 24.4% of the flocks feeding in this habitat. Only 5.7% of crane flocks selected alfalfa fields and only 5.7% of crane flocks selected abandoned fields. Although grassland and corn stubble show the highest values, grasslands were used only for pre-roost gathering with very low feeding activities.

Table 1. Use of different habitat types for feeding by Eurasian Cranes (*Grus grus*) during the study period 1996-1998

Habitat type	Average availability in study period (%)	Number of flocks	Percent of flocks (%)	Selection index
Freshly sown wheat field	25.4	6	4.9	0.193
Other	23.4	3	2.4	0.103
Unharvested corn field	14.0	26	21.1	1.507
Freshly ploughed corn stubble	11.5	15	12.2	1.061
Alfalfa field	8.1	7	5.7	0.704
Abandoned arable land	6.9	7	5.7	0.826
Corn stubble	5.8	30	24.4	4.207
Natural grassland	4.9	29	23.6	4.816
Total	100.0	123	100.0	

The percentage of immature cranes was 20.1% in the whole staging population in 1996–1998. Flock size varied between 2 and 2,000 birds with the average distance between feeding cranes varying from 0.5 to 40 m (mean: 4.7 m). The percentage of actively feeding cranes varied between 0 and 100%, averaging 69%. Flock size was significantly different between feeding habitats (χ^2=12.748, df = 6, $p < 0.05$, Kruskal-Wallis test) with the largest flocks utilizing corn stubble. The distance between cranes feeding near each other did not depend on the type of feeding area (χ^2=5.386, df=5, $p > 0.1$, Kruskal-Wallis test). The proportion of actively feeding cranes correlated significantly and negatively with flock size (r=-0.348, $p < 0.01$, Spearman rank correlation).

In 2007-2008, we recorded 184 flocks of Eurasian Cranes. Larger flocks showed a strong preference (82%) for corn stubble (Kruskal-Wallis, χ^2=23.822, p<0.001, Fig 2.), whereas isolated families preferred this habitat type less (48%), but fed often in grasslands (38%). Families often fed separately or joined other families, thus forming only small flocks.

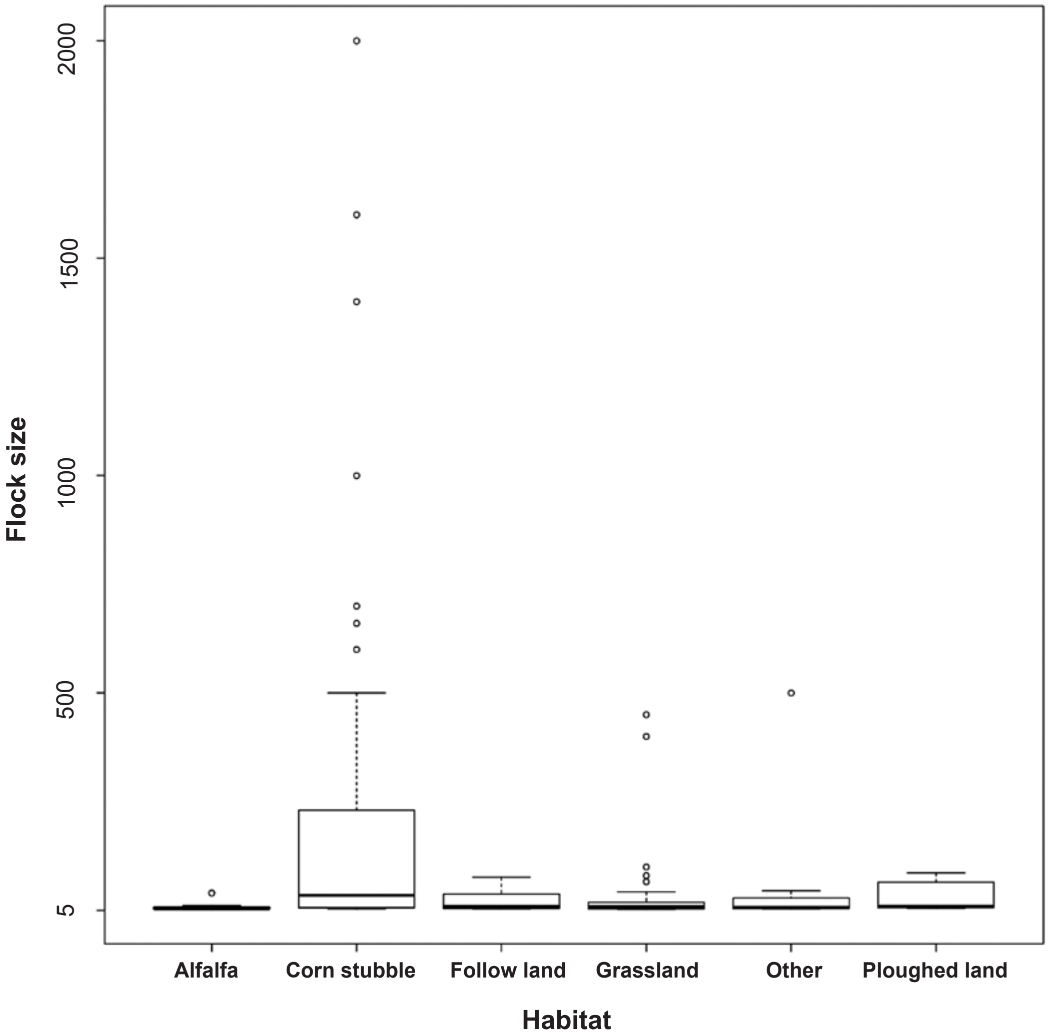

Fig. 2. Preferences for the different habitat types by Eurasian Cranes (*Grus grus)* during the study period 2007-2008

DISCUSSION

Our findings revealed that corn stubble is the most important type of feeding habitat for Eurasian Cranes staging at Hortobágy as they feed predominantly on waste corn seeds left behind by harvesting machines. However, cranes optionally feed on insects by foraging on natural grasslands, alfalfa fields, and fallow land. This behavior is more frequently observed in family groups, which feed often isolated from larger flocks. The separation of families comes along with a different use of habitat types and might be the result of a strategy of family members possibly aiming to reduce energy costs or to avoid predators (Treves 2000). Thus, the average group size varied considerably between habitat types, in parallel with the findings of Aviles and Bednekoff (2007).

So far, damage done by cranes in agricultural fields is only exceptionally observed in fields with hybrid corn varieties. However, as a result of an ongoing development in harvesting machinery and agricultural technology, harvesting has been getting faster and more efficient in the past decade. As part of the corn production technology, harvested fields are ploughed as soon as possible, spending less effort and time. Therefore cranes need to find newly harvested corn fields faster and can feed on available food resources for a shorter period of time, resulting possibly in a decreased overall energy uptake rate. Consequently, conflicts between conservation and farming might intensify as cranes potentially switch to spring wheat fields and to unharvested corn to compensate their need of food.

Already in 1999, cranes were seen feeding on hybrid breeds of corn, resulting in a court case. The court ruling was that farmers were not using appropriate technology and did not use all possible means of preventing the cranes from feeding in unharvested corn fields. Although this decision was in favor of the cranes, it has not decreased the tension between conservation and farming. Thus, we propose to use all possible financial and institutional tools to subsidize farmers in case of damages done by cranes.

In contrast to earlier expectation based on the energy constraint hypothesis (Alonso et al. 2004), we did not find a significant relationship between the distance to the closest areas of corn production (the main food of staging cranes) and probability of occupying roost sites; the distance to the main feeding areas turned out to be an unimportant factor for cranes, corroborating previous results (Végvári and Tar 2002). Based on the results of ongoing studies (Végvári and Barta in prep.), roost site selection is primarily driven by disturbance-related characteristics, active management of the roosting site, and the extent of wetland area at the site. The results of this investigation support the idea that changes in patterns of occupancy can be used to measure impacts of conservation actions and human disturbance (Burton et al. 1996), and that the size of roost sites affects the probability of occupation in managed sites. We therefore conclude that food availability still might not be a limiting factor for cranes in areas of increased corn production.

However, an expected future decline in average energy uptake rate might be a decisive factor not only in shaping roost site selection but also as a primary driver in migratory strategy. Specifically, cranes might leave the area sooner, due to a decrease in food availability. Earlier departures might negatively affect fat reserve volumes, thus affecting survival.

Conservation Implications

Our results support the hypothesis that cranes stage annually at Hortobágy for over two months because they can find a combination of abundant food resources and shallow, undisturbed roosting sites over a large area. Availability of roosting sites is stable as the largest fishponds used for roosting are drained during autumn waterbird migration. In addition, several hundred hectares of natural marshes are flooded artificially every year in late summer to provide feeding and roosting area for cranes, geese, ducks and waders. In contrast, the spatial and temporal distribution of food availability is unpredictable, as the timing of harvest and plowing depend on weather and economic conditions, and the length of food availability depends primarily on climatic situations such as continuous snow cover or frozen ground.

To eliminate possible conflicts between nature conservation and agriculture, a system of Environmentally Sensitive Areas (ESA) provides a novel legal means for subsidizing farmers taking part in species-specific conservation programs. This system, introduced in Hungary in 2009, includes a package called “creation of crane and goose friendly fields.” Farmers who agree to leave certain amounts of corn unharvested and use only specific pesticides will be subsidized.

To further decrease potential conflicts, the Hortobágy National Park Directorate began planting lure corn fields for cranes in agricultural lands inside the National Park to attract cranes from privately owned lands.

Finally, we suggest that farmers should exclude short corn varieties to prevent cranes from feeding in unharvested fields with this type of corn.

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THE EFFECTS OF CLIMATE CHANGE ON THE MIGRATORY PATTERNS OF THE EURASIAN CRANE IN THE BALTIC-HUNGARIAN FLYWAY

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Abstract: We investigated impacts of local and global climate indices on population dynamics, frequency of overwintering as well as migration phenology of the Eurasian Crane (*Grus grus*) along the Baltic-Hungarian Flyway. The study area was the Hortobágy National Park, the largest unbroken alkaline steppe of Europe and an important staging and wintering area for a number of endangered waterbird species. As response variables we used the results of weekly simultaneous censuses during fall migration and overwintering between 1995-2007 as well as data of daily spring migration surveys from 1969-2007. Data on local air temperatures and monthly values of the North-Atlantic Oscillation (NAO) were used as explanatory variables. To assess the effect of climatic predictors on spring migration phenology and fall migration dynamics, we fitted linear regressions on dependent variables. The results revealed a positive correlation between the first arrival dates (FAD) in spring and the local monthly temperatures and a negative association between FADs and local winter temperatures. Relationships between fall migration dynamics and climatic indices included relation between fall peak dates and monthly NAO indices (the later the date, the greater the NAO) as well as the association between the monthly mean minimum temperatures and the number of days between the date of peak and median. These findings show a consistent response to global change in the migratory pattern of the Eurasian Crane which benefits from a warming climate in several aspects.
Keywords: Eurasian Crane, climate change, Hortobágy

INTRODUCTION

Phenological benchmarks, such as the start of plant blooming, are known to be sensitive to climatic processes (Peñuelas and Filella 2001, Parmesan and Yohe 2003, Macmynowski et al. 2007), with several phenological phases currently advancing as a response to recent climate change (Bradley et al. 1999). For instance, changes in timing of bird migration is predicted by plant and invertebrate phenologies (Sparks et al. 2005) – there are tendencies to migrate earlier in response to earlier springs in the birds' breeding range (Strode 2003, Crick 2004, Lehikoinen et al. 2004).

Eurasian Cranes (*Grus grus)* breed in wooded bogs and wet forests of northern Eurasia and exhibit various migration strategies. While the majority of the crane populations are classified as short-distance migrants based on the results of satellite tracking, some subpopulations, such as those inhabiting the European part of Russia, proved to be long-distance migrants. Further, satellite tracking of several Eurasian Cranes nesting in Finland followed loops connecting Northern Europe, Hungary, Tunisia, Morocco, Spain and Germany. Interestingly, cranes that have recently started to breed in the British Isles are sedentary (Prange 1999).

Eurasian Cranes breeding in Europe migrate along at least four flyways: (1) the Atlantic Flyway connects the breeding grounds of Sweden, Norway and Germany with the wintering areas in France and Spain. (2) Cranes breeding in Finland, the Baltic States and Poland use the Baltic-Hungarian Flyway to spend winter in Serbia and North-east Africa as far south as Sudan and Ethiopia; at their stopover sites in Hortobбgy they roost in flocks of up to 55,000 birds (Prange 1999, Végvári and Tar 2002). (3) Cranes of the East-Baltic Region possibly migrate over the Black Sea and Turkey and spend the winter in Israel with some of them flying to Ethiopia covering ca. 4,000 km (A. Leito, pers. comm.). (4) Populations of the European part of Russia migrate across the Black Sea and winter in Turkey, Israel, and Ethiopia.

The Hortobágy National Park (HNP) is known as the largest stop-over site of the Eurasian Crane in the Baltic-Hungarian Flyway in Europe (Prange 1999), as the peak number of simultaneously roosting cranes during autumn migration has increased from 3,000 to 100,000 from 1980-2007. Further, this region is probably the second largest staging of cranes in the world, exceeded only by Nebraska, which hosts up to 500,000 Sandhill Cranes during spring migration (International Crane Foundation 2010). Although regular wintering has not yet been observed in the study area, the frequency of wintering in the southern part of the country has been increasing since 2000 (Z. Végvári unpublished data). As part of an active wetland management system, water depth is kept shallow all year on seven marshes and in one of the largest fishponds to attract cranes for roosting.

METHODS

Monitoring of Spring Migration

Our database was compiled from the field records of one of the authors (G. Kovács), collected from 1969-2007 during his regular field trips to the south-western part of the HNP following annual standardized census routes between 1 January and 31 May (for more details, see Végvári et al. 2010). This dataset yielded annual data on the first arrival date (FAD) of Eurasian Cranes. In our study, all data were collected by the same person following the same protocol, thus sampling effort was highly standardized and constant over the years.

Monitoring of Fall Staging

From 1995-2007, we performed weekly simultaneous censuses during fall migration and wintering with the help of a large number of experienced volunteers. We counted arriving cranes simultaneously once a week at all potential roost sites (marsh or fishpond) at HNP during the autumn migration period from 10 September to 31 December. Potential roost sites were identified weekly 2-3 days before the day of the count. Based on previous studies, only wetlands with minimum area of 3 ha and water depth of 40 cm or less (Végvári and Tar 2002) could be considered as potential roosting sites. If a potential roosting site was used by cranes, it was classified as an actual roosting site. To avoid double-counting on each count day we simultaneously surveyed 2-16 actual sites where cranes were present. Roosting counts started two hours before sunset and took three hours, applying roosting count methods suggested by Marsh and Wilkinson (1991), Prange (1999), and Alonso et al. (2004). Counts were performed from bird observation blinds or from one to four elevation points at each roost site to survey all flocks arriving from different directions. Surveys were conducted using 8-10X binoculars, and 20-60X as well as 32X spotting scopes.

Climatic Predictors

To evaluate the degree of association among variables related to migration phenology and dynamics as well as climatic proxies, we employed the annual FADs and the maximum and median of simultaneously staging birds during fall migration and corresponding dates as response variables. Wintering of cranes in the region was used as a logical independent variable. We used several climatic predictors on the local and continental scale as independent variables. Mean monthly temperatures between October and April (Tmean), minimum monthly temperatures between October and April (Tmin), mean winter (November-February, Twin) temperatures and mean autumn (September-November, Taut) temperatures were employed as local climatic response variables (measured near the town of Debrecen, ca. 30 km away from the study area). We included the monthly values of the North Atlantic Oscillation (NAO, difference in air pressure between Iceland and the Azores) and NAO averaged for the winter months from December through March as climatic proxies related to global climate.

Statistical Methods

To assess relationships between response variables describing the phenology and dynamics of crane migration, we fitted linear regression using climatic predictors as dependent variables.

RESULTS

Spring Migration and Local Climate

Our results revealed significant advancement of the spring arrival date during the study period (b=-1.409, r^2= 0.443, p < 0.01; Fig. 1). We found a positive relation between FADs and local monthly mean temperatures (b=4.307, r^2=0.236, p=0.003) indicating that earlier arriving birds experience colder temperatures, which is not surprising. The relationship between spring arrival date and local monthly minimum temperature was also positive (b=1.748, r^2=0.117, p=0.041). Further, we discovered a negative relation between FAD and local winter temperature (b=-5.788, r^2=0.208, p=0.006).

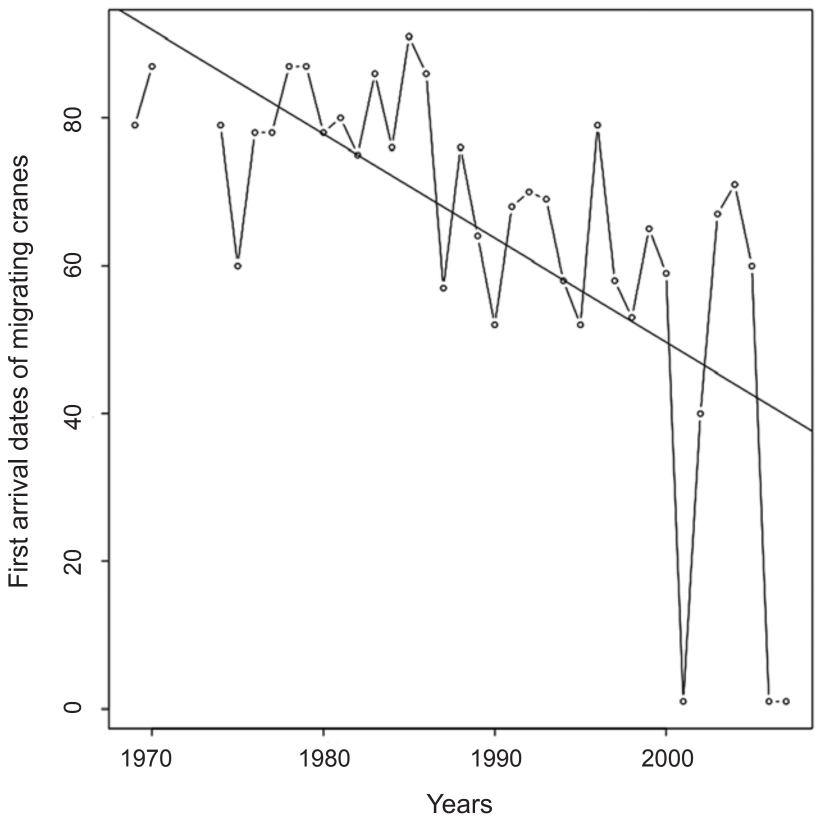

Fig. 1. First arrival dates of the Eurasian Crane during spring migration in Hortobágy

Spring Migration and Global Climate

Our findings revealed no clear trends of the FAD as a function of global climatic indices (b=-4.142, r^2=0.029, p=0.319 for the NAO values of the arrival month; b=-3.559, r^2=0.019, p=0.423 for the NAO values of the preceding month; b=-1.118, r^2=0.011, p=0.534 for winter NAO values).

Fall Migration and Climate

We detected a significant, positive relation between peak date and monthly NAO (r^2=0.407, p=0.019, Fig 2). The relation of the time difference between the timing of peak and median with the monthly mean of local minimum temperatures was also positive (r^2=0.369, p=0.028).

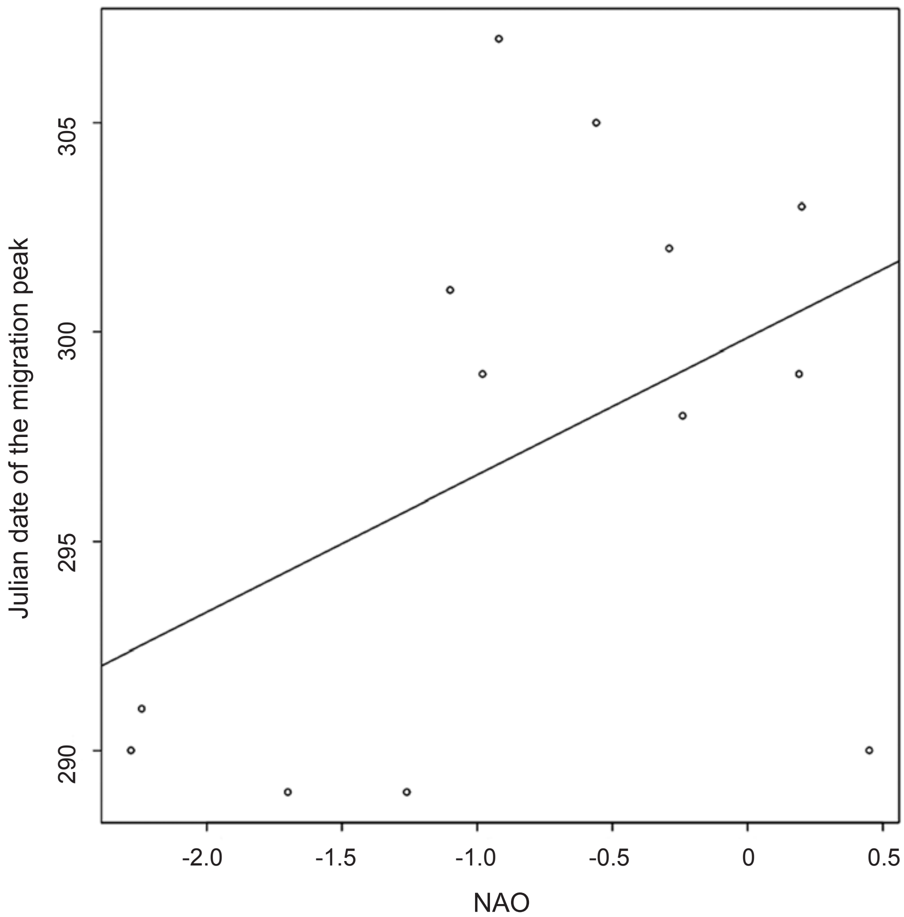

Fig. 2. Peak date of fall migration of the Eurasian Crane as a function of monthly NAO values

DISCUSSION

We detected a strong population increase of the Eurasian Cranes staging in Hortobágy during the study period. This development parallels the increase observed along the Atlantic Flyway, which corresponds to the increase of breeding populations throughout Europe (Prange 1999). Recently, a hypothesis has been put forward arguing that population growth in the Eurasian Crane might be partially driven by a warming climate in Northern Europe resulting in the northward shifting of the permafrost zone. However, this prediction has not been tested. We revealed a significant advancement of spring arrivals in the Eurasian Crane, a process also known along the Atlantic Flyway (Prange 1999). Further, an increasing number of cranes spending winter at Hortobágy might indicate a general shift of the wintering grounds northwards, as has already been detected along the Atlantic Flyway (Prange 1999). Similarly, our findings indicate that cranes migrate earlier after warmer winters, suggesting the northward shift of the northern border of the wintering area.

We showed that the peak date is shifting later for fall migration as a response to increasing NAO values typical for wetter and warmer climates. Similarly, we detected a delayed arrival of flocks arriving after the date of the median value, implying a delayed fall migration due to warmer conditions in the northern part of Europe. Summarizing, Eurasian Cranes might benefit from global warming like many other short-distance migrants do, by increased survival rates during winter and earlier arrivals on the breeding grounds.

Conservation Implications

Although in Europe the Eurasian Crane is not endangered and possibly benefits from global warming, its roosting sites in staging areas may be significantly reduced in the near future by human-induced and climate-related wetland losses, especially in southern Europe. However, there are indications that the West-Siberian population wintering in India may be declining probably as a result of wetland loss and structural changes in agricultural technology on the wintering grounds (Meine and Archibald 1996, Végvári and Hansbauer 2009).

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CHANGES IN THE EURASIAN CRANE (*GRUS GRUS*) STAGING AREAS DISTRIBUTION IN THE EUROPEAN PART OF RUSSIA FROM 1982 TO 2007

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Abstract. Data from questionnaires distributed in 1982-1983 and 2007 among game departments, protected areas and students were compared. This information, together with literature data and our own observations, showed changes in distribution of the Eurasian Crane (*Grus grus*) staging areas and crane numbers related to changes in agriculture after the collapse of the USSR in 1991. On the basis of these data, a C*atalogue of the Eurasian Crane Staging Areas* was created for the European part of Russia. In the north of this region ("zone of risky farming") crane staging areas almost disappeared after crop production stopped. In the center part of the region, where land areas planted with crops decreased and crop fields shrank, large staging areas split into small ones with cranes dispersed among them. In the south of the region, where conditions for agriculture development were better, cranes used crop fields mostly as migration stopovers. In Soviet time, cranes were distributed more evenly and stopped at migration stopovers for a shorter time. Now huge numbers of cranes congregate near a few well developed farms and stay there longer. This tendency has caused increased conflict between cranes and farmers, especially in the south of the European part of Russia.
Keywords: Eurasian Crane, European part of Russia, staging areas, distribution, agriculture

INTRODUCTION

The pre-migratory period is very important for cranes to prepare for a long passage. Its duration in Russia is usually 1.5-2 months. During this time cranes must accumulate enough fat for flight and try to spend less energy. To save energy, they use the most suitable and energy-rich foods such as agricultural plants.

During the pre-migratory period cranes gather at traditional staging areas. Their choice of staging areas depends on availability of suitable roosting sites and agricultural fields with preferred crops located within a 30-40 km radius from the roosting sites. For roosting, cranes use wetlands of different types: from shallow banks of rivers and lakes to vast marshes. By the mid 1900s, however, many wetlands had been destroyed or dried up due to extensive agricultural development. Reclamation of roost sites at staging areas may be the reason why cranes stopped using these areas. Thus it was important to determine traditionally used crane staging areas to ensure protection of their roosting sites (Markin et al. 1982).

To determine the autumn staging areas of Eurasian Cranes (*Grus grus*) in Russia, in 1982 the Oka State Nature Reserve prepared and distributed a questionnaire among hunters, staff of protected areas, and students. On the basis of the received data a *Catalogue of the Eurasian Crane Staging Areas* was created (Markin and Sotnikova 1986). Data from this Catalogue are still used by Russian ornithologists for crane monitoring at staging areas in their regions. Protected areas were established in several of the most important wetlands used by cranes.

Since the first questionnaire in 1982, agriculture in Russia has undergone significant changes due to collapse of the USSR in 1991 and reorganization of the agricultural system. To investigate the impact of changes in agriculture over a 25-year period on crane staging areas, in 2007 another questionnaire was distributed among the same target groups. This article presents a comparative analysis of questionnaire data from 1982 and 2007 on the number and distribution of crane staging areas in the European part of Russia.

MATERIALS AND METHODS

The first questionnaire was distributed among state game and nature protection agencies, protected areas staff and students in the Russian Federation in 1982 by Yuri Markin and Vladimir Krever of the Oka State Nature Reserve, with administrative support from the State Game Department of the Ministry of Agriculture of the Russian Federation. In 1983, the questionnaire was distributed again, this time among those rangers and hunters who provided information on Eurasian Crane staging areas in 1982, to specify data on crane pre-migratory roosting and feeding sites, agricultural plants used by cranes, and crane numbers. In 1983, the questionnaire was given also to rural school students who live near crane staging areas with the request to count cranes at the nearest staging areas on 1 September 1983.

In 2007, 25 years after the 1982 questionnaire, the same questionnaire was distributed in Russia among the federal game and nature protection agencies, protected areas staff, skilled ornithologists, students, and volunteers by the Crane Working Group of Eurasia (CWGE) with support from the Agricultural Department of the Netherlands Embassy. The Catalogue created in 1982 was used as the baseline. Questionnaire flyers were also shared with staff of regional (provincial) game management agencies and special protected areas through the Federal Service on Veterinary and Plant Sanitary Control and the Federal Service for Control over Use of Nature.

Response rates are presented in Table 1.

Table 1. Response rates for questionnaires of 1982 and 2007

Target Groups	Percentage of returned questionnaires	
	in 1982	in 2007
Hunters	39.5%	85.9%
Protected areas staff	10.5%	35.1%
Professional ornithologists	-	30.7%
Students and volunteers	10.9%	82.8%

To involve more students and volunteers, CWGE organized an All-Russia Crane Count on 8-9 September 2007 with support from the Agricultural Department of the Netherlands Embassy. A special colorful questionnaire flyer and a brochure on crane counting techniques at staging areas were prepared, printed and shared among students and volunteers. In addition, they were also uploaded on website of the Russian Bird Conservation Union www.rbcu.ru and also on www.mybirds.ru.

RESULTS AND DISCUSSION

Distribution of Autumn Staging Areas and Migration Stopovers According to Questionnaire of 1982

Analysis of returned questionnaires distributed among state game and nature protection agencies, protected areas, and students in Russia in 1982, as well as data from articles and our own observations, indicate that during the Soviet time number and distribution of the Eurasian Crane staging areas were relatively stable due to a relatively stable agriculture system.

In the Soviet time the agriculture system had centrally planned management. Large state investments supported collective farmers. Despite some problems connected with social issues and poor mechanization, areas under agricultural plants were fully developed.

Arable lands in Russia stretch from the north to the south and from the west to the east. Differences between agriculture in the west and in the east reflect density of human population: in the European part of Russia it is much higher than in West Siberia and the Asian part of Russia. Differences between agriculture in the north and the south are caused by climate conditions, with more favorable conditions in the south (Nefedova 2004).

Mapping of the Eurasian Crane staging areas on the basis of the 1982 questionnaire data indicated that a high density of staging areas with high crane numbers was located in the north of the East European Plain and southern Urals, known for high humidity and numerous lakes and swamps (Fig. 1). In addition, some concentrations of staging areas were found in the center of the European Part of Russia in Meshchera Lowlands between Middle Russian and Volga Uplands. This distribution can be explained by the fact that during the period of stable agriculture practices, almost all deforested areas were planted with potatoes and other crops, and cranes could find abundant food almost everywhere; therefore the selection of staging areas by cranes was mostly determined by availability of safe roosting sites (Markin et al. 1982).

Fig. 1. Distribution of the Eurasian Crane pre-migratory congregations in 1982 in Russia with crane numbers varying between 30 and 1,000 and more individuals: (1) – concentration of staging areas in the north of the East European Plain; (2) – concentration of staging areas in southern Ural

Mapping also showed that staging areas distribution coincided with cultivation of the main agricultural crops used by cranes – wheat (*Triticum* spp.), rye (*Secale cereale*), and barley (*Hordeum vulgare*) (Figs. 1, 2 a, b, c) (Sotnikova 1985, Markin and Sotnikova 1995).

During the years after the 1982 questionnaire, agriculture in Russia went from the relative stability of the Soviet time, through a crisis after the collapse of the USSR in 1991, to a slow recovery in some regions. The deepest collapse occurred in the late 1990s – early 2000s. During the transition period, total volume of agricultural production dropped by 40% and by 60% for collective farmers (Nefedova 2008), due to institutional changes and unstable economic conditions. According to the official statistics, areas covered by agricultural plants in Russia decreased from 108.7 million hectares in 1992 to 58.4 million hectares in 2008. Areas planted with crops decreased from 60 million hectares in 1992 to 35.4 million hectares in 2008, a reduction almost by half.

This article considers only the European part of Russia (EPR), which covers 3,960,000 km^2 and represents 25% of Russia and 40% of Europe. This region has a high density of human population as well as of the Eurasian Crane (*Grus grus grus*). EPR includes several federal regions: Northwestern, Central, Volga, Southern, and North Caucasus Federal Regions, that in turn include several administrative areas.

Staging areas are located mostly in Northwestern, Central, and Volga Federal Regions, in the main part of breeding area of this subspecies. In Southern and North Caucasus Federal Regions, Eurasian Crane breeds with low density only in a few administrative regions (Stavropol, Rostov and Volgograd ARs and the Republic of Kalmykia) located in the border between steppe and forest zones. Therefore the number of staging areas is very low there. Eurasian Cranes usually cross these federal regions during migration with short rest at migration stopovers in some ARs (Rostov, Stavropol and Volgograd).

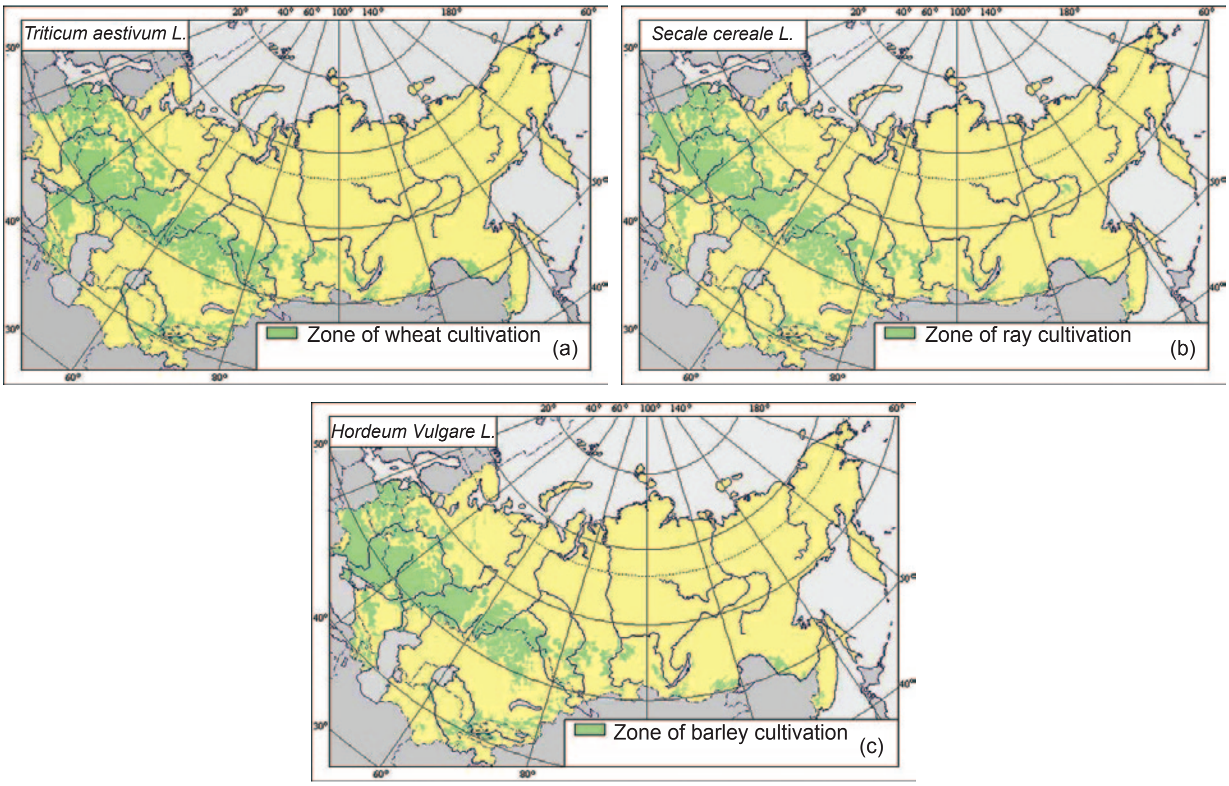

Fig. 2. Distribution of the Eurasian Crane pre-migratory congregations in 1982 (see Fig. 1) coincides with zones of wheat (a), rye (b), and barley (c) cultivation in the same year

Redistribution and Changes in Number of Staging Areas Connected With Polarization of Agriculture

A combination of natural and socio-economic factors brought about significant differences in agriculture management inside EPR, in both federal and administrative regions during the transition period after the collapse of the USSR in 1991. In the Northwestern and Central Federal Regions, only 25% of agricultural enterprises and private farms survived due to unfavorable natural and unstable economic conditions, compared with areas in the Southern Federal Region, where from 50% to 75% of agricultural enterprises developed successfully (Nefedova 2008). Shrinking of areas under crops in Northwestern and Central Federal Regions (the Non-Black Soil Zone) and recovery of agricultural areas in the south of the European Part of Russia constituted a polarization of agriculture and is still continuing (Fig. 3).

The crisis had deepest impact in northern areas of the *Northwest Federal Region*, a zone of so-called “risky” agriculture. Even in the Soviet time, this area was known for its few scattered crop fields and poor harvests. Therefore only a few staging areas with small numbers of cranes were observed there, excluding the huge staging area in the Arkhangelsk Administrative Region (AR) with crane numbers up to 3,000-4,000 (Anzigitova 1998, Anzigitova and Kuznetsov 2000). During the agriculture decline, crop productions in this zone had either stopped or significantly decreased (Nefedova 2004, 2008). Overall, in the Northwest Federal Region the number of staging areas, as well as crane numbers, had decreased (Table 2) due to their almost complete disappearance from Murmansk AR and the Republic of Karelia

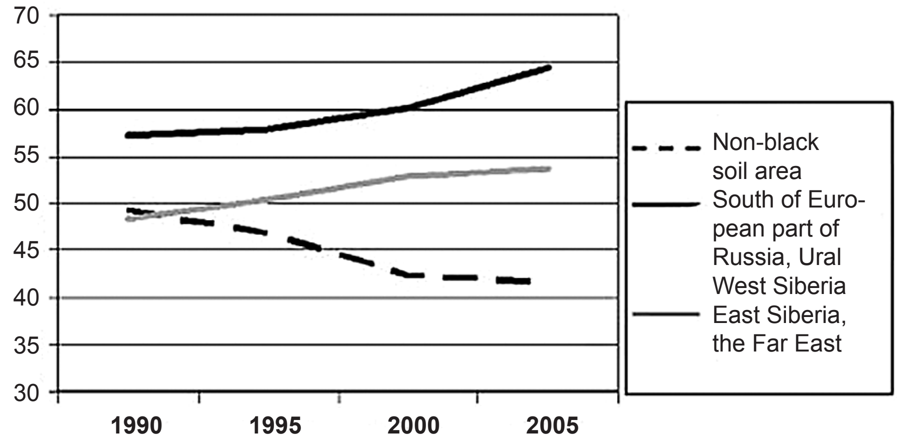

Fig. 3. Changes in areas planted under crops in the European Part of Russia, West and East Siberia and the Russian Far East from 1990 to 2005

(Khokhlova et al. 2007) and a drop in their number in Arkhangelsk AR (Khokhlova et al. 2006), Leningrad, and Pskov ARs (Fig. 4 a, b). For example, in Arkhangelsk AR, areas planted with crops had decreased by 42% from 2002 to 2003. Composition of crops also changed considerably. Many agricultural enterprises stopped sowing rye, barley, wheat and oats and reduced the planting of legumes (Artemjev et al. 2006). According to the questionnaires of 1982 and 2007, the number of staging areas in Arkhangelsk AR decreased from 32 to 12 and total crane numbers in the region decreased from 2,500 to 1,000 during this 25-year period (Fig. 5).

In some administrative regions of the *Central and Volga Federal Regions* areas planted with crops had decreased because of insufficient capacity for their development. In some areas, from 30% to 80% of agricultural fields were not used; many of them lay fallow and overgrown with bushes and trees (Nefedova 2008). As a result the number of staging areas decreased in Moscow, Ryazan, Vologda ARs (Central Federal Region) and Kirov, Kostroma, Novgorod, Samara, Saratov, and Tambov ARs, and in the Autonomous Chuvash Republic (Volga Federal Region) Regions (Fig. 4 a, b).

Areas with more successful agricultural development are located in the some administrative regions of the *South* (Rostov and Volgograd AR, and the Republic of Kalmykia) and *North Caucasian* (Stavropol AR) and Volga (Nizhniy Novgorod AR, the Republics of Tatarstan and Bashkortostan) Federal Regions (Figs. 4 a, b). According to the official statistics, in 1997 in the *Southern Federal Region*, most agricultural enterprises (up to 82%) were unprofitable, but already in 2000 almost half of them achieved profitability (Nefedova 2008). Thus, Stavropol and Rostov ARs are currently the leaders in agricultural production volume in EPR.

Due to more favorable feeding conditions in Stavropol and Rostov ARs compared with more northern areas, cranes arrive at migration stopovers early and stopped longer from one to one and a half months (in comparison with the Soviet time when cranes stopped only for a short time). They also leave for the south later, which may be the result of abundant food as well as of global warming. A few cases are known of the Eurasian Crane wintering in Stavropol AR (Ilyukh and Khokhlov 2008).

Redistribution of Staging Areas Connected With Dispersion of Areas Planted With Crops and Focused Agriculture Development

In addition to polarization, during this 25-year period there were two opposite processes influencing agriculture in EPR.

On the one hand, as a result of conversion of collective farms to private agricultural enterprises and farms, land area under agriculture in EPR had been extended. However, due to insufficient capacity for development, the former vast agricultural areas turned into extended waste lands with a mosaic of small scattered crop fields. Due to these changes in agriculture, many large staging areas of the 1980s were

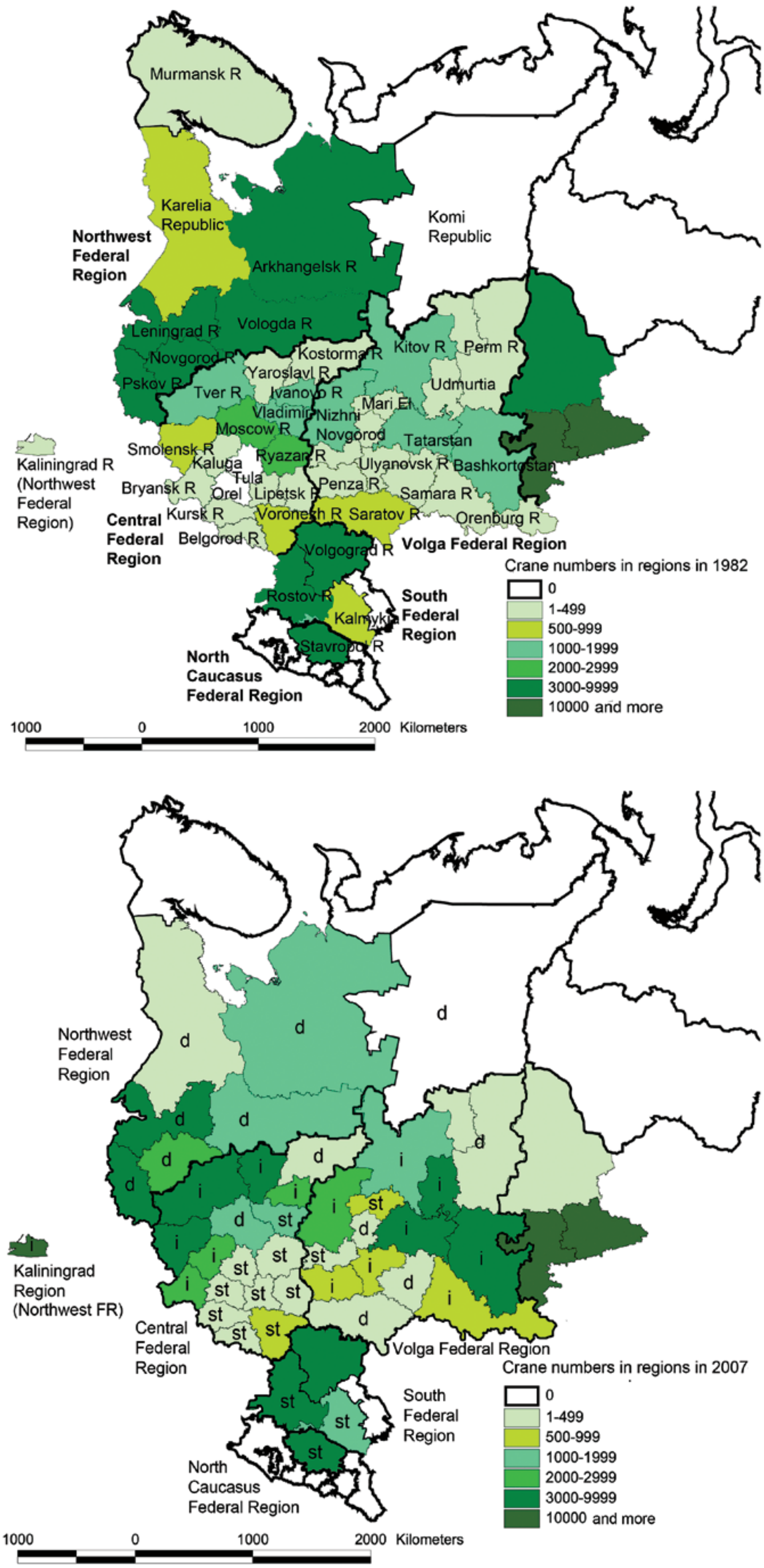

Fig. 4. Changes in number of staging areas in the European Part of Russia during 25-year period, from 1982 (a) to 2007 (b), due to changes in agriculture: i – increase; d – decrease; st – stable

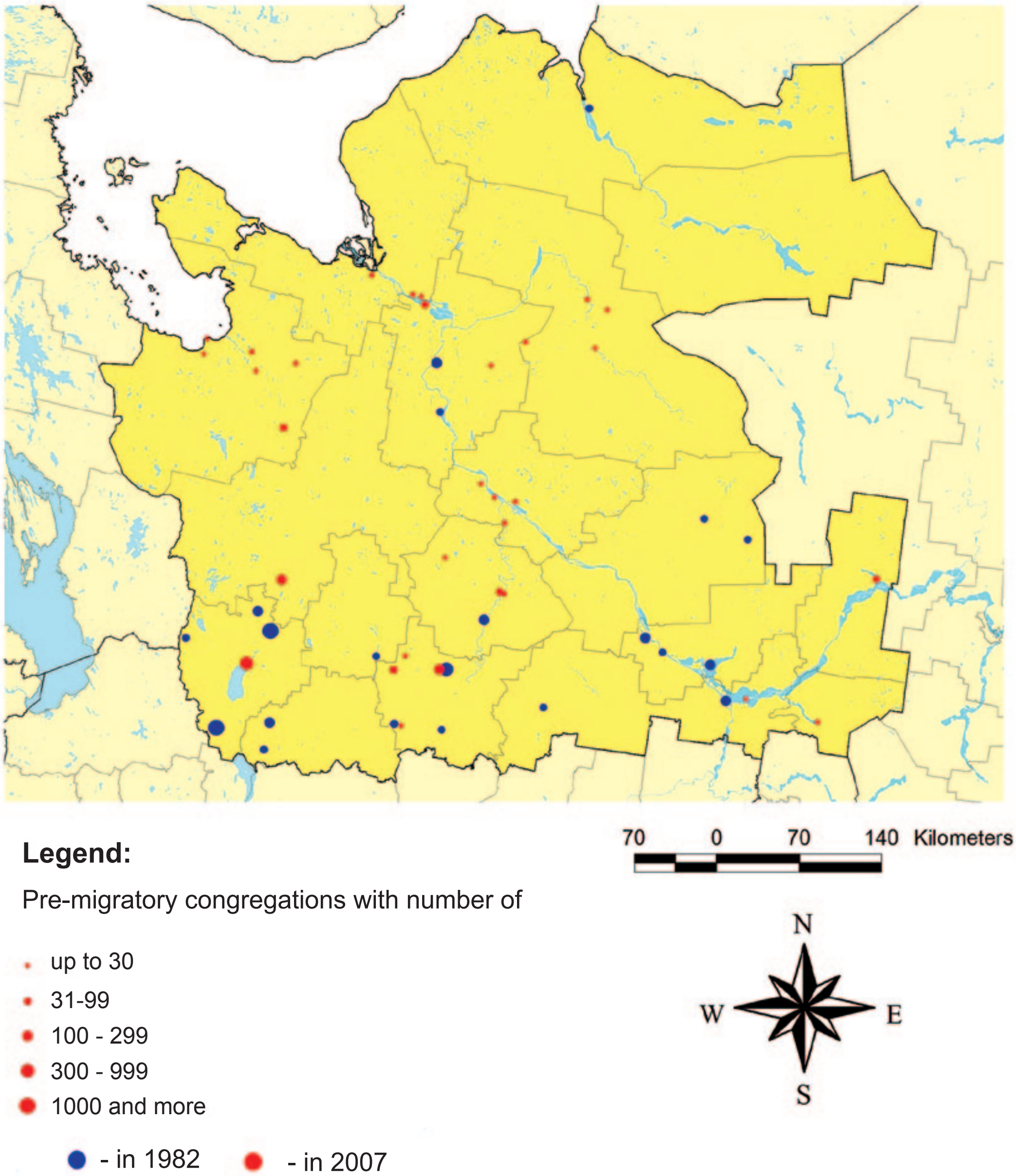

Fig. 5. Distribution of staging areas in Arkhangelsk Administrative Region in 1982 and 2007

among the fragmented small crop fields. For example, the known combined staging area and migration stopover, the Crane Homeland Refuge in Moscow Region, is now divided into three smaller staging areas (Grinchenko and Sviridova 2008). Connected with these changes, despite the decrease in number of staging areas in some administrative region of Central and Volga Federal Regions, the total number of staging areas in these federal regions increased (Table 2). In general, comparative analysis of questionnaires of 1982 and 2007 indicates that the total number of autumn staging areas in EPR has increased from 460 (Markin 2008a, Markin 2008b) to 569 (Fig. 6 and Table 2). This change may be caused not only by fragmentation but also by a general process of increasing numbers of Eurasian Crane in Europe and probably the European Part of Russia (Prange 2008).

On the other hand, among agricultural landscapes with a greatly dispersed mosaic of crops there are a few successful agricultural enterprises and private farms (Nefedova 2004). Cranes can gather at these large developed crop fields in huge flocks moving in from other staging areas with less favorable feeding conditions. Such large crane congregations at the fields of successful farms, in the context of generally unfavorable conditions in Central Federal Region, were observed in Ivanovo, Kaluga, Vladimir, Tver’, and Yaroslavl ARs. Such big congregations are also observed in Volga Federal Region with generally good agricultural conditions and more favorable conditions for development of private farms. For example, in Nizhniy Novgorod AR and in the Republics of Tatarstan and Bashkortostan the number of staging areas increased slightly, while crane numbers increased significantly (Table 2) due to formation of large crane congregations in the fields of successful agricultural enterprises and private farms.

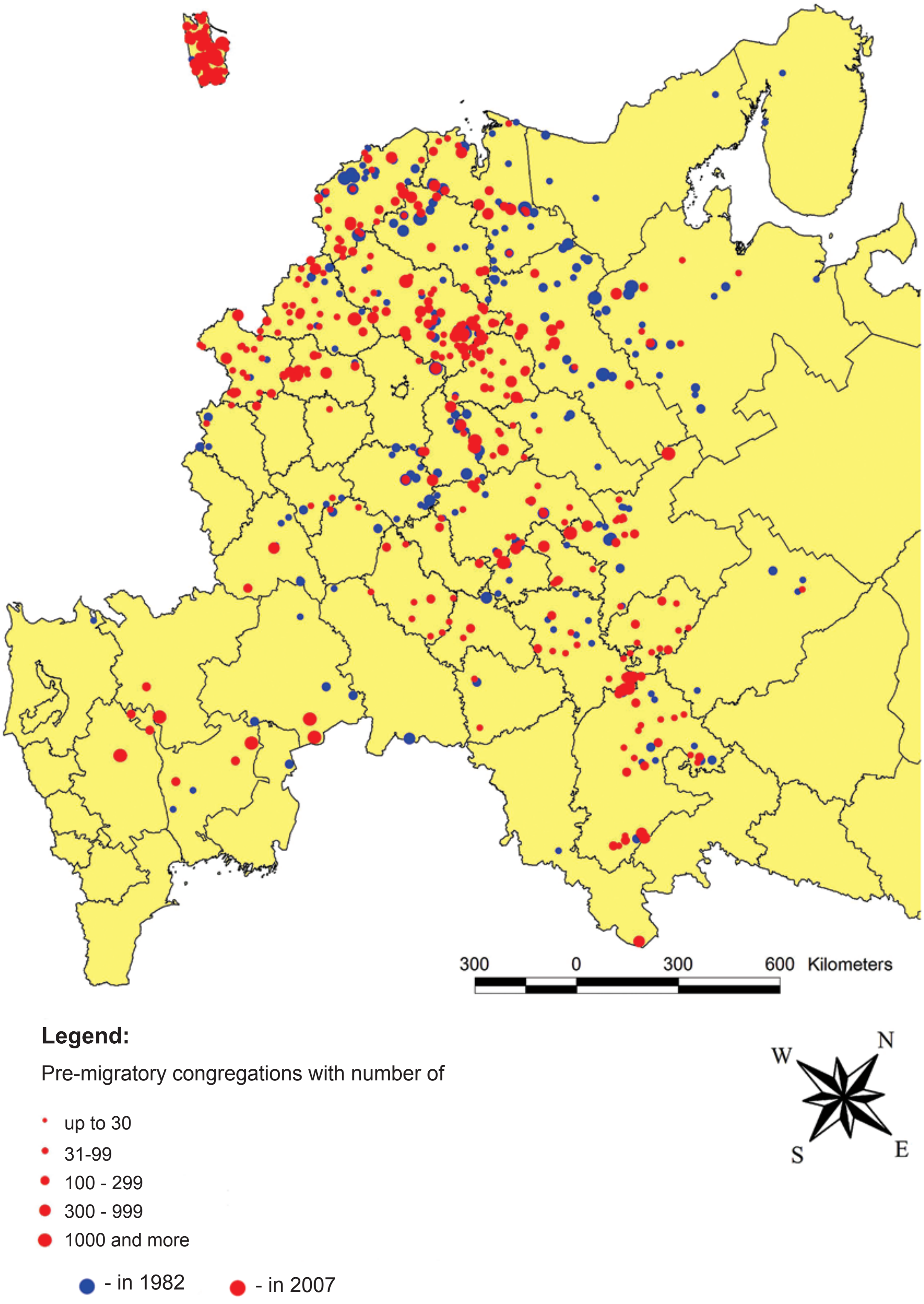

Fig. 6. Pre-migratory congregations of the Eurasian Crane in the European part of Russia in 1982 and 2007

Table 2. Changes in numbers of staging areas and estimated crane numbers from 1982-2007 in the European Part of Russia

Federal Regions of the European Part of Russia	Number of staging areas		Crane numbers		Tendency
	in 1982	in 2007	in 1982	in 2007	
Northwestern Federal Region	194	97	26,840	12,004	Decreased
Central Federal Region	132	279	11,220	44,397	Increased
Volga Federal Region	134	193	8,740	21,995	Increased
Total	460	569	46,800	78,396	Increased

Changes in Migration Routes Associated With the Agricultural Depression

It is very interesting to see a significant increase in numbers of staging areas in the western part of the Central Federal Region. In comparison with the 1980s, the number of staging areas in 2007 had increased in the most western administrative regions. The highest increase occurred in Kaliningrad AR: during the during 25-year period, number of staging areas with crane numbers from 10 to 1000 and more increased from 6 to 62, total crane numbers in the region increased from 340 to 13,300 (Fig. 7). Number of staging areas increased also in Smolensk (from 16 to 38), and Bryansk (from 3 to 24) ARs (Figs. 4 a,b). Usually during the pre-migratory period cranes gradually move south, southwest or/and southeast seeking better feeding conditions. The western movements of cranes could be due to the fact that neighboring West European countries provide more suitable feeding conditions. This suggestion appears to be confirmed by observations from West European countries where the number of migrating cranes has sharply increased since 1995 (Prange 2008). Confirmation is needed through color banding of cranes.

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Crane Damage to Agriculture During the Pre-migratory Period

In the Soviet time only a few cases of crane damage were known according to information from agronomists (Golovanova 1975), as agriculture was better managed and cranes had abundant food almost everywhere. In that time crane damage mostly took place in the northern regions of EPR, especially in years with late ripening of crops (Anzigitova et al. 2003). Cranes used the same crop fields for 2-3 weeks and could trample down the plants making harvesting impossible; such fields could only provide silage (Khokhlova et al. 2003).

During recent years complaints of crane damage have become frequent, mostly in the South Federal Region, where big flocks of migrating cranes stay longer, as well as in other areas with successful agriculture activities. Cranes here are considered the main pest of agriculture; sometimes there are calls to open crane hunting. The problem may be caused by two factors. First, areas planted with crops decreased significantly in some regions, and pressure by granivorous wildlife on the few developed fields became stronger. Second, after the collapse of the USSR collective farms were reorganized into private agricultural enterprises and farms, and their owners have been more highly interested in achieving good harvests (Markin 2008b).

Evaluation of crane damage to agriculture was conducted at the Eurasian Crane staging area in the buffer zone of the Oka State Nature Reserve (Markin 2008a). This research included studies of crane distribution among fields, crane numbers, feeding activity, competition, and alarm behavior. Similar research of crane feeding activity was conducted in the Crane Homeland Wildlife Refuge (Grinchenko and Sviridova 2008).

According to these studies, in the beginning of August, when flocks begin to form, cranes forage in uncut crop fields, mainly in oat fields or/and fields planted with legumes. In the middle of August, when crop harvesting begins, cranes move to stubble fields where they pick up leftover grain. In September, after winter crop planting, cranes prefer such fields to stubble. They move quickly along a planted field, picking

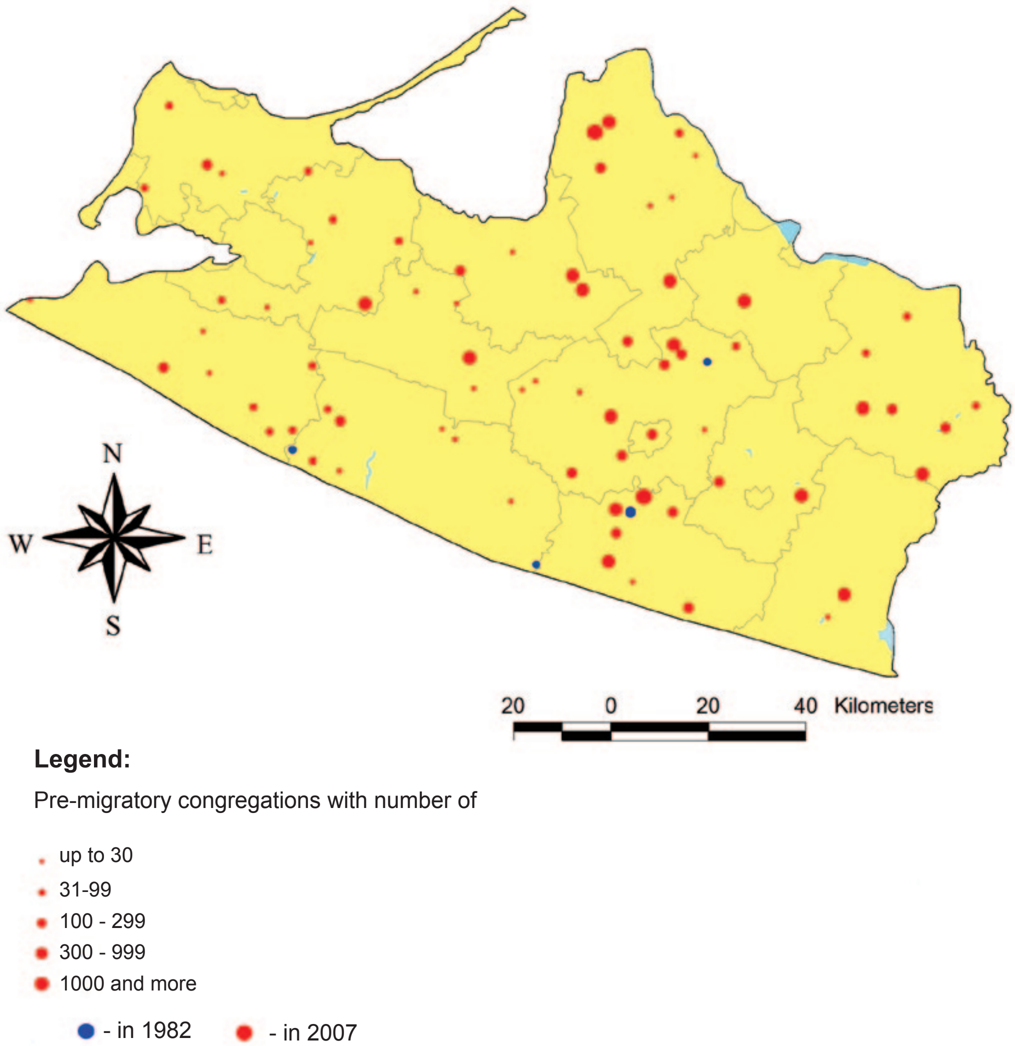

Fig. 7. Distribution of staging areas in Kaliningrad Administrative Region in 1982 and 2007

up newly planted seeds from the ground, without need to dig deeply. Cranes strongly prefer, however, winter crop fields where they can find germinating seeds with small emerging sprouts.

Thus, for a major portion of time during the pre-migratory period of 40 to 60 days the cranes feed in stubble crop fields or in recently planted fields, where they pick up grain close to surface. In the beginning of crane congregation, when small groups representing one third of the local crane breeding population gather in uncut crop fields, some damage can occur. Crane damage to winter crops also can occur at the end of the pre-migratory period and at migration stopovers. When feeding on small sprouts of winter crops, cranes uproot them in contrast to geese, which nip off plants bringing less damage.

Nevertheless crane damage to agriculture is relatively small, as cranes primarily use stubble fields. Damage to winter crops needs careful investigation. To avoid crane damage special measures can be undertaken such as planting lure fields to distract cranes from valuable crops (Goroshko 2012) or establishing crane feeding fields. The latter is practiced widely in Western Europe. In EPR there is only one site where this technique has been used for quite a long time – the Crane Homeland Wildlife Refuge.

CONCLUSIONS

1. During the 25-year period, from 1982 to 2007, agriculture in Russia went from the stage of relative stability in the Soviet time through a crisis after the collapse of the USSR in 1991, to a phase of slow recovery in several regions. Areas planted with crops are continuing to decrease in the north and center of EPR while slightly increasing in the south and east of the region.
2. Two main processes in agriculture in EPR during the study period had impact on number and distribution of the Eurasian Crane staging areas: polarization of agricultural development and fragmentation of crop fields.
3. Due to changes in agriculture, staging areas shifted to the west of the Central Federal Region and to the southeast, into Volga Federal Region. In these areas the number of staging areas as well as crane numbers increased. In all areas of the Northwest Federal Region and some areas of the Central and Volga Federal Regions staging areas disappeared or their number as well as crane numbers decreased significantly.
4. Crane damage occurs mainly in the north of EPR, especially in seasons with late crop ripening, as well as in the south of EPR in winter crop fields where cranes uproot sprouting seeds. Overall, however, crane damage is small as they use stubble fields for the most part in EPR.

ACKNOWLEDGMENTS

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A REVIEW OF THE CRANE-AGRICULTURE CONFLICT, HULA VALLEY, ISRAEL

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Abstract: Hula Valley in northeast Israel supports diverse ecosystems on its ~6000 ha, including wetland marshes and papyrus beds, now contained within the Hula Nature Reserve, and the newly restored Agamon Lake, as well as agricultural lands with open fields, fruit orchards and many fish farms. The intensification and diversification of land uses in the valley over the last 60 years has drastically changed the relationships among agriculture, tourism, nature, and resident communities. Since the 1990s, the distribution of wintering cranes in Israel underwent significant increases of staging and wintering birds at Hula Valley – from a few hundreds to 35,000 wintering cranes in 2010. The peak dates of migration have also shown a shift from 20 Nov – 10 Dec during the 1990s to 1–30 Nov with an overall longer “crane season.” Increasing numbers of cranes are an example of how land-use changes have significantly affected birds and impacted various resources both negatively and positively. Cranes have become a “Flagship Species” for the Hula Agamon complex. Intensive management and tourism infrastructure have produced a positive result by reducing agricultural damage and increasing public awareness and tourism with an estimated income of 25 million USD a year. It is clear that the large increase in wintering cranes at Hula is not only a result of population growth, but also of northerly shifts in wintering grounds. Understanding the relationship between crane behavior and land-use within the region is a critical issue for optimal management.
Keywords: Hula Valley, *Grus grus*, crane management, avian conflicts

BACKGROUND

The Hula Valley is located at the crossroads of Eurasia and Africa in northeast Israel, within the Great Rift Valley (35° 43′ E, 33° 03` N). Its approximately 6000 hectares support diverse ecosystems including wetland marshes and papyrus beds, as well as a matrix of agricultural lands comprising both open fields and fruit orchards as well as many fish farms. The valley once supported one of the largest freshwater wetlands in the Middle East. These wetlands were drained for agricultural purposes in 1953 and a small southern part of the region was protected as the Hula Nature Reserve (Dimentman et al. 1992, Ashkenazi and Dimentman 1998).

In 1994, as part of the Peat-Soils Reclamation Project, which had the primary aim to improve water quality and re-introduce agricultural land, a relatively large area of poor agricultural land (peat bog) just north of the existing Hula Reserve was re-flooded and restored to a shallow-water wetland. Before long, this newly created wetland that is currently managed by the Keren Kayemet L’Israel (JNF), attracted large numbers of waterbirds, raptors, waders and other birds, and the valley is now in the process of being nominated as a UNESCO World Heritage Site (Labinger and Skutelsky 2005). The intensification and diversification of land uses in the valley have drastically changed the relationships among agriculture, tourism, nature, and local communities.

CRANE POPULATION DYNAMICS

Since the 1990s, the distribution of wintering cranes in Israel has changed with significant increases of stopover and wintering birds at the Hula Valley – from a few hundreds to 35,000 wintering cranes in 2010. In autumn the peak dates of migration have also shown a shift from 20 November – 10 December during the 1990s to 1–30 November with an overall longer “crane season” (Fig. 1). This great increase in crane numbers in the valley parallels changes in agricultural management, especially the intensively grown crops of peanuts, which were not common in the valley before the early 1990s. The increasing crane wintering population together with a more efficient agro-technology has led to a very tense conflict with farmers. On the other hand, successful crane tourism has been established, and the Hula Valley is a growing market for domestic and international tourism with an estimated income of 25 million USD a year.

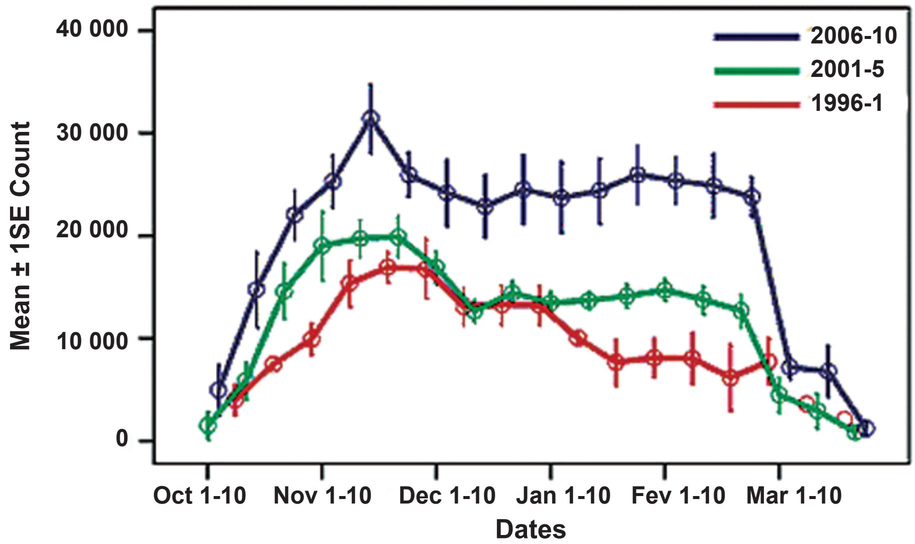

Fig. 1. Crane population dynamics as counted at the Hula during 1996-2010. Red lines – mean count results between 1996-1999; green – mean count results between 2001-2005; blue – mean count results between 2006-2010. Error bars represent ±1 S.E

MONITORING AND RESEARCH

Understanding the relationship between crane behaviour and land-use within the region is a critical issue for optimal management. Since the late 1990s, the crane population at the Hula Valley has been monitored through dawn counts of birds leaving their roost sites (Lake Agamon and Hula Reserve) over 10-day intervals during both migration and winter (1 October – 31 March). Time budget and habitat use were investigated during three separate studies (Alon 2001, Davidson 2004, I. Shanni 2008-2010 unpublished). A total of 220 cranes have been marked using color rings; of these, 25 birds were also equipped with different GPS and PTT devices during the three research schemes under different protocols.

The result of both GPS/PTT tracking and the color rings monitoring scheme suggest that most of the cranes that are using the Hula Valley are of Eastern European and Western Asian origin (Fig. 2). While some Finnish birds are also using the Hula, these cranes are mainly stopping over either during autumn or spring migration. During March 2011 a total of eight Finnish cranes with different rings were seen at the Hula; of these, one individual (M44774 Y-Bu-Y/G-Bk-G) is a bird that was seen during winter 2009-10 in Ethiopia (Finish Ringing Centre Ref. Number 1149296), thus confirming for the first time the Eurasian Crane migration route between Eurasia and Ethiopia, via Israel.

Our results indicate a strong population-based migration pattern. While the Israeli marked birds are predominantly seen during winter, most of the birds, which were marked out of Israel, are seen predominantly during migration. We believe that these results are good representatives of the population dynamics at the Hula. Our marked crane observations collection system is biased towards winter when the feeding attracts most cranes to the feeding area and many birds can be seen more than once during a single day. Thus the chances of not seeing a marked bird during winter are lower than during autumn and spring.

CRANE MANAGEMENT SCHEME

The increase of crane numbers is an example of how land-use changes have significantly affected birds and impacted various resources both negatively and positively. Cranes have become a “Flagship Species” for the entire Hula Agamon complex. Intensive management involving all relevant stakeholders has produced a positive result of reducing agricultural damage and increasing public awareness and tourism. Current crane management involves the following activities: (a) during autumn stopover period

(September through December), cranes are allowed to land and forage freely on a 'between fields' strategy, allowing them to use those fields where there is no potential damage; an abundance of leftover peanuts

Fig.2. General routes of cranes tagged in the Hula (lines) and origin of non-Israeli marked birds observed in the Hula as well as reports of Israeli marked birds out of Israel (grey balloons)

and corn is available in many fields; cranes are kept off of sensitive crop fields; (b) during the early winter stage, cranes are allowed to forage only in specifically designated areas and kept away from seeded fields through hazing techniques; in addition, a feeding station located within the Hula Agamon area provides food on a limited scale; and, (c) for the rest of the winter and spring, coinciding with insufficient food, low ground temperature and sensitive, newly planted crops, a massive, daily feeding is carried out at the feeding station in order to prevent crop damage while cranes are kept away from sensitive fields.

Rich and developing farmlands, coupled with supplemental feeding, have undoubtedly attracted more cranes, although increases may also be due to increasing winter survival rates. A recent work (I. Shanni unpublished) revealed both the importance of the Hula Valley as a staging site during autumn migration as well as the importance of the feeding station in holding birds in the Hula during winter. Fifteen GPS tagged cranes showed behavior patterns in accordance with central place foraging theory (Alonso et al. 1994, Alonso et al. 1995, Bautista et al. 1995) during autumn, while the feeding station is not operating, cranes move among fields surrounding the Agamon but once the feeding station starts its operation in the winter, most of the crane movement is restricted between the roost site and the feeding station. During spring, when the feeding station reduces substantially its operation, cranes show again a distinct pattern of movement among fields surrounding the Agamon with a growing distance from the roost as the season proceeds.

Mean mass of the tagged and ringed cranes during 2007-2010 shows an increase towards mid February and a slight decrease later on (Fig. 3). Although this pattern is not significant, probably due to the small sample size, it does appear to confirm our observations of reduced interest in feeding at the feeding station 2-5 days before the first departure date.

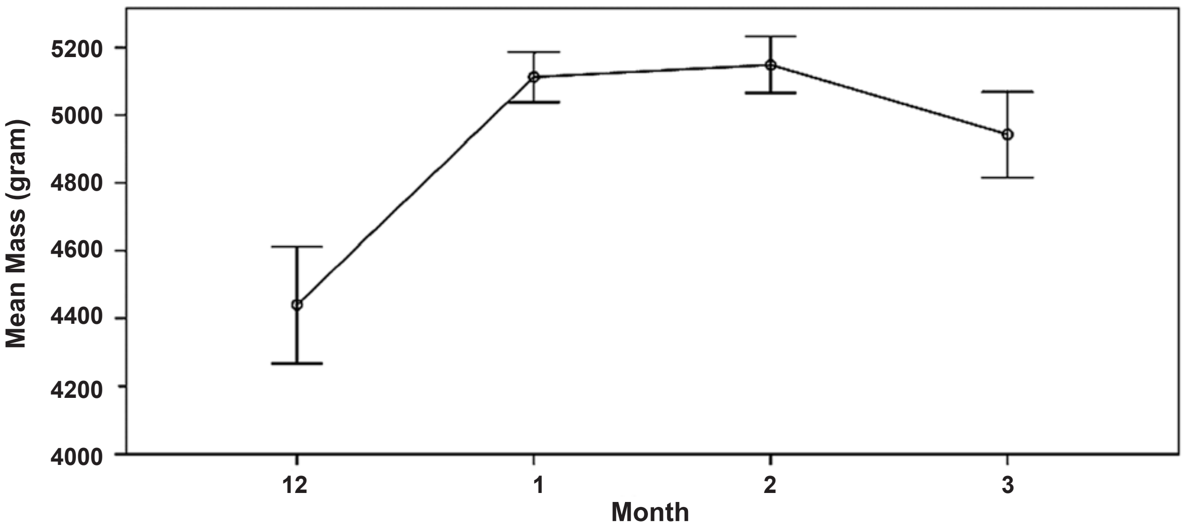

Fig. 3. Change in mean mass of tagged cranes during the winter months. Error bars represent +/- 1 SE

Our results indicate a very high use of the feeding station during the winter and suggest that the cranes may use an energy-minimizing strategy during early spring prior to migration. This result suggests that a different feeding protocol should be used to lower the high costs of feeding (at present ~30% of the total crane project), and yet maintain its efficiency as a tool in reducing crop damage. Optimal bird migration theories regarding fuel loads assume that birds will use either time-minimizing or energy-minimizing strategies (Hedenstrom and Alerstam 1997). According to these theories, a reduction of body mass prior to leaving the site (migrating) may suggest an energy minimizing strategy (by reducing the travel costs), although limited empirical research is available to support this (Berthold et al. 2000, 2006). This pattern of mass reduction towards the end of the wintering season may also represent the entry of southern migrants, which are already in active migration, to the wintering flock.

CONCLUSIONS

It is clear that the large increase in numbers of wintering cranes at the Hula is not only a result of population growth, but rather reflects a combination of population growth together with northerly shifts in wintering grounds and possibly higher survival rates. Based on the majority of the existing climate scenarios for the next decades, the conditions in Hula Valley will become much drier. Thus an increasing wintering population due to climate change could create an unbearable situation at the Hula, in which the crane management system will no longer be able to protect crops, and farmers will attempt to reduce wintering populations through lethal means. Another potential scenario is that local agriculture will undergo significant changes as a result of limited water supplies and this shift may negatively impact the staging and wintering cranes. This situation might also have a significant negative impact on the growing nature tourism in the valley.

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CRANES OF AFRICA, ASIA, AND NORTH AMERICA

CLIMATE CHANGE THREATENS THE AGRICULTURAL LANDSCAPE IMPORTANT FOR BLUE CRANES IN SOUTH AFRICA

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Abstract: The Blue Crane (*Anthropoides paradiseus*) is a near-endemic to South Africa. Around 50% of the global population of ~25,000 birds is found in the cereal crop (wheat) and dryland pastures of the Western Cape Province, one of two areas that will be most impacted by the effects of climate change in South Africa. Climate change models predict that the average temperature of the area will increase, precipitation will decrease and the rainfall season will extend into the summer months with an increase in extreme events of droughts and floods. Dependent on the scale of these changes, the area suitable for the current cultivars of wheat and pastures will decline, impacting directly on Blue Cranes as breeding and foraging habitat is reduced. The lack of confidence in the current models, however, provides little guidance on the future. Although change is anticipated, the extent of impact on cranes will depend on the extent of the change and the ability of agriculture and cranes to adapt to new conditions. In an already water stressed country, a decrease in precipitation will have a negative impact on cranes. Land users will become increasingly dependent on artificial water sources; water management will directly impact the cranes as they move among farms with chicks in search of water. These movements will expose the chicks to a greater risk of entanglement in fences and dehydration, threats that are already experienced in the area. Added to these potential climate-induced changes on Blue Cranes are other social and economic factors not directly related to climate change. Each of the various factors that could influence Blue Cranes in the Western Cape Province require careful consideration, planning and frequent review so that an adaptive conservation plan can be adopted.
Keywords: Blue Cranes, climate change, agriculture, Western Cape, adaptive management

SITUATION ANALYSIS

The Blue Crane (*Anthropoides paradiseus*) has the most restricted range of the world's 15 crane species. Numbering around 25,000 individuals in South Africa and only 35 in Namibia, the Blue Crane is a near endemic to South Africa (McCann 2002, A. Scott and M. Scott 2010). According to the South African National Crane Census held in 2002 (McCann 2002), 48% of the global population of Blue Cranes resides in the cereal crop (wheat) and dryland pastures of the Overberg and Swartland areas of the Western Cape Province; 29% in the natural grassy Karoo of the Eastern and Northern Cape Provinces; and 23% in the grasslands of South Africa.

Due to the population decline from over 100,000 (Allan 1994), the Blue Crane is now listed as Vulnerable on the IUCN Red Data List of Birds (BirdLife International 2008). Historically a species of the grasslands, the Blue Crane population declined across the grasslands in the 1980s, predominantly as a result of habitat loss, poisoning incidents and power line collisions (Archibald and Meine 1996, Allan 1997, Barnes 2000). Historically, the Blue Crane occurred in only small numbers in the Overberg and Swartland regions of the Western Cape Province of South Africa. The natural vegetation (Fynbos and Renosterveld) were slowly removed to make way for wheat crops. This slow transformation increased, following World War II when the South African government offered subsidies to landowners to grow wheat. By the early 1990s the change to a rotational system of small grain (predominantly wheat but also barley and oats) and dry-land pasture for small stock (mostly sheep) in the Overberg region was of such a nature that the region consisted of just over 50% dry-land pastures. It was in this artificial grassland state that the Blue Crane population established itself strongly and grew to a point where the area is now the stronghold for the species.

This ideal artificial grassland-like landscape of wheat fields and pastures is now under considerable threat as a result of climate change. The Cape Floristic Region, which geographically covers much of the key crane areas in the Western Cape, is considered one of the regions in South Africa to be most at risk from climate-induced warming and changes in precipitation (Midgley et al. 2005).

The Western Cape has traditionally had a Mediterranean climate with winter rainfall and dry summers, ideal for the current winter wheat production, which depends on late autumn and winter rains and warm August and September. Predictions suggest that the area will warm and show a drying trend from west to east, with less precipitation and potentially more summer rainfall. In addition, rainfall may become more sporadic with extreme incidents more intense (Midgley et al. 2005). Already, the past decade has shown shorter periods between droughts and floods (Niewoudt undated, Mukheibir and Zeirvogel 2007); the last 30 years have experienced a decrease in rainfall of between 10 and 20% (Midgley et al. 2005); the Western Cape has exhibited the greatest warming in South Africa (Du Plessis 2008); and an increase in extreme rainfall events in certain areas over the last few decades has been recorded (Fauchereau et al. 2000).

These changes in climate will affect agriculture in terms of water availability and utilisation, while the temperature changes will affect crop cycles and these shifts in turn will affect the socio economics driving agriculture in any one area. Although specific crop cultivars can adapt to an increase of 1ºC in temperature, the variability of extreme events and more significant long term changes in temperature together with the changes in precipitation, will have major impacts (Du Plessis 2008). Given the specific conditions required for any specific crop's growth cycle, changes in the climate will likely result in a change in crop calendars, crop rotation and ultimately the removal of present crops to make way for more tolerant crops or cultivars.

In terms of the agricultural landscape, any change could affect the Blue Crane population. The degree of impact will largely determine the resultant crops and landscape. Preliminary modelling results suggest that the extent of land in the Western Cape suitable for the current wheat production will reduce significantly (Estes, personal comm.). The questions lead to what the agricultural landscape will become: will a new wheat cultivar be found, and if so, will its growth cycle match the requirements for the Blue Crane's annual breeding cycle, or offer the opportunity for Blue Cranes to adapt their breeding cycle? If a new commercially viable crop is found, will this be suitable for cranes or not? It is only through staying abreast of model predictions, by keeping updated on the actual changes, and through monitoring the distribution, status, habitat use and breeding success of the Blue Cranes in this region that these questions may be answered.

Besides the potential changes to the agricultural landscape as a result of climatic changes, the Blue Cranes in the Western Cape will be affected by other factors that are linked to climate change as well. South Africa is a semi arid country with significant water scarcity and water quality problems, and the Western Cape already suffers from limited water availability (Midgley et al. 2005). The predicted decrease in precipitation and increase in temperature for the region will place an even greater strain on this already limiting resource. Farmers will need to become more efficient, with predicted climate change scenarios affecting future water supply capacity in the Western Cape ranging from marginally adequate when demand is low to inadequate when the demand is high (New 2002, Du Plessis 2008). Water scarcity will no doubt impact the Blue Cranes that are dependent on water for drinking. The higher temperatures and lack of water could result in a greater mortality of chicks through dehydration and entanglement in fences as family groups walk in search of water. This problem can be alleviated to a degree, however, by working with landowners where Blue Cranes breed and encouraging them to provide at least some water in the relevant territory during the time that the chicks are raised to fledging.

On the other end of the continuum, the more severe episodic events of flooding will likely result in a decrease in productivity as a result of nests being flooded, especially if these flooding events occur early in the breeding season. Altwegg and Anderson (2009), in a study on Blue Cranes in the arid Northern Cape in South Africa, predicted that early season breeders (spring to early summer) would likely be more successful than late season breeders. They also predicted that a wet early breeding season would likely be followed by a high reproductive output, and that late rains would result in improved survival. This finding would be important when considering the effects of climate change on Blue Cranes.

Although modelling suggests that the Blue Crane population in the Western Cape is currently either stable or increasing (Young et al. 2003, Pettifor et al. 2009), the population appears to be on a knife edge, with small changes in certain parameters potentially resulting in a rapid decline. Pettifor et al. (2009) determined that adult mortality was the most important driver of the population dynamics of Blue Cranes, but that mortality rates from egg laying to fledging and the proportion of reproductively mature individuals that breed in any given year also play a significant role in the dynamics of the population. These latter two parameters will be affected most by climate change, as described above, and, depending on the real impact on Blue Cranes, could result in significant changes in the population.

Added to these potentially climate-induced changes on Blue Cranes are other social and economic factors indirectly related to climate change, which guide the focus and agricultural practices of land users. Actual farm management and practices are usually slow to respond to the predicted climate change impacts (Estes, personal comm.). Most often, this tendency is a result of low confidence in the climate change predictions.

In order to better understand the response of the Blue Crane population to all of these factors, long term monitoring and regular analyses of these data, linked to the actual changes being experienced on the landscape, is imperative. This process admittedly is a challenge with Blue Cranes, a long lived and slowly reproducing species, where changes are not easy to detect at early stages. Yet such information is necessary so that adaptive action can be taken, and conservation priorities determined that will secure the future of the species across its range in South Africa.

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PROTECTING WETLANDS TO MITIGATE FOR CLIMATE CHANGE WHILE BENEFITING PEOPLE AND CRANES IN AFRICA

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Abstract: The Vulnerable Wattled (*Bugeranus carunculatus*) and Grey Crowned (*Balearica regulorum*) Cranes are dependent on wetlands for breeding and foraging. Often these are the same wetlands that local people depend on for their daily water requirements. Many wetlands are being degraded and lost through agriculture, drainage, overharvesting of natural resources, mining, dams and fires, with direct impacts on both cranes and people. Some of these wetlands are also peatlands, important for carbon sequestration and hence mitigating against climate change. There is an urgent need to secure key peatlands for cranes and people and to reduce the potential impacts of climate change through a system of legislative, carbon trading and community linked market based approaches. The aim of this project concept is to identify a number of peatlands across Africa that are important for Grey Crowned or Wattled Cranes and local people. Methods for securing each peatland will be explored including *inter alia* the development of legislated wetland management plans in collaboration with all stakeholders (Uganda), the inclusion of sites in a legally binding agreement under the Biodiversity Stewardship Programme (South Africa), the development of alternative livelihood options, and an exploration into the use of the Voluntary Carbon Markets for peatlands that will generate credible, verifiable and robust carbon offset projects. The effort will be initiated in Uganda, the country emitting the most green house gasses in Africa due to loss of peatlands, and South Africa, the country most familiar to the project participants. Several peatlands will be chosen in each of these countries to develop the methodology and processes to enable the expansion of the project into other key peatlands and countries in Africa.

Keywords: alternative livelihoods, carbon trading, Grey Crowned Crane, peatlands, Wattled Crane

INTRODUCTION

Africa's Wattled (*Bugeranus carunculatus*), Grey Crowned (*Balearica regulorum*) and Black Crowned (*Balearica pavonina*) Cranes are all dependent on wetlands for their survival as a result of their dependency on them for breeding and to a lesser degree, for foraging. All three are classified as Vulnerable on the IUCN Red Data List, primarily due to habitat loss, illegal removal from the wild and collisions with power lines. In many instances, it is the same wetland that cranes depend on that people living around the wetlands are dependent upon too for their daily supply of water for livelihoods. These same wetlands are being degraded and lost through encroaching agriculture, overgrazing, aforestation and deforestation depending on the area, drains, dams, incorrect or no fire management, mining, and other developments. People, cranes, and the other biodiversity within these systems are all being affected and their futures are increasingly precarious.

The African Crane Conservation Programme, a partnership between the International Crane Foundation and Endangered Wildlife Trust, is currently working with communities across South Africa, in the Driefontein Grasslands of Zimbabwe, the south-western districts of Uganda, the western districts of Kenya and the northern part of Rwanda. In all these key crane areas, wetland loss is affecting the cranes and in many instances, the local communities that depend on them as well. Over the years, conservation efforts have included awareness and education programmes, the development of alternative income generating activities outside of wetlands to encourage communities to reduce their impact on wetlands, the creation and involvement of Site Support Groups through our BirdLife partners within some countries and the development of community based legislative wetland management plans (Uganda). These activities have all contributed to the conservation of key wetlands and will continue over time, depending on what is most relevant in any particular area. In South Africa, the facilitation of legally binding Biodiversity Stewardship Agreements for key crane sites will be considered and the involvement of the South African National Biodiversity Institute's "Working for Wetlands" programme approached for sites that require rehabilitation. Similar tools for wetland conservation will be considered for key crane wetlands across Africa, and will be based on in-country legislation and the importance given to wetlands. In addition to these various tools, opportunities exist for the development of carbon offset projects at key sites. Linked to carbon trading markets, these projects could serve a pivotal role in securing wetlands, not only for cranes and people, but for their mitigating action in sequestering carbon.

PROJECT CONCEPT

Globally, diverse approaches to mitigating the effects of climate change are being explored extensively. Carbon trading and carbon offsets have become increasingly relevant as projects to conserve extensive areas of forest or to mitigate for their degradation have been identified as an effective way to ensure considerable sequestration of carbon. Peatlands, however, are one of the world's most important carbon sequestrators, storing in total an excess of twice the carbon stock of the world's total forest biomass or equivalent to 75% of the total amount of carbon found within the atmosphere (Parish et al. 2008). Although storing large amounts of carbon when in a whole state, peatlands release large amounts of carbon dioxide and nitrous oxide when dried out as a result of drainage and fires.

Africa's peatlands are poorly understood. We do know, however, that Sudan, Congo, Zambia, Uganda and the Democratic Republic of Congo are the five countries which have the most significant areas of peatlands. We know too that Uganda, followed by Zambia and the Sudan, are the three countries emitting the most carbon dioxide and other green house gasses as a result of the degradation of peatlands (Wetlands International 2010). Peatlands in South Africa, however, are better understood and have been clearly mapped into eco-regions (Marneweck et al. 2001).

Many of the wetlands on which cranes depend are peatlands. This project aims to better understand carbon offsets and the processes currently in place under which carbon trading occurs (peatlands would currently fall within the Voluntary Carbon Markets); to identify key crane peatlands for inclusion in the project and to develop the methodology required to measure carbon stores that will guide the development of credible and robust carbon offset projects while supporting communities and conserving biodiversity (Climate, Community and Biodiversity Standards); advocating for the inclusion of wetlands and peatlands in the larger, compliance markets; and developing offset projects at relevant sites.

South Africa and Uganda have been identified as the two countries where the project will be developed and demonstration sites initiated. South Africa was chosen as the country in Africa where the peatlands are best understood and where a number of the development team members are situated. Uganda will be the other country due to its high green house gas emissions as a result of peatland degradation and due to its proactive and informative wetland legislation and government support. Within each country, crane and peatland distributions will be overlaid. Uganda, however, will require a baseline project within key crane areas to gain a preliminary understanding of peatland distribution in the country. From this baseline study in Uganda, at least three sites will be chosen for the pilot projects.

Four sites have been proposed for the project in South Africa, but require additional evaluation. Lakenvlei, with Wattled, Grey Crowned and Blue Crane breeding pairs, on the Steenkampsberg Plateau north of Belfast is an 11,700 year old peatland with many complexities and serves as an important catchment for the Olifants River. The second is Tevrede Pan in Chrissiesmeer, a floating peatland within a pan. The third is the Wakkerstroom Wetland, with up to 11 Grey Crowned Crane breeding pairs, and for which all the work for its nomination as a Ramsar site has been concluded but not yet submitted. The fourth site has yet to be chosen, but will be a Wattled Crane breeding site within the KwaZulu-Natal Midlands; most crane breeding sites in this province are classified as mires and hence fit the definition of a developing peatland.

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HOW SHEPHERDS BECAME STEWARDS OF CRANES: A Case Study and Report of the AWCF Small Grant Project

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Abstract: Cranes need habitats for roosting, feeding and breeding. Climate change has resulted in more disasters and extreme harsh weather as well as diminishment of natural resources due to humans taking too much through non-sustainable approaches. What if no more natural resources are available for our offspring? With a small ($4,000 US) grant from the Asian Waterbird Conservation Fund (AWCF), Tumuji National Nature Reserve attempted a new public education method – "a student to a family; a school to a community, a community to a town" – to amplify project impacts. After less than a year, the new method had proved very successful and impacted environmental education with an established conservation stewardship. The new method provided local people not only with a relaxing and enjoyable education environment but also with an acceptable way that allowed local people, especially those poorly educated, to understand why we should preserve cranes and natural resources and why we should use a sustainable way in agriculture production. Almost all the citizens of Tumuji Township and many people in Zhalaiteqi Banner[3] became well aware of the AWCF project and began caring for environmental issues and taking action in crane conservation. This small grant project reached over 60,000 people.

Keywords: cranes, stewards, education, sustainable development

INTRODUCTION

Cranes represent one of the most important symbols in Chinese history and culture. They are so important that to many people over the last 3,000 years crane images have been iconic in their daily life. A crane means longevity, auspicious, beauty, glory, noble, elegance and much more to Chinese people. A pair of lotus and crane rectangular hu (pot or a wine vessel) were excavated from the tomb of the Duke of Zheng State (in Lijialou, Xizheng City, Henan Province) in 1923 and were estimated to be artifacts of the Spring and Autumn period (770-476 B.C.), before Confucius' time (551-479 B.C.). Confucius has come alive again with rapid economic growth since the 1980s after the Cultural Revolution. But what do cranes mean to Chinese people nowadays? Do people think about cranes under high pressure of living?

The answer is YES! The traditional thought is rooted in Chinese hearts and might be ignited with a single spark. Crane means HOPE! As long as the crane survives people's hope will continue. One way to maintain people's hope is to preserve the cranes and their habitats.

Fortunately, people living in Tumuji Township of Zhalaiteqi Banner, Inner Mongolia have amplified their hopes thanks to a grant from the Asian Waterbird Conservation Fund (AWCF) and support of Tumuji National Nature Reserve (NNR).

PROJECT SITE

Tumuji NNR lies in the far south of Zhalaiteqi, within the boundary area of Inner Mongolia, Heilongjiang and Jilin Provinces. This area is typical of the transition terrain from Daxing'anling Mountains to Songnen Plain, with combination of temperate grassland and wetland ecosystems. The total area of the reserve is 94,830 ha, including 7,360 ha of water surface, 29,425 ha of marsh, 36,890 ha of grassland and 7,319.8 ha of forest.

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[3] Banner is an administrative division representing the county level of government in the Inner Mongolia Autonomous Region.

Biodiversity is rich here. Based on the latest animal surveys conducted throughout the reserve, 516 animal species of 71 families were observed, of which 310 were birds, including 13 species of National Class I protected birds and 47 species of National Class II, such as Red-crowned Crane (*Grus japonensis*), Siberian Crane (*G. leucogeranus*), Oriental Stork (*Ciconia boyciana*), Swan Goose (*Anser cygnoides*), Great Bustard (*Otis tarda*) and Golden Eagle (*Aquila chrysaetos*). As one of 13 flyway monitoring sites under the UNEP/GEF Siberian Crane Wetland Project (SCWP - Project No: CF/2712-03), Tumuji NNR has observed an increasing number and diversity of migratory waterbirds in the past five years. The largest flock of Siberian Cranes observed was in spring 2008, numbering over 200 and accounting for about 6% of the world's population.

There are seven villages in the reserve with a population of 15,000. Mongolian ethnic people account for a majority, about 60%.

In recent years, rainfall has been decreasing, resulting in grassland degradation and wetland shrinkage. With rapid economic development, cranes and their habitats are facing more threats, such as reclamation, over-grazing and fishing.

GOAL, OBJECTIVES AND METHODOLOGY OF THE PROJECT

In February 2009, a project entitled "Establishment of Waterbirds Conservation Stewardship through School and Community-based Education and Interpretation" received an AWCF small grant. The project duration was from March 2009 to February 2010, with a budget of 4,000 USD.

The project goal was to establish waterbirds conservation stewardship through the implementation of a series of school and community-based educational and interpretive activities in Tumuji Township. The project objectives included: (i) five school teachers, five community representatives and five reserve staff members would participate in Training of Trainers (TOT); (ii) 80 school students and residents from the local community would be trained by the TOT trainees; (iii) a primary interpretation system would be established in and around the key sites of the reserve; (iv) at least two senior leaders of the local government would attend the main activities; (v) at least two media agencies would release news/articles about the project's activities/outputs.

A method of "a student to a family, a school to a community, a town to a county" was used to enlarge environmental education impacts and establish conservation stewardship. Everyone can be taught and everything is teachable. We focused on individual students and their schools. Learning through playing, students can bring environmental education impacts back to their families and share with their parents, relatives and friends as well. Impacts of school-based environmental education activities can further reach out to the community through community-based programs and media involvement. Larger impacts then can be achieved through families and communities from a town to a county and beyond.

IMPLEMENTATION OF THE PROJECT

The project began with intensive communication with the project execution team in order to make everyone fully aware of the project target and methodology. The project manager was urged to keep close contact with higher leadership so as to obtain adequate support from reserve managers and the local government.

Leadership of the local government and the Administration Bureau of Tumuji NNR were therefore well aware of the project goal and objectives as well as the significance of the project. Consequently they decided to provide co-financing, which proved to be a fundamental step for successful implementation of the project.

The first fruit was a kick-off meeting, co-financed by the Administration Bureau of Tumuji NNR, to officially announce the launching of the project. On 20 April 2009, the inception meeting occurred in the headquarters of Tumuji NNR. Fifty-two people attended, including representatives from the local community, teachers from primary and secondary schools, and local media. Four higher leaders from local government also attended and spoke at the meeting.

The event was well covered by local TV and newspapers. There is an old saying in China, "a good beginning is half-done." Closely following the project inception, a series of activities were carried out smoothly on schedule.

MULTIPLE RESULTS FROM TOT (TRAINING OF TRAINERS) WORKSHOP

A week-long “Training of Trainers (TOT) Workshop” was attended by 18 trainees including six reserve staff, six school teachers, and six representatives from the local community. Another ten people from the local community and the reserve participated in the workshop as observers.

During the workshop, interactive presentations were delivered by trainers. A participatory approach incorporating experiential games was used throughout the workshop. New concepts and advanced techniques of environmental education and interpretation were presented together with case studies. During the workshop, the trainers encouraged everyone to participate in all activities and games. Small gifts were awarded to trainees who joined in the game or activity. Before the conclusion of the workshop, all attendees, including observers, received at least one gift. Questions were always welcome. A field trip was also organized, which gave trainees a complete picture about what they had learned.

Attendees ranged in age from 20 to 60 years old. During the wrap-up session of the workshop, Mr. Bai Yuliang, age 63, said: “I had never experienced such an enjoyable lesson before. Learning through playing games allowed everyone to understand very easily the hot points of environmental issues and sustainable development. The main idea before was that human beings were the masters of nature and the Earth. Men could do whatever they wanted. Now it has become clear that we are only stewards of the natural resources and we should take care of those resources in order to keep them intact for future generations.” The other trainees, from young to old, agreed with Mr. Bai.

Mr. Yi Guoliang, the Director of Tumuji NNR, personally observed the TOT workshop for the first day. The approach and style of the training impressed him so much that he promised to provide co-financing for follow-up activities at the end of the workshop. His actions conveyed a signal to all the people that environmental education and follow-up events remain issues of high importance.

It is worth noting that it was raining the second day. Temperatures in Inner Mongolia were still cold in late April, below 10o Celsius. We worried that some trainees might not be able to come. Yet all trainees and observers arrived at the venue before the class began. One man from the local community walked into the classroom and requested to be involved as a volunteer. We accepted his request.

Local television and news agency conducted interviews and reported on the workshop. As a result, the impact of the event reached beyond the county to the whole prefecture.

STRIKE WHILE THE IRON IS HOT – ENHANCING TOT OUTCOMES WITH A SERIES OF FOLLOW-UP ACTIVITIES

Indoor Training and Lectures in Schools and Community

On 28 April, 21 trainees and observers of TOT were divided into three groups. They went to local primary and secondary schools and to the community to present environmental education lectures as a follow-up training program to train more students and local residents. The theme of the event was “Waterbirds and Life, Wetlands and Future.” All new trainers delivered lectures and training by using approaches and concepts learned from the TOT workshop in combination with their own knowledge and experiences. The interactive method drew students’ attention and they learned up-to-date techniques and concepts by playing games. Quoting the students, “It was the most impressive training we had ever had,” and, “Truly learning by enjoying and making things easy to understand is the best possible way.” All participants expressed gratitude to the project organizer.

In total, 85 students and community representatives participated in the training and lectures. At the end of the event, participants expressed their wish to be involved in further training and lecture activities and that they would share about their own experiences during the training. In doing so they should be able to teach their family members, relatives and friends about waterbird conservation and their wetland habitat conservation as stewards of cranes and natural resources. In this way, at least 300 people would be directly influenced by these trainees at home and/or in the community.

A Field Trip to Enhance Indoor Training Outcomes

On 29 April, to enhance the indoor training outcomes, 30 students and representatives from local schools and the community were invited to join in a field trip. The organizer took the participants to the nature museum and the wetland where they could physically touch nature with new feeling. Under the guidance of trainers as interpreters, all participants realized the beauty of wildness and biodiversity, things they had never cared about before.

At the end of the field trip, participants told the organizer that they more deeply understood what they were taught in the class and were really touched by the nature and living creatures. They wished the project could organize more such events so as to give opportunities to more people.

A Study Tour to Momoge NNR and Keerqin NNR

Based on my recommendation and a promise made by the Director of the reserve during the TOT workshop, Tumuji NNR co-financed a study tour to Momoge and Keerqin NNRs on 1-2 May, to learn good practices and methods in environmental education and community participatory co-management.

Nineteen people including six school teachers and four community representatives joined in the study tour to Momoge and Keerqin NNRs. Both Momoge and Keerqin administration bureaus warmly welcomed the study delegation. Vice Directors of both NNRs accompanied the group to local communities and schools and personally delivered a comprehensive introduction to what they had achieved through international projects using advanced participatory co-management concepts and approaches. Awareness and capacity for building within the local community and coordination between schools and the reserve for environmental education impressed the delegation so much that at the end of the trip they suggested that additional intensive training should be planned for the future to reach larger audiences.

Ms. Zhou Jingying, the Project Manager and Ms. Wu Youqin, the Assistant of the Project gave both NNRs a brief introduction to the project design and application. Leaders of both NNRs showed high interest and wished to establish a long term mechanism of learning through study tours among NNRs. The group leader Vice Director of Tumuji NNR Mr. Cheng Wanjun thanked the hosts and shared that it was also his idea to build such a mechanism.

Local news reporters tracked the event and reported the story in the local newspaper.

Celebration of "Love the BirdsWeek"

On 20-26 May 2009, celebration of "Love the Birds Week" was organized in downtown Tumuji and Yinde-er (capital of the banner) townships. The theme of this event was "Conserve Wetland and Save Waterbirds." The slogan was "Care for Birds and Protect Nature." During the celebration, a series of activities were organized. They included:

1) Opening Ceremony and drawing contest: some 400 people attended the ceremony on 20 May 2009 including five local government leaders. Local television and news agency reports appeared on television and in newspaper. Through this event, students realized that to protect birds and wildlife was not only an obligation but also an inherent responsibility. Human beings should humbly care about all creatures and allow them share the planet freely with humans.

2) Chalk Drawing Contest: The first "Chalk Drawing Contest" was conducted in Tumuji Zhongxin School on 22 May 2009. The theme was "Care for Birds – Let Birds Fly Freely in the Sky." Some 60 pupils participated. Art and nature teachers presented lectures relevant to birds before the contest. The lectures not only gave scientific information but also cultural facts. "This was really an excellent opportunity for everyone involved. In the process of the contest, everybody's heart and mind was flushed and cleansed. A strong concept for the care of nature and wildlife was established in the pure hearts of those little pupils," – said the Principal of Zhongxin School. "We should cooperate with the reserve in future to strengthen the environmental education."

3) Exhibition in downtown: On 23 May 2009, a large scale exhibition event was conducted in downtown Tumuji. Some 30 environmental educational signs and exhibits were displayed along

the main streets. All interpretation was undertaken by school students from Tumuji Lantian School and Zhongxin School under the guidance of teachers, community representatives and reserve staff (most were TOT trainees). Over 1,000 educational flyers were distributed to the public. The student interpreters, teachers and reserve staff also provided answers to queries raised by audiences. Through this event, students strengthened their ability and thoughts for what they were doing. Thousands of public audience members visited the exhibition and the stewardship concept was silently transplanted.

4) Other activities included Raising Flag Ceremony, lecture in Zhongxin School, and Solicitation of rticles. Over 310 students and teachers joined in the events plus hundreds of passerbys. During this week-long celebration, eight slogans and over 80 color flags were hung up along the main streets.

In fact, the "Love the Birds Week" had started early, in the beginning of May. On 4-10 May, schools began to solicit performance programs themed at "Love Birds and Protect Birds." All types of performances were welcome without limitation. Students were all active and involved in the process. There were a total of 25 programs from 23 classes involved in the solicitation. All plays were full of innovation and vigor and highlighted the theme. After selection through public appraisal, 12 programs were chosen to be performed during the celebration of "Love the Birds Week."

OUTREACH BEYOND THE BOUNDARY

Summer Camp

On 8-13 August 2009, a Summer Camp was organized on grassland near the Research Center. Twenty-five students, twelve boys and thirteen girls, from local schools were selected to participate in the Summer Camp. All the parents of these students were working in large cities far from Tumuji and facing economic difficulties, such as decline of rainfall and degradation of grassland. These students and their parents normally visited back and forth one or two times a year. This meant the project impacts would go beyond the town to the whole northeast China and further.

During the six-day Summer Camp, students played interesting games and participated in various activities under guidance of coaches, such as searching for treasures in bushes and grassland, catching insects, and making specimens for collection displays. Besides playing in the grassland, students also visited several facilities of the reserve, such as the Research Center, the Wildlife Rescue Center, and the Nature Museum. Lectures on astronomy and wetlands were also delivered.

In the Wildlife Rescue Center, they learned that most of the rescued wild birds were injured by poisoned seeds. Students wanted to share this information with other classmates, relatives and other farmers to stop this problem.

On the last day, students entered the Dongpao Marsh – the core area of the reserve – where they visited the protection station and key species monitoring station. Campers took off their shoes to experience the feeling of how waterbirds walk in a marsh. They observed thousands of waterbirds flying, swimming, or dancing in the marsh. The students found the birds' home to be so beautiful, something they had never realized before. This vision allowed them to better understand the meaning of stewardship, and they were better able to express social responsibilities to be taken up now and in the future.

Six leaders from relevant local government sectors observed the camping activities and gave a high score to this event. "This was the best camp we ever had and its outcome was the best we could have hoped for," – said Mrs. Jiang Yuyan, Chairperson of Zhalaiteqi Committee for the Wellbeing of Youth. Mr. Moergen, Vice Director of Tumuji NNR, pledged that the reserve would provide more opportunities to school students and would like to cooperate with schools and relevant organizations to deepen environmental education so as to establish a solid participatory co-management mechanism. Local government officials said that they would try their best to provide more resources for environmental education.

As for the project team, this camp was an excellent chance to further educate its own members. Through organizing these activities, their capacity was enhanced, and cooperation and relationships among sectors was strengthened. It was planned that Tumuji NNR would develop a series of native environmental education materials, especially Chinese and Mongolian bilingual books, for local school students and the community in coming years.

INTERPRETIVE SYSTEM PLAN

Interpretation is just as a bridge linking the reserve and visitors. Through establishment of the interpretive system, the goal and mission of the reserve can be expressed to broader audiences everywhere.

The Interpretive System of Tumuji NNR was one of the designed project activities. It was planned for two phases due to financial constraints. The AWCF small grant project would only support the conceptual design of the system in phase I.

In the process of conceptual planning, the project manager organized relevant staff to conduct in-depth surveys and analysis targeting potential audiences under the guidance of the project advisor. A participatory approach was adopted for the conceptual planning so that the design team could understand the targeted audiences. All stakeholders were invited for discussion and the project team encouraged their input and review. Comments were always welcome. The phase I plan was completed by all stakeholders, including leaders and staff of the reserve, local government officials, community representatives, school teachers and students.

The conceptual plan was targeted at one central theme supported by four sub-themes as storylines. The goal of the interpretive system plan was to inspire the audiences' curiosity, to motivate them to learn more and for them to have a better understanding, hence to care about and take care of nature, at last to become a steward of the world shared by all its creatures.

The ultimate goal of the Nature Center was to inspire audiences to understand the mission of the reserve and to help the reserve achieve its goal through achieving each objective. This systematic approach should result in the sustainable use of natural resources.

During the development of the plan, the working team also helped the reserve clarify its mission, vision and objectives – an extra bonus for the reserve and favorable for the future establishment of the interpretive system.

Closing Workshop

On 20 January 2010, the closing workshop of the project was organized in the meeting room of Tumuji Administration Bureau in Zhalaiteqi. Twenty-two participants attended including representatives of local community, school teachers, and the reserve staff.

Mr. Li Xueshan, the Head of the town emphasized that various research and environmental education workshops should be organized at all levels to enhance information exchange. He also recommended a series of native public education materials be developed with intensive exchange and cooperation with local schools so that the stewardship concept could finally be established through the approach of "a student to a family, a school to a community, a town to a county."

During the workshop, participants shared experiences obtained through the project. All participants recognized that awareness of environmental protection and participation of the local people, especially local farmers and herdsmen, had increased significantly through the execution of the project. This workshop should be the start of a larger and longer project that would look to the future.

SHEPHERDS BECAME STEWARDS OF CRANES

To save a crane is easy, but to change a person's mind is difficult and always a challenge. However, shepherds in Tumuji are unique. Shortly after the TOT training and its follow-up activities, their attitudes had drastically changed.

In the morning of 10 May 2009, a shepherd Xiang Qian, one of the trainees who participated in the TOT workshop and who lived by Dongpaozi Lake (the buffer zone of the reserve) found two Red-crowned Cranes staying by the lake with sheep passing by very closely. He felt this behavior abnormal and approached the cranes stealthily. He excitedly found that the two cranes were laying eggs. He crept quietly back from the cranes without disturbing them. As other shepherds were grazing in this area he decided to take care of the incubating cranes in order to avoid possible disturbance. From 11 May 2009, he herded sheep very early in the morning at a safe distance from the cranes to watch over the cranes and ensure that no people and no predators would disturb them. Late afternoons in early May are still cold, but he would only return home after he was sure the cranes were safe.

On the 28th day, he found that a chick had emerged from an egg. He was so excited and thought that the shepherds together should take care of the chick for it might not be possible for him to guard the chick all the time. So he began to talk with the other shepherds. They were happy to join as a team to protect the cranes.

This story came early during the project. Through the project, local people became aware of sustainable development and wise use of natural resources. They were searching for alternative livelihoods and environmentally friendly ways for development. Based on the survey by the project team after completion of the project, the number of livestock in the area has decreased gradually (see Table 1). Reclamation of wetland and grassland has decreased greatly compared with the situation before implementation of the project, and effectively protected grassland was extended to 36,890 ha. The quantity of pumped ground water was kept stable and local people now understood that only sustainable development might give them a better life and secure a better future for their offsprings.

Table 1. Comparison of livestock numbers before and after the project in Tumuji

Livestock	Before	After
Cattle and cows	5132	4884
Sheep	28280	26128
Goats	27749	23185
Horses	1898	1641

CONCLUSIONS

Through the project implementation, the people involved now know more about the modern community environmental education concepts and approaches. Project staff learned how to conduct public education and communication effectively through an enjoyable method. Now they much better how to communicate ideas of respect for nature and proper life values, and how to deliver new academic knowledge to their audiences through popularization of science. The cranes served as an effective flagship for conservation at Tumuji.

The number of people involved through the project reached up to 2,500. Diverse groups benefitted, such as leaders of local government, school teachers and students, community residents, farmers and herdsmen, and many more. The media covered most activities and published a dozen reports on prefecture and county television stations, radio stations, and newspapers. News websites of Inner Mongolia also reported the project activities. The project impacts were felt in the whole autonomous region, far beyond the project team’s earlier expectation.

Six points deserve emphasis as they secured successful achievements of the project: (i) a strong work team committed to achieve its targets was most important; (ii) support and involvement of the leadership was also key and resulted from effective communication with the leadership; (iii) stakeholder participation was essential; (iv) outside support such as consultation provided by experts and the financial support by the international community facilitated project impacts; (v) by drawing media attention, the project reached a broader audience; and last but not least (vi) attitude and learning ability as well as cooperativeness of the work team helped guarantee the project’s success. The initial capacity of the work team is not so important as long as the members are willing to learn.

Some recommendations came from the end of the project. Project staff realized environmental education must be conducted with the local community and schools through daily education and activities. Contact with the local education sector and linking environmental education to the schools’ curricula should be enhanced.

Native education books should be developed to fit the local people. Different education approaches should be suited to different backgrounds, ethnicities, ages, and genders of audiences. To achieve the mission of the nature reserve, it is essential to obtain local public support. Communication, especially through interpretation while receiving visitors, is of great importance.

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METHODS FOR REDUCTION OF CROP DEPREDATION BY CRANES TESTED IN DAURIA (TRANS-BAIKAL REGION)

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Abstract: Methods of reducing crop depredation by cranes were developed and tested at Daursky State Nature Biosphere Zapovednik (Reserve), in the southern Siberia steppes. Daursky Zapovednik (DZ) includes Torey Lakes that support autumn gatherings of cranes and waterfowl. Croplands (mainly wheat) attract staging cranes, geese, and ducks. Up to 42,000 Demoiselle Cranes (*Anthropoides virgo*) and 1,100 Hooded Cranes (*Grus monacha*) can feed in the fields near DZ, taking out up to 70% of grain in some wheat fields. From 1992-2004, several methods were proposed and tested to reduce the damage: (1) move crop fields farther from the wetlands where cranes roost; (2) plant lure crops (millet and wheat) at locations close to roosting sites; (3) provide an alternative food, Foxtail Grass (*Setaria viridis*), by growing it on fallow lands near wheat fields; (4) adjust dates and techniques of harvest. Experimental trials in 2000-2003 showed that cranes visited crop fields shifted 10-15 km away from roosting sites 15-30 times less often than the fields located 1-2 km from the Torey Lakes. Small (5-10 ha) lure millet fields attracted cranes the most, and the birds stayed out of adjacent wheat fields until after harvest. Before the harvest, cranes ate mainly millet (~90% of diet, with wheat comprising 10%). Cooperative farms began planting lure fields without governmental subsidies as soon as they realized that it costs them about one tenth of the damage caused by cranes.

Keywords: crop depredation, Daurian steppes, Demoiselle Crane, Torey Lakes, *Anthropoides virgo*

INTRIDUCTION

Crop depredation by staging cranes is a serious problem in many regions of the world. The author investigated this problem since 1992 in Daursky State Nature Biosphere Zapovednik (Reserve). Zapovedniks are a Russian system of strictly protected natural areas (significantly stricter than national parks and wildlife refuges). Daursky Zapovednik (DZ) is located in East Siberia’s zone of arid Daurian-Mongolian steppes. Lands around DZ are important for agriculture in Trans-Baikal Region. DZ includes the large Torey Lakes – a key stopover for more than 30,000 cranes of six species staging there during crop harvest in autumn (Goroshko 2000a). Cranes cause significant damage to crops (up to 70% in some wheat fields). In 1998, the author developed the first recommendations for reducing crop damage and explained them to local farmers. In 2001, joint research was conducted with Dr. Stephen Bouffard and Dr. John Cornely (Bouffard et al. 2005, Goroshko et al. 2008). The recommendations were later published (Goroshko 2002a) and distributed among local people. Since 2000, local farmers have been using the recommended methods successfully. This paper reports on development and results of the recommendations.

STUDY AREA

DZ was established in 1987 in the center of Global Transboundary (Russian-Mongolian-Chinese) Dauria Steppe Ecological Region. It is located in southeastern Siberia in the Trans-Baikal geographical region (about N 50°00’, E 115°30’) near the state borders with Mongolia and China (Fig. 1). The present-day administrative name of this region is Zabaikalsky Kray (Transbaikal Region) and the former name was Chitinskaya Oblast (Chita Region).

Forest, rocks, vast steppes and numerous wetlands all are present in the Dauria Ecological Region. DZ includes Torey Lakes, Imalka and Uldza Rivers running through the lowland, steppe grasslands, and rocks. The Torey Lakes are the largest lakes in Trans-Baikal Region (in wet years covering over 900 km^2). The lakes include a shallow Barun-Torey Lake that can have up to 12 islands and a deeper Zyun-Torey Lake with no or only one island (the number of islands depends on changing water level). The water in the lakes is quite alkaline because they have no outlet. The climate is dry continental. Duration of the growing season is 150-180 days per year. Total annual precipitation is ~250 mm, the bulk of which (50-70%) falls during July and August.

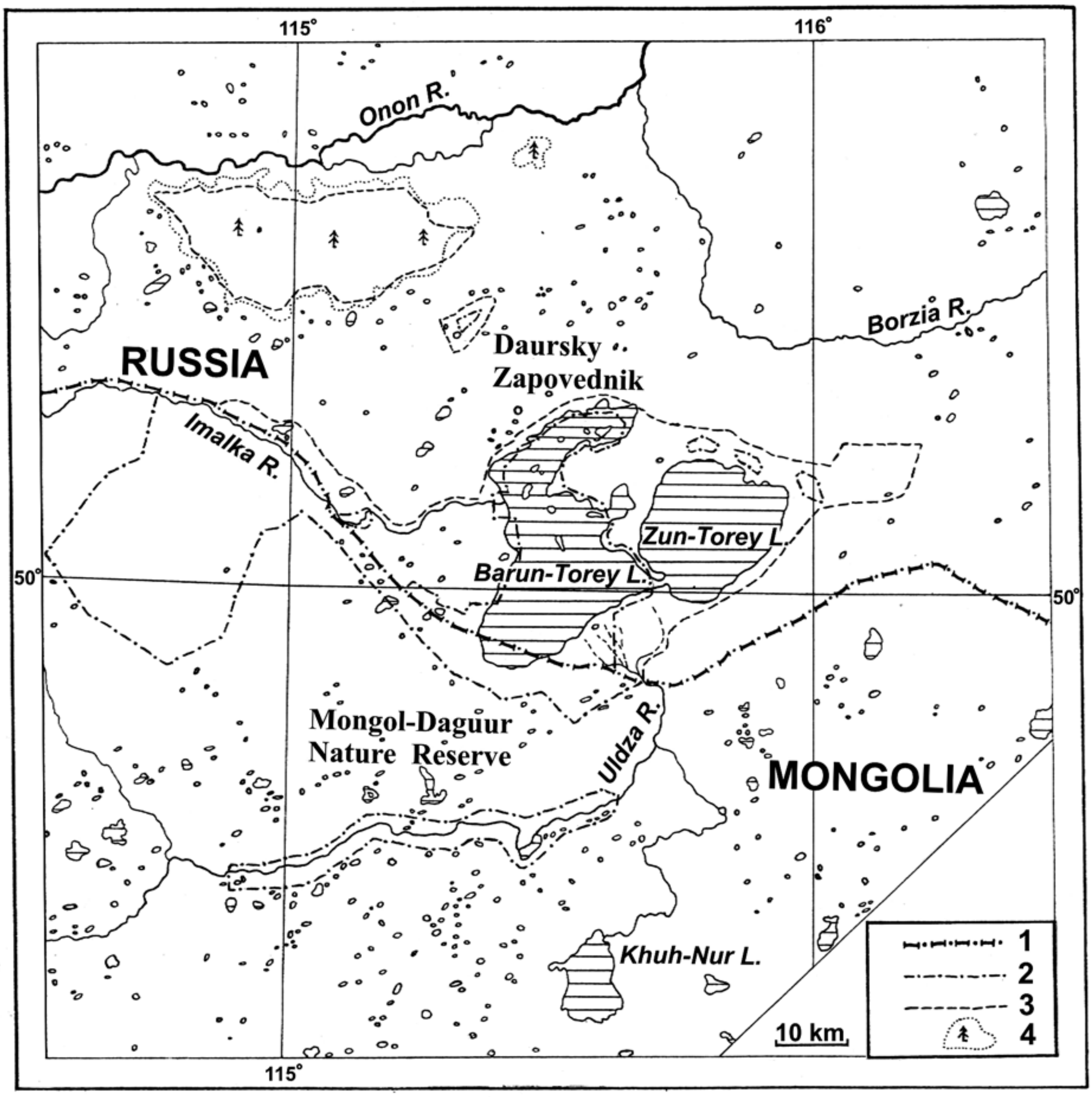

Fig. 1. Location of small lakes and nature protected areas in vicinity of the Torey Lakes: 1 – state border; 2 – core area of nature protected areas; 3 – buffer zone of nature protected areas; 4 – forest

The Torey Lakes (especially Barun-Torey Lake) are an internationally important site for breeding and migratory waterbirds. The lakes support tens of thousands of breeding waterbirds and about a million migratory waterbirds along two global flyways: the East Asian-Australasian Flyway and the Central Asian-Indian Flyway (Goroshko 2000a). DZ became a Ramsar Site in 1994 and was designated as a Biosphere Reserve in 1997. DZ was also included in the list of Internationally Important Bird Areas, in the Anatidae Site Network of the East Asian Flyway, and in the North East Asian Crane Site Network. In 1994, the International Chinese-Mongolian-Russian Reserve "Dauria" (Dauria International Protected Area) was established on the basis of three national nature reserves: Daursky (Russia), Mongol-Daguur (Mongolia), and Dalai Lake (China). Steppes around DZ include numerous unprotected wetlands – hundreds of middle-size and small lakes and rivers (Fig. 1). Almost all steppe lakes and rivers are very rich with food resources and present excellent habitats for breeding and migratory waterbirds. The steppe lakes are shallow with warm water. The rivers (even small ones) have very wide wet valleys with areas of shallow water, covered with reeds and sedge, and cereal meadows. Among vast arid steppe areas, these wetlands are nuclei of bird diversity. There are 19 globally threatened species of birds (IUCN 2011) in Dauria Region. For example, the Russian part of Dauria is an internationally important breeding or staging area of the White-naped Crane (*Grus vipio*), Red-crowned Crane (*G. japonensis*), Hooded Crane (*G. monacha*), Great Bustard (*Otis tarda*), Swan Goose (*Anser cygnoides*), and Relict Gull (*Larus relictus*). Forty one species of birds from the Red Book of the Russian Federation have been recorded in Dauria. This region is a very important breeding and stopover site for Demoiselle Cranes (Anthropoides virgo) and some other recovering or threatened species (Table 1).

Table 1. Breeding numbers of some rare species of birds in Dauria Region and DZ (1988-2009)

Species	Maximum number of birds / % of world population[a]	
	Russian part of Dauria Region	DZ
Swan Goose	550/1	392/1
Red-crowned Crane	56/2	2/<1
White-naped Crane	180/3	30/1
Great Bustard	450/30[b]	70/5[b]
Relict Gull	2,430/20	2,430/20
Demoiselle Crane	25,000/10	240/<1

[a]Estimates of world populations cited according to Wetlands International (2006).
[b] % of world population of eastern subspecies (O*tis tarda dybowskii*) according to O. A. Goroshko (2000b).

DZ has two protection zones: a strictly protected core area of 45,790 ha and a buffer zone of 163,530 ha (Figs. 1, 2). Presence of people and domestic animals, as well as any kind of human activity, are strictly prohibited in the core area. Limited human activity is allowed within the buffer zone, where over 2,000 people live in two villages. The main activities in the buffer zone and other areas adjacent to DZ are livestock (primarily sheep and cattle with lesser numbers of horses and a few camels) and grain production (mainly wheat and oats, more rarely barley, very rarely rape and millet; in some areas also buckwheat). Three cooperative farms with a total field area of 1,448 ha are located near DZ. About 20% of steppe lands of southeastern Trans-Baikal Region are developed for agriculture (Fig. 2). About half of the plowed land is used as crop fields and another half is fallowed for restoration of soil fertility. Most of the land is communally or governmentally owned. Staff of DZ (educators, researchers, and wardens) all conduct ecological education among local people and cooperate with them not only in the buffer zone and near DZ but also within the much larger territory of the Trans-Baikal Region (especially in the steppe zone).

Crop fields around the Torey Lakes attract multitudes of migratory cranes and waterfowl (Fig. 3) that feed in the fields, often causing significant crop damage (Goroshko 2002b). The main damage is caused by cranes, being the largest and the most numerous visitors to crop fields. In the early 1990s due to the changed economic situation after dissolution of the Soviet Union, the number and total area of crop fields in Dauria were greatly reduced. Since then the problem of crop damage has become very critical because of great concentration of cranes in the few remaining fields. Traditionally, cranes are loved by people in Russia, including the Trans-Baikal Region, but the crop damage issue changed attitude of local farmers toward cranes to negative. Their attitude toward DZ had also become negative because its staff protects cranes.

The Daurian ecosystems greatly depend on long-term climate cycles (about 30 years long) with intermittent wet and dry periods (Obiazov 1994, Goroshko 2002b). These cycles greatly affect quantity of precipitation (and consequently crop yields), condition of wetlands (Fig. 4), and population characteristics of cranes and other waterbirds, including numbers and distribution (Fig. 5), mortality and breeding success. From 1982-1998, the rainfall had increased (the 1990s were very wet for the most part); but since 1999 rainfall has been steadily decreasing, with 2000-2008 and the first half of 2009 being extremely dry.

METHODS

I have studied cranes and other waterbirds in DZ and surrounding areas from1988 to 2009. Since 1992, I have been studying the crop depredation problem. To document seasonal dynamics of bird gatherings and usage of habitats, regular observations were conducted from early July to late October, including counts of cranes of each species and other waterbirds in crop fields and roosting sites. Birds were counted using

Fig. 2. Location of lands, villages, and nature protected areas in vicinity of the Torey Lakes: 1 – state border; 2 – core area of nature protected areas; 3 – buffer zone of nature protected areas; 4 – plowed lands; 5 – forest; 6 – villages

binoculars (X8-10) and a telescope (X25-75). Counts were conducted for ~2 hours during the time of the most intensive feeding of cranes in the morning or evening (between the time of the last crane's arrival at a site and the time of the first crane's departure from the site). Usually counts were made from hill tops close to crop fields or wetlands; sometimes from the top of a vehicle (if there were no suitable hills nearby). For roosting wetlands, birds were counted in early morning, late evening, and at noon. To avoid facing the sun, I tried to take a position at the east border of the site for the morning counts, at the south border for noon counts, and at the west border for evening counts. During several days prior to conducting a count, I took notes of the timing of birds' visits to the fields, observed the area in detail, found main feeding sites of birds and selected best observation points for the count. I also planned optimal car routes between the count sites to perform the fastest census without causing disturbance to birds that might prompt them to leave the site.

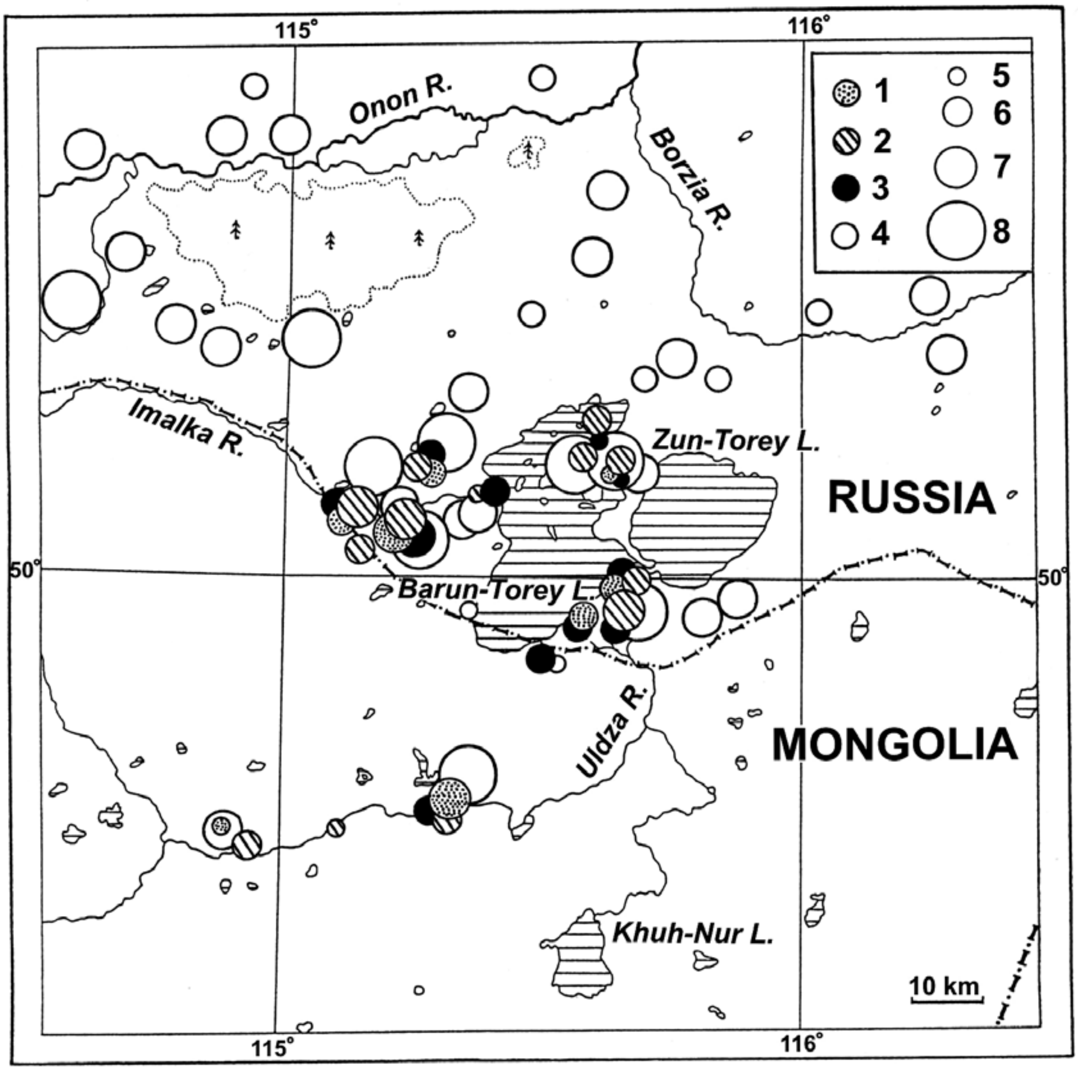

Fig. 3. Location of gathering sites of most abundant species of cranes in the vicinity of the Torey Lakes: 1 – Eurasian Cranes; 2 – White-naped Cranes; 3 – Hooded Cranes; 4 – Demoiselle Cranes; 5 – 1-10 birds; 6 – 11-100 birds; 7 – 101-1000 birds; 8 – 1001-10 000 birds

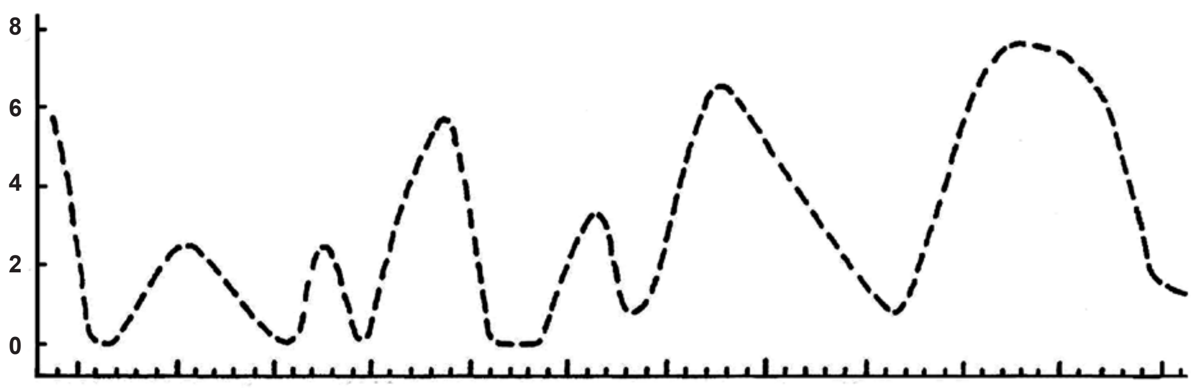

Fig. 4. Pattern of the long-term water level dynamics in the Torey Lakes (in meters) according to V. A. Obiazov (1994) with additions by O. A. Goroshko

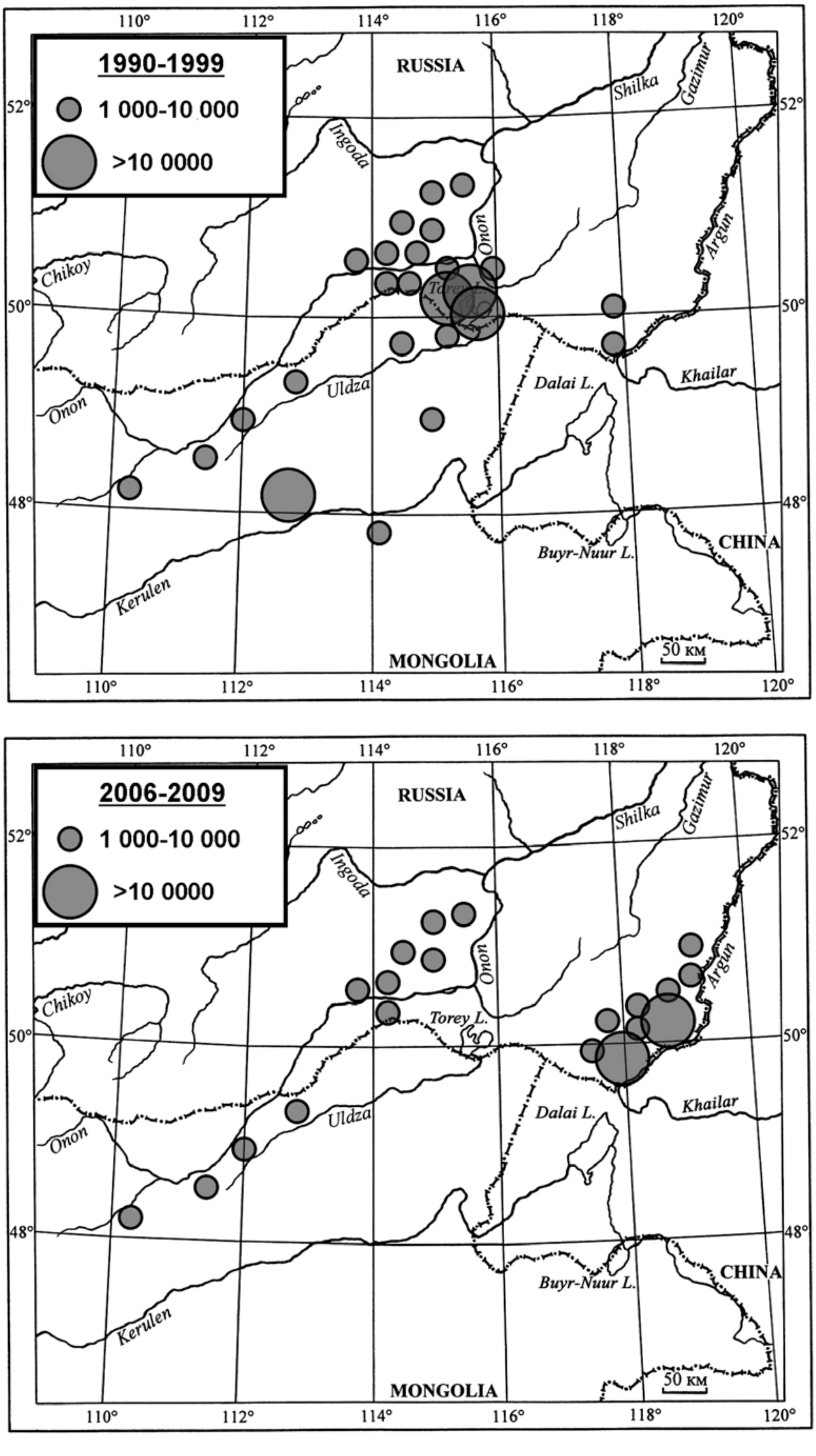

Fig. 5. Location of autumn gathering sites and numbers of cranes during peaks of wet (1990-1999: top map) and dry (2006-2009: bottom map) climate phases

Time budgets of birds were investigated regularly during the fall migration: in the beginning, at the peak, and at the end of the concentration period, and also in different weather conditions (sunny, cloudy, and rainy days; warm, cool, and cold days). During a day I kept records of all arriving flocks of each species of crane and other waterbirds, periodically counting birds feeding in the fields and making notes of departing cranes. From the top of a hill I could see flying and feeding birds very well. During the feeding time, I also recorded activities of birds in the field (feeding, walking, standing/watchful, pruning, standing/resting, and lying).

To study the birds' diet, I analyzed over 2,000 fecal samples collected at feeding, roosting and resting sites during different stages of fall migration. The samples were collected at a variety of feeding sites (crop fields) that differ by their distance from wetlands, abundance of weeds, kind of crop (wheat, oats, barley, rape or millet), and condition of the fields (standing or swathed crop, etc.). First, I watched the cranes through a telescope to understand what cranes eat. Then, I visited the feeding site, examined it, and collected crane fecal samples. If the ground was soft with footprints of the birds, I walked along the track of a crane and carefully examined all the latest damage to neighboring plants. On feeding site, I also collected plants and insects which cranes might eat, and used them to identify food fragments in fecal samples. After that I conducted a preliminary analysis of collected fecal samples right there, at the feeding site (examining the contents of the fecal samples and comparing the fragments of food with the potential food objects, which I collected at the feeding site). Then I re-analyzed in detail the fecal samples in the laboratory using a binocular microscope, using an assembled collection of plants and insects to aid identification of food fragments. This process allowed me to determine percentage of each type of food in fecal samples. Since in the fall cranes mainly feed on plant seeds, beetles and grasshoppers, the samples contained fragments of food that were large enough to identify. Crane foraging and resting behaviors were observed from hill tops and also from blinds placed in croplands and wetlands.

Several meetings were conducted with farmers and officials from the grain-producing co-ops, to discuss crop depredation problems, give recommendations, and explain cost-efficient options to reduce crop damage.

RESULTS AND DISCUSSION

Bird Concentrations

After the breeding season and until the departure for wintering grounds, the great majority of cranes and many other waterbirds gather in large numbers to feed in crop fields. In 1990-2002, about 30,000 cranes, 4,000 geese (*Anser cygnoides, A. anser, A. fabalis*), 5,000-15,000 Mallards (*Anas platyrhynchos*), and 5,000-15,000 Ruddy Shelducks (*Tadorna ferruginea*) fed in crop fields from late August to early September. The total number of waterbirds feeding in crop fields in the fall was estimated as ~40,000-60,000; in 2002, ~52,700-60,700 were counted (Goroshko 2003). Six species of cranes spend the summer near the Torey Lakes, and all of them are protected by law. It is a key breeding area of the Demoiselle Crane and a very important breeding area for the White-naped Crane (Table 1). Eurasian Cranes (*G. grus*) and Red-crowned Cranes rarely breed there. Density of breeding Demoiselle Cranes around the Torey Lakes is about 0.5 pair per 1 km². From 1995-2002, the total number of summering Demoiselle Cranes in the transboundary Dauria Region was estimated as ~60,800-73,000 birds (22,100-26,500 within the southeastern Trans-Baikal Region and 38,700-46,500 in the northeastern Mongolia) (Goroshko 2002b). Moreover, the Torey Lakes are an important habitat for non-breeding summering cranes of six species: Siberian (*G. leucogeranus*), Red-crowned, White-naped, Eurasian, Hooded, and Demoiselle Cranes. They spend summer in flocks that consist mainly of immature birds (2-3 years old). All species of cranes (except only a few Red-crowned Cranes) regularly visit crop fields for feeding.

The Demoiselle Crane is the most numerous summering species, with ~1,500 birds staying annually around the Torey Lakes during 1995-2002. Breeding birds join flocks of summering cranes between the end of the breeding period up to the end of fall concentrations (from early August to middle October). The number of gathering Demoiselles increases significantly from mid-August, and rises sharply at the end of the month. Usually, the first Demoiselle Cranes depart for wintering sites in early September; the main wave of fall migration falls in the middle of the month. Other species of cranes depart later – usually during the second half of September. During 1990-2004, several autumn gathering sites of Demoiselle Cranes were observed in Dauria Region (Fig. 3), but the Torey Lakes were the most important site, with cranes gathering there from the huge Trans-Baikal Region and from the adjacent areas of Mongolia. During the fall migration (since early September), the Torey Lakes are also an important stopover site for thousands of Demoiselle, Eurasian and Hooded Cranes migrating southward through Dauria Region (Table 2). The peak number of Demoiselle Cranes at the Torey Lakes was observed in late August and the first half of September. It is also the peak of the total number of all cranes and other waterbirds because the Demoiselle Crane is the most numerous species in the area. The last cranes depart from the Torey Lakes in late October.

Table 2. Protection status and number of cranes gathering during autumn at crop fields near the Torey Lakes (1988-2009)

Species	Protection status[a]	Maximum number			Present number (2008)
		Year	Birds	% of world population	
Siberian Crane	IUCN, RDB/R, RDB/T	1990	32	1	0
White-naped Crane	IUCN, RDB/R, RDB/T	1989	239	4	0
Eurasian Crane	RDB/T	2001, 2002	1,300	<1	20
Hooded Crane	IUCN, RDB/R, RDB/T	2001	1,120	11	10
Demoiselle Crane	RDB/R, RDB/T	1989	42,200	17	150

[a] IUCN – IUCN Red List (2011); RDB/R - Red Data Book of the Russian Federation (2001); RDB/T - Red Data Book of Trans-Baikal Region (Red Data Book of Chita Region and Aginsky Buryatsky Autonomous Area 2000)

Crop Damage

Grain harvest in Dauria is from late August to the first half of September, which means that the peak numbers of cranes and waterfowl feeding in the crop fields coincide with the grain harvest, leading to considerable damage, especially to wheat. Cranes and many other waterbirds prefer millet and wheat; geese sometimes may prefer oats, and Great Bustards rape. Because wheat is the main cultivated grain crop in the area while millet is cultivated very rarely, cranes feed and cause crop damage mainly in wheat fields. Thousands of ducks and geese also visit the fields and contribute to the depredation problem, but complaints of local people have focused primarily on cranes because they cause the main damage. All cranes and waterbirds prefer ripe wheat grains fallen to the ground. Cranes sometimes run in the field and beat wheat ears with their wings to shake ripe grain to the ground, so other birds (especially smaller ones, such as ducks) like to feed in the same fields with cranes. Cranes can also hull ripe or almost ripe grain from ears. If the grain is not ripe, birds cannot hull it and have to eat the grain with husks and pieces of ear stems, which they do not like. In millet fields, all cranes and waterbirds pluck grain that has comparatively soft husks, allowing them to feed easily on grain that is not fully ripe. Average damage to crops is about 20% in wheat fields located near the Torey Lakes, but in some fields favored by birds it can be~40-50%, sometimes as high as 70%. The damage includes consumed grain, dropped grain, and dropped (trampled down) ears.

To protect their crops, farmers often tried to scare the birds away but with little result because the flocks just moved over to neighboring fields that were abundant in the area, and also because the crop fields are very large in the steppe zone. The farmers requested compensatory damage payments from the government and the DZ; however, neither the government nor the zapovednik has a legal basis or budget for such payments. Although all species of cranes that use the area are protected by law (Table 2), local farmers began shooting cranes. Then the local hunters joined them (“to help the farmers”) and used the shot birds for food. Cranes of all species (except the Siberian Crane) had been shot at, with the most numerous species, the Demoiselle Crane, suffering the heaviest losses. From 1995-2003, the scope of the illegal shooting of cranes had been increasing every year (especially outside the DZ).

Cranes, geese, and ducks prefer feeding on low and sparse vegetation, so before the harvest begins, they select wheat fields with comparatively low crop. As the climate in Dauria is dry and the wheat crop is not rich, many wheat fields usually become feeding sites for cranes. During the harvest, cranes prefer gathering at harvested fields to collect waste grain from the ground and rarely visit fields with standing crop. They favor fields with crop in swathes (cut but not threshed plants). Feeding cranes move and scatter the swathes around, often producing huge damage in a short time because the grain harvesting combines cannot pick up spread-out, cut crop for threshing and a large part of it remains on the ground. Analysis of crane feces collected from the harvested (threshed) fields showed that cranes feed there on wheat grain.

Recommendations to Reduce Crop Damage

Before the harvest, some cranes and waterfowl visited fallowed fields for feeding, and some birds also visited these lands after the harvest. Analysis of fecal droppings on fallowed fields (n = 160 droppings) showed that birds picked seeds of two weeds: Foxtail Grass (*Setaria viridis*) and a self-seeding subspecies of millet (*Panicum miliaceum ruderale*). Foxtail Grass is a very common weed in crop fields in the Dauria Region and is also often abundant in recently fallowed lands. Foxtail Grass is widely distributed in the world including the North America. Many cranes select Foxtail Grass even in unharvested wheat fields (especially, in fields with unripe grain). According to the analysis of droppings, cranes prefer Foxtail Grass to a good crop of wheat. Seeds of Foxtail Grass represented about 50% of the birds' diet in unharvested fields – up to 90% in fields where this weed was common and wheat had not ripened yet (168 droppings analyzed). Cranes appear to prefer this weed due to its soft ears that make picking seeds from the grass much easier than picking unripe seeds of wheat from the hard ears. Besides, the Foxtail Grass usually ripens earlier than the wheat. Although cranes feed on this weed in unharvested fields, yet they cause extensive crop losses by shattering heads and knocking over stems of wheat plants.

Cranes roosted on barren sand or pebble beaches of steppe lakes (usually on capes, spits, and islands). For the noon rest, cranes also use wet grasslands near lakes or springs. Geese always roost on islands in the lakes. Most of the cranes visit fields located closer than 1 km from the wetlands used as roosting sites and very rarely do they fly to fields located farther than 5 km from roosting sites. If the distance is about 1 km, cranes do not fly but prefer to walk from the roosting site to the feeding place and back. Thus, the wheat fields located close to the Torey Lakes wetlands suffer the greatest damage.

In 1998, I prepared the following recommendations for crop damage reduction and explained them to the local farmers. The recommendations were also published as a brochure and distributed among many farmers in the Trans-Baikal Region (Goroshko 2002a).

1. Move the main crop fields farther from the wetlands (especially from the roosting sites). Obviously, since cranes can fly tens of kilometers away from roosting sites to feed, this strategy may work only if some food is left for them near the wetlands.
2. Plant lure crop fields at the most convenient places for birds near wetlands used as roosting sites (Fig.6). Lure fields shaped as long and narrow bands are preferable. Lure fields can be small (~5-10 ha). If there is no possibility to plant lure crop fields, planting of a lure band on the edge of crop fields is recommended. Millet and wheat can be used for lure crop. Millet is recommended as the best lure crop because it is the favorite food of cranes and waterfowl, and because self-seeding millet can grow in fallowed land during many years after the planting if the crop is not harvested. Birds strongly prefer to feed on such fallowed lands with millet. If wheat is used for lure crop, it should be cut and left in swathes (at least until the end of the harvest in crop fields). If millet is used for lure crop, it is better not to cut it (at least not until the end of the harvest in crop fields).
3. Cut and thresh the crop simultaneously (not leaving it in the fields in swathes).
4. Harvest first the crop fields closest to roosting wetlands, then the fields located farther from wetlands. If remote fields are harvested first, some cranes would fly there but other birds will continue feeding in unharvested fields near the wetlands.
5. Leave some fallow lands covered with Foxtail Grass and located near wheat fields or wetlands. Such lands draw away part of the cranes from crop fields before the harvest.

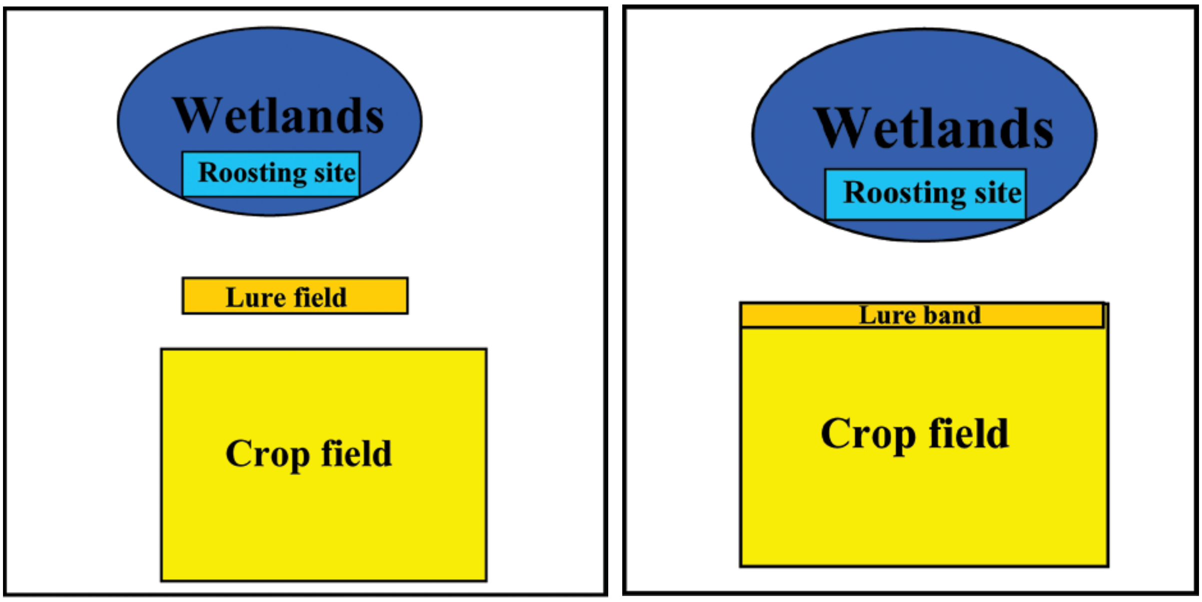

Fig. 6. Recommended locations for lure crop fields and bands

Using our recommendations, in 2000-2003 some farmers moved their main crop fields farther from the roosting sites (up to 15 km away from the Torey Lakes). This shift produced good results: cranes foraging in these fields dropped to 3–7% of the foraging levels in the fields located near the Torey Lakes. Since 2001, some farmers began to develop lure millet fields with very good results: the lure fields attracted cranes that stayed out of adjacent wheat fields until harvest. Moreover, many birds stayed in millet fields even after the harvest of wheat fields. The diet of cranes before harvest was about 90% millet and 10% wheat; after the harvest began, it was about 65% millet and 35% wheat waste grain (285 fecal droppings were analyzed). The costs of cultivation of lure fields (especially self-seeding millet) are only 10-20% of depredation losses in crop fields. Therefore, planting of lure fields is profitable to farmers even if they do not receive any financial support from the DZ or the government.

The farmers also successfully used our other recommendations; as a result, illegal shooting of cranes in the Torey Lakes area has significantly decreased.

Climate Change

From 2000-2009, a period of severe prolonged drought, the wetlands experienced drastic decline. In May-June 2008 and 2009, the area of wetlands in Daurian steppes represented ~2% of that in 1998, and the major part of crane habitats (steppe lakes and rivers) had dried completely. The Torey Lakes can also dry out during the peaks of dry climate (for example, the Barun-Torey Lake was completely dry in 1983 and in 2009, while the Zun-Torey Lake had some water left; Fig. 4). Number of cranes breeding in the vicinity of the Torey Lakes had greatly decreased in 2000-2007 (especially of White-naped Cranes closely affiliated with wet meadows, which dried out completely). Number of cranes staging at the Torey Lakes had also significantly decreased (Fig. 5). Agricultural crop production near the Torey Lakes was low in 2004-2005, and no crop was harvested in 2006-2008. Since 2006, there have been no gatherings of cranes near the Torey Lakes due to absence of crops. The quantity of precipitation in the forest-steppe zone is much higher and more stable than in the steppe zone, so prolonged droughts do not have such dramatic effect on wetlands and agricultural crops within the forest-steppe zone of the Dauria Region. Wetlands there are more stable, and although during 2000-2009 the quality of crops had slowly declined, in 2007-2009 the crops were still of average quality. As a result, in 2005 cranes began changing their staging area and since 2006 they have been gathering mainly within the forested steppe zone and stayed there in numerous small flocks spread out across a vast area. Consequently, since 2005 some farms located in forested steppe zone have been suffering crop damage. Since the autumn of 2008, I began studying the distribution of cranes in connection with the crop damage, in order to develop recommendations for farmers working the land in forested steppes.

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CONFLICTS BETWEEN SANDHILL CRANES AND FARMERS IN THE WESTERN UNITED STATES: EVOLVING ISSUES AND SOLUTIONS

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Abstract: The main conflicts between Sandhill Cranes (*Grus canadensis*) and farmers in western United States occur in the Rocky Mountain region during migration and wintering periods. Most crop damage by cranes occurs in mature wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*), young shoots of alfalfa (*Medicago sativa*) and cereal grains, chilies (*Capsicum annuum*), and silage corn (*Zea mays*). Damage is related to proximity of crop fields to roost sites and timing of crane concentrations relative to crop maturity or vulnerability. The evolution of conflicts between farmers and cranes and current solutions are described for two areas of the Rocky Mountains used by staging, migrating, or wintering cranes: Grays Lake, Idaho, and the Middle Rio Grande Valley, New Mexico. In both areas, conflicts with growing crane populations were aggravated by losses of wetlands and cropland, proximity of crops to roosts and other wetland areas, changing crop types and practices, and increasing urbanization. At Grays Lake, fall-staging cranes damaged barley fields near an important breeding refuge as well as fields 15-50 km away. In the Middle Rio Grande Valley, migrating and wintering cranes damaged young alfalfa fields, chilies, and silage corn. Solutions in both areas have been addressed through cooperative efforts among federal and state agencies, that manage wetlands and croplands to increase food availability and carrying capacity on public lands, provide hazing programs for private landowners, and strategically target crane hunting to problem areas. Sustaining the success of these programs will be challenging. Areas important to Sandhill Cranes in the western United Sates experience continued loss of habitat and food resources due to urbanization, changes in agricultural crops and practices, and water-use conflicts, which threaten the abilities of both public and private landowners to manage wetlands and croplands for cranes. Conservation of habitats and water resources are important to support crane populations and minimize future conflicts with agriculture.
Keywords: crop depredation, *Grus canadensis*, Rocky Mountains, staging, wintering

INTRODUCTION

Sandhill Cranes (*Grus canadensis*) in the western United States use riparian, wet meadow, grassland, and cropland habitats for roosting and feeding. These habitats also were the first to be developed for agriculture as the region was settled. As human settlements increased and agricultural use intensified throughout the west in the 1900s, cranes suffered habitat losses due to wetland drainage, water projects in riparian areas, and conversion of grasslands to cropland. Sandhill Cranes have demonstrated their generalist habits as they adapted to and benefitted from various crops that replaced their native habitats. Habitat loss and exploitation severely depressed crane populations during the 1800s-early 1900s, but numbers have rebounded in many areas (Tacha et al. 1994).

The western United States has five recognized populations of Sandhill Cranes, delineated geographically for management purposes (Kruse et al. 2009). The focus of this article is on the Rocky Mountain Population and the portion of the Mid-Continent Population that winters in the southern Rocky Mountain region. These cranes share an important wintering area and hence aspects of agricultural conflicts and solutions. The Rocky Mountain Population (RMP; 20,000 cranes) of Greater Sandhill Cranes (*G. c. tabida*) winters primarily in New Mexico and northern Mexico and breeds in Idaho, southwestern Montana, and western Wyoming (Drewien and Bizeau 1974, SRMGSC 2007). About 3% of the Mid-Continent Population (MCP; total 560,000 cranes), primarily Lesser Sandhill Cranes (*G. c. canadensis*), winter in New Mexico and Arizona, migrate via the Great Plains, and breed in western Alaska and northeastern Russia (Krapu and Brandt 2008).

Loss of traditional habitats and continued changes in land use in the flyways of the RMP and MCP have progressively pushed cranes into greater proximity with human activities, particularly on migration and wintering areas. Conflicts have been greatest in the Rocky Mountains, where topography constrains much of the crane habitat, along with agriculture and other human development, to the richer habitats in river valleys. I present here two examples of the changing environments and conflicts between Sandhill Cranes and agriculture in the western US: fall-staging cranes in the Grays Lake valley of southeastern Idaho, and staging and wintering cranes in the Middle Rio Grande Valley of New Mexico (Fig. 1). Solutions to conflicts in both areas share common features, as well as some common concerns for the future.

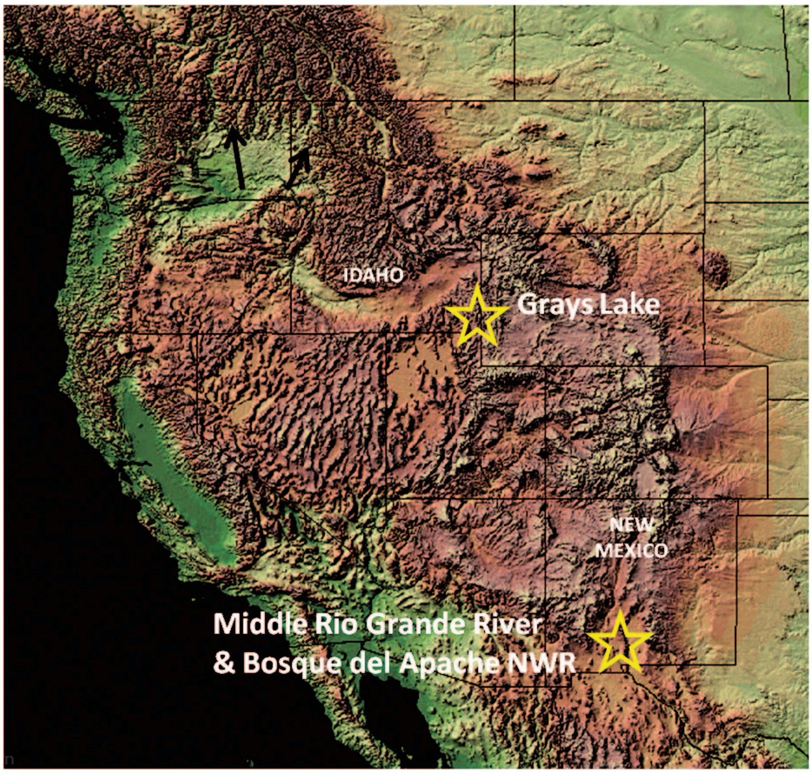

Fig. 1. Locations of Grays Lake, Idaho, and the Middle Rio Grande River, New Mexico

FALL-STAGING SANDHILL CRANES AT GRAYS LAKE, IDAHO

About 40% of the RMP stage in eastern Idaho (SRMGSC 2007). One important fall staging area is Grays Lake, a large (5,260-ha) montane wetland in southeastern Idaho that also supports 250 breeding pairs (Austin et al. 2007). Grays Lake National Wildlife Refuge (NWR) was established in 1965 to protect and manage the central wetland and a large portion of the wet meadows for Sandhill Cranes and other waterbirds. Fall aerial surveys have recorded 40- to 3,600 cranes at Grays Lake. Blackfoot Reservoir, located 15 km to the southwest in Caribou County, also is an important staging area for 228-2,300 cranes annually (1982-2009; USFWS unpublished data). Together, these areas held 1,979-2,782 cranes during the peak years of 1995-2001 (SRMGSC 2007).

The Grays Lake Valley was first settled in the 1860s and used primarily for grazing and small-scale farming through the 1960s. By the 1970s, small private crop fields in low-elevation areas were converted to hayfields, and the remaining cropland, mainly under barley (*Hordeum vulgare*), was located at higher elevations where mid-summer frosts were less likely to damage crops. Grain harvest occurred in mid-late September. Fall-staging cranes start arriving in mid-late August and numbers peak in mid-September.

In the 1980s and early 1990s, a confluence of events led to increasing conflicts with cranes (Fig. 2) (Austin 1998, Ball et al. 2003). Within the Grays Lake valley, private barley fields markedly declined; the last were converted to grasslands via the federal Conservation Reserve Program in the late 1990s. The refuge also stopped providing supplemental grain (barley) during September. This program had been conducted for >10 years to support an experimental introduction of Whooping Cranes (*Grus americana*). The refuge planted 28-47 ha of barley and wheat in refuge field, with a portion of fields fallowed annually to control weeds. Also, a prolonged drought and a series of late springs reduced production of grains and wetland foods during 1986-1993. Numbers of fall-staging cranes in the Grays Lake valley followed the changes in food availability; they appeared to move to other areas during the years of drought and cessation of supplemental grain. Outside the valley, barley acreage rapidly expanded after 1975, providing attractive food resources 20-50 km from the Grays Lake roost sites and near other roost sites on Blackfoot Reservoir (Fig. 3). The 1980s-1990s were marked by increasing complaints by farmers, inconsistent hazing programs to address complaints, and growing intolerance of crane damage to grains.

In 1996, the Idaho Department of Fish and Game (IDGF) and U.S. Fish and Wildlife Service jointly developed a strategy to reduce complaints using three approaches: hazing programs, strategic use of crane hunting, and, in the Blackfoot Reservoir area, improved distribution and abundance of lure crop fields (SRMGSC 2007). Idaho initiated a crane hunting season in 1996. A limited number of hunting permits are allocated to the area and attempts are made to direct hunters to fields experiencing crop damage. The IDGF or the U.S. Department of Agriculture’s Wildlife Services (WS) use visual and audible disturbance techniques such as propane cannons and predator decoys to disperse flocks on problematic fields. Hunting disturbances reinforce the hazing programs on private fields and encourage crane movements onto state and federal lands where hunting is prohibited.

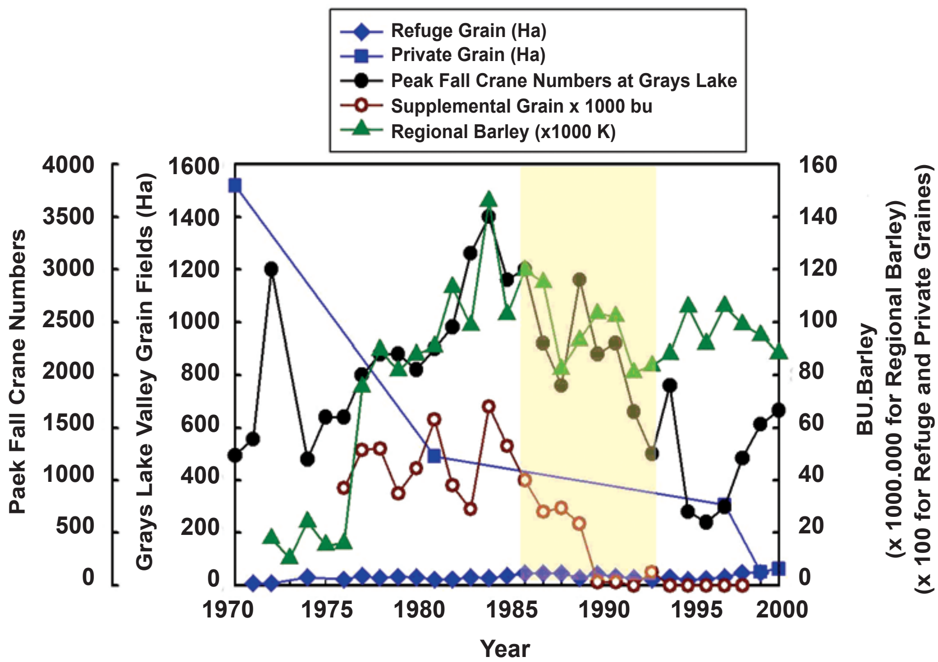

Fig. 2. Trends in acreage of barley grown in the two counties around Grays Lake, Idaho; grain acreage within the Grays Lake Valley (refuge and private fields); supplemental feed grain (bait) on the refuge; and peak fall numbers of Sandhill Cranes, 1970-2001. Shaded area indicates drought period. Modified from Ball et al. (2003)

Lure crop fields are located near roost areas in the Grays Lake valley and on private lands around Blackfoot Reservoir. On the refuge, improved field management and a shift to a barley-winter wheat rotation has enabled refuge grain acreage and production to stabilize at 47 ha annually. Improved precipitation since the mid-1990s has contributed to good grain production in most years, but weather can still severely hamper food production in the Grays Lake Valley in some years. Around Blackfoot Reservoir, barley or wheat is planted on 200-400 ha of private lands; these fields can be harvested after early October, when most cranes have departed (J Beck, IDGF, personal comm., unreferenced). Funding for these lure crops comes from interest earned on a Lure Crop Endowment, established with an initial federal investment of US$1 million. More recently implemented is an “area of impact” payment that farmers may receive for fields damaged by cranes but not planned as a lure crop; this payment also has enhanced farmers’ tolerance of damage. State private-lands biologists also encourage farmers to relocate some grain fields further from crane roost sites to reduce their attractiveness to cranes. The combination of these strategies has been successful in reducing crop damage complaints and improving farmer tolerance of cranes (J Beck, IDGF, personal comm., unreferenced). Crane numbers at Grays Lake clearly reflect changes in annual food resources, which vary with weather and management. Crane numbers around the Blackfoot Reservoir have declined to <500 (1995–2009, USFWS unpublished data), possibly due to hunting disturbances, changing agricultural patterns, or more attractive resources in other staging areas.

Fall aerial surveys indicate cranes readily shift their distributions as environmental conditions (food, water, and disturbance) change. Future relations between cranes and farmers will be influenced by continued changes in land use in southeast Idaho. Most important in the long term is the spread of development in the river valleys that are important to farmers, ranchers, and cranes. Continued loss of habitat and undisturbed feeding sites further reduces the area's capacity to support summering and staging cranes, concentrates cranes in remaining areas, and increases the potential for crop damage complaints. While housing developments have not yet reached the Grays Lake valley or Blackfoot Reservoir area, they have seriously impacted once-important habitats in the Salt River and Teton valleys to the east and north. Wind turbines are being established on ridges throughout southeast Idaho, potentially disrupting crane movements. Increasing water demands for crop irrigation and urban uses also may threaten crane habitat in some areas through reduced riparian flows and lowered water tables. Water availability will have greatest impact during drought years when crop yields and wetland foods are reduced. Protection of roosting and feeding areas will remain a critical tool to minimize future conflicts among cranes, agriculture, and human development. Hunting also may prove important to limit the growth of this population.

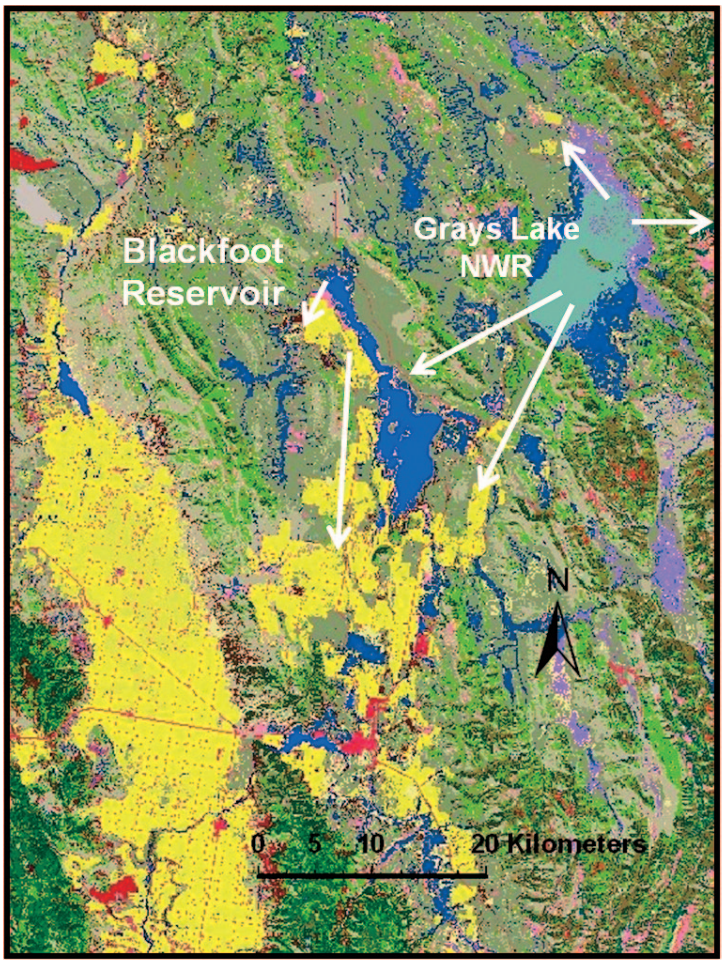

Fig. 3. Location of croplands relative to main roost areas for Sandhill Cranes at Grays Lake and Blackfoot Reservoir in southeastern Idaho. Croplands are indicated as yellow, open water as blue, marsh as blue-green, and wet meadow as purple, and forest or grassland as green. Land cover data was obtained from Idaho GAP program (at http://www.wildlife.uidaho.edu/idgap/)

MIGRATING AND WINTERING SANDHILL CRANES IN THE MIDDLE RIO GRANDE VALLEY, NEW MEXICO

The Middle Rio Grande Valley (MRGV), located in south-central New Mexico, encompasses two counties, 55 km of river, about 2,020 ha of managed wetlands, and limited areas suitable for agriculture (Fig. 4). Crane use is centered on Bosque del Apache NWR and the state’s Bernardo Wildlife Area, 65 km to the north. The area is the primary wintering area for about 80% of RMP cranes. The area also supports Lesser Sandhill Cranes from the western portion of the MCP and large numbers of light geese (*Chen* spp.) (Mitchusson 2003, SRMGSC 2007). Cranes roost primarily on state and federal wetlands and feed in irrigated crops (alfalfa *Medicago sativa*, chili *Capsicum annuum*, and corn *Zea mays*), shallow wetlands, and pastures up to 23 km from roosts (T Perkins, USFWS, unpublished data). Cranes forage largely on natural foods in wetlands, pastures, and alfalfa during mild weather but also seek out high-energy grains during colder periods. Federal and state agencies manage impounded wetlands and corn fields to provide food for cranes, geese, and ducks. Mid-winter counts in the MRGV have increased from about 5,000 cranes in 1967 to an average of 23,510 cranes (1987-2001; Mitchusson 2003); up to 75,000 may use the area during spring migration.

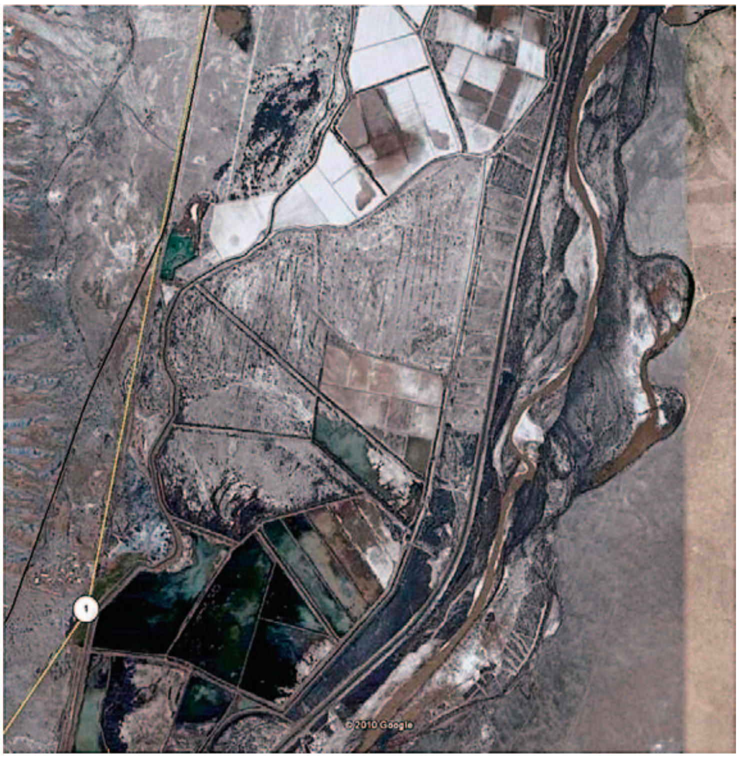

Fig. 4. Aerial view of a portion of Bosque del Apache National Wildlife Refuge, New Mexico, showing distribution of managed crop fields, wetlands, and the Middle Rio Grande River. From Google Earth

The region has a >500-year history of agriculture, with changes in crops from early crops of chilies, onions (*Allium cepa*), corn, and grazing to grains such as corn and sorghum in the early to mid-1900s that were more dependent on irrigation. Land-use changes since the 1970s, however, substantially reduced habitat and foods available for cranes, particularly losses of wetlands, field corn, and sorghum. Drainage of riparian wetlands and urban development along the river also reduced suitable foraging and roosting habitat. Areas under corn on private lands in the MRGV declined from >2,000 ha in 1981 to <600 ha in 1997 (Mitchusson 2003), as farmers converted from grains to alfalfa and silage grains for an expanding dairy industry or to chili and cotton (*Gossypium*) crops. Crop damage complaints before 1993 were >US$100,000 annually (Mitchusson 2003). Most reported damage by cranes was to alfalfa fields in late fall when newly planted fields were irrigated and arriving cranes probed for invertebrates and chufa (*Cyperus esculentus*) tubers in the fields (Taylor 1999). Cranes ate some alfalfa shoots, but most damage to plants was due to up-rooting young plants and trampling (Walker and Schemnitz 1987). Chilies and silage corn (in feedlots) were the other primary crop-damage complaints from farmers in the MRGV.

To address these conflicts in the MRGV and other areas in New Mexico, a cooperative agreement was developed in 2003 among the U.S. Fish and Wildlife Service, New Mexico Department of Game and Fish, and the New Mexico office of WS (Mitchusson 2003). The goal is to maintain a mean monthly population of 17,000-22,000 Sandhill Cranes during November-February on 6,900 ha of public lands while minimizing crop damage complaints. The strategy integrates three approaches, similar to that used at Grays Lake. First, timed manipulations of corn on refuge and state lands encourage cranes to remain on those areas and reduce agricultural damage on private fields (Taylor 1999). Standing corn is mown or pushed down (Fig. 5) as needed to attract cranes, based on weekly ground surveys. Second, WS hazes cranes using various disturbance techniques such as propane cannons and visual scaring devices to disperse flocks from private fields experiencing chronic damage. Third, hunting reinforces hazing efforts while also providing recreational opportunities. Hunters with permits are selectively assigned to private lands with depredation complaints. Average annual confirmed depredation loss due to cranes varies annually, depending in part on success of crop production on public lands. During 2005-2007, WS responded to an average of 394 incidents of crane and goose damage for alfalfa, pasture, silage, chili, and winter wheat (*Triticum aestivum*) fields with reported average damage of US$31,000 (USDA 2009).

Fig. 5. Sandhill Cranes in a corn field at Bosque del Apache National Wildlife Refuge, New Mexico. The corn has been pushed down to improve accessibility and use by cranes. Photograph from U.S. Fish and Wildlife Service

The coordinated program to control crop depredation by cranes and geese in the MRGV is generally viewed as a success by farmers and partners. Sustaining this success, however, will be challenging. Continued urbanization along the river and increasing water conflicts are expected to further reduce wetland and cropland habitats and the availability of high-energy foods for cranes (Case and Sanders 2009). Shrinking cropland availability has resulted in increased concentrations of cranes and geese on the remaining areas, exacerbating problems with avian cholera (U.S. Geological Survey, National Wildlife Health Laboratory, unpublished data). Reduced hydrological flows on the Middle Rio Grande River already have resulted in the loss or degradation of crane roost sites, which further limits their distribution within the valley. Future water availability for river flow, irrigation, and wetland management is very uncertain due to increasing urban demands, water rights issues, and climate change. Reduced water supplies will limit the ability of Bosque del Apache NWR and state wildlife areas to manage wetlands for roosting and feeding and to produce adequate grain for holding cranes on public lands. Also, the refuge farming program now struggles to find seed corn that is not genetically modified (a requirement on federal refuges). Crop losses to pests have contributed to reduced yields and hence food available for cranes in some years (J. Vradenburg, U.S. Fish and Wildlife Service, personal comm., unreferenced).

The MRGV has become an important area for wildlife tourism, with much of it focused around Bosque del Apache NWR and its fall "Festival of the Cranes." Local economic effects associated with recreational visits (nearly all non-consumptive wildlife tourism) in 2004 were estimated at over US$4 million (Caudill and Henderson 2005). Strong societal interest in Sandhill Cranes and other wildlife may help provide political support for conservation of crane habitat in the MRGV. Wildlife tourism sometimes can conflict with hazing programs, as landowners adjacent to fields hazed to disperse cranes may want to hold cranes for viewing (K. Price, personal comm., unreferenced). Balancing the needs of depredation control with wildlife viewing can be a delicate task, which likely will become more challenging as urbanization increases (Mitchusson 2003).

SUSTAINABLE SOLUTIONS?

Current solutions to minimize conflicts between cranes and farmers rely on a strategic balance of public land management, lure crops, hazing, and hunting. This strategy has largely been successful in reducing local conflicts while sustaining crane populations. The balance, scale, and nature of these strategies, however, must adapt to continued changes in the landscape just as the cranes adapt. Evolution of the western landscape now is driven by urbanization, water demands, and climate, which will in turn affect the agricultural environment. Water allocation in the southwestern United States is particularly challenging, with increasing urban demands pitted against needs for agriculture and wildlife. High-energy foods available to cranes on private lands may continue to decline as harvesting efficiency increases (Krapu et al. 2004) and farmers move toward other crops such as alfalfa or cotton. Cranes also face competition for waste grain with increasing populations of light geese (Krapu et al. 2006, Case and Sanders 2009). Tighter economics of farming may make farmers more sensitive to real or perceived crop damage by cranes and lead toward more complaints. These issues apply not only to the Rocky Mountain region but also crane populations elsewhere in the United States.

Sandhill Crane hunting in these areas has been an important component of crop depredation control as well as providing recreational opportunities and a means to control population growth. Harvest is closely managed to ensure the populations can sustain harvest levels while still meeting population and crop depredation goals. To be successful, however, harvest management should 1) be accompanied by regular crane surveys to monitor trends and distribution, 2) be closely managed to effectively target harvest to problem areas and fields, and 3) attract enough hunters to meet demand. Harvest management, surveys, and hazing programs require long-term commitments by state and federal agencies, which may be difficult under tightening budgets and pressures to address other issues. Also, use of hunting requires having hunters who are interested in pursuing cranes, which is not a traditional game animal in most Rocky Mountain states. A national trend of declining migratory bird hunters (USFWS and Census Bureau 2006) is raising concerns in the wildlife management community about the future of hunting, and implications of those trends for conservation. Wildlife managers also must balance goals of a large crane population and societal values of wildlife viewing and recreation with what can be sustained with the current landscape.

Wildlife managers recognize the critical need to conserve the limited habitat remaining for cranes in the MRGV. Strategies recently identified (Case and Sanders 2009) include: 1) conservation easements, leases, or purchases of remaining cropland and additional water rights in key areas in the MRGV; 2) development of new cooperative agreements with other land-management agencies to improve crane habitat on public lands; 3) promoting outreach and grant projects to encourage and enable public and private landowners to protect and improve crane habitat; 4) working with other groups to support habitat projects to protect and improve crane habitat; and 4) participating in local government decision-making to encourage maintenance of lands in agricultural production. While focused on the MRGV, these strategies may provide a valuable template for application in other regions.

Wildlife managers may want to reconsider the current reliance on crop farming, whether on public lands or via lure crops on private agricultural land, to support birds in migration and wintering areas. Sandhill Cranes are generalists and forage in a range of habitats from semipermanently flooded wetlands to dry grasslands. They have adapted to many environmental changes over thousands of years, including human settlements and climate. Efforts to conserve crane habitat and minimize future crane-farmer conflicts could focus on improving both the distribution and the diversity of food resources and roost sites locally and regionally. Diversification will provide greater security of foods and roost sites in the face of changing climate and agricultural environments. Dispersal of cranes to more areas will reduce concentrations and potential for agricultural conflicts and risks of disease. Water resources will be a critical element in conservation of natural crane habitats and foods as well as agriculture.

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ABSTRACTS OF PRESENTATIONS AT THE WORKSHOP [4]

A CHANGING WORLD THREATENS THE FUTURE FOR CRANES

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During recent decades we have had the privilege of studying and helping a charismatic and endangered family of birds – the cranes – through the work of a team of conservationists at the International Crane Foundation (ICF) in Wisconsin, USA and with the support of many colleagues from the Crane Specialist Group as well as government officials, other scientists, and members of the public with a passion for these birds. During that period, the two species of cranes in North America, the Whooping Crane *Grus americana* and the Sandhill Crane *G. canadensis* have increased as has the Eurasian Crane *G. grus* in Europe and the Red-crowned Crane *G. japonensis* in Japan. During this period, Chinese, Iranian and Russian colleagues discovered formerly unknown breeding and wintering sites for Siberian Cranes *G. leucogeranus*, and many protected areas were established for these and other threatened cranes in China, Russia, Kazakhstan, and Iran. In recent years, however, growing threats from hunting, poisoning, collisions with power lines, habitat loss, and trade threaten the survival of most crane species in the wild. This paper summarizes the impacts of these key threats on the viability of crane populations.

Agriculture has benefited many crane species that have adjusted their foraging habits to feed on waste grain that is available over vast areas. Yet crop damage by cranes has led to conflicts with farmers, and intensifying agriculture has led to destruction of wetlands critical for nesting, rearing of young and roosting by cranes. Climate change may have short-term benefits for cranes by providing milder conditions for both breeding and wintering periods. Impacts of climate change on water, however, are likely to intensify conflicts between water management projects such as dams and water diversions and conservation of wetlands with their rich biodiversity including cranes.

Keywords: cranes, threats, protected areas, agriculture, climate change

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[4] Only abstracts, for which full articles were not submitted, are included in this section.

DEVELOPING SOLUTIONS TO SANDHILL CRANE DAMAGE TO SEEDLING CORN IN THE UPPER MIDWEST, USA

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International Crane Foundation, Baraboo, Wisconsin, USA

The Sandhill Crane Grus canadensis nearly disappeared from Wisconsin and neighboring states during early parts of last century. Over the last 70 years, however, the species has made a dramatic recovery due to strict protection from hunting, restoration and protection of wetlands, and the crane's adaptation to feeding across agricultural landscapes. From less than 100 cranes in Wisconsin in the 1930s, the population has grown to well over 13,000 birds. The greatest crane densities occur not where wetlands are most abundant in the north but to the south and east on landscapes that are mosaics of wetlands and uplands with short vegetation such as croplands, pasture, and even residential areas. With growing crane numbers have grown complaints of crop damage. While potatoes and other crops are affected, the most widespread damage occurs to seedling corn.

Most cranes in the Upper Midwest live on private lands, to a large extent owned by farmers who manage wetlands alongside their crops and livestock. The International Crane Foundation (ICF) recognized that its commitment to crane conservation must include finding solutions to conflicts between cranes and farmers over crop damage. In the early 1990s, ICF initiated studies of the movements and habitat preferences of cranes so that we could learn when, where and how cranes caused damage. Seedling corn is at risk during the two to three weeks after planting. Cranes forage in fields close to wetlands where they breed or where non-breeding cranes roost in flocks. Fields at greatest risk are located close to roost locations distant from roads, farmhouses and human disturbance.

In the mid 1990s, one farmer told us that cranes did not damage corn he had treated with a pesticide containing Lindane, a highly toxic chemical used to coat the seeds before planting. The cranes did not like the taste and would not eat treated corn seeds. We tested the method and found it effective and having a great advantage over the common practice of hazing cranes – the cranes did not fly to other field to eat corn but stayed in the same fields and fed on other food items such as insects and waste grain from the previous year. This solution did not spread crop damage to other landowners. While cranes did not consume enough pesticide to be affected, we did not wish to promote Lindane's widespread use. Also, in 2006, Lindane was banned for agricultural use by the U.S. Environmental Protection Agency (EPA).

Over the past decade, we have worked with Arkion Life Science, the University of Wisconsin –Extension Service, USDA Wildlife Services, WI DNR and over fifty farming families to identify and test an alternative substance (9,10 anthraquinone) that is economically viable, non-toxic, compatible with farmers' machinery and planting methods, persistent on the seeds while they are vulnerable, and effective at deterring crane herbivory. Starting in 2006, with support from farming organizations, an emergency Section 18 permit has been issued each year by the U.S. EPA that has allowed use of anthraquinone in the Upper Midwest. At the same time that field testing occurred, laboratory tests assured the safety of the substance for use on seedling corn. We expect a Section 3 permit to be granted later this year, enabling regular commercial use of anthraquinone (under the commercial name Avipel) across the United States.
Keywords: Sandhill Crane, crop damage, anthraquinone, seeding corn, crane behavior

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ENVIRONMENTAL FLOWS AS A STRATEGY FOR CONSERVING BIODIVERSITY, SUSTAINING HUMAN LIVELIHOODS, AND ADAPTING TO CLIMATE CHANGE

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Environmental flows (EFs) describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems. The concept of EFs was developed in recent decades as a response to the well-documented worldwide impact of dams, diversions, and water resource development on biodiversity, food security, and ecosystem services, as well as the anticipated impacts of global climate change. In 2007, the *Brisbane Declaration on Environmental Flows* was endorsed by more than 800 delegates from 57 countries as an official pledge for governments and stakeholders to work together to ensure that benefits of water resource development projects are realized by those who need them and that social and environmental impacts are minimized. This presentation will overview the essentials of EFs and global experience in allocating water to maintain or restore biodiversity, improve food security, and secure ecosystem services.

Case studies will draw on the International Crane Foundation (ICF) experience with implementing environmental flows, with particular focus on the Zambezi River basin in southern Africa. The Zambezi basin features eight *Wetlands of International Importance*, including the Kafue Flats and Zambezi Delta. The Zambezi basin supports lucrative freshwater and coastal fisheries, productive subsistence and commercial agriculture and livestock, unparalleled tourism opportunities, and abundant natural resources. Over the past century, hydropower projects have substantially altered hydrological patterns and processes in the Zambezi basin. While providing valuable hydropower and flood control functions, these changes have also reduced ecosystem services and opportunities for rural livelihoods, and threaten protected areas and biodiversity in the system. Zambezi basin stakeholders are increasingly interested in new concepts and partnerships that will help them find the right balance between natural resource conservation and development including EFs to restore downstream habitats, fisheries, and agricultural lands without sacrificing hydropower generation. A stakeholder process to define EFs for the Lower Zambezi basin, building on more than a decade of bio-physical and socio-economic research, was undertaken to identify potential conflicts and tradeoffs among water users and other residents in the Zambezi Delta with respect to EFs (flood-related small-scale agriculture, commercial large-scale agriculture, estuarine ecology, coastal fisheries, freshwater fisheries, livestock, large mammals, waterbirds, floodplain vegetation, invasive vegetation, natural resource utilization, water quality, groundwater recharge/water supply, in-channel navigation, settlement patterns, human health) and to explore the potential for improving delta conditions through EFs from Cahora Bassa Dam. Simulation modeling exercises to assess the hydrological feasibility of EFs indicate that immediate improvement in the delta flow regime could be made with almost no impact on hydropower production. This outcome can be accomplished by redistributing releases of water to generate high flow pulses into the delta during the early wet season, thereby also providing improved storage capacity later in the wet season to attenuate large, potentially damaging floods (especially when downstream tributaries are in peak discharge). Experimental EF releases are now made at two key sites (Kafue Flats and Zambezi Delta). Furthermore, with IPCC climate change models suggesting that mean annual runoff in the Zambezi River basin may decrease by as much as 20-40% by 2050, planned EFs could be an important tool to help ameliorate the impacts of climate change on biodiversity and livelihoods. Other examples of ICF involvement in EF research and implementation include Zhalong Nature Reserve and Poyang Lake in China, the Mekong River basin in southeast Asia, and Aransas National Wildlife Refuge in Texas, USA.

Keywords: environmental flows, biodiversity, Zambezi Delta, sustainable livelihood, climate change

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GLOBAL CLIMATE CHANGE AND CONSERVATION OF CRANES IN THE AMUR RIVER BASIN

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There are seven species of cranes in the Amur River basin. The Amur basin is the key breeding area for the globally threatened Red-crowned Crane Grus japonensis and White-naped Crane *G. vipio*. The basin also has importance for two migratory threatened species: Siberian Crane *G. leucogeranus* and Hooded Crane *G. monacha*. The Daurian steppes in the upper Amur basin have large numbers of breeding Demoiselle Cranes Anthropoides virgo. Status of populations of these cranes and many other species of waterbirds significantly depends upon condition of the wetlands. In turn, the condition of wetlands is significantly affected by climate change. Mid-term climatic cycles have great influence upon wetlands in the arid upper parts of the Amur basin, including the transboundary Russian-Mongolian-Chinese Daurian steppes. Therefore, wetlands change quickly with changes in quantity of precipitation. The quantity of precipitation in the forest-steppe and forest zones in the middle Amur is much higher and more stable than in the steppe zone, so wetlands there are more stable. Wetlands are most stable in the humid low Amur basin located near the ocean.

In Dauria, condition of wetlands and status of waterbird populations has changed quickly and deeply during climatic cycles that last about 30 years – with alternation of periods of about 15 dry years and 15 wet years. There has been prolonged strong drought in Dauria since 2000. The present landscapes are now quite different from the 1990s. In the 1990s, more than 1,500 shallow lakes having very rich food resources were dispersed across the Daurian steppes; wide valleys along the steppe rivers (up to 10 and more km wide) were flooded. This great wetland network supported internationally important breeding populations of Red-crowned, White-naped Crane and Demoiselle Cranes. By 2007-2009, the number of steppe lakes became only about 2% of those present in 1995-1999; all other lakes and the main parts of rivers are completely dry now. Even the former key habitat of waterbirds – the big Barun-Torey Lake in Daursky Nature Reserve – had no water in 2009 (in the 1990s it covered more than 550 km²). In Dauria in total, about 95% of pairs of Red-crowned and White-naped Cranes have lost their nesting sites. Many birds have moved to new sites in Dauria (mainly to the comparatively wet forest-steppe areas), other birds have left Dauria. Probably some White-naped Cranes moved to the middle and low Amur basin where prolonged droughts have not had such dramatic effect on wetlands as in Dauria.

The main part of existing nature protected areas in Dauria has lost its wetlands and cannot support waterbird biodiversity now. Anthropogenic threats have increased much. Spring grassfires became very frequent – about half of the grasslands burn annually. Wetlands still having water attract large numbers of nomadic livestock and people. Waterbirds try to breed there, unsuccessfully because of huge disturbance from livestock and people. Cranes and most other waterbirds urgently need rescue. We know too little, however, about the influence of mid-term (30-year) and long-term climate change on these birds.

In response to recent changes, it is important to study present distribution of waterbird populations in Dauria and in the whole Amur basin, to collect and analyze other data about present status of cranes and their habitats, and to organize conservation of birds on new sites. It is important to manage remaining breeding habitats (wetlands shared between waterbirds and people) and/or organize new protected areas that can support waterbirds during these dry periods. It is important to reduce the main anthropogenic threats including spring grassfires, disturbance and spring hunting.
Keywords: cranes, climate change, Amur Basin, Dauria, wetlands, threats

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THE RETURN OF THE EURASIAN CRANE TO ITS FORMER BREEDING GROUNDS IN SOUTHERN GERMANY

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Until about 1890, the Eurasian Crane *Grus grus* had been breeding in Bavaria in southern Germany, but due to intense wetland drainage and peat harvesting it finally disappeared as a breeding bird. During the last 20 years, however, strong efforts have been undertaken to restore bogs and fens in southern Germany. Much work still needs to be done, but in those areas where restoration was successful the crane has returned, using the sites for stopovers on migration and in a few cases for overwintering. Increasing numbers of pairs make efforts to breed in restored wetlands. In the context of climate change the German Government has developed a program to reduce CO_2 and N emissions. One important task in this program is to promote wetland restoration. Thus, in southern Germany mitigation for climate change could be a chance to benefit biodiversity in these precious ecosystems of bogs and fens. The crane, as it is selecting the better habitats, might become a good indicator- and also flagship-species even in southern Germany, standing for the protection of wetlands and the awareness of climate change.
Keywords: Eurasian Cranes, Bavaria, climate change, wetland loss, wetland restoration

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THE AMUR RIVER DYNAMICS OF CLIMATE AND HYDROLOGICAL REGIME IN ITS MIDDLE STREAM DURING THE LAST HUNDRED YEARS

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Climate changes significantly and even radically in the course of geological epochs. These dynamics are connected with changes in the structure of the Earth surface and atmosphere, and with different astronomical factors, such as changes in the Earth rotation around the Sun, and especially fluctuations of solar activity. In recent decades, an issue of anthropogenic influence on climatic shifts has been widely discussed, because the changes have become rapid.

According to data from regular observations by a network of meteorological stations of the Amur Regional Center of Hydrometeorology and Environmental Monitoring, the most notable changes in climatic characteristics have occurred in the Amur Region during the last 25 years. First of all, these changes concern the dynamics of temperature regime. The average annual air temperature over the period of 1985-2009 has been +1.7°C, whereas for the period of 1900-1984 this index was +0.3°C. The years 2007 and 2008 were extreme for positive temperatures, with average annual temperatures of +2.9 and +3.3°C, respectively. Both warm and cold seasons underwent temperature changes that inevitably led to increases in evaporation from land and water surfaces, a drop in lake water levels, and a reduction in wetland areas. The dynamics of precipitation as a reaction to climatic change is difficult to assess: annual precipitation varies greatly from year to year, deviating from the climatic norm as much as 30-35%. Only in the 2000s a tendency toward decrease in annual precipitation had appeared but it had not stabilized yet. During the last decade, scarcity of annual precipitation (10-35% less than normal) was observed in six cases, and in three cases the annual amount exceeded the norm by 14-30%. Generally, since 2000, the decrease in precipitation has been reflected in a reduction in the average water level in the Amur River.

Hydrological regime of the Amur River is under the influence of the Zeya River; the Zeya's flow in turn has been affected by the reservoir of the Zeya Hydroelectric Station since 1975, which prevents significant floods. This practice inevitably affects the state of floodplain ecosystems of the Zeya and the Amur, formed under conditions of regular natural flooding. During the summer of 2007, the Zeya watershed experienced heavy rains and the volume of water flowing into the reservoir exceeded the normal rate 4- to 5-fold. Spring floods in the northern tributaries of Zeya River were the most powerful in the last fifty years. If there had been no reservoir, water levels in Zeya River would have been 1.5 meters higher, but the high water was withheld by the dam. The Zeya Reservoir played the role of a buffer, accumulating a huge amount of water. As a result, in the middle stream of Amur, below the confluence of Zeya, even the spring flooding had stopped. Thus, for the past quarter century, the floodplain of the Middle Amur did not have any large-scale floods, which were previously typical and observed on average 1-3 times every 10 years. The highest flood was recorded in 1984, when the water reached the mark of 126.47 m (with markers in the adjoining floodplain areas at 122-131 m) near the town of Grodekovo. To the south, closer to the mouth of the Gilchin River, the peak of the 1984 flood was ~121.3 m, with markers in surrounding areas at 119-125 m. Since 2000 the highest level of water in the Amur River has not risen higher than 122.8 m, and in some years water has not been observed overflowing the river banks onto the floodplain.

Regular and extensive man-made grassland fires negatively influence both the mesoclimate and the hydrological regime of the study area. Destroying the soil cover, these fires damage natural ecosystems and cause soil damage and erosion. In addition, they affect the amount of reflective radiation and the water balance. Active vertical transfer of heat and surface material occurring in the path of the fire can affect the nature of the atmospheric circulation, blocking in general the process of precipitation.

Keywords: Amur Basin, climate change, hydrology, dams, grassland fires

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SHAPING POSITIVE ATTITUDES TOWARD WILDLIFE CONSERVATION IN THE AMUR REGION OF RUSSIA

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Muraviovka Park is situated in the Amur Region where environmental education has traditionally been conducted in the classroom in academic manner. Prior to the Park’s establishment, the great majority of the Amur teachers and their students did not know animals and plants of the Amur Region, even though their cities and towns are surrounded by pristine natural areas. The Amur River basin has very rich biodiversity, attracting nature lovers from all over the world, but the vast majority of local people regard their homeland as ordinary, backward, and not an exciting place to live. Dr. Sergei Smirenski and his students from the Moscow State University conducted research and some public awareness activities in this area in 1982-1993. In 1990s, the Amur Region became the first region in Russia to teach ecology as a separate school subject thus provoking interest of students in ecology and biology; however, this mostly academic knowledge could not be applied by students to real life. Low environmental awareness added to poor use and management of natural habitats of cranes and other endangered species. Problems ranged from major impacts of water development projects, through widespread agricultural practices damaging to the environment, to careless attitude toward manmade grassfires. Combined with drought, the latter has resulted in major fires and drying of wetlands, causing huge damage to natural landscapes and breeding birds throughout the region – a problem that can be resolved by raising public awareness.

In 1994, the Park launched its environmental program based on hands-on outdoor activities to demonstrate the rich nature of the Amur Region to its people. Since then over 15 teams of American educators (organized by the International Crane Foundation) taught at summer camps at the Park. These activities exposed several thousands of local people of all ages to the unique Amur wildlife and raised their awareness about the environmental threats to the Amur River basin. The target groups of the Park’s education program are diverse due to the variety of our environmental and social projects. Our activities include international summer schools (environmental and linguistic), workshops, festivals, special days, excursions, art contests, lectures, and presentations. Special tours have been developed for such groups as deaf and blind people and orphans. Since the Park protects migratory species, our joint projects with Chinese, Korean, and Japanese partners became a vital part of our efforts.

The Park enhances professional skills of researchers and educators who receive training at the Park. Our programs – in part because of the international involvement – attract students who have never been interested in nature before. The Park also organizes training of local teachers in other regions of Russia, as well as in USA, China and South Korea. Having no education coordinator on staff, we receive strong support from teachers who join us in our diverse education projects (up to 5 national and international camp sessions, 4 festivals, 5 special days, 20 presentations, and 50 public tours annually). The Park not only teaches but provides practical examples of land management that benefit both people and nature. We actively involve visitors in conservation actions (such as planting trees as wind- and firebreaks, enhancing crane and stork nesting habitats, and protecting these sites from wildfires), giving volunteers an opportunity to feel the importance of doing good things rather than simply visiting nature sites as tourists. Due to our environmental education program, which is closely interwoven with conservation, sustainable agriculture, and nature tourism projects, we have managed to raise significantly the awareness about threats to cranes and wetlands and the direct impacts of farming practices on wildlife. Once the local people had understood the threats and sustainable ways to address these problems, they began supporting the Park’s projects as volunteers and/or donors and sometimes initiate their own conservation projects. As a result, more and more people are getting involved in conservation throughout the Amur Region.

Keywords: cranes, wetlands, environmental education, Amur Basin, attitude change, farming practices

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DYNAMICS OF TUNDRA LANDSCAPES IN AREAS OF SIBERIAN CRANE REPRODUCTION

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Breeding grounds of the Siberian Crane *Grus leucogeranus* lie within the maritime lowland tundra in north-eastern Yakutia. Tundra lowlands represent the only nesting grounds of Siberian Cranes in this area, which is closely related by its origin and evolution to the long-term permafrost zone – the foundation of the terrain formation and the only guarantor of the area's future.

As a result of abrasion/wave-beating and ground ice melting in tundra lakes, their coastlines are constantly subjected to erosion. In landscapes of middle and micro relief there is a tendency toward a steady expansion of ponds and flooded lowlands where the water surfaces change constantly. This paper provides data that throw some light on the scale and power of these processes.

We investigated changes in landscape characteristics of the breeding grounds of the eastern population of the Siberian Crane (about 26,000 km^2), surrounded by the Indigirka River's tributaries – Gusinaya in the north and Berelekh in the south, using the ESRI ArcView GIS 3.3 system. We also revised topographic maps of 1:100,000 and 1:200,000 scales, data of surveys of 1952-1960, 1971 and 1980 data from black and white surveys of 1976, of Landsat-7 ETM +, TM 2000 and 2004, 2005, 2009, and Alos-2007. Areas and perimeters of some large, middle and small lakes, islands and peninsulas, and inter-lake isthmuses with pingos (or hydrolaccoliths – mounds of earth-covered ice found in the Arctic and Subarctic) were identified.

We learned that lake islands and peninsulas within the study area are undergoing rather rapid erosion. Within a period of 40-48 years prior to the year 2000, in the area with high concentration of Siberian Cranes, the water surface of nine lakes from 11.4-49.6 sq. km^2 in size had increased by 0.3-2.9 %; of 16 lakes (0.25-106 km^2 in size) – by 3-11%, and of 17 lakes (1.7-35 km^2 in size) – by 15.9-31.5%. Shrinking was documented only for Lake Chonobul (17 km^2) by 3.5%, and for two small lakes. Also, two lakes near Berelekh River's tributary (116.2 and 74.7 ha) had totally disappeared.

Intensive erosion was found in all lake islands in the area. As a result, Lake Symytar's area has increased by 11.2 km^2, merging with two small lakes nearby. A 14-ha island on Lake Ukuchan has disappeared. Peninsulas in large lakes are also exposed to remarkable destruction. Peninsulas in three large lakes have shrunk by 16.4-53%. Many inter-lake isthmuses have disappeared and the lakes had merged.

Lowlands near lakes had also eroded. This process appears to be the most intensive in lowlands along the southern and south-western coastlines. Unlike lowlands near lakes, lowlands located far from lakes had expanded, probably due to underground ice melting and leveling of the middle relief. Absolute areas of large lowlands (marshes Kosukhino and Ogholoh-Sisi, lowland of Lake Alexeychan, etc.) have grown slightly, but the ponds within these areas have grown intensively with a corresponding decrease in dry zones. For example, the water surface of the Kosukhino marsh that was 42 sq. km^2, had increased by 4.2 km^2; lowlands surrounding Lake Alexeychan, with an area of 59.2 km^2, had increased by 6.29 km^2 during the study period.

We learned that two sites within the large study territory (squares 41 and 42, 1350 km^2 each) with high concentrations of Siberian Cranes have experienced an increase in open water surface area during 40-48 years, by 121 and 85.5 km^2 respectively. Analysis of spectral characteristics of these two areas, obtained by a survey conducted in 2000, shows that the increase in water surface is caused mainly by the expansion of lakes, as well as by flooding and open water areas increase in lowlands, where the nesting territories of Siberian Crane breeding pairs are situated.

This research had revealed significant differences in speed of water body's dynamics in different time periods. Comparison of satellite images from the years 2000, 2007 and 2009 represents a great interest. Considerable slowing in expansion of most large lakes (growth of only 0.4–1. 95%) was reported in 2007 when compared with the 2000 data from the main territory of the Resource Reserve Kytalyk, and for some lakes some shrinking was reported in August, 2009. Different parts of our study area, however, show conflicting trends.

Considerable changes have taken place within a relatively short time in our study area located within the main breeding grounds of the Siberian Crane. We believe that these changes are caused by erosion forces that depend on water levels. During the last seven years the tendency of change in the landscape has slowed down. Nevertheless, the trend of change in the tundra landscapes leads us to predict that climate warming in the future will lead to significant shrinking of habitats optimal for breeding of Siberian Cranes and may present a serious threat to the species' existence.
Keywords: Siberian Crane, reproduction, tundra, Yakutia, landscape dynamics

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EFFECT OF WEATHER CONDITIONS ON SIBERIAN CRANE REPRODUCTION AND START OF FALL MIGRATION

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Breeding success, and even the possibility of breeding, depends on a complex of environmental conditions optimal for the species survival and the duration of a species’ reproductive cycle. There are no reliable data on the duration of the Siberian Crane’s breeding cycle in nature as well as on how much time is required for its different phases to ensure breeding success and ability of young cranes to cover long distances during their first migration. In captive breeding centers Siberian Crane chicks develop ability to fly well on 75-76 days after hatching (Kashentseva 1995), while other sources report on the first flights on 71 to 89 days. Taking into account 27-28 days of incubating period, the minimal time from start of egg-laying and incubation to the first flight may be 103-104 days. As the complete forming of wing feathers requires at least 100 days (Kashentseva 1995), we may expect that in the wild at least 120 days are necessary for chicks to become fully ready for migration.

Analysis of weather conditions, comparison of data on breeding success of the population, satellite data on the correlation between the start of migration and establishment of a stable snow cover, high vulnerability of chicks to sharp changes in fall weather, show direct dependence of breeding success on duration of the snowless period in the breeding area. When it was 92 days or shorter (in 1996), the breeding success was 4.3-8.7% in the study area (data from the first decade of August); 109 days (1994) resulted in 49% breeding success; 120 days (1995) – 64.5%; and 125 days (2005) – ~80%. Since the timing of snow cover establishment and melting is highly variable and unpredictable, the duration of the snowless period in the researched part of the breeding area varied from 83-132 days. From 1945-2008 (n=63), years with different duration of snowless periods occurred at the following rates: 83-99 days – 25%; 100-109 days – 35%; 110-119 days – 28%; and 120 days or more – ~12%.

Effect of weather conditions on the Siberian Crane reproductive success was monitored throughout all stages of the breeding season in the study area. Egg-laying and incubation are considered the most critical times (Flint and Sorokin 1982), as well as first days after hatching and the start of fall migration, all being affected by weather. Mosquitoes, especially during the first days after hatching, may reduce chick survival in years with peaks of these insects’ reproduction.

These data indicate that the present weather conditions in the Siberian Crane breeding range are not favorable and in some years or months maybe very unfavorable. Although the duration of snowless period has increased during the last 8 years and the average temperatures increased to some extent, only ~12% of years provided optimal weather conditions for the Siberian Crane reproduction.
Keywords: Siberian Crane, timing of reproduction, migration, Yakutia

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IMPORTANCE OF AGRICULTURAL FIELDS FOR CRANES IN THE SOUTH OF THE AMUR REGION, RUSSIA

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Over 70% of the arable lands of the southern part of the Russian Far East are located in the Amur Region. Agricultural fields play an important role in the distribution pattern of nesting sites and stopovers of cranes. In the spring, cranes are especially attracted by the last year's corn fields that were not plowed after the harvest, as well as fields newly planted with small grain crops. During the incubation period White-naped Cranes, mostly males, visit such fields regularly, usually staying within 1 km radius from the nest. Some families begin visiting the fields when their chicks are just 10-14 days old. At this time, insects and invertebrates – not seeds and sprouts – represent the bulk of their diet. Breeding Red-crowned Cranes, however, feed only in wetlands. In the spring and in the summer some non-breeding cranes can be sighted in the crop fields, while in the fall they are joined by families with grown chicks. Most cranes species then feed in the harvested small grain crop fields. Siberian Cranes during their short spring stopovers stay in shallow water areas and have never been seen on farmlands. Concentrations of migrating Hooded and White-naped Cranes in Muraviovka Park and in the Amurski Wildlife Refuge, as well as the high nesting density of White-naped Cranes, can be explained by the closeness of safe roosting and breeding sites located in wetlands to plentiful feeding areas in the fields. Distribution of stopovers, distance between roosting to feeding sites, behavior and numbers of migrating cranes that use these areas as their resting grounds vary from year to year and depend on cultivated crops, conditions of the crop fields, water levels, weather, and other factors. In the spring we observed cranes feeding on planted seeds and sprouts of small grain and corn, but in the fall there was no visible damage to crops. Due to low numbers of cranes, however, even in areas with higher concentration of migratory flocks, damage to the crops was insignificant and local farmers remained good-natured toward cranes. Still, there were rare cases of crane shooting by poachers. Muraviovka Park annually cultivates up to 30 hectares of corn to create a safe environment for cranes and to diminish potential conflicts with farmers. This practice makes cranes more tolerant of people and allows visitors to watch cranes without disturbance.

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CURRENT CONSERVATION CHALLENGES IN THE LOWLANDS OF THE MIDDLE AMUR BASIN AND POSSIBLE SOLUTIONS

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In 2001, climate in the mid Amur River Basin entered its dry phase, with higher average annual air temperatures and lower annual amounts of precipitation. In the past, such dry periods affected water flow to the Amur Basin wetlands only insignificantly and temporarily, due to regular floods of the Amur tributaries. Construction of hydroelectric dams on the Zeya and Bureya Rivers and of smaller dams on numerous minor tributaries, however, combined with other human activities and the dry weather conditions, have caused drastic environmental changes in the mid Amur Basin. Fragmentation and reduction of wetland habitats, catastrophic wildfires, easy access to wetlands for hunters, herdsmen, and terrestrial predators have all impacted waterbirds and reduced their reproduction. Consequently, populations have drastically declined for endangered cranes (Red-crowned and White-naped), Oriental White Storks, and many other waterbirds.

Wildfires always existed in the area and were considered a common (although illegal) farming practice to remove the old grass from pastures and fields. Controlled burnings or fire prevention methods have never been used by the local population. Prior to dam construction, however, grassfires never caused such serious damage that could not be reversed by floods and rains. In this current dry phase of climate, wildfires have become a catastrophic factor for wildlife and people, due to high unstoppable winds, loss of trees (windbreaks), and fragmentation of wetlands. Spring hunting and widespread use of rifles cause additional disturbance for cranes, and also lead to wildfires.

The current change in climate is not the main factor for waterbird decline but rather a trigger that has unleashed and amplified the accompanying natural and manmade threats to wetlands and waterbirds. Measures such as the Kyoto Accord, even if adopted and implemented in Russia, cannot save the situation because the factors listed above will destroy the wetlands much sooner.

Muraviovka Park has designed a comprehensive program to diminish the effects of climate change. This program can serve as a model relevant to other parts of the upper and mid Amur Basin in Russia and China. It includes the following short term measures:

- Conduct fire prevention and suppression program;
- Lobby for total ban of spring hunting by conducting an aggressive program of public awareness;
- Continue and expand captive breeding and release of birds into the wild to replenish the wild populations; and
- Conduct surveys and develop maps of all existing and potential nesting habitats of endangered cranes and storks to put them under protection and prevent their reclamation.

This program also includes the following long-term measures:

- Creation and management of wetland habitats (micro-wetlands) for endangered cranes, storks and other important waterbirds;
- Construction of water pumping stations on Amur River to pump water to the wetlands; and
- Strengthen public awareness campaign and work with the government so that the dam companies can be fined for the damage caused to wetlands (existing laws provide for such fines); these fines should be used to fund the above-listed activities.

Keywords: cranes, wetlands, Amur Basin, drying climate, hydroelectric dams, spring hunting

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A STUDY OF WATER SUPPLY AND WETLAND RESTORATION IN ZHALONG NATIONAL NATURE RESERVE, CHINA

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Ecological supplementary water is an important component of wetland restoration. Accordingly, where and how much water should be supplemented to a wetland are key points in wetland restoration. Wetland degradation is one of the serious problems for Zhalong National Nature Reserve. Because of the need to restore Zhalong Wetland, this study calculated the ecological water requirement of the core area of the reserve and designed supplemental water units, water release locations, and release timing. Based on the topographical and hydrological characteristics of each supplemental water unit, we optimized the water allocation. Our analyses show that the optimal ecological water requirement for the core area is 2.56×108 m^3 in a normal year. The water needs to be re-allocated for the different units in a normal year. During a dry year or extremely dry year, the ecological water requirements are 2.88×108m3 and 3.21×108m^3, respectively; consequently, the supplemental water release needed will be 1.40×108 m3 and 2.59×108 m^3 respectively. The water allocation should be optimized on the basis of the ecological requirement of each unit. The results of this study provide a case study for using scientific information for wetland restoration and effective wetland management in theory and practice.

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Keywords: wetland restoration, ecological water supply, water supply units, Zhalong NNR

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WORKSHOP RESOLUTION

RESOLUTION OF THE INTERNATIONAL CRANE WORKSHOP "CLIMATE – CRANES – PEOPLE"

Thirty delegates from 14 countries and 5 continents met at Muraviovka Park in the Amur Region of Russia from 28 May to 3 June 2010 to discuss the future of crane conservation, especially with regard to agriculture and cranes, water and climate change. This meeting was organized by the International Crane Foundation and Muraviovka Park on behalf of the Wetlands International – IUCN Species Survival Commission Crane Specialist Group and co-financed by the Trust for Mutual Understanding and Woodland Park Zoo.

The workshop participants unanimously agreed upon this resolution, with recommendations for enhanced conservation action, to benefit cranes, wetlands, and people:

1) IN AMUR REGION OF THE RUSSIAN FEDERATION

The delegates have unanimously agreed that Muraviovka Park is a world treasure created over eons of time that provides a home for some of earth's greatest ecological wealth. Major limiting factors for cranes in the Amur Region are loss of habitats, wild fires, spring hunting and insufficient public awareness about endangered species. Participants of the symposium recommended:

1. To develop a comprehensive water conservation plan for Giltchin River watershed that would benefit both people and wildlife and could be used as a model for other small rivers of the Amur Region.
2. To undertake proactive measures including prescribed burning, public education, development of buffer zones along the borders of pastures, crop and hay fields (including restoration of the road to lowlands in Muraviovka Park, which would allow bringing fire trucks and tractors to this site), and training of fire fighters.
3. To join Transbaikal Region in enacting a total ban on spring hunting of waterfowl.
4. To help Muraviovka Park develop a comprehensive nature tourism program beneficial to wildlife and people of the Amur Region. In particular, the delegates expressed a hope that the government of the Amur Region will help enhance and expand the demonstration bird pens, build board walks and observation platforms for visitors as well as other facilities used by Muraviovka Park staff members who promote innovative environment education and wildlife tourism in East Asia.

2) IN ARGUN/HAILAR RIVER WATERSHED

The Argun River defines the border between Chita District (Russia) and Inner Mongolia (China). The wide floodplain of the Argun in that region is a major nesting area for the threatened Swan Goose (*Anser cygnoides*), the endangered Red-crowned Crane (*Grus japonensis*) and a plethora of other waterbirds. Now the floodplain is threatened by activities in both nations.

The following recommendations were advanced concerning the conservation of the floodplain of the Argun River:

1. That the natural contours of the river be preserved and that plans to straighten the river be abandoned.
2. That the region be declared an International Nature Preserve between Russia and China.
3. That the flow of water in the upstream region of the Argun River and its tributaries be maintained to provide water needed for the floodplain.
4. That the education programs for the local people in both countries be undertaken concerning the importance of the floodplain.
5. That applying concrete to the banks of the Argun be discontinued, to allow the normal functioning of the river and to meet the needs of the floodplain.

3) IN CHINA

Poyang Lake has extraordinary importance to millions of people in Jiangxi and the provinces downriver and also is recognized globally for its remarkable biodiversity. Construction of a dam at Poyang Lake would transform the ecology of the wetlands, with irreversible impacts on local and global values.

Participants of the workshop unanimously:

1. Recommend that decisions about the dam be postponed until the steps described in the Executive Summary of the IUCN report have been completed.
2. Support development of a management plan for the lake involving scientists, stakeholders and Jiangxi Provincial agencies that will maintain the ecological character of the wetland while helping to enhance local livelihoods.
3. Provide through IUCN or other organizations technical assistance to Jiangxi Province related to training, case studies, assessments, or implementation of an Ecosystem Approach at Poyang Lake.

4) IN ISRAEL

The Hula Valley is a major resting area for Eurasian Cranes *Grus grus* that migrate between Eurasia and Africa, and in recent decades it has become a major wintering area for many thousands of cranes. The cranes have an increasing potential to inflict serious damage on crops. Although the various farmers and stakeholders have admirably been working together to resolve these issues, we understand that the situation will only become more difficult and that better solutions are needed.

1. The delegates wish to propose that the government of Israel and the European Union provide financial support to the management and conservation of cranes in the Hula valley.
2. We feel it is of utmost importance to combine good science with appropriate management and thus we encourage the support for further research into the issues of reducing crop damage and better understanding of the mechanisms underlying the increasing number of wintering cranes, as well as supporting the current management costs which become too heavy for the local stakeholders, farmers and conservation organizations.
3. The International Crane Foundation has been working for the past four years with the Israeli Ornithological Center of the Society for the Protection of Nature in Israel. As such we are committed to assisting the efforts of all concerned in order to alleviate future conflicts and ultimately ensure the conservation of cranes on a global scale.

5) IN THE REPUBLIC OF KOREA

The sand bars of the Naktong River near Gumi provide safe roosting areas for the globally threatened White-naped *Grus vipio* and Hooded Cranes *Grus monacha* during their migration each autumn and spring, and for several pairs of White-naped Cranes throughout the winter. Unfortunately, the sand bars are threatened by the removal of the sand to increase the depth of the river for navigation.

The delegates expressed to the government of South Korea, the importance of maintaining the sand bars on the Naktong River as safe roosting areas for cranes.

[Since the June 2010 workshop, the Naktong River has been altered and no longer offers crane roost habitat near Gumi.]

6) IN THE UNITED STATES OF AMERICA

The wetlands in Texas within and near the Aransas National Wildlife Refuge, on the western side of the Gulf of Mexico, provide critical winter habitat to the rarest of cranes, the Whooping Crane *Grus americana*. These wetlands are brackish (mixture of salt and fresh water) through the interaction of the Gulf's water with the outflow of fresh water from the Guadalupe River. The brackish water provides habitat for Blue Crabs, the primary food in winter for the Whooping Cranes. Unfortunately, the Texas Center for Environmental Quality is issuing permits for the extraction of fresh water from the Guadalupe River to the degree that inadequate flow will be available for the coastal wetlands. A consequence will be increased salinity through evaporation and the immigration of Blue Crabs to the Gulf. Lacking the crabs, many cranes will starve.

The delegates wish to ask the Government of the United States to enforce the terms of the Endangered Species Act that assure the protection of critical habitats for Whooping Cranes.

Full text of recommendations on these topics have been sent to each of the relevant governments.

CRANES, AGRICULTURE, AND CLIMATE CHANGE

James Harris

International Crane Foundation