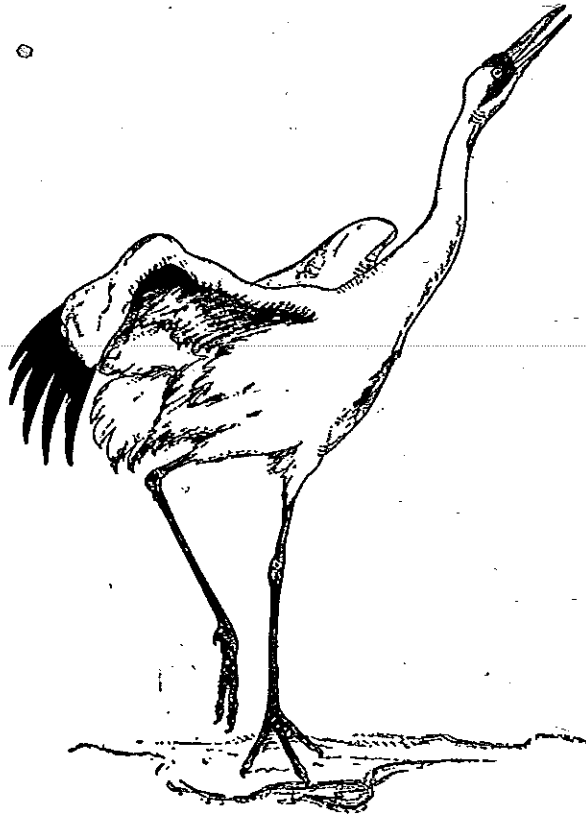


The WHOOPING CRANE

Research Report No. 3 of the
National Audubon Society

by
Robert Porter Allen



Published by

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THE WHOOPING CRANE

FOREWORD

THE National Audubon Society considers facts obtainable through scientific research the essential basis for wise policies governing the conservation of wildlife resources.

The second rarest living species of North American bird is the Whooping Crane. Through the advance of agriculture, human settlement and consequent changes in habitat, let alone excessive kill by man, this magnificent bird has reached the verge of extinction. But this means that man, through intelligent and determined action, might succeed in arresting and altering the trend. To attainment of that goal our partner in this project, the U. S. Fish and Wildlife Service, and this Society are irrevocably dedicated.

The first essential step, that of providing refuge on the wintering grounds, had been taken by the Service in 1937. It was decided in 1945, in spite of war conditions then prevailing, that our two agencies would cooperate in an extensive field research project to ascertain the facts as to the life history of the Whooping Crane; that we would then attempt to draw conclusions as to practical measures to restore their numbers and remove the threat of their extinction.

The U. S. Fish and Wildlife Service of the Department of the Interior has played a major part, not only through management practices applied on the bulk of the Whoopers' wintering range, but through the loan of transportation equipment, including planes, and the participation of its refuge and flyway biologist personnel.

Through the generosity of the Gothenburg, Nebraska, Rod and Gun Club and of the Audubon Park Commission in New Orleans and its director, George Douglass, an experiment with the breeding of the only Whooping Cranes in captivity was made possible; this in a large enclosure on the marsh on the refuge in Texas. The loan of the New Orleans bird, the only specimen in any zoo in the world, was an invaluable contribution and is deeply appreciated.

Through the fine assistance of Fred G. Bard, Jr., now Director of the Provincial Museum, Regina, Saskatchewan, Canada, a start was made. Through the cooperation of Carleton College at Northfield, Minnesota, we were then fortunate in enlisting the service of Dr. Olin Sewall Pettingill, Jr., its Associate Professor of Zoology. He spent many strenuous months in 1945-6 studying the life history of the cranes and combing the literature. He participated in an airplane search for the nesting grounds in northwest Canada, with the personal participation as pilot of Terris Moore, now President of the University of Alaska.

After four years in the Mine Planter Service of the U. S. Army, on sea duty, our own Robert P. Allen, of Roseate Spoonbill fame, returned from the wars for resumption of duty in the service of the Society. From late 1946 he has spent most of his time in the field, and has made two very extensive airplane searches for the nesting grounds. The U. S. Fish and Wildlife Service provided pilot-biologist Robert H. Smith and plane. This search covered many thousands of square miles in the Northwest Territories and along the Arctic Coast from Point

Barrow, Alaska, to Coppermine on Coronation Gulf; from Lakes Athabaska and Great Slave to Great Bear Lake and into the mountain valleys on the north Alaskan coast.

No better men could have been found than Allen and Smith for this particular assignment. Their interest is deep and sincere. To them, obstacles are simply something to surmount. No hardship discourages them; they have endurance and perseverance. If the Whooping Crane be saved, they and others who have so effectively aided this project will have been primarily responsible.

With characteristic modesty, Allen has neither signed nor initialed the 16 original drawings, and the maps reproduced in this report. You will want to know that they are all the product of his talent, some drawn in the field at the moment of observation.

No one or two men alone, however, could have done what has already been accomplished through the cooperation of many agencies and individuals, or could do what we all hope now will be accomplished through cooperative action on the recommendations in this report.

JOHN H. BAKER,
President,
National Audubon Society

New York, N. Y.
May 1, 1951

PREFACE

FOR many years there had been a great deal of talk about the unfortunate status of the Whooping Crane, but very little was done about it. One of the first measures to improve the welfare of this gravely endangered species was the establishment, in December 1937, of the U. S. Fish and Wildlife Service's Aransas National Wildlife Refuge near Austwell, Texas. Most of the Whoopers then surviving wintered within the confines of this refuge area, which contains 47,261 acres. A second effort of significant value was the field work of James O. Stevenson, who was the first refuge manager at Aransas. As a result of Stevenson's keen observations and thoughtful conclusions, which were eventually contained in his paper published in 1946 (Stevenson and Griffith, 1946), we had, for the first time in recent years, a realistic outline of the problems that face *Grus americana*.

Most of Stevenson's field investigations were made between October 1938 and November 1941. The writer, as well as many other interested persons, visited the refuge at various times during those years. It was very apparent that there was much to be learned as to the requirements of the Whooper, both while they were on the wintering grounds and after they had set off on their long and hazardous migration northward.

The establishment of Aransas Refuge and the work of Stevenson served to sharpen our perspective with regard to *Grus americana*. We knew of a few additional Whoopers, existing rather precariously on marshes near White Lake in southwest Louisiana, but were these and the Texas birds the only ones left? Where did they nest and through what regions did they migrate? A hundred questions were raised. We had satisfactory answers for scarcely any of them.

In 1945, as a direct result of this situation, the U. S. Fish and Wildlife Service and the National Audubon Society joined forces in setting up a Cooperative Whooping Crane Project. The purpose of the investigation was to find ways and means of securing sufficient added protection and of establishing a sound conservation program designed to insure the survival and increase of the Whooping Crane population. These measures could not be accomplished without the backlog of a thorough study of the life history of the species, including an exact knowledge of its relationship to environments throughout the various sectors of its wide range. While there was a considerable literature relating to *Grus americana*, it was devoted for the most part to distributional records. And even these were confused and lacking in comprehensiveuess.

As described elsewhere in this report, a good start in accumulating the facts necessary to an understanding of the entire problem was made in 1945 and 1946 by Fred Bard, Jr., of the Provincial Museum in Regina, and Dr. Olin Sewall Pettingill, Jr., of Carleton College. The writer was asked to take over the job in October 1946 and began his duties on the Texas coast the following month, shortly after the fall arrival of the migrant Whooping Crane population on the Aransas National Wildlife Refuge. From that date until the present, a total of thirty-nine months has been devoted to the project—27 months in the field in Texas, Louisiana, Oklahoma, Kansas, Nebraska, North and South Dakota, Canada and Alaska, including surveys by airplane in the Mackenzie Delta coun-

try and along the Arctic coast from Point Barrow to Bathurst Inlet, in the central Canadian Arctic. A total of approximately 12 months has been spent on library research and writing.

Most field work was centered in Texas, on the wintering range of the Whoopers, a total of about 19 months. Five months, much of it travel time from place to place, were given to search for the unknown breeding grounds in Canada; two months, to work along the migration route, from Texas to Saskatchewan; and approximately one month to investigations in Louisiana. Active search for Whooping Cranes in Mexico was made by personnel of the U. S. Fish and Wildlife Service, chiefly by Dr. George B. Saunders.

Airplanes were used, not only in the North, but in searching the Gulf Coast and Mexico, in scouting the Platte River country in Nebraska and making routine population counts in Texas and Louisiana. The writer traveled well over 20,000 miles in small planes during the course of the field investigations, most of it at low altitudes. Many nights were passed in tents, large and small, in late spring sleet storms in northwest Saskatchewan and in Texas "northers" that covered the taut canvas with layers of ice. In a single winter season in Texas nearly 6,000 miles were covered by jeep, making population and habitat studies on the Aransas Refuge. The project, like the Whooping Crane itself, spread out over a vast area. One month we were rubbing elbows with Mexican *vaqueros*, the next drinking tea with a family of Eskimos. With Robert H. Smith, of the U. S. Fish and Wildlife Service, flights were made over semi-arid Texas salt flats and, thousands of miles to the north, over the edge of pack ice, with nothing between our little plane and the Pole but more pack ice. It was a strenuous, adventuresome, exacting experience, but there was never a dull moment.

Unquestionably we now know much more about the Whooping Crane and its existence than we did before. We are better fitted to plan for its protection and recovery. The species is in a dangerous position. Our realization of this has been underscored by the certain knowledge that 33 migrant birds wintering on Aransas Refuge, and the two captive cranes in the experimental breeding enclosure on that area, are the only individuals of their race that survive. But we cannot limit our thinking to a mere numerical appraisal. Each one of these great birds is far more than simply "number one" or number "thirty-five." Each of them is a tremendous potentiality. When you sit crouched in a blind and watch an adult Whooper stride close by you, his head high and proud, his bearing arrogant and imposing, you feel the presence of a strength and of a stubborn will to survive that is one of the vital intangibles of this entire situation. Certainly it cannot be overlooked. We have a strong conviction that the Whooping Crane will keep his part of the bargain and will fight for survival every inch of the way. What are we going to do to help? Here, in this report, is the challenge, here is the job that must be done.

ROBERT P. ALLEN

New York, N. Y.
September 30, 1950

ACKNOWLEDGMENTS

SELDOM has a detailed inquiry into the habits and welfare of a single bird species covered such a wide area and enlisted the interest and active help of so many agencies and individuals as the recent cooperative study of the Whooping Crane. The investigation has been the joint undertaking of the U .S. Fish and Wildlife Service and the National Audubon Society, but little could have been accomplished without the support of the many who contributed migration and distribution reports, who aided in practical ways during our work in the field or who acquainted the general public with our efforts, and the need for a common endeavor on behalf of the Whooping Crane, through special articles in the newspapers and magazines and by means of radio broadcasts. In mere bulk the assembled correspondence of the last five years is immense, and, together with the collected newspaper clippings, articles and similar items, exceeds by several times the size of the final report itself. Although it is manifestly impossible to mention by name every one of those who contributed, in one way or another, to these joint efforts, their help has been greatly appreciated and we will always feel that this widespread interest has been a good omen.

From the first our good neighbors in Canada have been extremely active and helpful. Repeated assistance has been received from Dr. Harrison F. Lewis, Chief, and other personnel of the Canadian Wildlife Service. Also from the Saskatchewan Department of Natural Resources, the Royal Canadian Mounted Police, the Hudson's Bay Company, the Saskatchewan Fish and Game League, Ducks Unlimited, the Canadian Broadcasting Corporation and from many leading Canadian newspapers and other organizations and agencies.

Individually, much personal interest in the project was shown in Canada by James Barnett, Art May, Bill Heno, Helmar Johnson, Charlie

Murray, Lefty McLeod and Cliff Lebey, all of the Saskatchewan Department of Natural Resources in the Meadow Lake and Prince Albert Districts. These men were full of ideas and useful suggestions and McLeod and Lebey dropped out of the sky with mail on numerous occasions and but for them our Flotten Lake Camp, of May 1947, would often have been completely isolated. We are also grateful for the hospitality extended to us by various residents of Meadow Lake and by the families engaged in mink ranching at Flotten. We are indebted to Dave Lachausseurs for extricating us from the woods road near Waterhen Lake, to Mr. and Mrs. Gordon Lund of Prince Albert for many pleasant hours between flights and to George Hill, of the Imperial Oil Company at Meadow Lake, for arranging to install a gasoline supply on the shore of Flotten Lake.

At Fort Simpson, in 1948, Vic Shattuck went out of his way to be helpful and we still owe him a shear pin for the outboard that struck a snag in the flooding Liard River.

At Fort Smith, Paul Kaeser was always a cheerful host and we are grateful as well to Billy McNeil, who did his best to run down Whooping Crane records for us.

At Aklavik, where we spent considerable time while flying along the Arctic Coast, in June and July 1948, many persons gave us of their time and hospitality. Bill Carson, of the Hudson's Bay Company, found us quarters and entertained us with stories of his adventures. Doug and Pauline McNeice, of Canadian Pacific Airlines, not only entertained us, but fed us the best reindeer steak in that part of the world. Cliff Anderson and Carman Pearson, of the Aklavik Flying Service, were extremely helpful, especially when it came time for engine check-ups, and their little cabin was the gathering place for many pleasant hours during the endless sunshine of Arctic nights.

Various personnel of Canadian Pacific Airlines helped in different and always practical ways, especially Ernie Boffa, Sandy Tweed, Bill Hutchinson and the ground crew at Norman Wells.

The Aklavik detachment, Royal Canadian Mounted Police, took us in with a spirit that must be unequalled anywhere. They were our advisors, guides, friends and wholehearted co-operators in many ways and we are grateful to every one of them. To Sgt. Major R. A. (Red) McLeod and his men of the Royal Canadian Corps of Signals at Aklavik, we are indebted for numerous favors. Both George Roberts and Dave Jones, of Imperial Oil at Aklavik, helped in every way that they could.

At Coppermine we were made comfortable by D'Arcy Munro of the Hudson's Bay Company and were royally entertained by everyone on the post. We are indebted to Canon Webster, Dick Connick of the R.C.M.P. and each and every one stationed at Coppermine in that summer of 1948. At Yellowknife, Jock McMeekan was a delightful and informative host and we are grateful to him and to Mrs. McMeekan for their kindness.

At the airstrip on Sawmill Bay, as elsewhere, we were given every available facility, but the officers of the U. S. and Canadian Air Forces at Sawmill Bay were especially friendly and helpful, and at a time when, as never before, we were in need of warm food and a dry bed.

No one did more for the project in Canada than Fred G. Bard, Jr., Director of the Saskatchewan Provincial Museum in Regina. His wide acquaintance with people throughout the Provinces and his deep interest in the Whooping Crane not only got the job off to a splendid start, but continued to contribute materially to its progress throughout the period of active field investigations. It is safe to say that Fred Bard did more to tell the people of western Canada the value of the Whooping Crane and the urgent need for its protection than anyone be-

fore him. Our debt to him is very great.

More field work was undertaken in Texas, where all of the migrant Whoopers spend the winter, than anywhere else in either Canada or the United States. At the Aransas National Wildlife Refuge the following have taken part in the project and assisted in countless ways: Charles A. Keefer, Mrs. Elizabeth Keefer, Harold A. Blakey, Julian A. Howard, Mrs. Tally Howard, Leslie E. Beaty, Russell W. Clapper, Earl Benham, George and Julius Charmrad. Some of these people have given so much of their time, over such a long period, that any measure of thanks we might express here seems wholly inadequate. In every case they did more than their jobs called for, so that their interest became a personal one and thus their efforts have been rewarded in the best way of all. Also at Aransas Refuge, Guy Colbath, of the Texas Game, Fish and Oyster Commission, and the men of his staff, helped us over and over again. We are greatly indebted to him and to his family for their active personal interest and assistance.

Our food habits studies and basic ecological work could not have been accomplished without the pioneering investigations and the repeated assistance of Dr. Gordon Gunter and Joel W. Hedgpeth of the Institute of Marine Science, University of Texas. The service rendered by them has been considerable and is deeply appreciated. To J. L. Baughman and Wardens Mullinax and Earp, of the Texas Game, Fish and Oyster Commission, we are grateful for making it possible to undertake a survey trip to Cedar Bayou.

Numerous flights along the Texas coast, especially in population inventories at Aransas Refuge, were made with pilots Bob Tanner and Red Durham of Port Lavaca, Texas, and their enthusiastic personal interest did much to make these counts and surveys complete and valuable.

Thanks are due Toddie L. Wynne, of Dallas, for his important contribution in leasing to the

National Audubon Society a portion of Matagorda Island, inhabited in winter by Whooping Cranes. To Bob Hopper, of Austwell, Texas, we are indebted for many favors, including the loan of skiffs on a number of occasions. To Mr. and Mrs. A. F. Daniel, also of Austwell, we are grateful for their sincere and unquenchable interest in the Whooping Crane over many years. To many other residents of Austwell we owe our warm thanks for numerous favors and friendly cooperation. Special gratitude will always be felt towards Dr. G. E. Glover, of Tivoli, Texas, for the fine job he did in pulling the author of this report through a bad case of Tularemia, contracted while attempting to fit *Lepus californicus merriami* into the ecological puzzle.

In southwest Louisiana, the knowledge and personal interest of John J. Lynch, of the U. S. Fish and Wildlife Service, contributed much of what has been learned of the Whooping Cranes in that region. John Lynch was a student of the species from the early days at Aransas Refuge. He helped make counts, investigate the winter habitat, examine the food habits, and, in Louisiana in May 1939, discovered the last reported nesting of the Whooper on the Gulf Coast. Later, Lynch not only kept in close touch with the numbers and the distribution of the Louisiana birds, making his own aerial checks in recent years, but his work in building up a background of historic fact by interviewing natives who had known the species intimately since their youth, constitutes one of the major contributions to this project. Finally, it was Lynch who planned and directed the successful capture, by the aid of helicopters, of the last of the Louisiana Whooping Cranes and, with Nick Schexnayder, Superintendent of the Rainey Wildlife Sanctuary, assisted in its transfer to Texas. In this connection we are grateful also to the Petroleum Bell-Helicopter Services at Lafayette, Louisiana, for their enthusiastic cooperation. John H. Flynn, then of the Louisi-

ana Department of Wildlife and Fisheries, assisted with search flights and we are also appreciative of the cooperation of Commissioner L. S. Montgomery of that Department.

In New Orleans, George Douglass, Superintendent of the Audubon Park Commission, took over the care of the two captive Whoopers that we were interested in pairing. In 1948, through the generosity of the Commission, these two birds were transferred to a special enclosure on the Aransas Refuge in Texas, and the female, which had been on exhibit in the Audubon Park Zoo for some years, has remained at Aransas on a loan basis.

In the handling and shipment of the captive cranes we had the cooperation of Jack Kennedy, of Gothenburg, Nebraska; George P. Vierheller, of the St. Louis Zoological Park; Charles A. Keefer and his crew from Aransas Refuge, and Fred Stark of the San Antonio Zoo. To each of these we express thanks for their unselfish contributions of time, skill and effort.

Others in Louisiana have been helpful. For a number of years Dick Gordon and Nick Schexnayder, of the Rainey Wildlife Sanctuary, kept us informed regarding the Whooping Cranes near White Lake. We are grateful as well to Johnny Gaspard, Charlie Boudreaux and the many who reported on the status of the species, past and present, following the inquiries of John Lynch. The late E. A. McIlhenny, who was interested in the Whooping Crane in Louisiana for more than 50 years, turned over to us various unpublished recollections of considerable value.

In Oklahoma, observations along the migration route were made possible through the efforts of Seth H. Low, of the U. S. Fish and Wildlife Service, then stationed at the Salt Plains National Wildlife Refuge. We are also grateful to the Oklahoma Game and Fish Commission for alerting their ranger force.

In Kansas we had invaluable assistance from Melvin E. Ramsey, U. S. Game Management Agent stationed at Hutchinson. Valuable records were obtained through the cooperation of Mr. Ramsey, District Game Protector Arthur Jones and pilots at the Hoisington airport. Thanks are also due Dave Leahy, Director of the Kansas Forestry, Fish and Game Commission, for his assistance.

Nebraska has been a center of interest in the Whooping Crane for many years and the cooperation that we received there has been most heartening. Dr. R. Allyn Moser, of Omaha, and Wilson Tout, of North Platte, representing the Nebraska Ornithologists' Union and the North Platte Bird Club, respectively, put us in touch with many helpful people and assisted in numerous ways. During the migration studies that were made along the Platte River in March and April 1947, much valuable cooperation was given the project by so many individuals that it is impractical to attempt listing them here. However, we wish especially to acknowledge the assistance of Paul S. Smith, U. S. Game Management Agent at Ames; Lee Jensen, State Conservation Agent at North Platte; Cy Black and Eddie Brown and Mrs. Brown at Kearney; Loren Bunney, Conservation Agent at Ogallala; Jimmy Kirkman of the North Platte *Telegraph-Bulletin*; Joe Di Natali of radio station KODY, North Platte; Mr. and Mrs. Earl E. Mathers of Lincoln County and John Clinch of the North Platte airport.

Our debt to the late Myron H. Swenk, already expressed in this report, cannot be stated with sufficient adequacy. Professor Swenk, almost single-handed, kept interest in the Whooping Crane alive over many trying years, but even a voice crying in the wilderness may some day be heard, and it was largely due to Swenk's insistent warnings that the spotlight was finally turned on *Grus americana*.

Likewise in Nebraska, the Lincoln County Sportsmen's Association showed sincere interest

in our work and assisted in every way that they could to put us in touch with local people and situations. We are also grateful to the North Platte Lion's Club. Most of all, however, we are indebted to that great army of school teachers, housewives, bus drivers, farmers, section hands, motorists and other casual observers who were interested enough to report birds that they believed were Whooping Cranes. Sometimes these reports proved accurate, more often they did not; but the show of interest, the demonstration of awareness is of a primary importance and has meant a great deal to us.

In North Dakota, which has always been one of the major Whooping Crane states, a small nucleus of interest has continued through the years. Burnie Maurek made regular reports of migrant birds and, more recently, excellent publicity has been obtained by Russell Reid and by J. E. Campbell, Deputy Game and Fish Commissioner and Editor of *North Dakota Outdoors*. Some of those who assisted with records and in other ways have included Cordia J. Henry, of the Lower Souris National Wildlife Refuge; H. E. Fields of Marion; Mr. and Mrs. Harry C. Jones of the Washburn district; and Joe Hill and Norris Loney of Portal.

For their outstanding cooperation in dealing with the potentially dangerous oil-drilling problem at Aransas Refuge, we wish to express our gratitude to the Continental Oil Company and the Western Natural Gas Company. In particular we are appreciative of the intelligent direction of L. F. McCollum, Charles A. Perlitz, Jr., Dr. J. A. Culbertson and Emerson G. Smith of Continental, and H. O. Weaver, W. K. Davis, Paul Wright and Harry E. Russell of Western Natural Gas.

Information regarding egg and skin collections, and in many instances, extensive measurements, were generously contributed by the following institutions: Academy of Natural Sciences, Philadelphia; American Museum of Natural History, New York; Bethel College, North

Newton, Kansas; British Museum, London; Carnegie Museum, Pittsburgh; Chicago Academy of Sciences; Chicago Natural History Museum; the Cleveland and Colorado Museums of Natural History, Denver; Dallas Museum; Hastings Museum, Hastings, Nebr.; Kansas State College of Agriculture and Applied Science, Manhattan, Kans.; Milwaukee Public Museum; Museum of Comparative Zoology, Cambridge, Mass.; Muséum National d'Histoire Naturelle, Paris; National Museum of Canada, Ottawa; New England Museum of Natural History, Boston; New York State Museum, Albany; Ohio State Museum, Columbus; Oklahoma Agricultural and Mechanical College, Stillwater; Peabody Museum of Natural History, New Haven; Regar Memorial Museum of Natural History, Anniston, Alabama; Rijksmuseum van Natuurlijke Histoire, Leiden; Royal Ontario Museum, Toronto; San Diego Natural History Museum; Saskatchewan Provincial Museum, Regina; State University of Iowa, Iowa City; U. S. National Museum, Washington; University of Kansas, Lawrence; University of Michigan, Ann Arbor; University of Minnesota, Minneapolis; University of North Dakota, Grand Forks; University of South Dakota, Vermillion; University of Wisconsin, Madison; University of Wyoming, Laramie; Vassar College, Poughkeepsie; Museum Alexander Koenig, Bonn and the Zoological Museum of Berlin.

Individuals who kindly provided data from private sources included John R. Cruttenden of Quincy, Illinois; Hamilton M. Laing of Comox, B. C.; J. A. Munro of Okanagan Landing, B. C.; Prof. William Rowan of Edmonton and Max Schonwetter of Gotha, Germany.

A great many of the staff of the U. S. Fish and Wildlife Service, from the Director on down, have helped in various ways, and the keen personal interest demonstrated by these men has been a heartening and invaluable asset in the conduct of our investigations. We are especially grateful to Dr. Clarence Cottam, J. Clark Salyer II, Dr. John W. Aldrich, F. M. Uhler, John Gat-

lin, and Dr. Gustav A. Swanson, formerly Chief of the Research Branch, in addition to Service personnel already mentioned in these acknowledgements. We owe much to the inspiration, advice and encouragement of James O. Stevenson and to the quiet enthusiasm, skill and sound judgment of Robert H. Smith, both of this Service. The job could not have been done without their help.

Most of the plant identifications were undertaken by John J. Lynch, U. S. Fish and Wildlife Service. Work on the fishes was the contribution of Dr. Gordon Gunter of the Institute of Marine Science at Port Aransas, Texas, and marine invertebrates were determined by Joel W. Hedgpeth, now on leave from that same institution. Dr. Horton H. Hobbs, Jr., of the University of Virginia, kindly studied the crayfish we sent him (describing two new species in the process). Other specialists gave freely of their time and advice and to each of them we are grateful.

The considerable task of assembling and combing through the ornithological literature was saved of much of its normal drudgery by the expert and keenly appreciative assistance of Monica de la Salle, librarian of the National Audubon Society. Without falling into Dr. Coue's classic classification, she is, nonetheless, a rarely gifted and inspired bibliographer. We are grateful to her for many hours of patient "digging."

To all those who have offered the use of photographs, drawings, paintings, or other material, we express sincere thanks, whether it has been possible to use their items or not. We are particularly grateful to Mrs. Louis Agassiz Fuertes for permission to reproduce a halftone of her late husband's splendid painting of a flock of Whooping Cranes in full flight, and to Dr. Arthur A. Allen, of Cornell University, for photographing the original. Thanks are also due the Film and Photo Department of the National Audubon Society, one and all, for their cooperation in many small details that have proved im-

mensely helpful.

To Don Bleitz I am greatly indebted for his contribution of the right to reproduce as frontispiece his beautiful transparency of an adult Whooping Crane, as well as a carbro print.

Pen and ink drawings that are not the work of the author were contributed by Mrs. Eugene E. Morton and Joel W. Hedgpeth. It is a pleasure to acknowledge also the cheerful encouragement of both individuals, in addition to these material donations.

Assistance in the typing of the manuscript was given by Mrs. Lois Pinder and Mrs. Jack Wilkinson of Tavernier, Florida, and Miss Elizabeth Cressman of Miami. The bibliography was typed in final form by Mrs. Archibald Maclay of the National Audubon staff. Shirley Miller very kindly typed numerous revised portions of the manuscript and helped to rearrange the always troublesome footnotes.

The arrangement of illustrations, selection of type and general layout is the work of Fred Hahn. To Elizabeth Sterling Manning I wish

to give thanks for her careful reading of the proof.

To the writer's immediate family, who again followed his wanderings and vicissitudes "through thick and thin," I can only add this more or less formal word of thanks to the appreciation I have constantly tried to express. It was not always fun and it was often dreary, but they came through like old troupers.

Our greatest debt is to John H. Baker, President of the National Audubon Society, who has been responsible for the conception and direction of these research studies and who set up and, with characteristic energy, pushed to completion, the present phase of the Whooping Crane project. It is a professional and a personal pleasure to work with one who has such an encouraging brand of confidence, such a wide grasp of detail and such a willingness to pioneer. Wildlife conservation in general, and of threatened North American species in particular, owes him much.

ROBERT P. ALLEN

Tavernier, Fla.
December 1, 1950.

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INTRODUCTION

HUMAN knowledge of the cranes had its beginning in myths and legends. The Ionian philosophers of Asia Minor, who were among the first people to investigate Nature, wove a small pattern of reality into these stories. By the time of that great Ionian, Aristotle (384-322 B.C.), we perceive in the midst of fancy the strong threads of truth, the results of careful and attentive observation. Anyone interested in mythology and folk lore will find considerable entertainment in these ancient descriptions of cranes battling with pygmies in the Nile marshes, or of plump Taoist gods riding about the countryside on the backs of cranes. Unfortunately or otherwise, none of these myths concern the subject of this study, the Whooping Crane of North America. When we consider the present situation that faces this species it seems apparent that what *Grus americana* needs is the benefit of our strict adherence to fact. The immediate and practical purpose of this report is to eliminate fancy and reach an understanding of the very down-to-earth problem of extinction that now confronts the Whooping Crane.

Some of the early background material with regard to the cranes, in addition to mere intellectual interest, is of value, however, in shaping our philosophical approach to the entire subject of threatened species. There is something heartening in a realization that Homer, who sang of many wondrous things, found beauty and majesty in the flight of cranes.

As when the cranes,
Flying the wintry storms, send forth on high
Their dissonant clamors, while o'er the ocean
stream

They steer their course

From the beginning, there were always those who were interested in cranes merely as game or as food. The hawking gentry, from remote Tartar chieftains to that literate and energetic emperor, Frederick II of Germany, considered

these birds among the most worthy victims of their trim falcons. In ancient Japan only the peregrines of the Emperor could be used against the magnificent Tancho, *Grus japonensis*, the crane of many a screen and vase. In England of the 14th century, Chaucer turned an appreciative ear to the sky and wrote of "the crane the giant, with his trompes sounne." But the wealthy barons, who seem to get blamed for a lot of things, are said to have cared more for the taste of *Grus grus grus* when cooked in its own spiced gravy. At any rate, by about 1600, the species no longer bred in the fen country and is a rare vagrant today throughout the British Isles. It is evidently still abundant elsewhere.

According to the current standard* there are twenty-three species and subspecies of cranes in the World, fourteen of these forms being considered full species and the remainder geographic races or subspecies. Cranes belong to the Order Gruiformes, the crane-like birds (cranes, rails, coots, gallinules, sun-grebes, sun-bitterns). In the present system that takes up the lowest orders first, the Gruiformes are preceded by the Galliformes (guans, chachalacas, grouse, ptarmigan, pheasants, partridges, quail, guinea fowl, turkeys) and are followed, in the evolutionary scale, by the Charadriiformes or plover-like birds (jacanas, thick-knees, oystercatchers, turnstones, surfbirds, plovers, snipes, sandpipers, phalaropes, avocets, stilts, skimmers, terns, gulls, skuas, jaegers, auks). The Suborder Grues contains the cranes and limpkins and the Family Gruidae, the cranes. There are four genera: *Grus*, *Bugeranus*, *Anthropoides* and *Balearicinae*. Only the Genus *Grus* is represented in North America: *Grus americana* and *Grus canadensis* and its subspecies.

Cranes are native to every continent except South America. The Genus *Grus*, in addition to North America, is represented by breeding species in Europe, Asia and Australia, and one form, the Common Crane (*Grus grus grus*)

* Peters (1934); Ridgway and Friedmann (1941).

winters in northeastern Africa. The Wattled Crane (*Bucconas carunculatus*), the only form in its genus, lives in eastern and southern Africa. There are two species in the Genus *Anthropoides*, and one of these, the Demoiselle Crane (*A. virgo*) has a tremendously wide distribution in Europe, Asia and Africa, breeding in all three. The other species of this genus, the Stanley Crane (*A. paradisea*) is found only in the high veld region of Africa south of the Zambesi. The fourth group, the Crowned Cranes of the Genus *Balearica*, are all African in distribution.

Asia has the greatest number of species with a total of eight, and ten forms all together of geographical races are included. Of these, the Saras Cranes are confined to India and Burma and most of the others are distributed through eastern and central Asia. Two species are found in Europe, the Common Crane and the Demoiselle. In Australia there are two forms of *Grus rubicunda rubicunda*, one in the northwest and north and the other in the east and south. This latter race also occurs in the swampy lowlands of New Guinea. Africa has a total of four species and seven forms all told. Three genera are represented. The African races are smaller and more elegant than the more typical cranes of the Genus *Grus* occurring in Eurasia, North America and Australia. In North America there are two species and a total of five distinct forms, the Sandhill Cranes being separated into four races, the Lesser Sandhill, Greater Sandhill, Florida Crane and Cuban Sandhill. The other North American race, the Whooping Crane, is a distinct species and is found only on that continent. The Lesser Sandhill (*Grus canadensis canadensis*) crosses the Bering Straits to the Arctic coast of eastern Siberia, where it nests in the region of Cape Baranov and the Chukchi Peninsula, in addition to its wide breeding range in North America.

It should be of value and interest to give a concise picture of the range of each of these cranes and a general description of their appear-

ance. The ranges, unless stated otherwise, are from James Lee Peters' *Check-List of the Birds of the World* (1934), and the descriptions of general plumage characteristics and appearance are for the most part from the classic *Monograph of the Cranes* by Frans Ernst Blaauw (1897). Only 170 copies of Blaauw's work were printed and thus a comprehensive idea of what the various cranes look like is not widely available.

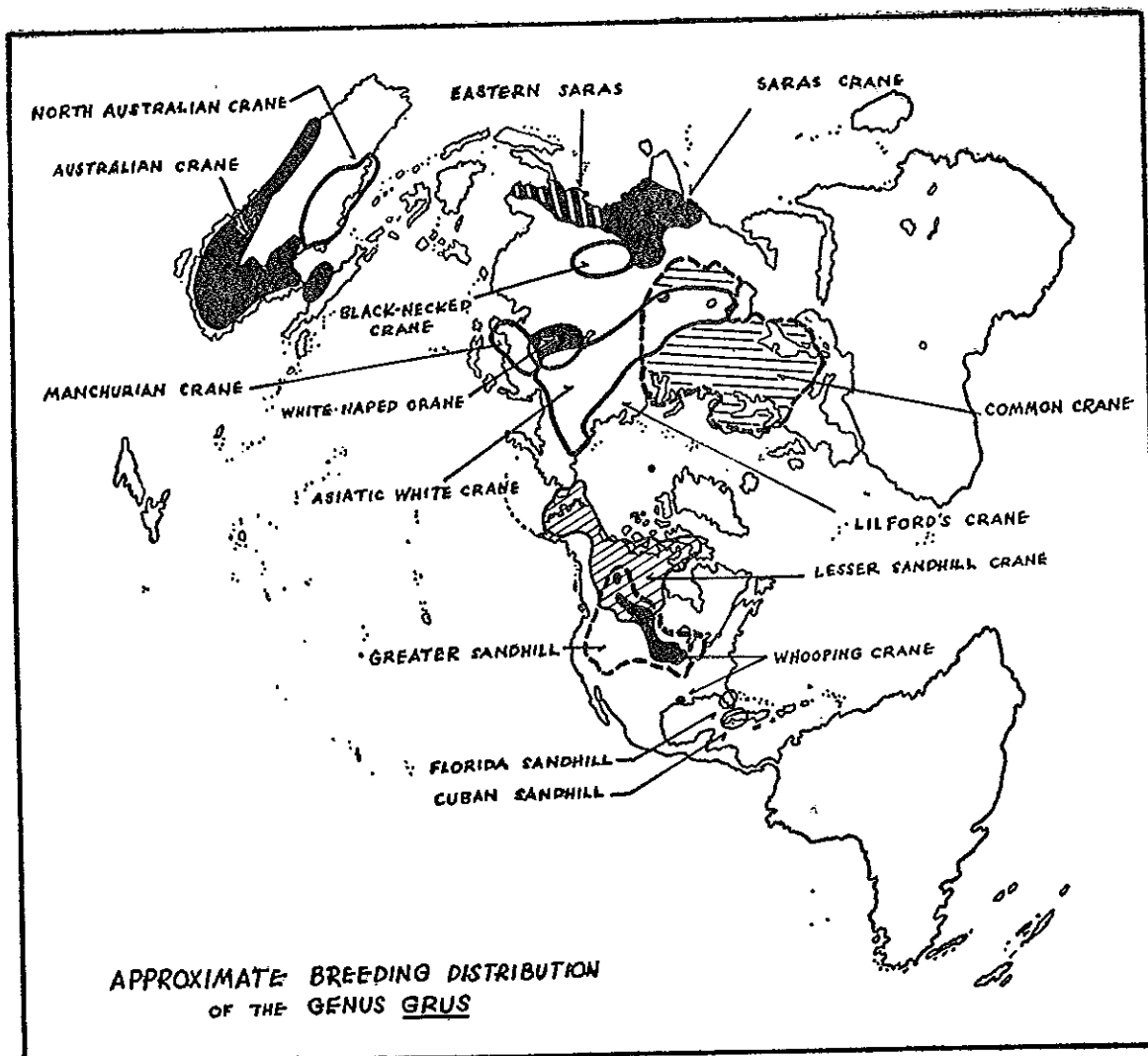
THE COMMON CRANE (*Grus grus grus*)

Range: Breeds from Scandinavia, Finland, Livonia, Russia and west Siberia, south to Germany, the Balkan States, Asia Minor and Turkestan; locally in southern Spain and northern Italy. Winters in the Mediterranean countries and in northeastern Africa south to Kordofan and Ethiopia.

Description: General color of the *adult bird ashy or pearl gray, slightly shaded with brown*. Primaries and primary coverts, secondaries and tail blackish. Tertials falcated, decomposed and erectile. In color the tertials are either light or dark gray with black tips or, rarely, uniform slaty black. *Forehead and crown bare*. Skin of forehead and fore part of crown black and covered with black hairs. Remainder of crown red and granulated. Rest of *head and neck dark slate with a white band beginning behind each eye and running along length of neck*, meeting behind on lower part of neck. Bill greenish, pink at base. Iris yellow. Legs grayish horn color. The immature bird is like the adult but all feathers have brown margins. The down of the chick is a yellowish-buff with rich chestnut on the back.

LILFORD'S CRANE (*Grus grus lilfordi*)

Range: Known breeding area is in Transbaikalia or Tarei-nor and the Onon and Argun Rivers; the breeding range probably extends from the basin of the Yenessei eastward. Winters in China, Island of Hainan and northern India.



Breeding Ranges of Cranes of the Genus *Grus* Show a Wide Distribution. Not Included Are Cranes of the Three Other Genera, All of Which Are African, although the Demoiselle Crane also Reaches Europe and Asia. The Breeding Limits of the Hooded Crane (*Grus monacha*) Are Uncertain and Are Not Included.

Description: A geographic race of the preceding, which it resembles.

BLACK-NECKED CRANE (*Grus nigricollis*)

Range: Breeds about the lakes of high central Asia from Ladak to Koko-nor. Recorded in winter from Yunnan and Tonkin.

Description: General color of adult a very pale ashy gray, passing into white when the feathers get older. Feathers of back with darkish shafts and yellowish margins. Under parts almost pure white with slight amount of yellowish. Tail black, upper coverts grayish, under coverts white. Primaries and most of secondaries

black. Tertiaries falcated, elongated, slightly decomposed and erectile. Alula black with pale gray coverts. *Crown naked* with a rough red skin covered with a few small hairs. *Rest of head and upper part of neck smoky black. A small white spot behind each eye.* Bill greenish horn color. Iris yellow. Legs black.

HOODED CRANE (*Grus monacha*)

Range: Breeding range not definitely known, but the species is recorded either in summer or as a spring and fall migrant in southeastern Siberia from Lake Baikal to the Amur, south to northwestern Mongolia and Ussuriland, also in Korea and Japan. Winters in China south to the Yangste Valley.

Description: General color of *adult slaty gray with brownish margins* to feathers of upper surface, especially wing coverts. Primaries and secondaries, *tail and tail coverts slaty black.* Tertiaries lengthened, falcated, decomposed and drooping. Forehead covered with black, hair-like bristles. *Fore part of crown bare* with rough, red skin and a few black hairs. *Remainder of head and greater part of neck pure white,* slightly tinged with gray, but pure white in breeding season. Bill yellowish horn color. Iris orange brown. Legs and feet black horn color.

The immature bird is uniformly brownish black and attains full adult plumage in the third year. The chick is not described.

LESSER SANDHILL CRANE (*Grus canadensis canadensis*)

Range: Breeds on the Arctic coast of eastern Siberia (summer specimens known from Cape Baranov) and the Chukchi Peninsula; known to breed on St. Lawrence Island, and from northern and western Alaska, Melville and Baffin Islands south to the southern mainland of Alaska, southern Mackenzie and Hudson Bay. Winters from California and Texas south to northern Lower California and central Mexico.

For a more detailed description of the ranges of the various Sandhill Cranes see Walkinshaw (1949b, appendix B).

Description: General color of *adult gray,* lighter and ranging to bluish gray on neck. Breast and upper wing coverts with lighter gray margins tinged with brownish. Primaries blackish with light shafts. Secondaries dark gray. Tertiaries gray, slightly tinged with brownish, slightly falcated but not decomposed. Tail slaty gray. *Crown bare,* granulated and *bluish pink,* with a few black hairs. *Feathers beneath eye and on cheeks and throat, white.* Bill grayish horn color. Iris brownish yellow. Legs and feet blackish.

The immature bird is similar but the head is feathered and the entire plumage mixed with rusty brown. The chick is covered with yellowish brown down, lighter to white on underparts and chestnut brown on back and across wings.

For additional details see Walkinshaw (1949b, pp. 11-12).

GREATER SANDHILL CRANE (*Grus canadensis tabida*)

Range: Bred, formerly, from British Columbia east to western Ontario and south to northern California and Ohio; now breeds chiefly from British Columbia to Manitoba and south to northern California, Wisconsin and Michigan. Winters from California, Texas and Louisiana south to Mexico.

Description: "All plumages similar to the corresponding stages of the nominate race, but larger" (Ridgway and Friedmann, 1941). Peters (1925) states that it is similar to the Florida race but paler throughout, especially on the occiput and back of the neck. Also, wing and bill measurements longer than in Florida bird, tarsus shorter. See also Walkinshaw (1949b).

FLORIDA SANDHILL CRANE (*Grus canadensis pratensis*)

Range: Southern Georgia and peninsular Flor-

ida, probably also southern Louisiana and Alabama (Peters, 1941). Walkinshaw gives more details and confines its present distribution to relatively small areas in Georgia, Florida and Mississippi (Walkinshaw, 1949b). In Florida "there are three general areas . . . where the birds are found. The great bulk of them are inhabitants of the Kissimmee Prairie, but this area may be considered to have two extensions. (One is a certain small portion of the St. Johns River marshes of Brevard County, and an area about Punta Gorda and Sarasota on the west coast.) The second and main area is in the northern part of the state between Gainesville and Palatka. The third is in the Big Cypress, Everglades, in the general vicinity of Immokalee, the group there ranging into Lee, Henry, and Collier counties" (Beard, *et al.*, 1942). On the whole, as with the Greater Sandhill Crane, the range has been reduced since former times.

Description: "All plumages as in *Grus canadensis canadensis* and *Grus canadensis tabida*, but larger than the former, and the adults with the occiput and hind neck darker than the latter" (Ridgway and Friedmann, 1941). See also Walkinshaw (1949b).

CUBAN SANDHILL CRANE (*Grus canadensis nesiotus*)

Range: Isle of Pines and western Cuba (Peters, 1934). Western Pinar del Rio—chiefly in arid savanna country—Vinales, Mendoza; Guane; Mantanzos Province—Alacranes; Union de Reyes; Aguada de Pasajeros; Puerto Principe, all in Cuba. On the Isle of Pines: Pasadeta, La Vega and Los Indios (Ridgway and Friedmann, 1941). Walkinshaw (1949b) found this race near Los Indios, Isle of Pines, and had reports of them in western Pinar del Rio and possibly other remote areas of southwestern Cuba. There may also be other groups of this race in the Gran Cienaga de Zapata in southern Cuba, according to Walkinshaw.

Description: "Similar to *Grus canadensis pra-*

tensis but smaller, with shorter tarsus; bill shorter and relatively heavier" (Ridgway and Friedmann, 1941). See also Walkinshaw (1949b).

MANCHURIAN CRANE (*Grus japonensis*)

Range: Breeds in Manchuria, the Ussuri region north to the middle Amur, and Korea. Winters in eastern China south to the Yangtze Valley. Occurs in Japan on migration.

Description: General color of *adult pure white, secondaries black. Tertials black*, pointed, broadened and somewhat pendant, some of them being more or less decomposed and erectile. *Throat and cheeks slaty gray or dark pearl gray, continuing down the neck on each side* and meeting near the base of the neck behind. *Forehead and crown bare, papillose and crimson.* Black hairs on forehead. Bill greenish horn color. Iris dark brown. Legs grayish black.

The immature bird is all white mixed with cinnamon brown. Neck stripe coffee brown. Secondaries dull black and primaries white with black points (individual about one year old). A three weeks old bird showed brown edges to all the feathers. The chick is cinnamon brown, darkest on the back and shoulders. Its bill and legs are a grayish flesh color.

WHOOPIING CRANE (*Grus americana*)

Range: See the chapter on *Distribution* in this report.

Description: See the chapter on *Molts, Plumages and Anatomy* in this report.

WHITE-NAPPED CRANE (*Grus vipio*)

Range: Breeds from Transbaikalia and northwestern Mongolia east through Manchuria to Ussuriland. Winters in Korea and eastern China and south to the Yangtze. Occurs in Japan on migration.

Description: *Adult slaty gray above*, the wing coverts lighter and the greater coverts white at the ends. Primaries blackish with white shafts, *secondaries blackish* with white bases. *Tertials*

white, falcated, lengthened and pendant. Tail dark gray. *Forehead and eye region bare*, with red skin to behind ears, which are covered with a patch of gray feathers. Black hairs over the red skin, especially at base of bill. *The whole hind part of neck, from crown to mantle, white. Also sides of upper neck and throat.* Remainder of neck and underparts, dark slaty gray. Bill greenish. Iris brownish yellow. Legs bluish pink.

The immature bird is cinnamon brown, the throat yellowish white and a grayish yellow beneath. Tail and wing feathers blackish gray (individual 85 days old).

SARAS CRANE (*Grus antigone antigone*)

Range: Breeds in northern India from the Indus to western Assam, south to the Bombay Presidency on the west and to the Godavery River on the east.

Description: Adult a uniform bluish gray. Primaries darker gray, secondaries ashy gray on outer webs, lighter on inner webs. *Tertials almost pure white*, elongated but not decomposed. *Neck below bare portion, pure white, forming a collar. Head and upper neck bare*, except gray feather patches over ears, and *scarlet* and papillose, except forehead and crown which are pale ashy green. Black hairs on throat forming a beard that is especially prominent in male birds. Bill greenish horn color. Iris brownish yellow. Legs bluish pink.

The immature is brownish gray, the edges of the feathers cinnamon brown. Head and upper neck feathered and brown. Chick yellowish brown-buff, darker on the upper parts.

EASTERN SARUS CRANE (*Grus antigone sharpii*)

Range: Eastern Assam, Burma, Siam and CochinChina.

Description: Like the Saras Crane of India but *no white color on neck and the tertials are gray instead of white.* Beard less prominent. It is also *slightly smaller.*

The immature is similar to that of the Indian Saras and the chick is considered almost identical in appearance.

NORTH AUSTRALIAN CRANE (*Grus rubicunda argentea*)

Range: Northwest Australia and Northern Territory.

Description: Similar to *Grus rubicunda rubicunda*.

AUSTRALIAN CRANE (*Grus rubicunda rubicunda*)

Range: Eastern and southern Australia and the swampy lowlands of southern New Guinea.

Description: Adult bluish gray. Primaries black and secondaries gray. Tertials elongated, broadened and bent. Tail gray, blackish towards tips. *The crown is feathered and olive green. Coral red and bare around the ears* except for a small patch of gray feathers over the ear. *Orange above and below eyes*, less brilliant on sides of face, which, with gular sac, is covered with fine black hairs. The gular sac is pendulous in old males. Bill olive green. Iris fine orange yellow. Legs and feet purplish black.

The immature is gray mixed with brown and has a feathered head.

ASIATIC WHITE CRANE (*Grus leucogeranus*)

Range: Breeds locally in southeastern Russia and in Siberia from the lower Ural River, the Tobol, the mouths of the Yana, Indigirka, and the Kolyma rivers south to Turgai, the upper Ob, northern Turkestan, Transbaikalia and Ussuriland. Winters in northwestern India and in China.

Description: The adult is pure white, primaries, primary coverts and alula black. The forehead and face bare and red to the eyes, with fine white hairs at the base of the upper mandible in front, black hairs where the skin meets the feathers of the crown and at the base of the lower mandible. Bill not described. Iris sul-

phur yellow. Legs flesh color. The immature is white mixed with cinnamon brown.

WATTLED CRANE (*Bugeranus carunculatus*)

Range: Eastern and southern Africa from Somaliland to Benguella, Damaraland, Cape Province and Natal.

Description: The adult is ashy gray above. Lower back, rump, upper tail coverts and tail black. Mantle blackish gray, sometimes washed with brown. Primaries black, greater coverts pearly gray. Secondaries grayish black. Tertiaries black, enormously lengthened and pendant. The crown slaty gray. Entire neck, nape to mantle, and the sides of the face and throat, white. White feathers of chest elongated. Base of bill naked and granulated to nostrils, some of the granulations forming fleshy threads. This bare skin is red. "On the lower mandible the granulated red skin extends as far as beneath the middle of the eyes, and continues, but without granulations, to the fore part of the feathered lappet which hangs on each side of the throat." Bill brownish horn. Iris orange yellow. Legs grayish black.

The immature and chick are not described.

DEMOISELLE CRANE (*Anthropoides virgo*)

Range: Breeds in southeastern Europe and the greater part of central Asia from Kiev, Turgai Province, Government of Tomsk, the upper Lena River north to latitude 60 degrees N. and on the Yana River; south to the Dobruscha, lower Ilek River, the Tian Shans, the Altai and northern Mongolia; also on the high plateaus of Algeria and perhaps in Morocco and southern Spain. Winters in northeastern Africa to the White and Blue Niles and Ethiopia; in India, Burma and China.

Description: General color of adult bluish pearly gray. Alula, primaries and primary coverts blackish washed with gray. Secondaries partly slate color, blackish towards ends. Tertiaries enormously elongated, gray with dark tips, fal-

cated and pendant. Tail dark gray. The crown is gray. Remainder of head slaty black, continuing on the throat and down the neck in front. Feathers of foreneck elongated and pendant. A white streak of feathers extends from above the ears in an elongated, silky plume. The bill is grayish olive with a reddish tip. Iris crimson but varies. Legs grayish horn color.

The immature is similar but more dusky. The ear plumes are small, gray tufts. The chick has yellowish white on the head, with the rest of the body brownish gray.

STANLEY CRANE (*Anthropoides paradisea*)

Range: High veld region of Africa south of the Zambesi.

Description: General color of the adult bluish pearl gray. The feathers of the upper parts show ashy gray margins. Primaries black, secondaries dark gray. The tertiaries are gray with black tips, enormously elongated, falcated, pointed and nearly touching the ground. Foreneck feathers elongated and pointed. Loes and crown white. Feathers of the cheek, ear region and nape dark ashy gray, lengthened, disintegrated and loose, forming a sort of ball. Bill flesh color. Iris blackish brown. Legs grayish horn color.

The immature is similar but lighter. The chick is pearly gray with a yellowish head.

CROWNED CRANE (*Balearica pavonina pavonina*)

Range: West Africa from Senegal to Lake Chad and south to Sierra Leone, Gold Coast, northern Nigeria and the middle Shari River.

Description: Adult dark slaty gray to black above and below. Upper parts darker, the feathers pointed and more or less falcated. Wing coverts white. Tertiaries straw colored and of disintegrated plumes. Alula and primary coverts white. Primaries black. Secondaries maroon-chestnut. The tertiaries are broad, long and slightly decomposed. Tail black. The crown is covered with velvety black feathers, the occiput

with tufted, straw-like feathers, tipped with black. The lores, side of face and cheek bare. This area is white on the upper half, pink on the lower half. The throat has a patch of black, down-like feathers, and below that, on the mid-throat, there is an area of bare red skin, folded vertically. The feathers of the lower neck are elongated, lanceolate and lighter in color. The bill is black. Iris white. Legs black.

The immature is black, the upper parts edged with rufous, the under parts with sandy buff margins. The white wing coverts are edged with rufous and have black subterminal markings. Head and neck sandy rufous. Crown chestnut with a black base. Lores bare. The face and cheek is covered with down. The chick is yellow beneath and dark chestnut and brown above. The down on the crown is lengthened.

NILE CROWNED CRANE (*Balearica pavonina ceciliae*)

Range: Nile Valley from Khartoum south along the Blue and White Niles to Fashoda, east to the Hawash Valley and the Ethiopian lakes.

Description: Similar to the preceding (see Mitchell, 1904).

EAST AFRICAN CROWNED CRANE
(*Balearica pavonina gibbericeps*)

Range: East Africa from eastern Belgian Congo, Uganda and Kenya Colony south to central Tanganyika Territory.

Description: Similar to *Balearica pavonina pavonina* (see Reichenow, 1892). Of this race Evans (1909) says, ". . . the bare skin of the face extends almost to the nape."

CAPE CROWNED CRANE (*Balearica pavonina regulorum*)

Range: Africa from the Cunene, Nyasaland and Portuguese East Africa southward; absent from the southern part of the South-West African Protectorate and the western half of Cape Province.

Description: The adult is similar to the nominate race but lighter. The pendant wattle at the throat is bright red. There is more white on the bare skin of the face and this area appears more or less swollen. Iris grayish white and legs and bill black horn color.

The immature bird is like that of *B. p. pavonina*. It shows a yellow-white down on the wattle space. Chick similar to that of the nominate race.

Students interested in the taxonomy of the cranes may refer to Peters (1934), Ridgeway and Friedmann (1941) and the key contained in Appendix A of Walkinshaw's monograph of the Sandhill Cranes (Walkinshaw, 1949). Blaauw (1897) gives some details as to the habits of the various forms. No attempt will be made here to compare these other cranes with *Grus americana*. It should be pointed out, however, that the Whooping Crane of North America is apparently the only species, of fourteen full species and twenty-three races described over the world, that is now faced with the threat of extinction.

This situation constitutes an obvious challenge to everyone in the United States and Canada who is actively concerned with the preservation of our heritage of wilderness and wilderness forms that are of outstanding inspirational and spectacle value. Among the living, animal examples of this heritage the Whooping Crane stands forth as an imposing symbol of our best hopes. We are determined that these hopes shall be fully realized.

Part I. Distribution

LIKE the bird itself, the range of the Whooping Crane is big and impressive. During the nesting season in summer, it reaches far into the Canadian wilderness, but in autumn the *Wapo Oocheechawk* of the Cree becomes the *Grulla Blanca* of the Mexican. At the northern limit of their distribution, these great birds once crossed the Arctic Circle and apparently nested close to the Arctic Sea, while in winter, far to the south, they were seen on the high plateau of central Mexico, below the Tropic of Cancer. The abandoned site of old Fort Anderson, near the northernmost tip of the District of Mackenzie, where from 1862 to 1865 Roderick Ross MacFarlane saw migrant Whooping Cranes in both spring and fall, lies at approximately 68° 30' North Latitude. The region of La Barca, near Lago de Chapala, Jalisco, where E. A. Goldman had reports of the species as late as the winter of 1903, lies very near 20° North. These two points, some 48 degrees of latitude apart, appear to be the northern and southern extremes at which *Grus americana* has actually been recorded.

We can only theorize why a bird must range to such extremes of latitude, but we can learn much concerning its habitat preferences within the geographical—and, more significantly, the ecological—limits of its distribution. The range of this species, though continental in spread, demonstrates a definite choice of certain natural areas in which it has been found during the different seasons and according to the various phases of its life cycle.

Essentially the Whooping Crane would appear to be a bird of the interior grasslands of North America, but this is only true in a general way and needs considerable defining. In the United States and Mexico, the range of the migratory birds is well marked at its eastern limit by the curving line of the Grama Grass-Antelope Biome as delineated by Shelford.¹ To the west, the 3000-foot contour, more or less an

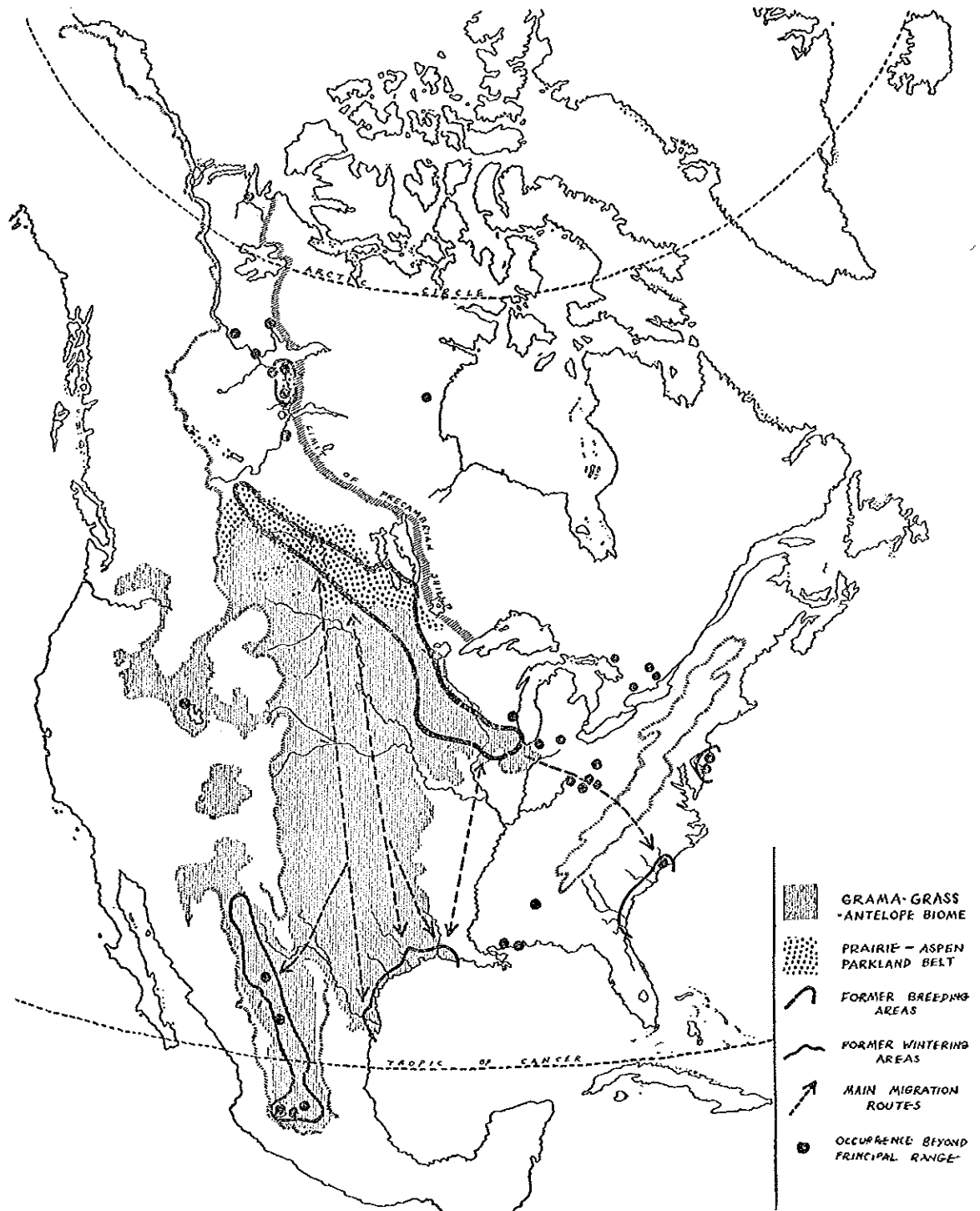
indicator of the western boundary of the Great Plains, is a reasonably accurate limit in that direction. Thus, to some degree, the limiting factor to the west would appear to be elevation, for the grasslands extend westward to the Cascades of Washington and Oregon, but the Whooping Crane has not been reported from that region with any certainty and it is far removed from their normal track. Originally, within the United States, it was the lush prairie communities extending from the central Illinois marshes northwestward across northern Iowa, western Minnesota and eastern North Dakota, that were attractive as nesting habitat. There were sound ecological reasons for this, as will be discussed later. The higher grasslands, like the semi-arid plains, were evidently not suited to the special demands of the nesting birds.

The several habitats of the original winter range—high grasslands in Mexico and central Texas, coastal lagoons and beaches in Texas and tallgrass prairie, sea-rim and brackish coastal marshes in Louisiana—present a variety of considerable interest, and it will be seen that all of these contained features in common, that are essential to their regular occupancy by Whooping Cranes.

The grasslands extend sparsely into southern Manitoba, where some tall grass is present in sections, now mostly under cultivation, but there are more extensive areas in southwestern Saskatchewan and southern Alberta. In those two Provinces the grass is the short variety of the more arid regions. Available records demonstrate that nearly all Canadian nesting of the Whooping Crane has been in aspen parkland habitat, or the closely allied transitional belt that lies between plains and parklands. There are not even many occurrence records from the plains areas and this is notably true for the wide stretches of this type in Saskatchewan and Alberta. There appears to be greater precipitation in the parklands, and the black soils of these areas are evidently better adapted for holding surface water. At any rate the shortgrass

¹ Shelford (1935).

THE WHOOPING CRANE



The Original Range of *Grus americana* in Recent Times Related to Major Habitats.

plains do not provide the shallow sloughs, bulrush, cattail and sedge marshes and ponds in the abundance and variety that constitute true Whooping Crane country.

These facts suggest that, in order to evaluate the distribution of the species, we must learn a good deal about its relationship to the environments in which it lives. To understand the distribution we must know something of the ecology involved.

When approached from this point of view, the subject of Distribution, instead of a dull recital of the bare names of obscure hamlets and forgotten byways, becomes vital and alive, like the flesh and blood creatures in whose movements we wish to find an understandable purpose and rhythm. There are also these additional considerations: in any comprehensive appraisal of the range of the Whooping Crane we are dealing, not only with an area of tremendous size and diversity, but with an extended period of time. If we are to start at the beginning we must go back into prehistory. After that, for a century and a half after civilized man met with and described the species, we must find our way haltingly along trails that are poorly and often incorrectly marked. In so doing, it will lend some order to our march, if we set down the mileposts in chronological succession. The first of these lies somewhere in the dimly discerned Pleistocene.

Prehistory Period

We can assume, from existing information, that the Whooping Crane first appeared during the early Pleistocene. Just where this appearance fits in with the advance and retreat of the various ice caps, we can only guess. It seems likely that the spreading layers of ice were major factors in the distribution of the species during that period. The entire breeding range of Recent times lay within the glaciated area, and though we can only theorize that the big cranes nested on the Gulf Coast and elsewhere during these

prolonged and repeated intervals, this theory might account for the wider distribution of the Pleistocene and for the seemingly incongruous Gulf Coast nesting of very recent years.²

We do not know the status and dispersal of the human animals of that early period in North America. It seems likely that the bird, that was to become *Grus americana*, sounded its loud bugle call across the vast prairies and wet savannas of a continent that as yet had no human inhabitants. We feel reasonably certain that the Pleistocene may have been its heyday. Instead of being confined to a relatively restricted belt through the interior length of the continent, it ranged from southern California east and north to Idaho, still farther east to Kansas, and on, all the way to the Atlantic Coast near the present site of Melbourne, Florida. In addition to our theory regarding the pressure of the ice caps on distribution, we may suppose that in that early day there were more grasslands, and especially more extensive savannas, than in the Recent period. Also, the continental water table may have been higher.

In our studies of *Grus americana* we have been impressed by the fact that this crane is more of a water bird than the other North American forms of the Genus *Grus*. Closely related to such groups as the limpkins, rails and sun-bitterns, it is evident that the cranes evolved from strictly marsh-dwelling ancestors. All of them continue to spend a portion of their life cycle in marshes or on wet prairies, all build their nests in or not far from water, but the Sandhill Cranes have "graduated," in a sense, in that they have become more of an upland species than *G. americana*.

In discussing birds in relation to their habitats, James Fisher (1939) says, "Some birds, like cranes, originally adapted for wading, may desert swamps and shores and return to plains." I am not sure if this constitutes a "return" or a sort

² The modern nesting of the White Pelican on the Gulf Coast in Texas and Mexico is another case in point.

of evolutionary "graduation" as already suggested. At any rate, it is very apparent in the Texas winter quarters, that the Whooper prefers the marine habitat while the Sandhill remains in the uplands. Whereas the Whooper is seldom observed above the three-foot contour, the Sandhill is rarely seen below that line. For one thing, there is a difference in feeding habits. The Whooping Crane, in that region, feeds almost entirely on animal items, chiefly decapod crustaceans, while the Sandhill feeds largely on acorns and other vegetable matter, including waste grain in the farmlands.

Even as such things go, there is very little Whooping Crane material from the prehistory period. Bone fragments, representing the remains of no less than seven birds of this species, have been identified. Until a few years ago it had not been recorded as a fossil. Then material, from excavations that had been made in various sections of Florida, was studied by Dr. Wetmore and a number of fragments were identified as belonging to *Grus americana* (Wetmore, 1931). It is of considerable interest to note the other bird species present in the same Pleistocene deposits, birds that, like the Whooper, are not found in the Florida of today. Altogether there are nine forms in this category:

Whooping Crane	A small gray crane
Trumpeter Swan	A shearwater
California Condor	A South American eagle
Jabiru Stork	A tropical wood rail
Mexican Turkey Vulture	

The shearwater was *Puffinis puffinis*, and the small gray crane was either the Lesser Sandhill or the Cuban Sandhill. This list seems to go along with the suggestion that conditions during the Pleistocene were favorable for a wider distribution of many birds, as well as for the existence of larger forms. It should be noted that the topography of Florida was quite different during the Ice Age than it is today. The slow formation of the great ice caps, and the equally

slow melting stage that followed, had an important effect on sea levels.³ During the times of melting ice the sea levels were high and while a new ice cap was being formed the levels subsided. When trumpeter swans, jabiru storks and Whooping Cranes were searching for food along the same shorelines, the Pamlico Sea may have covered all of southern Florida up to the 25-foot level. Later on, after the Peorian interglacial stage, this sea receded and, during the last (Wisconsin) ice period, there was a lower sea level, possibly 25 feet below the present level.⁴ Both extremes must have presented conditions that favored many kinds of water birds, causing, as they undoubtedly did, widespread movement and dispersal of marine animals, a gradual but constant ebb and flow of marine life in new environments, and by change, turning over the sea life as a gardener's spade turns and reenergizes the soil.

The Florida deposits where Whooping Crane remains were found are as follows (Wetmore, 1931):

1. Seminole Field, Pinellas County ... fragments of metacarpus, tibiotarsus and femur and three ulnae (W. W. Holmes).
2. Itchtucknee R., Columbia County... two fragmentary ulnae and one radius (Fla. Geol. Surv. Coll.).
3. Melbourne, Brevard County part of an ulna (Stratum No. 2, 1930, Gidley).
4. Melbourne, Brevard County part of an ulna (Stratum No. 2, 1929, Singleton, M.C.Z.).

From the above, it is evident that at least four Whooping Cranes are represented in the Florida deposits, using the ulnae as criteria, two from Seminole Field and one each from the other diggings.

³ Davis (1943).

⁴ Vaughn (1914).

The Rancho La Brea (California) example consists of a small tibial fragment (Miller, 1925; 1944), and the Snake River (Idaho) material is also a well-preserved tibial fragment (Miller, 1944). This last is from late Pliocene or early Pleistocene.

There is also a fragmentary maxilla listed as *Grus americana* in the U. S. National Museum (No. 346687) from diggings in Scott County, Kansas.

In all there are, at a minimum, seven individuals represented by this material. Their wide distribution is of particular interest.

The Ice Age has been dated at perhaps 300,000 B.C. to 10,000 B.C. In this dim past, when the great sheets of ice crushed and ground their way as far south as Central Europe, and in North America, as far as Ohio, primitive man appeared. It is thought that he did not reach our hemisphere until about 18,000 B.C., but this is mere theorizing and these figures are altered each time new evidence of one sort or another is uncovered. It is interesting to speculate, however, that the Whooping Crane's first contact with man could have taken place in northwest Canada, for it is not difficult to visualize those distant ancestors of our American Indians—squat, Neanderthal-like Mongolians—pushing relentlessly upstream along the Mackenzie route, spurred on by the restless urge that was to carry them the length of two continents, to the farthest south land of the Fuegians.

Our first recorded contact between man and *Grus americana* is much, much later, nearly 20,000 years later, more or less. The centuries between are a misty blank, a period of slow growth or gradual recession, of dynamic change or static withdrawal, of fierce struggles between animals and plants and the great physical forces that shape the earth's destiny. But it saw the dawn of the Age of Man spread until it had touched every continent and covered every sea.

Grus americana, unchanged, moved through these shifting scenes with the same nobility, the same dignity we know today. After unknown

generations of existence, the drama—the tragic drama—of its meeting with “civilized” man was about to unfold.

Captain Amadas to Mark Gatesby (1584-1722)

During the early days of exploration and the first coastal settlements by Europeans on the shores of North America, there appeared in the literature a number of references to “cranes,” all of them somewhat ambiguous. If Whooping Cranes were present at that time on the Atlantic Coast—and definite evidence from New Jersey, South Carolina and possibly Georgia and Florida was to be obtained later—the comments of these adventuresome gentlemen, while not by any means conclusive, are at least interesting. Some of these reports can be discarded on first examination, others, while not actually acceptable, could have referred to this species.

The first of such items, one that has been frequently quoted⁵ as a definite allusion to *Grus americana*, is the account of the landing, on Wokokon Island in Pamlico Sound, by the party of Captain Philip Amadas.⁶ On going ashore the men, “having discharged their harquebass-shot, such a focke of Cranes (the most part white) arose, with such a crye, re-doubled by many ecchoes, as if an armie of men had showted altogether.” Forbush (1912), accepting the birds as Whooping Cranes, comments: “These birds probably were breeding there, as otherwise they would not have been there in such numbers at that season. The great cry described could have been produced only by Cranes.” The season was July, the latitude approximately 35° N. (more than 250 miles to the south of the southernmost breeding record claimed for Cape May), and we have to stretch our credulity to even consider the possibility of the Whooper breeding in this location. Nevertheless, their presence is not wholly impossible

⁵ Pennant (1785); Turnbull (1869); Forbush (1912); etc.

⁶ Hakluyt (1589).

on this score alone. Less convincing is the apparent size of the "flocke." From our present knowledge of the species, gregariousness, even on the wintering grounds, is not a characteristic of the Whooping Crane. Nor does the word "crane" necessarily refer to the Genus *Grus*. These could have been great post nuptial flocks of egrets and the "crye" could have been the voices of terns, gulls and skimmers also present on the island, but not specifically noted by the chronicler. On the other hand, at a much earlier date, the *Gruidae* were known as "cranes," and evidently differentiated from the "herons." The "grues" were known to the ancient Greeks and were hunted throughout Asia and in England of the Middle Ages.

Samuel de Champlain⁷ listed a number of birds, including both "herons" and "cranes," on Cormorant Island, Cape Sable (Hope Island), Nova Scotia. Some of the names he used are difficult to identify but he appears to have seen puffins ("sea-parrots"), "cormorants, three kinds of ducks . . . Snipe . . . large sea-gulls . . . ospreys," to give the names of those that are easily recognizable. The large gull was probably *Larus marinus*. This location is some distance from the nearest known breeding or occurrence of either the Greater Sandhill (Rond Eau, Ontario), or the Little Brown (Cape Eskimo, Southampton Island), but, once again, we cannot be sure but that many distributional changes took place between this early date and the advent of reliable records. However, there seems no reason to suggest that *Grus americana* could have been referred to in this instance, and we must reject the location entirely.

Champlain also described many "cranes, white as swans," in the eastern part of Lake Ontario in 1615. There are four reports of Whooping Cranes for Ontario between 1871 and 1900. Three of these are from areas close to Lake Ontario, two near the eastern part.

Another early account from northern lati-

⁷ Champlain (1604-1610).

tudes, one that has come into the literature of *Grus americana*, seems equally equivocal, but, as with Captain Amadas' "cranes," we will mention it, if only for the sake of questioning the already published claim (Christy, 1894) that it may have referred to this species. This has already been done, as a matter of fact, by Dr. Sutton (1932) who quotes from Capt. Luke Fox's journal of 1631 as follows:

At Marble Island (Note: Marble Island is on the northwest side of Hudson's Bay approximately 200 miles north of Eskimo Point.) on July 29 he saw "great store of Fowle, especially water-fowle. . . . They brought on board two goodly Swannes, and a young Tall Fowle alive; it was long-headed, long-neckt, and a body almost unanswerable. I could not discern whether it was an Estridge or no, for it was but pen-feathered. Within 3 or 4 dayes, the legges by mischance were broken and it dyed."

Christy, in commenting on this passage (1894, p. 375) says in a footnote: "Fox's idea of an ostrich (or 'estridge' as he calls it) in the Arctic regions is very comic. The bird was, no doubt, a young Whooping Crane (*Grus americana*), or perhaps a Sandhill Crane (*Grus canadensis*). The Master calls it 'a young stork'."

Sutton comments: "The bird was more than likely a Little Brown Crane, *Grus c. canadensis*." Sutton (1931) previously pointed out that while the Southampton Island Eskimos know the Little Brown Crane, and call it (from the voice) *Tutteeghuk* or *Teteeghuk*, they have no name for the Whooper. Farther south, however, along the west shore of Hudson's Bay near Nunalla, the natives use the same name (*Tutteeghuk*, etc.) in referring to the Whooping Crane. Nunalla is below Eskimo Point at about 60° N. latitude. Certainly it is more likely that Fox's "Estridge" was an immature Little Brown, but in view of the early year, the remarks of Dr. Sutton with regard to the apparent familiarity of the Nunalla Eskimos with Whooping Cranes, and the fact that the latter species is known to have reached at least 68° N. latitude farther west, we must place this location on the "possible" list.

Forbush also thought well of the report of

David Pieterszoon De Vries⁸ of white cranes near the mouth of Hudson River and along the Achter Col (the Back Bay, i.e., Newark Bay). DeVries mentioned "white and gray cranes" as well as "white and gray herons in great numbers." It is perfectly possible that Whooping Cranes might have occurred at this point as early in the history of the colonies as the 1630's, but the record must remain hypothetical. "Cranes" were likewise mentioned by several chroniclers of 17th Century New England, and these are quoted by Forbush as possibly referring to *Grus americana*. I would question as uncertain the use of the word "crane" by Hubbard⁹ in his *General History of New England* (1610). Morton¹⁰ (1632) may have meant the Sandhill Crane. The reference in Wood's *New England Prospect* (1629-34)¹¹ is likewise too uncertain to have any value.

There was just enough historic rumor of the Whooping Crane's presence in New England, during these early years, to set up a sort of tradition on the subject. Yet no specimens have been or are today in evidence. In 1868 Coues (1868a) stated flatly, "It's occurrence (in New England) must be regarded as extremely problematical." Coues was speaking, not only for contemporaneous New England, but for colonial New England as well. Just to clinch the matter he wrote, in a later publication (Coues 1874a), "I find no satisfactory evidence of its occurrence in New England. . . ." Nevertheless, in his *Revised List of the Birds of Massachusetts* (1886), Joel Asaph Allen said, "Unquestionably occurred at the time of first settlement."¹² Cooke (1914), reviewing the records, considered that

the species was seen in Vermont and Massachusetts in colonial times, but that it "ceased to visit New England 100 years ago" (circa 1814).

The vague reports of the colonial period, and later give the impression that if the bird did occur in New England at all it must have been as a straggler. We cannot overlook a number of seemingly authentic Atlantic Coast records for locations to the south of New England, including those of Wilson and Turnbull for southern New Jersey (the individual pictured by Wilson was No. 3704 of the Peale Museum and, according to Dr. Mease,¹³ this specimen came from "the Capes of the Delaware"), as well as the Waccamaw River specimen in the Charleston Museum and the fresh skin from which Catesby painted his portrait of the species while in South Carolina. The Whooping Crane did occur in several places in Florida during the Pleistocene, and survived on the Atlantic Coast until at least 1857, which is the date of Turnbull's Beesley's Point record of three birds. As to the abundance and general distribution of the species along the Atlantic Coast at the time of the first settlements, we simply do not have conclusive data. That it was there we can be sure, but we can add little more by way of details.

Probably these Atlantic Coast birds, including those in New Jersey, migrated in the spring in a northwesterly direction. We know of no breeding reports east of Illinois (except the indefinite Cape May claim) and there are no egg sets from any point east of Iowa. Butler (1898), may have been correct in reporting that they once nested in the Kankakee Marshes of northwest Indiana before that area was drained, but there is no real evidence of this. If, as we may suppose, Atlantic Coast birds moved towards breeding grounds somewhere to the northwest, their route would certainly miss New England completely. There are sight records of the species at a few points in Ontario, one Ontario specimen (Ma-

⁸ De Vries (1655).

⁹ Hubbard (1610).

¹⁰ Morton (1632).

¹¹ Wood (1629-1634).

¹² Apparently after Emmons (Hitchcock, 1835) and Thompson (1853). Zadock Thompson wrote: "Occasionally seen during its migrations in Vermont," but substantiation is lacking. See also Allen (1876) and Stearns (1883).

¹³ Mease, 1811; Burns, 1932. This specimen is now M.C.Z. No. 67828.

coun, 1900), and one questionable kill record from Cayuga Lake, New York. Birds at these points, as in New England, would almost certainly be stragglers.

Before leaving this period of indefinite descriptions and no specimens, we must consider the cranes described by John Lawson (1709), who left Charleston in December 1700, and journeyed about the colony. His birds are about five feet high when extended, "are of a cream color and have a crimson spot on the crown of their heads." This could be a poor picture of the Sandhill. He goes on to say, "Among them often frequent storks, which are here seen, and nowhere besides in America, that I have yet heard of." These "storks" might have been Whooping Cranes, but they could just as well have been Wood Ibises.

It is not until the date of Catesby's landing at Charleston, that we reach the end of this long span of ignorance regarding the identity and appearance of *Grus americana*. After Catesby, who described and painted the bird, the first to do so, our path is not so dim nor so difficult to follow.

Catesby to Professor Baird (1722-1858)

Mark Catesby arrived in Charleston, South Carolina, in May 1722. In the course of his subsequent travels, there occurred a dramatic meeting between him and an unnamed Indian. The native presented Catesby with "the entire skin" of a large white crane. Realizing that here was something entirely new, Catesby made a drawing of the head and neck, and described it fully in his *Natural History*. The Whooping Crane (as *Grus americana alba*) was in this manner introduced to the world.

It is the opinion of Alexander Sprunt, Jr. (*in litt.*) that this particular bird was killed at the mouth of one of the South Carolina rivers, the Santee, Waccamaw or Edisto. We can only speculate. Catesby wrote that the Indian "told me that early in the Spring great multitudes of

them frequent the lower parts of the Rivers near the Sea, and return to the mountains in the Summer. This relation was afterwards confirmed to me by a white Man; who added, that they make a remarkable hooping noise; and that he hath seen them at the mouth of the Savannah, Aratamaha (i.e., Altamaha) and other rivers near St. Augustine, but never saw any so far North as the Settlements of Carolina." Buffon (1770-86) later cast a somewhat different light on Catesby's words by writing (Tome VII, pp. 308-10): "they are seen in the Savannas at the mouth of the Aratamaha and other rivers near Saint-Augustin in Florida, and also in Carolina; but . . . he has never seen them further north."

It is not exactly clear, from this confused testimony, whether Catesby considered that the species occurred in South Carolina or not. He does not appear to have observed them there, or seen any specimens, dead or alive, other than the skin mentioned. Much later (in 1850) their presence, on the Waccamaw River in South Carolina, was confirmed by a specimen (Wayne, 1910), but we wonder at the unknown Indian's "multitudes."

Gradually more details were added to this first meager knowledge of the Whooping Crane and its distribution. George Edwards, in London, received a skin "brought from Hudson's-Bay very well preserved dry, by Mr. Isham." His interesting drawing is labeled "G. Edwards, 1748. The great white Crane from north America," and in the text he says, "This figure is reduced from the natural bigness," following this with measurements, including the extreme one from "bill point to end of claws," which was recorded at 5 ft., 7 in.

On the subject of distribution, Edwards suggests that Catesby was wrong in thinking that the "Hooping Crane" breeds in the mountains in summer, since his own specimen indicates their presence on Hudson's Bay at that season, and "this is sufficient proof that these are birds

Early Drawing of Whooping Crane Borrowed
from the Portraits in Buffon (1780) and
Wilson (1814).



THE WHOOPING CRANE.

Audubon's Painting Was "Drawn at New
Orleans in the Month of April," 1821.
(American Museum of Natural History)



An 1881 Portrait from Studer's Popular
Ornithology of that Period.

of passage."

Buffon had some ideas of his own regarding the occurrence of the species. "There is all evidence that the crane went from one continent to the other, as, in preference, it haunts the septentrional regions of Europe and Asia, and that the North is the great road taken by species common to the two worlds; and, in fact, a white crane is found in America, and one or two kinds of gray and brown cranes; however, the white crane, which is only an accidental variety on our continent, seems to have formed a constant race on the other, founded on rather marked and rather distinct characteristics, so that it may be considered as having been very anciently separated of the common species, and modified since a long time by the influence of climate . . . it is very certain that they travel to the highest latitudes; it is the same white crane that can be found in Virginia,¹⁴ in Canada¹⁵ up to Hudson Bay, because the white crane of that region, given by Mr. Edwards is, as he notes, exactly the same as Catesby's." This statement supported the correct opinion that these birds migrated from, presumably, somewhere on the southeast Atlantic Coast to the higher latitudes around Hudson's Bay, but it does not appear to add anything really new on distribution.

Samuel Hearne (1795), "who made his famous journey of exploration in 1770-71, was the first civilized traveler to penetrate the Great Slave Lake region. Though not a naturalist, he had a general knowledge of the larger birds and mammals, was a good observer, and recorded in his narrative many notes on the fauna."¹⁶ Of the "Hooping Crane" Hearne said,¹⁷ "This bird visits Hudson's Bay in the Spring, though not in

great numbers. They are generally seen only in pairs, and that not very often. . . . It usually frequents open swamps, the sides of rivers, and the margins of lakes and ponds, feeds on frogs and small fish, and is esteemed good eating. The wing-bones of this bird are so long and large, that I have known them made into flutes with tolerable success. It seldom has more than two young, and retires southward early in the Fall." Here, at last, are some scraps of accurate information, although Hearne's account did not extend the existing knowledge of the range.

Except for inclusion in Bartram's list (as *Grus clamator*, 1791), following his Florida travels on the St. Johns River, the Alachua Savanna, and in the Tallahassee region, where he saw only Florida Sandhill Cranes, there is no further information on distribution until Lewis and Clark and their bold journey across the continent in 1805-06. On April 11, 1805, just above the mouth of the Little Missouri River (now Dunn County, North Dakota) "we killed two geese, and saw some cranes, the largest bird of that kind common to the Missouri and Mississippi, perfectly white except the large feathers on the first joint of the wing, which are black . . ." (Lewis, 1804-05-06).

Up to this time there had been no cross-country travel west of the Mississippi, except the early journeys in Canada by Hearne (from Churchill to Coppermine on foot) and Mackenzie (in 1792-93 via the Peace, the Parsnip, the Fraser and the Bella Coola to the Pacific Ocean). Lewis and Clark were followed by Pike (1805-06-07), Maximilian, Prinz von Neuwied Wied in 1833-35, and much later by Fremont and others (in the 1840's and '50's). The long isolation of the vast region of the Great Plains was coming to an end.

In the 130 years from Mark Catesby to the railroad surveys of the 1850's great changes took place as a result of wars, explorations, political alterations and the spread and growth of new settlements. From a narrow belt of scattered

¹⁴ De Laet (1640). "The first travelers in America tell about the cranes they saw there. . . ."

¹⁵ "We have (in Canada) cranes of two colors; some are all white, the others pale grey, all make excellent soup." (Charlevoix 1744).

¹⁶ Preble (1908).

¹⁷ Chap. X, *An Account of some of the principal Birds found in the Northern Parts of Hudson's Bay*.

communities on the Atlantic Coast and widely separated forts and trading posts along some of the interior tributaries, a series of events sent the human population westward in a steady tide. After Catesby's time came the French and Indian Wars, which opened the great wilderness of Canada to Alexander Mackenzie and those who followed. The American Revolution paved the way for a surge of expansion into a new, free land. Between 1787 and 1819 the Northwest Territory, from the Great Lakes to Tennessee, became a part of the Union and grew steadily in population. The Louisiana Purchase of 1803 added a vast inland empire and Texas, the Southwest, the far West and Oregon Territory became a part of the Union between 1845 and the Gadsen Purchase of 1853.

For the first time human beings in great numbers began to penetrate the West, the coastal prairies of Texas, the rolling prairies and plains of Kansas, Nebraska, Illinois and Iowa. *Whooping Cranes disappeared from many areas leaving no record behind them.* Between 1722 and 1858 only 11 examples of *Grus americana* enter our "Kill Record." Only five of these are known to have been deposited in museums.¹⁸

Meanwhile, the early ornithologists continued their efforts to describe the distribution of the Whooping Crane. Audubon's confusion regarding the distinction between the Sandhill and the Whooper render his remarks of little value to us. This is highly unfortunate, as he traveled extensively in Kentucky, Mississippi, Louisiana and Florida between 1810 and 1832 and was on Galveston Island, Texas, in 1837. However, any effort to extract data from his text¹⁹ leads invariably to uncertainty as to the species involved. It seems likely that Whooping Cranes were seen by him, in company with Alexander Wilson, at Louisville, Kentucky, March 20, 1810. The live

¹⁸ One each in the Peale Museum, Philadelphia; the Charleston Museum; the Zoological Museum of Berlin; the Museum d'Histoire Naturelle in Paris and, in June 1858, the Smithsonian in Washington.

¹⁹ Orn. Biog., III, 202-213, 1835.

bird given to him by Captain Clack "of the United States Navy, commander of the Erie sloop of war," and obtained on the coast of Florida, was "changing from greyish-brown to white," but the measurements given seem very small for even an immature Whooper.

Audubon's striking portrait of the Whooping Crane was "drawn at New Orleans in the month of April." The identity here, of course, is beyond question.

Wilson (1829) added considerably to our slowly emerging picture of the range of the Whooper, although he stretched the distribution somewhat beyond his actual ken. The habitat, he wrote, comprises the "extensive salt marshes, desolate swamps and open morasses in the neighborhood of the sea." The migrations were regular and extensive "reaching from the shores and inundated tracts of South America to the arctic circle." This, it would seem, was sheer guesswork, at best! He went on, "A few sometimes make their appearance in the marshes of Cape May in December, particularly near Egg Island, where they are known by the name of *Storks*." He tells of their feeding on marshes and mud flats on marine worms, a food item of the species only recently verified. This is a convincing point insofar as identification at first hand is concerned. Other distributional records given by Wilson: Feb. 10, 1810, Waccamaw River (S. C.), a location where the Charleston Museum specimen was to be collected 40 years later; March 20, 1810, the Louisville record already mentioned.

Wilson²⁰ properly describes the young of the Whooping Crane, adding that never having seen a "Brown Crane" he considers that it is "nothing more than the young of the Whooping Crane." The editor of the 1829 version, however, corrects this in a footnote, an admission of error Audubon was never able to make.

Thomas Nuttall, an English botanist, wrote

²⁰ Amer. Orn., VIII, 1814.

with enthusiasm of the Whooping Crane, but a critical examination of his text convinces me that he may never have seen or even heard the species. It is regrettable that one of his passages, describing the "mighty host" of Whooping Cranes migrating down the Mississippi River in 1811, has been so widely quoted. Like other accounts of Nuttall's, this one clearly refers to Sandhill Cranes.

Nuttall "was chiefly a botanist and not much of a zoologist. But he was fond of birds, had an eye for their forms, colors, and actions, and especially an ear for their notes, and wrote two small volumes which appeared in 1832 and 1834, respectively. This was when Ord and Bonaparte had finished with Wilson; Swainson and Richardson had just appeared (1831); and Audubon had arisen above the horizon."²¹

Nuttall's treatment of the distribution of the Whooper is as imaginary as his description of their habits. "This stately Crane," he wrote, "the largest of all the feathered tribes in the United States, like the rest of its family dwelling amidst marshes and dark and desolate swamps, according to the season, is met with in almost every part of North America, from the islands of the West Indies, to which it retires to pass the winter, to the utmost habitable regions and fur countries of the North."

The following description is so far from the mark that by itself it convinces one that Nuttall never saw this species in life. "Ever wary, and stealing from the view of all observers, these gaunt shades of something which constantly avoids the social light impress the mind no less with curiosity than aversion; and it is surprising that, furtive and inharmonious as owls, they have not excited the prejudices of the superstitious." He also wrote that they "build their nest on the ground . . . raising its sides to suit their convenience so as to sit upon it with extended legs"!

Nuttall probably heard Sandhill Cranes in their roosts in Florida and Georgia, but, even in his description of the "clamorous cries" of this bird, he let his words run riot. He compared them to the "howling-monkeys, or preachers, of South America" and in the "roosting flocks" heard individuals "uttering a round number of discordant, sonorous, and braying tones . . . jingling and trumpeting hurrahs." This is either a fanciful account of the sounds emitting from a Sandhill Crane roost (Bartram had termed this "seraphic music") or else Nuttall had unwittingly come upon a hidden corral full of jackasses. The sounds described could not, by any distortion of fact, be referred even remotely to the voice of *Grus americana*. Not to mention that the Whooping Crane does not roost in flocks like its gregarious kin.

Finally, because it has been quoted frequently in the literature and needs comment, we must repeat, once more, Nuttall's passage beginning, "In the month of December, 1811, while leisurely descending on the bosom of the Mississippi," etc. He went on, "I had an opportunity of witnessing one of these vast migrations of the Whooping Cranes, assembled by many thousands from all the marshes and impassable swamps of the North and West . . ." It was night and "the clangor of these numerous legions passing along high in the air seemed almost deafening . . . and as the vocal call continued nearly throughout the whole night without intermission, some idea may be formed of the immensity of the numbers now assembled on their annual journey to the regions of the South." We now have good reason to believe that the Whooping Crane was never very numerous, and this point will be fully discussed in the section on *Abundance*. Certainly, to the best of our knowledge, no one but Thomas Nuttall ever saw the species in such numbers as he described. All other observers employ extremely moderate terms, and some emphasize the species' lack of abundance and their small numbers compared

²¹ *The Nation*, 1891. Review of the Chamberlain Edition.

with the Sandhills. The general agreement on this is unanimous, except for Thomas Nuttall. He presents a one-man minority opinion on this point. His evidence is unconvincing, and, from what we have learned of the species, I feel certain that his "numerous legions" were Sandhill Cranes. The description as it stands can be referred to that species without difficulty—it is contrary to everything that we know about *Grus americana*.

In 1820 Thomas Say observed that "great flights of geese, swans, ducks, brant and cranes have been passing up the (Missouri) river," arriving March 19th opposite Engineer Cantonment (Fort Calhoun, Washington County, Nebraska), and Swenk (1933) believed these must have been Whooping Cranes. "That he does not refer to the Sandhill Crane in this statement is shown by his record of the arrival of that species on April 13, 1820." It seems more reasonable to suppose that "great flocks" were chiefly Sandhill Cranes, with perhaps some Whoopers here and there, and that the April 13th observation was simply another record. In his 1933 paper, Swenk gives March 10th as the earliest date Whooping Cranes reach Nebraska, and Bent (1926) gives March 28 as the earliest Nebraska date for the Little Brown Crane. However, in recent years the Brown Cranes may be established in their roosts on the Platte as much as two weeks before the first Whooping Crane migrant appears.

Latham (1824) stated that the "Hooping Crane . . . arrives at Hudson's Bay in May." No details are given.

In the *Fauna Boreali-Americana* of Richardson and Swainson (1831), we detect at once the source of some of Nuttall's material, which was published shortly after the present work. Even their allusion to a nocturnal migration habit may have stirred Nuttall's inspired passage. Richardson and Swainson's "this stately bird" becomes Nuttall's "this stately Crane," and "frequents every part of the fur-countries" becomes

"is met with in almost every part of North America . . . to the utmost habitable regions and fur countries. . . ." These authors were in error in stating that "a few pass the winter in the southern parts of the United States; but the greater part go still farther south." Distribution was still largely a matter of guesswork and this comment about going "still farther south" may have been interpreted as "West Indies" by Nuttall. Wilson, on the other hand, had said that their migration reached to "the shores and inundated tracts of South America."

Hearne's comment on the use of the wing-bone as a flute is repeated here. The flight at takeoff, the inferiority of the flesh to that of the Sandhill, the appearance of the eggs and of a male specimen killed along the Saskatchewan River on May 7, 1827, are described with fair accuracy. Here, indeed, are evidences of progress!

On July 8th and 9th, 1834, John K. Townsend, accompanied by the energetic Prof. Nuttall, was camped on Bear River in what is now Idaho (then Oregon Territory). He wrote, "We saw here the Whooping Crane . . ." (Townsend, 1839). C. Hart Merriam (1891) concluded, "I do not feel justified in inserting the species without additional authority." Whooping Cranes have since unquestionably been observed at Jackson Lake, Wyoming (in 1906), and in Yellowstone National Park (in 1914, 1930 and 1945), all of which are not much more than 100 miles from the nearest point on Bear River. It is my feeling that Prof. Nuttall finally *did* see a Whooping Crane.

Coming back East we have, for the Wisconsin of these early days, a unique and valuable record of the status of many species of birds before the pressure of increased settlement. This record is contained largely in the papers of Dr. Philo Romayne Hoy, Wisconsin's pioneer zoologist.²² Dudley's *Grus hoyianus*, described as a new species (1854), but actually the immature of *Grus*

²² There is an interesting article on Hoy by Schorger (1944), from which the above material is quoted.

americana, was named for Dr. Hoy. It was shot on the Sugar River in Dane County. Hoy's observations were made chiefly in the vicinity of Racine, on the shores of Lake Michigan north of Chicago. In 1844, in the *Racine Advocate*, he told of a side-hunt that took place in 1836. "Crows, Ravens, Owls and Cranes," counted 30 points each. Hoy had specimens of the Whooping Crane in his private collection and, according to Schorger, as late as 1886, he mounted one of these birds that had been killed in Nebraska. Schorger says, "It is of interest that he never saw more than a dozen Whooping Cranes in all in the vicinity of Racine." Kumlén and Hollister (1903), stated that the species was rare along Lake Michigan as long ago as 1840, probably on the evidence of Dr. Hoy. We can see on our general distribution map that the Racine area is outside the limit of prairie habitat (Grass-Antelope Biome), and those birds that did occur there must have been simply stragglers. The persuasion that the immature Whooping Crane was a separate species new to science (Dudley, 1854), indicates a complete unfamiliarity with nesting Whoopers, although Kumlén and Hollister said, "unquestionably breeding to some extent," presumably in the southern and western part of the State at an early date. This seems a possibility near the Mississippi River, in the southwest corner of the State close to Iowa. But there is no actual evidence.

One of the best early reports is that of Col. George A. McCall, U. S. Army, who was in parts of Texas and the Southwest in 1845. On the long journey from San Antonio to the Upper Rio Grande in New Mexico, only one pair of Whooping Cranes was observed, at Arroyo Hondo, above San Antonio, in November. At Corpus Christi, on the coast, however, the species was seen occasionally in pairs or in parties of 3 or 4, but never in large flocks, nor in company with *Grus canadensis*, although the latter were innumerable. Col. McCall noted that the

Whoopers preferred the water's edge of river banks, or fresh water ponds, as well as "the sandy points that extend into the salt water of the Bay." Whereas, "the Brown Crane frequented mostly the low prairies at some distance from the Bay or River." These keen observations are confirmed by our studies of the habits of the two birds on the Texas Coast, a century later.

In 1857 Turnbull (1869) saw three Whooping Cranes at Beesley's Point, Great Egg Bay, west of Ocean City, New Jersey. These were the first reported in the literature from that region since Wilson's time, and the last for New Jersey, except for a doubtful record at Cape May in 1879.²³ It is also the last of the handful of seemingly authentic records for the Atlantic seaboard.

Valuable information from Saskatchewan was supplied about this time by Henry Youle Hind (1860), who was with the Canadian Red River Exploring Expedition of 1857 and the Assiniboine and Saskatchewan Expedition of 1858. Hind reported a single Whooping Crane "beyond Weed River" (some 45 miles north of Regina and just west of the Touchwood Hills). He also wrote that the species was common in the Qu'Appelle Valley and Touchwood Hill Range, where they appeared in "flocks of 4 to 7."

The last item in this first historical period is reached with the publication of the zoological results of the railroad route explorations of 1853-56, contained in the pages of Baird, Cassin and Lawrence (1858). Data on the Whooping Crane's distribution was still scarce and the record still contained errors. These authors, of necessity, gave this inadequate description of distribution, "Florida and Texas; straggler in the Mississippi Valley." Much of the Plains country was still unknown.

The real significance of this year of 1858 lies in Spencer Fullerton Baird's awareness of the

²³ Furnez, letter in U. S. National Museum files dated November 17, 1882.

inadequacy of existing knowledge of *Grus americana*. In an additional comment he wrote, "The *G. americanus*, though common in Texas and Florida, is yet one of the rarest birds in collections. There are none in any of the public museums of the United States, as far as I have been able to ascertain . . ." However, he managed to obtain a specimen from Thomas E. Blackney of Chicago, and this individual, an adult, is described. It is still No. 10384 in the U. S. National Museum, where it was catalogued in June 1858.

Thus did an era come to a close. From this point on, more especially following the Civil War, the accelerated rate of settlement westward and, with the rapid growth of populations, a wider interest in Ornithology, produced an increased knowledge of the distribution and habits of many species of birds, including the Whooping Crane. And there was another result, soon apparent. It was as if Professor Baird's words had unwittingly served to mobilize all the collectors in the country. There was a general feeling that the Whooping Crane was a doomed species, and skins and egg sets were eagerly sought after. From 1858 to the date of the "last" nest at Muddy Lake, Saskatchewan, in 1922, a period of 64 years, our *Kill Record* contains data on 268 Whooping Cranes. These are only those individuals whose demise was placed on record. Obviously, several times this total number were killed without the dignity of a written record, shot down in their role as the most wary of game birds, and slaughtered by farmers, cattle drovers, railroad crews, river-boat roustabouts, anyone and everyone who marched into the West and Southwest under the bold and irresistible banner of Progress.

For a time there seemed to be plenty of eggs and specimens. One early advertisement titled, "Reduced Prices of North American Birds' Eggs," offered Whooping Crane eggs in sets of two for 50¢ each. On April 9, 1887, Daniel H. Talbot paid \$2.50 each for five Whooping Crane

skins and \$1 each for ten Sandhill Crane skins. He also agreed to pay \$2 each for Whooping Crane skins in lots of one dozen or more (Stephens, 1944). In 1890 eggs of the Whooping Crane were quoted at \$2 each, and skins at \$8 to \$18 according to condition (*Oologist*, 1889; 1890). It is of interest to note that at this same time the skins of Eskimo curlews, trumpeter swans, roseate spoonbills and ivory-billed woodpeckers were not as rare as those of the Whooping Crane and were rated below them in value. There were no prices quoted for the almost unobtainable skins of the condor, Labrador duck and heath hen.

It was the beginning of a new era, and, for most of its kind, it was an end for the Whooping Crane. Ironically, as knowledge of the distribution and life history of the species was gained, the great birds slowly disappeared from much of their range, almost at the same moment that the limits of this range were being described.

Professor Baird to Muddy Lake (1858-1922)

From Professor Baird, who had found the cupboard bare, and who gave us, thereby, one of our best clues to the normal abundance of the species, to Muddy Lake, where the last observed nesting took place in 1922! In these two generations, the frontier had disappeared, and with it much of the wilderness. Perhaps 90% of the Whooping Crane population went with them. It is an obvious comparison for which we scarcely need a sheet of graph paper. As the human population curve goes up, the Whooping Crane curve goes down. This is a bird that cannot compromise or adjust its way of life to ours. Could not by its very nature; could not even if we had allowed it the opportunity, which we did not. For the Whooping Crane there is no freedom but that of unbounded wilderness, no life except its own. Without meekness, without a sign of humility, it has refused to accept our idea of what the World should be like. If we

succeed in preserving the wild remnant that still survives, it will be no credit to us; the glory will rest on this bird whose stubborn vigor has kept it alive in the face of increasing and seemingly hopeless odds.

At this time, during the advent of the 1860's, there were still many blanks in our knowledge of distribution, and some of the almost traditional errors persisted. But a new light had come over the horizon in the person of Elliott Coues. His presence soon resulted in a sound appraisal of existing information, and from him we have our first really comprehensive description of range. Coues typified the new era in Ornithology. From this point on, to use the common phrase, things were different.

Elliott Coues and the New Era

The initial contribution of Coues to the literature of the Whooping Crane was contained in his paper, *A List of the Birds of New England*, published by the Essex Institute in 1868. As already described, Coues pointed out that the occurrence of the species in New England "must be regarded as extremely problematical." There has been no valid evidence to the contrary down to the present day.²⁴

Until this period, Florida continued to be mentioned as within the range of the species, which was reported as "common" there by Baird, Cassin and Lawrence. Now doubts began to appear. Joel Asaph Allen (1871) was in Florida during the winters of 1868 and 1869. The areas covered were Jacksonville and Enterprise, along the St. Johns River; Upper St. Johns River and Indian River; Dummitt's, 20 miles south of New Smyrna. Familiar with the species in Iowa, he

saw none of the white birds in Florida. There have been no authentic Florida records since,²⁵ in spite of numberless reports down to the present, the Florida residents insisting upon calling the Florida Sandhill by the name "Whooping Crane." It is simply a literal and descriptive term.

Some writers continued to copy the distributional errors of an earlier period. Alexander M. Ross (1872) said that the Whooping Crane "occasionally" visited Western Canada, and "its migrations extend from South America to the Arctic Circle." Shades of Alexander Wilson!

Coues very soon turned a bright light on these matters. In his important work *Birds of the Northwest* (1874a), he gave the range as "Interior of North America. Up the Mississippi Valley, spreading through the Fur Countries. Texas to Florida, and occasionally up the coast to the middle states. Not obtained by any of the expeditions." Much of this is based on the more reasonable ideas on range then existent. The real value of Coues' contribution lies in his critical comment that follows: "The distribution of the Whooping Crane appears to be somewhat peculiar, as may be gathered from the foregoing indications. It is said to be found throughout the Fur Countries; but in the United States its dispersion is limited, and there is a difficulty in determining from the accounts, since several authors have confounded it with the Sandhill Crane. I find no satisfactory evidence of its occurrence in New England, and Mr. Lawrence omits it from his New York list. Dr. Turnbull gives it as now very rare, but remarks that in Wilson's time it bred at Cape May, New Jersey. It is said to be common in Florida, where, how-

²⁴ The specimen labeled "Conn. or Lower Mass.," in the collection of the Boston Society of Natural History, may have been an aviary bird that died or escaped and was then shot. I have consulted Mr. Ludlow Griscom, of the Museum of Comparative Zoology at Cambridge, who is the accepted arbiter of New England records, and, after examining the facts, it is his opinion that this specimen does not represent a valid record.

²⁵ I was puzzled by John Krider's statement (in *Forty Years Notes of a Field Ornithologist*, 1879): "I have seen them (Whooping Cranes) in Florida build their nests in sloughs and lakes upon muskrat houses." Apparently this incongruity is explained by the comment on *Forty Years Notes* made by Dr. Witmer Stone (1894): "The offspring of a fading memory rather than the carefully kept data of a systematic worker. Contains little of value."

ever, Mr. Allen 'saw no White Cranes.' It occurs in Texas, I have never seen it alive excepting in North Dakota, where I observed it in August, September and October, and where, probably, it breeds. Its principal line of migration appears to be the Mississippi Valley at large; accounts of its presence all along this belt, from Texas to Minnesota, for a considerable breadth, are unanimous and conclusive. Here it seems to be chiefly migratory, but there is every reason to believe that it breeds in Minnesota and, as just said, in Dakota, as it also does further north."

For the first time we get a fair picture of the actual extent and shape of the birds' distribution. The records along the "Mississippi Valley at large" add much to this picture, as do Coues' own observations in North Dakota, and his opinion with regard to the migration route and the status in Minnesota.

In an article published this same year in *Forest and Stream* (then nearly as much of an ornithological as a sporting journal), Coues (1874b) added more first-hand information: "I have seen it alive" in North Dakota and Minnesota "frequently in the summer of 1873." In June 1874 he observed it "frequently" while ascending the Missouri River near Fort Stevenson, also, "a few days ago," near Brainerd, Minnesota, adding, "I have no doubt it breeds in this region." This article was dated June 10, 1874. Coues, at this time attached to the U. S. Geological Survey of the Territories, likewise stated that the species was *not* seen in New Mexico, Arizona or California.

A decade later Baird, Brewer and Ridgway (1884) were able to add still further details. They extended the distribution eastward to Ohio, westward to Colorado and south to Guanaquato, Central Mexico, this last as a result of the presence there of Prof. A. Duges, who later on was to make additional contributions to the Mexican history of the species. The Ohio claim was evidently based on Langdon (1877), who gave the observation of Mr. Mapes of a flock

of "over 50" Whooping Cranes flying over Cincinnati on November 26, 1876. I find this record difficult to accept, both because of the number of birds involved and the location, which is well over 200 miles southwest of the (then) nearest possible area of concentration (the Chicago region). However, Langdon also lists "two or three" killed above Cincinnati (1876 or earlier) and strays in such numbers seem possible. No doubt Baird, Brewer and Ridgway also considered this last item acceptable.

The Colorado extension is evidently as a result of Aiken (1872), who lists the species as "common during their migrations" in Wyoming and Colorado. No details are added.

The statement of J. A. Allen (1871) concerning the absence of the species in certain parts of East Florida in winter does not deter the continued claim by Baird, Brewer and Ridgway that they pass the winter months "in the swamps of Florida and Texas."

By this date, although only a decade after Coues' *Birds of the Northwest*, there were many more actual breeding records at hand than ever before and Baird, Brewer and Ridgway present a more complete idea of the breeding range than had been seen up to this time. They wrote that the species was breeding in the more northern portions of the continent, in "favorable localities" in the region north of the 43rd parallel (a line through southern Wisconsin, northern Iowa and the boundary between Nebraska and South Dakota), with "some, however, nesting in the prairies of central Illinois, Iowa, Minnesota and Dakota."

According to the data collected in our present study there have been 49 Whooping Crane nests observed, and placed on record, between 1864 and 1922. Prior to 1884, the year of the publication under discussion, 28 of these nests (57% of the total) had been found, the eggs collected from 24 of them and several of the adult birds shot. This, in the 26 years immediately following Prof. Baird's comment. No authenticated

nesting is reported in North Dakota after this year of 1884, only one more nest was to be found in Iowa (in 1894) and the last Minnesota eggs were collected five years later, in 1889. Illinois birds failed to hold out long enough to get into these records of observed nestings at all, probably giving up by 1880.

The birds lasted a little longer in Canada, only 7 nests having been found by 1884 (and the eggs taken from at least 6 of them).

Twenty-six years after Prof. Baird mentioned the alarming dearth of specimens, the Whooping Crane was within two final nests of disappearing forever as a breeding bird in the United States. In point of time this final moment was just ten years away.

These same authors give Dresser's Texas and Mexican records, published in the *Ibis* in 1866. They also state that J. A. Allen was informed that the Whooping Crane "is tolerably common in the valley of Great Salt Lake both in the spring and in the fall." Blaauw, in his *Monograph* (1897), remarks, ". . . from its appearance in spring and autumn near Great Salt Lake it is evident that high mountain ranges form no impediment to the travels." There are several good records for the region around Bechler River, Jackson Lake (Wyoming) and other locations in that part of the West. There are also Idaho records and reports from Montana. Probably the reports received by Allen were correct. However, the birds can reach the high grasslands of that general area, including those near Great Salt Lake, without actually crossing mountain ranges. One route lies along the course of the North Platte River to the present Pathfinder Reservoir and on across the grasslands that extend through southwestern Wyoming into Utah. Another, from the north, follows the grasslands that reach the headwaters of the Missouri, towards the Yellowstone Park region on the one hand and the Snake River Plateau on the other. Most of these reports are of spring and summer birds. It is not clear, of

course, whether the summer individuals reached these extra limital areas in spring from the east, or were nonbreeders that came down from Canada early and in their wanderings took a route to the west.

Baird, Brewer and Ridgway go on to state that "Mr. Boardman writes me (probably Baird) that so far as he is aware this species is wholly unknown on the coast of Maine; and I can find no certain evidence that it has ever been seen in any part of New England. It is not given by Giraud²⁰ as a bird of Long Island, and is very rare on any part of the coast north of the Chesapeake. . . ." Turnbull is then quoted as an exception to this last observation. It is also noted that the species has never been observed west of the Great Plains (overlooking or not considering J. A. Allen's Great Salt Lake report), or on the Pacific Coast.

The first check-list of the American Ornithologist's Union appeared in 1886. The distribution (then termed "the habitat") followed Baird, Brewer and Ridgway (1884) closely and apparently chose to ignore Coues' 1868 remark that New England records "must be regarded as extremely problematical," as well as Baird's 1884 comment of similar meaning. Florida continues to be included. "Habitat—Interior of North America, from the Fur Countries to Florida, Texas and Mexico, and from Ohio to Colorado. Formerly on the Atlantic Coast, at least casually, to New England." The 1895 edition, nine years later, made no change in this wording. The Utah stragglers are not mentioned.

The Introduction of Bird Watching

During the 1880's Wells W. Cooke engaged in an entirely new method of ornithological investigation. From a desk in Washington, where he was connected with the Division of Economic Ornithology of the U. S. Department of Agriculture, he set up an elaborate correspondence with

²⁰ 1844, *The Birds of Long Island*.

people throughout the United States and Canada who were interested in birds and especially in bird migration. In 1888 Cooke's bulletin was published on migration in the Mississippi Valley during the years 1884-85. Here was another turning point. This bulletin contained a wealth of material on the migratory movements of the Whooping Crane and presented an altogether new picture of the winter distribution. It had been assembled by simple and effective methods that had not been possible previously. From here on the records are dominated by a vast array of amateur observers—correspondents, hunters, school teachers, collectors, eggers, housewives and plain ordinary citizens. The reports of this small army are legion, some of them in print, others in unpublished letters and files, others, like the ballads of old, passing from one to another by word of mouth. The value of this new trend is in the coverage; it reached into the farthest nooks and corners. The difficulty today lies in the necessity for examining each of these records with a critical eye before including it in this record. On this score we have done the best we could.

The great number of reports that now began to accumulate so rapidly came from widely separated and seemingly varied habitats. They resulted from observations made on well-watered parklands near Quill Lake, 1700 feet above sea level, and from bare mud flats along the Texas Coast, scarcely one foot above mean low tide. They included distant and highly divergent environments that changed from one type to a wholly different one as the great birds moved out across the length of the continent in their annual migrations. Many of these areas disappear from view, swallowed up by the progress of drainage and agriculture, even while our image of them is being formed, and far too many of the Whooping Cranes that once dominated their undisturbed ponds and unfurrowed prairies have long since been turned back into elemental substances.

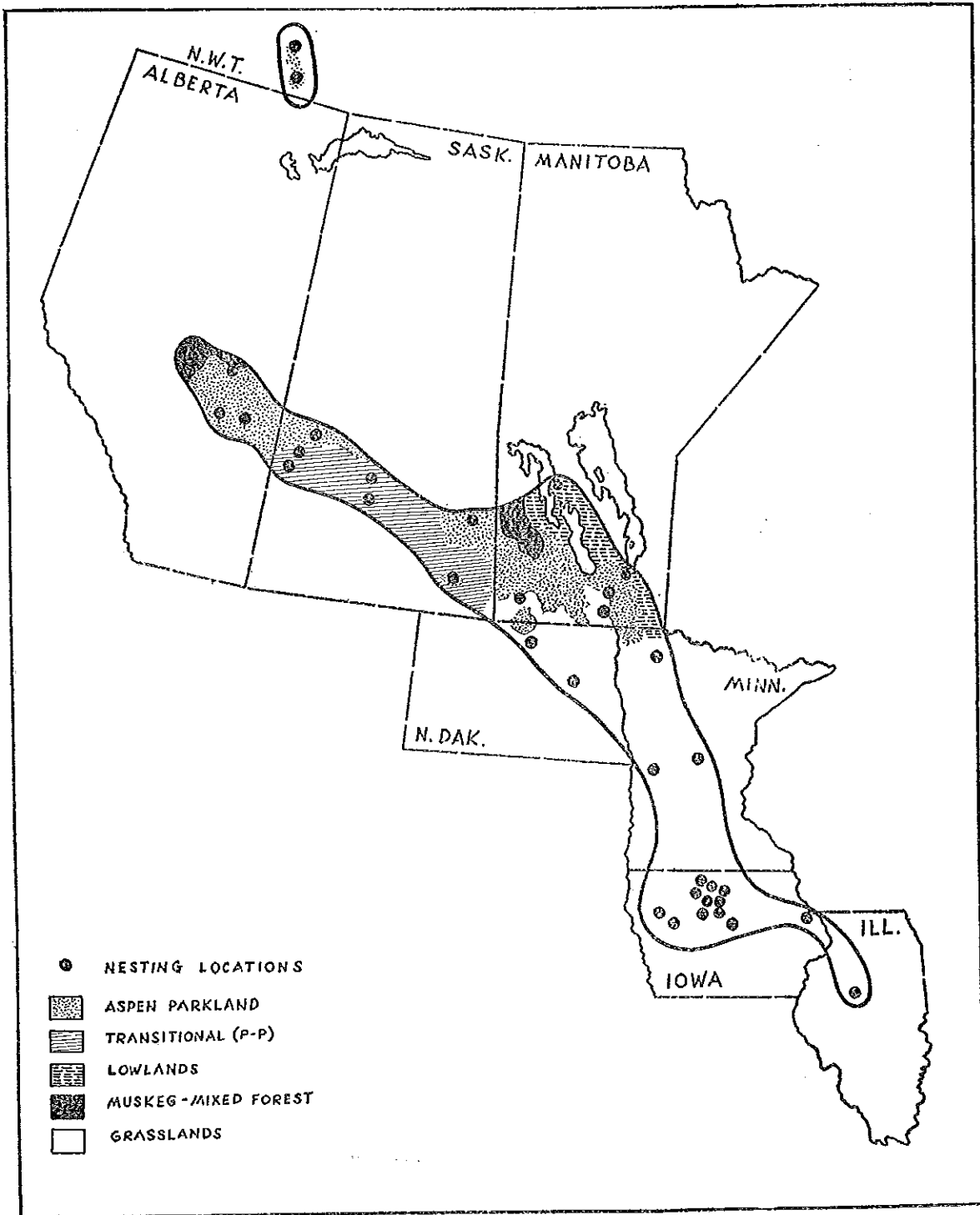
Before arriving at any conclusions regarding that distribution of the cranes, let us look at the details of this widespread scene in the order of the seasons, following them as they journey from one type of location to another. In this manner we should be able to see the distribution picture more clearly and at the same time correlate with this general impression the rapid changes that take place during this brief but eventful period.

Summer Distribution: the Record to 1922

The Whooping Crane's distribution can be divided into four distinct categories during the summer months. The main group, made up of paired adults, moves from the wintering grounds to breeding areas lying north of 41° North Latitude (formerly northwestward from the Central Illinois marshes). With them travel for a time the young of the previous nesting season and probably sub-adults not yet of breeding age, or as yet unpaired. Also, unpaired or senile older birds. This heterogeneous group (nonbreeders) may reach the nesting grounds, or vicinity, but will pass the summer months wandering, sometimes far from the normal paths. A third group may be comprised of senile or injured birds, or, not infrequently, of a family group (paired adults and one or two young) that from undetermined causes fail to take part in the spring migration northward. Birds of this group remain on the wintering grounds through the summer, perhaps, if undisturbed, not traveling more than five miles in any given direction during the six months or more that the main flock is making its long journey north, completing its full cycle of nesting and returning southward. The fourth group, now extirpated, is the resident flock that once remained throughout the year, chiefly in the *Paille-fine* between the Mermentau and Pine Island in southwestern Louisiana, and nested there in numbers prior to 1900 and sparsely down to recent years.

This pattern of distribution suggests the exist-

Grus americana—Major Nesting Area Related to Main Habitat Types.



ence of a diverse assortment of habitats occupied by Whooping Cranes during the months of April through most of October, or better than one-half of the calendar year. Actually it will be seen that a majority of the birds that reach the northern breeding grounds, whether they are nesting adults or wandering nonbreeders, spend the entire period in a relatively limited type of environment. There are occurrence reports, to be sure, from vastly dissimilar types, but many of these represent birds passing through on migration.

The summer range can be divided, therefore, into these categories:

- (1) *Major Nesting Area* (Paired Adults)
- (2) *Northern Summering Area* (Nonbreeding Migrants)
- (3) *Gulf Coast Summering Area* (Nonbreeding Nonmigrants)
- (4) *Louisiana Nesting Area* (Resident Flocks)

Each of these divisions contains its peculiar characteristics and, to understand the summer distribution of the Whooping Crane, it is necessary to examine these characteristics as carefully as our information permits. Herein lie the factors that mould the entire pattern of distribution.

These divisions obviously exclude a variety of country over which the outbound migrants journey in moving from the wintering grounds to the major nesting area and back again in the fall. This pathway, during the last century, has reached mainly across the length of the Great Plains, from North to South. Of chief interest to the migrating birds are some of the larger rivers that bisect this route, in particular the Red River of the South, the Platte and the Missouri. On isolated sandbars in these rivers the cranes stop to rest, and to feed on minnows and crayfish. They also come down in stubble fields, to pick up waste grain, rodents and insects. The entire diagram of this phase of the species' life is outlined in the section on *Migration*.

Major Nesting Area: Canada

From a geographical aspect there are parts of seven States and Provinces and of the District of Mackenzie within the known limits of the major nesting area. The first nest on record²⁷ was found in 1864 by James Lockhart of the Hudson's Bay Company, one of the many employees of that organization inspired to undertake natural history collecting by Professor Baird's protege, Robert Kennicott. As a matter of fact Lockhart discovered two Whooping Crane nests that same year, one near Salt River, another near Fort Resolution, both locations in the District of Mackenzie, North West Territories. The eggs are in the collection of the U. S. National Museum. It is not on record which of these nests was discovered first.

It was 40 years later, in 1904, that the limits of the nesting area were finally rounded by the discovery of a nest in Alberta, the first reported from that Province. It was found by Frank L. Farley, 12 miles north of Killam, in the heart of the aspen parkland belt that lies in a broad band across the east central portion of Alberta.

From 1748, when Mr. Isham shipped a Whooping Crane skin from Hudson's Bay to London, until 1922, when Mr. Bradshaw found the famous "last" nest at Muddy Lake, the species was observed in Canada at no less than 74 recorded geographical locations. These were distributed as follows:

- (1) *Saskatchewan* 27 occurrence locations
(including 7 nesting sites)
- (2) *Manitoba* 18 occurrence locations
(including 5 nesting sites)
- (3) *Alberta* 15 occurrence locations
(including 4 nesting sites)
- (4) *Mackenzie* 10 occurrence locations
(including 2 nesting sites)
- (5) *Ontario* 4 occurrence locations

²⁷ Turnbull (1869) wrote that the Whooping Crane nested in the Cape May, N. J., region in Alexander Wilson's time (possibly around 1810). No real evidence, however, has been preserved.

These comprise the occurrence locations and nesting sites for which the evidence is reasonably convincing. A number of reports from additional areas are questionable, or simply lack details and are not included. Occasionally a doubt is raised and never resolved, as in the case of Shoal Lake (Manitoba) as a nesting site. Thompson (i.e., Seton, 1891) says, "have seen specimens from Shoal Lake, where it is said to breed." This may have been a perfectly good nesting location, but Thompson (i.e., Seton) never checked it, so far as I am aware, and we must pass it by. Of the 18 Canadian nesting sites considered as probably reliable, we have one or more sets of eggs for 10 of them. The evidence with regard to the remainder is accepted without much question, except for two or three for which some doubt is felt and these will be discussed.

The distribution of the 74 occurrence points is extremely interesting, especially that of the 18 key locations where the species reportedly nested. It has not been possible for the writer to visit all of these sites and, as a matter of fact, first-hand observation of some of them demonstrates that time, and the "improvements" wrought by man, have so altered the face of the earth in many instances that today we gain but a poor conception of the original character of the region by first-hand observation. Dr. Olin Sewall Pettingill, then Fellow of the Whooping Crane Project, flew by airplane over Muddy Lake in the summer of 1946 and found it as dry as dust.

The 18 nesting sites were distributed among several types of habitats. From our present knowledge of the pattern of vegetation and forest cover we can do a reasonably accurate job of reconstructing the arrangement of these particular nesting spots. Remember that there were unquestionably many more such sites; these are but a few sample areas that we are fortunate enough to know about. But there are enough of them to give us a good idea of the sort of natural habitats the Whooping Crane chose for

the location of its nest. We may also learn what habitats the species does *not* choose for nesting sites. It is possible that at least five types may have been so occupied. Here is the record. Figures refer to number of nesting sites.

Aspen Parkland	9
Transitional (Plains to Parkland)	5
Manitoba Lowlands	2
Transitional (Parkland to Mixed Forest)	1 (doubtful)
Shortgrass Plains	1 (doubtful)

The evidence is strongest for those sites in Parkland, Transitional (Plain to Parkland) and Manitoba Lowlands. It is weakest for those sites referred to as Transitional (Parkland to Mixed Forest) and Shortgrass Plains. However, there is sufficient value and interest in all of these records to permit their inclusion in this list.

From what we know of the habits of the Whooping Crane, the two environments that claim 14 of the 18 nesting locations (77%) seem particularly well suited to the special demands of the species. The parklands or savannas of Central North America are described as an ecotone or area of stress between grassland and forest. The aspen type lies between northern mixed and coniferous forests and true prairie. It is confined to Canada, except for small areas in northern North Dakota and Northwest Minnesota. As the shortgrass plains meet the parklands there is a narrow, irregular belt that is transitional in character, that is, it combines features of both plains and parklands. In many instances there are areas within this transitional belt that duplicate biotic communities of the parkland and it is quite possible that all of the 14 nesting sites were in the same biotic types, probably the sloughs and shallow lakes of one of the willow communities.

The Manitoba Lowlands is a region lying to the southeast, and to the west, of Lake Winnipeg, entirely surrounding such larger lakes as Winnipegosis, Swan, Pelican, Waterhen, Upper Lake Manitoba and St. Martin, all in Manitoba. It is an area of many small lakes, open as well

as treed muskegs, grassy depressions between former beach ridges, bulrush marshes and patches of mixed forest. Two of our nesting sites are given as "Lake Winnipeg" and "Lake Winnipegosis." Exact locations are not on record and we can only surmise the choice of habitat.

There is one record²⁸ of a nesting site beyond the limit of aspen parklands in the transitional belt between parklands and the muskegs of the mixed forest. This transitional type tends more towards the habitat conditions of the mixed forest region than the richer, black soil environment of the parklands. The transitional soil is grey and extends into the relatively "poor" area of the Precambrian rock country, which is not outstanding for its varied and abundant biotic communities. Most of the open portions of the mixed forest, in addition to the large deep lakes, are treeless muskeg on which insect-feeding black terns are the principal water birds. Waterfowl are scarce, as they are on most of the lakes of this region, lakes that are deep, with steep, rocky shores that are thickly forested to their rims. Here and there we see patches of bulrush or *Phragmites* marsh, as on Prinrose Lake in west central Saskatchewan. Here there are colonies of western grebes, but it is not Whooping Crane country. Other mixed forest lakes, such as Kazan, also in Saskatchewan, have fairly extensive marshes and numbers of breeding waterfowl, but Whooping Cranes would find neither the feeding conditions of the typical slough area they prefer, nor the isolation and security of open country. The record prior to 1922 contains this one nesting report and a total of four additional occurrence locations within this habitat. This is only 8% of all occurrence locations reported for Canada during this period.

River deltas may provide low, flat areas of rich, alluvial soils, including swales and channel lakes and ponds. The bars and flats may be bare

²⁸ Stansell (1909). See criticism of this record by W. E. Saunders (Saunders, 1910a and 1910b).

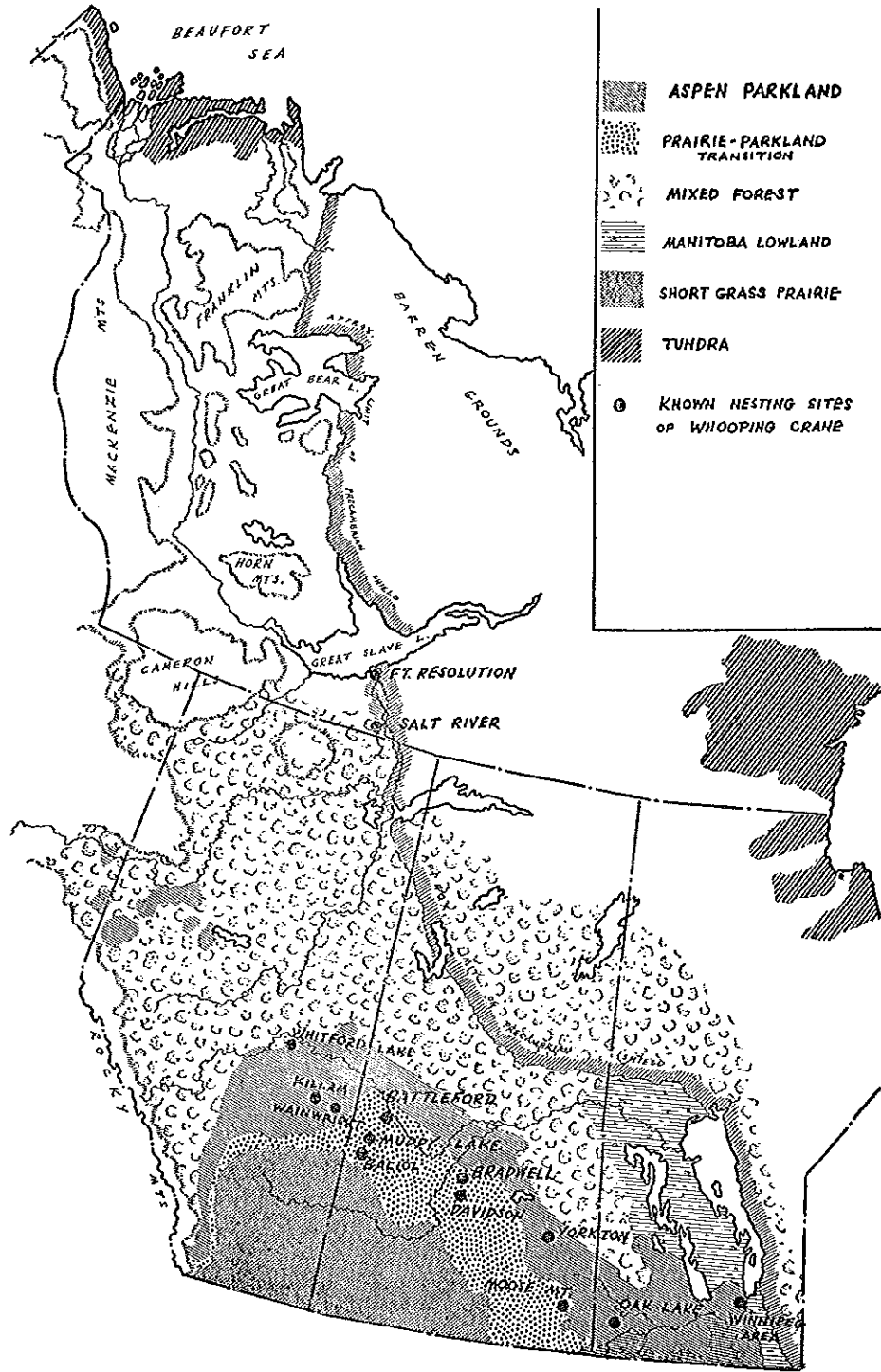
or quite heavily vegetated over wide, meadow-like stretches, with a normal succession towards willows. Delta lakes develop an aquatic flora leading to marsh or bog types, unless the succession is arrested by flood action. Such a varied habitat is of value to many forms of wildlife, particularly ducks and geese. According to Walter Raine (1892), the Whooping Crane nested in 1891 on the Netley Marsh in the delta of the Red River, where it empties into Lake Winnipeg (Manitoba). There are two additional nesting records marked "Lake Winnipeg" that may refer to the same marsh, but unfortunately we lack details. One set of eggs in the collection of Mr. Cruttenden is labeled, "Lake Winnipeg, 1877, collected by L. D. Schultz." Another set, also from Lake Winnipeg, is dated May 18, 1883, in the collection of Mr. P. B. Phillip. Raine's set, from "near the mouth of the Red River of the North near the shore of Lake Winnipeg" is simply dated 1891. Raine describes the "great marshes about the mouth of Red River" and undoubtedly referred to Netley Marsh. In addition to Whooping Cranes, he wrote of the nesting of Little Brown Cranes, bitterns, western, Holboell's, horned and eared grebes, gulls, many varieties of ducks and rails.

Netley is still an excellent waterfowl marsh and in 1947 it was estimated that the nesting population averaged 107 ducks per square mile.²⁹ However, Raine's 1891 record is the last Whooping Crane report in our files from this region.

It is possible that other delta habitats were once populated by nesting Whoopers. A. E. Porsild, in his valuable paper on the birds of the Mackenzie Delta (1943), remarks that one of the older Eskimos, Douglas Oniak, recalled seeing the Whooping Crane in that region many years ago. The migrants observed by MacFarlane along the Upper Anderson may have been heading for the Kugaluk or Anderson deltas. The species was also recorded in some numbers

²⁹ Williams, *et al.* (1948).

Major Nesting Locations of *Grus americana* in Canada Related to Habitats.



by King (1836), near Fort Chipewyan on June 22, 1835. In that region the broad delta of the Athabaska may well have been a nesting site in former times.

A single nesting location may have been located on the semi-arid shortgrass plains southwest of Winnipeg. There is considerable reason, however, to doubt the exact locale in this instance. The files state that a set of two eggs was taken by C. P. Forge on May 30, 1906, in "Duff County," Manitoba. Dr. Harrison F. Lewis (*in litt.*) advises that there is no trace of "Duff County." However, "Dufferin County," an obsolete term, was formerly located southwest of Winnipeg. It is well within the realm of possibility that this site was actually in the narrow belt of aspen parkland habitat some 50 miles southwest of Winnipeg. The intervening type is grassland.

As unsatisfactory as some few of these nesting records are, most of them constitute a valid picture of the former breeding of the species in Canada. It would seem very significant that 77% of these sites were in identical, or very similar, biotic types. No nests were reported from muskeg and mixed forest except the doubtful one from the "bush," lying to the northwest of Edmonton. None are reported from the Coniferous Forest to the north or from the Precambrian rock shield. There are no breeding records for the tundra.

The 14 locations on which our conception of the Canadian nesting habitat must depend are listed below, with the year or years in which the observations were made, or egg sets collected. Numbers in parenthesis refer to the distribution list at the end of this section.

Aspen Parkland Habitat

1. (6) 12 mi. N. of Killam (Alberta) 1904
1905
2. (11) Whitford Lake (Alberta) 1909
(eggs probably collected)
3. (13) Buffalo Park, near Wainwright (Alberta) 1914
4. (45) Fort Resolution Area (Mackenzie) 1864
(1 egg collected)

5. (48) Salt River (Mackenzie) 1864
(1 egg collected)
 6. (157) near Winnipeg (Manitoba) 1871
(1 egg set collected)
 7. (166) Oak Lake (Manitoba) 1891
(5 egg sets collected) 1893
1894
1900
1900
 8. (335) Moose Mountain Area (Saskatchewan) .. 1881
 9. (341) near Yorkton (Saskatchewan) 1900
(1 egg set collected)
- Transitional (Plains to Parkland)*
10. (336) near Battleford (Saskatchewan) 1884
(1 egg set collected)
 11. (348) 20 mi. N. of Davidson (Saskatchewan) .. 1911
 12. (349) near Bradwell (Saskatchewan) 1912
 13. (350) near Baliol (Saskatchewan) 1922
 14. (358) Muddy Lake (Saskatchewan) 1922
(1 egg and 1 downy yg. collected)

The following table summarizes the occurrence of the Whooping Crane in the various Canadian habitats from which it was reported between 1748 and 1922. There is good reason, in addition to the special significance of Muddy Lake, for ending the present discussion at 1922. Not only did this year mark the discovery of the last nest within the areas of settlement in the western Provinces, but it typified the beginning of another "new era." After 1922, which was of course, the rapidly changing period that followed World War I, there were increasing population movements, not only to many sections of hitherto untouched farmlands within the fertile parkland country, but beyond that into the "bush," as the edge of the mixed forest is termed. Large tracts were cleared and new settlements raised. The occurrence reports that come later, after 1922, reflect this and, as we will see, our distribution story is thereby broadened and given a more complete form.

The present tabulation emphasizes again the importance of the parkland environment, which claimed 47% of all occurrence locations during this 174-year period.

TABLE A: Whooping Crane Occurrence Locations in Canada by Habitat (1748-1922)

Habitat Type	Occurrence Locations (Numbers Refer to Items in List of Important Distribution Reports)	% of Total
Aspen Parkland	Nos. 5-14-15-16-17-18-159-160-161-162-164-165-168-169-170-331-333-337 (part)-338-339-346-347-353-356-357.	47%
Transitional (Plains to Parkland)	Nos. 332-334-342-343-344-345-352-354.	(8) 15%
Northern Coniferous Forest	Nos. 44-46-47-49-50-51-52.	(7) 13%
Shortgrass Plains	Nos. 167-171-173-340.	(4) 8%
Northern Mixed Forest	Nos. 8-9-12-355.	(4) 8%
River Delta	Nos. 4-53.	(2) 4%
Transitional (Parklands to Mixed Forest)	Nos. 10-337 (part).	(1.5) 3%
Tundra	No. 156	(1) 2%

The four Ontario locations are omitted. Canadian nesting sites are treated separately.

Major Nesting Area: North Central U. S.

The occurrence of Whooping Cranes during the summer months in the north central United States has been a thing of the past for at least 40 years. We have nesting records from four states: Iowa, Minnesota, North Dakota and Illinois. There have been no reports of nesting in Illinois since the 1870's; none from Minnesota since 1889; none from Iowa since 1894; and the last record from North Dakota, Mr. Eastgate's statement that the species bred in Nelson County "until 1908," is without confirmation.³⁰ The last set of eggs collected in North Dakota is dated June 3, 1871.

There are, of course, numerous spring and fall occurrence reports of later date, but these involve migrants moving to and from the Canadian breeding area. Even in this category a lapse occurs. There are no records for Illinois after 1891. The breeding group that was reported from the central Illinois marshes in the vicinity

of Peoria during the 1870's evidently disappeared by the '80's and the few stragglers that returned to the vicinity over the next decade soon came no more. The last occurrence date for Iowa is April 9, 1911, when Ira Gabrielson saw 5 migrants near Webb, Clay County. This year coincides with the period of serious depletion of the species in Louisiana, of which more will be said later. In Minnesota, the Whooping Crane ceased to breed a short time after the last nest was found in 1889. Possibly this nest was, in fact, the last one. There have been no occurrence reports considered authentic since April 23, 1917, when two were shot by a farmer in Roseau County. One of these birds is mounted in the Pipestone Prairie group in the Minnesota Museum of Natural History. Roseau County borders Manitoba. The last previous date for a Minnesota record was April 29, 1899.

Of the four States where the species once nested it occurs today in only one, North Dakota, where the small band of migrants that continue to make the long flight to northern breeding grounds pass through in spring and fall.

³⁰ Likewise no confirmation for nesting reports at Larimore, Grand Forks Co. (n.d.) (Eastgate, in USFWS files) and Turtle Mts., Rolette Co. (n.d.) (Judd 1917).

Although it is convenient to describe distribution according to state lines, the limiting factor, of course, is habitat type. All of these U. S. nesting sites were in prairie environments. The river marshes near Peoria, in central Illinois, were slightly different in character from true prairie marsh, but were literally surrounded by prairie. Thief Lake, in northwestern Minnesota, lies close to prairie, parkland and lowlands country. From Ernest L. Brown's rather full description we can reconstruct a scene that must have been typical of most of these nesting sites. There were tall stands of cattail and other nesting birds included mallards, shovellers, teal, rails, coots, bitterns, yellow-headed blackbirds and marsh wrens. All of these are characteristic birds of the willow communities described by Ralph Bird (Bird, 1930) within the aspen parkland. Once again it would appear that each of these nesting places falls very nearly within the same biotic type.

Perhaps the original prairies of northern Iowa may be considered as the heart of the former nesting range of the Whooping Crane. Nowhere else is there evidence of such concentrated nesting and 66% of the north central U. S. sites were in this region of less than 10,000 square miles. It extended from Cherokee and Sac Counties on the west, to Winnebago County on the Minnesota line and Blackhawk County to the east.³¹ Most of this area is drained by the Des Moines, Iowa and Cedar Rivers, which empty into the Mississippi. The western portion is drained by the Little Sioux, Maple and Boyer Rivers, flowing into the Missouri. The elevation is in the neighborhood of 1200 feet above sea level and the terrain was originally open, gently rolling prairie, with many shallow ponds, marshes and mudflats. At the heads of the draws there were patches of heavier growth and straggling timber grew along the banks of the smaller streams. The larger streams were often broad

³¹ This does not include the 1868 Dubuque County site, which lies outside the region under discussion, or "Oakland Valley," the exact location of which is doubtful.

and shallow, with shifting sandbars and frequent mudflats.

In May 1883, J. W. Preston drove across these prairies. His description of the marshes at the headwaters of the Iowa River presents a first-hand picture of this general habitat (Preston, 1899).

Years ago, when northwestern Iowa was a vast prairie, out onto which few settlers had ventured and the monotony was seldom broken save by some wood-fringed lake or a herder's shanty . . . my way lay along the Iowa River, from the headwaters of which stream, westward, was a great, flat prairie, interspersed with marshes and small lakes, about which swarmed countless numbers of shore birds. . . .

In an earlier account Preston (1886) wrote in detail of that part of the marsh where the Whooping Cranes had built their nests.

Pond and shallow water, overgrown with rushes, stretched for miles with occasional tracts of tussocks. Among these I wandered about, getting sight of a pair of Geese here, a frightened Rail there. Occasionally a flock of Sand-peeps whistled by me. Hours passed away, and when I was turning campward I caught sight of the snowy forms of a pair of White Cranes flying slowly toward me. . . .

Anderson, who found the last U. S. nest in this same marsh in 1894, wrote that other birds in the area included the pied-billed grebe, mallard, pintail, blue-winged teal, and, on this date, May 26th, dozens of Wilson's phalaropes and black terns (Anderson, 1907).

There are only five reports of summer birds in these north central States in locations not identified with nesting. All are in North Dakota. The dates are:

- July 6, 1879—(Pembina County, close to both Minnesota and Manitoba)
- Aug. 2, 1883—(40 or 50 mi. S. of Jamestown; possibly in Dickey County)
- June 24, 1921—(East of Medina, Stutsman Co.)
- Aug. 13, 1930—(Long Lake, Kidder County and N. of Mercer, McLean Co.; two reports)

There is also a single summer record for Nebraska, where the species was reported from

the Niobrara River on June 24, 1889. Wolcott (1909), writing of Nebraska's bird fauna, said of the Whooping Crane, "May have once bred." Much of the eastern half of that State is prairie, but we have no evidence that the species ever nested there.

Outside of Canada, which has already been mentioned, and Mexico, Texas and Louisiana, which will be considered later, the only other summer reports are of wanderers in Idaho and Wyoming and two records from the Mississippi River at Hickman, Kentucky (Aug. 20 and Aug. 26, 1886). The occurrence of these birds will be discussed when we look into the subject of the nonbreeding migrants.

Normal summer occurrence within this north central region, therefore, is limited almost exclusively to the 18 nesting sites³² of which we have knowledge. These are listed in the tabulation that follows, together with the dates when nests were observed, if available.

TABLE B: North Central U. S. Nesting Sites
(Numbers in parenthesis refer to items in List of Important
Distribution Reports)

IOWA*	
1. (80)	Sac County.....to 1869
2. (81)	Dubuque County.....Apr. 25, 1868
3. (85)	Blackhawk County.....May 12, 1871
	May 15, 1871
4. (88)	Lake Mills, Winnebago County.....May 12, 1879
5. (89)	Oakland Valley (Henry County?).....May 6, 1874
6. (91)	Cherokee County.....May 8, 1877
7. (93)	Franklin County.....May 2, 1880
8. (94)	Clear Lake, Cerro Gordo County.....May 4, 1880
	May 2, 1882
9. (96)	Wright County.....May 8, 1881
10. (97)	Kossuth County.....May 14, 1881
11. (98)	Eagle Lake, Hancock County.....May 4, 1883
	May 26, 1894
12. (99)	Midway.....1883
MINNESOTA	
13. (191)	Morrison County.....July 1874
14. (192)	Elbow Lake, Grant County.....May 21, 1876
15. (200)	Thief Lake, Marshall County.....June 19, 1889
NORTH DAKOTA	
16. (297)	Rolette County, near Ina.....June 3, 1871
17. (304)	Nelson County....."until 1908"
ILLINOIS	
18. (67)	central Illinois marshes, near Peoria.....1870's

*In addition, egg sets were taken in 1866 and 1871 in "Northwest Iowa", "Western Iowa" and "25 miles North". These may duplicate one or more of the above sites.

³² It is of interest to note in passing that we have information showing that eggs were taken from nests at 14 of these 18 sites. At one of them two sets were taken in the same year, from two different nests, and there are four other sets on record for which we have no definite locations. These last were in Iowa.

It is probably significant that all summer records away from breeding locations in the north central States are in North Dakota. The migration route through that State has always been important and for the past 25 years or more this route has been almost the only one traveled. The record shows that the regular fall migration of breeding pairs and family groups passes through North Dakota from mid-September to mid-October, as a rule, there being 9 September records, 10 October records and one for November 9 (1901). This last was a straggler that was killed. It seems safe to assume that summer birds observed along this route belong to the group classified as nonbreeding summer wanderers. Additional data on this group comes from Canada and from high grassland regions in the United States, lying west of the usual track. Because the presence of these wandering birds repeatedly gives rise to rumors of nesting, and otherwise confuses the picture, it will be well to examine their status with some care. However, since much of the data on this general subject is of recent date, it will be discussed further along in this section of the report.³³

Winter Distribution: the Record to 1922

It was mentioned earlier in this discussion that several habitats were included within the original winter range of the Whooping Crane. In a very general sense these may be described as follows:

- (1) Coastal lagoons and maritime beaches.
- (2) Interior tallgrass prairies.
- (3) Sea-rim and brackish marshes.
- (4) Fresh swales and marshes.
- (5) High interior grasslands (tablelands).

From what we have learned up to this point of the relation between distribution and habitat preference, it seems probable that the greatest wintering concentrations were once located on

³³ See discussion under *Nonbreeding Summer Wanderers* at the end of this section on *Distribution*.

the tallgrass prairies of southwestern Louisiana. However, this is mere speculation, for there is remarkably little in the actual record to support this supposition. That hunting and exploring parties reached the prairies west of the Bayou Teche at a very early date, we may be certain. Apparently bison were once present in this region, at least seasonally, but were destroyed or driven off before a satisfactory record had been made. As early as 1807 and 1808, a herd, possibly one of the last, was destroyed by settlers near the Bayou Saline, in Arkansas, above Monroe, Louisiana.³⁴ We can speculate that early hunters and settlers not only shot and drove off the bison of the Louisiana prairies, but disturbed the flocks of wintering Whooping Cranes for the first time to any serious degree.

These events may have taken place before 1800, and no one has recorded so much as a word, written or spoken, regarding the presence of the Whooper in that region prior to the 1880's. By that time their original numbers may have been already somewhat reduced. It was in the early '80's that the late E. A. McIlhenny (*verbal*) traveled with his father to the prairies nearest Avery Island, to hunt prairie chickens. There were then only five houses in the settlement on the Vermilion River now known as Abbeville, and not a fence post had been set up between there and the Sabine River. The railroad came later, as did the towns of Crowley, Jennings, Lafayette, etc. Cattle raising was then the only regular occupation of the relatively few inhabitants of the prairie country. Both Sandhill and Whooping Cranes wintered in some numbers. It was in 1887 that rice began to be important, and, from 1889 to the present, Louisiana has lead the other states in the raising of this crop. The rich prairie soils were well adapted to rice culture and the rapid growth of the rice industry resulted in the equally rapid decline of wintering cranes. A glance at the *List of Important Distribution Reports* shows only

three entries for the prairie habitat. The last of these is for 1918 and, significantly, is a record of the shooting of twelve Whoopers that were feeding on rice that had fallen from the separator door of a thrasher. (Daigle, *Lynch Records*).

The prairie habitat was not unlike that in northern Iowa, where the species may have found optimum nesting conditions. No doubt there were many close similarities from a biotic point of view. The Louisiana climate is humid, in contrast to the sub-humid and semi-arid zones of the Texas coast, and it seems reasonable to speculate that the carrying capacity for these Louisiana prairies, as originally constituted, was several times greater than that of the sea-rim and brackish marshes (three-corner, coco and salt cane environments), which were not as uniformly favorable, doubtless being occupied chiefly in areas that had been closely burned, and that provided other features in the way of brackish sloughs and shallow estuaries. It is equally probable that wide stretches of the Texas coast did not provide favorable Whooping Crane habitat, particularly in the semi-arid region below Baffin Bay. I would consider that, on the whole, the original distribution in Texas was spotty, whereas on the tallgrass prairies of southwestern Louisiana it was probably somewhat concentrated. These conclusions are based chiefly on (1) our knowledge of the character of the Whooping Crane's *biotic niche* and (2) the climate, soil, vegetation and drainage of the respective sectors of coast and adjacent interior, from Marsh Island to the Rio Grande.

It is possible that another, though much smaller, area of concentration was to be found originally in the Rio Grande Delta Basin, including portions of Cameron, Willacy and Hidalgo Counties, Texas. Dresser (1866) was the first to record the species there and it is to be noted that the museum collections contain 20 specimens taken there between 1889 and 1904. Reference to these will be made later.

Of minor importance as winter quarters were

³⁴Gunter (1933).

the interior tablelands, grassy plateaus near San Angelo and to the southwest of San Antonio, in Texas, and similar though much higher areas in central Mexico.³⁵ It is possible that most of these birds were associated with the large flocks of Sandhills that wintered in these localities. There is evidence that this may have been the case, as well as strong indications that the numbers of Whooping Cranes that passed the winter in this type of habitat were not large.

The details of this winter distribution are contained in a fairly considerable literature, although this conventional part of the record presents abundant gaps, some of them rather astonishing. In looking briefly at this distribution pattern it will be useful to divide the discussion under the following groupings:³⁶

- (1) Tallgrass Prairie (S.W. Louisiana; East Texas).
- (2) Panicum Marsh (*Paille-fine*) (Vermilion Parish, Louisiana).
- (3) Prairie Swale and Prairie Marsh (S.W. Louisiana).
- (4) Sawgrass and Deep Marsh (S.W. Louisiana).
- (5) Sea-rim and Brackish Marsh (S.W. Louisiana).
- (6) Sea-rim and Brackish Marshes: Humid Zone (Sabine River to Brazos River, Texas).
- (7) Coastal Lagoons and Beaches: Wet Half of Sub-Humid Zone (Brazos River to Aransas Bay, Texas).
- (8) Coastal Lagoons and Beaches: Dry Half of Sub-Humid Zone (Aransas Bay to Baffin Bay, Texas).
- (9) Coastal Lagoons and Beaches: Semi-Arid Zone (Baffin Bay to Willacy County Line, Texas).
- (10) Rio Grande Delta Plain (Cameron, Willacy and Hidalgo Counties, Texas; Matamoros area, Tamulipas).
- (11) Interior Grassland Plateaus (Tom Green and Concha Counties, etc., Texas; Central Mexico).

These are not presented as ecological categories, but simply as sectors of the winter range labeled according to the characteristics that seem

³⁵ Reference should be made to items in the *List* at the end of this section, as follows: Texas, numbers 420, 426, 428; Mexico, numbers 180 to 186, inclusive.

³⁶ I am indebted to John J. Lynch, of the U. S. Fish and Wildlife Service, for many details and suggestions on the habitat of the Louisiana country concerned. The climatic divisions which have proved useful in separating the various Texas regions are based on Thornthwaite (1941).

to have the greatest bearing on our subject.

What does the record indicate with regard to the Whooping Crane's relationship to these various sectors of range? We will consider each area separately and try to evaluate it in terms of Whooping Crane use.

(1) *Tallgrass Prairie*

Since this is a distributional account, rather than a discussion of the ecology of the winter range, it will be limited to the barest essentials insofar as habitat characteristics are concerned. As already remarked, the record contains little real data on the presence of Whooping Cranes on these tallgrass prairies. Audubon was the first to write of the species in Louisiana, but in this instance his accounts are of no value. Actually, our first distributional date for Louisiana is the early 1880's. E. A. McIlhenny told me that in the first half of that decade the species was still abundant on the prairies of the parishes of Calcasieu, Jeff Davis, Allen, Evangaline and Acadia. In addition, there was some prairie land in Cameron, Vermilion, Lafayette, Iberia, and Landry Parishes. These tallgrass areas were divided by the bottom lands formed by the Calcasieu River, Bayou Lacasine, Nezpique Bayou, Mementau River, Bayou Cannes, Bayou Plaquemine, Bayou Queue de Tortue and Vermilion River. Along the stream bottoms the vegetation was mixed hardwoods, and these bottom lands were of little direct interest to Whooping Cranes. All told there may have been something like 1,800,000 acres of tallgrass prairie in southwestern Louisiana before the advent of rice culture. If only half of this acreage was originally occupied by wintering Whoopers, and making allowances for the territorial demands of the species (of which more later), there was still ample carrying capacity for no less than 2500 Whooping Cranes³⁷ in this type of habitat alone. None

³⁷ This figure represents potential carrying capacity and is unquestionably much higher than actual numbers present even under original conditions.

of the other ten sectors that are known to have been major wintering areas provided anything even approaching this capacity. There have been no reports of wintering Whoopers from the prairies since 1918.

(2) *Panicum Marsh (Paille-fine)*

According to Lynch (*in litt.*) there are fragmentary stands of *Panicum* marsh at numerous places along the landward limits of the "Deep Marshes" (sawgrass, etc.) of southwestern Louisiana, but "the only stand of *Panicum* in true type and extensive enough to be indicated on a map of small scale would be that above White Lake. In other stands it would be mixed with Prairie Marsh on the one hand and Deep Marsh on the other." The location and extent of this White Lake stand is shown on the accompanying map. It covers a little more than 40,000 acres.

There are some remarkable facts concerning this particular marsh. Until comparatively recent years much of it was inaccessible even to the local residents. This was due in part to the depth of the underlying peat, in part to the general character and location of the area. Lynch describes the marsh type as "fresh marsh-meadow." He writes (*unpublished MS.*) "The Yellow Grass (*Panicum hemitomom*),³⁸ which comprises this marsh type, forms extensive low meadows in which there is normally little or no tall vegetation." Surface water, often averaging from 5 to 8 inches in depth, is nearly permanent. It was not until the U. S. Army Engineers extended the Intracoastal Waterway from the Vermilion River to Grand Lake (in 1929-30), that access to the marsh became general enough to constitute a final threat to the survival of the Whooping Crane population. It was at this same time that the presence of the species in this particular region was first realized by the "outside world." Since then, Lynch, who has given

more attention to the White Lake area than anyone else, sought out and talked with a number of local people who had been born and reared and spent all of their lives in that region. Typical of these "old timers" was O'Neil Nunez, who was born in that vicinity in 1882 and started trapping and hunting alligators when he was eight years old, in 1890. The keen recollections of men and women of that generation, through Lynch's patient and intelligent research, have given us an incomparable picture of the status and habits of the Whooping Crane in this and other parts of Louisiana in the early days. Unquestionably, the White Lake birds comprised a resident, nesting group. Nunez and several others have contributed a wealth of detail on this score, indicating a fairly extensive resident colony that was centered in the White Lake marshes, extending as far west as Mallard Bay, the northeast arm of Grand Lake. After 1900 the decline in numbers was rapid and Nunez saw his last Whooper nest nearly 50 years ago.

By 1922, when our present discussion ends, there was no "official" knowledge of this resident colony. In that year it had probably been reduced very close to the numbers found there by Lynch 17 years later.

It seems doubtful if this sector was occupied to any extent by wintering birds.

(3) *Prairie Swale and Prairie Marsh*

A type map of Louisiana would show an intermediate area between the Deep Marsh and Tallgrass Prairie labeled as above (narrow strip of solid black along Intracoastal Waterway on map). This narrow strip may be about evenly divided between prairie marsh towards the sawgrass (Deep Marsh), and prairie swale towards the true prairie. Giant cutgrass and bulrush characterize the marsh portion, and such indicator plants as spikerush, duck potato, arrowheads, rush, smartweeds and pickerelweeds, typify the swale. The marsh has nearly permanent standing fresh water, deeper where the

³⁸ Also called *paille-fine*, *canouche* and maidencane.

bulrush grows, less so on the slightly higher ground supporting cut-grass. The swale areas contain intermittent ponds. Both were excellent Whooping Crane areas, especially as feeding places. There is evidence that the species may have nested to some extent in the swales, where there were isolated stands of *paille-fine*. The White Lake birds were observed in later years (after 1930) feeding in these habitats near the Intracoastal Waterway. Apparently these areas were of more importance to resident than to wintering birds.

It should be noted that in the three sectors or types discussed thus far there are significant similarities of detail. No complete ecological study has been made, but such a study would probably have demonstrated that geological "pocks" or wallows in the tallgrass prairie, open sloughs and ponds in the prairie swale and marsh and shallow depressions in the *Panicum* habitat were closely allied in a biotic sense. Allowing for differences in latitude, and, therefore, in the geographic forms and races of the typical plants and animals concerned, there must likewise have been a biotic similarity between these fresh water environments and those of the Iowa, Minnesota and Dakota prairies and the willow communities of the Canadian parklands.

(4) *Sawgrass and Deep Marsh*

This sector (labeled on map) may have been one of the least important insofar as use by Whooping Cranes in Louisiana was concerned. Here the water is fresh to moderately brackish, sawgrass is the climax vegetation and only in intermittent ponds among such subclimax plants as *Nymphaea* and *Crinum*, close to the prairie marsh, would the Whoopers find anything of interest. There are no important locations for this type of habitat on our distribution list.

(5) *Sea-rim and Brackish Marsh* (S.W. Louisiana)

After World War I the value of muskrat pelts

went beyond \$1 each and the Louisiana trapping boom of the 1920's made local history. It also brought thousands of trappers to the *coco* and *three-square* marshes that lie inside the high brackish sea-rim marshes, from the Mississippi Delta to the Port Arthur region of East Texas. Previously there had been only small-scale trapping, while cattle raising on the sea-rim marsh did not require the participation of a large human population. The old settlers interviewed by John Lynch have made it clear that the Whooping Cranes on these coastal marshes were migrants that were present in winter only and more recent information bears this out. Earliest dates in our *List* are for "about 1895." In 1916 we have the first reports, from ornithologists like Stanley Arthur and Alfred Bailey, of Whooping Cranes at such locations as the *coco* and *three-square* marsh west of Chenier au Tigre and along Big Bayou Constance. In fact, these first reports of the species in Louisiana are only preceded in the literature by the accounts of Audubon and Vernon Bailey. The latter wrote that the Whooper was reportedly "common" on the prairies near Iowa, Calcasieu Parish, in the winter of 1899. Once more the attention of ornithologists and conservationists had to await the exploitation of a region. It has always been too late.

From 1895 to 1922 the species was reported in winter from Chenier la Croix on Marsh Island; Big Bayou Constance in Cameron Parish (Rockefeller Wildlife Refuge); Hellhole area, Vermilion Parish (Rainey Wildlife Sanctuary); the coastal strip from Grand Chenier to Johnson's Bayou; the Louisiana State Refuge in Vermilion Parish; near Chenier au Tigre, Vermilion Parish; and from near Pecan Island, below White Lake. After 1916 no reports came from Marsh Island, the Hellhole area or the nearby Louisiana State Refuge.

The brackish marshes are predominately three-square except the strip from just west of Tiger Point (Chenier au Tigre) to approximately Calcasien Pass, which is chiefly *coco*. The

three-square is the better muskrat marsh and it was in the *coco* around Mulberry Island that these coastal strip birds made their last stand. But a few were still to be found in several coastal locations in 1922. They were observed in winter only, so we can assume that these last individuals were migrants. By the time we learn much about them, say from 1916 on, their numbers were reduced to no more than seven or eight birds, according to the available records. From this it would seem ridiculous to blame the muskrat trappers for the destruction of these wintering Whoopers. The damage had already been done, possibly to a large extent on the long migration highway northward. That this surviving handful was doomed to disappear before too many years was fairly inevitable because of their small numbers and precarious status as migrants.

Probably "burns" and goose and muskrat "eat-outs" in the marsh were of special value to the Whoopers that winter on the coast, as they are to shorebirds, certain waterfowl and other water birds.

It seems evident that the sea-rim and brackish marshes could not compete with the tallgrass prairie as winter quarters. There is no indication that really large numbers of Whoopers gathered in this sector. In extent it is considerably smaller than the prairie region, averaging something like five miles in extreme width and stretching along some 130 miles of coast from the eastern tip of Marsh Island westward to Sabine Pass. From what we know of the situation, however, it is probable that only a small portion of this entire area was actually occupied by Whooping Cranes.

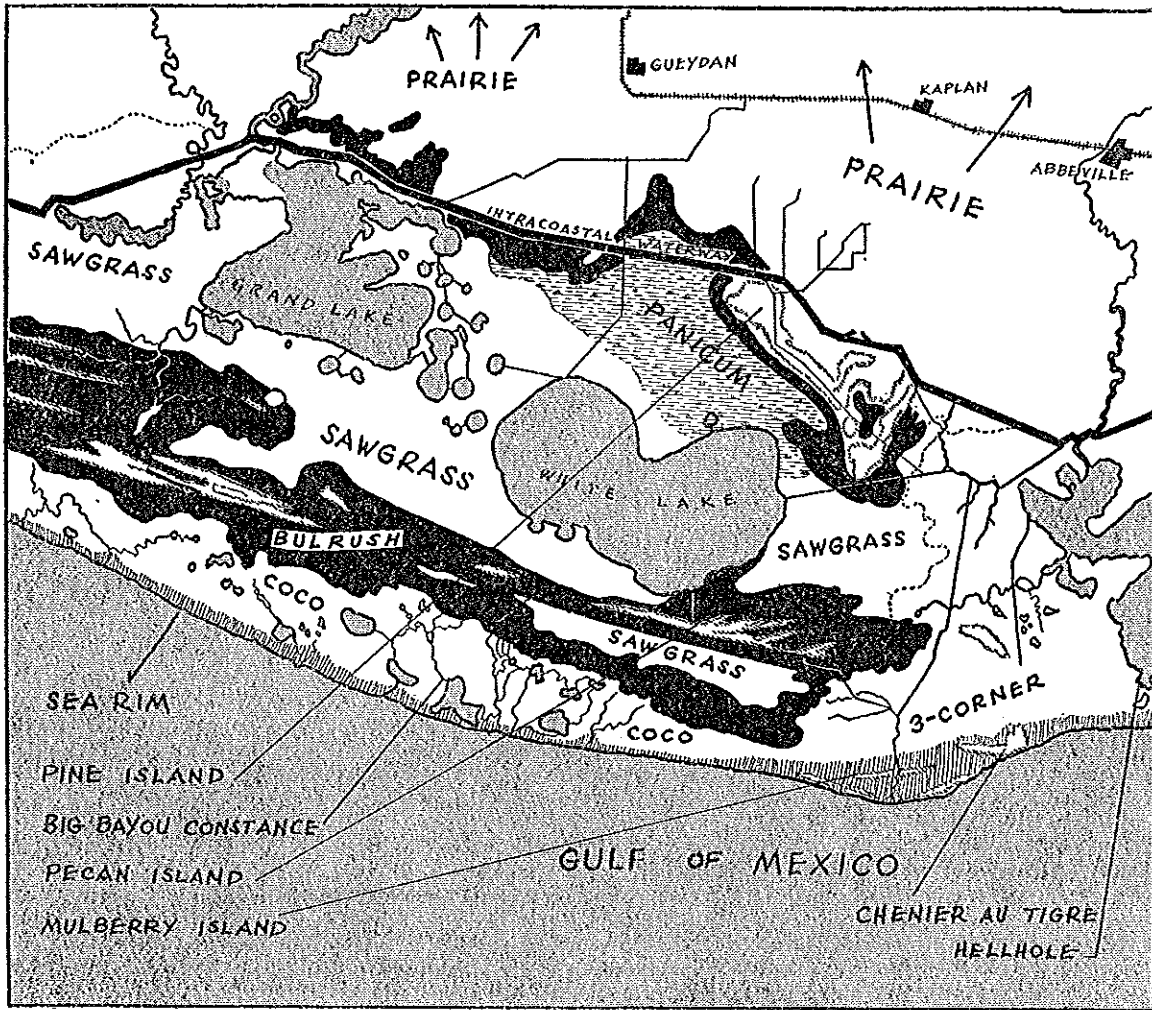
(6) *Sea-rim and Brackish Marsh: Humid Zone*

This sector lies along the Texas Gulf coast, from Sabine Pass to the mouth of the Brazos River. It is a humid area, but the coastal marshes are not as extensive as those of Louisiana and, according to Lynch, O'Neil and Lay

(1947), are slightly different in character, being higher and firmer. The largest marsh is the area of Olney's three-square and of *coco*, lying east of High Island, towards Port Arthur. Some 500 trappers take muskrats from this marsh each winter and when I flew over it on December 24, 1946, it was evident that there was no room left for Whooping Cranes. In fact, reports for the species in this general region are scarce. Dresser (1866) was informed that they were observed at the mouth of the Brazos and on Galveston Island. There is a specimen from near Beaumont, an immature female killed, December 23, 1886. On November 2, 1913, Mrs. Bruce Reid observed the arrival of migrant Whooping Cranes near Port Arthur, presumably birds still wintering in the brackish marshes between High Island and Texas Point. By 1922 a few may still have survived but if so their days were numbered. Trapping, cattle raising, hunting and other recreational activities, the development of oil resources, building and operation of refineries and of the sulphur industry at Freeport, on the mouth of the Brazos, these and allied human activities were soon to render this entire sector as inhospitable to wintering Whooping Cranes as the center of the growing city of Houston not many miles inland. However, it seems doubtful if this sector of coast was ever outstanding as winter quarters for the species.

(7) *Coastal Lagoons and Beaches: Wet Half of Sub-Humid Zone*

This region extends from the Brazos River to Aransas Bay, and is characterized by less precipitation, and a different type of marsh environment, than the brackish area to the east. There were wintering Whoopers in favorable locations between the San Bernard and Matagorda, a strip that included some excellent fresh to brackish marshes and ponds, particularly those south of Bay City. In the winter of 1917-18 Alexander Wetmore looked for the species in this area, but did not find it present. Today, rice farming, cattle-



Major Habitats of the Coastal Marshes of Southwest Louisiana in the Vicinity of White Lake and Some Important Localities Mentioned in the Text.

raising and other enterprises have completed the destruction of the isolation factor and most of the marshlands. The brackish flats on the inside of the Matagorda Peninsula provided another type of habitat, similar to that 50 miles farther south, along the north shore of Matagorda and St. Joseph Islands, where the species continues to winter down to the present. A single specimen was taken at Kane's Landing, on the inside of the peninsula, January 23, 1885, and Mr. Lloyd observed a group of three that "went every day to the same feeding ground on the Peninsula, January 6 to February 20, 1892." There are no records for this vicinity since.

The shores of Matagorda Bay may have provided winter quarters for a limited number of Whoopers, but the brackish sloughs, lagoons and beaches from the present Powderhorn Ranch, Espiritu Santo Bay and Pass Cavallo, southwest to Aransas Bay, were doubtless more of a winter haven from the first than other sections of the Texas coast, possibly excluding the Rio Grande Delta Plain. Not only do the records attest to this, but the environment itself would seem to demonstrate the reason for this attractiveness. We have been placing the Whooping Crane, with mounting bits of evidence, in a biotic niche that is essentially a fresh-water type. It now seems inconsistent to come upon a brackish community and discover that it is well adapted to the daily requirements of the species. On the one hand, are lush sloughs and marshes covered with several inches of permanent fresh water and grown to bulrushes, cattails, and the many edible tubers of such an environment. Fresh-water minnows, crayfish, frogs, and aquatic insects abound, and were important and essential links in the food chain of the Whoopers. On the other hand we find brackish mudflats, narrow stands of *Spartina alterniflora*, wide meadows of short wiry *Monanthochloe littoralis*, beds of the salt flat grass, *Distichlis spicata*, and muddy tidal lagoons. But if tubers and other edible plants are lacking there is an amazing abundance of animal life. This is the realm of

the decapod crustaceans, and the Whoopers feed here on blue crabs, various shrimps and prawns, small minnows like the *Cyprinodontes*, even marine worms. They commonly drink the brackish water, which varies in salinity from 2 parts per thousand to 20 parts or higher.

It seems likely that the large wintering group once present on the tallgrass prairies of Louisiana were the same birds that nested on the prairies of Iowa, Minnesota, and eastern North Dakota, and in the eastern portions, at least, of the Canadian habitats. The north central U. S. nesting grounds were depleted by 1895, at which time rice farming on the Louisiana prairies had been underway for some ten years. Already the wintering groups there must have declined considerably in total numbers. The last Canadian nesting, in the aspen parkland and adjacent transition belt within the settled portions of the prairie provinces, was found in 1922. That year may likewise have marked the last record for the Louisiana prairies, our final data being for 1918, when Alcie Daigle shot 12 Whoopers at his rice thrasher on the prairie above Sweet Lake. These 12 seem to have been nearly the last prairie birds.

The first reports from the Blackjack Peninsula, present site of the last wintering colony on the Aransas National Wildlife Refuge, came from J. A. Brundrett, who lived there in 1885 (Stevenson, 1946). One was shot by a hunting party at Mustang Lake in the fall of 1895 (Hough, 1895), but we get the impression that even at these early dates the species was not numerous. When we consider carrying capacity in relation to the Whooping Crane we must make allowances for territorial peculiarities. We have estimated that each pair or family group, which remains intact and aloof even from their own kind through the winter months, require as much as 400 to 500 acres for their winter quarters.

Thomas Webb, who lived on the Blackjack Peninsula about 1910, observed the species there (Stevenson, 1946), but it was not until the

winter of 1935-36 that their presence came to general notice. Meanwhile, in Refugio County nearby, a few were recorded by J. J. Carroll in the winters from 1896 to 1900 (Carroll, 1900). On Matagorda Island, near the Blackjack Peninsula, H. C. Oberholser saw three that frequented the tidal flats along the north shore. The dates were March 29th to April 2, 1900. After their "rediscovery" in 1935-36 there are endless records and our discussion of *Winter Life* will cover these in such detail as seems essential.

(8) *Coastal Lagoons and Beaches: Dry Half of Sub-Humid Zone*

Distribution in this sector was apparently even more spotty than in the preceding. Outstanding areas were the shores of Aransas and Corpus Christi Bays, the area around Laguna Larga, and intermittent ponds between that location and Baffin Bay, both on the King Ranch, and brackish tidal flats on the inside of Mustang and Padre Islands. Colonel McCall describes small groups of Whooping Cranes on maritime beaches near Corpus Christi in 1845 and there are other records from there in 1891 and 1904. The last was a specimen taken in February. In March and April 1891, Dr. F. M. Chapman did not observe the species in this area.

At the head of Padre Island, George B. Sennett observed the Whooping Crane in late March 1878, and Mr. Lloyd watched groups of 6 and 7 feeding on acorns in the same area. This was on August 20-30⁸⁹ and November 1-12, 1891. Lloyd collected an adult male here on November 10, 1891.

Whooping Cranes on the Laureles Ranch, and other parts of the King Ranch were first noted by Richard M. Kleberg about 1915 (Pearson, 1922). In the winter of 1919-20 Mr. Kleberg believed that there were as many as 10 of the birds from Laguna Larga south to Baffin Bay. In varying numbers they were observed by several ornithologists over the next few years. When

Dr. T. Gilbert Pearson saw four of the species on the Laureles Ranch on December 23, 1921, these were the only wintering Whoopers known, aside from 7 or 8 noted by Arthur and Bailey on the Louisiana coast a few years earlier.

The general character of this sector is somewhat like that of the Wet Half of the Sub-Humid Zone but, as it approaches the Semi-Arid sector which begins at Baffin Bay, there is less precipitation, smaller run-off and higher evaporation. These factors, which do not tend to increase the value of the region to Whooping Cranes, have been accentuated by grazing practices, and other factors, over the past 50 years. Price and Gunter (1942) believe that the major causes of important geological and biological changes in south Texas in recent times, have been overgrazing, which has lowered the water table, and a "progressive change in climate tending to more arid conditions, the effect of which may or may not have been increased by overgrazing." There were never great numbers of Whoopers in this particular region and since they were chiefly migratory (some remained through the summer, as has been observed since at Aransas Refuge) their small numbers no doubt would have slowly dwindled whether the water level in Laguna Larga remained constant or not. The gradual losses did not occur in Texas, it would appear, but elsewhere, along the flight lines.

The fact that this relatively unfavorable habitat should hold one of the last surviving groups of wintering Whoopers some years beyond their survival on the tallgrass prairies of Louisiana, where optimum conditions prevailed, suggests two facts: (1) the Louisiana birds, as already proposed, comprised a unit of the population that nested and wintered in environments that were completely destroyed in their usefulness to the species and (2) isolation as a welfare factor may rank above even optimum habitat conditions. There has never been any evidence that Louisiana birds have shifted to Texas, or vice-versa.

⁸⁹ These may have been summering birds.

(9) *Coastal Lagoons and Beaches:
Semi-Arid Zone*

Most of this sector, from Baffin Bay to approximately the Willacy County line and the Rio Grande Delta Basin, is entirely unsuited to Whooping Cranes. It is dry and for wide stretches along Laguna Madre is today virtually without vegetation. There are extensive salt flats devoid of life. For the period down to 1922 no records for the species are available from this region, although a few occurrence reports will appear later.

(10) *Rio Grande Delta Plain*

The Rio Grande Delta country was first settled by Spanish-Americans in 1749 but, as pointed out by Price and Gunter (1942), it was not heavily settled until much later, chiefly after 1916. From the beginning of settlement there was cattle grazing and there is considerable evidence that this practice, coupled with farming, drainage and a series of hard droughts that began in the 1880's, has brought about many physical changes in the character of this and other south Texas habitats. The Delta Plain has been altered as much as any other sector. The drying up of perennial streams of portions of the nearby Reynosa cuesta, silting of the Rio Grande and Laguna Madre, loss of salt marsh and lagoonal plain areas as a result of silting, flood action and related factors, the change from oak vegetation to near-desert environment over most of Padre Island, brought about, in part, by sheep grazing, these alterations have gone hand in hand with an increased human occupancy and have created a habitat that must differ markedly from that in which Dresser first observed Whooping Cranes in June 1863.

Dresser saw 9 or 10 birds in a lagoon near Matamoros, on the Mexican side of the Rio Grande, and others near Point Isabel. Mexicans that he talked with claimed that they nested in a lagoon southwest of Bagdad known as Boca del Rio Grande. Unfortunately, Dresser was unable

to check the accuracy of this claim. Fourteen years later Sennett "frequently saw these noble birds of the prairies feeding in the lagoons, as we went down the coast, and in the wet places about Brownsville up to about April 1st." This was in 1877. No one after Dresser suggests that the species may have been nesting; nevertheless all of his birds were observed in June.

From the date of Sennett's visit, in March 1877, there is a steady record of collecting trips to this area. Specimens were taken on the following dates:

Cameron County

Feb. 2, 1889 (adult male)
Feb. 16, 1889 (adult female; juv. female)
Feb. 22, 1889 (adult male)
Spring 1889 (adult)
April 2, 1890 (adult male)
Jan. 5, 1891 (adult male)
Dec. 20, 1891 (adult male)
Feb. 18, 1894 (?)
Nov. 29, 1896 (adult male)
Feb. 20, 1904 (adult male)
Jan. 16, 1904 (adult female)
Feb. 10, 1904 (adult male)

Hidalgo County

Feb. 22, 1891 (juv. female)
Nov. 15, 1892 (adult male)
Dec. 2, 1892 (?)
Dec. 7, 1892 (adult female)
Dec. 14, 1892 (adult male)
Jan. 2, 1893 (adult male; adult female)

The 1893 date, above, is the last on record from Hidalgo County. Mr. and Mrs. Vernon Bailey reported two of the species from the Arroyo Colorado, presumably in Willacy County, May 6, 1900. At Brownsville, L. R. Cowen saw three, February 15-27, 1911, none the following year. The last report from the Rio Grande Delta Plain was to come in 1924, two years after the end of the period under discussion. It is possible, of course, that these twenty specimens, collected over a period of 15 years, comprised the bulk of the surviving population in this region. On the record there were only two more observations, three birds in 1911 and five (apparently including a family group, with one

young bird, and two others, a pair or sub-adult "companions") in 1924. These five were the last. It is to be noted that the specimens shot between 1889 and 1904 comprised 11 adult males, 4 adult females, 2 juvenal females and three not identified. This ratio is something of an index to the total Rio Grande population. It was unquestionably an important wintering group.

(11) *Interior Grassland Plateaus*

It has already been suggested that most of the Whooping Cranes that wintered on tablelands were in company with flocks of Sandhill Cranes. This fact seems well established for those that passed the winter on the high plateau of central Mexico. In 1891 Alfred Duges wrote Ridgway that "It is with difficulty that one sees 4 or 6 among 2000 *Grus canadensis*, with which they live." This was written from Guanajuato in central Mexico. Our Mexican records cover a period of 40 years and include data on something like 40 Whooping Cranes, all told.

Dresser's Matamoros reports for 1863 are the first reported from Mexico, but these Tamaulipas birds were a part of the Rio Grande Delta Plain group, already discussed. Following this, M. Duges, from Guanajuato, reported the presence of the species in that region for the first time in 1869 (Duges, 1869-70). In 1889 a specimen was taken at Lerdo, which is near Torreon, in Durango. This bird, a juvenal, was collected by Dr. Fischer and is in the Dresden Museum. Jouy, writing in 1894, reported several captives at the Hacienda el Molino, near La Barca in Jalisco, and E. W. Nelson, who has contributed distributional data on the species from Illinois and Louisiana, found them on the marshes of Lago de Chapala, not far from La Barca, about 1896 (Nelson, 1929). He also recorded that the specimen in the Museum at Guanajuato (possibly the one referred to by Duges) had been killed in winter on the plains of Silao, Guanajuato (U. S. Nat. Mus. files, Friedmann, *in litt.*).

Meanwhile, about 1894, Theodore S. Van Dyke, an American sportsman who wrote books of his prowess with rifle and shotgun, went on a hunting expedition to the Bolson del Mapini, which in those days, although essentially a desert, included a broad, shallow lake on the banks of which corn had been raised. Here he found both Sandhill and Whooping Cranes, the latter evidently in some numbers. Van Dyke lay concealed in the corn stalks and, when the Whoopers were almost directly above him, rose to his feet and scored a double shot. His description of the splendid creatures plummeting to earth is one of the best examples of this sort of prose that we have in the varied literature of *Grus americana*.

The final chapter is contributed by E. A. Goldman, who was at La Barca January 17 to 22, 1903. In the U. S. National Museum files is this record which I have seen through the courtesy of Dr. Herbert Friedmann: "While at La Barca I heard of 3 of these birds which were in the habit of frequenting certain fields half a day's journey from town. An individual of this species has been kept alive at the Hacienda of Buena Vista near La Barca for some years." There are no further reports from Mexico.

I am indebted to Dr. George B. Saunders, U. S. Fish and Wildlife Service, for a description of these Mexican locations and for assistance in arriving at an interpretation of the probable status of the Whooping Cranes that once wintered there. For a number of years Dr. Saunders has traveled over Mexico, studying the waterfowl distribution. He has also given considerable attention to cranes and, although some of the wintering flocks of Sandhills numbered 50,000 individuals, he has never seen a Whooper among them.

It is Dr. Saunders' observation that the bulk of the Sandhills (chiefly or entirely Lesser Sandhill Cranes) formerly entered Mexico on a broad front between El Paso and Columbus. Some may have crossed the Big Bend farther to the east. "The general route was along a strip

from the vicinity of Laguna de Guzman eastward to Laguna de Patos and southward to the Laguna de Bavicora and the Laguna de Bustillos on the west, eastward to a line from El Paso to about Torreon; then a strip about 25-50 miles wide down the plateau across Zacatecas, a corner of San Luis Potosi, across Aguascalientes, and Jalisco to the delta of Lago de Chapala and to Lago de Uria in Guerrero and Lago de Cuitzeo in Michoacan." It is close to 1,000 miles from El Paso to Lago de Cuitzeo, as a bird flies.

The general sector from Laguna de Guzman (Chihuahua) to the Laguna de Bavicora and Laguna Bustillos (Crane Lake) is the principal wintering ground for the Sandhill Cranes in Mexico. Dr. Saunders writes me, "In former years, when Whooping Cranes were more numerous, a few probably wintered here and elsewhere on the central plateau of Mexico at favorite crane lakes from Chihuahua and Durango southward to Jalisco, Michoacan and Guanajuato." He adds that far more Sandhills winter today in Chihuahua than on the coast of Tamaulipas. It seems doubtful if Whoopers ever spread out down the coast of Tamaulipas much below the Rio Grande. South of Soto la Marina, according to Saunders, the coastal plain is very narrow until the broad delta of the Rio Tamesi and Rio Panuco is reached at Tampico.

Saunders writes me that the Bolson de Mapimi was dry when scouted in February 1947. "Most of the natural lakes of Chihuahua and Durango," he adds, "are broad and shallow and situated in extensive basins which formerly held many times their present water surface. Today the water area is surrounded by an immense alkali flat, by cultivated fields or by arid grassland. . . . The large acreage of corn and other grains grown in this district undoubtedly adds to its attractiveness for the common cranes. . . . Silao is in a high intermontane basin, elevation 5,800 feet, which contains many reservoirs and lakes of small size. In former times some of these lakes were large, but drainage, agricultural developments and deforestation have greatly re-

duced all natural surface waters in this sector. Formerly, the lakes near Silao were probably surrounded by good grassland, but overgrazing has changed the plant association and it is much more arid now. Much of the acreage is in cultivation, some of it irrigated from reservoirs recently constructed. As to Jalisco, the terrain varies greatly with the locality. La Barca is in the delta of the Rio Lerma at the head of Lago de Chapala. This was formerly a very extensive marsh and wet meadow, but in recent years much of it was diked, drained and put in cultivation."

So the story goes. It is the same one that we have heard before, from Texas, from Iowa, from Louisiana, even from portions of the prairie provinces of Canada. Only the details differ and these but slightly. For which crop and in what manner scarcely matters now, the result in each case has been a serious lowering of the water table and the Whooping Crane is not the only loser.

There were other grassland areas where the species once wintered. One of Cooke's correspondents, W. Lloyd, reported that "a few flocks" remained all winter on high land in Tom Green and Concha Counties, Texas. This was in the early 1880's. Lloyd also is quoted as stating that "the Nueces canon is the winter home of countless myriads" (Cooke, 1888). That he referred here to Sandhill Cranes is unquestionable and unpublished files kindly placed at my disposal by the U. S. Fish and Wildlife Service throw a different light on this record, their Whooping Crane item under Lloyd's name reading, "Frio and Nueces Canons: 1881-82 (winter); abundant, probably in migration."

Nehrling (1882) wrote that from November to the end of March the Whooping Crane was "exceedingly abundant on all low prairies in the vicinity of Houston." This habitat was probably a continuation of the tallgrass of southwest Louisiana and is not referable to the high grasslands under discussion.

There are two reports from New Mexico, both within the grassland habitat. One is Dr. T. C.

Henry's record of 1853-54, from Fort Thorn, an Army Post of that period located on the Rio Grande, 10 miles west of Rincon in Dona Ana County. This is 69 miles northwest of El Paso and probably involved the flight into Mexico already described. Dr. Henry wrote, "Quite common during March and October on their northward and southward migration." He said that the flights were principally of the young, "the adults in full plumage only occasionally seen and never in large flocks." Obviously the "young" were actually Sandhills and this description, thus interpreted, gives us another early picture of the relative numbers of Whooping Cranes in these large flights of the more common species. Mrs. Bailey quotes Cooke to this same effect (Bailey, 1928). The other New Mexican record is recent (winter of 1938). This was a lone Whooper in company with large numbers of Sandhills that raided peanut fields near Portales (Vinzant, *in litt.*)

Present Distribution: Since Muddy Lake (1922-1948)

The years since Muddy Lake have seen a stubborn but steady retreat. Although at least two pairs of Whooping Cranes were nesting in west central Saskatchewan, during April and May of 1922, they were already hemmed in by settlements. Since then a few pairs have continued to rear their now thrice-precious young, building their nests in a remote section of the Canadian wilderness that has thus far successfully resisted all of our efforts to find it. According to the evidence, the species has retreated from several strategic portions of its range since Muddy Lake. The last group of Whoopers in the Rio Grande Delta country was seen in 1924. The last wintering pair on the brackish coastal marshes of Louisiana departed in 1935 and have never returned. On the Texas Coast, the final report of the species for the sector between Matagorda Bay and the Sabine River was made in 1936. And on the King Ranch, where small groups had been wintering, the last two de-

parted in the spring of 1937. None of these have returned.

Perhaps the most telling blow was the tragic disaster of 1940 that reduced the White Lake colony, in Louisiana, from 13 to 6 individuals, almost overnight. As this is written we have just completed the transfer of the last individual of this Louisiana group to Texas, following its successful capture. We now face the bare fact that the thirty-odd birds on the Aransas Refuge are the only wintering group, and the only Whooping Cranes, left.

While these losses on the wintering grounds were taking place, the Whoopers continued to turn up along the migration highway that still carries them through Oklahoma, Kansas, Nebraska and the Dakotas into Saskatchewan, Alberta and, rarely during this period, into Manitoba, the Mackenzie District and, on one occasion at least, into distant Keewatin. In order to evaluate these occurrence reports of recent years the following tables have been prepared. For purposes of comparison they include all acceptable occurrence reports for which dates and identifiable locations are given. The time periods are arranged so as to permit 10-year comparisons for the last thirty years of record. These are preceded by a 20-year span (1899-1918), a 30-year span (1869-1898), and finally, a period that goes on back nearly a century and a half, to the first reports of 1722-23.

In selecting the data for these tabulations a certain amount of purely arbitrary choice had to be exercised, but in so doing an effort has been made to eliminate and pare down, rather than include data about which there has been any reasonable doubt. The figures for Saskatchewan top all other divisions for the decade 1939-1948, as a result of the unprecedented publicity received by our project through the exemplary efforts of Mr. Fred G. Bard, Jr., of the Provincial Museum in Regina. In a smaller way, numerically, this also applies to Alberta and Manitoba figures. The latter would have shown a blank for this last decade, but for Mr. Bard's cam-

paign to obtain authentic reports of occurrence.

There are three tables, the first of which shows the number of occurrence *locations* by States, Provinces and Territorial Districts and by time periods.

TABLE C: Number of Occurrence Locations by States, Provinces, etc.

	1722- 1868	1869- 1898	1899- 1918	1919- 1928	1929- 1938	1939- 1948	Actual Total*
1. Saskatchewan	4	7	15	11	1	44	74
2. Nebraska	1	21	21	11	15	14	58
3. Iowa	3	27	5	..	..	..	39
4. Texas	5	18	12	5	8	5	37
5. No. Dakota	2	13	13	7	5	3	34
6. Alberta	1	1	9	6	1	11	30
7. Manitoba	1	14	8	..	1	3	22
8. Minnesota	..	17	2	..	..	..	21
9. Kansas	1	4	9	1	1	2	17
10. Louisiana	..	8	6	3	6	2	14
11. So. Dakota	..	11	3	..	..	..	14
12. Illinois	1	8	..	..	..	..	10
13. Mackenzie	6	..	4	1	..	2	10
14. Mexico	2	5	2	..	..	..	9
15. Missouri	1	6	2	..	..	..	8
16. Oklahoma	1	..	4	1	..	1	6
17. Colorado	..	1	..	..	1	1	5
18. Wyoming	..	..	3	..	3	1	5
19. Ohio	..	3	1	..	..	..	4
20. Ontario	..	4	..	..	..	..	4
21. Wisconsin	3	1	..	..	..	..	4
22. Alabama	..	..	1	..	..	..	3
23. Arkansas	..	2	1	..	..	..	3
24. Georgia	2	..	..	..	..	..	3
25. Indiana	..	1	..	..	..	..	3
26. Montana	..	..	3	..	..	..	3
27. Idaho	1	..	1	..	..	..	2
28. Kentucky	1	1	..	..	..	..	2
29. Michigan	..	2	..	..	..	..	2
30. New Jersey	2	..	..	..	1	..	2
31. New Mexico	1	..	..	..	1	..	2
32. Florida	1	..	..	..	..	..	1
33. Keewatin	..	..	..	..	1	..	1
34. Mississippi	..	..	1	..	..	..	1
35. So. Carolina	1	..	..	..	..	..	1
36. Utah	..	1	..	..	..	..	1
	41	176	126	46	44	89	454*

*Actual total of occurrence locations for which year of record is known. There were 68 instances in which Whooping Cranes were observed more than once in a given location so that "repeats" occur in the time period columns. In addition, occurrence locations for which no date is available are not included in above total, although these may appear in the *List* at the end of this section.

It should be noted that because of "repeats" (birds reported from the same location in more than one time period), the sum of the totals at the bottom of each column exceeds the sum of the *actual* totals.

Prior to 1869 there were only 41 occurrence locations on record for this period of 146 years. Lack of distributional data from the important states of Minnesota and Louisiana is noteworthy. It is also of interest that the District of Mackenzie leads all other divisions with 6 locations, and that Texas, at the other end of the line, is second with 5 locations.

The total for the 30-year period, 1869-1898, divided into decades, gives as a 10-year average the figure 58. Iowa is now on top with Nebraska, Texas and Minnesota following in that order. Illinois attained its brief prominence also, but this, and the other nesting States of Iowa, Minnesota, and the Province of Manitoba, faded rapidly during this period, as evidenced by the data that follows. Four of the original divisions—Florida, Georgia, South Carolina, and New Jersey—do not appear at all in this second grouping and, in fact, are not to appear again.

The 10-year average for the period 1899-1918 moves up to 63 locations, but seven divisions of the previous grouping have now gone for good. These are Utah, Indiana, Michigan, Wisconsin, Kentucky, Illinois and Ontario. Thus, by 1899 the species was no longer to be observed in 11 states from which it had once been reported. This represents a loss of 30% of the categories as listed. Admittedly, this is not a fully significant appraisal of actual decline. By this same year, 1899, it seems likely that actual losses in numbers of Whooping Cranes may have reached a considerably higher percentage of the original population than this. However, in our discussion we are attempting to measure loss of range. Since we have no data in terms of acreage or square miles, we must deal in terms of States, etc. This is not entirely satisfactory, but in the end we will obtain a fair impression of both trend and total decline.

It is not immediately discernible, but, during the two decades, 1899-1918, the numerical decline was very rapid. This is reflected, however, in the data for the 10-year period that follows (1919-1928). Absent are occurrence locations in 10 more states and all of Mexico, 11 of our divisions as listed. The species has not been reported since 1918 from Alabama, Idaho, Mississippi, Ohio, South Dakota, Iowa, Missouri, Arkansas, Minnesota, Montana or Mexico, as a group. Individually many of these dropped from the list early in the preceding period (the last Mexican record was for 1903).

As of 1919, the range had been depleted by the loss of 22 of the 36 divisions listed (61%). There were 49 occurrence locations given for the decade 1919-1928, and 42 for 1929-1938. A levelling off appears to have taken place. Only two more divisions (Keewatin and New Mexico) failed to answer the rollcall in the most recent 10-year period (1939-1948). In this last decade 12 divisions are represented of the original 36, three of them with a slim contribution of one location each. The total loss to date, on this basis, is thus 66%.

It will be noted that the number of locations has doubled to a total of 89 for this last period. However one-half of these are in Saskatchewan, where every man, woman and child has been on the alert. As agreeable as this awakened interest may be, the figures are, in effect, padded. Less Whooping Cranes, not more Whooping Cranes, are actually involved. They have simply been reported from twice as many locations.

More significant, perhaps, than all other com-

parisons is that between the grand total of actual occurrence locations, 454, and the number of places from which the species has been reported over the last decade. This shows a loss of 80%, there being 365 abandoned locations in the records against 89 occupied over the last 10 years.

The overall trend is illustrated in this next tabulation of occurrence locations in the order of their disappearance from the scene. The growing area of blank spaces across the upper right-hand portion of the table is a graphic illustration of steady shrinkage of range. The dates in the column labeled "Year of Last Record" are not necessarily the actual dates of final occurrence.

There have been 925 reports of occurrence sufficiently well documented, and with enough detail, to be considered authentic. These are included in the following tabulation, where they

TABLE D: Reported Locations Tabulated to Show Range Shrinkage (1722-1948)

	1722-1868	1869-1898	1899-1918	1919-1928	1929-1938	1939-1948	Year of Last Record
1. Florida	1						1723
2. Georgia	2						1723
3. So. Carolina	1						1850
4. New Jersey	2						1867
5. Utah	..	1					1880
6. Indiana	..	1					1881
7. Michigan	..	2					1882
8. Wisconsin	3	1					1884
9. Kentucky	1	1					1886
10. Illinois	1	8					1891
11. Ontario	..	4					1895
12. Alabama	..	..	1				1899
13. Idaho	1	..	1				1899
14. Mississippi	..	..	1				1902
15. Ohio	..	3	1				1902
16. Mexico	2	5	2				1903
17. So. Dakota	..	11	3				1909
18. Iowa	3	27	6				1911
19. Missouri	1	6	2				1913
20. Arkansas	..	2	1				1914
21. Minnesota	..	17	2				1917
22. Montana	..	..	3				1918
23. Keewatin	..	..	..	1	..		1930
24. New Mexico	1	..	..	1	..		1938
25. Colorado	..	1	..	1	1		1941
26. Wyoming	..	..	3	3	1		1945
27. Oklahoma	1	..	4	1	..	1	1946
28. Kansas	1	4	9	1	1	2	1947
29. Mackenzie	6	..	4	1	..	2	1947
30. No. Dakota	2	13	13	7	5	3	1947
31. Alberta	1	1	9	6	1	11	1948
32. Louisiana	..	8	6	3	6	2	1948
33. Manitoba	1	14	8	..	1	3	1948
34. Nebraska	1	21	21	11	15	14	1948
35. Saskatchewan	4	7	15	11	1	44	1948
36. Texas	5	18	12	5	8	5	1948

TABLE E: Number of Occurrence Reports by States, Provinces, etc.

	1722-1868	1869-1898	1899-1918	1919-1928	1929-1938	1939-1948	Totals
1. Nebraska	1	33	61	34	30	19	178
2. Saskatchewan	4	9	24	14	1	70	122
3. Texas	6	64	15	13	16	3*	117*
4. No. Dakota	2	25	20	13	6	5	71
5. Iowa	4	54	7	..	..	..	65
6. Louisiana	..	11	8	3	24	11	57
7. Manitoba	2	27	23	..	1	3	56
8. So. Dakota	..	36	3	..	..	..	39
9. Alberta	1	2	13	6	1	12	35
10. Kansas	2	13	10	4	1	3	33
11. Minnesota	..	31	2	..	..	..	33
12. Mackenzie	11	..	5	1	..	2	19
13. Missouri	1	9	6	..	..	..	16
14. Mexico	2	7	2	..	..	..	11
15. Wyoming	..	..	6	3	1	1	11
16. Oklahoma	1	..	7	1	..	1	10
17. Illinois	1	8	..	..	..	..	9
18. Ohio	..	3	2	..	..	..	5
19. Colorado	..	2	..	..	1	1	4
20. Ontario	..	4	..	..	..	..	4
21. Wisconsin	3	1	..	..	..	..	4
22. Arkansas	..	2	1	..	..	..	3
23. Kentucky	1	2	..	..	..	..	3
24. Montana	..	..	3	..	..	..	3
25. Georgia	2	..	..	..	..	..	2
26. Idaho	1	..	1	..	..	..	2
27. Michigan	..	2	..	..	..	..	2
28. New Jersey	2	..	..	..	..	..	2
29. New Mexico	1	..	..	..	1	..	2
30. Alabama	..	..	1	..	..	..	1
31. Florida	1	..	..	..	..	..	1
32. Indiana	..	1	..	..	..	..	1
33. Keewatin	..	..	1	..	..	..	1
34. Mississippi	1	..	..	..	..	..	1
35. So. Carolina	..	1	..	..	..	..	1
36. Utah	..	1	..	..	..	..	1
	50	347	221	92	84	131	925

*Not included are the innumerable reports from the Blackjack Peninsula (Aransas National Wildlife Refuge), Matagorda Island and St. Joseph Island, Texas.

are arranged in numerical order (by States, Provinces and Territorial Districts), and by time periods.

Today we count a round dozen States, Provinces and Districts where the Whooping Crane may be expected to appear. It is a vast area in which to trace 34 birds, regardless of their great size. The small strip of coast still occupied by wintering Whoopers, the narrow migration routes traveled and spots in which nonbreeding summer wanderers have shown up from time to time, do not take up much space on a map of North America. The role of these summer wanderers should be given our consideration in order that we may fit them into the distribution picture. This will require a separate discussion.

Nonbreeding Summer Wanderers

In order that we may understand the status of summer wanderers within the total group of Whooping Crane migrants, we must examine "flock" composition and the pertinent subject of breeding cycle schedules and related migration dates. Because these matters are to be discussed in their own right later on in this report, we will reduce the present consideration to essentials.

(a) *Composition of the Migrant Group*

I avoid the word "flock" and substitute "group" for the excellent reason that this species does not flock in the usual sense. Group, as here used, means the totality or entire body of migrants, from the first pair to leave to the last, for the Whooping Crane now migrates by pairs, families or small loosely knit bands that I believe are made up either of adult pairs still followed by their offspring of the previous season, plus one or more two-year-olds, or of families or pairs that band together at the last moment, as the routine of winter behavior breaks down and the excitement of migration takes its place. A careful record was kept in the spring of 1948 of the departure of migrants from the Aransas National Wildlife Refuge in Texas.

The 28 birds involved disappeared on the night preceding, or early on the morning, of the following dates, in the numbers shown:

March 27	3
April 6	4
April 10	4
April 12	3
April 14	3
April 15	7
April 18	4

The first 3 included a pair without offspring and a "single" that had associated with them occasionally during the winter.

The next 4 included a pair without young, plus an adult female⁴⁰ and her young of the previous season (the male of this family was evidently lost in the southward migration). These 4 birds had occupied overlapping territories during the winter, and, although the female and young were not tolerated by other neighboring pairs, there was no friction observed between these four.

The next 4 consisted of two pairs without young that had no particular affiliation and may have departed separately.

The next 3 made up a family group that apparently left on its own.

The same applies to the family group comprising the next three.

The last 4 were a family group and a "single." This last individual had spent the winter on Matagorda Island with another adult (or sub-adult). At the last moment, its partner, or "companion," responded to the call notes of a crippled male that had remained on the refuge throughout the year and joined him in his exile.

In the above migrant group, then, we had 11 adults with young, 6 young-of-the-year, and 11 birds of unexplained status. The last 11 had spent the winter as follows:

- (a) 8 as pairs or companions.
- (b) 3 as unattached singles or loosely attached companions.

⁴⁰ Distinguished as female by general behavior, chiefly an inability to claim and defend a definite territory.

With certain exceptions, their ages, sex and relationship to each other were unknown. In leaving on migration they apparently attached themselves in the following manner:

- (a) One "single" and two of the 8 companions may have migrated together.
- (b) Two of the remaining 6 companions were joined by the odd female and her young-of-the-year.
- (c) The last 4 of the remaining companions may have departed as two separate units.
- (d) The two remaining "singles" each may have joined, or trailed after, two family groups that departed separately.

In using the term "companions" for the 8 adults without young, I do so because of an uncertainty as to the respective sex and relationship of at least half of these birds. However, from observation, it is reasonably certain that 4 of them (2 pairs) were the identical pairs that had showed up with young the previous year. This leaves only two actual sets of companions and 3 singles of unknown age, sex and relationship, 7 in all.

The migrant group can now be further broken down by indicating the number of known males and females. There are 5 males and 6 females in the family groups and 2 males and 2 females in the category of known pairs without young. This total is 7 males and 8 females or 15 of the 28.

Of the remaining thirteen there are 6 young-of-the-year, for which we will assume a balanced sex ratio (3 males and 3 females). The estimated total ratio is now 10 males and 11 females.

For the seven that remain we have no evidence. Losses have certainly been of such a character as to upset sex ratios. However, more male birds appear in our *Kill Record* than females,⁴¹ possibly because they are bolder, more aggressive and therefore more frequently shot than females. Among these seven, it seems likely

⁴¹The ratio is 52 to 35 for all age groups. Only these 87 had been sexed out of a total of 389 individuals in the *Kill Record*.

that females predominate, but we can only guess at the ratio.

Examining the record we find that a basis for determining long range figures on the composition of the migrant group is contained in the data on number of young brought to winter quarters each year. The first tabulation (Table F) lists the estimated number of migrants, the *actual* number of successful breeding pairs, and the percentage of the total that may be classed as successful adults. The *average* of this last category is 34% of the total or approximately one-third. Applying this average we obtain a column showing the *average* expectancy for number of successful adults.

TABLE F: Composition of the Migrant Group

Year (Spring)	Est. No. Migrants	No. Successful Breeding Adults	% of Total that are Successful Adults	One-third of Total	One-half of Total	Difference or Un-successful Adults
1939	18	8	44%	6	9	3
1940	19	10	53%	6	9	3
1941	23	8	35%	7	11	4
1942	15	4	27%	5	7	2
1943	19	6	31%	6	9	3
1944	21	10	48%	7	10	3
1945	18	6	33%	6	9	3
1946	23	4	17%	7	11	4
1947	23	6	26%	7	11	4
1948	28	12	43%	9	14	5
1949	29	6	21%	9	14	5
average	21	average 7	average 34%			average 3.5

Since we are aware that unsuccessful but potential breeding pairs are included in the migrant group, in addition to those classified as "successful," we must add to the figures in the one-third column to obtain figures under the heading *Potential Breeding Adults*. In 1948 we could account for two pairs that were evidently in this category. However, the successful crop of young for the previous summer had been unusually high (6 compared with the 11-year average of 4.09) and the number of actual breeding pairs (6) was far in excess of the 11-year average (3.6).

Thus it seems obvious that the category *Potential Breeding Adults* could not be expected, on the average, to exceed or even duplicate the percentage of the total calculated for Spring 1948, which was 8 pairs or 16 birds, a

percentage of 57%. In the tables, therefore, we have arbitrarily established 50% as the average number of a migrant group that may be considered as *potential* breeding pairs.

The second table (G), on this basis, lists the probable number of nonbreeders in migrant groups for the period 1939-1949. This category includes young of the previous season, sub-adults (2-year-olds), senile and other nonbreeding adults. It is with these birds that we are now concerned in their summer role as nonbreeding wanderers. In order to separate them from the breeding pairs we must examine certain vital characteristics of the individuals in that category.

TABLE G: Estimated Total Number of Nonbreeders in Migrant Group

Year (Spring)	Est. Number Migrants	Potential Breeding Adults	Young of Previous Season	Sub-adults, Senile & other Nonbreeding Adults	Estimated Total Nonbreeders
1939	18	9	4	5	9
1940	19	9	7	3	10
1941	23	11	5	7	12
1942	15	7	2	6	8
1943	10	9	4	6	10
1944	21	10	5	6	11
1945	18	9	3	6	9
1946	23	11	3	9	12
1947	23	11	3	9	12
1948	28	14	6	8	14
1949	29	14	3	12	15
	average 21	average 10	average 4.09	average 7	average 11

(b) *Breeding Pairs and the Time Element*

In a bird as large as the Whooping Crane the incubation period is relatively long (34-35 days) and the growth and development of the young is comparatively slow. Unfortunately, however, we can muster few facts that bear on these important points. When we attempt to "manage" the welfare of a wild bird species we must usually begin by recognizing that we know remarkably little about its life history. The Whooping Crane has been no exception. In spite of an extensive literature relating to *Grus americana*, one searches in vain for actual data of real consequence on what we may term the "species characteristics." Many questions that are now vital to our efforts on behalf of the

Whooper still remain unanswered, fundamental questions that are often extremely difficult to determine. For example, when do the breeding pairs arrive on their nesting grounds, on the average? How soon does incubation begin? Is our estimate of the incubation period substantially correct? How soon do the young attempt trial flights? When is strong, normal flight possible? How do these events coincide with the molt of the parent birds? Is this a complete or partial molt? Are the adults flightless during the course of this molt? At what age do the young set out with their parents on the southward migration? And so on and on, questions that should be answered, at least in part, or in theory, if we are to understand the problems involved in the Whooping Crane's existence, and if we are to tackle with intelligence and completeness the task of its rehabilitation.

The present question of properly evaluating the relative status of birds observed in late spring and summer is a practical example of the sort of problem that might be solved if some of the species characteristics were better known. For instance, if we knew the *last possible date* on which a breeding pair could begin incubation and still have time to get its young on the wing, and away from the Provinces by early October, we might produce in the same breath a yardstick for estimating the status of any Whooping Crane observed in Canada during the spring and summer season.

There are certain characters in any species that cannot be altered to suit our purpose, no matter how urgent the situation from our point of view. Most individuals of a species, that is of an identical race, take part in the same activities, and do the same things, at approximately the same time. Important survival values are concerned in this synchronization of effort. The breeding cycle of *Grus americana* has probably unfolded according to an established rhythm for many centuries. In this cycle there are undoubtedly *average* dates on which the breeding pairs arrive on the nest site, engage in nest building

and copulation, and deposit the first egg. There is, by the same token, an average date for the start of incubation. This date may have differed slightly from central Iowa to central Alberta and Arctic Canada, owing to differences in latitude and, therefore, in other values, but this variation may not have been great.

Just what are the knowns and the unknowns involved? We have on record a single hatching date for the species (May 29), and we know the approximate incubation period (34-35 days). The records also indicate that most Whooping Cranes have left the Provinces by mid-October, the majority of them departing early in that month; while family groups seem to move southward through Nebraska (Platte River) between October 10 and 25. In recent years, the family groups have arrived on the Texas Gulf Coast (Aransas Refuge), on the average, between November 2 and November 8.

Dr. Lawrence H. Walkinshaw of Battle Creek, who has given many years to the study of Sandhill Cranes, has obtained some interesting data of this kind on the Greater Sandhill in Michigan and Alberta, and the Lesser Sandhill in

Arctic Canada and Alaska. From some of his data, and the scant information of this sort that we have on the Whooping Crane, it is possible to assemble the following useful tabulation.

The hatching dates are known in each case. Assuming incubation periods of 34-35 days for *G. americana*, and 31-32 days for the two Sandhill Cranes (*G. c. canadensis* and *G. c. tabida*), the dates for start of incubation are calculated. As time of incubation differs according to egg volume, then it is possible that the period for the Lesser Sandhill is slightly shorter than that for the Greater Sandhill. Thus it could be as little as 29-30 days for the Lesser. In the tabulation, however, it is assumed, on the average, both Sandhills require either 31 or 32 days, which cannot be very far from correct in either case.

The date when the young make their first attempts to fly is less certain. Walkinshaw observed a captive Greater Sandhill in Michigan and found that initial attempts to fly were made 59 days after hatching. But normal flight was not observed until 92 days after hatching. There might be some variation in the span of these periods in the wild, and there might well be a difference in the growth rate of the young in Arctic Canada or Alaska, for example, as compared with Michigan, or even central Alberta. This is an important point, as it bears directly on the problem of the breeding cycle dates of *G. americana*. There is some indication that the 24-hour daylight of the Arctic summer may speed up the growth and development of fledgling birds, enabling those individuals that nest in the Arctic to complete their breeding cycles in less time than is required by individuals of the same species that nest in lower latitudes. The most compelling sort of evidence of this so-called "telescoping" of the cycle is a comparison of dates such as we have made in the above table. If growth rates are the same for young of the Lesser Sandhill hatched in Alaska and young of the Greater Sandhill hatched in Michigan, then the three Alaskan examples given in the

TABLE H: Known and Calculated Breeding Cycle Dates

Race	Locate	Start of Incubation	Hatching	Trial Flight of Young	Normal Flight of Young	Start of Southward Migration
<i>G. c. tabida</i>	Mich.	Apr. 8-9	May 10	July 8	Aug. 10	Oct. 24-Nov. 25 (one record: Dec. 16)
	Upper Peninsular Mich.	May 7-11	June 7-12	Aug. 5-10	Sept. 7-12	gone by Sept. 15 (1940, Henry)
	Central Alberta	Apr. 26-27	May 28	July 26	Aug. 28	Sept. 15-Oct. 1
		Apr. 28-29 May 7-8	May 30 June 8	July 28 Aug. 6	Aug. 30 Sept. 8	" "
<i>G. C. canadensis</i>	Arctic Canada	May 27-30	June 29- July 2	Aug. 27-30 (?)	Sept. 18 (?)	early Sept.
	Alaska	May 20-21	June 21	Aug. 19 (?)	Sept. 18 (?)	early Sept.
		May 21-22	June 22	Aug. 20 (?)	Sept. 18 (?)	"
		May 22-23	June 23	Aug. 21 (?)	Sept. 18 (?)	"
<i>G. americana</i>	Central Sask.	Apr. 24-25	May 29	July 27	Aug. 29	early Oct.

table (which hatched June 21, 22 and 23) would not be ready for normal flight until September 21, 22 and 23. But, according to Walkinshaw (*in litt.*), Lesser Sandhills are not seen in Alaska after *early* September.

On this same point Bent (1926) gives as "late dates of fall departure" from Alaska: September 4, 15, 17, 18.

From these, and similar comparisons, we may assume that young birds that fledge in the Arctic must actually attain normal flight in less time than is required farther south. The example in the table for Arctic Canada (hatching date between June 29 and July 2) is even more to the point than is the example of the Alaskan birds. Walkinshaw writes me that E. W. Nelson, former Chief of the U. S. Biological Survey, found nests of the Lesser Sandhill Crane in Siberia still being incubated as late as July 28. These birds migrate across the Bering Straits by August 18-30, when snow starts falling in northeastern Siberia. It seems likely from this that some young cranes cannot hatch early enough in the Arctic to reach the normal flight stage by the time the parents are ready for the southward migration.

These questions serve to emphasize the point that cranes, with a relatively long incubation period and a relatively slow growth period, must begin incubation at a reasonably early date in order to rear their young successfully. This is evidently true regardless of any differences that may exist between races, or between individuals nesting in widely separated latitudes.

From the information at hand it is apparent that the critical date we have labeled "start of incubation" may vary in these birds from as early as April 8 (in Michigan) to as late as May 30 (in Arctic Canada). In spite of this considerable difference it will be seen that even a Lesser Sandhill pair, nesting in Arctic Canada and not hatching their eggs until July 2, can still have 78 days in which to bring their young to the normal flying stage and migrate by September 18. The difference between 92 days

and 78 days is just two weeks and may represent the gain in time that is achieved by Arctic nesting pairs. However, this schedule does not allow additional time for practice flying and experience, prior to actual migration.

Applying these speculations to the Whooping Crane we find a series of dates in the record on which eggs have been observed, in nests and still being incubated. There are 28 of these observed nestings for which the month is given. Of this total, 23 were May dates, 1 April, 3 June and 1 July. The average May date when eggs were observed was May 14. For U. S. nests (Iowa, Minnesota and North Dakota), the average May date was May 10. For Canadian nests it was slightly later, May 18. The April date was the 25th; June dates were the 3rd, the 17th and 19th. No exact day is given for the single July record.

Thus, with the exception of four sets of eggs, that may have been extremes, all nests of the Whooping Crane observed could have hatched by June 1. Late departure dates for Whooping Cranes leaving Canada, as given by Bent (1926), are October 2, 5, 12, 16, and 20. The most northerly point cited is Ft. McMurray, Alberta (Oct. 16). Other dates are for central or southern points in the Provinces. Thus, assuming that June 1 is the average hatching date, and October 11 the average late departure date (from the Provinces), the young would have the maximum 92 days for attaining normal flight plus more than a month (39 days) for practice and experience. Walkinshaw points out (*in litt.*) that young of the Greater Sandhill Crane in Michigan may be "on the wing" (i.e., have attained normal flight) by August 1, yet the southward migration does not usually take place before the last week in October, and sometimes much later. Walkinshaw adds, "Thus our cranes have a great deal of experience in flying before migrating." This practice may be of considerable survival value.

Except for those pairs that may once have nested in the Arctic regions, it would appear

that the average period in which Whooping Cranes started incubation may have been about April 24 to May 7. It has been noted (in the spring of 1948) that potential breeding pairs left the Texas Coast over a span of 14 days. The median point for start of incubation would thus be April 30-May 1, and the average hatching date between June 3 and June 5. These dates fit the data that we have, including departure of spring migrants from winter quarters, and departure of family groups from the Provinces in the fall. Unfortunately, we can find only one migration date for the far North, May 25 (MacFarlane, 1891). If these were breeding birds they could scarcely have begun incubation before, say, May 28, in which case hatching would have been no earlier than July 1. This would have given the young 61 days to attain normal flight by September, when weather conditions on the Arctic Coast would certainly force departure southward.

We do not know where our present group of breeding pairs are nesting and thus cannot apply these average dates to them with any certainty. However, in view of the fact that a fairly rigid breeding cycle schedule appears to be essential, regardless of the latitude of the nesting grounds, it must be considered in connection with the present population. The most critical date in this schedule—for the start of incubation—cannot be moved much beyond the average late date of May 7. Certainly any breeding pairs of Whooping Cranes observed in Canada will be established on their nest sites by May 15. Any others seen after that date, and not already defending a nest territory, will almost certainly be nonbreeders.

(c) *Behavior Pattern of Breeding Pairs*

Daily observations of the pair that nested unsuccessfully in captivity on the Aransas Refuge were made in May 1949. From their formalized behavior pattern, and such additional information as is available, we may know what to expect

in the general behavior of a nesting pair. They do not act like Whooping Cranes on the wintering grounds or like nonbreeding birds, interested only in feeding and in safeguarding their general welfare. In the first place, one of the pair is *always* close to the nest. Two Whooping Cranes, observed together during the critical period, and *not* guarding a nest, are almost certain to be nonbreeders. Both birds may sometimes remain close to the nest, but one never leaves. They take turns at incubation and the free bird, when it moves away from the vicinity of the nest to feed, usually skulks off with exaggerated secrecy. The free bird, particularly the male, spends a good deal of time chasing other birds out of a large area around the nest. In the case of the Aransas pair this territory was almost one mile in length, by more than a quarter mile in width, but was limited by fencing. The marsh near Baliol, Saskatchewan, where Neil Gilmour found a nest in 1922, was described as "approximately 3 miles long and from 1 to 2 miles in width and comprises an area of upwards of 3,000 acres."

In general, the reaction of a pair with a nest to an intruder is unmistakable. Their concern is extremely manifest and once the nest is approached closely they become loudly vocal, whooping in a long series of alarm notes.

From these facts we can speculate that Whooping Cranes observed in Canada after the first week of May are (a) either a breeding pair already established on their nesting site (where their behavior is formalized and unmistakably that of nesting birds), or (b) they are nonbreeding summer wanderers. If a breeding pair it will be extremely unusual to see them *together*, unless they are next to their nest.

The matter of habitat is also an important consideration. Summer wanderers are sometimes reported in Canada from the edge of the "bush," the transition belt between parklands and mixed forest. This is also the region of muskegs. Except for one doubtful record, none of the 18 known Canadian nesting sites were in

this type of habitat, as previously noted. Throughout the species' history there is overwhelming evidence that its preferred niche, especially when nesting, is a flat, or slightly rolling, open area interspersed with bulrush, cattail and sedge marshes and swales, covered with standing water and having the biotic characteristics found in the willow communities of the aspen parkland.⁴² There must be a great abundance of small animal life, including basic invertebrate forms. The entire area must be several hundred (or even several thousand) acres in size and completely isolated from human disturbances of any sort.

The definite existence of a considerable percentage of non-breeding birds in the total migratory group cannot be over-emphasized. By analysis of certain known characteristics of the group we have arrived at a hypothetical average figure for this non-breeding segment. It is felt that this figure is probably close to the actual one and the presence of so many (from 8 to 15) non-breeders could easily account for all of the authentic summer records and many of the migration records of the last few years, especially those from settled areas in the western Provinces.

Although this discussion has been rather prolonged, it has seemed necessary in order to explain the status of the Whooping Cranes observed in recent years during the summer months. Nearly all of these observations have been from Canada.

(d) *The Record of Summer Nonbreeders*

Actually, there are not many authentic reports of summer wanderers. An increase in the number of reports has occurred since the institution of the Whooping Crane Project. Through the interest and efforts of Dr. L. H. Walkinshaw of Battle Creek, Maurice Street of Nipawin, and other residents of the area, a number of late spring and summer reports were turned up in

the district around Nipawin, Snowden and Choiceland, Saskatchewan. Others wandered about the parklands east of Regina (Qu'Appelle Valley), or showed up in or near parkland "islands" in western Alberta. Nearly all of these locations are close to settlements; many are abandoned nesting locations. The magnet of the biotic niche is irresistible!

There have been 48 individuals recorded from Canada between May 15 and August 31 that were not breeding birds. The record by years was as follows:

1861.....	1
1865.....	3
1923.....	4
1930.....	1
1942.....	1
1944.....	2
1945.....	3
1946.....	3
1947.....	15
1948.....	15

The recent increase is due, I believe, to the increased number of interested observers rather than to a sudden boost in the number of non-breeding birds. It is possible, of course, that the present reduced population, highly inbred as it undoubtedly is, contains a greater percentage of infertile individuals than formerly. But I doubt this. The composition of the migrant group, as worked out, seems to provide for the characteristics of the species on all counts and probably the 50-50 ratio is close to normal.

By Provinces and Districts the 35 reports of summer birds originated as follows:

Saskatchewan	15
Alberta	12
Manitoba	4
Mackenzie	3
Keewatin	1

Broken down by habitat types these locations show an interesting preference for parklands,

⁴² See Bird (1930).

look like adults. Possibly these reports in both instances were actually of two adult Whooping Cranes, in company with brown-plumaged Sand-

hills.

One more point should be mentioned, to complete this discussion of distribution. It is the exceptional and unusual record that often requires the greatest amount of inquiry. We have tried to find a pattern, a normal or average outline, on which to hang our picture of distribution. We have even attempted to set up a hypothetical schedule, likewise average, to which the migrant breeding pairs may be expected to adhere. In explaining the presence of nonbreeding individuals in Canada, and elsewhere, during the summer months, we have resorted to analysis, tables of figures and speculative discussion. To avoid the possibility of mistaken conceptions, we have apparently given more attention to the report that is in error, or outside of the pattern, than we have to the authentic records. This course has seemed unavoidable.

Even so, there is much that defies analysis and that will not be explained. There is, for example, the lone Whooping Crane observed in late August, 1886, flying north along the Mississippi River at Island No. 6, opposite Hickman, Kentucky (Pindar, 1887; 1925). And the normal-appearing family group, two apparently healthy adults and their vigorous offspring of the previous summer, lingering on the winter range at Aransas Refuge, in Texas, where, with James O. Stevenson, I watched them in late May and on into June. They remained all of the following summer and we can find no entirely satisfactory explanation.

Or the Whooping Cranes that spent several summers on the King Ranch, where Mr. Richard Kleberg thought they must be nesting. No nests were ever found, to my knowledge, and again we can only guess that there was a physiological deficiency, or something of that nature, that retarded migration. Of course, Dresser observed the species around Matamoros in June, except for birds in the hand. At 100 yards they

and for the transitional muskeg between park-land and mixed forest.

(Number of reports by habitat types).

Aspen Parkland	17
Transition (Parkland to Mixed Forest)	10
Northern Mixed Forest	3
Northern Coniferous Forest	3
Precambrian Shield	1
Delta	1

Size of groups is a possible source of further conjecture. Six examples (out of 24) consist of "pairs." The numbers, as reported, were as follows:

7	2	1	1
4	2	1	1
4	2	1	1
3	2	1	1
3	2	1	1
3	2	1	1
3	2	1	1

Some of the above birds were reported more than once, so that the total of the above figures exceeds the actual total.

Not many summer records of recent date have been reported from the western U. S. These are the most recent:

- Colorado
- 1. Fort Collins June 20, 1931. 1
- Wyoming
- 1. Yellowstone Park Area..... August 4, 1914. 5
- Summer 1930. 4
- Summer 1945. 3

Both the 1930 and 1945 groups reported from Yellowstone were said to contain young birds. It is obviously impossible for young-of-the-year to hatch before about May 25, at the very earliest, or to reach Yellowstone before late September, fledgling Whoopers can migrate before the estimated 120 ± days, which does not seem likely. Two-year olds are not recognizable as such, except for birds in the hand. At 100 yards they

1863, and the Mexicans told him that they were nesting on the Boca del Rio Grande, but a few years later Sennett did not appear to find them present in the region after April 1st. These are some of the minor mysteries. The best speculation may be that since the summer distribution of these individuals is abnormal, then the birds themselves must be abnormal as well. Doubtless the explanation is physiological. Waterfowl with even a slight touch of lead poisoning, from swallowing shot picked up from the bottom of ponds near shooting blinds, may show a retarded gonadal development and fail to migrate. There are always a certain number of ducks scattered along the Gulf Coast in summer that normally should have migrated northward. Some of these may be sterile birds that have recovered from the effects of swallowing a few lead pellets. Whether or not Whooping Cranes pick up lead pellets has not been established. They are equipped with a gizzard and use sand and pebbles for grinding (N. B. Moore found that the stomachs of six Florida Sandhill Cranes contained "much sand, small white quartz, and larger brown pebbles," the amount in a single stomach weighing two ounces after drying).⁴³ And Whooping Cranes, frequenting ponds, sandbars and lakes, where shooting has taken place, would have ample opportunity for picking up lead shot.

Another summering bird on Aransas Refuge is a large individual, probably a male, with a curious injury, or deficiency in the left wing. We have caught and handled this bird and there does not appear to be a break in the wing bones. Yet, the member hangs limp and almost useless. It could be that there is a partial paralysis in the muscles and this might conceivably result from a lead pellet lodged in the muscle, or in the gizzard.

But, here we are speculating, and moving beyond the scope of the present discussion. And I have not even mentioned another summering

individual on Aransas Refuge that was unable to migrate because of a badly broken wing; or another that attached "herself" to the crippled male described above, and walked at his side through all the summer that followed, only deserting him the next spring when the urge to lift herself into the freedom of the sky, and journey northward with the other migrants, proved irresistible. These two, at least, can be explained.

This then, is the story of the distribution of *Grus americana*. From an area of vast and impressive extent, reaching in broad bands from the Arctic shores to the lofty plateaus of central Mexico and from the Great Salt Lake to the Atlantic seaboard, it has steadily dwindled in size until today it is represented on a distributional map by only a few dots—pinpoints of occurrence—dots that are connected by thin trails leading resolutely north and south. It still covers many miles of distance but it is now a mere trace, a path so dim that it becomes difficult for us to follow. The present breeding distribution is unknown, but wide areas of isolation still exist in which the Whooping Crane can survive. There is reason for hope and sound reason for hoping.

*List of Important Distribution
Reports: 1722-1948*

In the following tabulations an attempt has been made to list all locations in North America where Whooping Cranes have occurred during the 226 years covered by existing records. Reports that seemed weak on identification, or uncertain for other reasons, have been omitted, although some very old records are included on rather slim evidence, both because of their obvious historic value and because the presence of the species at the location in question appears logical with relation to time, place and the general pattern of distribution. Authorities are given for both published and unpublished data.

⁴³ Quoted by Bent (1926).

For convenient reference, the reports are arranged chronologically by States, Provinces, etc. Each distinct locale is numbered for easy reference elsewhere in the text.

The location is given in the first column, the time of occurrence—year or actual date if available—in the second. In the third column the name of the observer or collector appears, if on record. The last column contains the authority. Names followed by year (thus: Golsan and Holt, 1914) refer to the listings in the bibliography at the end of this report. The designation *USFWS files* indicates that supporting data is on file with the U. S. Fish & Wildlife Service. *Bard Records* are those items selected from the wealth of material submitted to Fred G. Bard, Jr., Director of the Provincial Museum in Regina, as a result of his untiring efforts to stimulate interest in the Whooping Crane throughout Canada. *Lynch Records* are those compiled by John J. Lynch, U. S. Fish & Wildlife Service, Abbeville, Louisiana, who interviewed many "old timers" in the marsh country of southwestern Louisiana to obtain valuable historic data. Abbreviations made use of frequently are as follows: USNM (U. S. National Museum); MCZ (Museum of Comparative Zoology, Cambridge, Mass.); ROMZ (Royal Ontario Museum of Zoology). Other designations should be self-explanatory, including NHM (Natural History Museum) and MNH (Museum of Natural History).

No acceptable report has been consciously omitted. However, it is inevitable that some perfectly authentic records will not be found in the tabulations that follow. In addition to any that have been simply overlooked, many recent reports that are convincing in most respects have not been included because of a lack of detail. This lack is chiefly in the description of the birds themselves, their manner of flight, etc. Since the purpose of this summary is to present existing evidence with regard to the geographical distribution of the species, it is believed that the reports selected will suffice.

ALABAMA			
1. Dauphin Island (entrance to Mobile Bay)	"formerly" (winter)	Capt. Sprinkle	Howell (1928)
2. Cypress Slough, Millwood	"many years ago"	?	Avery (1890)
3. Creek near Alabama R., 6 mi. from Prattville	Nov. or Dec. 1899	Thos. Hook	Golsan and Holt (1914)
ALBERTA			
4. Fort Chipewyan	June 22, 1835	Richard King	King (1836)
5. Battle River S. of Camrose	spring & fall 1886	F. L. Farley	USFWS files
6. 12 mi. N. of Killam	nested 1904; noted 1905	Farley	USFWS files
7. 30 mi. NW of Edmonton	nested 1906-09	Sidney Stansell	Stansell (1909).
8. Lower Athabaska R. ⁴	Oct. 11, 1907	Seton & Preble	Seton (1911)
9. Athabaska R., below Ft. McMurray	Oct. 16, 1907	Seton & Preble	Seton (1911)
10. Stony Plain	May 21, 1909	Stansell	Cooke (1914)
11. Whitford Lake	nested 1909	Allan Brooks	USFWS files
12. 6 mi. up Swan R. (S. of Lesser Slave L.)	May 1913 (<i>specimen</i>)	Farley	USFWS files
13. Buffalo Park, Wainright	1914 <i>nesting</i>	park keeper (Seton)	Bent (1920)
14. Red Deer R., E. of Red Deer	"some years ago" (1917)	Dr. George	Taverner (1919a)
15. 7 mi. W. of Tofield	summer 1919	Farley	USFWS files
16. (near) Islay	Oct. 15, 1919	J. Dewey Soper (Farley)	USFWS files
17. Sullivan Lake	Sept. 13, 1920	Farley	USFWS files
18. 10 mi. W. of Birch L.	April 1922	C. E. Mills (Henderson)	Bent (1926)
19. Camrose	June 4, 1923	Farley	USFWS files
20. Bittern L., W. of Camrose	Sept. 22, 1927	Farley	USFWS files
21. Paddle River	fall 1933 (1 killed)	J. P. Gillese	Gillesse (1948)
22. 4 mi. N., 1½ mi. W. of Grimshaw	spring 1945	Ralph Haas	Bard Records
23. (near) Houcher Lake, 9 mi. S. of Czar	summer 1947	J. S. Stewart	Stewart (letter 11-6-47)
24. Lesser Slave Lake	summer 1947	L. M. Johnston	Rowan (letter 4-21-48)
25. 17 mi. S., 2 mi. W. of Vermillion	Aug. 30, 1947	Buster Harle	Edmonton Jour. 9-3-47; Calgary Herald 9-4-47; Jean Hale & Mrs. O. L. Wollers (letters 9-5-47)
26. 3 mi. E. of Cochrane	Sept. 1, 1947	Bloss Rutter	Bard Records
27. 80 mi. SW of Edmonton	May 5, 1948	W. Hawkins	Rowan (letter 7-15-48)
28. Steen River (between Grimshaw H'way & Hay R.)	June 1 July 7, 1948	E. L. Mattice	Heustis (letter 7-19-48); Soper (letter 8-8-48)
29. Bear L. near Grande Prairie	July 11, 1948	B. Hamm	Hamm (letter 7-11-48)
30. 4 mi. S. of Hastings L., near Tofield	spring 1948; July 1948	J. Druce	Druce (letter July 1948)
31. Between Grande Prairie & Fort St. John ⁴	summer 1948	D. Featherstonecaugh	Featherstonecaugh (verbal)
32. Archer L. region, 30 mi. S. of Old Fort Bay (Athabaska L.)	Aug. 19, 1948	J. C. Nesbitt	Nesbitt (radiogram 8-19-48)

⁴Seton heard other Whooping Cranes earlier on the same day. Phillips (1926) reported two shot in same region in 1913 and several observed in 1914.

⁴Two birds observed on three occasions, or three pairs seen in same general area. This location may be over the line in B. C.

53. Kiriemulr Dist. near Sounding L.	"very old" record (specimen)	?	Parliament Collection, Edmonton (Rowan, letter 3-22-46)			
ARKANSAS						
54. Crockett's Bluff, White River	Nov. 5, 1882	D. B. Wier ("Byrne")	Wier (1882)			
55. Sunken Lands	1888-89	L. O. Pindar	Pindar (1924)			
56. Corning, 31 mi. S. of Poplar Buff, Mo.	April 22, 1914	Spencer	USFWS files; Bent (1926)			
CALIFORNIA						
57. Rancho La Brea, Los Angeles	Pleistocene	.....	Howard (1930)			
COLORADO						
58. No specific location	1872	C. E. Aiken	Aiken (1873)			
59. Loveland, eastern Larimer County	April 8, 1889 April 16, 1890	Smith	Cooke (1914); Bent (1920)			
60. Barr L. Dist., Adams County	"not in recent years" (1909)	Hersey & Rockwell	Hersey & Rockwell (1909)			
61. Ft. Collins eastern Larimer County	June 20, 1931	Mrs. Clara Gordon	Bergtold (1931)			
62. Kit Carson Refuge, Cheyenne County	Oct. 13-17, 1941	F. F. Poley & E. R. Kalmbach	Kalmbach (1942)			
DISTRICT OF KHEWATIN						
63. 70 mi. inland from Eskimo Pt.	summer 1930 (1 killed)	Koonook	Sutton (1931)			
DISTRICT OF MACKENZIE						
64. Ft. Simpson	June 10, 1891 (specimen)	B. R. Ross	Ross (1862); British Mus., Reg. No. 63.1.28.135			
65. Ft. Resolution, Great Slave L.	1864 (?) (specimen)	J. Lockhart (?)	Baird, Brewer & Ridgway (1884); USNM No. 19893; USNM No. 9288			
	(nesting, 1 egg coll.)	J. Lockhart	MacFarlane (1891)			
66. Ft. Anderson Anderson R.	May 25, 1865 also each spring & fall 1862-65 (to June '65)	R. R. MacFarlane	MacFarlane (1891)			
67. Ft. Rae (?), Great Slave L.	186-(?) (skull)	MacFarlane(?)	Baird, Brewer & Ridgway (1884); USNM No. 7333			
68. Salt River, Slave R. region	n.d. (skull, foot, & wing bones)	Jno. Reid	Baird, Brewer & Ridgway (1884); USNM No. 11094; USNM No. 9288			
	(nesting, 1 egg coll.)	Lockhart	.....		
69. Big Island(?), Great Slave L.	n.d. (skull, foot & wing bones)	John Reid	Baird, Brewer & Ridgway (1884); USNM No. 31290			
70. Willow River	May 13, 1905 n.d. (specimen)	H. H. Jones ?	Preble (1908); Preble (1908); J. H. Camsell (verbal)			
71. Hay River	May 12, 1908 spring 1923 (2 killed) May 1947	? Slavey Indian Osborne (D.O.T.) J. C. Nesbitt	Cooke (1914) Camsell (verbal) Osborne (verbal) Nesbitt (letter 8-4-47)			
72. Pine Point	July 1944	J. C. Nesbitt	Foralid (1943)			
73. Mackenzie R. Delta	about 1900	Douglas Onlæk				
FLORIDA						
74. Seminole Field, Pinellas County	Pleistocene		W. W. Holmes			Wetmore (1931)
75. Itchtucknee River	Pleistocene		Fla. Geol. Surv. Collect.			Wetmore (1931)
76. Melbourne, Brevard County	Pleistocene		Gidley; Singleton			Wetmore (1931)
77. Rivers near St. Augustine	1722-23(?)		?			Catesby (1771)
78. No specific locality (labeled: "Florida")	n.d. (specimen)		?			MCZ No. 46872
	n.d. (specimen)		?			MCZ No. 46873
GEORGIA						
79. Savannah R. (mouth) ⁴⁶	1722-23		"a white man"			Catesby (1771)
80. Aratamaha R. (i.e., Altamaha) (mouth)	1722-23					Catesby (1771)
81. St. Simon's Island	n.d. (sternum & trachea)		?			Acad. Nat. Sci. Phila. No. 24778 (Bond, letter 3-19-46)
82. No specific locality	n.d. (humerus)		W. L. Jones			USNM No. 3920
IDAHO						
83. Snake R., 13 mi. NW of Grandview	Pliocene ⁴⁷ (tibial frog)	.....				Miller (1944)
84. Bear River	July 8 or 9, 1834		J. K. Townsend and Thos. Nuttall			Townsend (1839)
85. Rathdrum	April 8, 1899		Danby			USFWS files
ILLINOIS						
86. Chicago ⁴⁸ region	185-(?) (specimen)		T. E. Blackney			Baird, Cassin & Lawrence (1858); USNM No. 10384
87. Central Illinois marshes ⁴⁹	1870's (nesting)		E. W. Nelson			Nelson (1877)
88. Champaigne County	March 27, 1871 (specimen)		?			MCZ No. 35730 (ex-Greene Smith Museum)
89. Warsaw	Oct. 23, 1879 (specimen)		?			Ohio State Mus. No. 467
90. Cairo	1880 (specimen)		Fuchs			Württembergische Naturalliensammlung, Stuttgart
91. Weston	April 15, 1881 (specimen)		?			Ohio State Mus. No. 468
92. Bernadotte	March 30, 1888		Strode			USFWS files
93. New Rochelle	March 17, 1889 (specimen)		R. A. Turtle			Conover Collection, Chi. NHM.
94. Old Apple R., Jo Davless Co.	April, 1891 (2 specimens)		?			Conover Coll, Chi. NHM.
95. Mt. Carmel	March 6 (year?) (specimen)		?			Bent (1926)
INDIANA						
96. Kankakee marshes, Lake County	n.d.		L. T. Meyer; Timothy H. Ball			Butler (1898)
97. La Porte County	March 28, 1881 (specimen)		?			MCZ No. 20536
98. (near) Bloomington	n.d. (specimen)		?			Cuvier Club (Cincinnati) (Butler, 1898)
IOWA						
99. Northwest Iowa	June, 1866 (nesting, 1 eggs coll.)		R. B. Christ			Chi. NHM No. 5543
	June, 1867 (nesting, 2 eggs coll.)		R. B. Christ			Chi. NHM No. 5544

⁴⁶This general region could also be referred to South Carolina.

⁴⁷Deposit may be Early Pleistocene (Howard, letter 10-15-47).

⁴⁸There are numerous records for the Chicago region. See Woodruff (1907), Nelson (1928).

⁴⁹Possibly the region referred to by Ridgway (1915).

80. Sac County (Wall Lake)	1868 (nesting until 1869) March 21-24 1904	S. Tiberghien J. A. Spurrell	Spurrell (1917) Spurrell (1917)	May 26, 1894 (nesting) n.d.	R. M. Anderson ?	Anderson (1907) Regar MNH (Anniston, Ala.)
81. Dubuque County	April 26, 1808 (nesting, 2 eggs coll.)	Blackburn	Coneg (1874a); USNM No. 9833	June 5, 1897 ¹⁰	local farmers	Anderson (1907) USFWS files
82. Jefferson County	1870 (specimen)	?	Shaffer Col- lection, Fair- field (DuMont, 1933)	1883 (nesting) Mar. 26, 1884	Farmer Bond	USFWS files
	1873 (specimen)	?	Shaffer Col- lection, Fair- field (DuMont, 1933)	Mar. 22-25, 1886 Mar. 25, 1887 Mar. 25, 30; April 3, 1888 Mar. 29, 1884	Preston	USFWS files
83. "26 miles north"	May 0, 1871 (nesting, 2 eggs coll.)	J. & J. W. Mailliard (Bent)	USFWS files	101. Iowa City, Johnson Co.		
84. Western Iowa	May 10, 1871 (nesting, 2 eggs coll.)	J. P. Norris (Bent)	USFWS files	102. Woodbury County (Wolf Cr. Slough)	April 13, 1884 (specimen)	State Univ. Iowa No. 5398 (DuMont, 1933)
85. Blackhawk County	May 12, 1871 (nesting, 2 eggs coll.) May 15, 1871 (nesting, 2 eggs coll.)	J. H. Bowles (Bent) John Krider (Bent)	USFWS files USFWS files	(Sioux City)	Mar. 30; Apr. 5; May 7, 1885 Apr. 3, 8, 1887 Apr. 10, 1900 May 5, 1909 Mar. 23; Apr. 1, 1895	Scougal Rich Rich Cline USFWS files USFWS files USFWS files Cooke (1888)
(Waterloo)	April, 1873 (wounded bird)	?	Wilson (1933)	103. Emmetsburg, Palo Alto County		
(La Porte City)	Mar. 30, 1885	Peck	Cooke (1888)	104. Kanis Landing ¹¹	Jan. 23, 1886 (specimen)	Colo. MNH. No. 11717 State Univ. Iowa Nos. 5397, 5399, 5400; Colo. MNH No. 12408
86. Decatur County	Nov. 10-12, 1871	Parker Parker Parker	Parker (1871) Parker (1871) Parker (1871)	105. Holly Springs Woodbury Co.	Apr. 8, 1887 (4 specimens)	Talbot Collection
87. Tama County	1873	John Krider	Krider (1873)		Apr. 1887	Talbot Col. State Univ. Iowa No. 5396 USFWS files
88. Lake Mills, Winnebago Co.	May 12, 1879 (nesting, 2 eggs coll.) 1870 (specimen)	Krider W. L. Abbott Collection	Krider (1879); NHM. DuMont (1933); Acad. Nat. Sci. Phila. No. 26044	106. Garner, Han- cock County	Apr. 2, 3, 4, 1889	Byington
	May 6, 1874 (nesting, 1 egg coll.)	E. Dickinson	USNM No. 21389	107. Ferry	March 23, 1890	Eveland
89. Oakland Valley	Oct. 1876 (specimen)	"D.O. of B."	"D.O. of B." (1876)	108. (near) Hawarden, Sioux Co.	Summer 1890	Berry Anderson (1907)
90. Spirit L., Dickinson County	April 7, 8, 0, 1886	Mosker	USFWS files	migration 1890	Johnson	Anderson (1907) USFWS files
91. Cherokee County	May 8, 1877 (nesting, 2 eggs coll.)	W. Rice	AMNH No. 7649	109. Gilbert Station	Mar. 22, 29, 30, Apr. 10, 1891 Mar. 25, 29, 30, 1893 Apr. 3, 1891	Shearer Collett USFWS files
92. Cedar Cr., Calhoun Co.	Oct. 30, 1877 (specimen)	"Sandpiper"	"Sandpiper" (1877)	110. Glidden, Carroll Co.	Apr. 3, 1891	Collett
93. Franklin County	May 2, 1880 (nesting, 2 eggs coll.)	W. C. Reice	Milwaukee Public Museum	111. Forest City, Winnebago Co.	May 15; June 5, 1897	Anderson
94. Clear Lake, Cerro Gordo County	May 4, 1880 (nesting, 2 eggs coll.) May 2, 1882 (nesting)	S. Howland (for C.M.G.) ?	AMNH No. 418 Cooke (1914)	112. Aiden, Harding Co.	Apr. 2, 1900	Bigelow USFWS files
95. Cedar Rapids, Linn County	1880 (specimen)	Sinclair	Coe College Mus. No. 402 (DuMont, 1933)	113. Indianola, Warren Co.	Mar. 29, 30; Apr. 1, 2; Sept. 23-25, 1900	Jeffrey USFWS files; Anderson (1907); Bent (1926)
96. Wright County	May 8, 1881 (nesting, 2 eggs coll.)	C. M. Jones (for E. S. Stebbins)	Minn. MNH No. 979	114. Pottawattamie County	n.d.	Trostler Anderson (1907)
97. Kossuth County	May 14, 1881 (nesting, 2 eggs coll.)	Rev. C. M. Jones	Merrill Coll. Peabody Mus. Nat. Hist. No. 7712	115. Mills County	n.d.	Trostler Anderson (1907) USFWS files
98. Eagle Lake, Hancock Co.	May 4, 1883 (nesting, 1 egg coll.)	J. W. Preston	Preston (1886); Chi. NHM No. 6537	116. Jefferson, Greene Co.	n.d.	Hall
				117. Polk County	n.d.	Johnson Anderson (1907)
				118. Humboldt, Humboldt Co.	n.d. (specimen)	? State Univ. Iowa No. 5392 (DuMont, 1933)

¹⁰On May 5, 1897, Anderson observed a single Whooping Crane circling over the old nesting place. On June 5th, several farmers saw a pair near the site; they did not nest. The 1894 date (above) is the last reported breeding record for wild birds in the U. S.

¹¹There is no record of this place name for Iowa, although the specimen is catalogued as above. Perhaps it should be "Kane's Landing," which was on the Matagorda Peninsula, Texas (see item No. 432).

119. Jackson County	n.d. (specimen)	?	Ellis Collection, Moquoketa (DuMont, 1933)	(Island No. 6) Aug. 26, 1886 ?	Pindar (1887) (1925); Cooke (1914)
120. Poweshlck County	n.d.	Kelsey	Anderson (1907)		Audubon (1835)
121. (near) Webb, Clay County	Apr. 9, 1911	Ira N. Gabrielson	Gabrielson (1917); DuMont (1933)		McIlhenny (verbal) (1938)
KANSAS					
122. Scott County	Pleistocene (?) (frag. maxilla) 1866	W. Wedel	USNM No. 346827		Jno. Gaspard (Lynch Records)
123. Burlington, Coffey Co.	Apr. 15, 1867 (specimen) 1878-1904	A. Crocker	USNM No. 6555		
124. Manhattan, Riley County	Apr. 8, 1882 Mar. 18, 1890 Apr. 18, 1891 Apr. 6, 1896 1884 (captive)	Blachly Lantz ?	USNM No. 50826 USFWS files USFWS files		Crain (Lynch Records)
125. Emporia, Lyon Co.	Mar. 27, 1884	Kellogg	Blachly (1884) USFWS files		Ulysee Marceaux (Lynch Records)
126. Richmond, Franklin Co.	Mar. 18, 1885 Mar. 21, 1885 Mar. 7, 28; Apr. 8, 15, 1887 spring 1893 (specimen) Apr. 1903	Kellogg Smith J. A. Bryant	Cooke (1888) USFWS files; Cooke (1888) Harris (1919)		Nunez (Lynch Records)
127. Jackson County	Mar. 18-25, 1904	Monahan	Jaques (verbal) USFWS files; Bent (1926) USFWS files		Nunez (Lynch Records)
128. Durham, Marion Co.	fall 1905 (specimen)	C. W. Miller	Collection		O'Neil Nunez (Lynch Records)
129. Baldwin, Douglas Co.	late March or early April 1906 (specimen)	P. B. Peabody	Chl. NHM No. 131657		R. B. Worthen (1938)
130. Hays, Ellis Co.	Oct. 13, 1906 (specimen)	W. M. McClom	Univ. Kans. No. 7702; Douthitt (1918) Cooke (1914)		L. J. Merovka (letter 9-19-45) Oberholser (1938)
131. Blue Rapids, Marshall Co.	Oct. 18, 20, 1907	Crevecoeur			Ambrose Daigre (1938)
132. Ford County	fall 1907, 1919, 1922 (4 + killed) 1907-1918	Hal G. Everts	Everts (1923a)		Gaspard (Lynch Records)
133. Onaga, Pottawatomie Co.	1900-1910 fall 1944	H. D. Burchell	Burchell (letter 10-1-45) Isley (1912) Burchell (letter 10-1-45) USNM No. 212985	Jan. 16, 1937 (none observed)	Gordon (letter 1-10-37)
134. Stafford ²¹ County	n.d. ²¹	?		Jan. 27, 1937 ²²	Gordon (letter 1-28-37); Simmons (1937a; 1937b)
135. Sedgwick County	1912 (specimen)	C. B. Heinrichs	Chl. NHM No. 45420	June 5, 1937	J. H. Baker and Rich. Gordon Simmons, Gordon & Schexnayder
136. Saline River	spring 1929	?	Imler (1936)	Winter 1937-38	E. A. McIlhenny
137. Burrton, Harvey Co.	Oct. 20, 1942	M. E. Ramsey	Ramsey (letter 5-6-40)		C. E. Gillham
138. Graham Co.	Apr. 18, 1947	airplane pilot	Ramsey (letter 4-25-47)	Jan. 30, 1939	Gillham (Report to USFWS 1938)
139. Cheyenne Bottoms, Barton Co.	KENTUCKY				
140. Louisville ²⁴	Mar. 20, 1810	Audubon & Wilson	Wilson (1814); Audubon (1835) Pindar (1887) (1925); Cooke (1914)	May 15, 1939 (adults with unfledged young)	J. J. Lynch
141. Hickman	Aug. 20, 1886	?		Winter, 1940-41	J. J. Lynch
LOUISIANA					
142. (near) New Orleans (?) ²⁵	April	?			J. J. Lynch
143. Avery Island, Iberia Parish	early 1880's	E. A. McIlhenny		June 5, 1937	McIlhenny
144. White Lake Marshes, close to Pine Island, Vermillion Parish	(circa) 1883 (nesting)	Mrs. Gaspard		before 1900	Duncan Crain
145. White Lake Marshes from near Florence to Mermentau R., Vermillion and Cameron Parishes	1890-95 (nesting)	O'Neil Nunez		before 1900 (nesting) 1890's and 1900, 1910	Crain (Lynch Records)
	1900 (last nest)	O'Neil Nunez		1901-1935	Marceaux (Lynch Records)
	Jan. 1933	R. B. Worthen			Nunez (Lynch Records)
	1934-40	L. J. Merovka			Nunez (Lynch Records)
	Nov. 23, 1935	Ambrose Daigre			Oberholser (1938)
	Dec. 1935 (wounded captive) ²⁶	Jno. Gaspard and Ovid Abshire			Gaspard (Lynch Records)
	April 1936 (Adult with two young)	Jno. Gaspard and Ovid Abshire			Gaspard (Lynch Records)
	Fall 1936 (specimen)	Geo. Welch			Dept. of Wildlife and Fisheries Mns. (New Orleans); Oberholser (1938)
					Gordon (letter 1-28-37); Simmons (1937a; 1937b)
					McIlhenny (1938)
					Gillham (Report to USFWS 1938)
					Lynch (Report to USFWS 1939)
					Lynch (unpubl. MS, 1939)
					Stevenson and Griffith (1940)

²¹Salt marsh used as stopping place by migrants. There are records of several birds shot here and doubtless many others were killed at this location without record.

²²Died in National Zoological Park (Washington), Jan. 13, 1910 (USFWS files).

²³Unquestionably Audubon observed the species at other locations in Kentucky, probably at the Slim Pond near Henderson, for example, but this confusion regarding the separate identity of the Sandhill Crane makes these records uncertain.

²⁴Audubon's painting of the Whooping Crane (Pl. CCXXVI) was "drawn at New Orleans" and presumably the bird was killed in that vicinity.

²⁵Died after a few days (at Florence Club).

²⁶It was on this occasion that Mr. Albert Simmons made his remarkable photograph of two Whooping Cranes in flight.

	Jan., 1944	R. H. Smith	Smith (Report to USFWS 1944)	154. (near) Pecan Island	"Years ago" Mar. 11, 1928	Ulyese Veazey E. W. Nelson and Ulyese Veazey	Nelson (1929) Nelson (1929)
	Feb. 2, 1946	R. H. Smith	Smith (Report to USFWS 1946)	155. (near) Mulberry Island	Jan. 7, 1929 Winters of 1931-36	Veazey Ralph Sagera	Nelson (1929) Sagera (Lynch Records)
	Dec. 15, 1946	R. P. Allen and J. H. Flynn	Allen (Report to Nat'l Audubon Soc'y 1946)	156. Hudson's Bay (Ft. Prince of Wales, i.e., Churchill)	(circa 1748) (specimen)	MANITOBA Isham	Edwards (1750)
	Jan. 10, 1947	Wallace Salzman	Gaspard (Lynch Records) Peterson (1948)		1770-71	Samuel Hearne	Hearne (1796)
	Jan. 1, 1948	R. H. Smith and R. T. Peterson	Lynch (letter 4-22-48)	157. (near) Winnipeg	Aug. 1871 (nesting, 2 eggs coll.)	?	Barnes Collection (Chi. N.H.M. No. 5546)
	Apr. 21, 1948	J. J. Lynch	Lynch (letter 1-17-49)		1890	Wm. Hine	Thompson (1891)
	Dec. 1948	Lynch	Lynch (memo 12-5-49)	158. Lake Winnipeg	1877 (nesting, 2 eggs coll.)	L. D. Schultz	Crutenden Coll. (J. Crutenden, in lit.)
	Dec. 2, 1949	Lynch, Crissey & Wellen	McIlhenny (verbal)		May 18, 1883 (nesting, 2 eggs coll.)	?	P. B. Phillip Coll. (Bent-USFWS files)
146. Tall Grass Prairie of Calcasieu, Jeff Davis, Allen, Evangaline and Acadia Parishes (Iowa, Calcasieu Parish)	until the late 1880's and early 1890's (wintering)	McIlhenny			1891 (nesting, 2 eggs coll.)	W. Raine ⁴¹	Raine (1892)
(Prairie North of Creole Ferry and Holmwood)	Winter 1899 (wintering) ⁴² to 1918 (wintering only)	?	Vernon Bailey (Oberholser 1938)	159. (near ?) Carberry	Apr. 19, 1882	E. E. Thompson (Seton)	Thompson (1891)
		Alcie Daigle	Daigle (Lynch Records)	160. Oak Point, se corner L. Manitoba	1890 May 1, 1884	A. T. Small	Cooke (1914) USFWS files
147. Delcambre Area, Vermillion and Iberia Parishes	(circa) 1895-1910 (wintering only)	Delcambre	Delcambre (Lynch Records)		Apr. 15 & 17, 1885 1885 (breeding ?)	Small	Cooke (1914) USFWS files
148. Chenier la Croix, Marsh Island	(circa) 1895 ⁴³ (wintering only)	Delcambre	Delcambre (Lynch Records)	161. Portage la Prairie	(circa) 1884 (specimen)	F. Cresswell	R.O.M.Z.
149. Big Bayou Constance, Cameron Parish (Rockefeller Wildlife Refuge)	(circa) 1895 (wintering only)	Delcambre	Delcambre (Lynch Records)	162. Shell River	Apr. 30, 1885	E. Calcutt	Thompson (1891)
	Feb. 1916	S. C. Arthur	Oberholser (1938)		May 3, 1885 Apr. 16, 1890	Calcutt Calcutt	USFWS files; (Bent 1926) Barnes Coll. (Chi. N.H.M. No. 5540) Seton (1886)
150. Hellhole Area, Vermillion Parish (Rainey Sanctuary)	Winter 1928-29 (circa) 1895	S. C. Arthur Grevillen Chote	Arthur (1931) Schexnayder (verbal)	163. Lake Winnipegosis	May 9, 1885 (nesting, 2 eggs coll.)	?	Barnes Coll. (Chi. N.H.M. No. 5540) Seton (1886)
51. Coastal Strip, Grand Chenier to Johnson's Bayou	(circa) 1895	Duncan Crain	Crain (Lynch Records)	164. Shoal Lake	1886 (breeding?) (circa) 1890 (specimens) 1901, 1916, 1917 to 1924 (except 1915-16-17)	E. E. Thompson (Seton) Ward brothers ⁴⁴	Thompson (1891) Taverner (1919b) Ward (1943)
	Winter ⁴⁵ 1941-42	A.O.U. Comm. on Bird Protection	A.O.U. Comm. Report (1943)	165. (near) Westbourne	Spring and Summer (circa 1890)	C. W. Nash	Thompson (1891)
152. Louisiana State Refuge, Vermillion Parish	Winter 1916	?	S. C. Arthur (1948)	166. Oak Lake	June 17, 1891 (nesting, 2 eggs coll.) May 21, 1893 (nesting, 1 egg coll.) May 13, 1894 (nesting, 2 eggs coll.)	Walter Raine W. Raine W. Raine	Raine (1892)
153. (near) Chenier au Tigre, Vermillion Parish	Nov. 1916	A. M. Bailey and S. C. Arthur	A. M. Bailey (1928)				Macoun (1900); N. M. Canada P. B. Phillip Coll. (Bent, USFWS files); AMNH No. 7618
	Fall 1917	A. M. Bailey	Bailey & Wright (1931)				
	Winter	?	Bailey & Wright (1931)				
	Winters 1929, 1930 and 1931	?	Bailey & Wright (1931)				
	Winter 1934	trappers	Bailey (1934)				
	Dec. 16, 1934	Lionel LeBlanc	Bailey (1934)				

⁴¹In April 1899 Bailey was told that the species was "common in winter" in that vicinity.

⁴²Many of these old records collected by Lynch in 1946-47 are for the period "about 50 years ago." Except on interior prairies the Whooping Crane population then was still close to normal in abundance.

⁴³On Sabline National Wildlife Refuge.

⁴⁴In the past the records of this collector have contained errors and are now accepted with reservations. In some instances, as at Oak Lake, where others have established the nesting of the species, the data would appear beyond question.

⁴⁵"Used to breed and be fairly plentiful." Reported 30 together in 1901, which must have been unusual. In recent years P. C. Ward reports 3 in 1934 and 9 on April 26, 1943. Because of the year, the number of birds involved and the location, this last record seems very doubtful. In this instance the observation was described simply as of "white birds." Aside from this source there have been only four acceptable reports from Manitoba since 1913, the surviving migrants now moving into Saskatchewan to the west of North Portal and Estevan (Sask.).

	May 10, 1900 ? (nesting, 2 eggs coll.)		T. W. Richards (USNM No. 34504)	183. Marshes on Lago de Cha- pala, Jalisco	1890's	E. W. Nelson	Nelson (1929)
	May 18, 1900 ? (nesting, 2 eggs coll.)		Barnes Col- lection (Chi. N.H.M. No. 5539)	184. Bolson del Mapimi, Dur- ango	(circa) 1804 (killed)	T. S. Van Dyke	(Van Dyke 1895)
167. Whitewater Lake	(circa) 1805 ?		Chi. N.H.M. (Conover Collection)	185. Hacienda de Bnena Vista (near) La Bar- ca, Jalisco	Jan. 1903 ? (coplice)		Goldman (USNM files, Friedmann)
	1904-5 ? (4 specimens)		Laing (letter 3-16-48)	186. (near) La Barca	Jan. 1903	.....	Goldman (USNM files)
	Sept. 15, 1905 (specimen)	A. M. Laing	Laing (letter 3-16-48)	MICHIGAN			
168. Aweme (SE of Brandon)	April 12, 1895	Talbot Criddle ⁴¹	USFWS files	187. Geddesburg, Washtenaw County	June 8, 1877 ? (specimen)		Covert (MS, 1894-96); Barrows (1912)
	April 6, 1900	Criddle	Cooke (1914)	188. Brighton	April 1882 ⁴² (3 specimens)	Chas. Cushing	Barrows (1912)
	Oct. 12, 1904	Criddle	Cooke (1914) Bent (1926) USFWS files	MINNESOTA			
169. Neepawa	April 10 & 17, 1896	Wemyss	USFWS files	189. Southern Minn.	Feb. 27, 1864 ⁴³	Hatch	Hatch (1892)
170. Reaburn	April 15 & 16, 1897	Wemyss	USFWS files	190. Between Otter Tail L. and Mille Lacs	Spring, Sum- mer, & Fall 1870	T. M. Trippe	Trippe (1871)
	May 23 & 27, 1898	Wemyss	USFWS files	191. (near) Brainerd, Morrison Co.	Summer 1873	Coues	Coues (1874b)
	April 9 & 19, 1900	Wemyss	Bent (1926)		June 10, 1874 (prob. breeds)		
171. Boyne Marsh ⁴⁴ (Prob. Boyne or Morris R., SW of Winni- peg-Lewis in Ill.)	Oct. 19, 1900 (specimen)	C. K. Worthen	USNM No. 175237		July 1874 (nesting, 2 eggs coll.)	R. B. Christ	Chi. NHM No. 5545
172. "Duff County" ⁴⁴ (prob. "Duff- erin County" SW of Winni- peg-Lewis, in Ill.)	May 30, 1900 (nesting, 2 eggs coll.)	C. P. Forge	E. Arnold Coll. (Bent, USFWS files)	192. Elbow Lake, Grant Co.	May 20, 1876 (2 specimens)	J. N. Sanford	Deane (1923); AMNH No. 79768-79769
173. Margaret	April 25 & 29; July 14; Aug. 10; Oct. 20, 1909	Black	USFWS files		May 21, 1876 (specimen)	G. B. Sennett	Deane (1923); AMNH No. 70770
	Aug. 10 & 20; Sept. 12, 1911	Black	USFWS files	193. Cedar Mills, Mecker Co.	(nesting, 2 eggs coll.) Sept. 17, 1878 (specimen)	Wm. Howling	AMNH Nos. 416, 417 (?) Minn. MNH No. 8482
	April 18, 27; May 3, 10, 1912			194. (near) Herman, Grant Co.	early June 1879	T. S. Roberts	Roberts and Benner (1880)
174. Rocky Lake (near the Pas)	April 12, 1913 Spring 1936 (wing-tips)	Black Cree Indian (Taverner)	Bent (1926) Nat'l Mus. Canada, Nos. 28129-A, 28129-B.	195. (near) St. Peter, Nicollet Co.	summer? 1883 ⁴⁵ ? (specimen)		Roberts (1936) Minn. MNH No. 8483
175. 33 mi. S., 1 mi. E. of the Pas	Late April 1945	C. C. Plummer	Plummer (Bard records)	196. Heron Lake, Jackson Co.	March 30, 1884	Miller	Cooke (1914); USFWS files
176. (near) Ridgeville (1/2 mi. N. of Int. Boundary)	(about) May 5, 1947	Edna Stewart	Stewart (in Ill.)		March 31; Apr. 3; Nov. 13, 1885		
177. Benito	May 10-27, 1948	Pete & Joe Nadink (A. Isfred)	Bard Records		April 12, 1887 April 3, 7, 1888 March 20, 1889 March 25; Apr. 6, 17, 1891	P. B. Peabody	Roberts (1936)
MEXICO							
178. Matamoros, Tamaulipas	June 1863	H. E. Dresser	Dresser (1866)	197. Lanesboro, Fillmore Co.	March 31, 1884	Dr. J. C. Huoslef	Roberts (1938)
179. Boca del Rio Grande, SW of Bagdad, Tamaulipas	June 1863 (reported nesting)	Dresser	Dresser (1866)	198. North Star	April 11, 14, 15, 1888; March 28, 30, April 7, 1890	Schrooten	USFWS files
180. Guanajuato, Plains of Silao	1869 (specimen)	Alfred Duges	Duges (1870); Nelson (USNM files) USNM files (Friedmann)	199. Waverly, Wright Co.	March 28, 30; Apr. 7, 25, 1889	Schrooten	USFWS files; Bent, (1926)
181. Lerdo, Durango	1889 (specimen)	Dr. Fischer	Dresden Museum	200. Thief Lake, Marshall Co.	June 19, 1889 (nesting, 2 eggs coll.)	E. L. Brown	Nute (1945)
182. Hacienda el Molino, (near) LaBarca, Jalisco	1804 (several coplices)	Jouy	Jouy (1894)	201. (near) Fergus Falls, Otter Tail County	1890? 1890?	Washburn	Hatch (1892)
				202. Warren, Mar- shall County	April 12, 1892 (specimen)	B. M. Slee	Univ. Kans. MNH No. 8790
					April 16, 1892 (specimen)	C. B. Miller	Univ. Kans. MNH No. 11919

⁴¹There are numerous additional records in USFWS files for this location by the same observer, the observations extending from 1895 to 1909. In 1937 Mr. Criddle reported a flock of 32 Whooping Cranes, same location, on May 13th. I believe this to have been an error. Our total migrating group that year has been estimated as containing only 23 individuals.

⁴²Boyne Marsh is located in Dufferin County and there is the possibility that these two locations—Nos. 171 and 172—are identical.

⁴³This record was found written on the margin of Covert's copy of Coues' Key.

⁴⁴Earliest arrival date recorded. Hatch (1892) said it was a mild spring.

⁴⁵No data, but the body filling of old mount was Reported by the St. Peter, Minn., Tribune for Aug. 22, 1883.

203. Dawson, Lac Qui Parle County	April 10, 1893 (specimen)	Albert Lano	Minn. MNH No. 3812	228. Cherry County (Valentine)	n.d. Oct. 1-2, 1893	J. M. Bates	Swenk (1933)
204. Madison, Lac Qui Parle County	April 21, 1894 (specimen)	Albert Lano	Minn. MNH No. 3813	229. Grand Island, Hall County	Apr. 1, 1894 n.d.	J. M. Bates F. J. Brezee	USFWS files USFWS files Swenk (1933)
205. 14 mi. S. of Madison, Lac Qui Parle County	April 10, 1895 (specimen)	G. T. Ojum	Minn. MNH No. 3812		Spring 1899 (2 specimens)	Fred Gunther	Hastings, Mus. No. 3823.
206. (near) St. Vicent, Kittson County	April 15, 16, 1896	P. B. Peabody	USFWS files (Roberts 1936)		Oct. 18, 1907 (specimen)	Fred Gunther	Hastings Mus. No. 6124
207. Faribault Co.	Mar. 20, 1898	A. Hewitt	Roberts (1936)	230. Gage County	Oct. 20, 1912 (2 killed)	goose hunters	Swenk (1913) Swenk (1933)
208. Hallock, Kittson Co.	April 29, 1899	Peabody	USFWS files	231. Wood River, Hall Co.	n.d. Oct. 24, 1884 (specimen)	F. A. Colby ?	Swenk (1933) Swenk (1933)
209. Badger, Roseau Co.	April 23, 1917 (2 killed, one specimen)	a farmer	Minn. MNH No. 8717		Spring, 1931	Mrs. Will Burmood S. W. Wells	Colo. MNH No. 12407 Burmood (1934) Brooking (1934)
MISSISSIPPI					May 2, 1934 ⁷¹		Brooking (1943a) ⁷²
210. Bay St. Louis	April 15, 1902	?	Cooke (1914) Burlough (1944)	232. Elm Creek ⁷³ , Buffalo Co.	Nov. 7, 1884 (specimen)	?	Talbot Coll. State Univ. Iowa No. 5391
MISSOURI					Oct. 26, 1931 Apr. 6, 1933	Anthony Roeser Herbert Richardson	Swenk (1933) Swenk (1933)
211. The Grand Prairie, Dunklin County	1864 (winged captive)	?	Widmann (1907)		Apr. 11, 1948	Eddie Brown	Brown (letter n.d.) ⁷⁴
212. (near) St. Louis	March 17, 1884 (specimen)	?	Hurter Coll. Widmann (1907)	233. Alda, Hall Co.	Mar. 24, 1884	Powell	USFWS files
	March 25, 1888	Otto Widmann	Widmann (1907)	234. O'Neill, Boyd County	Apr. 1, 1936 Apr. 2 & 9, 1887	Adams Miller	Black (1930) USFWS files
213. Mt. Carmel, Audrain Co.	March 25, 1885	Musk	Cooke (1888); Widmann (1907)	235. Niobrara River	June 24, 1889	Baker	USFWS files
214. Freistatt, Lawrence Co.	March 27, 1880	Hy Nehrling	Widmann (1907)	236. Gibbon, Buffalo County	Apr. 10, 1889	Thatcher	USFWS files
215. Laclede, Lynn County	March 20 & 27, 1889	P. L. Ong	Widmann (1907)		Mar. 19 & 20, 1890	Powell	USFWS files
216. Jackson Co.	spring 1893 (specimen)	J. A. Bryant	Harris (1919)		Apr. 6 & 12, 1902	Ashburn	USFWS files
	April 14, 1904 (specimen)	Chas. Dankers	Harris (1919)		Apr. 14, 1922 ⁷⁵ Apr. 9, 1928	C. A. Black C. A. Black	Swenk (1933) Swenk (1933)
	spring 1906	Dankers			Apr. 18, 1934 ⁷⁶	B. Armitage	Brooking (1943a)
217. Stotsbury	March 27, 1913 March 9, 10, & 15, 1894	Dankers T. Surber	Widmann (1907)	237. Falls City, Richardson County	Apr. 2, 1937 ⁷⁷ March 16 & 19, 1890	J. Shields Wilson	Black (1937b) USFWS files
218. Corning, Atchison Co.	March 23 & 26, 1907 March 27, 1913	Dankers	USFWS files		Sept. 19, 1891 Mar. 21, 23; May 16; Nov. 12, 1890	Heatb	USFWS files
MONTANA ⁶⁸					Apr. 5, 6, 7; Sept. 28, 1891	Earl	USFWS files
219. Big Sandy	May 1-5, 1903	Coubeaux	Saunders (1921)	239. Chambers, Boyd Co.	Apr. 11, 12, 14, 1891		USFWS files
220. Terry	Oct. 5, 1904	Cameron	Cooke (1914)	240. Gresham, York Co.	Oct. 11, 1896	Dickinson	USFWS files
221. Billings	April 8, 1918	Thomas	Saunders (1921)	241. (near) Long Pine	Mar. 31, 1807	Bates	USFWS files
NEBRASKA				242. (near) Gothenburg, Dawson Co.	Spring 1807	J. Kennedy	Kennedy (verbal)
222. Engineer Cantonment Ft. Calhoun, Washington County ⁶⁹	March 19, 1820	Thos. Say	Say (1820)		Oct. 1905 (1 killed)	Wm. Kennedy	J. Kennedy (letter and photographs, 4-13-48)
223. Omaha, Douglas County	n.d. ⁷⁰ March 12, 1918	L. Bruner, L. Skow ?	Swenk (1933)		Spring 1915	J. Kennedy	Kennedy (letter 6-5-48)
	Fall (?) 1918 (1 killed)	unknown hunter	Brooking (USFWS files) Brooking (USFWS files)		April 19, 1941	C. Swanson	Brooking (1943a)
224. Craig, Burt County	n.d.	L. Bruner	Swenk (1933)		Fall 1946 ⁷¹	J. Kennedy	Kennedy (verbal)
225. West Point, Cuming Co.	n.d.	L. Bruner	Swenk (1933)				
226. Wolf Creek	n.d.	D. H. Talbot	Swenk (1933)				
227. Holt County	n.d.	L. Bruner	Swenk (1933)				

⁶⁸There is one specimen, an adult, probably killed in Montana. It is mounted and on display in the courthouse at Great Falls (Harlow B. Mills, letter, 3-27-46.)

⁶⁹Whooping Cranes are not mentioned specifically, but this was a regular migration route and doubtless the species was included in Say's term "cranes." See Swenk (1933, p. 112).

⁷⁰Nos. 223 to 230 (incl.) with a n.d. entry are from records of the 1880's and early 1890's (Swenk, 1933, p. 112).

⁷¹Given simply as "May" in later publication (Brooking 1943a).

⁷²Licking (1940) may have questioned this record.

⁷³Given on original label as "Elm Crick" (Nov. 7, 1884).

⁷⁴Brown wrote that he had more than 45 phone calls reporting the presence of this pair of Whooping Cranes (*in litt.*).

⁷⁵Three birds reported by "Guy Smith's son," same date, but location given as "10 mi. E. of Kearney" (Swenk 1933). Above record is of 7 birds, but there could be some duplication involved.

⁷⁶Listed by Brooking (1943a) as 10 mi. E. of Kearney.

⁷⁷Listed by Black (1937b) as 9 mi. E. of Kearney.

⁷⁸Two reports for this area, one 3 mi. East and the other South of Gothenburg.

243. S. of Holdrege, Harlan County	spring and fall 1898-1927	Loren Bunney	Bunney (verbal)	Apr. 3, 1930	A. Easterling	Swenk (1933)	
244. Neligh, Antelope Co.	Mar. 20-Apr. 1; Oct. 15-30 (1899) ¹⁹	Merritt Cary	Cary (1900)	Apr. 1, 3, 1931	C. A. Black Bert Procter	Brooking (1943a)	
245. Badger	Oct. 12, 18, 25, 1899 Mar. 23, 25; April 18; Oct. 8, 10, 12, 1900 Apr. 6, 7; May 14, Oct. 1, 2, 8, 22, 1901 Apr. 18, 24, 27; May 11, 1902 Apr. 6, 8, 9, 30; Oct. 5, 6, 8, 1903 Mar. 23, 25; Apr. 18; Oct. 8, 10, 12, 18, 1900	Colt	USFWS files	Apr. 10, 1937 Apr. 4, 1943	Geo. Eaglestrom C. A. Black	Black (1937c) Brooking (1943) Brooking (1944)	
	Apr. 6, 7; May 14; Oct. 1, 2, 8, 22, 1901			Apr. 2, 1944	Eddie Brown	Brooking (1944)	
	Apr. 18, 24, 27; May 11, 1902 Apr. 6, 8, 9, 30; Oct. 5, 6, 8, 1903	Colt	USFWS files	248. (near) Harvard, Clay Co. 249. Atkinson, Holt County 250. Wood Lake, Cherry Co. 251. 3 mi. N. of Greenwood, Cass Co.	Mar. 12, 1908 (specimen) ²⁵ Apr. 22, 1909 (2 specimens) Oct. 16, 1912 (4 killed) Mar. 29, 1913	Geo. Schupan ? H. T. Clark & Mr. Quick J. Armstrong	Brooking (Coll.) Swenk (1933) Swenk (1933) Swenk (1933)
246. Lincoln, Lancaster Co.	Oct. 27, 1899	Wolcott, et al.	USFWS files	252. Newark, Kearny Co.	April 1914 (specimen)	Ed. Larson Hastings Mus. No. 13139	
	1900	J. S. Hunter	Hunter (1900)		Oct. 15, 1927 Sept. 22, 1928 Oct. 24, 1928	farmer L. & H. Brown F. R. Kingsley	Swenk (1933) Swenk (1933) Swenk (1933)
	spring 1903	L. Bruner & Myron Swenk	Swenk (1933)	253. (near) Ogallala, Keith Co. 254. N. of Prosser, Hall Co. 255. Post Lake, Brown Co.	Mar. 10, 1915 (specimen) spring 1915 (2 specimens) Oct. 10, 1915	J. Koehr L. Pitcarthley ?	Swenk (1933) Swenk (1933) Swenk (1933)
247. Kearney Area, Buffalo Co.	Apr. 12, 1901 (specimen)	?	J. L. Childs Coll. AMNH No. 436490	256. Overton, Dawson Co.	Spring 1916 (specimen) Oct. 25, 1925 ²⁶ Apr. 4, 1933 Mar. 31, 1936	Link Milburn J. Q. Holmes B. Armitage C. Lanphear	Swenk (1933) Swenk (1933) Brooking (1943a)
	Oct. 3, 1917 (1 killed) ²⁶	hunter	Brooking (USFWS files)		Apr. 14, 1947	Eddie Brown	Brown (telegram 4-14-47) Hastings Mus. No. 12334
	Mar. 15, 1918	hunter	Swenk (1933) ²⁷	257. Loup City, Sherman Co.	April 1917 (specimen)	H. Jenner	Swenk (1933)
	Mar. 29, 1919	Harry Connor	Swenk (1933)	258. (near) Minden, Kearney Co. 259. Red Deer Lake, Cherry Co.	Spring 1917 (specimen) 1918 Oct. 14, 1921 (1 killed) Oct. 22, 1922 (specimen)	? F. G. Caldwell farm-boy ?	Fuertes (1923) Conover (1922) Conover Coll. Chf. NHM Swenk (1933)
	Apr. 2, 5; Oct. 20, 1921	C. A. Black	Swenk (1933)		Sept. 1923	A. Nooka	Swenk (1933)
	May 1-5, 1922	A. R. Golay	Swenk (1933)	260. (near) Inland, Clay County	Oct. 12, 1925 ²⁷	R. Swanson & Wm. Hicks	Swenk (1933)
	Oct. 20, 1922	C. A. Black	Swenk (1933)		Oct. 25, 1925 Apr. 18, 1926 Apr. 26, 1926 Oct. 20, 1926 ²⁸ Mar. 27, 1929 ²⁹ Oct. 1, 1933 Oct. 22, 1942	Wm. Hicks A. Webert Roy Knapp C. A. Black B. Armitage J. Flannery J. Gebre	Swenk (1933) Swenk (1933) Swenk (1933) Swenk (1933) Black (1934a) Brooking (1943a)
	Apr. 13; Oct. 16, 1924	C. A. Black	Swenk (1933)	261. Odessa, Buffalo County	Apr. 28, 1946	W. E. Paine	J. C. Hill (letter 2-18-47) Brown (letter n.d.) Swenk (1933)
	Apr. 5, 1925 ³⁰ Apr. 7, 1925 ³⁰	L. Pitcarthley C. A. Black & Guy Smith	Swenk (1933) Swenk (1933)		Apr. 14, 1948	Eddie Brown	Swenk (1933)
	Oct. 19, 1925 ³¹	Geo. Tracy & Oscar Blevens	Swenk (1933)	262. N. of Amherst, Buffalo Co. 263. Lowell, Kearney County	Apr. 2, 1924 Apr. 5, 1926	C. A. Black J. C. Chapman	Swenk (1933) Swenk (1933)
	Apr. 4-8, 1926 ³¹	A. R. Golay, H. Lilga, C. A. Black, Mrs. Frances Garvin	Swenk (1933)		Apr. 10, 1929 Apr. 15 or 16, 1934 Apr. 8-18, 1926 ³² ?	Chas. Radborn Chris Zwink	Swenk (1933) Brooking (1943a) Swenk (1933)
	Apr. 1, 2, 1927	A. R. Golay	Swenk (1933)	264. Wilcox, Kearney County	Apr. 6, 1928 Apr. 10, 1930 Apr. 5, 1932	A. R. Marsteller A. R. Marsteller A. R. Marsteller	Swenk (1933) Swenk (1933) Swenk (1933)
	Apr. 18, 1929	A. R. Golay	Swenk (1933)				
	Oct. 12, 13, 1929	C. A. Black	Swenk (1933)				
	Apr. 2, 3, 1930	A. R. Golay, B. Armitage, Don Golay, C. A. Black, H. Lilga	Swenk (1933)				

¹⁹Dates given are span of occurrence. Records cover 1890-1899.

²⁶Two and possibly three more are on record as killed by a hunter and buried "through fear of the law"; this location, autumn of 1917 (Swenk 1921; 1933)

²⁷Some of these records were published earlier as separate notes. Since most of them were summarized by Swenk (1933) and Brooking (1943a) these authors will be given as source whenever possible, and often other references to same items omitted.

²⁸Between April 5 and April 10, there were from 1 to 4 birds on the river in this same area (see Swenk, 1933). It is impossible to know how many individuals were actually involved.

²⁹Possibly same individual reported to Black by two hunters near Axtell, Kearny County (Swenk, 1933).

³⁰Various reports, possibly of same birds.

²⁵This may be the same bird now in the Colorado Museum of Natural History, catalogued as No. 16385, "April 1908, Inland, Nebraska, C. Shupen." Inland and Harvard are a few miles apart in Clay County.

²⁸Swenk (1933): "Probably the same birds" as those reported "a few miles west of Odessa, Buffalo County" on same date (see item 261 this tabulation, item for Oct. 25, 1925).

²⁹Listed as 12 miles W. of Kearney (Swenk, 1933).

³⁰Listed as 10 miles W. of Kearney (Swenk, 1933)

³¹Listed as 10 miles W. of Kearney (Swenk, 1933).

265. Axtel, Kearney County	Apr. 8-18, 1926**?		Swenk (1933)	286. (near) Fort Stevenson, McLean Co.	June 1874	Elliott Coues	Coues (1874b)
266. Antioch, Sheridan County	Oct. 9, 1927	Keller	USFWS files (letter 10-9-27)	287. Coteau des Prairies, Burke Co.	spring & fall 1876 to 1878	C. E. McCheaney	McCheaney (1879)
267. Merriman, Cherry County	March 1929	Phillip Mensinger	Hastings Mus. No. 9906	288. Pembina Co. (Pembina) (Bathgate)	July 6, 1879 (specimens?) Apr. 18, 1890 May 6, 1893 Apr. 10, 17, 1894 Apr. 11, 1895 (specimen)	W. L. Abbott Bowen	Abbott (1880) USFWS files
268. (near) Ell, Cherry County	Oct. 3, 1930 (1 killed)	hunter	Swenk (1933)	(Glasston)	1899 (specimen)	W. H. Williams	Hale Coll. (Wood, 1923a)
269. 90 Ranch S. of Gothenburg, Dawson County	spring 1933 May 1936 (wounded captive)**	?	Ramsey (letter 5-6-46)	(Big Slough)	1899 (specimen)	W. H. Williams	Williams (1926)
271. Cozad, Dawson County	Apr. 1, 1936 Oct. 22, 1939**	Conover & Foley ?	Brooking (1943a) Brooking (1943a)	(Hamilton)	Apr. 12, 1912 (specimen)	D. D. Warren	Wood (1923a)
272. Lexington, Dawson County	Apr. 7, 1942	Burman Guyer**	Brooking (1943a)	(LeRoy)	Fall 1919 (specimen)	?	Wood (1923a)
273. S. of Madrid, Perkins County	About Apr. 8, 1940	J. E. Black	Vance (letter 4-24-40)	289. Fort Berthold, McLean Co.	Sept. 1881	W. J. Hoffmau	Hoffman (1882)
274. 3 mi. S. and 1 1/2 mi. W. of Shelton, Buffalo County	May 27, 1946	Mrs. Mortimer et al.	Mrs. Brooking (1946)	290. 40 or 50 mi. So. of Jamestown (prob. Dickey County.)	Aug. 2, 1883	E. S. Gaylord	Roberts (1930)
275. (near) Lewellyn, Garden County	Nov. 13, 14, 1946	Loren Bunney	Bunney (verbal)	291. Dawson area, (Kidder Co.)	1880's** Oct. 11, 1889 (specimen)	Wm. B. Mershon Louis A. Yorke	Mershon (1934) Max Minor Peet Coll., Univ., Mich. Mershon (1928)
270. North Platte Area, Lincoln County	Apr. 19, 1947 Apr. 1-13, 1948	R. P. Allen Mose Trego, Gordon Potter	Allen (1947c) Trego (card 4-1-48) (letter 4-10-48) Kirkman (letters 4-1-48 & 4-14-48) Smith (card 4-9-48)	(Steele)**	Early 1890's** (specimen) Oct. 18, 1920 (specimen) Sept. 29, 1931	Mershon G. Bruening	USFWS files
277. (near) Sutherland	Apr. 8, 1948	Lee Jensen & Art Edmunds	Kennedy (letter 4-13-48)		Sept. 30, 1932	Bernie Maurek & Russell Reid Tyler	Reported by Pearson to Bernie Maurek (Swenk, 1933) Reid (1946)
278. Darr, Dawson Co.	Apr. 1948	R. Brown					
NEW JERSEY							
279. Cape May area** (Egg)	1810? (wintering; breeding?)	Alexander Wilson	Wilson (1814)	292. Menoken, Burleigh County	Apr. 5, 12, 14, 1885	E. T. Judd	Cooke (1883); USFWS files Judd (1891)
280. Beesley's Point, Great Egg Bay	1857	Wm. P. Turnbull	Turnbull (1869)	293. Towner County	Oct. 5, 1890	?	N. Y. State Mus. No. 1746
NEW MEXICO							
281. Fort Thorn	1853-54	Dr. T. C. Henry	Henry (1855)	294. Morton County (Mandan)	June 1891 (specimen)	?	State Hist. Soc. Mus. (Reid 1946)
282. (near) Portales	1938	W. G. Vinzant	Vinzant (letter in N.A.S. files)	(Mandan)	1908 (2 specimens)	J. D. Allan	Chi. Acad. Sci. Nos. 4916; 4917 USFWS files
NORTH DAKOTA							
283. Mouth of Little Missouri River (Dunn County)	Apr. 11, 1805	Lewis & Clark	Lewis (1804-05-06)	295. Grand Forks Co. (Larimore) (Larimore)	Apr. 8, 21, 23, 1893 May 18, 1894 (nested?) Oct. 18, 1904	Eastgate Eastgate Colling	USFWS files; Cooke (1914) USFWS files (Bent, 1926) USFWS files
284. (near) Fort Union Williams County; (also Ft. Clark, Mercer County but n.d.; between Ft. Union and Fort William [Buford] Oct. 16 [1833?])	Sept. 22, 1833	Maximilian	Wied-Neu-ered (1840-43)	296. Argusville	Apr. 28, 1894	Edwards	Chi. NHM No. 131658
285. (near) Ina, Rolette County**	June 3, 1871 (nesting, 1 egg coll.)	Detos Hatch	Chi. NHM No. 5541	297. Rolette Co. (Turtle Mts.)	Fall 1894 (specimen) Apr. 13, (1917?) 1917? ("prob. nests")	E. T. Judd ?	Wood (1923a) Judd (1917)
				298. Lake Benton	Nov. 9, 1901	?	Milwaukee Pnb. Mus. No. 260 USFWS files
				299. Devils Lake, Ramsey Co.	Apr. 11, 12, 16, 1903	Bowman	State Mus. (Bismark)**
				300. Cavalier Co. (Calvin)	n.d. (specimen) Apr. 20, 1907 (specimen)	?	Wood (1923a)
				301. Antler, Bottineau Co.	May 3, 1908	Currie	USFWS files
				302. Sherwood, (Ren-ville Co.)	Sept. 19, 1908 (specimen)	A. J. Clark	Wood (1923a)

**Wilcox and Axtel are only about 7 miles apart (straight line) and obviously the flock reported from both areas on these dates was a single group of birds.

**This was the Gothenburg captive, later donated to our project by the Gothenburg Gun Club.

**Listed as between Cozad and Darr (Brooking, 1943a).

**Listed as "Burman and Guyer" (Brooking, 1943a).

**There is a single specimen, reputed to be from "the Capes of the Delaware." It was in the Peale Museum and is now MCZ No. 67828.

**Recorded as "Iona" but evidently this location was Ina in Rolette County, as given above.

**Between 1884 and 1890 Mershon hunted around Dawson (Mershon, 1923).

**Steele is 5 miles W. of Dawson. Other locations in Kidder County have a distinct individuality and are listed as separate items.

**On loan from Univ. of No. Dakota.

303. Chase Lake, Stutsman Co.	(about) May 1, 1908 May 7; Oct. 11, 1913	H. H. McCumber	USFWS files	322. 35 mi. N. of Wichita Falls (Tex.)	Oct. 1899	W. A. Mayer	F. W. Miller (letter 4-2-46)
304. Nelson Co. (Lakota)	until 1908 (nesting) 1919 (specimen)	Eastgate W. H. Williams	Wood(1923a) Wood(1923a)	323. Woods County	Apr. 7, 1907 (2 specimens) 1909-1912	?	Mus. at Alva (Nice, 1931) Lewis (1930)
305. (near) Lake George Kidder County	Fall 1910 (1 killed)	?	J. E. Campbell (verbal to O. S. Pettillingill) Phillips (1926)	324. Harper and Beaver Co.		W. E. Lewis	formerly Okla. A. and M. (Baumgartner, letter 3-22-36)
306. Towner, McHenry County	Spring 1915 ⁹⁹ (nestling)?	?		325. (near) Stillwater	Oct. 1928 (specimen)	a hunter	Low (telegram 4-2-40)
307. Bismark, Burleigh Co.	Sept. 16, 1920	Russell Reid	Wood(1923a)	ONTARIO			
308. E. of Medina, Stutsman Co.	Apr. 8, 1922 June 24, 1921	N. A. Wood	Wood(1923a)	327. Township of Camden, Ad-dington Co. ¹⁰²	Sept. 27, 1871 (specimen)	Wesley Potter	McIlwraith (1894); Macoun (1900)
309. Long Lake, Kidder Co.	Oct. 2, 1921 (specimen) Sept. 1-17, 1922	C. E. Boardman	Colo. MNH No. 10272 Wetmore (USFWS files) Bent (1926)	328. Ardtra	May 9, 1886	Blair	USFWS files
	Sept., Oct., 1923	Boardman		329. (near) Toronto	1880's (?)	Wm. Loane	Chamberlain (1887)
310. Walsh County (near Edinburg) (Slough w. of Edinburg) (near Grafton)	Aug. 13, 1930 Spring 1923 Spring 1923	Bernie Maurek H. V. Williams H. V. Williams	Reid (1946) Wood(1923b) Wood (1923b)	330. Emsdale	1895	Handy	Niemiing (1901)
	April 1923	H. V. Williams	Williams (1920)	SASKATCHEWAN			
311. N. of Mercer, McLean Co.	Oct. 15, 1924 Aug. 13, 1930	H. V. Williams Bernie Maurek	USFWS files Roberts (1936); Reid (1946)	331. Saskatchewan R.	May 7, 1827 (specimen)	?	Richardson and Swainson (1831)
312. (near) Hazelton, Emmons Co.	Oct. 1933 (specimen)	?	State Hist. Soc. Mus. Coll. (Reid, 1946)	332. Beyond "Weed River" ¹⁰³	1858	H. Y. Hind	Hind (1860)
313. (near) Cashel	1935	H. V. Williams	USFWS files	333. Qu'Appelle Valley (Qu'Appelle)	Apr. 28, May 1, 1884 (?) Apr. 20, 1901 Apr. 19, 21, 24; Sept. 25; Oct. 2, 1904	Guernsey Cates Lang	Thompson (1891) USFWS files USFWS files
314. Horsehead Lake, Kidder County	(about) Oct. 25, 1944	O. E. Hulsebus	Hulsebus (verbal to O. S. Pettillingill)	(Indian Head)	Apr. 26, 27; May 1, 1905 (circa) 1908 (specimen)	Lang C. G. Harold	USFWS files Nat. Mus. Canada No. 18871
	Oct. 1946	?	Fields (letter 10-21-46)	(Indian Head)	Apr. 27, 1910 Apr. 15, 1920 Fall 1921	Lang Lang J. R. Garden	USFWS files Bent (1926) Bent (1926)
315. 6 mi. W. of North Portal, Burke County	Spring 1947	Joe Hill	Norris Loney (verbal and letter 4-18-49)	(Qu'Appelle and Tynan)	Spring 1923	?	Bent (1920)
	Late Sept. & early Oct. 1947	Munro Dunbar	Dunbar (verbal and letter 10-8-47)	334. Touchwood Hills	1858	Hind	Hind (1860)
316. 8 mi. W. and 2 mi. S. of Washburn, Oliver Co.	Apr. 23, 1947	Harry C. Jones	J. E. Campbell (letter 5-2-47); N. Dak. Outdoors. IX, 12, 7 (1947)	335. (east of) Moose Mountain Area (nestling)	1881(?)	Macoun	Macoun (1882); Seton (1886); Thompson (1891) Raine (1892)
OHIO ¹⁰⁰				336. (near) Battleford (North Sask. R.)	1884 (nestling, 2 eggs coll.)	Macdonald	
317. (above) Cincinnati	1876 (?) (2 or 3 killed)	?	Langdon (1877)	337. White Sand River	1884(?)	Christy	Christy (1886); Thompson (1891)
318. Granville	March 28, 1887	Tight	USFWS files	338. Red Deer Hill (near Prince Albert)	1892 (2 specimens)	Thos. McKay (?)	N.M.C. Nos. 1323, 1324
319. Little Miami R. (near Indian Hill Station)	Aug. 1895	F. B. Magill	Drury (1900)	339. Osler	May 1, 2, 5, 25, 1893	Colt	USFWS files
320. Scioto R., (Waverly)	1002(?) (specimen) 1902 (?) (captive)	?	Bannan Coll. (Henninger 1902) Henninger (1902)	340. Twelve Mile Lake, Wood Mts.	June 6, 1895 ("likely breeding")	Macoun	Macoun (1900)
OKLAHOMA ¹⁰¹				341. (near) Yorkton ¹⁰⁴	May 16, 1900 (nestling, 2 eggs coll.)	Cowboy Brown	Cooke (1914); Bent (1926); Thayer Coll. MCZ ROMZ
321. Cleveland Co.	Oct. 29, 1832 1901-02	Latrobe C. D. Bunker	Latrobe (1830) Nice (1931)	342. Yellow Grass	Sept. 1905 (3 specimens)	?	

⁹⁹Remington Kellogg (USFWS files) reported that James Lymburner showed him remains of four nests (July 20-Aug. 8, 1916). The evidence, however, is not conclusive enough to place this report in the record as definite.

¹⁰⁰Dawson (1903) gives records for Cincinnati, Columbus and Cleveland, without details. These are omitted as indefinite and doubtful.

¹⁰¹Dr. Glisan's "east flocks of white cranes" seen at night above a prairie fire near Fort Arbuckle (1874, *Jour. of Army Life*, p. 69) could have been Little Brown Cranes that may have appeared while in the firelight.

¹⁰²Evidently the same as the record given by Cooke (1914) and Bent (1926). Cooke cites Ewart as authority and Bent, under *Casual Records*, gives "Yarker, September 21, 1871."

¹⁰³Lat. 51° N., Long. 104° 30' W. or about 3 miles N. of Southey, Sask., near Loon Creek.

343. Buffalo Lake	Oct. 11, 1900 (specimen)	C. H. Davis	Mershon Coll. Univ. Mich. Mus. No. 84001	384. Snowden ¹⁰⁴	Early June 1942	A. & E. Johnston local farmers	Walkinshaw (1949a)
	Oct. 1910 (specimen)	Davis	Mershon Coll. Univ. Mich. Mus. No. 61812		summers of 1943-46	G. Harrison	Walkinshaw (1949a)
344. (near) Lajord	May 1908	H. H. Hanson	Hanson (letter 5-26-48)	385. Mozart	Oct. 5, 1942	Dean Lightbody	Walkinshaw (1949a)
	Oct. 12, 1948	B. A. Hanson	Hanson (Bard Records)	386. Nipawin area ¹⁰⁷	May 10, 1944	C. S. Francis	Street (1946)
345. Last Mountain ¹⁰⁴ Lake & Vicinity	first week Apr. 1909 (specimen)	?	Fleming Coll. No. 15386, ROMZ		May 13, 1944	W. G. Karstad	Street (1946)
	Oct. 14-19, 1943	J. H. Wilson	USFWS files		Apr. 29-June 13, 1945	J. Lyons and J. Wark; M. Street	Street (1946)
W. of Hatfield	May 3, 1947	F. Bard, Sr.	(verbal)		Apr. 25, 1946	S. Anklovitch 2 farmers	Bard Records (1949a)
346. 50 mi. N. of Quill Lake (near Resource?)	Spring 1909	?	Ferry (1910)		May 3, 1947	Billy Matthews	M. Street (letter 11-1-47)
347. N. end of Big Quill Lake ¹⁰⁵	Spring 1909	Ferry	Ferry (1910)	387. Imperial—Simpson Area	May 1944	K. J. Smith	Bard Records
348. 20 mi. N. of Davidson	1911 (nesting)	R. Lloyd	Mitchell (1924)		May 3, 1947	F. Bard, Sr.	Bard Sr. (verbal)
349. Bradwell	1911-1912 (nesting, 1 killed)	L. G. Moore	Bard Records		Sept. 5-25, 1948	V. C. Huggins, Fred Lehrman, J. C. Lightle, Constable Jordans, A. McKenzie	Bard Records
350. (near) Kerrobert	summer 1913	E. Margaret Estlin	Pearson (1922)	388. (near) Raddison	Sept. 2 & 6, 1946	Mrs. Tom Elliot	Bard Records (RCMP report)
	autumn 1921	Neil Gilmour	Bent (1926); Lewis (letter 2-5-49)		May 3, 1946	E. Gust	Bard Records (RCMP report)
(near Ballol, 9 mi. NW of Kerrobert)	May 19, 1922 (nesting)			389. Regina	Apr. 12, 1946	F. Bard, Sr., Phyllis Bard, L. T. Carmichael	Bard Records
351. Vauada	1913 (specimen)	?	J. A. Munro (letter 3-25-46)	370. N. of Duck Lake	Apr. 17, 1946	Mrs. E. Unruh and family	Bard Records
352. 10 mi. N. of Semans	Fall 1913 (2 killed; 1 mounted)	Thos. L. James	A. S. Taulbut Coll. (letter Mrs. James 3-14-48)	371. (near) South Mackwa	Apr. 17, 1946	Mrs. F. Nicholas	Bard Records
353. Beaver Hills area (NE of Ituna)	1913 (1 killed)	a farmer	Henry Casswell (letter 2-5-48)		Apr. 20, 1946	W. O. Warner	Bard Records
354. Forget	Oct. 1914 (2 specimens)	?	Provincial Mus. (Regina), Nos. 376, 1025; (Mitchell, 1924)	372. (near) Witche-kan	Sept. 22, 1947 (about) Apr. 29, 1946	A. & P. Gehl	Bard Records
355. 5 mi. up Jackfish Cr., Lake Athabaska	(circa) 1917	Bobbie Herron	Francis Harper (personal journal, 8-31-20)		Apr. 30, 1946	V. Goodman	Bard Records
356. Tullywilt Dlst. (12 mi. S. of Ituna) (Van Veen Lake)	(circa) 1919 (1 killed)	Indian	Henry Casswell (letter 2-5-48)	373. Slough 12 mi. from Hughton	May 6, 1946	Mrs. A. Hyland	Bard Records
	1925			374. (near) Meadow Lake	first week of May 1946	E. Zurolak	Bard Records
357. Balcarres	(circa) 1920 (1 killed)	?	H. Casswell (letter 2-5-48)		Apr. 20, 1947	F. Fraser & Erickson	Howland (letter 4-20-47)
358. Muddy Lake (7 mi. S. of Unity)	May 28-June 1 1922 (nesting 1 egg and 1 yg. coll.)	Fred Bradshaw	Bent (1926); Fleming Coll. No. 30393 (ROMZ)		May 7 & 11, 1946	Wm. Cockburn	Bard Records
359. Findlater	May 3, 1924	H. L. Felt	Bent (1926)	376. 10 mi. S. of Lucky Lake	May 10, 1946	E. D. Mills	Bard Records
360. Wiseton	Apr. 18-19, 1926	Miss B. M. Dickson	USFWS files	377. Between Stalwart & Davidson	May 10, 1946	L. Cruise	Bard Records
361. (near) Estevan	Oct. 20, 1927 (specimen)	a farmer	Mershon (1928 & 1934); Prov. Mus. (Regina No. 1999)	378. 6½ mi. S. of Parke View	(about) May 10, 1946	W. L. Kalibaba	Bard Records
362. Liberty	Nov. 3, 1927 (specimen)	?	Prov. Mus. (Regina) No. 1998	379. 2 mi. N. of Melfort	May 11, 1946	W. Lobb (R. Flavel)	Bard Records
363. 5 mi. S. of Isham	Spring 1937 or 1938	R. H. Carruthers	Hicks (Bard Records)	380. Saltcoats	May 1946	W. Domon	Walkinshaw (1949a)
				381. Loreburn	Sept. 27-Oct. 3, 1946	G. Book	Bard Records
				382. Major area	Sept. 28, 1946	J. T. Finley	Bard Records
					Oct. 1, 1946	W. Widenhammer	Bard Records
					Oct. 5, 1946	A. Schiebelbein & R. J. Coulter	Bard Records
				383. 4 mi. S. of Livelong	Sept. 1946 (possibly until Oct.)	Clarence Pilling (Griffith)	Bard Records
				384. Sailor's Bay, Last Mountain L., East of Stalwart	Oct. 19, 1946	W. Gullacher & S. G. Thompson	Bard Records

¹⁰⁴For other reports from this general vicinity see: 367 (Imperial-Simpson area), 377 (Stalwart-Davidson), 384 (Sailor's Bay, east of Stalwart). See also, footnote 106.

¹⁰⁵Bent (1926) found no Whooping Cranes at Quill Lake during May and June 1917. See footnote 106.

¹⁰⁶No Whooping Cranes were observed by Walkinshaw at Yorkton, Quill Lakes and Last Mountain Lake (May 27, 1947); Nipawin to Big Sandy and Deschambault Lakes and Candle Lake (May 28, 29, 30, 1947); Nipawin, Fishing Lake and the Snowden area (June 1-16, 1947) (Walkinshaw 1949a).

¹⁰⁷No Whooping Cranes were observed by Walkinshaw at Nipawin to Big Sandy and Deschambault Lakes and Candle Lake (May 28, 29, 30, 1947); Nipawin, Fishing Lake and the Snowden area (June 1-16, 1947) (Walkinshaw 1949a).

423. Galveston Island	1860's	?	Dresser (1866)	Dec. 7, 1892 (specimen)	Webster (for Sennett)	Carnegie Mus. No. 324
424. Mouth of Brazos R.	1960's	?	Dresser (1860)	Dec. 14, 1892 (specimen)	Webster (for Sennett)	Carnegie Mus. No. 322
425. Head of Padre Is. (Nueces Co.)	Late March 1878	Sennett	Sennett (1870)	Jan. 2, 1893 (2 specimens)	Webster (for Sennett)	AMNH No. 364209; Carnegie Mus. No. 49750
	Aug. 20-30; Nov. 1-12, 1891	W. Lloyd	USFWS files			
	Nov. 10, 1891 (specimen)	Lloyd	USNM No. 141491	438. Refugio Co. (near Austwell)	Spring & Winter (1896-1900) Jan. & Feb. 1941	J. J. Carroll J. O. Stevenson
426. Frio and Nueces Canons	winter 1881-82	Lloyd	USFWS files Cooke (1888)	(near Tivoli)	winter 1948	local ranchers
427. Houston Area	Nov.-Mar. 31, (1881-82?) Jan. 4, 1893 (specimen)	H. Nehrling Jas. Whyte	Nehrling (1882) USNM Nos. 128016 and 19171	439. Arroyo Colorado, Willacy and Cameron Counties ¹¹³	May 6, 1900	Vernon Bailey
428. Tom Green Co. Concha Co. (San Angelo)	winter (to Mar. 5) 1884-86	Lloyd	USFWS files Cooke (1888)	440. Matagorda Island ¹¹⁴	Mar. 29-Apr. 2, 1900 1938-1941	H. C. Oberholser J. O. Stevenson L. E. Beaty et al.
429. Williamson Co.	Mar. Apr. May, 1884	G. B. Benners	Benners (1887)	441. Tarkington Prairie, near Cleveland	Apr. 23, 1905	Gaut
430. Comal County	Mar. Apr. May, 1884	Benners	Benners (1887)	442. Worsham Ranch, 8 mi. E. of Henrietta, Clay Co.	(circa) 1908 (several specimens)	R. L. More(?)
431. Blackjack Peninsula, Aransas County ¹¹¹	1885	J. A. Bruudrett	Stevenson and Griffith (1948)	443. Port Arthur, Jefferson Co.	Nov. 2, 1913	Mrs. Bruce Reid
	Fall 1895 1910	E. Hough Thos. Webb	Hough (1805) Stevenson and Griffith (1948)	444. Laguna Larga Area, (Laureles Ranch), Nueces Co. & Kleberg Co.	winter 1915	Richard Kleberg
	Winter "1931 on"	J. G. Fuller (Sprunt)	USFWS files		1919-1923 Dec. 23, 1921	Kleberg T. G. Pearson & Kleberg
	Winter 1935-36	G. B. Saunders	Craven (1946)		Jan. 12, 1923	Ludlow Griscom & Maunsell Crosby
	Jan. 25; Feb. 8, 10, 20; Mar. 3, 8, 1936	Neil Hotchkiss	USFWS files		Feb. 12, 1926 Jan. 5, 1934 Mar. 23, 24, 1935	Baker J. J. Carroll Carroll
432. Matagorda Peninsula (Kane's Landing)	Jan. 23, 1885 (specimen)	?	Univ. Iowa (USFWS files)	445. Coastal Strip ¹¹⁶ from Matagorda to mouth of San Bernard R.	prior to 1917-1918	Carroll Neil Hotchkiss Carroll A. Wetmore
	Jan. 6-Feb. 20, 1892	Lloyd	USFWS files	446. Red River near Vernon, Wilbarger Co.	n.d. (2 specimens)	?
433. Gainesville, Cooke Co.	March 31, 1885	Ragsdale	USFWS files; Cooke (1888)	447. Dallas Region (Lake Worth)	1920 1927	Jno. B. Litsey Mrs. Bruce Reid
434. Bonham, Fannin County	Mar. 23, 27, 30; Apr. 4; Nov. 9, 16, 1885	Peters	USFWS files; Cooke (1888, 1914)	448. (near) Maxwell, Caldwell Co.	1928-1929 (1 killed)	R. W. Strandtmann
	Mar. 25, Apr. 2, 9, 1886			449. 20 mi. S. of Laguna Larga (S. of Baffin Bay)	Jan. 1923	Griscom & Crosby
	Oct. 8, 9, 15; Nov. 22, 1888			450. Mission Lake, Calhoun Co.	Nov. 10 or 12, 1932	W. H. Bauer
	Oct. 22, 23; Nov. 8, 18, 1889			451. St. Joseph Island ¹¹⁷	Dec. 1, 1932 1938-1941	O. B. Kuippa J. O. Stevenson, L. E. Beaty, et al.
435. McLennan Co. ¹¹² (near Waco)	Mar. 23, 24; Apr. 2, 1890 1886	"Elanoides"	"Elanoides" (1890)	452. Yturria Ranch, 63 mi. N. of Brownsville	Jan. 23, 1933 Feb. 8, 1933	H. C. Oberholser T. H. Clegg
	1888 1889					
	Apr. 1890 (specimen)	?	Formerly Baylor Univ. Mus. (Strecker 1927)			
436. Beaumont Area	Dec. 23, 1886 (specimen)	?	Harry Merrill Coll., Peabody MNH (Vale) No. 7569			
437. Hidalgo Co.	Feb. 22, 1891 (specimen) Nov. 16, 1892 (specimen) Dec. 2, 1892 (specimen)	F. S. Webster (for Sennett) Webster (for Sennett) ?	Carnegie Mus. No. 323 Carnegie Mns. No. 325 Dwight Coll. (Griscom & Crosby, 1926)			

¹¹⁰Last recorded occurrence for the "Laguna Country" around Brownsville.

¹¹¹Present location of Aransas National Wildlife Refuge, established in December 1937.

Innumerable records for this location (to 1949) are on file but will not be listed here. The section of this report on *Winter Life* discusses this area in detail.

¹¹²In 1927 Strecker (*Notes on the Ornithology of McLennan County, Texas*, Baylor Univ. Special Bulletin No. 1, 1927) wrote that the species was formerly abundant in this county but that none had been observed since 1907.

¹¹³Given as "Rio Coloral."

¹¹⁴Numerous records on file (to 1949). This location is discussed in detail in the section of this report on *Winter Life*.

¹¹⁵This is believed to be the last report of Whooping Cranes on Laureles Ranch. Two birds were observed by Mr. Carroll between the ranch buildings and Laguna Larga.

¹¹⁶None seen here by Dr. Wetmore, Dec. 25, 1917 to Jan. 2, 1918 although there were earlier reports. No records since.

THE WHOOPING CRANE

453. Espiritu Santo Bay (Dewberry Is.)	Jan. 10, 1933	Oberholser	USFWS files						
	Mar. 14, 28, 1934	J. J. Carroll	USFWS files						
454. 30 mi. S. of Corpus Christi (above Baffin Bay)	Jan. 14, 1938	Bob Snow	Snow (letter 1-14-38)						
455. East Bay, Chambers County	Jan. 19, 1930	Mrs. Bruce Reid	USFWS files						
456. El Campo area, Wharton County	Fall 1948	local ranchers	C. A. Keefer and L. E. Beaty (verbal)						
UTAH									
457. Great Salt Lake area	1880's(?)	?	J. A. Allen (Baird, Brewer and Ridgeway 1884; Blaauw, 1897)						
WISCONSIN									
458. Lake Michigan, near Racine	1840's (specimens)	P. R. Hoy(?)	Kumlien & Hollister (1903; rev. by Schorger, 1948). Court House Coll. (Racine)						
459. Southwest Wisconsin (along Miss. R.)	1840's	Hoy(?)	Kumlien and Hollister (1903). (rev.						
				460. Sugar River, Dane County	(circa) 1854	?			by Schorger, 1948)
				461. Green County	Oct. 1878 (specimen)	?			Dudley (1854)
									Thure Kumlien Coll. (Kumlien & Hollister, 1903; rev. by Schorger, 1948)
				462. Twin Bluffs	1884		C. McCollum		McCollum (1884)
WYOMING									
				463. Jackson Lake...	Spring 1908 Feb. 1912		Wm. Richard		Grave & Walker (1913)
				464. Cody	1906-1912		Richard		Grave & Walker (1913)
				465. Yellowstone Park (Shoshone R.) (Bechler R.)	Aug. 4, 1914 1915 or 1916 summer 1930		M. P. Skinner ? T. G. Pearson; Ranger Bicknell		Bent (1926) Everts (1923) Kemsies (1930)
				(West Yellowstone)	Summer 1946		W. L. Wilcox		Wilcox (letter 10-3-45)
				466. Star Valley	May 1934		Ray Wolfley		McCreary (1937)
				467. Osage	May 1935 (about) Apr. 23, 1934 (specimen)		Theone Wolfley J. F. Bock		Alabama Poly. Inst. (Cottam, memo. 12-8-44); Roahen (letter 12-16-34)

¹Numerous records on file (to 1940). This location is discussed in detail in the section of this report on *Winter Life*.

DISTRIBUTION: SUMMARY

1. The evidence contained in fossil deposits suggests that *Grus americana* first appeared during the Pleistocene. Distribution of fossil remains indicates a wider range in that period than during Recent times, bone fragments having been found in California, Idaho, Kansas and Florida. In Recent times the range extended north to at least 68° 30' No. Lat. (and probably to the Arctic Coast); south nearly to 20° N. Lat. (Lago de Chapala, Jalisco); west to Utah (Great Salt Lake); and east to the Atlantic seaboard in New Jersey, South Carolina and possibly Georgia and Florida.

2. Many early reports from the Atlantic seaboard, attributed to this species, appear to be in error. The first authentic description was that of Catesby, who received a dried skin in South Carolina in 1722 or 1723.

3. Catesby's account of the distribution suggested that the Whooping Crane nested in the Appalachian Mountains, wintered on the coast of South Carolina, Georgia and Florida. Publication of Edward's account of the species (1751) shifted the nesting area to Hudson's Bay.

4. Records of early occurrence in New England (Vermont and Massachusetts) are confused by a lack of both specimens and specific descriptions. If the species did occur there it was probably as a straggler.

5. Lewis and Clark, in 1805, observed Whooping Cranes on the Little Missouri River, in what is now North Dakota. This is the earliest report from the heart of their range. In 1810, Wilson reported the species from South Carolina (Waccamaw River) and he and Audubon saw migrants at Louisville, Kentucky. About this same time, Wilson saw wintering Whoopers in the Cape May, New Jersey, region. Turnbull's record for the same area, in 1857, is the last of these East Coast reports. It is doubtful if the species was numerous east of the interior grasslands after Pleistocene times. On the record,

there are only six occurrence locations on the Atlantic seaboard and three others for the entire region east of the Ohio and Mississippi Rivers.

6. Wilson was in error in stating that the Whooping Crane wintered in South America and Nuttall in including the West Indies within winter range.

7. The first record for Saskatchewan was that of Swainson and Richardson, in 1827. In 1834, Townsend evidently saw the species on Bear River, Oregon Territory (now s. e. Idaho). In the 1840's, Hoy collected Whooping Cranes in the vicinity of Racine, on Lake Michigan, and, in 1845, Col. McCall contributed the first account of winter life from observations made in grasslands near San Antonio and on the coast at Corpus Christi, Texas.

8. In the 1850's, Hind added valuable distributional data from Saskatchewan. The railroad survey expeditions penetrated the American West during this decade and, as pointed out by Coues (1874a), did not secure a specimen of *Grus americana*, which even then was not an abundant species. In 1858, Spencer Fullerton Baird noted that "though common in Texas and Florida" there were no specimens in any U. S. public museum. The myth of the Whooping Crane's abundance in Florida was shaken by the visit there (in 1868-69) of Dr. J. A. Allen, the distinguished New England ornithologist, who, though familiar with the species, found none in Florida. There is no definite evidence that it has occurred in that State since the Pleistocene. In 1863, Dresser observed the Whooping Crane in the Rio Grande Delta region in both Texas and Mexico.

9. Elliott Coues presented the first adequate description of the distribution of the Whooping Crane, in 1874. He was the first to remark that the range was limited rather than widespread or general. "Interior of North America. Up the Mississippi Valley, spreading through the Fur Countries. Texas to Florida, and occasionally up the coast to the middle states." He added personal observations from North Dakota and,

later (1874b), from Minnesota. In 1884, Baird, Brewer and Ridgway added Ohio to the east, Colorado to the west and, following the reports published by Duges (1869-1870), central Mexico.

10. Between 1864 and 1884 a total of 57% of all recorded nests of the species had been located. The breeding distribution was known to include sites in Iowa, Illinois, Minnesota, North Dakota, Saskatchewan, Manitoba and the District of Mackenzie. The first Alberta nest was not reported until 1904. These eight geographical divisions were included in the northern breeding area.

11. In the 1895 edition of the American Ornithologists' Union Checklist, the distribution is given as: "Interior of North America from the Fur Countries to Florida, Texas and Mexico and from Ohio to Colorado. Formerly on the Atlantic Coast at least casually to New England."

12. The migration studies of Wells W. Cooke, of the U. S. Department of Agriculture (begun in the early 1880's), added new details on distribution at a rapid pace. These reports, chiefly from the new army of amateur observers, become numerous enough to permit relating distribution to environment.

13. Summer distribution (to 1922) is considered. The range at this season is divided into four categories and each is discussed with relation to its significance to Whooping Cranes. Most summer occurrence is of breeding pairs. These were found chiefly in aspen parkland and traditional (plains to parkland) habitat types in Canada and in prairie communities in the North Central U. S.

14. A tabulation of occurrence locations in Canada (1748-1922) indicates that 47% were in aspen parkland; 15% in transitional (plains to parkland); 13% in northern coniferous forest; 8% each in shortgrass plains and northern mixed forests; 4% in river deltas; 3% in transitional (parklands to mixed forest) and 2% in tundra. All U. S. nesting sites and summer occurrence locations were in prairie habitat, with

the exception of the Gulf Coast resident and summering birds and one late August record from the Mississippi River in extreme western Kentucky. Iowa nesting sites may have presented optimum breeding conditions for the species.

15. Winter distribution (to 1922) is discussed in relation to habitats. It is considered that the tallgrass prairie of southwest Louisiana was the most favorable winter range. Other types, in probable order of desirability, included: sea-rim and brackish marshes, coastal lagoons and maritime beaches and high interior grasslands or tablelands.

16. The winter range is divided into eleven sectors and the relation of the Whooping Crane's winter distribution to each is discussed. The potential carrying capacity of the major habitats of each sector is considered. A resident breeding colony was formerly located in *Panicum* marshes above White Lake in southwest Louisiana and the distribution in this habitat is also discussed.

17. Present distribution (since Muddy Lake, 1922-1948) is outlined and the lost ground described. Tabulations are given showing the relation of the number of occurrence locations to the 36 States, Provinces and Districts concerned, and to periods of time. Shrinkage of range, on this basis, is found to include 30% of these geographical divisions by 1899, 61% by 1919 and 66% by 1948.

18. In another tabulation it is indicated that there are 365 abandoned occurrence locations on record. This represents 80% of the total of 454 such locations on record, and for which there is more or less complete data.

19. Another tabulation illustrates the chronology of depletion of range and gives the "Year of Last Record" for the 36 geographical divisions. Today, the occurrence of Whooping Cranes may be expected in 12 of the original 36 divisions, is of more or less regular expectance in only 8 or 9.

20. There have been 925 reports of occurrence (1722-1948). These are tabulated by States, etc., and by periods of time.

21. The status and distribution of nonbreeding summer wanderers is discussed. There are four headings: (a) the composition of the entire migrant group is analyzed and tables are presented showing probable breakdown for this group. It is believed that about 50% consist of potential breeding pairs and 50% of a combination of young-of-the-previous-year, sub-adults (2 year olds), senile individuals and other unpaired adults. A probable time schedule for breeding pairs (b) is worked out in detail indicating a full breeding cycle (arrival on breeding grounds to start of the southbound migration with young-of-the-year) calculated at a minimum of 168 days. Critical average dates imply that Whooping Cranes observed in Canada after about May 15th are either (1) a breeding pair established on their nest site and given to formalized behavior, or (2) nonbreeding summer wanderers. The formalized behavior pattern of breeding birds is discussed briefly (c). Finally (d), the actual record of these nonbreeding migrants is given. Most birds in this category occur in Canada (chiefly in Saskatchewan and Alberta). 49% of these reports are from aspen parkland habitats, near former nesting sites; 29% are from transitional (parklands to mixed forest) habitat and scattering 9% each from mixed forest and coniferous forest. One report is from the Precambrian Shield country and one from a river delta. There are few summer records in recent years from the U. S. In the last decade Whooping Cranes have been seen in summer in Colorado and Wyoming. On the Gulf Coast, besides the remnant of the former resident colony above White Lake, there have been three

instances of summering birds on Aransas Refuge. In 1941, a family group remained through the summer and a total of three nonbreeding individuals, two of them with injured wings, stayed on the refuge during the summers of 1947, 1948 and 1949.

22. The range of the Whooping Crane, that once (prior to 1860), reached from the Arctic Coast to Central Mexico, and from Utah to New Jersey and South Carolina, dwindled rapidly as a result of the impact of settlements, drainage, agriculture and other activities of mankind and the gradual loss of perhaps 97% of the original Whooping Crane population. The shrinkage of range was probably most rapid between 1865 and 1899. It continued at a steady pace down to 1922 (when the last observed nests were reported from Saskatchewan) and has proceeded with stubborn slowness down to the present.

Today the range consists of a few dots, mere pin points of occurrence, on the distributional map, dots that are connected by thin traces that mark the current migration routes.

The Whooping Crane now winters on the Aransas Refuge (Blackjack Peninsula) and nearby Matagorda and St. Joseph Islands, on the Texas Coast. These birds migrate through Oklahoma, Kansas, Nebraska and the Dakotas into Canada. Approximately one-half of the group, consisting of nonbreeders, scatters out from the Manitoba-Saskatchewan line to western Alberta during the summer months. The remainder continue to their nesting grounds, where they rear an average of four young annually. The location of the present breeding area is unknown.

Part II. Abundance

How many Whooping Cranes are there? A few years ago the reports of Professor Swenk, of the total number of these birds migrating through Nebraska, were awaited with interest in most ornithological and conservation circles. More recently this interest has become general and the public at large is keeping tally. A syndicated cartoon, reaching millions of readers through Sunday newspaper editions distributed from coast to coast, depicted a likeness of a Whooping Crane over the caption: "Whooping Cranes are (a) extinct, (b) almost extinct, (c) increasing in number." A brewery advertisement, a gaudy, full-page color reproduction of two of the birds, announced that "there are less than thirty 'Whoopers' in the world!" A book review in one of the more sophisticated magazines began, "Along with the whooping crane, the adventure story has been having a hard time of it in this country. The two seem to have followed the same pattern of decline. In the days of the open frontier, when James Fenimore Cooper was writing the first notable American adventure stories, whooping cranes were as numerous as buffalo. Ever since then, however, things have been getting rougher and rougher. At last count, there were less than fifty of the big birds alive."

Oddly enough the testimony in ornithological literature, with regard to the Whooping Crane population over the years, has been, on occasion, just as carefree as these remarks from lay sources. This is especially true of the general, though quite erroneous impression that *Grus americana* was once "as numerous as buffalo." Perhaps there was a feeling that all rare species, like the passenger pigeon and the bison, must have existed at one time in untold millions. There is no basis for such a belief, in spite of these classic examples, and, on the contrary, an original lack of abundance might be a major factor in bringing certain forms close to the vanishing point in a relatively brief time. Some of those

who wrote of the Whooping Crane seemed to agree that, while they were certainly reduced in numbers, there was no immediate danger. Others pointed out that very few birds were reported and possibly the species was not doing so well after all. From time to time doubts on this score were raised and there were even those who stated, almost forty years ago, that the Whooping Crane was extinct, or nearly so. This confused testimony has not helped to secure the direct action so long needed to avert disaster.

The myth of superabundance seems to have started with Thomas Nuttall's eloquent but erroneous account of the migrant "hosts" that he heard passing over him as he floated down the Mississippi River in December of 1811. The facts suggest that there was never a very considerable movement of Whoopers along the Mississippi flyway (there are only a few scattered occurrence records near the junction of the Ohio, involving less than a half dozen birds), the main flight traveling across the grasslands farther west. As previously remarked, Nuttall's legions must have been Sandhill Cranes. Yet, in spite of a good deal of evidence to the contrary, it has been popular to quote this passage and to refer to it for comparison. Nuttall's enthusiastic imagination must have been fired by Catesby's account, in which an Indian is reported to have said that "great multitudes" frequented the lower parts of rivers near the Atlantic Ocean. We wonder what words or signs this unnamed redskin employed to indicate the term "great multitudes." Catesby saw one dried skin and apparently never encountered the species alive. Later Richardson and Swainson (1831), while stating that the Whooping Crane was not found "in such numbers as the Brown Crane," wrote that "it migrates in flocks, performing its journeys in the night and at such an altitude that its passage is known only by the peculiar shrill scream which it utters." This information is only vaguely accurate and obvi-

ously not based on personal observation, but doubtless on hearsay current at the time. However, it was evidently sufficient, along with Gatesby's remarks, to inspire Professor Nuttall's eager mind and the wishful thinking that followed was an easy and perfectly natural result. Yet, even at an early date, accurate estimates had been made.

Hearne, who had been in the North country in 1770-71, wrote, "This bird visits Hudson's Bay in the Spring, though not in great numbers. They are generally seen only in pairs, and that not very often." McCall, only a decade after the publication of Nuttall's item, traveled along the Texas Coast near Corpus Christi and saw the Whooper "occasionally in pairs or in parties of 3 or 4 but never in large flocks." The Sandhill Crane, on the other hand, was "innumerable" and in New Mexico for a stretch of fifty miles "the ground appeared to be covered with them. They filled the cornfields and alighted close to the houses, never being disturbed by the gun."

Still, the impression had been created, and, among many others, Edward Howe Forbush (1912) quoted Nuttall's description and added, "What a change has come in a century!" In this same year of 1912, Forbush also wrote: "The Whooping Crane is doomed to extinction. It has disappeared from its former habitat in the east and is now found only in uninhabited places. It can hardly be said to be common anywhere, except perhaps locally in the far north." The following year, Dr. William T. Hornaday, of the New York Zoological Park, predicted that "this splendid bird will almost certainly be the next North American species to be totally exterminated." He stated that there were "less than six alive in captivity" and that in a wild state the species is "so rare as to be almost unobtainable." For nearly five years, he wrote, "an English gentleman" has been offering \$1,000 for a pair of Whooping Cranes alive, "and the most enterprising bird collector in America has been

quite unable to fill the order." The situation now seemed to have reached rock bottom and it was evidently felt, in some circles, that the only hope was to breed the species in captivity. Dr. Hornaday had one of the birds and in 1916 an item in the bulletin of the American Game Protection Association (1916) suggested finding a mate for the Whooping Crane in the Bronx Zoo, "the only one in captivity."

In 1923 Hal G. Everts, writing in the *Saturday Evening Post*, announced: "Another species of our American birds has passed. The Whooping Crane, perhaps the most majestic bird of all our feathered hosts, has traveled the long trail into oblivion." There follows an interesting account of how the Whoopers were shot year after year, during their migrations over a west Kansas salt marsh. Enterprising people in nearby Hutchinson, Kansas, obtained two crippled birds and, according to Everts, were offered \$3,500 in trade for the pair by a live bird dealer in Pretoria, South Africa. As a sequel to this, it came to our notice only recently that these two Whooping Cranes were actually sold, to a dealer in New York City, reportedly for the sum of \$1,900. They were said to be destined for shipment to Sydney, Australia (!) but died meanwhile in the Bronx Zoo. Everts was given the mounted skin of the Whooper that he called "the last straggler" and presented it to the Yellowstone Park Museum.

But the Whooping Crane had not perished, although, in 1926, Percy A. Taverner, author of *The Birds of Canada*, wrote, "it has been practically exterminated within the last thirty years." Arthur C. Bent, in his *Life Histories* (1926), summarized: "Like many of our larger birds and mammals, particularly those that lived on the broad plains of the interior, the Whooping Crane has been steadily reduced in numbers and has become entirely extirpated in much of its former range. It has retreated before the advance of civilization, farther west and then farther north." In the same year, 1926, John G. Phillips, as reported in the *Proceedings of the IV*

International Ornithological Congress (Copenhagen 1926), said that the Whooping Crane "is now confined to a few pairs in Saskatchewan near Indian Head and Fort Qu'Appelle, possibly 2 or 3 pairs in McHenry and Kidder Counties, North Dakota, while a few winter near the Gulf Coast of Texas near Corpus Christi."

In other quarters, the situation was not interpreted as being so critical. In 1922, the year of Evert's "last straggler," two nests were found in Saskatchewan and, in 1925, Professor Myron H. Swenk, in Nebraska, reported a spring flight of at least 65 Whooping Cranes, northward across the Platte River. In fact, the Nebraska reports were so encouraging that they tended to lull any undue alarms that might have been felt concerning the possibility of speedy extinction. Speaking before a convention of conservation officials in 1932, Dr. T. Gilbert Pearson, President of the National Association of Audubon Societies, said of the Whooping Crane, "Dr. John C. Phillips wrote in 1926 that there are probably less than a dozen pairs in existence, but recent information contributed by Professor M. H. Swenk and others indicates that today they are somewhat more numerous" (Pearson, 1926). This expressed the general feeling of many of those interested. Under date of April 8, 1937, I had a letter from Prof. Swenk in which he wrote, "The birds seem to run a total, on the average, of about 100." This referred to the spring flight, when, as Swenk was convinced, there was always "the big flock," in addition to the small groups of "four to eight birds, rarely up to ten or twelve, or . . . lone birds, pairs or trios." It is perfectly true that at an earlier date, when they were more numerous, Whooping Cranes migrated to some extent in relatively large flocks of 25 or even 50 individuals during the spring movement. But the day arrived when the entire population was so reduced that these large groups were seen no more. It is difficult to fix a year for this change and undoubtedly the decline was a gradual one. Even old residents with whom I talked along

the Platte River disagreed on the year, although their testimony regarding the change itself was unanimous. Probably large groups ceased to appear in one sector and continued a few seasons more in another.

In appraising these Nebraska migrants, we cannot overlook the fact that during the winter months nearly all of these birds occupied winter territories on the Louisiana and Texas Coasts. Very few had ever followed the Little Brown Cranes into Mexico (none since 1903 of which we have record) and none have wintered elsewhere since long before the turn of the century. So we have, in the numbers observed in winter in Louisiana and Texas, a reliable index to the total population. Tables will be introduced later showing the decline in numbers as recorded on the wintering grounds. It will suffice, at this point, to mention that the species was not observed on interior grasslands in Texas after 1893; was no more than a rare straggler in the Rio Grande Delta country after about 1905 (and has not been recorded there even as a straggler since 1924); disappeared from the general region lying east of Matagorda Bay, in Texas, before 1917 (the last stragglers were two Whoopers seen on East Bay in 1936); steadily declined on the King Ranch after about 1925, until none have reappeared there since 1937; were reduced to the last few pairs on the prairies of southwest Louisiana by 1918; were reduced to 7 or 8 birds on the coastal marshes of Louisiana by 1916 and disappeared from that region after 1935. The dozen or so birds that survived above White Lake were not migrants and do not enter into this discussion.

Thus, between 1893 and 1937, all of these wintering areas were gradually deserted. In fact, after 1918, when the Louisiana migrants dropped to a mere dribble and migration reports in eastern Nebraska had nearly ended, we can account for only three regular wintering sites: the King Ranch (in 1918 there were perhaps as many as 16 birds); the Blackjack Peninsula and adjacent islands (presumably an average of 25

birds, according to Mr. LeRoy Denman and other local observers); and the brackish and sea-rim marshes of the Louisiana Coast (6 birds). This gives us a grand total of 47 Whooping Cranes for 1918 and even if a few stragglers managed to winter elsewhere without being observed, which is not very likely, as suitable habitats are not unlimited, there were no more than 50 or so migrant Whoopers in existence by, let us say, 1920.

So, to look for "the big flock" in Nebraska during spring flights from 1920 on was mere wishful thinking. I am convinced that reports from Nebraska, and elsewhere, of large numbers of Whooping Cranes during these recent years, are honest mistakes of identification. Prof. Swenk, who was very little in the field during these years and had to rely on the observations of others, was well aware of the possibility of such mistakes. In his classic paper on the status of the Whooping Crane, published in *The Nebraska Bird Review* in October, 1933, he said: "No one can be more cognizant of the fact that such records as are here presented must inherently carry a certain amount of uncertainty than is the writer; nevertheless, they are the best evidence at present obtainable, and there is no doubt in his mind that the great majority, if not all, of these records represent correct identifications." There is further evidence bearing on this important question that will be discussed later on.

Swenk's work was eventually taken over by A. M. Brooking, of the Hastings Museum, who collected reports beginning with the spring flight of 1934. While Swenk had collected data at his desk in Lincoln, some of his most active correspondents in the field were centered around Kearney and this, in addition to the fact that Kearney is located in the Big Bend of the Platte, through which most of the migrating Whoopers passed, tended to result in a preponderance of reports from the region within a few miles of that place. Now Mr. Brooking influenced an

entirely new set of observers to go out along the river and watch for Whooping Cranes. When the 1934 flight was over, there were not only many new names among the list of observers, but the records tended to move a little to the eastward, closer to Hastings. Still more startling was the fact that these people, in perfectly good faith, reported a total of between 248 and 263 Whooping Cranes on the spring flight! Brooking later pared this to 134 plus (see Brooking and Hickey, 1944).

In spite of the facts surrounding this situation, the desire to wish the species well was so general, and so well established, that these figures became "official." In the report of the Bird Protection Committee of the American Ornithologists' Union for 1941, we read: "Estimates made in 1938 place the Whooping Crane population at less than 300." That was a perfectly safe statement. There were reported in that year, 11 birds on the White Lake marshes in Louisiana and 18 on the Aransas Refuge in Texas, a total of 29 Whooping Cranes. The last two individuals observed on the King Ranch had been seen there by J. J. Carroll the year before. The last two on the coastal marshes near Mulberry Island, in Louisiana, were observed there by Ralph Sagrera, in 1935. There were no others.

In December 1937, the U. S. Fish and Wildlife Service established a 47,000 acre refuge for waterfowl on the Texas Coast, between San Antonio Bay and Aransas Bay. The Chief of the Service at that time was Dr. Ira N. Gabrielson, who had known the Whooping Crane as a boy in his native Iowa and who reported the last sight record for the species in that State, in 1911. It was no accident that the area selected for the Aransas National Wildlife Refuge was the major wintering ground for more than 60% of the Whooping Cranes then alive. There were in that year 11 resident birds in Louisiana, 18 or 19 migrants wintering in Texas, and one captive, the latter at Gothenburg, Nebraska,

near where it had been badly shot the year before. This was a known total of 30 or 31 Whooping Cranes. The refuge area was set up just in time. Many changes were to come in the next decade, changes that destroyed forever the isolation that had been the chief bulwark between these last few birds and the innate destructiveness of Man. That these are no idle words has been demonstrated in Louisiana, where there is no refuge, and where the Whooping Crane population has been wiped out during these past twelve years.

The careful population counts, made at Aransas by James O. Stevenson and his various successors as refuge manager, brought the subject of numbers into sharp focus. When it was announced that the 1940-41 Aransas population had increased to 26 Whoopers, including 5 young, Francis H. Allen, a student of detail and a respected critic, wrote in the *Auk*, "With this apparent rate of reproduction the outlook for the species seems not very encouraging." As a matter of fact, the number of young that season was above the average; the real blow was the sudden loss of 7 of the Louisiana birds, in the autumn of 1940. But even greater losses were to come. The A. O. U. Bird Protection Committee's report for 1942 announced that the status of the Whooping Crane "is more precarious than ever." The Aransas population in the winter of 1941-42 had dropped alarmingly, to only 15 birds, including two young. For the first time, the following factors were mentioned: (a) low-flying airplanes, (b) establishment of a bombing and machine range on Matagorda Island, (c) oil well production in the waters of San Antonio Bay and (d) increased activity on the newly constructed Intracoastal Waterway, ten miles of which had been cut directly through the refuge where it was used by wintering Whoopers. In that same winter there were only six birds surviving on the Louisiana marshes, so that the total population, exclusive of captives, was at the record low of 21 individuals.

Meanwhile, in Nebraska, Mr. Brooking's ob-

servers failed to locate the excessive numbers of Whooping Cranes they had reported in the period 1934-1940. In 1941 only 3 were seen, in 1942 only 4, and in 1943 just one lone bird. The A. O. U. Committee, in the report that appeared in the *Auk* for October 1944, called for action. "This alarming report calls for action and the Committee believes that the Fish and Wildlife Service and the National Audubon Society should take immediate steps to learn the exact status of this species throughout its range and institute practical measures to forestall its extinction." In the *Wilson Bulletin* in that same year (1944), a review of the "overlooked status" of the Whooping Crane appeared, with a similar plea for action. It was signed by the Wilson Club's Wildlife Conservation Committee. The conflagration that had been smouldering along for more than eighty mortal years had at last blazed into a four alarm fire! *It was about time.*

So much for the general background of the subject of numbers. These have been the errors and misunderstandings of the past and it has been necessary to touch on them in order that the analysis of the subject, that now follows, can be properly explained and presented in as clear a light as possible. Today, we know all too well how many Whooping Cranes there are; but what do these numbers represent? Countless questions come to mind, but the one that overshadows them all is the difficult and significant query: How many Whooping Cranes were there?

The Original Population

There is reason to believe that the Whooping Crane may have been more numerous during the Pleistocene than at any time since, but all we can do is speculate. It is extremely interesting speculation, however, and takes us back, even farther than the Pleistocene, to the era of such creatures as *Phororhacos*, the gigantic flightless bird of Patagonia, with a huge, eagle-like head larger than the skull of a modern horse. This monster probably lost the power of flight because it lived on the open pampas, with virtually no

enemies and no need for the safeguard of flight. Its huge size may also have been a factor. Or *Dinornis maximus*, one of the giant flightless birds of New Zealand, or the large extinct crane, *Grus primigenia*, of Europe, or *Grus conferta* from the Pliocene of California, a bird of about the same size as the Whooping Crane. *Phororhacos* is thought by some authorities to have been a remote ancestor of the cranes, as well as of the trumpeters and bustards. Its long legs enabled it to run down its prey, "as a chicken runs down a grasshopper," to quote William Beebe¹¹⁸, another reason for neglecting the normal function of its wings. Yet, this great creature, perhaps eight feet tall, without any contact with Man, became extinct. A change in climate that affected its food supply could have been the influencing factor, as it may have become too specialized and, like many other animals, been unable to adapt itself to the new conditions.

Dinornis maximus and the other moas, undisturbed by Man for thousands of years, slipped into an easy way of life that finally left them flightless. But, the discontent and navigating ability of a group of Polynesians, who left the Society Islands about 1350 A.D.,¹¹⁹ landed them in New Zealand and the great flightless moas were unable to meet this new situation. With their dogs running in front of them, the vigorous and hungry invaders must have killed the big birds quite easily, although there were some twenty species and subspecies to be thus destroyed.

It is not known what brought about the extinction of *G. primigenia*, although Milne Edwards¹²⁰ supposed that it may have succumbed to the Ice Age cold, which seems to cast doubt on its ability to fly. Nor do we know exactly

what happened to other extinct cranes, *Grus nannodes*, from the Pliocene of Kansas, smaller than the Lesser Sandhill, *G. proavus*, from the Pleistocene of New Jersey, a crane almost as large as *canadensis*, and *G. nobilis*, from the Eocene of Wyoming, another smaller example. (Miller, 1944).

We can hazard the guess, however, that the extermination of some of these birds was connected in some manner with what Dr. Loye Miller, Emeritus Professor of the University of California at Los Angeles, has termed (*in litt.*) a "crystalized psychology," a loss of adaptability. There are modern examples of this tendency. Dr. Miller points out that the turkey vulture thrives where the condor has gone down; the pileated woodpecker survives happily where the ivory-bill would not change its way of life and use other types of habitat and food; the short-tailed albatross may already be extinct, because it refused to breed on any except its own particular Pacific Islands.

Dr. Hildegard Howard, Curator of Avian Paleontology of the Los Angeles County Museum, suggests (*in litt.*) that cranes of large size apparently first appeared during the Pleistocene, those of earlier periods being smaller. Thus the Pleistocene may have been a favorable time for cranes, and we can speculate that there were, in that period, more extensive grasslands areas, broad savannas and wet prairies, for the continental water tables, during certain interglacial periods, were frequently a good deal higher than anything recorded in Recent times. It is not difficult to picture the appearance of wide expanses of the continent after the last glacier had receded and before the normal succession of plant life had reached the eventual climax of the forested regions. There may have been a long period when the grasses predominated and possibly it was long enough to assist the cranes to spread out and attain maximum abundance. Then, these conditions gradually changed. Grass gave way to oak and beech, to spruce and fir.

¹¹⁸ Beebe (1906).

¹¹⁹ Buck (1938).

¹²⁰ Milne Edwards (1867-71).

The water table settled down to a level that was somewhat lower than it had been in the past. The cranes, finding themselves in mixed forest, on semi-arid plains, or in dry sandhill country, either adapted themselves to these new circumstances or retreated to the more limited areas that still retained the characteristics of the wet savannas. Apparently the modern Sandhill Cranes were the races that proved to be adaptable; the Whooping Crane, through some peculiarity of its nature, retreated with the gradual shrinkage of its preferred habitat.

These are mere speculations, but they may help us to understand certain aspects of the problem of numbers. Dr. Howard believes that the Whooping Crane may never have been as abundant as the more adaptable Sandhills. The ratio of Lesser Sandhill Cranes to Whooping Cranes in the Pleistocene deposits of Rancho La Brea were 29:1. Today there may be something like 150,000 Lesser Sandhills to 36 Whooping Cranes. We can trace the destruction of what must have been the bulk of the Recent continental population of *G. americana*, starting with the first considerable inroads of the 1870's. There is no convincing evidence that this original Recent population had been greatly reduced prior to that decade. If we can find a reliable index to numbers, as they were between 1850 and 1870, we should have a reasonably accurate impression of original numbers and thus be able to evaluate the actual decline that has taken place. There are several methods of approaching this problem.

The Indices to Past Numbers

We have data on 389 Whooping Cranes that were killed, or died from other causes, between 1722 and the present. Most of these records are well documented. What we would like to know, of course, is the percentage of the original total that is represented by this figure 389.

We have used recent data to estimate the average percentage of unreported losses and

tables will be presented showing the manner in which an overall figure has been obtained, a hypothetical figure representing the unreported losses, resulting from both kills and from natural causes. This figure, added to the recorded kill, will give us a hypothetical total for the population as of the years prior to 1870.

Another possible source of similar information is the record of actual numbers reported. This has been pared down to what are believed to be the acceptable reports. There are possible duplications throughout this list, but some interesting and significant breakdowns of the data can be made.

Numbers reported from the winter range are especially useful because the duplication factor is almost entirely absent or can readily be

TABLE I: Kill Record—Chronological Table of Numbers Reported (1722-1948)

Year	Number Reported	Year	Number Reported
1722	1	1898	2
1748	1	1899	7
1827	1	1900	1
1827	1	1901	4
1828	1	1902	2
1847	2	1903	7
1840	1	1904	8
1857	1	1905	8
1850	1	1906	3
1854	1	1907	11
1861	1	1908	13
1864	1	1909	8
1865	1	1910	2
1867	1	1911	1
1869	1	1912	14
1870	1	1913	6
1871	3	1914	3
1872	1	1915	3
1873	3	1916	1
1874	8	1917	8
1875	2	1918	14
1876	4	1919	3
1877	2	1920	2
1878	2	1921	0
1879	3	1922	2
1880	4	1923	3
1881	3	1927	2
1882	4	1928	2
1883	2	1929	3
1884	6	1930	1
1885	5	1933	2
1886	3	1934	1
1887	5	1935	1
1888	1	1936	3
1889	11	1937	1
1890	3	1940	7
1891	8	1941	1
1892	9	1942	1
1893	13	1943	1
1894	8	1945	1
1895	8	1947	1
1896	2	1948	2
1897	7		

eliminated. A knowledge of the average size and character of winter territories is helpful in applying these figures on numbers to probable carrying capacity of the available winter range.

Revised figures for the number of Whoopers reported from the Platte River in Nebraska are extremely useful for comparison with data from these other sources, and these comparisons are made.

The first table, which follows, shows by years the number of Whooping Cranes reported as killed or otherwise lost. A total of 313 can be related to this category, there being no dates for 76 individual items in the Kill Record.

Before 1870 there are only 16 individuals in the Kill Record. There are no reports at all for most of these early years. From 1870 until the year 1924, a period of 54 years, there is not one year without a recorded kill and the total number reported is 267. In the 25 years since 1923, there are reports for 16 of these years and the total has dropped to 30 individuals on record. Broken down by decades the recorded kill since 1869 is as follows:

<i>Period</i>	<i>Number Reported Killed</i>
1870's	29
1880's	44
1890's	67
1900's	59
1910's	55
1920's	20
1930's	9
1940's	14

An analysis of the records indicates that the greatest number were killed during migration. This data is available for 190 individuals and compares as follows:

Spring Migration

(Mar. 15-May 14) 69 (36%) Reported Killed

Fall Migration

Sept. 1-Nov. 14) 57 (30%) Reported Killed

Migration

(Spring and Fall) 126 (66%) Reported Killed

Winter

(Nov. 15-Mar. 14) 54 (28%) Reported Killed

Summer

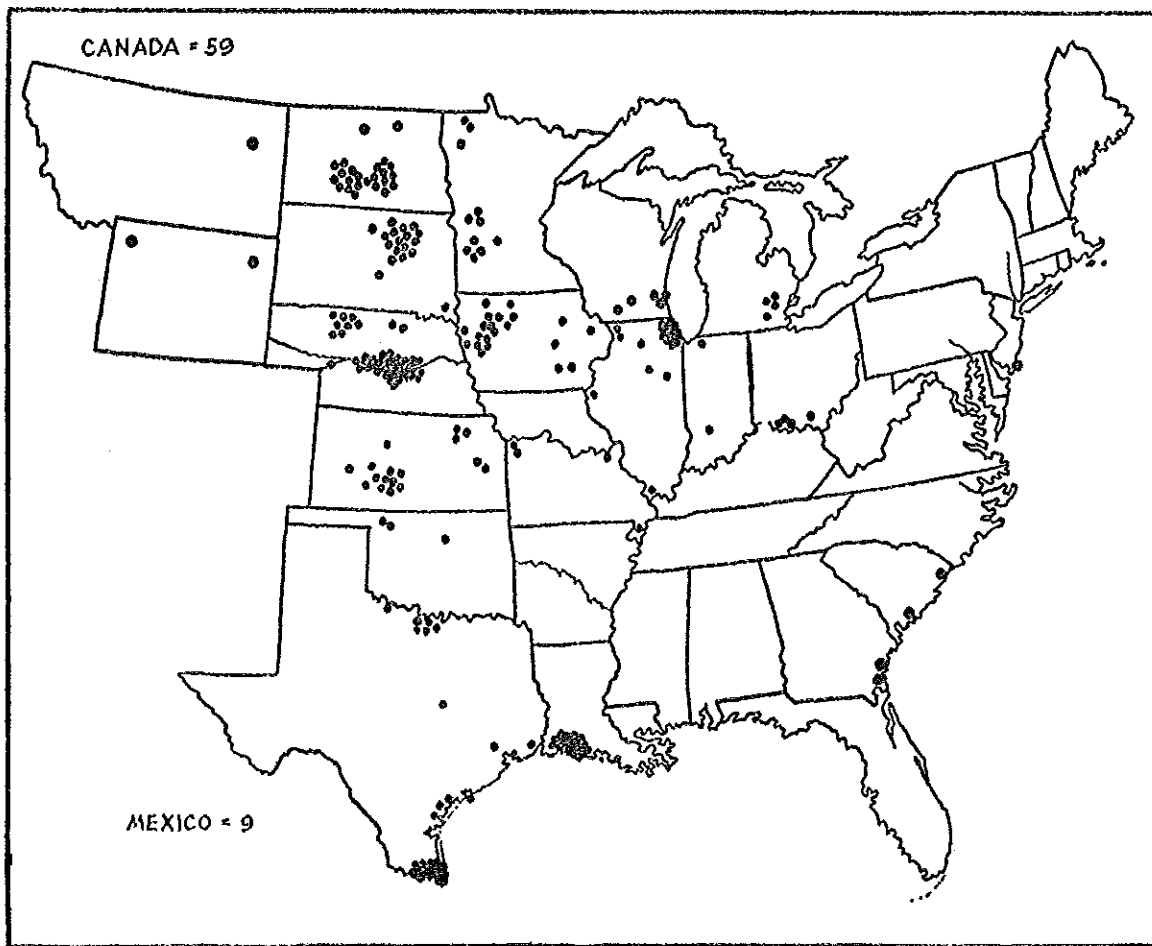
(May 15-Aug. 31) 10 (5%) Reported Killed

It is of additional interest to learn where these birds were killed. In a general way, the following table illustrates this point by showing the number killed by States, Provinces and Districts. Inclusive dates of these reports for each State, etc., are given, as well as a column indicating the percentage of the total killed in each separate locale.

Table 1: Kill Record-Numbers Reported by States, Provinces, etc

<i>State, etc</i>	<i>Number Reported</i>	<i>% of Total</i>	<i>Inclusive Dates</i>
1. Nebraska.....	45	13%	1884 to 1936
2. Texas.....	40	12%	1885 to 1948
3. Louisiana.....	37	11%	1885 to 1948
4. Saskatchewan.....	28	8%	1827 to 1948
5. No. Dakota.....	24	7%	1879 to 1921
6. Iowa.....	21	6%	1870 to 1887
7. Illinois.....	21	6%	185- to 1891
8. So. Dakota.....	18	5%	1883 to 1900
9. Kansas.....	17	5%	1865 to 1923
10. Manitoba.....	15	4%	1748 to 1936
11. Minnesota.....	12	4%	1876 to 1917
12. Mexico.....	9	3%	1840 to 1903
13. Mackenzie.....	8	2%	1861 to 1923
14. Alberta.....	6	2%	1913 to 1933
15. Wisconsin.....	5	1%	184- to 1878
16. Missouri.....	4	1%	1864 to 1904
17. Ohio.....	4	1%	187- to 1902
18. Michigan.....	4	1%	1877 to 1882
19. Oklahoma.....	3	.....	1907 to 1928
20. Georgia.....	2	.....	n.d.
21. Indiana.....	2	.....	1881
22. Wyoming.....	2	.....	1912 to 1934
23. So. Carolina.....	2	.....	1722 to 1850
24. New Jersey.....	1	.....	182-
25. Ontario.....	1	.....	1871
26. Keewatin.....	1	.....	1930
27. Montana.....	1	.....	1918
	333		

These tables have presented some of the more obvious points to be determined from an examination of the Kill Record. One cannot escape the impression that rather small numbers of birds are involved, for records covering a period of no less than 226 years. But this is not necessarily significant in itself. If a similar record were obtained for a currently abundant race, like the Lesser Sandhill Crane, it would be not more impressive on this count alone. It is essential that we look farther, into the contemporary



Available Kill Record Locations in the United States.

remarks of early authorities, as we have done briefly in the introductory paragraphs of this discussion of *Abundance*, and into the additional sources of population data at our disposal. The table that follows is made up from reliable recent data and provides an important basis for evaluating the question of unreported losses.

The value of this chart lies in the fact that it is based on actual counts of known accuracy. The yearly population figures for Louisiana and Texas, and the counts of young birds brought to Texas each fall, are the result of careful checking and rechecking by trained field person-

nel. Only one slight adjustment has been necessary, as explained in the footnote at the bottom of the tabulation.

The important and useful figures on "potential total" are obtained by adding the actual total for any given year and the number of young produced the following year. The difference between potential total and actual total gives the actual loss. Difference between the number of birds reported as killed and the actual loss as calculated for any given year, determines the unreported loss. This, too, is a significant category.

TABLE K: Potential Total Population and Unreported Losses
(1939-1948)

Year	Louis- iana	Texas	Young Inclu- ded	Poten- tial Total	Actual Total	Report- ed Killed	Actual Loss	Unre- ported Loss
1938..	11	18	4	?	29	0	?	?
1939..	13	22	7	36	35	0	1	1
1940..	6	26	5	40	32	7	8	1
1941..	6	16	2	34	21	1	13	12
1942..	5	19	4	25	24	1	1	0
1943..	4	21	5	29	25	1	4	3
1944..	3	22*	3	28	25	0	3	3
1945..	2	25	3	28	27	1	1	0
1946..	2	25	3	30	27	0	3	3
1947..	1	31	0	33	32	1	1	0
1948..	1	30	3	35	31	2	4	2
						14	39	25

*The Aransas count for the winter of 1944-45 showed a total of 18 (Craven, 1946). Analysis indicates that four individuals must have been overlooked or spent the winter elsewhere on the Texas Coast. The 1938 total (29) plus the total number of young (41) that followed over the next ten years equals a potential total of 70 for 1948. Actual 1948 total of 31 is 39 less than this potential and represents the actual loss (39). The totals for Reported Kill and Unreported Loss must add up to this same Actual Loss figure.

It will be seen, from inspection, that the actual loss for the ten-year period 1939-1948 was 39 Whooping Cranes. A total of 14 of these birds were killed and reported (36%), while 25 were killed, or died from natural causes, and were unreported (64%). In this unreported percentage, we have a key to past abundance, since the reported category is known.

The above percentages are too recent, and based on too short a period of time, to be applied over a span of several decades. It seems likely, however, that over a long period more losses went unreported than in the decade 1939-1948, when interest in the status of the species was evidently greater than at any previous time. We will consider, therefore, that since the serious population decline began about 1870, the unreported losses have been 70% of the total and the reported losses 30%. Based on comparison with the more recent figures, these percentages would seem to be a reasonable estimate of the probable ratio over a longer period.

From 1870 to 1948, inclusive, the loss of 373 Whooping Cranes was reported. If this number comprises 30% of the total loss, then the unreported figure is 870 (70%). However, no kill reports were made for a total of five years be-

tween 1870 and 1939 (when our detailed population chart begins). If we apply the chart average of 3.9 birds lost annually, we may add another 19 individuals to the unreported losses. This gives us a total of 889 Whooping Cranes whose loss in this period we can estimate as unreported.

On this basis a grand total of 1,262 Whooping Cranes were killed, or died from natural causes, since 1869. Added to the 36 birds that survive today, we obtain the total population figure of approximately 1300 (1298).

How does this total, considered as the original population, compare with the various sources of data on past numbers? In analyzing the records, there is no convincing evidence that the original total ever exceeded this approximation. A study of numbers actually reported, while disclosing a certain amount of duplication, as individual cranes and groups of cranes were recorded in the same year at different locations, is impressive in its repeated emphasis on small numbers. For example, an appraisal of the published record for the period 1722-1869 reveals that a total of only 88 Whooping Cranes are actually mentioned. In the decade 1870-79, 53 Whooping Cranes are mentioned in the records, published and unpublished, and more than one-half of these (29) were reported killed. Revised figures for the 69 years since 1879, indicate that only 1016 Whooping Cranes have been actually reported during spring and fall migrations, and some of these individuals were reported more than once in the same year. Using the numbers reported from Nebraska in the spring migration as an index, we find that in the 64 years from 1884 to 1948 a total of 323 Whooping Cranes were actually mentioned. This is the revised total obtained by eliminating indefinite and uncertain reports.

There is personal testimony on numbers seen in Nebraska that sheds additional light on this subject. The late A. M. Brooking, of the Hastings Museum, who compiled the Nebraska rec-

ord from 1934 to 1944, and whose knowledge of the species went back many years, had this to say in an article on *The Vanishing Bird Life of Nebraska*, published in 1942 (Brooking, 1942): "Authorities do not seem to agree upon the former abundance of the Whooping Crane. Personally I can say that in our section there was never enough of a migration to class them as common, although every spring one or two were usually killed during the hunting season. I have mounted about twenty-five during my lifetime and have a total of ten in my collection."

While in Nebraska a few years ago I talked with Loren Bunney, State Conservation Agent at Ogallala. He told me that he had lived as a boy in Harlan County, south of Holdrege, between the Republican and Platte Rivers. He started hunting as a boy of ten, "some fifty years ago," and, even at that time (about 1897), Whooping Cranes were a rare sight, although the area in which he lived was in the main pathway of their migration. When flocks of Sandhill Cranes went through he always "looked them over for the big white ones." Now and then a few were seen. Sometimes, back in those days, there would be a flock of 24 or 25 Whoopers migrating in a single group, but not often. More often they would be seen in groups of 2, 4 or 6. Since 1927, Mr. Bunney said, he has observed very few "white ones," although his work has taken him up and down the Platte River during the migration period.

Jack Kennedy, now living near Gothenburg, told me that in Dawson County, about 1897, he recalls seeing an occasional flock of as many as 50 Whooping Cranes. More often, however, they were observed in small groups of 2 or 3, or perhaps as many as 9.

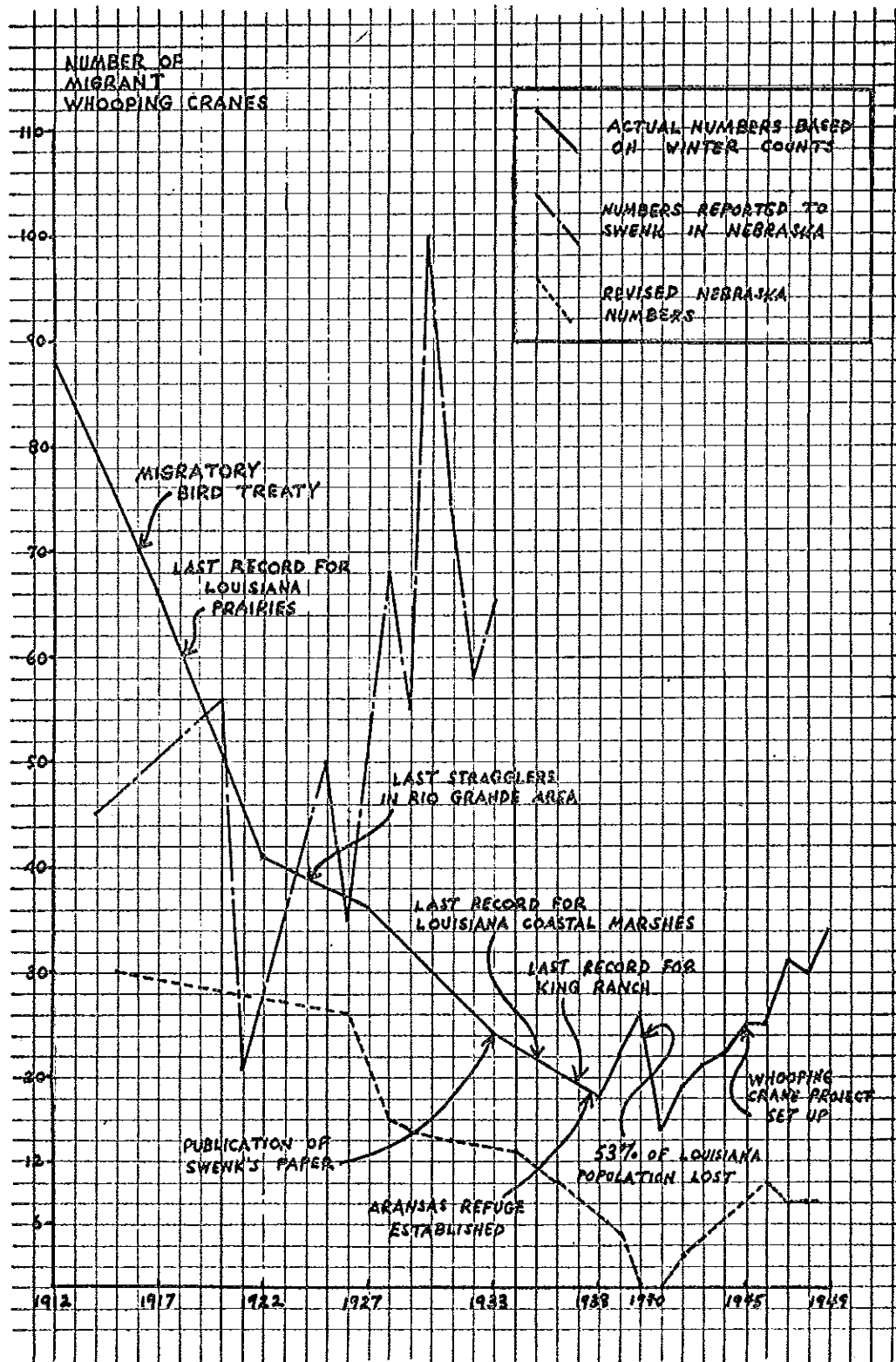
Near Durham, Kansas, in April 1903, Francis L. Jaques, the well-known bird artist, saw a migrating flock of approximately 25 Whooping Cranes (Jaques, *verbal*).

It is of additional significance that only some 147 Whoopers were recorded outside of

Nebraska between 1912 and 1933, as reported by Myron Swenk (Swenk, 1933). The largest single group listed by Mr. Swenk was of 16 birds, observed at "Laguna Larga" on the King Ranch, in Texas. Doubtless, there were no more than 8 individuals at Laguna Larga, the remainder probably having been reported from a point south of that location.

Professor Swenk evidently felt that this total of 147 birds was not representative. He wrote (Swenk, 1933): "Without wishing in the least to minimize the exceedingly grave situation surrounding the hopes for the survival of the Whooping Crane, the writer believes that this small total of published records of this species from outside of Nebraska does not accurately reflect its actual recent and present status. His chief reason for so believing is that these birds have been seen in Nebraska with greater regularity, and in larger numbers, than in any of the other states included in the above summary." He then goes on to say that, between 1912 and 1933, "no fewer than 998 migrant Whooping Cranes have been seen in the state of Nebraska alone." Dr. Thomas S. Roberts (1936) commented: "Where all these birds go to nest or spend the winter is not known to ornithologists at present." This remark may not have been critical by intent, but it pointed to the winter range, a fairly limited area that had been adequately covered by ornithologists during most of the period under consideration, and where the Whooping Crane population was extremely scarce after 1912.

A description of this winter range has already been presented in some detail, in our discussion of the distribution of the species. Earlier in the present account we have also shown that by 1918 or 1920 the number of Whooping Cranes, on the various sectors of winter range still occupied, had been reduced to no more than approximately 50 birds. These comprised the total continental population. In 1912, a somewhat larger number might have been counted,



Whooping Crane Population Trend—1912-1949.

but the general decline was rapid and steady. Between 1912 and 1920 the species disappeared from the prairie region of Louisiana and dropped off to a mere half dozen on the coastal marshes. The small wintering group that had been present along that section of the Texas Coast lying east of Matagorda Bay, was no longer in evidence when Dr. Wetmore visited the area in the winter of 1917-18. From the record, the estimated number of migrants during this period was as follows (the resident flock in Louisiana excluded):

TABLE L: Estimated Decline of Winter Population (Winter Range) (1912 to 1933 and 1949)

Location	Number of Whooping Cranes					
	1912	1917	1923	1927	1933	1949
(a) Louisiana Prairies.....	20	15*	0	0	0	0
(b) Louisiana Coast.....	12				***	0
(c) Texas: Port Arthur marshes	2***	0	0	0	0	0
(d) Texas: Matagorda Area..	4	0	0	0	0	0
(e) Texas: BlackJack Area...	30	28	26	24	21	33
(f) Texas; King Ranch.....	20	16	9	6	3	0
(g) Texas: Rio Grande Area..	0	0	0	0	0	0
(h) Texas: Grasslands.....	0	0	0	0	0	0
(i) Mexico: Grasslands.....	0	0	0	0	0	0
	88	66	41	36	30****	33

*Twelve cranes from this group were killed the following year and there have been no reports from the prairie region since.
 **Possibly one more individual present. Seven were reported from Chenier au Tigre on Dec. 16, 1933 (Bailey, 1934).
 ***Last definite report of fall migrants was for Nov. 2, 1913 (Reid, USFWS files).
 ****Low point was reached in fall of 1941 when only 15 migrants were counted (Aransas Refuge, Texas).

The decline of the migrant population, as reflected in the diminishing numbers on the winter range, is also demonstrated by the accompanying graph. The solid line represents the total migrant population. For the period 1912-1937 the trend is plotted from the totals in the preceding table. Thereafter (1938-1949) the figures are from counts made on the Texas Coast. Likewise plotted are peak figures for numbers actually reported on the spring flight through Nebraska. These are the revised totals and the general trend in this category com-

pared closely with the downward trend for the entire migrant population, even following the upswing that began after the establishment of Aransas Refuge.

The revised total for the spring flight in Nebraska, 1912-1933, is 196 Whooping Cranes actually observed. A few of these are records not included by Swenk in his 1933 paper. This is considerably less than Swenk's total of 684 for the spring flights during the twenty-year period, 1914-1933. In the same period the revised total is 191 birds, eliminating 493 of those accepted by Professor Swenk. Only 15 rejected reports are involved. In each instance the rejection is based on doubt as to the validity of the numbers reported. They simply included too many Whooping Cranes for the years in question. The following totals, by years, list the number of birds per flock, as reported:

1914	40 or 50
1920	56
1921	21
1925	50
1926	35 (three groups)
1928	50
	18
1929	50 or 60
1930	40
	59
1931	75
1932	48 or 86
	15
1933	50
	15

These rejected numbers total 617 for the minimum figure and 680 for the maximum. Swenk interpreted his data as indicating that a 20-year total of 684 Whooping Cranes migrated through Nebraska during spring flights from 1914 through 1933. Most of these we believe to represent excessive numbers, simply as a result of honest misidentification. In view of the relatively small number of Whoopers present on winter range during these same years it does not seem vaguely possible that flocks of large size could have existed during this period. It is of

interest to see the result of plotting these excessive numbers on the population graph. It seems obvious that the erratic nature of their curve is completely out of line with the general trend as it can now be demonstrated. Only two of these reported flocks would appear, from this comparison, to have been even vaguely possible. It is not believed, however, that groups of such size were formed after the total numbers had declined as far as they had by the dates involved.

On this important question of misidentification there are numerous examples that serve to illustrate the manner in which such errors may occur. In conversation with State Conservation Agent Bunney of Ogallala, he volunteered that it was his impression that many of the reports on Whooping Cranes in recent years have been errors of identification. He stated that in fifty years along the Platte River he has never observed flocks of 50 or 75 Whooping Cranes, not even in the 1890's. He said that he believed that many erroneous reports were of Sandhill Cranes that appeared to be white as they turned and wheeled in bright sunlight at some distance. Others were doubtless white pelicans or snow geese.

In the spring of 1947, I worked out of North Platte, Nebraska, for several weeks, my object being to study the movement of Whooping Cranes through that area. As a result of widespread publicity in the local press and over the radio, a number of messages reached me of the reported presence of Whooping Cranes in the region. (I finally observed and photographed a migrating group of five birds on April 19.) I investigated each of these reports and in the list that follows are the results.

Obviously, if all of these reports had been accepted, without investigation, the total spring flight in that year would have seemed highly encouraging. As a matter of fact, with the advantage of a well-organized plan for daily observations along nearly 200 miles of the Platte River,

Date	No. Reported	Actual Identity
March 25.....	25	Ring-billed Gulls
March 29.....	3	White Pelicans
April 4.....	1	Snow Goose
April 9.....	14	Lesser Sandhill Cranes
April 10.....	8	Ring-billed Gulls
April 10.....	25	White Pelicans
April 13.....	18	Lesser Sandhill Cranes
April 16.....	35	Lesser Sandhill Cranes
April 21.....	15	Snow Geese
	144	

and information on the departure of the birds from the Texas Coast arriving by telegraph, my associates and I observed only 8 of the 23 migrants that went North that spring. This is 34% of the number of birds involved. In the years 1939-1948 an average of 18% of the possible total moving North through Nebraska were actually observed and reported. The total number of migrants that departed from Texas, and presumably made their way through Nebraska, in these ten years, was 210 (an average of 21 for each spring). Reliable reports were made on 38 of these birds (an average of 3.8 annually).

Before closing this discussion of the confusion and misunderstanding caused by mistakes in identification, mention should be made of an amusing case that began with an item in the *Wilson Bulletin* for March 1938. The note was headed, "Whooping Cranes in Southwestern Missouri," but every detail in the lengthy description of the three birds involved presented convincing, though quite unintentional evidence, that they could not have been *Grus americana* by any stretch of the imagination. The late Mr. E. A. McIlhenny, who had been intimately acquainted with that species in Louisiana, wrote the editor a well-considered protest. The upshot of his remarks was that the birds were *not* Whooping Cranes. Appended to this protest was a long defense of the record, every word of which merely added to one's conviction that Mr. McIlhenny was correct. The case is only of interest now in that it illustrates the extremes to which such errors can go, and the

fact that the Whooping Crane was so little known that an item of this sort could get past the editor of an ornithological journal of such standing.

Returning briefly to the winter range, it is important to remember that for every pair and family group, on the average, there must be somewhere between 400 and 500 acres available as winter territory. The character of this habitat is important, too. For example, the Whooping Cranes on Aransas Refuge, in Texas, prefer wet, brackish flats lying below the three-foot contour and spend most of their five months in winter quarters between sea-level and the two-foot contour. The character of the habitats was different, in a general way, between these Texas salt flats and the prairies of southwestern Louisiana, but similar in the important details. The need for extensive acreage, however, probably remained the same in any environment.

Outside of the prairie region of Louisiana, really extensive Whooping Crane range did not exist, but small, favorable areas were scattered along a considerable coastline, from Marsh Island, Louisiana, to the Rio Grande Delta Plain in Mexico, and together added up to a total acreage of some size. A careful study of topographic charts, coupled with a first-hand knowledge of the entire route, convinces me that the various segments of winter range once occupied by Whooping Cranes were only just extensive enough for a population of less than 1500 individuals, considering that the average number per territory was probably close to the present figure of 2.4 and that each territory may have averaged some 400 acres.

From all of the foregoing, it is my belief that the original population of *Grus americana*, in Recent times, and down to 1860, or possibly 1870, totalled between 1300 and 1400 individuals.

The Present Population

We have already discussed in some detail the

makeup of the present population. The most recent counts show a slight increase to the encouraging total of 37 individuals. Two of these are captive birds, now living within the large enclosure built for them on the Aransas National Wildlife Refuge in Texas. The wild, migrant population there was last reported on in December, 1949 and, according to Refuge Manager Julian A. Howard, of the U. S. Fish and Wildlife Service, totalled 34 individuals, including 4, young-of-the-year. Since that time the one surviving bird of the resident Louisiana population has been caught and placed on the Aransas salt flats in Texas. This individual made the total 37 Whooping Cranes. Its age, at this writing, cannot be less than 10 years and, regardless of unusual longevity records for captive Whooping Cranes (one individual lived at the Lilford Hall aviary for almost 40 years) there is reason to believe that in a wild state the normal life span is much shorter than for captives.

Since the 1949 totals have been received it is possible to add another line to the data in *Table K*. These figures apply to the wild population, for it is in this category that we may look for signs of the population trend. The totals listed for each year are as accurate as the refuge personnel could make them, but there is always the possibility that some birds were overlooked, as we have indicated for 1944-45 (see footnote at bottom of *Table K*). On the other hand, the figures in this table, as adjusted, balance in the various columns that show potential and actual totals, actual losses, etc., and it is believed that they are reasonably accurate throughout. Nevertheless, there are always several ways of interpreting this kind of data, depending on what the results are intended to demonstrate. In this instance the chief value to be derived from an analysis would seem to be a reliable clue to the current population trend. In order to avoid the possibility that basic figures might be incomplete, we have selected the 1940 data for comparison with the most recent

counts. It is believed that the 1940 totals are accurate and that the comparison will be a true index to current trends. The two sets of figures compare as follows:

Year	Louisiana	Texas	Captives	Grand Total
1940	6	26	1	33
1949	1	34	2	37
9 yrs.	-5	+8	+1	+4

On this basis, with an overall gain of 4 birds in the total population of wild and captive individuals, the rate of overall gain has been .44 annually. Actual losses must be figured from the difference between starting point (the 1940 total of 33) plus young added, and the actual total. The starting figure added to young produced equals a potential total of 66 (33 + 33). The difference is therefore 33, which represents the actual loss during the 9-year period. The rate of loss is thus 3.6 annually.

Considering the total number of young produced over the entire 12 years of record (1938-1949), which totals 49, the average number per year has been 4.08. If we subtract the average annual gain figure (.44) from this 4.08 average we find that the difference is 3.64, or the same as the annual rate of loss as calculated. Thus, on the average, although four young are produced each year, the rate of loss has been sufficient to take most of these and it has required 3 years to gain one Whooping Crane in the overall total.

The record indicates that most losses occur on migration. Analysis of the *Kill Record* demonstrates that the number of known losses that took place during migration over a long period was 66% of the total number lost. Of

¹²¹The captive bird in the Texas enclosure, on loan from Audubon Park in New Orleans, was shot by a farmer in Evangeline Parish in the autumn of 1940, according to information supplied by Mr. George Douglass of the Audubon Park Commission. This was the same period when flood waters drove all resident cranes from the White Lake marshes and it is believed that this individual may have been one of this group. In our records, however, it is listed solely in the "captive" category, since its actual origin is unknown.

the 39 birds (exclusive of captives) that died or were killed during the period 1939-1949, 13 were known to have been shot on the Gulf Coast. This is 33% of the total. However, 12 of these disappeared, and were presumably shot,¹²¹ on the Louisiana marshes, where they had no effective protection. Only one bird was killed on the Texas Coast during the same period, representing but 2% of the total loss.

The annual exchange between winter quarters, to breeding or summering grounds and return, was accomplished in 1949 without a single loss. This is the first time on record that this has occurred, and it is believed that the widespread publicity the Whooping Crane has received in the newspapers and popular magazines of this country and Canada, has been a major factor in this improvement.

If, as the data indicates, most losses occur on the migration route, then we can reduce the problem to realistic terms in the form of a man or boy with a gun in his hands. How are we going to reach into the mind and heart of this person and prevent him from squeezing the trigger on a Whooping Crane? Only ignorance would prompt the deliberate destruction of one of these splendid creatures, at this critical point in their long and precarious existence.

At the rate of increase suggested by our analysis of the 9-year figures, we can hope for a gain of only 4 Whooping Cranes in the next decade. Losses, meanwhile, would total some 36 birds. Let us face these possibilities squarely. The losses must be reduced, by as much as 50% if possible. Probably the normal loss from natural causes will average no more than one-half the present loss figures. Everything may rest in the heart of that man or boy with a gun. We must continue to fight the ignorance that would cause him to destroy the Whooping Crane's chance of survival.

Abundance: Summary

1. The ornithological literature contains con-

fused testimony on the original abundance of the Whooping Crane. A "myth of superabundance" has clouded the true facts and may stem from a misinterpretation of some of the early writings on the status of the species. Actually, there is evidence that the Whooping Crane was never observed in large numbers, even one hundred or more years ago.

2. In more recent years there were two schools of thought as to the surviving numbers of the species. One group was alarmed at the prospect of immediate extinction, some writers actually announcing that the Whooping Crane was already gone—while another group seemed to feel that these alarms were not founded on fact, there being more of the big birds left than was generally realized. This confusion may have postponed the active interest and protection so long needed.

3. The outstanding reason for believing that the Whooping Crane was in no immediate danger of extinction was the excessive number of migrants reported each year from Nebraska. However, these totals overlooked the status of the species on the wintering grounds, where it had become a scarce bird after 1912, the year when the detailed Nebraska records began. A brief comparison is made between the situation on the wintering grounds and the reported numbers in Nebraska. It is felt that the discrepancy is due to the inclusion of records that were mistakes in identification, and to the fact that there was no comprehensive knowledge of the distribution and numbers of the migrants in winter quarters.

4. The establishment in Texas of the Aransas National Wildlife Refuge (by the U. S. Fish and Wildlife Service) came just in time. The entire population by that year (1937) had been reduced to only 30 or 31 individuals. Approximately 60% of these Whooping Cranes were then wintering on or close to the new refuge. In Louisiana, where there has not been a refuge, the surviving population plummeted from a

peak of 13 to 1 bird during the next decade.

5. The refuge in Texas not only awakened a general interest in the fortunes of *Grus americana*, but the careful population counts initiated there brought the whole subject of surviving numbers into sharp focus. When the population fell off suddenly in Louisiana, and the Texas group dropped to a low of 15 (in the fall of 1941), there was a general hue and cry. The Cooperative Whooping Crane Project, set up by the U. S. Fish and Wildlife Service and the National Audubon Society in 1945, was a direct result of the obvious need for action.

6. The prehistory background of the original Whooping Crane population is discussed and the subject of over-specialized birds that have become extinct in the past, or are rare today, is introduced. It is suggested that the Whooping Crane may have been at a numerical peak during the Pleistocene, but might not have been as adaptable, and, therefore, not as abundant, as were races like *Grus canadensis*.

7. Possible indices to past numbers are discussed, and tables introduced for the purpose of arriving at a hypothetical figure for total numbers prior to the period of serious decline. Data is available on 389 Whooping Cranes that died, or were killed, between 1722 and 1948, inclusive. The indications are that the heaviest kill took place between 1880 and 1919, a peak having been reached in the 1890's. The record also reveals that most of the birds were killed while on migration (66%), while approximately 28% were killed on the wintering grounds and 5% during the breeding season. The number killed is shown by States, Provinces and Districts.

8. A tabulation is included showing the "Potential Total Population" and "Unreported Losses." From the data in this table it is estimated that, over a period of some length, the reported kill is approximately 30% of the total number of birds actually lost, the unreported loss being 70%. On this basis, the original population (as of 1869) is calculated at approxi-

mately 1300 Whooping Cranes.

9. Evidence on numbers is sought from various sources: numbers actually reported, the revised totals for Nebraska, the personal testimony of first-hand observers and the known numbers on the winter range. A tabulation of population figures for the several sectors of winter range is given and the decline recorded on a graph. The trend is compared with revised figures for Nebraska and with the excessive numbers reported from that State. It is felt that numbers present on winter range after 1912, and the steady decline demonstrated, is justification for the revision of Nebraska totals that has been made. The possibility of errors in identification are discussed.

10. It is suggested that the winter range, outside of the original Louisiana prairies, was not extensive, but was made up of a number of small but favorable areas along a considerable coastline. The original extent of the total winter range may have provided carrying capacity for not more than 1500 Whooping Cranes, considering that the average per territory was 2.4 birds and the size of average territory about 400 acres.

From all these sources it is estimated that the population, down to 1860 or 1870, may have totalled somewhere between 1300 and 1400

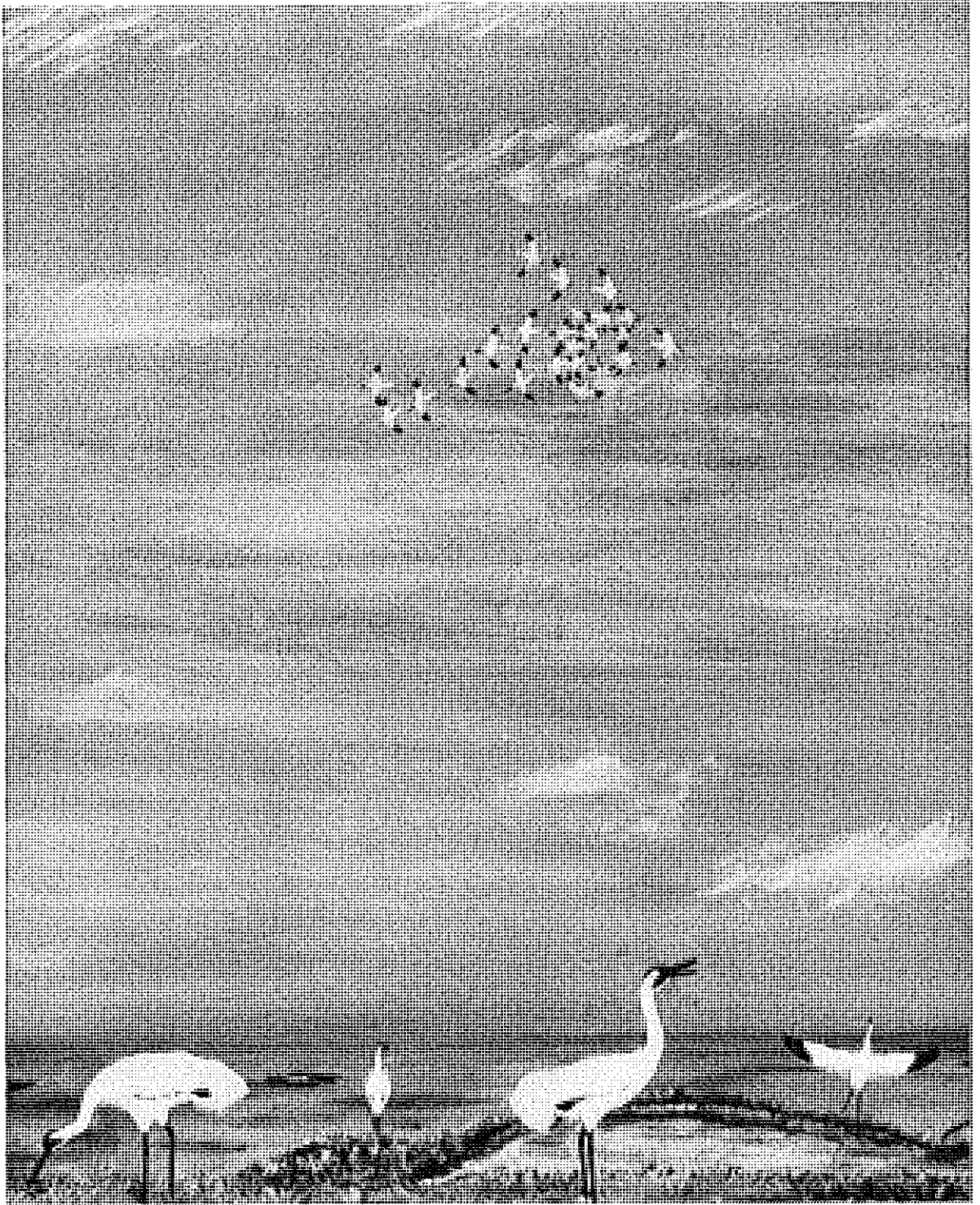
Whooping Cranes.

11. The available population figures for the 12 years from 1938 to 1949 are discussed. On a basis of a comparison between the totals for 1940 and 1949, both of which are considered to be reliable, it is found that the rate of gain over this 9-year period has been .44 birds annually. Actual losses, meanwhile, have totalled 33 birds for the same period, at a rate of 3.6 individuals each year, on the average. Since most losses from other than natural causes may occur on the migration routes, as indicated by an analysis of Kill Records, the key to the problem may rest with continued education of the public-at-large, especially that portion of the public that goes into the field with a gun. For the first time on record there were no losses on migration in 1949, and this may reflect the widespread publicity that has been given the Whooping Crane and its plight.

12. If the loss and gain rates of the last 9 years continue we can hope for a gain of only 4 Whooping Cranes in the next decade. Losses, meanwhile, will total some 36 birds. It is believed that these losses can be cut by 50% and perhaps this can only be accomplished by continued education through popular articles and similar publicity calculated to reach "the man with the gun."



Whoopers Taking to the Air.
(Photographed in Louisiana by Albert D. Simmons, Jan. 27, 1937)



A Nebraska Scene of Fifty Years Ago as Remembered by Mr. Jack Kennedy.

Part III. Migration

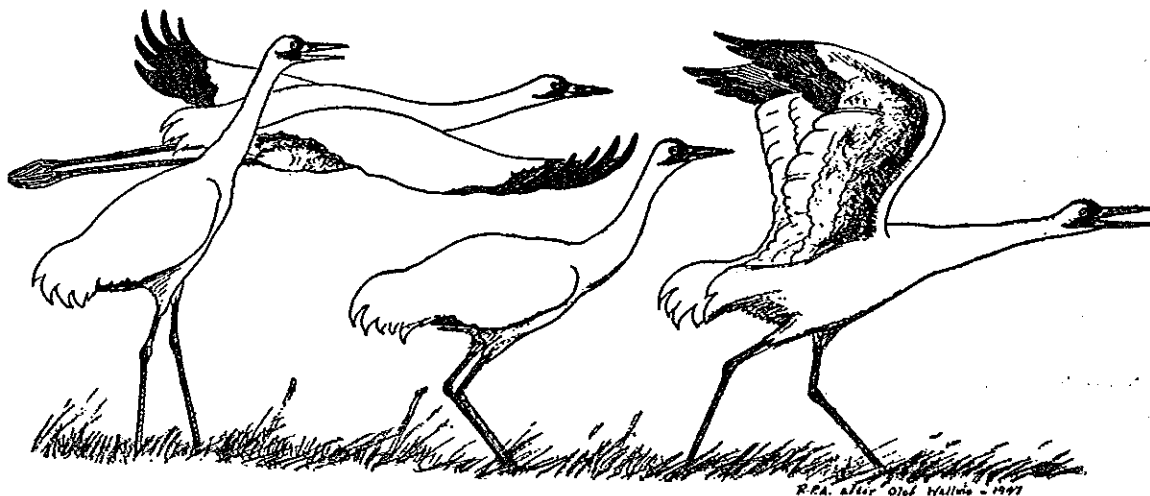
The sight of a Whooping Crane in the air is an experience packed with beauty and drama. We see the broad sweep of the great wings in their stiff, almost ponderous motion, the flash of sunlight on the satin white plumage. As we drive down the narrow trail that borders the low salt flats close to Mullet Bay, a trio of the big fellows may appear, quite suddenly, in the waist-high oak brush, where they have been feeding on acorns. Their heads come up and the shrill, bugle-like notes, *Ker-loo! Ker-lee-oo!* send a shiver along the length of your spine. They are up at once, leaning forward, running a few steps and then lifting their heavy bodies in straight-away, horizontal flight. Neck and head are extended forward, like a spear or lance, and slightly down. The long black legs stretch out behind. The wing stroke is like that of the other cranes, and of the limpkins as well. The complete arc of the stroke is narrow and there is a powerful *flick* on the upbeat. Normal flight produces about two beats to the second and there is ease and competence in the way these giants skim low over the salt grass towards the shore of the bay.

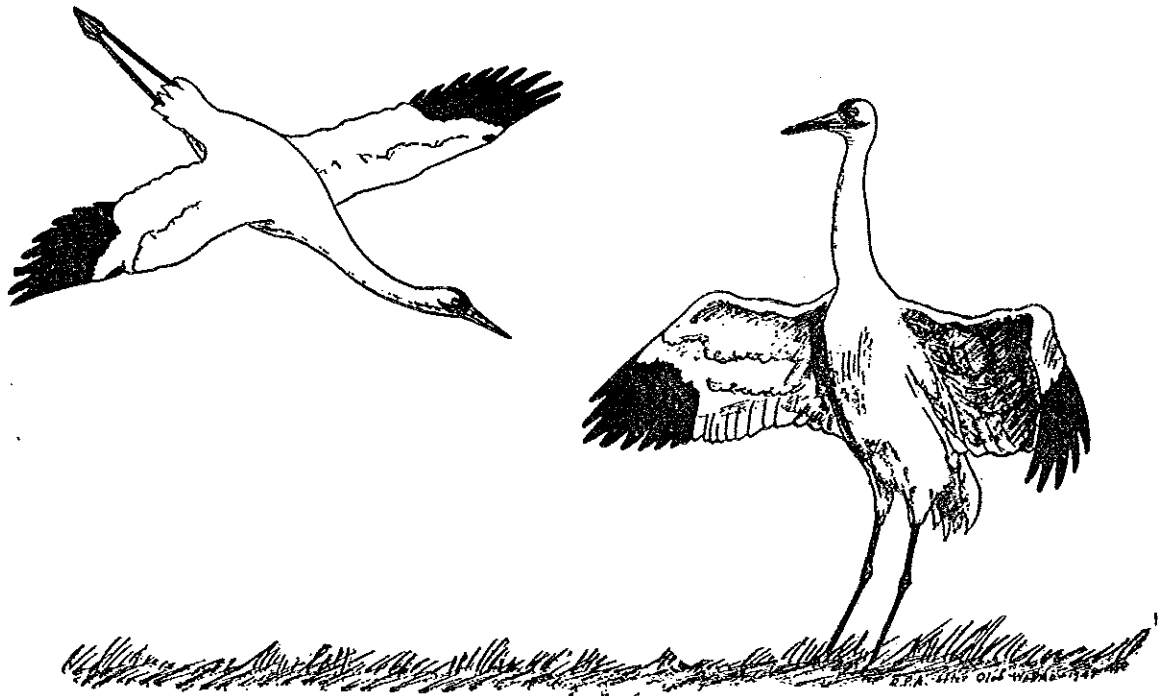
In the grim aspect of the features, in the

whole trim of the birds as they move, silently now, there is a dignity and a sense of unconquered wildness, of an obstinate will to survive. We watch them with admiration and with hope. In spite of its glowing reality, it is like a brief and unexpected look at the World as it was in the beginning.

Although they have unquestionable ability in the air, these birds are even more impressive as pedestrians. As we came to know the species intimately, through daily association with the group wintering on the Texas Coast, we were impressed by the fact that the Whooping Crane walks a good deal more than it flies. This, of course, applies to the individuals that spend the months from late October to mid-April, or nearly half the year, on the salt flats bordering on Mesquite Bay and the adjacent bays and lagoons of that portion of the Texas Coast. This predilection for walking has not been stressed sufficiently in the literature. It has been more popular to describe the Whooping Crane engaging in aerial evolutions, high in the sky, a comparatively rare sight. Picket (1883) said that "In fine, calm weather he (the Whooping

Flight Postures: Alarm, Crouch, Take-off and (Background) Airborne.





Flight Postures: Coming in for a Landing and Applying the "Brakes."

Crane) delights to mount up, in great, undulating spirals, to the height of a mile or so, and take a quiet float, while he whoops at neighbors in the adjoining counties.

"After airing himself to his heart's content, he descends, sometimes spirally as he rose, at other times with great plunges and wild, reckless dives, until within about 50 feet of the earth when he hangs himself upon the air with his long, spindling legs down, gently settles and alights." Huntington (1903), described "a large flock of white cranes" that rose from a marsh and flew directly towards him, ascending far beyond range as they approached. "When quite overhead, in the azure sky, their white feathers gleaming in the sunlight, they proceeded to go through many graceful evolutions, flying about in a circle, forming sides and crossing over and back and dancing in midair to their own loud music. We were much entertained by their performance, and observed them until the exhibi-

tion was ended and they continued their flight until quite out of sight."

I have never observed such flights except just prior to the spring migration. Apparently they also occur during the progress of migration and a painting, done from memory by Mr. Kennedy of Gothenburg, Nebraska, shows a flock of 24 or 25 Whoopers, circling and wheeling as they seek to gain altitude. In a progress report written while in the field in 1947, I commented on pre-migration behavior as follows: "In late February and early March, some breakdown in the territorial scheme was noted, but much of this apparent capriciousness may have been due to the presence of an extensive *burn* adjacent to several territories. However, early in March, some conduct was noted that may well have presaged a change from *winter behavior* to *pre-migration behavior*. For example, the Slough Pair, after feeding in a burn some distance west of the head of Mustang Slough, was observed

returning to their usual feeding area near the slough by flying at a much greater altitude than previously noted. In so doing they obviously sought out the advantages by rising thermals and soared in wide circles as they progressed slowly eastward. Over the head of the slough they plummeted to the ground with elaborate spirals and side-slips." This exhibition was similar to that described by Picket.

Again, on April 17, 1948, my notes read: "10:31 a.m.—Birds were heard calling as I was driving southwest on the East Shore Road, near Carlos Field (Aransas Refuge). Looking up I saw four Whoopers, fully 1,000 ft. in the air, circling and sailing. One of them seemed to be trying to lead the other three off towards the North, breaking out of the circle and heading in a northerly direction. But the others continued circling away towards Mullet Bay to the South. Finally the eager individual joined them, all calling steadily, and they settled to the ground, alighting on the shore of the bay." On this date, 24 cranes had already migrated northward and the four individuals described above disappeared during that same night, or early the next morning.

In late March, 1947, I was stationed along the Platte River, in Nebraska, for the purpose of observing migrating Whoopers. At the same time, Olaf Wallmo, assistant to the refuge biologist, remained on Aransas and gave full time to a study of the departure of the wintering cranes. His interesting report, on the events leading up to the actual start of migration northward, is included in full.

Pre-Migration Behavior (Spring)

The determination of precise information on the date of departure of Whooping Cranes from Aransas Refuge, and their behavior prior to departure, was set as the major project. This assignment required trips over the entire extent of the available crane range, which could be accomplished by driving from Refuge Headquarters to Dunham Point, a round-trip distance, including side-trips, of about 45 miles. At first this trip was scheduled 3 times weekly, but in April the trip was made daily to

assure constant observation.

These daily trips resulted in the discovery of an additional mainland bird, the South Single, bringing the total on the Refuge to 21 birds. The trips also established the territories of the Dunham Bay Pair and the South Pair, previously not definitely known. Generally speaking, there were no great changes in behavior indicative of the coming migration flight.

The most significant development was the territorial shift occurring about the end of March. The Slough Pair, occupying Mustang Slough, Redfish Slough and Mustang Lake in March, deserted Mustang Slough and used Redfish Slough, and occasionally Mustang Lake, in April.

During the month prior to migration there was no observed increase in recrudescence sexual activity. The only definite "dances" observed occurred on April 4 and 7. On April 4, the Middle Pair engaged in a dance in which both birds participated, bowing and flapping perhaps 100 feet apart. On April 7, both the Bay Pair and South Pair were seen dancing, but in both cases only the larger bird (presumably the male) went through the dance motions.

During April, it was noted that when the Whoopers alighted from flight they usually landed on high spots of land, seldom in water. And, of a pair, the larger bird (male?) immediately assumed an erect posture, with body more or less horizontal, plumes ruffled and head and neck erect. The smaller bird (female?) ordinarily assumed a more relaxed posture on alighting, with the neck crooked. The erect "strut" posture of the male (?) was also observed to occur just before that bird went into a dance. The North Family deserted Long Pond and used the shore of Mullet Bay. The Dike Pair had usually been found on the southwest end of Long Pond and the adjacent land-locked ponds south of there. After the movement of the North Family, the Dike Pair expanded their territory, using all of Long Pond and ranging to the shore of Mullet Bay. The Refuge Single, whose earlier preference was for Middle Pond with the Middle Pair, shifted to Mullet Bay. The Middle Pair, however, still were found mostly in Middle Pond, occasionally ranging to Mullet Bay.

Early in March the Middle Family and South Family ceased to use the ponds (especially Camp Pond) and were found in Mullet Bay. In April the South Family was again frequently found in the ponds.

The Bay Pair and South Pair divided Dunham Bay between them and their territories remained unchanged. The South Single was an unpredictable bird. When present it was found in the Dunham Point Ponds, but frequently it was absent, presumably being on one of the outlying islands.

On March 20 the Middle and South Family Groups were found together; that is, all of the birds were within a fifty-foot radius. However, they maintained two distinct groups. There appeared to be some friction between the males (largest birds) of the two groups. They stood perhaps 10 feet apart, each with his family behind him.

and gaped at each other, occasionally pumping their necks and darting their bills at each other. Their plumes were ruffled up and very prominent.

When the birds observed me, at a distance of about 300 yards, they began to cry in unison, the young apparently also giving voice. Both groups then walked into adjacent Mullet Bay, one moving northward, the other southward. This manifestation of intra-specific friction (in the form of territorial dispute), while interrupted, showed that along with the friction there was also some attraction to account for the six birds remaining together. The actions of the two "males" were never actively combative.

During the period of intensive observation, it was found that the most satisfactory means of observing whooping cranes at close range was to "creep" them, crawling through the vegetation, using an approach that made it possible to remain concealed. It is possible, thus, to approach within 100 yards or less of the birds, depending on terrain. Several times, while driving along the shore of Dunham Bay on the *Monanthochloe* flats, I passed within 100 yards of the Bay Pair and South Pair without flushing them or noticeably disturbing them. It was even possible to stop the car and watch them, but if I stepped out of the car they immediately flew. My experience with watching whoopers from a blind was very unsatisfactory. However, I believe they can be lured to any simple blind with artificial feed.¹²

In April, observations were accompanied by great anxiety, but nothing transpired to forewarn of the coming departure. On April 11, 2 pairs, one family, and a single were missed, but it did not necessarily follow that they had departed.

On April 12 and 13 there was a severe wind and rain storm, which prevented field work. Late on April 13, after 4 inches of rain, a trip was made as far as flooded roads would permit. No cranes were found. On April 14 a thorough check was made on foot. A trio of whooping cranes *all in adult plumage* was found on the shore of Mullet Bay. They flew when they saw me and landed on Ayres Island. The composition of the group, and the direction of their flight, suggests that they were none of the familiar mainland birds. On April 15 another thorough check failed to reveal any birds on the mainland. Later (on April 21) Mr. Earl Benham, a refuge employe, informed me that on the 18th the ranch foreman, Mr. Sullivan, saw 3 whoopers near Bill Mott Bayou, on the west side of the Refuge. Road conditions prevented my searching that area.

On April 19 an airplane flight was made from Mr. Robert Tanner's airport, Port Lavaca, Texas, with Mr. Durham as pilot. We found no whooping cranes on Aransas Refuge. A single bird was found on Matagorda Island.

From these observations it is believed that the departure of the main body of the whooping cranes from

¹² This was accomplished with fair success the following winter (R.P.A.).

Aransas Refuge occurred on April 12 and/or 13. It is possible that the severe storm occurring on these dates had some effect in precipitating the departure.

Spring Departure

While I was moving up and down the Platte River, making my observations by car and airplane, Olaf Wallmo kept me informed of possible departures. Obviously, it was difficult to know just when birds actually headed North. A pair or two would be missed when the rounds were made, but it was always possible that the birds had moved to another location or had been overlooked. However, from Wallmo's data we are able to construct a table of *apparent* departures, and this, plus a similar table for 1948, remain the best information available on this subject.

In addition to this first-hand data, the literature contains a number of clues with regard to spring departure from Gulf Coast wintering grounds. For the Louisiana migrants we have no departure dates for those Whooping Cranes that wintered on the prairies, although, under original conditions, these were evidently the most numerous and the most typical group. Oberholser (1938), considering only the handful of migrants still present at that time on the coastal marshes, gives the extreme dates, November 23 to March 11, as the period of winter residency. The November date is from a report of nine observed near Gueydan, Louisiana, by Ambrose Daigre (Oberholser, 1938). However, these birds unquestionably belonged to the resident breeding group of the *paille-fine* and were not migrants. The March 11th date is from Nelson's observation of two birds near Pecan Island (Nelson, 1929). Thus, it is not actually a departure date, although these birds were certainly migrants.

From the above it is evident that we do not have information as to the departure of Whooping Cranes on the spring flight from Louisiana. It is now too late to obtain such data, beyond questioning older residents of the prairies and

coast, but to date, such details have not been forthcoming from this source. There is the final possibility that we might obtain at least a conjecture by a study of spring migration dates for the species from locations to the north of Louisiana.

There is accurate data on departures from Texas. Some late spring dates may well represent observation of Whoopers that remained on the Gulf Coast through the summer. For what they are worth, the following late dates of occurrence at Gulf Coast locations, appear in the literature:

June, 1863	
Matamoros	Dresser (1866)
April 1, 1877	
Brownsville	Sennett (1878)
Late March, 1878	
Head of Padre Island	Sennett (1878)
April 2, 1890	
Brownsville	Rothschild Coll.
Mar. 29-Apr. 2, 1900	
Matagorda Island	Oberholser (USFWS files)
May 6, 1900	
Arroyo Colorado	Griscom and Crosby (1925)
Summer (occasionally)	1919-1923
Laguna Larga	Bent (1926)
March 14, 28, 1934	
Espiritu Santo Bay	Carroll (USFWS files)
March 23, 24, 1935	
Laguna Larga	Carroll (USFWS files)

These are the latest spring dates in the record, prior to the observations made at Aransas Refuge. The only ones that are really extreme are the June records of Dresser, the May 6 observation and the summer reports turned in by Mr. Kleberg from Laguna Larga. All of these could have been summering birds.

The first detailed information on actual departures was obtained by James O. Stevenson, when he was refuge manager at Aransas (October, 1938 to November, 1941). These records were continued by Earl Craven, the succeeding manager, for the spring departures of 1942-1945. Examination of Stevenson's data indicates that departures were observed between April 6 and

23. This gives as median dates, April 14-15 (Stevenson and Griffith, 1946).

Craven (1946) recorded the extreme departure dates of March 23 and May 5. However, the median dates were April 13-14.

Olaf Wallmo's data (*MS. Report*) suggests that in the spring of 1947, departures took place between April 6 and 18, a span of 13 days. The median date was April 12.

My own observations, made in the spring of 1948, indicated that departures took place between April 5 and 18, a span of 14 days. The median dates were April 11-12.

The extremes for median dates, as given above, are April 11 to April 15.

In general, it would appear that most of the Whooping Cranes now wintering on the Texas Coast may start the spring migration before April 15, with April 13 as the average date. Evidently weather conditions may have some effect on the actual beginning of such a movement, as suggested by Wallmo, and this might explain the variations from normal. In 1939, only 50% of the migrants had departed by April 22. In 1944, 90% had gone by April 21.

A breakdown of apparent departure dates for 1947 and 1948 show some interesting similarities. In 1947 some 39% of the migrants had evidently departed by April 12. In 1948 some 39% had gone by April 11. In 1947 it appeared that 82% had gone by April 13 and, the following year, 85% had departed by April 15. Finally, all had departed by April 18 in both years.

It is believed that the regular beat or rhythm of the gonadal cycle is probably more important in directing these departures than are other factors. From this meager knowledge that we have on actual departure dates, there appears to be an overall span that is remarkably limited. We have previously advanced the possibility that arrival of the potential breeding pairs on the nesting grounds must be accomplished within a limited period, theoretically about April 22 to May 5. It will be of interest, with this 14-day period in mind, to examine the progress of

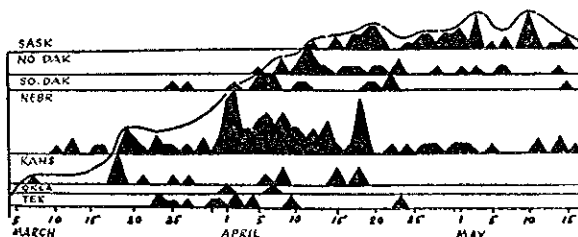
migration northward from the Texas Gulf Coast, as contained in the record.

The Spring Flight: Texas to Saskatchewan

All available spring migration dates for Oklahoma, Kansas, Nebraska, South Dakota, North Dakota and Saskatchewan have been plotted on the accompanying graph. Outstanding peaks are joined by a curving line that roughly approximates the progress of the heaviest flights. The first such peak, a minor one, occurs in Kansas on March 18, followed by an initial flight in Nebraska on March 19, and heavy Nebraska flights between April 1 and April 14, with a final spurt on April 18. In the Dakotas the major peaks occur on April 5 and April 11-12. By April 19 a major peak is attained in Saskatchewan, followed by a steady and increasingly heavy flight from April 24 until the final peak is reached on May 3. The apparent peak of May 10, when analyzed, is found to involve four reports of wandering single birds, and a report of two birds that was turned in by a school boy, and not verified.

In general, it is seen that the main body of migrants reached Nebraska between April 1 and April 18, and Saskatchewan between April 17 and May 3. These peak periods cover 18 and 17 days each. Thus, migrants leaving the Texas Coast about March 24 may have landed on the Platte River, in Nebraska, on April 1, passed some days in that vicinity and not turned up in Saskatchewan until April 17. It must be borne

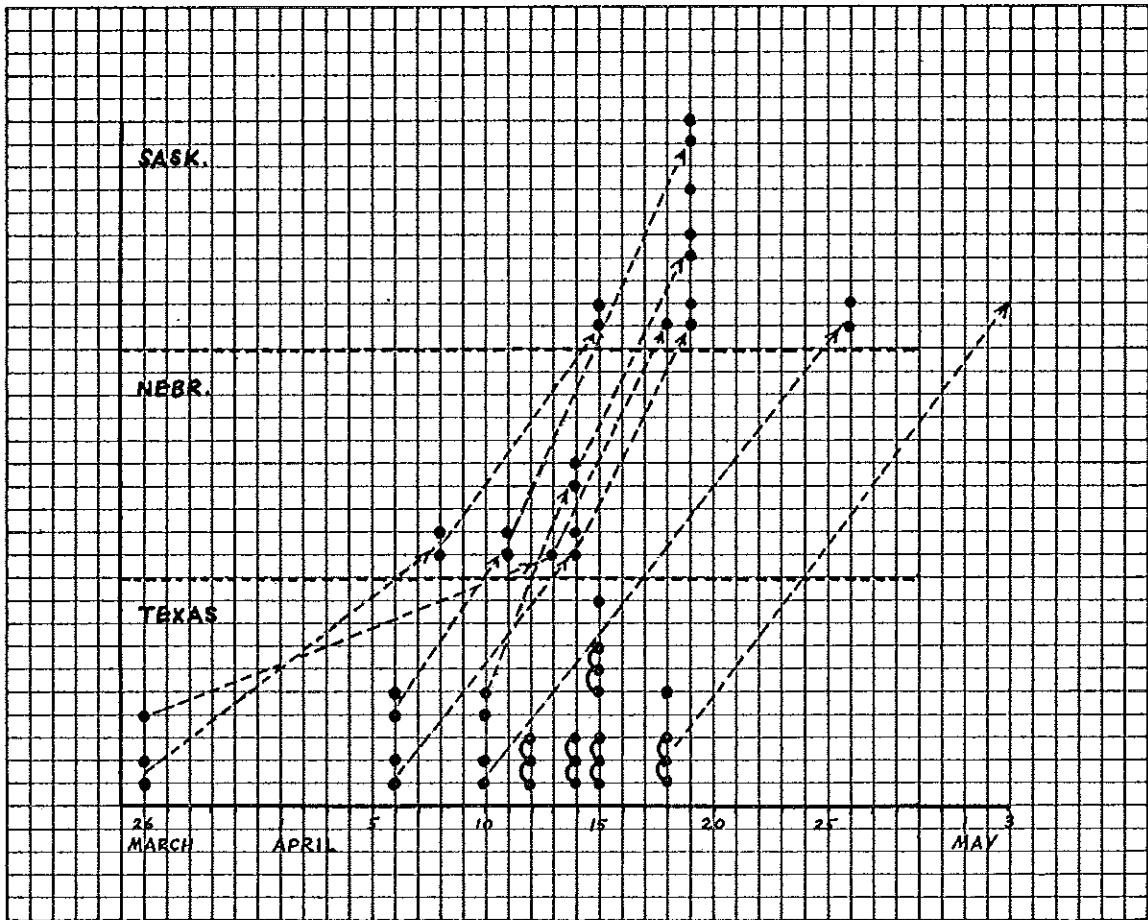
Progress of Spring Flights from Texas. Based on Number of Reports for the Dates Involved.



in mind that these reports are based on records that go back some years, so that such an average or typical example may no longer apply. However, as outlined, it seems to fit the migration dates on record and likewise, it will be noted, allows ample time for arrival on the nesting site within the critical period estimated as April 22-May 5.

The approximate distance, straight line, from the Texas Coast, at Aransas Refuge, to the latitude of Regina, Saskatchewan, is 1600 statute miles. Since it is believed that the cranes make several stops at favorable feeding and resting places en route, the course may be irregular, so that the actual distance flown may be as much as 1800 miles. The diagram shows the number of Whooping Cranes reported as departing from Aransas in April, 1948, plotted according to the probable dates of such departure. Also plotted are the numbers reported from Nebraska and Saskatchewan in the same month. Lines are drawn to connect pairs and singles that may have been identical cranes, observed in all three locales. It should be noted that groups of three (families) were not reported after departing from Aransas. No explanation is known. From this diagram it can be demonstrated that the entire journey from the Texas Coast to Saskatchewan (latitude of Regina) may require from 9 to 23 days, more or less. The average elapsed time would appear to be 15-16 days. The minimum time (9 days) would require a maintained average of 200 miles per day. If 23 days elapsed, the daily average would be only 78 miles. And the average time (15-16 days) would mean from 112 to 120 miles per day. Actually, daily mileage probably depends on distances between stopping, i.e., feeding) places. Ground speed (i.e., distance made good over the ground) is affected unpredictably by winds. From checks made in the field it is believed that the "cruising rate" of the Whooping Cranes approximates 45 m.p.h., air speed.

It will be seen that the last family group to leave Texas, April 18, could have made the



Dates of 1948 Departures from Aransas Refuge Compared with Nebraska and Saskatchewan Reports.

journey in the average time calculated (15-16 days) and reached the latitude of Regina on May 2 or 3. If we are correct in estimating that the last possible date for arrival on the nesting site is May 5, it would appear that this pair could just manage to get in under the wire, provided their trip was made within this time limit.

Obviously, there is a time lag between actual arrival in Nebraska or Saskatchewan and observation. It is thought that potential breeding pairs make the journey to the nesting grounds within a practical minimum, but we do not know enough about the requirements of the species to analyze the factors that govern this mini-

mum. However, the time lag between arrival and observation cannot be very great.

The five Whooping Cranes that I observed on a sandbar in the Platte River on the morning of April 19, 1947, included an immature bird that I was able to identify, by markings on the head, as the young of the North Family. It was still accompanied by its parents. According to Olaf Wallmo's detailed record of departures, the North Family was seen at Aransas on April 11, but was no longer observed from April 14 on. It was presumed that departure of this group took place April 12-13. Thus, in this instance, it would appear that the journey from Aransas

Refuge to the Platte River required either 6 or 7 days.

There are comparatively few spring migration records from the region between Texas and the Nebraska line. Apparently there were two distinct pathways through this area, one followed by the Texas migrants and the other, off to the east towards the Missouri River, followed by the Louisiana birds. Texas birds formerly crossed the Red River into Oklahoma in a wide swath extending from the vicinity of Henrietta, in Clay County, through Gainesville and east to Bonham, in Fannin County. Thus, the path at this point was about 120 miles in width. All of the Oklahoma records are for locations towards the western portion of that State, from Cotton County on the south to Harper and Beaver Counties, at the root of the Panhandle, and Woods and Alfalfa Counties, on the border of Kansas. The two routes are again evident in Kansas, one through the center of the State, the other more to the east. A straight line from the Blackjack Peninsula, in Texas, to Portal, North Dakota, strikes directly through Stafford, Barton and Ellis Counties, Kansas. This was, and still is, the main route of the Texas migrants. There are old records for the vicinity of the Arkansas River in Sumner, Sedgwick, and Harvey Counties, and a single report from Marion County. These, too, were probably Texas birds. But the old records for counties to the east (1865 to 1913) were very likely of Louisiana migrants.

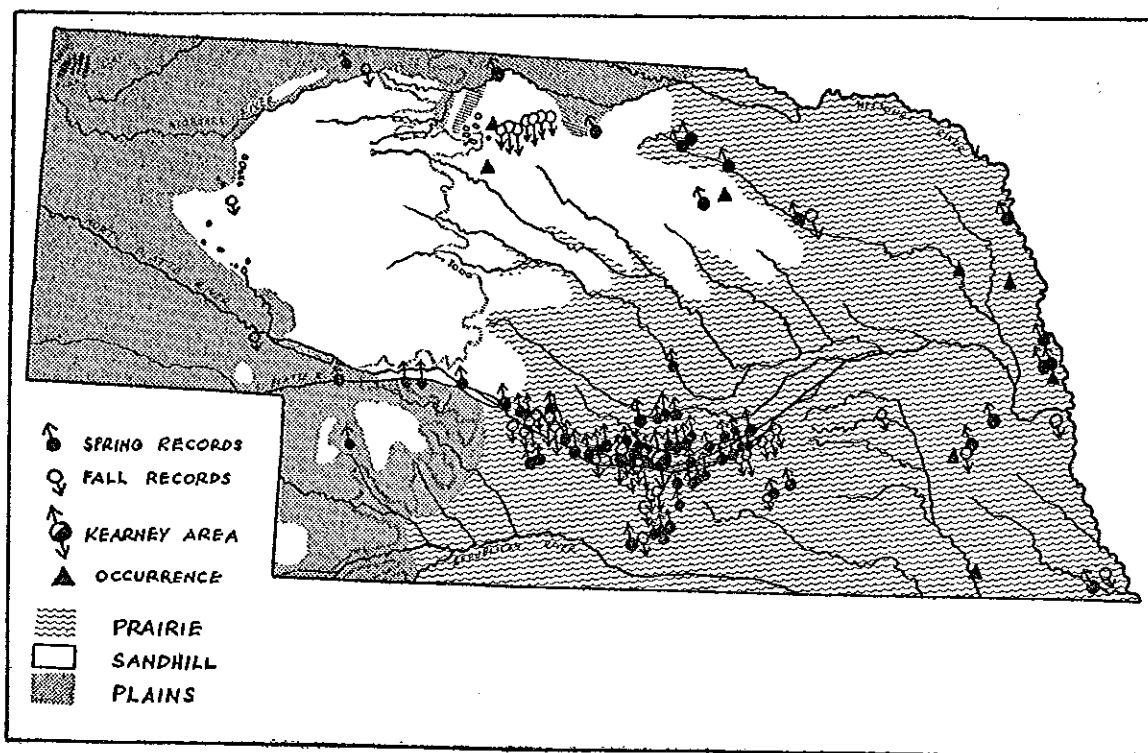
In Nebraska the two routes are in evidence until 1919, which year doubtless saw the end of large numbers of Louisiana migrants.

I believe that one reason for the great number of migration reports from Nebraska, most of them from the Platte River area, is that the Whooping Cranes make that territory a major stop, remaining in the region for some days. When the species was more numerous, according to Jack Kennedy, who was a resident of Dawson County, Nebraska, during the 1890's and early in the century, they sometimes remained in the vicinity of the Platte River for a week or longer.

Mr. Kennedy's recollections contain some vivid pictures of the behavior of the Whooping Crane on this major migration highway 50 or more years ago. He told me that they were not so dependent on the river for food in those days, as there were still many buffalo wallows on the prairies. They roosted on the river bars at night and came to the wallows early in the morning. Here he watched them feeding on frog and toad egg masses, for the wallows were filled with and alive with all sorts of aquatic life. The Sandhill Cranes, established in vast roosts on the river bars, did not appear on the prairies until towards noon. The Whoopers avoided them, keeping off by themselves, 200 or 300 yards from the Sandhill flocks as a rule, although an occasional Whooper would join one of those flocks and travel with it. The Whoopers, Mr. Kennedy recalls, walked a good deal more than the Sandhills, covering a large expanse of ground during a single day. They seemed to like the open stretches of short buffalo grass and he watched them turning over the cattle chips and feeding on the beetles that live underneath.

Some of the Whoopers, Mr. Kennedy told me, remained along the Platte until May 1, after all other migrants had gone with the exception of the white pelicans, that stayed as late as June. In the late spring, there were fields of young green wheat south of the river and the cranes seemed to like to walk over these. They probably took cutworms and other insects, for the most part. When a group had been in the area for some days, and were ready to resume their journey northward, they would gather in the afternoon, rising and circling higher and higher until, as Mr. Kennedy expressed it, "they found the right air current." Then, with their shrill bugle notes growing fainter and fainter, they disappeared in the blue haze of the sky, far to the north.

Their course, upon leaving the Platte behind, was "a few degrees west of north," according to Mr. Kennedy. The route shown by Myron Swenk, on his map of the line of migration



The Distribution of Spring and Fall Occurrence Locations in Nebraska Related to Major Habitats.

(Swenk, 1933, p. 117), is a straight line from approximately the neighborhood of Houston, Texas, to the extreme northeast corner of Alberta. This line is about 15 degrees west of north. Study of the records indicates that the main body of Texas migrants, starting north from such widely separated locations as Brownsville and Houston, probably narrowed the field of their path as they approached the Big Bend of the Platte (see map). Their pathway would have resembled a narrow triangle, with the apex at Kearney, Nebraska. From the Platte, the migrating groups struck out on a line slightly to the west of north, as Mr. Kennedy describes. This route carried them across the Nebraska sandhills, east of the 3,000 ft. contour, and joined with the Missouri River somewhere below Pierre, South Dakota. They could then follow the Missouri, with its sandbars for resting and feeding,

to a point in mid-North Dakota. Here a fanning out must have taken place, some birds heading off towards North Dakota nesting sites and the southwest corner of Manitoba, others keeping on towards Saskatchewan and beyond, to Alberta.

This outline assumes that the majority of the original nesting groups in Illinois, Iowa and Minnesota, wintered on the prairies and the coastal marshes of Louisiana. Although the last recorded nesting for these three States (in Iowa, 1894) occurred when there was still a fair wintering population in the Louisiana country, it seems likely that many, and perhaps most, of the birds nesting in Manitoba, also wintered in Louisiana. The last record of a Manitoba nesting is for 1906. The last prairie occurrence for Louisiana came just 12 years later, in 1918.

Once arrived in Canada, the Whoopers for-

merly spread out to nesting sites scattered over the Provinces from the vicinity of Winnipeg west towards Edmonton. Other birds continued northward, nesting in parkland areas near the Slave River, in North West Territories, and possibly in the marshes of the Athabaska Delta. Still others were seen on or near river deltas close to the Arctic Coast, and probably nested there in small numbers. At the present time the Texas migrants spread over much of southern Saskatchewan, east to the Manitoba line and west to parkland habitats on the borders of Alberta and British Columbia. Migrants continue to appear north of the now settled regions and there are recent records from the south shore of Great Slave Lake. But the migration pathway, beyond the settled areas, is unknown. Whatever its route, it evidently leads the last few breeding pairs to their unknown nesting grounds.

The Spring Flight: Louisiana to the North Central U. S. and Manitoba

Migration dates for Missouri, Illinois, Iowa, Minnesota and Manitoba have been plotted and are shown on the graph. As might be expected for migrants that do not have so far to travel, the peaks representing the greatest number of reports are attained ahead of similar peaks on the graph for Texas birds. The progressive

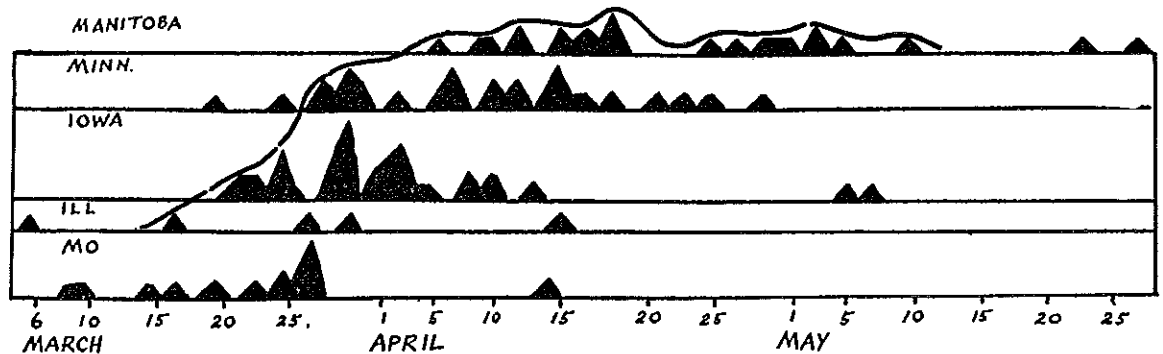
trend of migration is approximated by the curving line that joins major points of heaviest flights. The strongest and most sustained movement through Missouri appears to have taken place March 23-27. In Iowa the heavy flight evidently began at about this same time and peaks were reached March 25, 30 and April 3. In Minnesota the initial peaks occurred March 28, 30. There are no Manitoba records until April 6 and the most important dates appear to be April 12, 15, 17 and 19. Most of the few Illinois reports are scattered through March.

It must not be overlooked that Illinois, Iowa and Minnesota contained nesting areas, so that only a small percentage of the migrants reported from there were transients. According to the trend on the graph, it would appear that by about April 19 most of the breeding pairs on this flyway had reached their nesting grounds.

Evidently, spring departures from the Louisiana wintering areas were no earlier than those from the Texas Coast. A comparison of the two graphs suggests this, as well as illustrating the apparent fact that when Iowa, Minnesota and Manitoba birds had reached their nest sites, the Texas migrants were just crossing the line into the Provinces in fairly large numbers.

The Louisiana birds may have followed the Mississippi River on their northward swing, but there is only one report from south of Missouri.

Progress of the Spring Flights from Louisiana (to 1917). Based on Number of Reports for the Dates Involved.

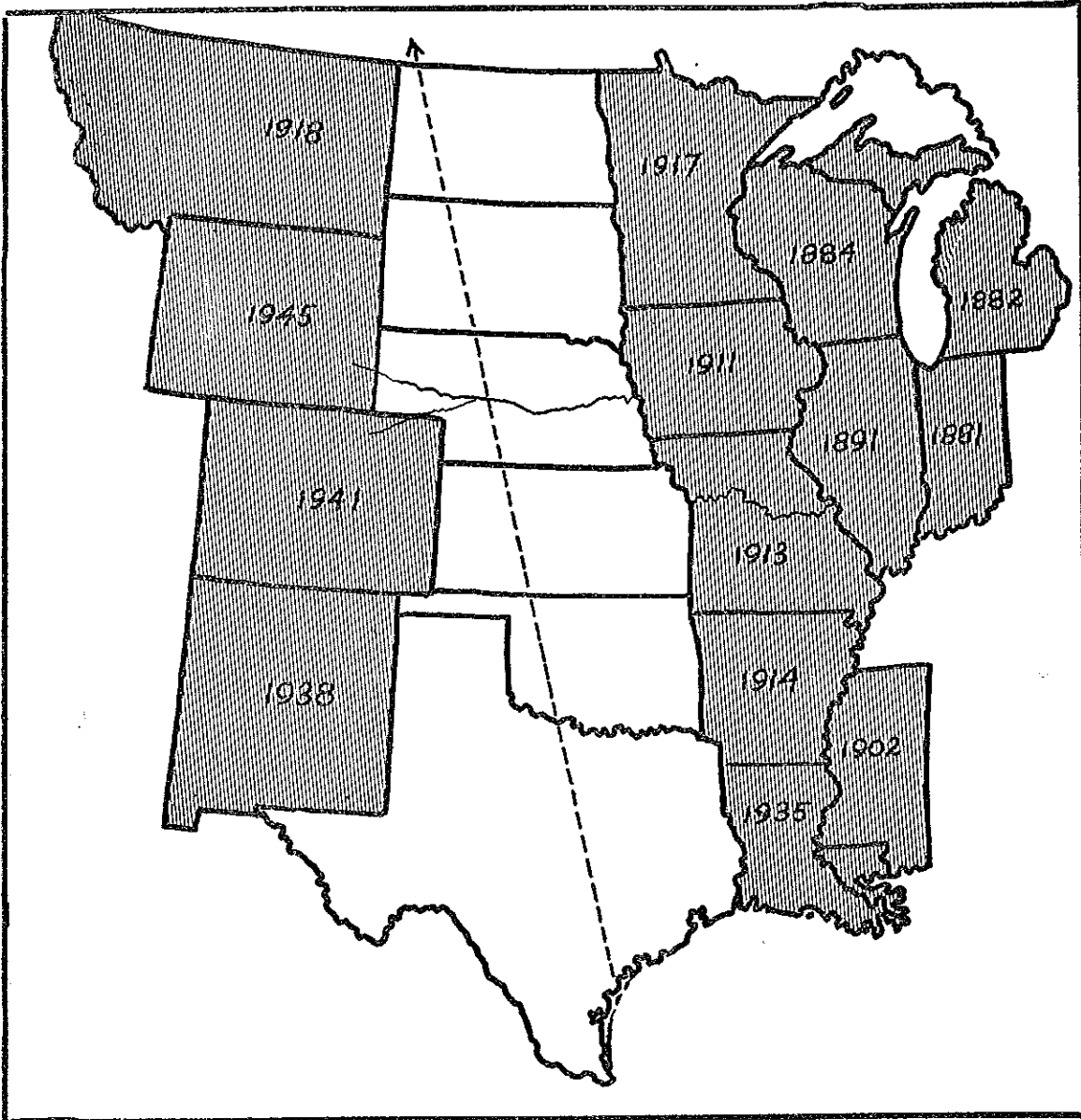


Perhaps most of them struck out across the Arkansas swamps, and several Missouri records suggest this. Stragglers along the Ohio River were doubtless Louisiana birds, as were those reported from Indiana and Ohio. Obviously,

stragglers in Mississippi and Alabama were from the Louisiana group.

Little is known of the migration route that once carried Whooping Cranes across the Appalachians to the Atlantic seaboard in New Jersey,

States Through which the Present Migrant Flock of Whooping Cranes Travel and Years of Last Record for Surrounding States.



South Carolina and to river mouths farther south. Beyond the presence of the species at these eastern points, and such conjecture as we wish to indulge in as to how they got there, we have only Audubon's and Wilson's observations from Kentucky (March 20, 1810). The last eastern record was in 1857 and it is extremely unlikely that Ohio, Indiana and Kentucky records of some years later were other than stray birds from the Louisiana flyway.

In our discussion of *Distribution* we have related all that is known regarding the migrants that traveled with the Sandhill Cranes into Mexico. This, also, is a lost chapter.

In general, then, the spring migration was divided, in former times, into four distinct routes. The main wintering area, on the prairies of southwest Louisiana, plus a smaller area on the coastal marshes, sent its quota of migrants north to Illinois, Iowa, Minnesota, eastern North Dakota and Manitoba, where they nested. The disappearance of the species from these north central U. S. sites, and from Manitoba, coincides with its depletion in Louisiana. Thus, this flyway was greatly reduced soon after the turn of the century and years of final occurrence were 1911 for Iowa, 1913 for Missouri, 1917 for Minnesota. The last Illinois report was for 1891. In Manitoba a few birds may continue to drift in during the summer from Saskatchewan, but these are of Texas origin. The last Manitoba nest, as previously mentioned, was discovered in 1906.

In Louisiana, by way of correlation, the final report of wintering birds on the prairies was dated 1918, an important date that has also been mentioned several times. A half dozen or so migrants survived on the Louisiana coastal marshes until 1935. Where they traveled on migration is not known, but from the complete dearth of occurrence records along the old Louisiana flyway between 1917 and 1935 it is apparent that they must have swerved to the west and joined the Texas birds on the Platte

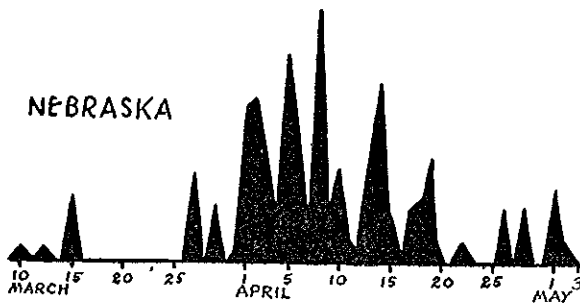
River. Nelson (1929), writing of the Whooping Cranes that he observed near Pecan Island in March 1928, said, "This is the fourth successive winter they have passed on this section of the marsh, always without young." I have seen no reference to the presence of young-of-the-year among these Louisiana coastal birds, records of which go back in the literature to 1916.

The Texas migrants formerly journeyed northward from wintering areas on the Rio Grande Delta Plain and other coastal points east to the marshes near Port Arthur. They converged at the Platte River, in Nebraska, moving on from there to nesting grounds in Saskatchewan, Alberta, North West Territories and, possibly, to some extent, Manitoba. Today what remains of this pathway has its beginning in the vicinity of Aransas Refuge, Texas, and follows a rather straight line, slightly west of north, through Nebraska, between North Platte and Kearney, and into Saskatchewan southeast of Regina. Its course beyond the settled areas is unknown.

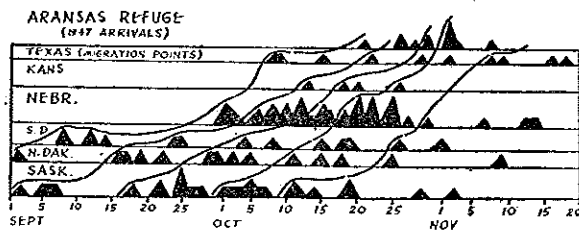
The old route across the Appalachians to the Atlantic seaboard, deserted since 1857, according to the records, may have been a regular migration path, as Swenk (1933) claimed, but there is no existing evidence to indicate that it was ever of more than minor consequence.

In a true sense, the route into Old Mexico was that of the Lesser Sandhill Crane and it is very possible that the Whooping Cranes wintering there merely followed along with *G. c. canadensis*. However, the former presence of the Whooper in Mexico has been well established and their numbers were sufficient to enable us to include this route in our present list.

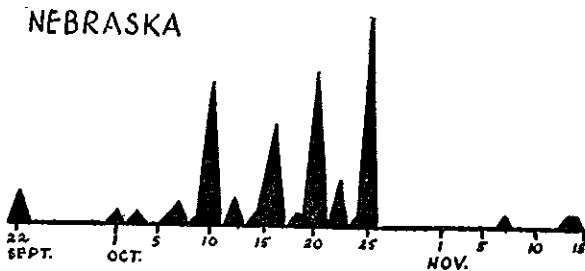
Extreme dates for spring migration were March 6 to May 15. Occurrences beyond May 15 are considered nonbreeders and not true migrants, in the sense that they are not journeying from winter quarters to nesting grounds. The times of heaviest migratory movement in the various States and Provinces concerned, and on



A Revised Graph of Numbers of Whooping Cranes Reported in Nebraska for the Dates Involved (Spring).



Progress of Fall Flights from Saskatchewan to Texas and Aransas Refuge. Based on Number of Reports for the Dates Involved.



A Revised Graph of Numbers of Whooping Cranes Reported in Nebraska for the Dates Involved (Fall).

the two major migration pathways, are illustrated on the accompanying graphs.

Thus far we have discussed graphs built on the revised number of migration reports for any given day of the month. The peak of the spring flight through Nebraska appears to be April 2, since, over the years, there were more reports of migrants on that day than on any other. We have avoided speculations based on the number of Whooping Cranes reported. In his paper *The Present Status of the Whooping Crane* (1933), Myron Swenk presented two graphs, one "showing the number of Whooping Cranes observed in Nebraska each spring and autumn over a twenty-year period," and the other "showing the dates of occurrence of 684 spring and 142 autumn Whooping Crane migrants in Nebraska over a twenty-year period." Except for the fact that it made use of some figures that I believe to have been in error, the second graph is useful and employs a practical method of demonstrating the trend of migrant numbers. The first graph, on the other hand, is based not only on erroneous data, but on an analysis of this data that is grossly misleading. Swenk assumed that "the number of Whooping Cranes observed in Nebraska" was the same as the actual number of Whooping Cranes extant, at least on that flyway. Twenty years before the publication of his paper, Swenk began collecting reports on the occurrence of the species. Quite naturally, as the years went by, many persons in Nebraska learned of this and the contributors increased in number. Reports reached Swenk at second and even third hand. They were turned in by amateur bird watchers, but also by farmers, hunters, and small boys. The graph of "the number of Whooping Cranes" shows a jagged line that climbs steadily upward! Swenk wrote (p. 117): "But the particularly significant point in connection with these data is that there has been no permanent diminution in numbers of the species observed in Nebraska, during the past two decades; in fact, "only a superficial

glance at the graph indicates that there has been a distinct recovery of the species since 1916, when the ratification of the Migratory Bird Treaty between the United States and Great Britain, which permanently closed the season on this bird over the United States and Canada, took place."

We have already demonstrated, by discussion and with population graphs and tables, that the continental population of *Grus americana* was seriously reduced and still on a steady, downhill plunge throughout the years covered by Swenk's data. There was only a slight leveling off following ratification of the Treaty, and this did not occur until several years after the Enabling Act had been passed in 1918. Probably the end of legal spring shooting was the most important factor in this; but even then it was almost too late to avert complete disaster. The number of birds on the various sectors of winter range decreased steadily right down to 1938.

The false increase on Swenk's graph was actually an increase in number of observers, number of duplications and number of errors. In *Table E* we have given the number of occurrence reports by States, etc. There were certainly more Whooping Cranes in Saskatchewan in the period 1869-1898 than in the period 1939-1948, yet there were only 9 occurrence reports in the earlier period compared with 70 such reports during the recent period. Even if duplications and errors could be entirely eliminated, there is no way of accurately balancing this discrepancy between number of observers and number of cranes, insofar as migration reports are concerned. Only on the more or less limited areas of winter range, where the birds "stay put" within relatively compact territories, have we been able to find a reasonably accurate index to actual numbers.

This further criticism of Swenk's migration graphs and population analysis has been made to account for the dissimilarity of our graphs and because his mistaken estimate of "a distinct recovery of the species" was almost a fatal error.

On the strength of this rosy picture, direct action on behalf of the Whooping Crane was seriously delayed. Of course, no one would be more distressed by this fact than Myron Swenk. His overall contribution, in spite of the misconceptions involved, was the one spark that kept alive a general interest in the species. Through many years he labored almost alone. Perhaps if he had received more active assistance the errors could have been avoided.

The following graph has been modeled after Swenk's second diagram, showing dates of occurrence in Nebraska. The numbers included have been carefully revised and the result differs considerably from Swenk's. It should be noted that the period of greatest numbers on the spring flight (April 1-19), compares favorably with the same period on the graph that is based on number of reports. However, on the present graph the peak for numbers is April 8, whereas the peak for number of reports is April 2.

From our observations of departing cranes on Aransas Refuge, and an examination of the reports on which this spring graph is drawn, it is believed that the first individuals to migrate have been single birds and pairs without young. Perhaps the bonds between such birds and the winter territory is not so strong in these as in pairs with young. On the other hand, if gonadal development and "stage" is largely responsible for the migration urge, would not the most advanced individuals sexually be the first to take off? Nevertheless, groups of three seen together do not appear until April 2. For these Nebraska records, there are no further groups of three after April 14. Since few observers could detect immature plumage in young of this age (over 10 months) there is no certainty as to whether three birds seen together on spring migration are always a family group. The family I saw in 1947 was feeding, and possibly traveling, with two other birds. This situation is entirely different in the fall, when young-of-the-year, in their russet plumage, are conspicuous.

The Fall Migration

In our discussion of the role of nonbreeding summer wanderers in the Distribution picture, we introduced the question of fall departure. Previously, we had assumed that June 1 is the average hatching date for Whooping Cranes, and October 11 the average "late departure date from the Provinces." Late departure dates, as given by Bent (1926), are October 2, 5, 12, 16 and 20. How do these figures compare with our knowledge of the start and progress of the fall migration?

Occurrence records from September 1 on are plotted on the accompanying graph, so as to illustrate the gradual trend of movements between Saskatchewan and Texas. Apparently, the fall flight can be divided into several "waves," the earliest of which is reflected by the appearance of the species in both North and South Dakota before mid-September. These are single birds and pairs of nonbreeders, or others unsuccessful in rearing their young, according to the reports. Single individuals are not unusual, both before and after the main body of migrants that appear in Nebraska in mid-October. Pairs without young generally reach the Texas Coast before those traveling with 4-month-old offspring and these pairs are apparently represented in the next two waves. Finally, on October 10, or thereabouts, the family groups begin to reach the Platte. From that date until October 25, all family groups generally pass through Nebraska on their way south. In estimating this period of more than two weeks we have drawn out over 20 years of data. Now that the total population is even more reduced than it was two or three decades ago, this span has doubtless narrowed. On the Aransas Refuge, in the fall of 1947, five pairs with young-of-the-year arrived between November 2 and November 8. Three families arrived on the same day (Nov. 2), one family on November 3, one on November 8, and a sixth, minus the male of the pair, as late as the first week of December. These

arrivals are represented at the end of the fall graph.

Excluding Canadian data, which may refer merely to occurrence prior to actual migration from the Provinces, the apparent extreme dates of fall migration, on this Texas route, are Sept. 1- Dec. 4-10. Exact arrival date of these December birds is not known. However, some of the early birds in the Dakotas could have been summer wanderers and not true migrants, while the female that arrived in December, with her young but without her mate, must have survived an accident en route and been delayed far beyond the normal extreme. The extreme dates of the main migration appear to be Sept. 25- Nov. 8.

From their appearance on the Platte River, between October 10 and October 25, and their subsequent arrival on the Texas Coast in early November, it is evident that family groups must leave the Provinces during the first week of October. Some may get away in late September. Reversing our speculations as to elapsed time for the journey between Texas, Nebraska and Saskatchewan, we can now see that a family departing from the Regina latitude as late as October 17, and taking 16 successive travel days for the trip, will just manage to reach the Platte River by October 25 and Aransas Refuge early on November 2. Sixteen days was the average elapsed time estimated for the spring flight. However, encumbered as they are with young only four months old, it seems likely that a family group, returning in the fall, will require even more time than the maximum (23 days) for spring migrants, and their arrival at Aransas after all other birds are in, seems to indicate that this is the case. Therefore, it is probable that family groups have left the region in which they actually nested by late September and that they depart from the Provinces between October 1 and 10. October 10 may be a fairly average late departure date for families.

With reference to Bent's late dates for the

Provinces we can add only two, both of single birds, present in Canada after his final date of October 20. These were reported killed, October 29 and November 3, in Saskatchewan. Both skins are in the collection of the Provincial Museum, in Regina.

An additional fall graph shows the dates of occurrence of fall migrants through Nebraska. The passage of family groups, between October 10 and 25, is reflected in the greater number of reports recorded during this period. Most of them are for groups of three or more birds. Actual data on the presence of immature birds among migrants, is contained in the records for October 16, 20 and 25.

The general migration map indicates that the southbound route differs very little from the spring highway already discussed. There are fewer reports of fall migrants, possibly because the enthusiasm of the average bird watcher, after the long fast of winter, reaches its highest pitch in the spring. On the other hand, many autumn reports, especially from Nebraska, are contributed by hunters. The fact that more Whoopers were killed in Nebraska than in any other State, Province or District, doubtless resulted in part from the "funneling" that took place here, at the Big Bend of the Platte River. Also, there has always been considerable waterfowl shooting along the Platte and many Whooping Cranes have been killed from duck or goose blinds. A resident of Nebraska told me that, as a boy of ten or eleven, while sitting in a blind with his uncle, he saw a family group of Whoopers alight on a sandbar within gunshot range. It was fall and the young bird of the group was in the cinnamon, russet and buff plumage. "Shoot!" whispered the uncle, "and be sure to aim at the reddish one. He's the best eating." Many of the immature birds must have been killed in just this manner.

Migration: Summary

1. Towards the end of the winter season there

are several changes in the behavior of the Whooping Crane that mark the beginning of pre-migration behavior. One of these is the rare spectacle of high, circling flight, which will eventually result in the actual movement northward. Another is a restless shifting of habitual territories, or, perhaps, a breakdown of the territorial complex. "Dancing" is more or less regular, but shows no decided increase during the final month prior to migration. Other displays may reflect increased sexual excitement, however.

2. Spring departure dates from the former Louisiana winter range are unknown. In Texas late occurrence dates may represent birds that spent the summer on the Gulf Coast. Spring departures from Aransas Refuge appear to average, in recent years, between April 11 and April 15, for median dates calculated from all available data. The entire migrant group may depart within a period as long as 44 days or as short as 13 days. However, in 1947 and 1948 the average was apparently between 13 and 14 days. Extremes recorded are March 23 and May 5. Both appear to be unusual.

3. It is suggested that weather conditions may be an important influence in producing variation in departure dates. However, the regular rhythm of the gonadal cycle may be the main factor directing these departures, for normal birds.

4. A graph of migration dates for the spring flight between Texas and Saskatchewan suggests that initial flights have reached a minor peak in Kansas by March 18, in Nebraska by March 19. Heavy flights through Nebraska apparently were attained between April 1 and 14, with a final spurt April 18. In the Dakotas the major peaks occurred April 5 and April 11-12. The first major flight into Saskatchewan is shown as April 19, with a steady and increasingly heavy migration from April 24 to the final peak on May 3. These dates are discussed with relation to the breeding cycle dates previously advanced.

5. The journey from Aransas Refuge to Saskatchewan (latitude of Regina) is estimated to require from 9 to 23 days—average 15-16 days—for the spring movement. One known family group observed in Nebraska had evidently departed from Aransas Refuge 6 or 7 days previously.

6. The migration pathway is described and it is indicated that there were originally at least four distinct routes. The main routes were those between Louisiana and the nesting grounds in Illinois, Iowa, Minnesota, North Dakota and Manitoba, and the other from Texas and the Rio Grande Delta region of Mexico to nesting grounds in North Dakota, the Canadian Provinces and Northwest Territories.

7. A set of graphs is discussed that demonstrate the trend of migratory flights, with relation to dates, on the flyway between Louisiana and Manitoba. Old records show a strong flight through Missouri as early as March 23-27. In Iowa peaks were attained March 25 to April 3. In Minnesota early flights occurred March 28 and 30, while first Manitoba records do not appear until April 6, peaks being reached April 12 to 19.

8. Texas and Louisiana migrants may have departed close to the same date, on the average, but the Louisiana birds had reached their nesting grounds when Texas birds were just crossing into the Provinces, according to a comparison of the graphs.

9. The migration route over the Appalachians to the Atlantic seaboard may have been regular, but there is no evidence that it was other than of minor importance.

10. It is shown that decline and disappearance of the species, particularly as a breeding bird, in Manitoba, Minnesota, and Iowa, coincides with

its decline and disappearance in Louisiana wintering areas.

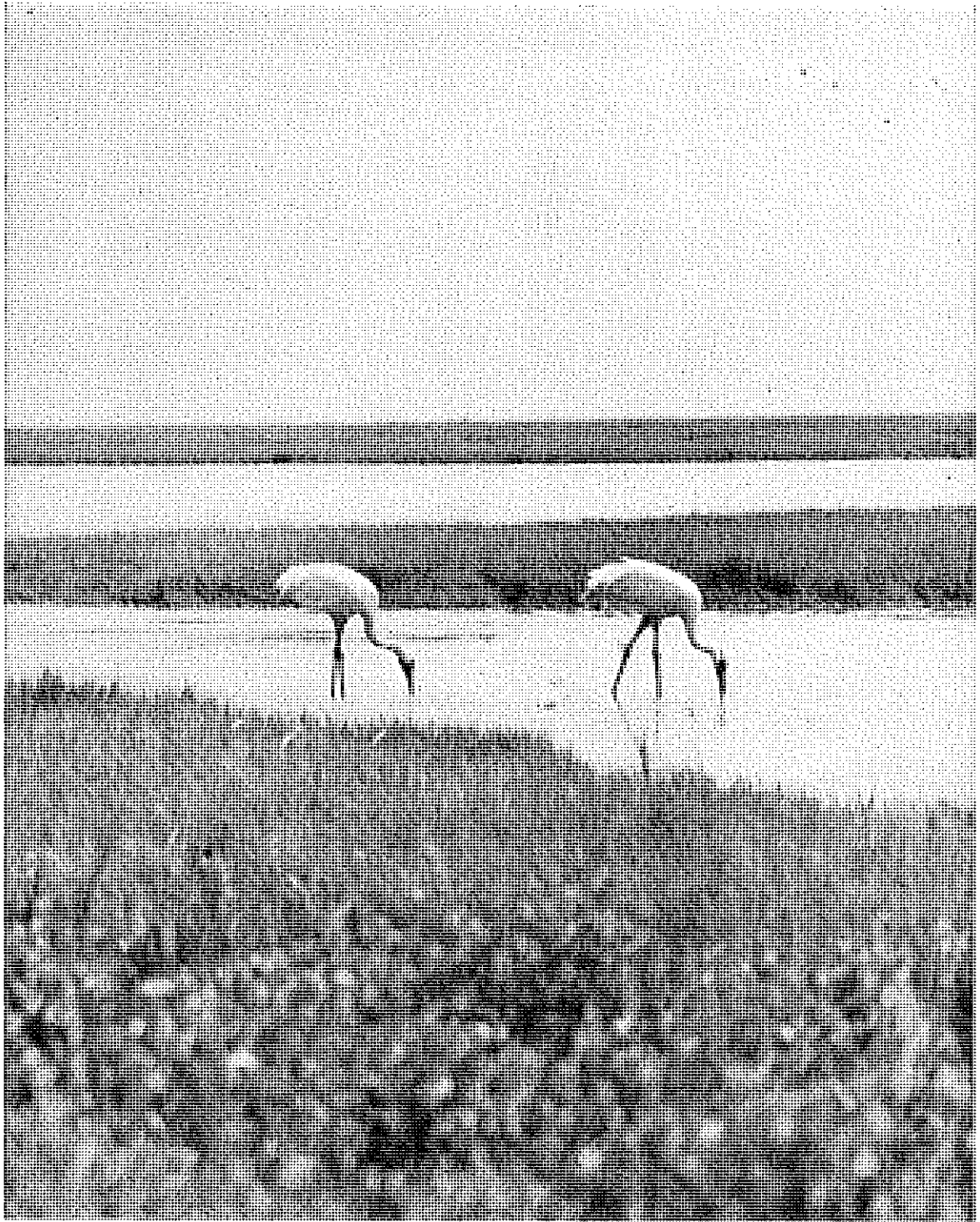
11. The migration route into Old Mexico was chiefly the path of Lesser Sandhill Cranes and it is believed that Whoopers merely trailed along with that race in reaching wintering grounds on the plateaus of the central intermontane region.

12. Extreme dates for spring migration were March 6-May 15. Birds that have not migrated to nesting grounds by May 15 are probably not migrants in the true sense.

13. The validity of Swenk's graphs of Whooping Crane numbers migrating through Nebraska is discussed. It is pointed out that during the years Swenk graphed data to indicate an increasing population, the total numbers were actually declining steadily, as shown by the gradual decrease on the wintering grounds. A corrected graph indicates that the greatest numbers moved through Nebraska April 8.

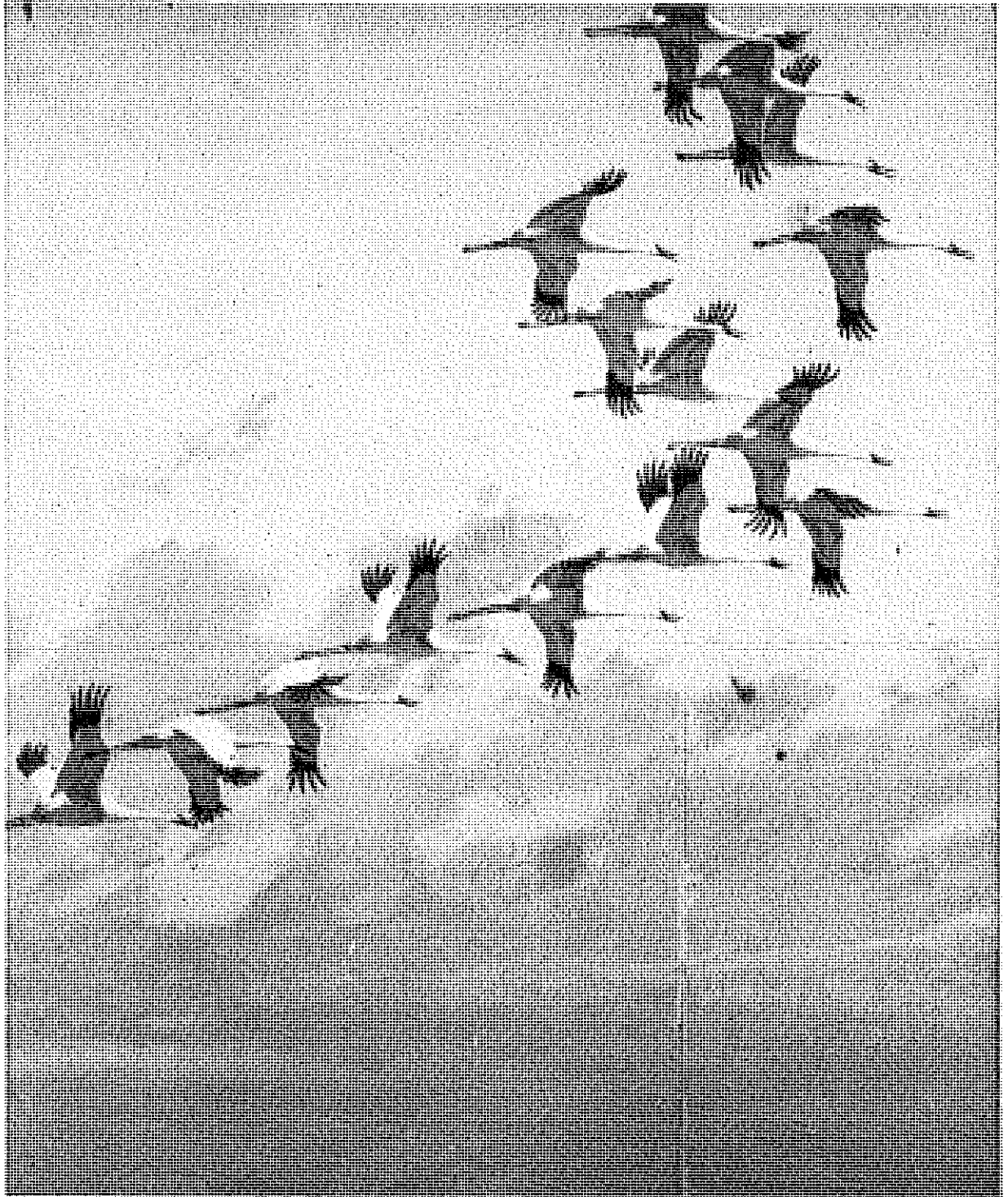
14. The fall migration is demonstrated by a graphing of flight dates. This return flight appears to develop in successive "waves," single birds and pairs without young migrating in the first two or three waves, followed by the family groups at a later date. Extreme dates recorded are September 1 and December 4-10. Family groups containing young-of-the-year apparently leave their nesting region by late September and the Provinces between October 1 and 10. They cross the Platte between October 10 and 25, and, of late years, reach winter quarters, on the Texas Coast, in early November (in 1947: Nov. 2 to 8 for normal groups).

15. It is believed that successful pairs, returning with young only four months of age, require more time for the trip south (i.e., more time to rest and feed) than other migrants or than any spring migrants.



Whoopers Probing for Marine Worms.
(*Photograph of Captive Birds in Texas by Allan D. Cruickshank, 1948.*)

A Whooping Crane Flock in Migration Must Be Classed with the Grand Canyon and Yosemite among the Great Natural Wonders of North America.
(From a hitherto unpublished watercolor by the late Louis Agassiz Fuertes, reproduced through the kindness of Mrs. Fuertes.)



Part IV. Food Habits

Little has been known, except in a general way, about the food habits of the Whooping Crane. There are doubtless several reasons for this and one of them is certainly the fact that the species has been rare for so many years. The literature, down to the publication of Bent's *Bulletin 135*, in 1926, contained only the remarks of Audubon (1840), Nuttall (1834) and Col. N. S. Goss (1891), and these seem to be based largely on assumption. Furthermore, the comments of Audubon, who usually made a point of describing the feeding habits and even the stomach contents, are again suspect, because we are not certain if he is speaking of the Whooping Crane, the Sandhill Crane, or both! However, Audubon mentions only the "large roots of the great water lily . . . which they greedily devour." In addition, his plate, of an adult whooper, shows it attacking a young alligator.

Nuttall, who could scarcely have had much experience with the species at first hand, describes them as "prowling in the low grounds and rice fields of the Southern States in quest of insects, grain, and reptiles; they swallow also mice, moles, rats and frogs with great avidity. . . ." By inference, a small amount of fish is also included in their diet.

Col. Goss, author of the *History of the Birds of Kansas* (1891), simply elaborated a little on Nuttall's list of food items. "In their food habits omnivorous," he wrote, "feeding freely upon the various kinds of grains, vegetables, plants, bulbous roots, worms, reptiles, mice, grasshoppers, etc." Bent quotes the lists given by Audubon and Nuttall and adds, "In the fall whooping cranes resort to the grain fields and feed among the stubble, with the sandhill cranes, on various kinds of grains. They are also said to eat vegetables, plants, bulbous roots, snakes, frogs, mice, tadpoles, snails, slugs, worms, grasshoppers, and sometimes a few fish."

Samuel Aughey, in a report on the *Nature of*

the Food of the Birds of Nebraska (1878), wrote of the Whooping Crane, "I place it among the list of locust-eating birds because of its known habits and because of the characters of the next species (the Sandhill Crane), to which it seems to be nearly related, though I have obtained no specimens for examination." This, of course, fails to add anything of a definite nature.

In a paper on *Amphibians and Reptiles in Relation to Birds* (1927), Netting states that the Whooping Crane feeds upon snakes, lizards, and frogs. With this addition of lizards to the list we complete our knowledge of the food habits of the species, as contained in the published literature to 1943. Summarized, this meager amount of data may be listed as follows:

Animal Food

worms	frogs
slugs	tadpoles
snails	reptiles (lizards, snakes)
insects (grasshoppers)	moles
fish	mice
	rats

Vegetable Food

bulbous roots	vegetables
plants	grains

There is no indication, beyond Nuttall's rather vague remarks, whether these food items were to be found in the Saskatchewan habitat, the Louisiana marshes, the brackish flats of the Texas Coast or on the high tablelands of central Mexico. Or in all of these widely separated parts of the species' range. As a matter of fact, one suspects that Mr. Nuttall's list is pretty much a result of guess work. He said that "In the winter season, dispersed from their native haunts in quest of subsistence, they are often seen prowling in the low grounds and rice fields, etc." As we now know so well, Whooping Cranes spend most of their time in and around ponds or sloughs that are feeding grounds, resting and preening areas, night roosts and, in fact, "their native haunts," in the fullest sense of the

term. Whooping Cranes do not feed in actual flocks, do not resort to night roosts, along with large numbers of their fellows, do not leave such roosts at dawn, in clamorous bands, to forage throughout the countryside, as the Sandhills do. Except on rare occasions, a pair or family group does not leave the invisible boundaries of its winter territory. Within this territory there is generally a sufficient supply of food to last out the winter months. Possibly the species has been known to feed on every one of the items listed above, but it seems obvious that, so far as published accounts were concerned, no very definite knowledge on the subject existed.

In southwest Louisiana, however, the *Cajun* residents of the marsh and prairie, living on a cultural frontier, had the alert interest and keen observation peculiar to people much in the outdoors and free of the benumbing distractions of city life. These are the same people who have charming and imaginative French names for almost every bird, no matter how small, for every flower and for even the uncommon marsh plants, while their "educated" neighbors in nearby towns scarcely know that these things exist, much less have names for them. It is not surprising that people like these could tell us more about the food habits of the Whooping Crane than was contained in all the books and collections of scientific papers in the Library of Congress! Thanks to the efforts of John Lynch, of the U. S. Fish and Wildlife Service, much of this native knowledge has been collected, translated and made available for use in this report. Some of the food items and feeding habits described apply to Whoopers in the resident group above White Lake and others to migrants wintering on the coastal marshes. Excerpts from Lynch's notes follow:

Nunez (O'Neil Nunez, of Gueydan, Louisiana) thinks that crayfish (*Cambarus* subsp.) were the main food of the Whoopers. He remembers seeing tracks and bill marks around and in crayfish "chimneys" and holes. "The droppings of the cranes were always red after

eating crayfish," he said. This is likewise the case with egrets, ducks and raccoons. He thinks also that small fish and water insects were eaten, after noting the birds walking in shallow marsh, picking here and there in the water. Many aquatic *Odonata* (dragonflies, damselflies), *Coleoptera* (beetles), *Hemiptera* (true bugs, including water-boatmen, backswimmers, etc.), *Diptera* (including larval forms of mosquitoes, flies, midges) would be available in the prairie marsh. Among the plant foods, Nunez is absolutely certain that Whoopers pulled up and ate the white roots of "marsh onion" (*Crinum americanum*), locally called *glaièul*, from the French for gladiola. The small "prairie lily" (*Nothoscordum bivalve*) also was pulled up in spring, and its "onion" (enlarged basal portion) eaten. *Nothoscordum* is abundant on low prairie that is frequently flooded and is known to be a Canada goose food in this region. Whoopers did not seem to bother crops to the extent the Sandhills did, according to Nunez. Sandhills were bad on sprouting grains and sweet potatoes, especially on isolated garden patches. On original prairies, the farm house occupied the highest knoll, and adjacent knolls that were dry enough were farmed. Whoopers were partial to sprouted corn. Sandhills were attracted to new "burns" in the prairie vegetation, and also fed in heavily grazed cattle pastures. Whoopers, on the other hand, used such places but little and preferred the swale marshes, including those that were opened up by cattle.

It should be interpolated here that the above notes refer to an area that "includes the lower limits of the Pleistocene prairies in western Vermilion and eastern Cameron Parishes, between Florence, north of White Lake, and the Mermentau River at its entrance into Grand Lake below Lake Arthur. A series of 'islands' or prairie outcrops surrounded formerly by marsh, extend east to west through the region" (Lynch, *unpubl. notes*). These have names like, *Isle Nid-d'aigle*, *Isle Cordonnier*, *Isle Cerisier*, *Coteau du Chene*, *Isle Perdue* and *Isle Mulet*. The Nunez family have lived in this region for three generations. Cattle raising was the chief occupation for many years, but now the entire area is given over to rice, with the exception of the deepest marshes.

Farther to the east, on both long grass prairie farther inland and brackish marshes near Vermilion Bay, Mr. Delcambre recalls that the Whoopers were migrants that were present in winter only. They came down from the prairie

into the three-square and coco (*Scirpus*) marshes and fed on crayfish (*Gambarus* subsp.) and blue crabs (*Callinectes sapidus*). Delcambre states that they liked "burns" in the *Scirpus* marsh and ploughed fields in the prairie. He also recalled that they ate sweet potatoes, and E. A. McIlhenny told me that they raided the sweet potato fields near Avery Island, which is just east of the Delcambre marshes. Charles Boudreaux, of Abbeville, said that his father recalled them feeding on crayfish (*Gambarus* subsp.) along Bayou Vermilion.

The Whoopers of the coastal *chenieres*, from Grand Chenier to Johnson Bayou, were also winter residents. Duncan Crain recalled that he watched them pulling up the roots of three-square (*Scirpus olneyi*) and "popping cane" (*Spartina alterniflora*). He likewise remembered that they went after sweet potatoes on farms in that vicinity.

From these observations we can add the following details to our data on the food habits of the species:

Animal Food

- crayfish (*Gambarus* subsp.)
- blue crab (*Callinectes sapidus*)
- aquatic insects
 - (probably including:
 - dragonflies
 - beetles
 - water-boatmen
 - backswimmers
 - etc.)
- fresh water minnows

Plant Food

- marsh onion (*Crinum americanum*)
- prairie lily (*Nothoscordum bivalve*)
- three-square (*Scirpus olneyi*)
- popping cane (*Spartina alterniflora*)
- sweet potatoes
- sprouting corn

With the establishment of the Aransas Refuge in Texas, observations of the feeding habits were made by various individuals. In 1943,

James Stevenson published a short article¹²³ that contained the first of his numerous and extremely valuable contributions to our knowledge of the Whooping Crane's food preferences. Following discussion with old residents of the Black-jack Peninsula, where the refuge is located, Stevenson wrote, "Their occasional raids on sweet potato patches near ranch houses made them none too popular with housewives. Generally, though, they preferred to feed on shellfish and mullet (*Mugil cephalus*), which they picked up in the salt marshes and ponds near St. Charles, San Antonio, or Mullet Bays. The sandhill crane, a much commoner bird, usually stayed inland on the prairies or in the brush lands. Mexican cowhands recognized this habitat preference of the Whooper, and, with their penchant for picturesque names, called it *viejo del agua*—the old man of the water."

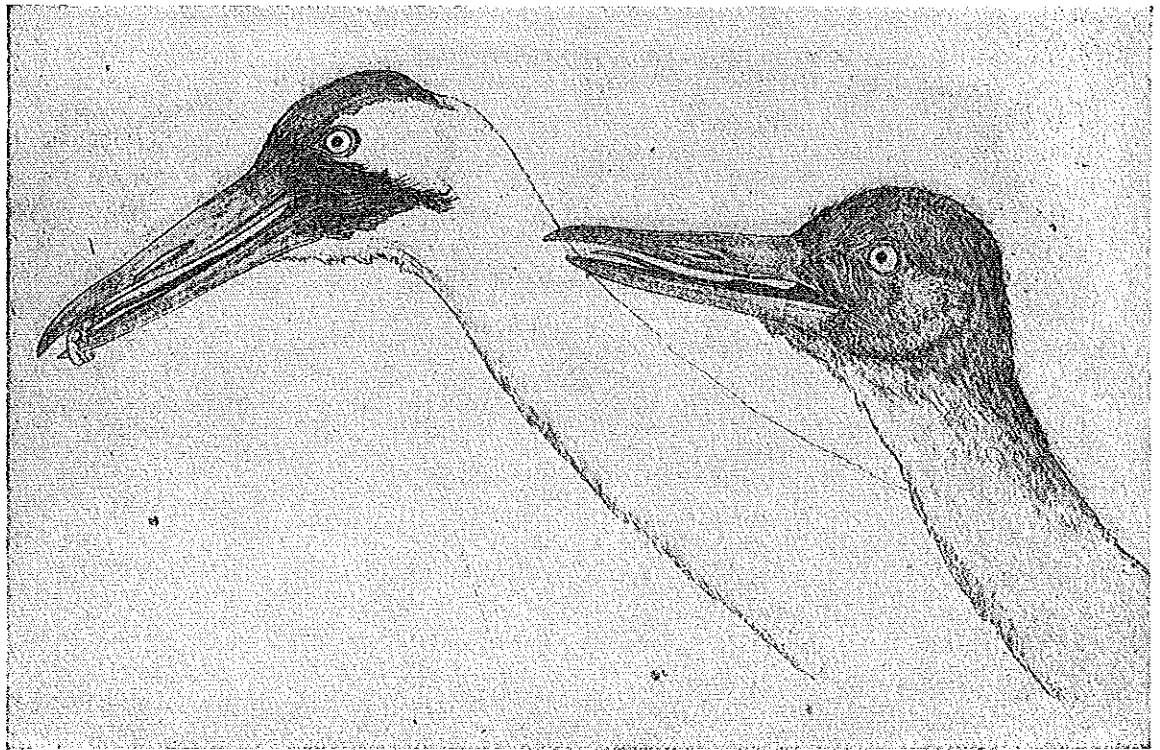
Not mentioned in this article were the previous observations of John Lynch, who had visited Aransas Refuge in the winter of 1939-40. Lynch's unpublished notes (dated December 9, 1939) read as follows:

Two adults and one immature (Whooping Cranes) on Mustang Lake, wading in water from 5 to 10 inches deep, lowering heads at intervals. Tracks followed after birds departed. Bill marks could be observed in holes of clams and burrowing crustacea. One clam (*Ensis* sp.) found freshly opened near new track, but it seems doubtful that cranes could dig many of these deep burrowers. Many burrows inhabited by burrowing crustacea.¹²⁴ If this item is taken in quantities, birds must catch it at mouth of burrow. Marks show bill inserted into burrow 3 or 4 inches, and no burrows dug into. A spade was necessary to collect specimens, which went to the bottom of their holes when disturbed.

On December 11, the same group was seen foraging in 4 to 5 inches of water, this time probing soft bottom ooze. One adult was seen to catch a small crustacean (probably *Callinectes*) and break it up for the immature, which ate the fragments. The other adult caught and ate several items, apparently crustacea, since these were held in the bill for a moment and crushed before being swallowed.

¹²³ Stevenson (1943a; 1943b).

¹²⁴ Probably the burrowing mud shrimp, *Callinassa jamaicensis* var. *louisianensis* Schmitt.



Adult Preparing Food for Its Young.

These observations were a beginning, and, from that winter on, the Whoopers at Aransas were subjected to careful scrutiny, particularly with regard to their feeding habits. Before the results were made available in published form, however, the Whooping Crane Project had been inaugurated and, in December, 1945, Dr. O. S. Pettingill, then in charge of field investigations, was at Aransas for the purpose of preliminary observations and arrangements for a study of the food resources available to the cranes. In his subsequent report (September 18, 1946), he made these original comments:

Adults habitually drink brackish water. Have interesting method of sucking water into mouths.

Fish used extensively for food. Method of fishing similar to methods of herons except that there is no stalking. Believe that fish form a large percentage of food. (The keeper of the Gothenburg captive Whooping Crane relates that the bird will take fish whenever possible, even though grain and other food materials are available.)

Young accept food from adults. Adults "prepare" food and entice young to take it.

Attached to Dr. Pettingill's report was a progress report on the food resources studies begun by Dr. Gordon Gunter, Research Associate of the Institute of Marine Science, University of Texas, and Joel W. Hedgpeth, Marine Biologist, Texas Game, Fish and Oyster Commission. The main results of this contribution will be discussed shortly. Meanwhile, in 1946, the comprehensive and original observations already con-

ducted at Aransas Refuge, chiefly by James O. Stevenson and other U. S. Fish and Wildlife Service personnel, were published under the title, *Winter Life of the Whooping Crane* (Stevenson and Griffith, 1946). This paper, which was revolutionary in its fresh and intelligent approach to the subject, introduced a number of entirely new facts concerning the food and feeding habits of the Whooping Crane. Many of the descriptions of feeding methods and similar details will be included, with my own observations, in the section of this report on *Winter Life*. In general, Stevenson and his associates discovered that a certain amount of data on food habits could be gathered by simple observation. For corroborative material Stevenson collected 17 droppings, which were analyzed by the staff of the Patuxent Research Refuge, principally Francis M. Uhler. These samples, together with others taken in the same general area during our subsequent studies, have given us the most detailed and most certain data on the food habits of the Whooping Crane in that environment. Tables are included that summarize these results, as well as other details on the food of the species, from additional sources.

In the section on *Winter Life* we have gone into ecological considerations of the Aransas habitat in some detail. Free use has been made of the faunal and floral lists supplied by various biologists who have worked on the refuge. Of outstanding value have been the lists prepared, with notes, by Gunter and Hedgpeth, as a result of their studies there in 1946. The numbers, distribution and life history data of the fishes and marine invertebrates of the Aransas area are directly concerned with the food habits of the Whooping Crane. It was necessary to have a rather complete picture of the food items available to the cranes, and also to determine the character of such items in the different types of feeding places, the causes of any fluctuations in numbers that was observed, and other matters affecting the existence of *Grus americana*

in this particular sector of winter range. No similar work of an ecological nature was undertaken elsewhere, due chiefly to the limited amount of time available for field studies. However, some general observations were made in Louisiana, other parts of Texas, the Platte River region in Nebraska and in Canada, and from these we can estimate the probable food resources available in these portions of the range.

In this section it is our chief purpose to describe the actual food habits of the Whooping Crane and now that we have sketched the state of our knowledge up to 1943, and mentioned something concerning the special studies that were conducted at the Aransas Refuge in the next several years, it will be appropriate to explain the methods of study employed. We will then follow with a resumé of the results.

Methods of Study

There were three main methods employed in these food habits studies. Each is described briefly.

(1) *Analysis of Droppings*

Stevenson and Beaty collected a total of 17 faecal droppings of the Whooping Crane and these were analyzed by the staff of the Patuxent Research Refuge, principally Francis M. Uhler. Between February 13, 1947 and January 22, 1948, we obtained 18 faecal droppings and these have been reported on by Mr. Uhler. We found that it is difficult to collect droppings in ponds or other water areas, as the material is scattered and mixed with the soft mud of the bottom. In "preening sites," usually heavy growths of *Distichlis spicata* on banks of ponds, the faecal material is difficult to locate. We had our greatest success in "burns," where the birds congregated after feeding in the salt flat pond environment, and where it was relatively easy to watch their movements and pick up droppings very shortly after they were deposited. In fresh burns,

we soon learned that it is a simple matter to distinguish Whooping Crane droppings from those of other birds in the area—meadowlarks, cowbirds and geese, etc. Sandhill Cranes were not abundant on the refuge during that winter, and we were unable to locate these birds in the same area, so as to obtain faecal samples for comparison. The Whooper droppings that we secured were alike in general characteristics: either pinkish-gray or pinkish-olive in color, less often green with pinkish material included. They averaged 10.3 cc. before washing. Except for minute hard particles, the fresh droppings were moderately soft and without specific form. They spread out on the ground over an area that would approximate a diameter of 75 mm., on the average. Probably the pinkish cast would not be present except when the food included crustaceans such as *Callinectes* sp. or prawns (*Palaemonetes*).

(2) Observation of Feeding Birds

Although considerable information has been obtained by observing feeding birds, this is a difficult method owing to the lack of opportunities for close approach. Blinds are one way of overcoming this, but more often than not, the difficulties are only increased because feeding birds may walk directly away from a blind and not return. They are not inordinately suspicious of blinds, but the salt flats are so extensive and the feeding areas so numerous, that it is almost impossible to place a blind one day, enter it before dawn the next, and do so with any assurance that the birds will come within a mile of the location!

Sometimes, under favorable conditions, it is possible to "crawl" feeding birds. But even at 50 or 75 yards it is not easy to determine what they are feeding on.

(3) Inspection of Feeding Ponds, etc.

We learned that the Whoopers on Aransas

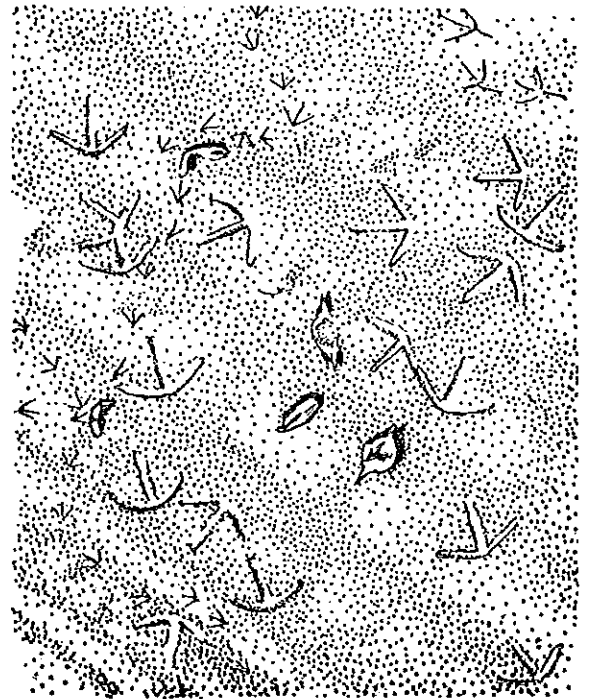
Refuge resort to water areas for most of their feeding. These water areas may be ponds indirectly connected with outside bays, flooded pastures, or other types of water. Each type supports a variety of animals, and to a lesser extent, plant life. The character of the water area determines the variety and quantity of its animal population, and the presence or absence of aquatic plants. A separate study of pond, lake and slough types was undertaken and the results are discussed in *Winter Life*.

This method of investigating the feeding habits consisted of selecting typical water areas and obtaining a quantitative estimate of their organic contents. Quantitative records have been presented elsewhere (see *Winter Life*).

We also discovered that Whooping Cranes employ different feeding methods for different kinds of prey. Thus, when taking blue crabs

Track Pattern When Feeding on Blue Crabs.

(Drawing by Kay G. Morton)



(*Callinectes* sp.) they move around in circles, as it were, while in probing for mud shrimps (*Callinassa jamaicensis* var. *louisianensis*) or marine worms (*Nereidae*) they stalk shallow edges of ponds in single file. We were able to determine from inspection of an area in which cranes had been feeding the previous day, what the nature of their prey had been.

The following tables summarize the results of all droppings analyses, including those made of the material collected by Stevenson, which has already been described (Stevenson and Griffith, 1946, Table 2, p. 172).

TABLE M: Summary of Droppings Analyses

Number of Samples	Date Collected	Location	Contents	%
4	1-30-40 3-1-40 (J.O.S.)	Mustang L. & False Liveoak Point	Fragments of blue crab (<i>Callinectes</i> sp.)	1
			Many fragments of many pelecypods, apparently chiefly short razor clams. (<i>Togallus gibbus</i>)	09
			Fish bones, trace	..
			Shoalgrass? (<i>Halodule</i> , sp.), trace	..
1	12-1-40 (J.O.S.)	Cape Carlos	Fragments of acorns (<i>Quercus</i> sp.)	100
3	1-23-41 (J.O.S.)	Rattlesnake Point	Fragments of blue crab, <i>Callinectes (sapidus?)</i>	4
			Fragments of pelecypod (razor clam, <i>Solen?</i>)	95
3	1-23-41 (J.O.S.)	Cape Carlos	Fragments of blue crab, (<i>Callinectes</i> , prob. <i>sapidus</i>) and a smaller-sized crab; fish scales (unidentified)	100
0	1-24-41 (J.O.S.)	½ mi. east of Brahamas Well	Numerous fragments of blue crab, <i>Callinectes (sapidus?)</i> and a smaller-sized crab	60
			Fragments of razor clam (<i>Solen?</i>)	20
			Bones of fish, resembling mullet (<i>Mugil</i> sp.)	20
2	2-18-47 (R.P.A.)	Dunham Pond	Fragments of blue crab (<i>Callinectes</i> sp.)	70
			Small cycloid fish scale, trace	..
			White, woody shreds from fresh stems of salt flat cranberry (<i>Lycium carolinianum</i>)	30
			Glumes of saltgrass (<i>Distichlis spicata</i>), trace	..
2	2-28-47 (R.P.A.)	Carlos Field	Fragments of blue crab (<i>Callinectes</i> sp.)	94
			Amphipods? traces	..
			Remains of at least two species of snails, chiefly <i>Cerithidea</i> sp.	2
			Killifish (<i>Poeciliidae</i>), traces	..
3	2-28-47 (R.P.A.)	Carlos Field	Fragments of tubers of <i>Cyperus</i> sp. (not "chufa")	4
			Bits of charred vegetable debris	..
			Rough, light colored gravel*	..
			Fragments of several blue crabs (<i>Callinectes</i> sp.)	95
			Remains of at least 5 snails (<i>Cerithidea</i> sp.)	2
			Few fragments of a killifish (<i>Poeciliidae</i>), trace	..
			Fragments of acorns (<i>Quercus</i> sp.)	3
			Bits of charred grass (debris)	..
1	3-3-47 (R.P.A.)	Middle Pond	Fragments of blue crab (<i>Callinectes</i> sp.)	100
2	3-4-47 (R.P.A.)	Camp Pond	Fragments of blue crab (<i>Callinectes</i> sp.)	65
			Finely broken clam shells (<i>Pelecypoda</i>) too fragmentary to identify further	20
			Finely ground green leaves resembling <i>Lycium carolinianum</i>	15
			Green grass leaves (<i>Graminae</i>), traces	..
1	1-20-48 (R.P.A.)	Brush above Camp Pond	Acorn fragments (<i>Quercus</i> sp.)	95
			Crayfish fragments (<i>Cambarus</i> sp.)	4
			Fragments of praying mantid (<i>Mantidae</i>) egg-mass	1
1	1-20-48 (R.P.A.)	Brush above Camp Pond	Acorn fragments (<i>Quercus</i> sp.)	80
			Crayfish fragments (<i>Cambarus</i> sp.)	20
			2 mandibles of Polychaeta worm, trace	..
			Beakrush (<i>Rynchospora</i> sp.), trace	..
1	1-20-48 (R.P.A.)	Brush above Camp Pond	Acorn fragments (<i>Quercus</i> sp.)	60
			Blue crab fragments (<i>Callinectes</i> sp.)	35
			Crayfish fragments (<i>Cambarus</i> sp.)	5
			One other crustacean, trace	..
			Few mollusc fragments with grooved interior resembling <i>Melampus</i> sp., ear snail, trace	..
1	1-20-48 (R.P.A.)	Brush above Camp Pond	Acorn fragments (<i>Quercus</i> sp.)	85
			Crayfish fragments (<i>Cambarus</i> sp.)	10
			Blue crab fragments (<i>Callinectes</i> sp.)	5
			<i>Mantidae</i> egg-mass fragments, trace	..
1	1-20-48 (R.P.A.)	Brush above Camp Pond	Blue crab fragments (<i>Callinectes</i> sp.)	65
			Acorn fragments (<i>Quercus</i> sp.)	30
			Crayfish fragments (<i>Cambarus</i> sp.)	5
			Few mollusc fragments with grooved interior resembling aperture of <i>Melampus</i> sp., ear snail, trace	..
1	1-20-48 (R.P.A.)	Brush and swales West of Salada Well	Blue crab fragments (<i>Callinectes</i> sp.)	70
			Acorn fragments (<i>Quercus</i> sp.)	28
			Crayfish fragments (<i>Cambarus</i> sp.)	2
1	1-22-48 (R.P.A.)	Brush and swales West of Salada Well	Acorn fragments (<i>Quercus</i> sp.)	95

			Crayfish fragments (<i>Cambarus</i> sp.).....	4
			Cycloid fish scales and few bone fragments, possibly <i>Pundulus</i> sp.....	1
			Charred seeds of <i>Paspalum</i> sp. and <i>Croton</i> sp., traces	..
1	1-22-48	Brush and swales (R.P.A.) West of Salada Well	Acorn fragments (<i>Quercus</i> sp.).....	100
			Crayfish (<i>Cambarus</i> sp.), trace.....	..
			Water scavenger beetle (<i>Tropisternus</i> sp.), trace.....	..
			Spikerush (<i>Eleocharis</i> sp.) seed, trace.....	..
35				1799

Analysis of Droppings

Each sample analyzed in *Table M* represents one Whooping Crane dropping. Where the number of samples given for a single analysis is more than one, samples were bulked together and the volume of the contents considered as a whole unit. All locations are on the Aransas National Wildlife Refuge, in Aransas County, Texas. Descriptions of contents are essentially as reported by the laboratory. Initials following "Date Collected" refer to the collectors ("J.O.S.," James O. Stevenson; "R.P.A.," Robert P. Allen).

The summary of the contents of these 35 Whooping Crane droppings gives us definite and valuable data on the food habits of the species. However, a quantitative evaluation of the items concerned is made difficult because of the unknown degree to which the digestive processes work on each different item. For this reason additional tabulations have been prepared, designed to breakdown the information in *Table M* so as to discover all possible clues to the quantitative relationships involved. The first of these (*Table N*) shows the number of times outstanding items were found in samples, and the percentage of such occurrence. The percentages of the volume of contents for each item are totaled and then the average percentage of volume figured for each of the sixteen items listed. Finally, the relative value of each item is figured, in terms of its percentage of the total volume of contents for all samples.

TABLE N: Relative Values of Food Items Identified in Droppings

Food Item	Number of times found in samples	% of occurrence in samples	Total of percentages by volume	Average % of volume per sample	% of total volume of all samples
1. Blue Crab.....	30	85%	761%	58%	42%
2. Acorns.....	10	28%	670%	67%	37%
3. Razor Clam.....	13	37%	214%	71%	11%
4. Crayfish.....	8	22%	50%	6%	2%
5. Salt Flat Cranberry.....	2	5%	45%	37%	2%
6. Other Pelceypods.....	2	5%	20%	20%	1%
7. Fish.....	19	54%	21%	3.5%	1%
8. Grass (<i>Graminiae</i>).....	2	5%	30%	30%	1%
9. Snails (<i>Cerithidea</i>).....	5	14%	4%	2%	0.2%
10. Sedge (<i>Cyperus</i>).....	2	5%	4%	4%	0.2%
11. Mantis egg-mass.....	2	5%	1%	0.5%	0.05%
12. Amphipods.....	1	2%	trace	trace	trace
13. Snail (<i>Melampus</i>).....	2	5%	trace	trace	trace
14. Polychaeta Worm.....	1	2%	trace	trace	trace
15. Water Scavenger Beetle.....	1	1%	trace	trace	trace
16. All other plants and grasses.....	7	20%	trace	trace	trace
					97.45+%

While this last category is interesting, from a standpoint of comparative volume, it does not necessarily indicate relative preference. Perhaps preference is more nearly demonstrated by the arrangement in *Table O*. Here the items are listed in the order of their occurrence in the samples, and the percentage of such occurrence is given. Since over one-half of the samples were bulked together and analyzed in groups of 2 or 3 it has not always been possible to determine accurately whether or not a given item actually occurred in every such sample. For this reason the results in this tabulation, while of obvious value, are not decisive.

As still another manner of determining relative value, and perhaps some degree of preference, *Table P* presents the various items in the order of the number of times each is listed, in the analysis reports.

It is seen that the blue crab (*Callinectes sapidus*) is at the top of all three listings. Acorns (*Quercus* sp.), razor clams (*Tagellus gibbus* and *Solen* sp.) and crayfish (*Cambarus* sp.) remain in the first five on all three counts, while fish are near the top of two of the lists and the salt flat cranberry (*Lycium carolinianum*) occurs in fifth place in *Table N*.

It should be obvious that a detailed knowledge of the distribution and abundance (i.e.,

The Smallest Frog Is Not Overlooked.

(*Photograph of Captive Birds in Texas by Dr. R. T. Congdon, 1950*)



A Whooping Crane Family Group on Their Territory: Late Winter.

(Photograph of Wild Birds in Texas by Allan D. Cruickshank, January, 1948)



The Male of the Pair (Right) Is Slightly Larger and More Alert.

(Photograph of Wild Birds in Texas by Allan D. Cruickshank, January, 1948)



the availability) of the food animals and plants of the area, as well as an intimate understanding of the feeding methods and habits of the cranes themselves, is essential to a final interpretation of this data. For example, the two razor clams mentioned were of some importance in 1940 and 1941 but do not appear again (unless the "other

TABLE O: Comparison of Food Items on Basis of Number of Occurrences in Droppings Samples

Food Item	Number of times found in samples	% of occurrence in samples
1. Blue Crab.....	30	85%
2. Fish.....	19	54%
3. Razor Clam.....	13	37%
4. Acorns.....	10	28%
5. Crayfish.....	8	22%
6. Other plants & grasses.....	7	20%
7. Snails (<i>Cerithidea</i>).....	6	14%
8. Other Pelecypods.....	2	5%
9. Snail (<i>Melampus</i>).....	2	5%
10. Praying Mantis egg mass.....	2	5%
11. Salt Flat Cranberry.....	2	5%
12. Grass (<i>Graminiae</i>).....	2	5%
13. Sedge (<i>Cyperus</i>).....	2	5%
14. Amphipods.....	1	2%
15. Polychaeta Worm.....	1	2%
16. Water Scavenger Beetle.....	1	2%

TABLE P: Food Items Arranged by Number of Times Listed

1. Blue Crab.....	13
2. Acorns.....	10
3. Fish.....	8
4. Crayfish.....	4
5. Razor Clam.....	4
6. "Smaller-sized Crab".....	2
7. Snails (<i>Cerithidea</i>).....	2
8. Egg mass of Praying Mantis.....	2
9. Snail (<i>Melampus</i> sp.).....	2
10. Salt Flat Cranberry.....	2
11. Charred vegetable debris.....	1
12. Unidentified Crustacean.....	1
13. Water Scavenger Beetle.....	1
14. Shoalgrass? (<i>Halodule?</i>).....	1
15. Amphipod?.....	1
16. Sedge (<i>Cyperus</i>).....	1
17. Grass (<i>Graminiae</i>).....	1
18. Beakrush (<i>Rynchospora</i> sp.).....	1
19. <i>Paspalum</i> sp.....	1
20. <i>Croton</i> sp.....	1
21. Saltgrass (<i>Distichlis spicata</i>).....	1
22. Gravel.....	1

Pelecypods," too broken for determination, were of these forms, and these may have been dead shells taken in place of gravel). In those earlier years I was on this same area studying the Roseate Spoonbill. Razor clams were reasonably abundant and live specimens were collected. Yet, in 1946 Hedgpeth found no live specimens, nor did I discover any during the two following winters (1946-47 and 1947-48). From the tabulations it would appear that the Whooping



(Drawing by Kay G. Morton)

Crane no longer fed on razor clams. Actually, these molluscs have apparently disappeared from the Aransas habitat, possibly as the result of environmental changes that we have not discovered. Perhaps the dredging of a canal 12 feet in depth through a considerable portion of the area has been a contributing factor, or oil exploration and drilling activities nearby and the presence of leaky oil barges in the canal may enter into the picture. At any rate, the razor clam is now extremely scarce and may have disappeared in that region.

Many seemingly minor food items, viewed from a basis of these droppings reports, may have far greater value as Whooping Crane food than the data indicates. Other items, that appear of some possible importance in these tables, can have but minor significance in actuality; in order to separate them from the rest we must know their distribution and abundance on the area, as well as something of the daily habits of the cranes. It will be necessary, therefore, to examine the food habits from additional angles.

Direct Observation of Feeding Cranes

Some very satisfactory evidence of types of food taken can be obtained by direct observation of feeding birds. Because, generally speaking, it is difficult to get close to Whooping Cranes in the wild, this kind of data is limited. Nevertheless, thirteen of the 22 items listed, as a result of direct observation, do not appear in the summary of droppings contents. These observations are from Stevenson and Griffith (1946) and the verbal accounts of Beaty, Keefer, Pettingill, Tisdale and our own observations of recent date. The following items were reported. All reports were from locations on the Aransas Refuge, with

Animal Food

- | | |
|----------------------|---------------------------|
| 1. Pistol Shrimp | 6. Mullet sp. |
| 2. Mud Shrimp | 7. Other Fish sp. |
| 3. Blue Crab | 8. Cottonmouth Moccasin |
| 4. Common Periwinkle | 9. (Clark's?) Water Snake |
| 5. Grasshopper sp. | 10. Ducklings sp. |

Vegetable Food

- | | |
|------------------------------|--------------------------|
| 7. Glasswort sp. | 1. <i>Paspalum</i> sp. |
| 8. Saltwort | 2. <i>Andropogon</i> sp. |
| 9. Oats sprouts | 3. Grass shoots sp. |
| 10. Yellow corn | 4. Acorns of Live oak |
| 11. Grains (wheat, sorghums) | 5. Acorns or Pin oak |
| 12. Potatoes | 6. Acorns of Blackjack |

the exception of the ducklings, which were taken from a Whooping Crane shot in Manitoba.

Inspection of Feeding Ponds, etc.

Feeding birds were nearly always observed in water, either in a pond or along the shallow edge of a bay or in flooded pasture (temporary prairie swales). Eventually, as our studies of the various types of water habitats progressed, we were able to learn something of the feeding habits by inspection of such areas after the cranes had departed. Our ecological studies of ponds and other water areas had acquainted us with the character of their major animal populations. After watching cranes feed in a given area, we would check the location. Sometimes, in the soft mud of typical "yellow" or "trap" ponds the great tracks of *Grus americana* would appear in a confused pattern of circles and irregular tangents. Here and there would be a broken carapace of *Callinectes* and two hard chelipeds, disconnected and lying in the mud and shallow water just as they had fallen when broken off. Here the great birds had fed on blue crabs, digging them out of their burrows, grabbing them as they sought to escape by running off in their skittish, sidewise manner. The whole story, from beginning to end, lay before us in a characteristic diagram.

In other ponds, especially those having some connection with the outside bays ("green" ponds), the shoreline is a little firmer and the mud is mixed somewhat with sand. On the edge of such ponds the large population of marine worms (*Nereidae*) is indicated by the great number of open holes or burrows in the bottom. In one such location of average burrow density, we



(Drawing by Kay G. Morton)

took samples and after painstaking counts, estimated the Annelid population at 200 worms per cubic foot of mud. That means over 8,700,000 worms per surface acre of similar bottom, of which there are literally hundreds of acres in the whole pond complex. There are also mud shrimps (*Callinassa jamicense* var. *louisianensis*) in this type of bottom, but we were unable to obtain any quantitative estimates. Shorebirds, waterfowl and fish take these worms as food, but it never occurred to us that the Whooping Crane would be interested in food of such small individual size. However, we watched cranes treading slowly and cautiously along such shorelines as these and probing briefly with their bills. Inspection of the tracks showed that the birds had walked in a fairly straight line, pausing to turn slightly and probe to right or left. The bill marks were plainly indicated, the whole pattern precise, delicate and evidently predetermined by the character of this sort of pond edge. The highly chitinized mandibles of the *Nereidae* are very resistant to digestive action, according to Mr. Uhler, and they have been found in the droppings samples, although not in the quantity in which they are probably eaten.

Using these methods, we were able to determine the relative value of certain types of water habitats to the cranes at the time the observations were made. It seems certain that in all types the value in food resources will shift, both as to emphasis on different animal forms and in their quantity and availability as food. An understanding of the water habitat on the crane

wintering range is essential to an appreciation of this whole question of food and feeding habits. Detailed discussion of these matters is included in the section on *Winter Life*.



Track Pattern When Feeding on Marine Worms.
(Drawing by Kay G. Morton)

*The Food of the Whooping Crane
on the Winter Range*

From these studies we have learned something fairly definite about the food and feeding habits of the Whooping Crane in certain habitats in Texas and, to a lesser extent, in Louisiana. We can only speculate as to these habits in other sectors of the winter range: the more arid region on the King Ranch, the delta country at the mouth of the Rio Grande and the high tablelands of the interior, including the central plateaus of Mexico. From this glimpse of the general nature of the species' food preferences, however, we gain at least an impression of the character of its food, regardless of the locale. The Whooper is more aquatic in its habits than the Sandhill Cranes and seems to have a far greater preference for animal foods. By comparison, the Lesser Sandhill is reported as feeding on grain and *Sagittaria* "bulbs" on the winter range in California (Grinnell, Bryant and Storer, 1918); bulbous rootlets, foliage of young plants and barley in Nevada (Fisher, 1893) and largely on berries and grass, with a few insects and possibly mice, on the breeding grounds in Alaska (Grinnell, 1900). Writing of the Florida Sandhill, N. B. Moore said (quoted in Bent, 1926), "In six stomachs, opened by me at varying times of the year, I was unable to designate any portion of the contents, but in no one did I discover any sign of animal food."

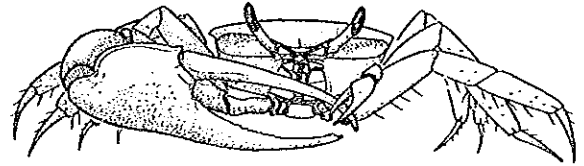
The closely related limpkins and rails, on the other hand, feed on molluscs, crustaceans, frogs, lizards, worms, aquatic insects, small fish and, in the main, items that nearly duplicate the food of the Whooping Crane. It is interesting to speculate that all of the so-called cranelike birds, the *Gruiformes*, may have sprung from common ancestors having similar food habits. Undoubtedly the primordial habitat was aquatic in nature, but some of the subsequent races have come out of the ponds and sloughs to a large extent, as have the Sandhill Cranes, and by their greater adaptability, particularly with regard to

the limits of their choice of food, are today the more successful races in the Order.

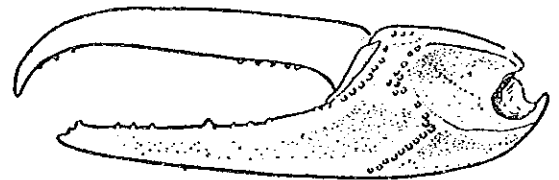
Following is a list of animals and plants that we have established, with reasonable certainty, as food items taken by the Whooping Crane on the winter range in parts of Texas and Louisiana. In a sense, these individual items are only *indicators*. For example, only three fishes are

(Drawing by Joel W. Hedgpeth)

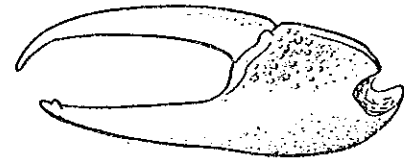
Uca pugilator



Uca pugnax



Uca pugilator



listed, but Dr. Gordon Gunter (1950a) found 58 species of fish in waters within the Whooping Crane habitat on the Aransas Refuge, many of which may be taken as food, at one time or another.

Animal Food

Annelida

- Polychaeta** (Amphipod)
 1. *Neanthes succinea* (Frey and Leuckart).
 *2. *Laonereis culveri* (Webster).
 3. *Notomastus* sp.

Arthropoda

Crustacea

4. *Amphipoda* (traces of Amphipod (?) in drop-pings).
 *5. *Crangon helerochaelis* (Say) Pistol Shrimp.
 *6. *Callinassa jamaicensis* var. *louisianensis* Schmitt Mud Shrimp.
 *7. *Callinectes sapidus* Rathbun Blue Crab.
 8. *Uca pugilator* (Bosc) Common Fiddler Crab.
 *9. *Cambarus hedgpethi* Hobbs Hedgpeth's Crayfish.
 10. *Cambarus* sp.

Insecta

11. *Odonata* (unidentified dragonflies).
 12. *Phasmomantis carolina* Praying mantis.
 13. *Locustidae* (unidentified grasshoppers).
 14. *Hemiptera* (including *Notonectidae*, back swimmers; *Belostomatidae*, giant water bugs; *Corixidae*, water boatmen.)
 15. *Diptera* (larval and nymph forms of flies, midges, etc.)
 16. *Coleoptera* (various aquatic beetles, including *Hydrophilidae*, water scavenger beetle.)

Mollusca

Pelecypoda

- *17. *Tagellus gibbus* (Spengler) Short Razor Clam.
 *18. *Solen (viridis?)* Green Razor Clam.

Gastropoda

19. *Littorina irrorata* Say Common Periwinkle.
 20. *Melampus coffeus* (Linn.) Ear Snail.
 21. *Cerithidea* sp.

Chordata

Pisces

22. *Fundulus* sp. (possibly *F. similis*) (Baird and Girard) Black Chub.
 23. *Cyprinodon variegatus variegatus* Lacépède Sheepshead Minnow.
 24. *Mugil cephalus* Linnaeus Striped Mullet.

Amphibia

25. *Rana pipiens berlandieri* Leopard Frog.

Reptilia

26. *Aghistrodon piscivorus* Cottonmouth Moccasin.
 27. *Natrix sipedon clarkii* Clark's Water Snake.

Aves

28. *Anatinae* (stomach of Whooping Crane killed in Manitoba contained several small ducklings, probably from this group.)

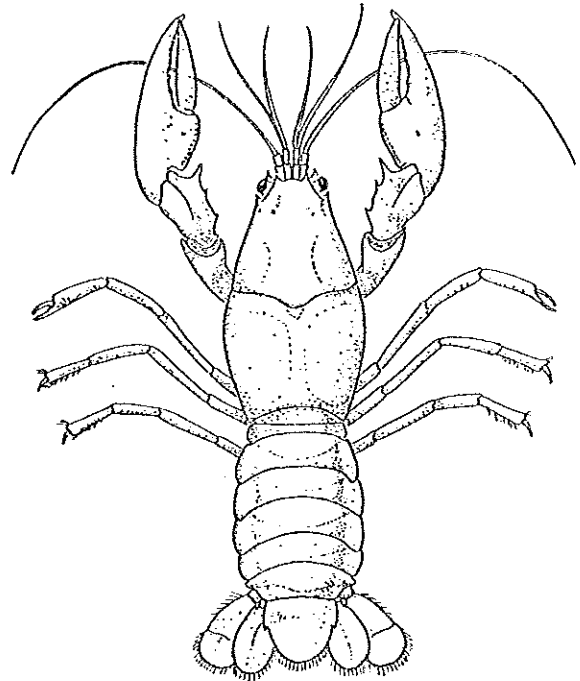
Vegetable Food

1. *Halodule (wrightii?)* Shoalgrass.
 2. *Paspalum* sp. Jointgrass.
 3. *Andropogon* sp. Broomgrass.
 4. *Spartina alterniflora* Loisel Popping Cane.
 5. *Distichlis spicata* (L.) Greene Saltgrass.
 6. *Gramineae* sp. Manna-grass.
 7. *Cyperus* sp. Galingale.
 8. *Scirpus olneyi* A. Gray Three-square Rush.
 9. *Rynchospora* sp. Beakrush.
 10. *Nothoscordum bivalve* (L.) Britton. Prairie Lily.
 11. *Crinum americanum* L. Marsh Onion.
 12. *Quercus virginiana* Mill. Live-oak.
 13. *Quercus myrtifolia* Willd. Pin oak.
 14. *Quercus marilandica* Muench Blackjack Oak.
 15. *Salicornia (bigelovii?)* Glasswort.
 16. *Batis maritima* L. Saltwort.
 17. *Lycium carolinianum* Walt Salt Flat Cranberry.

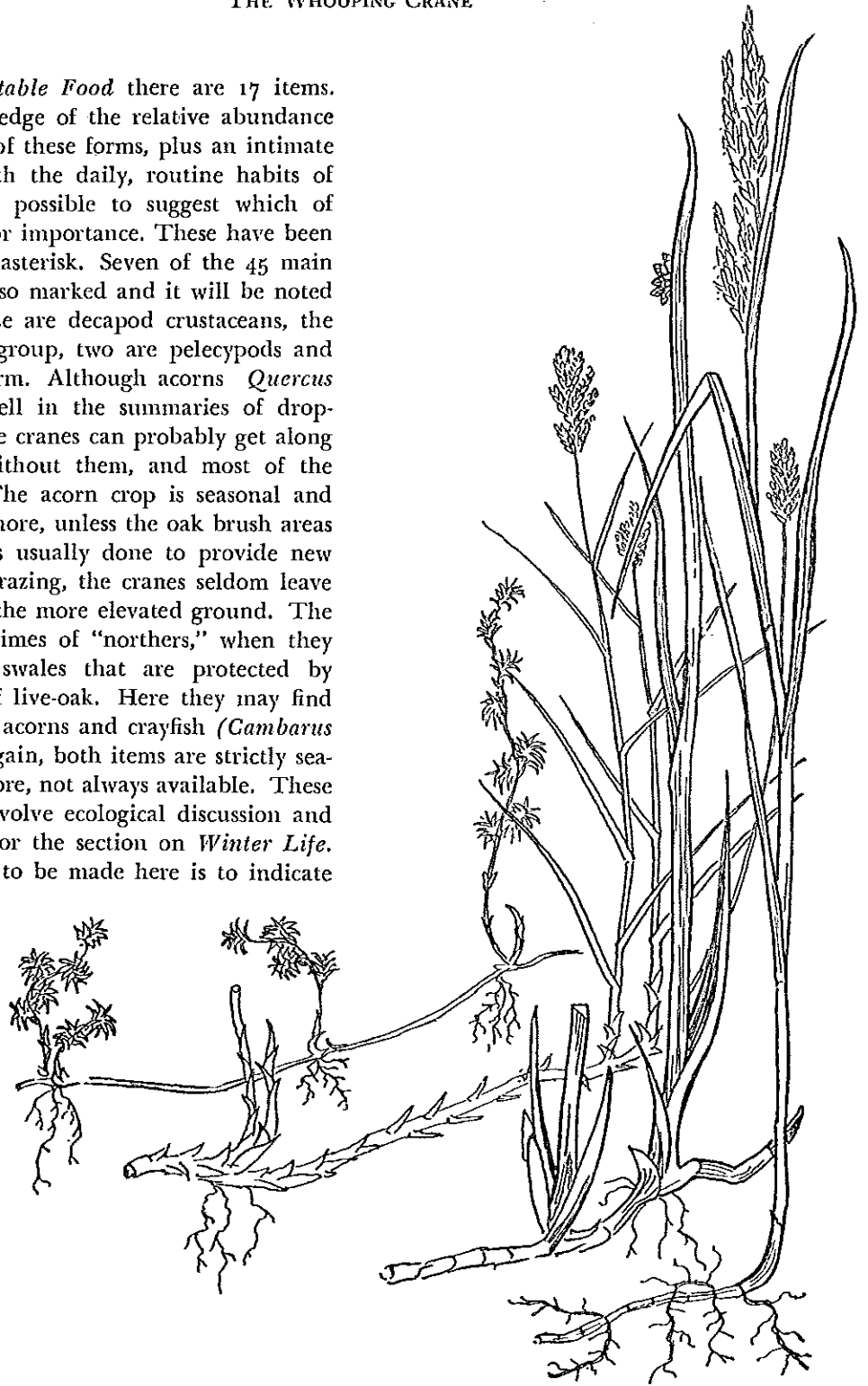
Under *Animal Food* there are 28 items listed

The Most Abundant Crayfish on the Present Winter Range of the Whooping Crane is a New Species, *Cambarus hedgpethi*, Recently Described by Dr. H. H. Hobbs.

(Drawing by Joel W. Hedgpeth)



and under *Vegetable Food* there are 17 items. From our knowledge of the relative abundance and availability of these forms, plus an intimate acquaintance with the daily, routine habits of the cranes, it is possible to suggest which of these are of major importance. These have been marked with an asterisk. Seven of the 45 main items have been so marked and it will be noted that four of these are decapod crustaceans, the most important group, two are pelecypods and one a nereid worm. Although acorns (*Quercus* sp.) show up well in the summaries of droppings analyses the cranes can probably get along perfectly well without them, and most of the time they do. The acorn crop is seasonal and erratic. Furthermore, unless the oak brush areas are burned, as is usually done to provide new grass for cattle grazing, the cranes seldom leave the salt flats for the more elevated ground. The exception is in times of "northers," when they seek shelter in swales that are protected by heavy growths of live-oak. Here they may find equal interest in acorns and crayfish (*Cambarus* sp.), but, once again, both items are strictly seasonal and, therefore, not always available. These considerations involve ecological discussion and this is reserved for the section on *Winter Life*. The main point to be made here is to indicate



(Drawing by
Kay G. Morton)

the extent of our present knowledge of the species' food habits. However, this discussion is for the most part limited to the food itself. Daily schedules, manner of feeding on different types of food, and similar descriptive material, fits in more naturally with the narrative account of the winter existence.

There are excellent reasons why the decapods are of the most important food of the Whooping Crane on the Aransas area. The shallow ponds, sloughs and narrow tidal estuaries of this brackish, transitional environment are the natural home of these highly organized crustaceans. Hedgpeth (1950) found that "more than 50 per cent of the invertebrate fauna of this area is composed of decapod crustaceans." This situation is discussed in the section that follows.

Many of the relatively small animal forms on our list may be more important than our present information indicates. The nereid worms are one example and the aquatic insects, mantis egg masses, dragonflies and grasshoppers are others. The difficulty of watching the feeding activities of the Whoopers at close range was solved, however, when we established captive birds within a large enclosure. Captive Whoopers lose their fear of the human animal very quickly and we have been able to observe their feeding from a distance of only a few yards. Insects are often pursued, the larger forms, like dragonflies and grasshoppers, in particular. In the course of a day many of them must be eaten, but no evidence shows up in analyses of droppings. It should be noted that our list of insects is merely a suggested grouping, based entirely on observation. From what we have seen, however, it is doubtless safe to assume that all of these, and a good many others, are more or less regular items in the diet.

Although, when available, razor clams were evidently an important food, small gastropods like the common periwinkle and the ear snail do not seem to be much sought after. Yet, these, and a half dozen or more additional varieties of gastropods, are fairly abundant on the salt flats

or in the tension zone that lies between the 3-foot contour and the fully developed oak mottes of the higher ground.

Fish bones and scales show up well in the droppings but two winter's observations of the cranes did not suggest that fish are a major food. A good many are taken it is true, but blue crabs, mud shrimps and other decapods are taken first and apparently by preference. Whooping Cranes will stride through a school of mullet in the water almost to their bellies to reach a shallow area where decapods are readily captured in the mouth of their burrows or in the soft mud of the bottom. The depth of water and the relative agility of the prey must be factors of some consequence, but the cranes will also hunt mud shrimp (*Callinassa*) and pistol shrimps (*Crangon*) in water of such depth that they must feed with their heads submerged. Under certain conditions of water depth and the availability of the prey, mullet are captured and also the much smaller killifishes, such as the abundant sheepshead minnow (*Cyprinodon*). But the decapods, more abundant and more easily secured, are first on the list.

Like insects, reptiles seem to be chance prey, taken when an opportunity is offered and the crane is not occupied with other matters. I have seen one of the captive birds walk around a diamond-backed rattlesnake (*Crotalus atrox atrox*) and then turn and feint at it, wings flapping, bill thrust forward in a purely mock attack, the bird leaping gingerly off the ground. But it never showed any intention of attacking this particular snake with serious intent. On the other hand, the same bird later was observed feeding on a fairly large cottonmouth moccasin (*Agkistrodon piscivorous*) that it had evidently killed. After beating the anterior end of the snake to a pulp, the entire creature was swallowed, end for end. And this is the same bird that picks delicately at the tiny egg mass of a praying-mantis and eats it as casually as it does a two-foot snake. There are some 30 kinds of reptiles on the Aransas area: alligators, turtles,

lizards, skinks, chameleons and snakes. Most of them are snakes. But only a limited number of these are found in that part of the refuge usually inhabited by the Whoopers.

It is possible that frogs are a more important food than our records indicate, but they are seasonal in their abundance and not always available. Also, the cranes must leave the salt flats and feed in the upland swales or borrow ditches if they are to obtain frogs. There are at least six kinds of frogs and toads on the entire Aransas area, some of them, like *Rana pipiens berlandieri*, extremely abundant for limited periods, but it seems doubtful if they are other than a sort of auxiliary food. In the Louisiana prairies and fresh water marshes it would have been a different story.

I have seen young Whooping Cranes, perhaps six months old, attempt to capture birds. One such youngster grabbed several times at boat-tailed grackles, without success, and then stalked a group of mallards, green-winged teal and pintails. He seemed to be after the teal, and they had to fly to escape him, but it must be said that he did not even come close to capturing them. Nevertheless, it is not surprising that a Whooping Crane stomach contained several downy young of one of the pond ducks. People with whom I talked in Louisiana recalled that captive Whoopers were always a pest around the farm because of their liking for young chickens. Such cranes would be wing-clipped and so would chase and run down the flightless half-grown chicks on foot. There were a number of independent testimonies as to this habit.

For the most part we have considered food animals that are eaten, or that may be eaten, by the wintering Whooping Cranes on the Aransas Refuge area in Texas. We have less detailed information for the Louisiana habitat, but we can safely conjecture that while decapods may have been important to the cranes wintering in brackish marshes on the coast, the fresh water swales, including those of the prairies, produced other forms that replaced the blue crab and the

mud shrimp as primary food items. Among these were certainly crayfish and frogs, as well as other aquatic animals, but the chief difference was in the abundance of edible plants like the marsh onion (*Crinum*) and the prairie lily (*Nothoscordum*). In Louisiana, away from the sea-rim and brackish coastal marshes, vegetable food was probably of considerable importance. In the Texas environment, vegetable items seem to be taken, for the most part, in a very casual manner and not in quantities. Obviously, this is because of the relative absence of bulbous or tuber-bearing plants in a brackish habitat. We can add nothing as to food on interior wintering locations, as on the high tablelands of Central Mexico. As for the lagoons and estuarine environments of the King Ranch and the Rio Grande Delta, we would expect to find much the same transitional forms of life as we have in the Aransas waters, with significant differences in relative abundance, seasonal fluctuations, etc. These differences are tied in closely with the original winter distribution of the Whooping Crane on the Gulf Coast, but it is too late now to gather the data that would help us to understand it fully. Thus, without detailed information regarding the food of the major group of wintering Whoopers on the Louisiana prairies, we must base our conclusions on the habits of the Texas birds. At the same time we can state, with reasonable certainty, that for the species as a whole, vegetable food, while not as important as animal food, was more of an item in the diet than the current Texas evidence indicates.

The Food of the Whooping Crane During Migration

In the long migration trek across a large portion of the continent, what do the Whooping Cranes feed on? We know that stops are made on mud flats and sandbars in some of the rivers that bisect the route, and that the birds may come down in stubble fields, in open prairies where cattle are grazing (and where bison once

grazed) and in fields where the young wheat has broken through the ground. What is available to them in the way of food?

In old buffalo wallows on the prairies of Nebraska and elsewhere they fed on the egg masses of frogs and toads, as described by Jack Kennedy (*verbal*). They also turned over cattle chips (as they once turned over buffalo chips) to secure the beetles underneath. What did they find along the river banks and on the edges of the sandbars, where they roost at night? Dr. Gordon Gunter, at that time engaged in research at the Scripps Institution of Oceanography at La Jolla, became interested in these matters and, as a result, began making some inquiries. He has since prepared a paper on the *Potential Food of the Whooping Crane along the Platte River, Nebraska* (unpubl. Ms.) and has kindly permitted me to quote from it in this report.

It is known that *Grus americana* eats both plant and animal food, although the latter seems to be more important. This discussion will be limited to potential animal food, but it is to be hoped that someone will give attention to available plant food along the Platte River. The Whooping Crane is known to eat fish and crustacea on the Texas Coast, and it would seem that crustacea, fishes, amphibians and reptiles in the shallows of the Platte River constitute the bulk of its food in that area.

Dr. Horton H. Hobbs, Jr., of the Miller School of Biology of the University of Virginia, informed me in letters dated December 23, 1948, and January 8, 1949, that there are few records of crawfishes from the State of Nebraska and four species are listed in the National Museum collections. They are *Cambarus diogenes* Girard, *Orconectes nais* (Faxon), *O. virilis* (Hagen) and *O. immunitus pedianus* (Creaser). The last species seems to be the most common and there is one record from the Platte River.

It seems probable that fishes are the most important food of the crane along the Platte River. Johnson (unpubl. thesis) has made an extensive study of the fishes of Nebraska. He lists the following species from the middle course of the river: *Carpilodes forbesi*, *Platygobio gracilis communis*, *Notropis deliciosus missurensis*, *N. l. lutrensis*, *Hybognathus p. placitus* and *H. n. nuchalis*. The marshes along the stream harbor *Hybognathus hankinsoni*. Johnson gives the Platte Valley as the northern boundary in Nebraska for *Plancterus kansae* and *Poecilichthys spectabilis pulchellus* and the southern limit in the state for *Fundulus sciadicus* and *Poecilichthys exilis*. Certain salmonids and centrarchids have been intro-

duced in the sandpits and sandlakes along the Platte. These areas are not known to be haunts of the cranes.

In a letter dated December 8, 1948, Doctor Johnson has written that many small species of fishes should be located in shallow water in March and April, when large volumes of snow water are draining down, but that the chief ones would be *Fundulus*, *Notropis dorsalis* and *N. lutrensis*.

The following collection of fishes were taken in a seine by Robert P. Allen, of the National Audubon Society, in March, 1947 at a location where he saw the cranes feeding. The locality is the South Platte River, near the junction with the North Platte. They were identified by Dr. Carl L. Hubbs, to whom I am also indebted for the loan of a copy of Dr. Johnson's thesis.

CATASTOMIDAE

Catostomus commersonii sucklii (Girard), White sucker, 2 juveniles, 67 and 78 mm. in total length.

CYPRINIDAE

Semotilus atromaculatus atromaculatus (Mitchill), Northern creek chub, 3 specimens, 90, 77 and 60 mm. long.

Notropis deliciosus missurensis (Cope), Plains sand shiner, 5 specimens, 57 to 74 mm. long.

Notropis dorsalis: dorsalis piptolepis, an intergrade form, 2 specimens, 57 and 65 mm. in total length.

Hybognathus hankinsoni Hubbs, Brassy minnow, 2 specimens, 61 and 68 mm. in length.

CYPRINODONTIDAE

Plancterus kansae (Garnen), Plains killifish, 2 specimens, 54 and 58 mm. long.

Dr. A. N. Bragg, of the University of Oklahoma, who is the leading authority on the life history of amphibians of the mid-West, has written in a letter dated December 21, 1948, that the following frogs and toads could be expected to be breeding on the floodplain near the junction of the North and South Platte Rivers in April and May: *Rana catasbiana* Shaw, *Rana pipiens* (in one of its many forms), *Acris crepitans* Baird, *Pseudacris triseriata* Wied, and *Bufo w. woodhousii* Girard. Concerning frogs along the Platte River, Dr. Johnson states (letter cited above) "... there were always concentrations of *Rana pipiens*, *Pseudacris triseriata* and *Acris crepitans*. The latter species was common only east of North Platte, but all three were generally scared up easily by walking through the grassy margins of the stream." He added that it is likely that swarms of tadpoles should be present in April. Karl P. Schmidt wrote me that neotenus larvae of *Ambystoma tigrinum mavortium* would be present in ponds in the spring.

Concerning snakes Dr. Johnson said: "There were also many species of snakes common along the river banks, but two were outstanding in abundance and at being at home in the water. They were *Thamnophis radix* and *T. sirtalis parietalis*. Both species are efficient fishermen and seem to catch fishes with ease." These are garter

snakes. According to Mr. Schmidt, the common water snake, *Natrix sipedon sipedon*, is also present. He added the turtles, *Chelydra serpentina*, and *Chrysemys bellii bellii*, to the list, saying the hatchlings would be present in the spring. They should be freely taken by the cranes.

Thus, faunal lists show that the Whooping Crane may have a considerable variety of potential food organisms along the Platte River, consisting of fishes, frogs, snakes and turtles. However, the only evidence from the observed feeding areas of the bird in shallow water shows that common cyprinid, catostomid and cyprinodontid fishes were the only animals present in any numbers at the time the collection was made.

It is probably true that similar food animals are present at other points along the migration route—on the Red River of the South and the Missouri, for example. Future biological and ecological studies may give us more complete information in time, meanwhile Dr. Gunter's survey supplies an interesting and valuable series of lists and some useful speculations.

The nature of the food habits on the breeding grounds is not known, but a description of the biotic complex of the major nesting habitats (in the section on *Breeding Cycle*) will present a fair picture of the general character of both the animal and plant components. From our knowledge of the apparent preferences of the species we should be able to speculate rather accurately as to their food habits in the environments concerned.

Food Habits: Summary

1. Early accounts of the food of the Whooping Crane may be based largely on assumption. Most authors down to 1943 repeated the remarks of Nuttall (1834), but his list of food items may not have been accurate.

2. Residents of the marsh and prairie country of southwestern Louisiana were acquainted with the food habits of the species in those habitats and describe them with accuracy and in some detail. A list of 10 animal and vegetable food groups is given.

3. Careful observations of the food and feeding habits of the Whooping Crane on the Texas

Coast were made following the establishment of the Aransas Refuge. These observations are discussed. There have been three chief methods of obtaining data on this subject: (a) by analysis of droppings, (b) by direct observation of feeding cranes and (c) by inspection of feeding areas after the cranes have departed. These are discussed and the results of each presented.

4. A table is introduced listing 22 items found in droppings contents from Aransas Refuge. Additional tables attempt to discover the relative value of these items from a quantitative or preference viewpoint. However, because of uncertainty as to relative effect of digestive processes on these and other potential food items, no conclusions appear tenable on this basis.

5. By direct observation some 13 additional food items are added to the list. Some of these are substantiated by means of inspection of feeding places.

6. A comprehensive list of known animal and vegetable food items is given, based on results of all methods of determination. There are 28 animal and 17 vegetable items. However, it is concluded that only 7 of these are of major importance in the Aransas Refuge habitat, and all are animal in character. The most important of these are decapod crustaceans. Actual observations of feeding habits are discussed in relation to the status, as Whooping Crane food, of minor items in the overall list.

7. It is considered that the Louisiana wintering groups—one in the brackish coastal marshes, the other on the prairies—had different food habits than the present Texas birds, when examined in detail. Those on the coast probably resembled the Texas birds and depended chiefly on decapods, but the prairie wintering group may have fed chiefly on crayfish, frogs and other fresh water aquatic forms, plus a greater percentage of vegetable items than Whooping Cranes in other wintering locations. In general, the species may have fed on vegetable food to a greater extent than current Texas observations suggest, but animal items have doubtless been of

major importance.

8. Observations and speculations regarding the food habits of the species along the migration route are presented. The food available on

the breeding grounds is not known, but the section on *The Breeding Cycle* presents a picture of the biotic nature of the major nesting habitats from which conjectures can be made.

Part V. Winter Life

For almost half the year, from late October or early November until mid-April, the one remaining group of migrant Whooping Cranes occupy winter quarters on brackish flats that surround Mesquite Bay, Aransas County, Texas. We have scant information on the behavior of the species on its breeding grounds and only scattered details as to its mode of existence along the migration routes, but the winter life of *Grus americana* in this Texas environment has been investigated with considerable care. Not so much attention was given the Louisiana migrants, now extirpated, although some details have been collected regarding the life history of the resident colony that was located in the vicinity of White Lake, Vermilion Parish. In this section of the report it is our purpose to examine the winter habitat of the migrant birds and their relationship to it in all its parts. We have outlined the original winter distribution in the opening section and this outline is repeated here in very general terms, in order that we may fully appreciate the relationship of the present limited wintering area to the whole geographic region once occupied. But, for details of ecology and behavior, we must turn to the information obtained on the Aransas Refuge and current wintering habitats in that immediate vicinity.

Limits of Original Winter Range

The original winter range of the Whooping Crane, although confined mainly to a coastal strip extending from Marsh Island, Louisiana, southwestward to the vicinity of Matamoros, Tamaulipas, Mexico, included several interior locations—mere spots on the map—as well as narrow coastal strips or spots along the Atlantic seaboard. The northernmost location on record was Beesley's Point, Great Egg Bay, New Jersey, where Turnbull observed the species in 1857. This is approximately 39° North Latitude. At

Lago de Chapala, some 1,500 miles to the south, in Old Mexico, the southern limits were reached. The latitude there is close to 20° North, which means that it is below the Tropic of Cancer. The New Jersey wintering sites, Beesley's Point and Egg Island, near Cape May, were also the easternmost limits, while the lakes in northwestern Chihuahua, Mexico, where the Whoopers evidently occurred in former times, were at the extreme western limit for wintering birds. This region is almost 2,000 miles west of the longitude of Cape May.

In our discussion of Winter Distribution, earlier in this report, we described 11 sectors of winter range, some of them separated on a purely climatic basis. From a viewpoint of the different habitat types involved, five chief categories are listed. These were as follows:

- (1) Coastal lagoons and maritime beaches.
- (2) Interior tallgrass prairies.
- (3) Sea-rim and brackish marshes.
- (4) Fresh swales and marshes.
- (5) High interior grasslands (tablelands).

Each of these is described, in general terms, in the Distribution section. Today, only the first category—coastal lagoons and beaches—is occupied by migrant Whooping Cranes on winter quarters. It is with this habitat that we will deal in our discussion of the winter life.

The Present Winter Range: Description of the Environment

The general nature of the Whooping Crane range and its adjacent environments on the Aransas Refuge (Blackjack Peninsula) have already been described by Stevenson (1943) and, Stevenson and Griffith (1946). Gunter (1950a) has described the pond complex, as it relates to the fish population, and Hedgpeth (1950) with particular reference to the marine invertebrate fauna. The additional range on portions of

Matagorda and St. Joseph Islands has not been adequately described. The Aransas Refuge contains 47,261.19 acres. Broken down according to general character or present use, this acreage may be divided in this manner.

Grazing	18,169.73 acres
Brush-Grazing	15,870.75 acres
Brush	7,977.25 acres
Marsh	4,145.35 acres
Water	1,098.11 acres
	47,261.19 acres

Approximately 5,000 acres of this total is included in the "marsh" and water areas of the salt flats that comprise the principal wintering area of the Whoopers. There are, in addition, some 1,200 acres of suitable range on St. Joseph Island and perhaps 3,000 acres, or less, on Matagorda. The biotic nature of these two smaller areas is only slightly different from that of the flats on Aransas Refuge. Since the Whoopers spend a certain amount of the time in habitats adjacent to the salt flats proper, and, in order to relate all of these adjoining environments with each other, it will be well to describe the entire region, beginning with a brief account of its origins.

In his paper on tidal basins of this coast,¹²⁵ Dr. W. Armstrong Price wrote: "The tidewater region of the Gulf of Mexico from the Mississippi delta to the Rio Grande delta is the site of numerous shallow, more or less flat-bottomed lagoons, bays and lakes lying in unconsolidated sands and clays. Most of these are what we here term, 'enclosed,' although they are connected with the Gulf more or less indirectly through inlets in the offshore bars and other long or short channels, some of which are locally 2 or 3 times as deep as the associated bays and lagoons. . . . The recent coastal lagoon lies behind the present offshore bars. The abandoned Ingleside Pleistocene coastal lagoon segments run parallel

with the recent lagoon back of it, separated by segments of the offshore bar of Ingleside time, now a sandy ridge along the mainland shore of the southern Texas coast. Laguna Madre and shorter segments known as Redfish Bay, Aransas Bay, Mesquite Bay, Espiritu Santo Bay, Oyster Bay, West Bay, East Bay and others constitute the coastal lagoons of Texas. . . ."

Dr. Price showed me aerial photographs of the Blackjack Peninsula that illustrate the gradual movement of the offshore bar outward, away from the mainland, towards its present position. On this photograph the ancient beach ridges can be seen as parallel lines running across the length of the peninsula. Between them are troughs or inter-ridge depressions. At the edge of the present lagoons (typified in this immediate area by Mesquite, Mullet, Ayres and Back Bays) the old inter-ridge depression, extending almost the length of the eastern face of the peninsula, constitutes the salt flat and pond complex that is the present winter habitat of the Whooping Crane.

Drained Ingleside lagoon areas, inland beyond the upper end of the peninsula, contain rich black soils now given over to cattle grazing or agriculture. Although they were once tallgrass prairie, these areas have been much overgrown with brush, particularly, in this region, since the period of World War I.¹²⁶ However, except for infrequent lapses, the Whoopers prefer the salt flat ponds to the prairie of this section and have probably followed the progressive movement of the inter-ridge depressions towards the Gulf since Pleistocene times.

The Blackjack Peninsula, therefore, was a part of the former Pleistocene Ingleside offshore bar. In one description of its general character, Stevenson (1943) wrote, "Heart-shaped, the peninsula is fringed with salt marshes which are dotted with brackish ponds and bayous. The gently rolling interior of the refuge is prairie-like, much

¹²⁵ Price (1947).

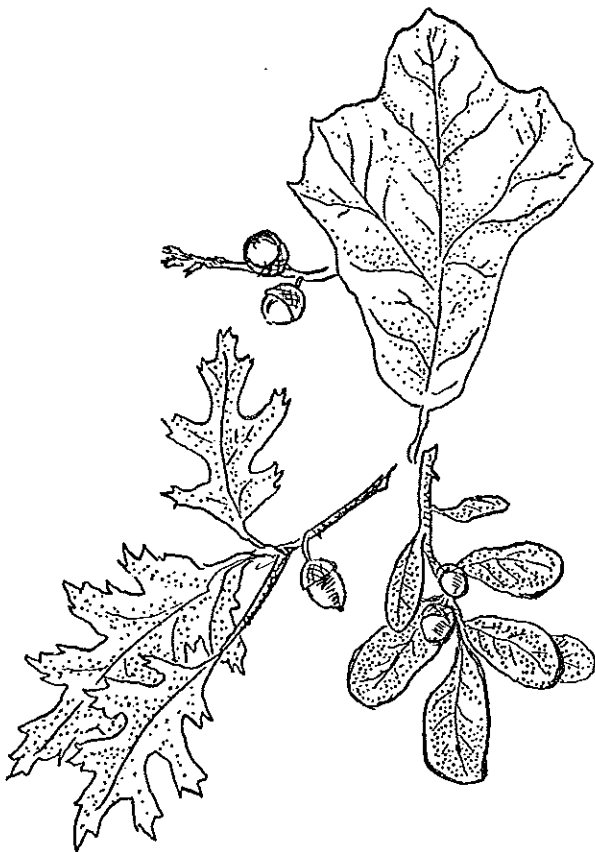
¹²⁶ Price and Gunter (1942).

of it covered with oak and sweet bay brush. There are scattered mottes or groves of large, wind-swept, gnarled live oaks, wrapped with mustang grapevines, and an understory of mulberry and palmetto." A more detailed description (Stevenson and Griffith, 1946) listed some of the outstanding vegetation: "The gently rolling interior contains much oak brush, mainly live oak (*Quercus virginiana*) and myrtleleaf oak (*Q. myrtifolia*). Blackjack oak (*Q. marilandica*) is also common. Associated species are

prickly ash (*Xanthoxylum clava herculis*) and sweet bay (*Persea bordonia*). Interior grasslands contain swales or 'wet weather' ponds, dominated by little bluestem (*Andropogon scoparius*) and associated grasses of the genus *Paspalum*. These grasslands are dotted with groves or mottes of live oak. Areas around cattle tanks and some fresh water ponds are covered with Bermuda grass (*Cynodon dactylon*):

"The main wintering area for cranes is the 'east shore flats,' a brackish water flat adjacent to San Antonio, Mullet and Aransas bays. . . . The vegetation of the region is dominated by salt grass (*Distichlis spicata*), saltwort (*Batis maritima*), glasswort (*Salicornia*), and salt-flat grass (*Monanthochloe littoralis*). The inland margin of the flat is dominated by needle cordgrass (*Spartina spartinae*). Tidewater inlets and some of the depressions (ephemeral ponds) are bordered with salt marsh cordgrass (*Spartina alterniflora*)."

The ponds on the East Shore Flats are described by Gunter (Gunter, 1950a). "Scattered over the flat are numerous semi-permanent and permanent ponds of brackish and salt water. One of these, known as Long Lake, is a long slough running for several miles down the middle of the flat. The ponds are all shallow and usually less than 50 yards wide. "Their level rises and falls, and consequently their area changes considerably, with fluctuations in rainfall. Some of the ponds do not receive enough water to be maintained permanently and go dry in summer. Possibly all of them go dry in dry years." Another cause of varying water levels is direction and duration of wind. In 1947 a prolonged diurnal east wind blew steadily from September 24 until October 7, a period of two weeks. Wind force averaged between 15 and 20 m.p.h. Redfish Slough, open to San Antonio Bay except for a low spillway, over which the wind-swept water flowed throughout the period, was not only filled with a volume of water far beyond its normal winter depth, but was heavily stocked



(Drawing by Kay G. Morton)

with fish, crustaceans and other marine life from the bay. On October 8, the wind direction having shifted to south and moderated to 5-8 m.p.h., the bay level at the spillway dropped 2 inches below the overflow point, trapping great numbers of marine animals within the slough. The area was one of the most attractive to birdlife on the entire refuge for several weeks thereafter, and remained outstanding throughout the winter.

The same east wind affected water levels throughout the whole pond complex, blowing the water out of the northeast end of Long Pond (Gunter: "Long Lake"), for a distance of nearly one mile, and flooding all ponds and bayous, as well as much of the salt flat, beyond the narrow bayou at the southwest end of Long Pond. The larger water areas, such as Dunham Pond and Camp Pond (see map), were alive with bay fishes, mullet in particular.

As Dr. Gunter observes, in the same paper on the distribution of the fishes of the area, "The ponds get their water from rainfall, sheet drainage towards the bay and from flooding by high tides, which regularly occur in the spring and fall. The chief flooding tides are not daily, but seasonal. Characteristically, in the enclosed Texas bays the tide rises and stays high, practically at a level, for days or a week or two at a time every spring and fall." It should be apparent that these ponds will show considerable variation in salinity and temperature of the water and in the abundance and even, at different times, in the character of the animal and plant contents. Extremes of salinity range were noted during the entire winter periods of 1946-47 and 1947-48. At pond stations the lowest reading taken (expressed in parts per thousand) was 1.4 at the northeast end of Long Pond in March 1947. The highest salinity noted was 28.5 at Camp Pond (Upper Exclosure Fence) in September 1947. This last reading was made during the prolonged east wind previously described and reflected the flooding of the area

by water from the bays. Water temperatures varied from freezing during winter "northers" to as high as 34.5° C. in summer.

Such variations in the character of the water environment have a vital bearing on the animal and plant inhabitants. It has been pointed out by Dr. Gunter¹²⁷ that "Marine animals as a whole are better able to tolerate a lowering of salinity than fresh-water animals to tolerate a rise in salinity . . . which accounts for the fact that brackish-water, bay and estuarine faunas are marine and not fresh-water." This has also been described by Dr. Pearse in his interesting discussion of the migrations of animals from sea to land.¹²⁸ Gunter (1950) writes: "It is evident that in the small pond environment, where they are subjected to great extremes of heat, cold, and salinity and probably lack of oxygen, too, the Cyprinodontes reign supreme. The ability of this group of small fishes, known as killifishes, to withstand hard environmental conditions is proverbial among ichthyologists. Their abundance "in waters undergoing extreme variations of temperature and salinity, such as those on the Aransas Refuge, is an *a priori* expectation."

Tables presented by Dr. Gunter in this same paper demonstrate that killifishes (Cyprinodontes) made up 28.5% of the fishes caught along the bay shore at Aransas Refuge, 67% of those taken in salt flat ponds and 79.3% of those taken in fresh water ponds. He had already shown, in his study of marine fishes of Texas,¹²⁹ that "as the salinity gradient declines, from the open sea to the river mouths, the number of species of fishes declines." Thus, the Aransas Refuge studies demonstrated that the numbers of species declined from the bay shores to the fresh water ponds farthest from the bay. Gunter caught 29 species of fish in the bay, 17 on the salt flats, 8 in fresh water ponds having had

¹²⁷ Gunter (1947).

¹²⁸ Pearse (1936).

¹²⁹ Gunter (1945;1950a).

previous connections with the bay, and only four in an isolated fresh water pond.

The relation of marine invertebrates to this environment is extremely interesting and has been discussed in some detail by Hedgpeth, in his paper (1950) on the marine invertebrate fauna of these salt flat areas, which he has generously contributed in its entirety, for inclusion, as required, in this report. The following discussion of the invertebrate population is quoted from his paper.

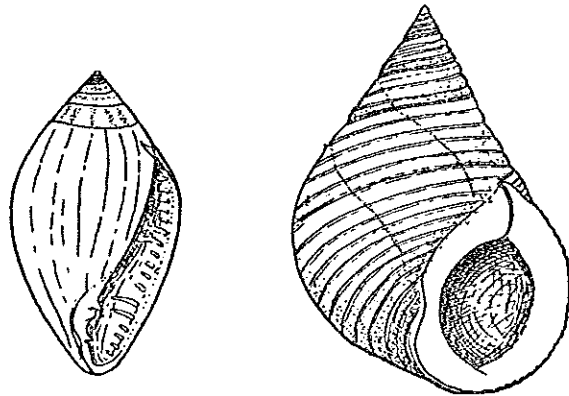
As might be expected from the marginal nature of the environment, the invertebrate fauna is not rich in species, although certain forms, especially the worms, grass shrimp and blue crab, are often abundant. The nereid worms are evidently one of the staple items in the diet of many of the birds, including even such a large bird as the whooping crane, for its characteristic bill marks were observed at the site of many worm burrows. Such salt flats as these are ideal locations for fiddler crabs, but they were not as abundant on the flats during the time of the study as they were in other areas, especially on St. Joseph Island, a few miles across the bay from the Refuge.

In all, seventeen species of invertebrates, which might be termed marine or brackish water types, have been found on Aransas Refuge. This total includes the pulmonate *Melampus coffeus*, which is found only among the salt marsh plants. One fresh-water shrimp, *Macrobrachium ohione*, was found on the bay shore in a haul composed principally of *Peneus aztecus*. On two occasions corixid bugs were found, in water at salinities of 5.0 and 16.0‰, and once a large beetle larva was collected in water of 12.8‰.

While the salinities ranged from 2.0 to 18.6‰ at the stations during the six months of the study, the actual salinities, insofar as many of the burrowing forms are concerned, were probably much higher. At station 2 (Headquarters Pond) on July 24, the water was about two inches deep and it was necessary to bury the bottle in the mud in order to obtain enough water for a sample. This pond had been dry a few days before, and the water present on that date had come from a recent rain. Yet the salinity was 16.0‰, the highest recorded for that station in the six-month period. This capacity of the substratum to retain water of higher salinity than the overflowing water has been noted by Reid,¹⁰⁰ and Alexander, Southgate and Bassindale,¹⁰¹ and these authors suggest that this retention of salts by the bottom may be

a factor favoring the growth of burrowing animals in such situations.

Although the general size and shape of the ponds has been fairly constant for the last several years, to judge from aerial photographs, they are subject to considerable seasonal and periodic variations because of fluctuations in precipitation and prevailing winds. Rainfall during 1946 and 1947 on the Aransas Refuge was ten inches in excess of the 21-year average for Austwell, a few miles away, and the monthly differences are even more striking. Summer fluctuations are especially marked. In 1946 the rainfall was .61 inches in July and 9.88 inches in August. Such an increase, occurring in a month when strong northerly winds are rare, means a good stand of water in



The Ear Snail (*Melampus coffeus*) and the Common Periwinkle (*Littorina irrorata*), both of which are eaten by Whooping Cranes.

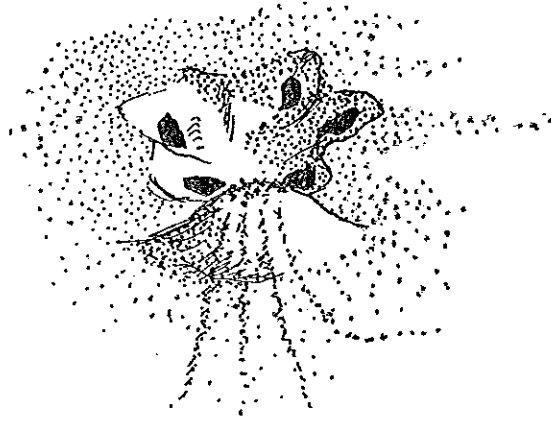
(Drawing by Joel W. Hedgpeth)

the ponds during the fall. During the late fall and winter, northerly and northeasterly winds often sweep the shallow ponds bare of water or pile it up at the southern ends of the ponds.

While the tidal range is comparatively slight, tide water is often pushed into the salt flat ponds by southeasterly winds during the early summer, and there are occasional abnormal high summer tides associated with tropical disturbances in the Gulf of Mexico. The area lacks, however, the regular tidal fluctuation which is so marked on the California or New England coasts, and the general aspect of the fauna is more constant. Nevertheless, an interesting change was noted in this fauna in the winter of 1947-48, when the pistol shrimp, *Crangon heterochaelis*, made its appearance on the salt flats in considerable numbers. Whether this represents a new invasion for this species, which is common along the bay shores in shallow holes and under oyster shells, or the upswing of a population cycle, cannot be determined. A

¹⁰⁰ Reid (1932).

¹⁰¹ Alexander, Southgate and Bassindale (1932).



The Cranes Apparently Catch the Pistol Shrimp at the Opening of Its Burrow or on Its Feeding Mound.

(Drawings by Kay G. Morton)

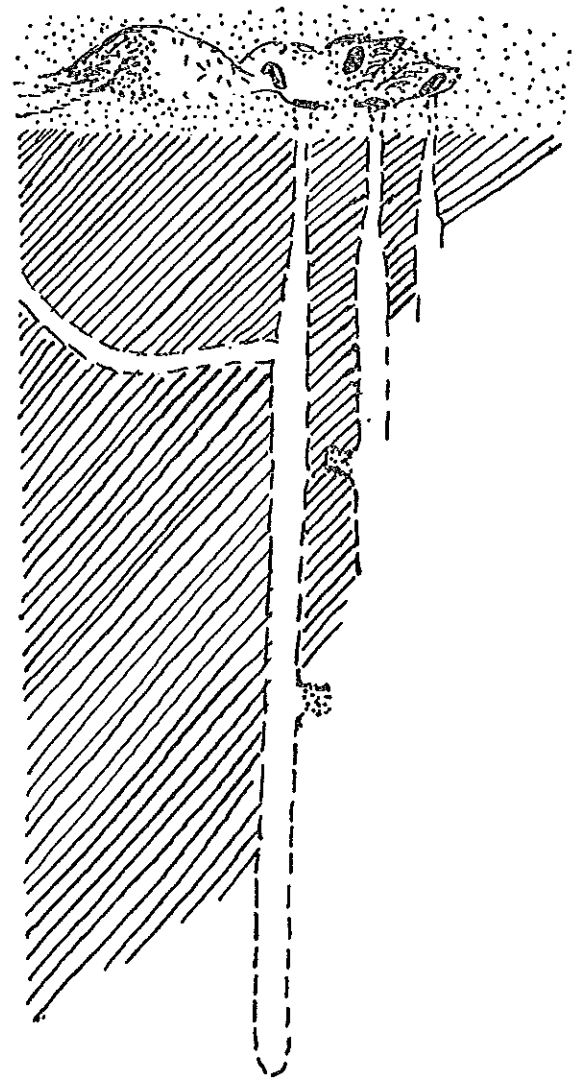
similar case seems to be that of the razor clam, *Tagellus gibbus*. This clam was often found alive in this area by Allen in a previous study,¹²⁹ but no live specimens were collected in 1947 or 1948. It would appear, from the numerous shell fragments, that *Tagellus* is not altogether absent, but it is evidently rarer than it was in 1940. These apparent fluctuations seem to emphasize the tolerance of the remaining species to an environment whose changes are irregular and sometimes extreme.

On the basis of this field study, it appears that the dominant invertebrate of the salt flats is the blue crab, *Callinectes sapidus*. Crabs were observed at all stations, and their remains indicate their importance as a food item for both birds and raccoons. Probably of almost equal importance in species mass is the shrimp *Peneus aztecus*, but its occurrence is more seasonal. Because of the blue crab's protracted spawning season in Texas waters, there is always a reservoir of potential emigrants to the salt flats in the bays at all times of the year except during cold periods when the crabs do not move about. Crabs breed in the bays, often at low salinities, but the females must go to the lower bays or the gulf to spawn. Probably few crabs ever leave the Refuge alive. The worms are apparently the base of the food pyramid on the salt flats, for there is little else on the bottom in the way of food for the crabs and shrimp, except each other. In some areas, especially at lower Long Lake, each dip of the spade turns up at least half a dozen worms, and the population per acre must be immense.¹³²

¹²⁹ Allen (1942).

¹³² On the average number counted in one cubic foot of mud, the author estimated that the Nereidae averaged 8,712,000 per acre of pond bottom.

With the exception of *Melampus*, *Palaemonites*, an occasional fiddler crab, and possibly *Callinassa*, all the invertebrates found on the Refuge must return to the bay, and some of them to the Gulf of Mexico, to spawn. Therefore the bulk of the invertebrate population is maintained by migration from the adjacent bays. At one time it was planned to convert the salt flat areas of the Aransas Refuge to a fresh water marsh by an elaborate system of dykes and ditches, and several extensive ditches were, in fact, dug. Such a project, if feasible from an engineering standpoint, might in time produce a fresh water environment, although the retained salts in the mud would probably make the area an unsuitable environment for either brackish water or purely fresh water types for



some time, until a new equilibrium had become established.

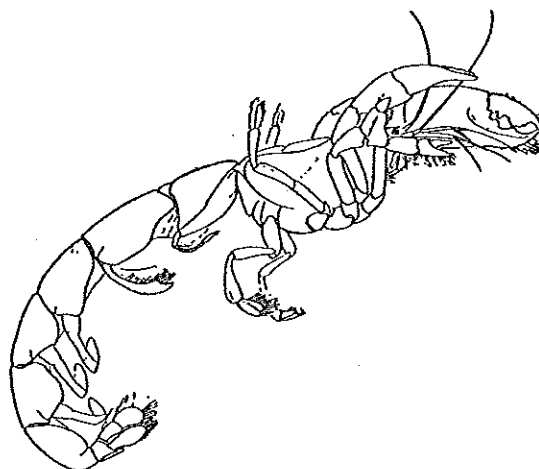
The present equilibrium is one of long standing, in human terms, for the parallel complex of ponds and separating ridges represents the troughs and bars of the former Pleistocene shore line. Although the fluctuations of tide, wind and rainfall impose their own system of dynamics on the fauna which has found foothold or persists here, the situation is one of precarious equilibrium rather than that of the "tension zone" of a tidal estuary.¹³⁴ The fauna of the salt flat ponds is marine, above the three-foot contour line this fauna abruptly ends except for the sporadic forays of individual blue crabs, and it is replaced in the ponds and ditches of the higher ground by a fauna composed of crayfish, aquatic insects, freshwater entomotraca, ostracods, gammarids and molluscs. The "tension zone" is not in the salt flat ponds, but in the region between them and the fresh water ponds, which in some areas is temporarily connected during periods of heavy rainfall.

The marine character of the fauna of brackish, low salinity waters bordering the sea has been emphasized by Gunter (1945), and its significance for the problem of the migration of animals from sea to land has been summarized by Pearse (1936, pp. 19-27). Pearse's summary is concerned principally with estuaries, but his generalization (p. 27) holds true for the peculiar environment found on these salt flats as well: "Many animals struggle long ages to get through (an estuarine doorway) and fail. Only a few attain freshwater by this route." It is not without significance that more than 50 per cent of the invertebrate fauna of this area is composed of decapod crustaceans, and that *Cambarus*, which forms extensive colonies above the critical line between salt and fresh water, is also a decapod crustacean. The decapod crustaceans are by far the most successful forms in this region (as they are in many other transitional environments) which is neither altogether land nor still remains part of the sea.

It is this marginal area—neither land nor sea—that is of chief importance to the Whooping Cranes. As we have seen, from our discussion of food and feeding habits, the major food items of the species in this region are animal in character and four of these are decapod crustaceans. Of the other three, one is a Nereid worm and two are razor clams. All of these are typical residents of this kind of transitional habitat, although the clams may be more sensitive to slight environmental changes than the others. The entire salt flat and pond complex occupies a long, rather

The Pistol Shrimp (*Crangon heterochaelis*).

(Drawing by Joel W. Hedgpeth)



narrow strip, never more than one mile in width and often much less. From the head of Mustang Lake to the farthest limit of the flats near Bird Point (East Pocket), following in a continuous line along the shore of the bays, is approximately 15 statute miles. In these 5,000 acres, and in smaller but similar areas on the barrier islands, the wintering Whoopers spend something like 95% of their period of residency.

The vegetation of the peninsula is such that it has little to offer the Whooping Crane in the way of plant food, except for the occasional acorn crops. A more detailed description of the vegetation will be given when discussing the ecological relationships of the species. Widgeon-grass (*Ruppia maritima*), a plant with an amazing adaptation to changes in salinity and water depth, grows on the bottoms of a number of the ponds. It was a good deal more abundant in the winter of 1947-48 than in the previous winter. This grass appeared in greatest abundance soon after these same ponds had been thoroughly flooded with bay water as a result of prolonged east winds. It was not seen in more or less stagnant ponds having no connections with the bays. During the same period the pistol shrimp (*Crangon heterochaelis*) also appeared in con-

¹³⁴ Pitelka (1942).

siderable abundance, but whether these events were in any way related is not known. Whooping Cranes fed regularly on the shrimp, but the widgeongrass was of no direct interest or value to them, although it probably offered cover, and possibly food, for some of the animals that are taken by the cranes.

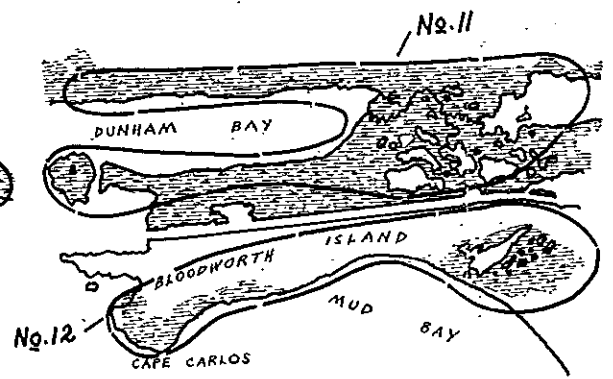
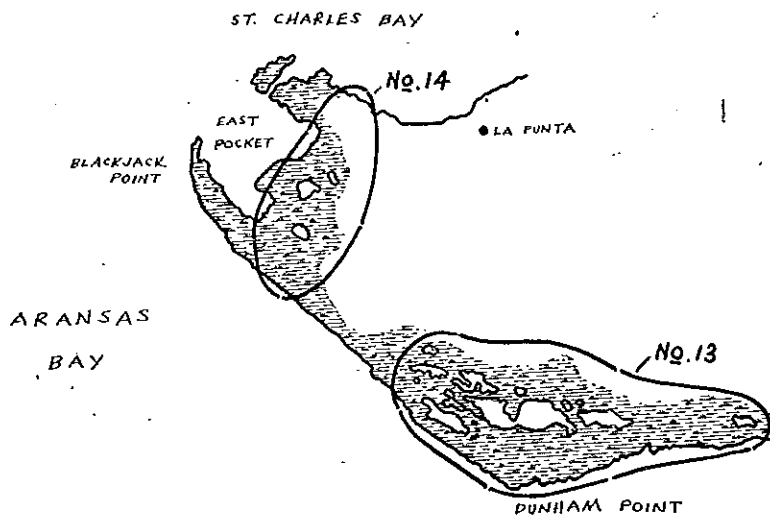
As an overlay to these details we should have a picture of a rather wild and fairly isolated coastal area, flat and rimmed by distant and often hazy horizons on the side towards the bays, rising to the rounded, wind-carved crowns of the closely bunched live-oak mottes, towards the interior. The flats are deceiving from the ground, since the perspective is such that the eye cannot capture the actual pattern. From the air it is like looking down, from several miles high, on an array of great lakes and shining rivers. The whole spread of the flats, from this vantage point, appears like an entire continent in miniature, the open bays off to one side serving as the ocean.

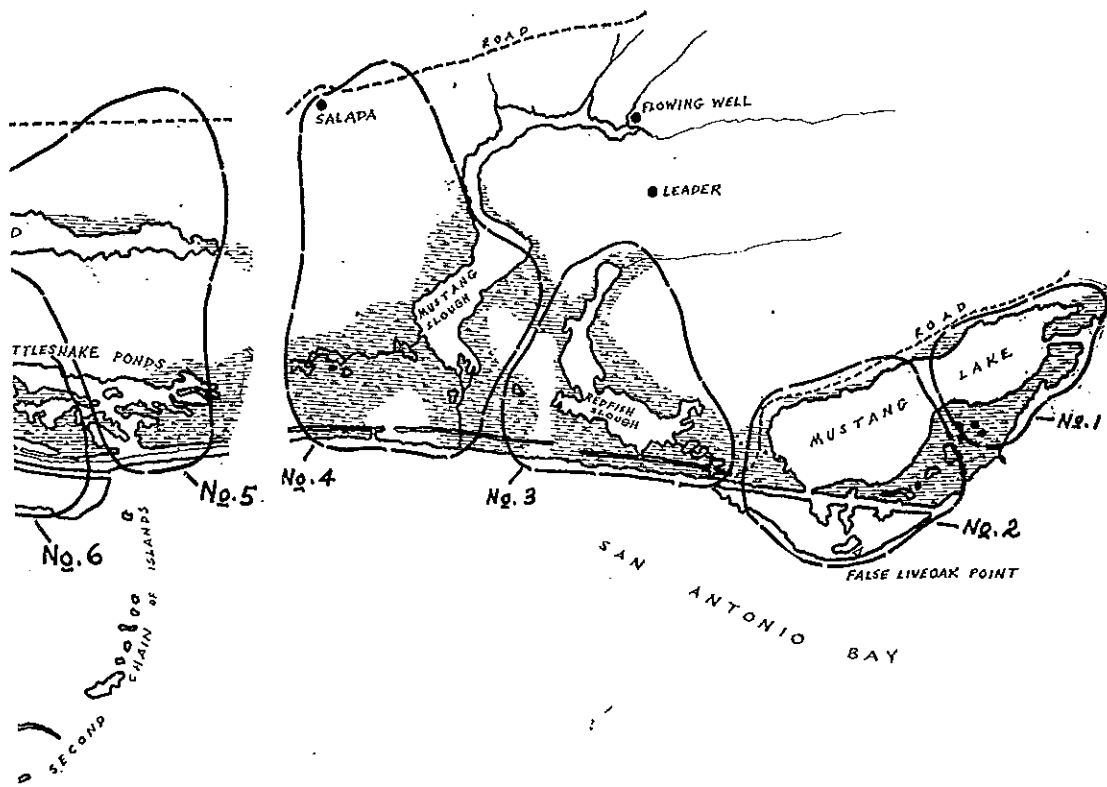
From a closer aerial perspective the pattern of the various types of ponds and lakes, bays and narrow, twisting estuaries, lies before one like a huge, animated map. To the east is Mustang Lake, its long side facing the direction of the prevailing southeast winds. Redfish and Mustang Sloughs appear next, their outlines veering off in the direction of the drainage from interrupted depressions or troughs towards Jones Lake. From the northeast end of Long Pond the line of another trough extends, with numerous breaks, through Middle Pond and Camp Pond to the edge of higher ground close to Dunham Bay. There are pintails, widgeon, green-winged teal, mallards and mottled ducks on Long Pond. A small group of snow geese and larger numbers of lesser Canadas rise from the dark patches of salt-flat grass towards the bay. Willets, flashing black and white signals, turn in the winter sunlight. Far out on the wet area below Middle Pond a white-tailed deer lifts his antlered head and sniffs the cool air. Alongside the many-

channeled bayou leading into Camp Pond a group of white pelicans glisten hugely, a clean white against the uniform color of mud and brown water. A stout javelina, followed by three identical, pint-sized reproductions, trots across an open "cranberry mound" below the Camp Motte. Inland, on the higher ground where the live oaks grow in large and beautiful clusters, wild turkeys feed near the rim of a grassy swale, stepping around the scattered clumps of oak brush. Nearby, loping along in the direction of a colony of pocket gophers, a red wolf pauses to turn his dog-like face and stare at a movement in the brush. There are pairs and family groups of Whooping Cranes at several locations, and they stand, tall and alert, on the edge of a shallow pond, in the middle of Long Pond, or close to the rim of Mullet Bay. As dusk approaches, eager, hurrying bands of raccoons come out of cover and bustle around the shore of ponds and sloughs. They, too, are hunting for blue crabs, but, like many of the inhabitants of the salt flats, they will investigate almost anything that crosses their path, and eat most of the things they can readily capture.

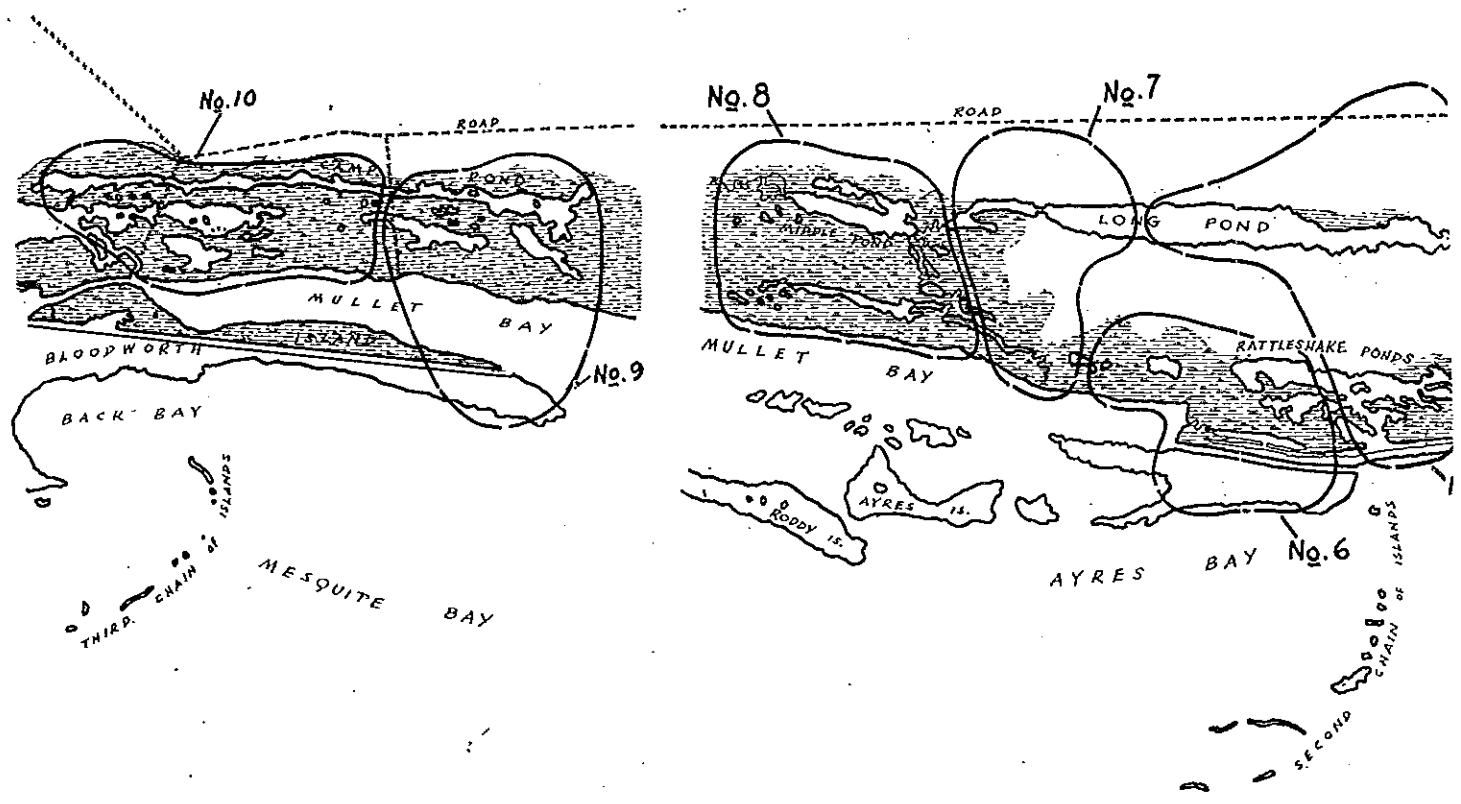
Several small, partly wooded islands hug the inside edge of the bays and curving reefs and still smaller islands stretch in narrow arcs towards the low shorelines of the large barrier islands facing the open Gulf. On these salt flats that face the North and border on both Mesquite and San Antonio Bays, other Whooping Cranes may be seen. They do not wander on, into the sand dunes that rise in back of the shelving beach, or go down to meet the muddy waters of the Gulf of Mexico. Small flocks of Sandhill Cranes are sometimes seen among the dunes, where a few acorn-bearing oaks have survived the cattle browsing, but to the Whoopers this, and the immensity of water beyond, is *terra incognita*.

On the opposite side of their winter habitat, across Mesquite Bay to the north, the Whoopers will leave the brackish area that lies below the





Approximate Outlines of Winter Territories on Aransas Refuge



three-foot contour, and, infrequently, move into the oak brush region beyond the 6- or 7-foot line. Under normal conditions these forays are seldom extended beyond the *tension zone* (between salt flats and the interior fresh water ponds). They are generally associated with (a) the peak of an acorn crop, (b) a sudden burgeoning of crayfish, (c) the presence of a "burn" or (d) the occurrence of a "norther," which may sometimes be severe enough to ice the edges of the brackish ponds and send the cranes to the oak brush for cover. "Burns" were made, under certain conditions of wind and precipitation, to create a fresh growth of grass for cattle grazing. At present their purpose is confined to brush control. Under the terms of a Special Use Permit issued by the Chief, U. S. Fish and Wildlife Service, administrators of the Aransas National Wildlife Refuge, an average of 3,000 head of adult livestock are grazed on various portions of the area. The relationship of these cattle to wildlife, and especially to the Whooping Cranes, will be fully discussed further along in this section of the report. Deer benefit from these burns, as do several kinds of birds, particularly the Whoopers. The details of this will be considered later.

During heavy droughts, increased salinity of the feeding ponds and a general lack of fresh water over the area, will force the cranes to seek both food and drinking water in unexpected places. In the dry winter of 1938-39, such a location was the Flowing Well, at the head of Mustang Slough. Here there was water and, once the presence of the birds was discovered, artificial foods were provided, mainly corn and miscellaneous vegetable items. As observed by Stevenson (Stevenson and Griffith, 1946), they came to the well twice a day, and mingled, though reluctantly, with Sandhill Cranes, Canada geese, widgeon, pintails, deer, wild turkeys and other animals, most of which would not ordinarily frequent this particular spot, or be observed in one another's company.

As a rule, adult Whoopers with young-of-the-

year in tow, and pairs that are well established and have brought young to the area in previous years, are more firmly attached to definite winter territories, on the salt flat environment, than single birds or "companions" (two birds of the same sex, perhaps sub-adults, or possibly older individuals that have lost their mates). The story of these territories is both important and interesting and in relating it we will discover further details having to do with the Whooping Crane's habitat and their behavior on winter quarters.

Winter Territories and Social Segregation

In a discussion of the evolutionary significance of flocks and family units, Dr. Ernst Mayr¹³⁵ remarked that "Geese are among the very few birds in which the family does not break up at the end of the breeding season, but parents and the young stay together for nearly a year. They migrate together to the winter quarters, they spend the entire winter together, and they do not separate until after the return to their nesting area." Exactly the same claims can be made for *Grus americana*, although the inbreeding that undoubtedly results from this form of social segregation has not produced pronounced races as in the geese. It is too late to investigate the possibility of slight, and perhaps purely psychological, differences between these Texas birds, that bred in the Provinces and on into Northwest Territories and wintered on brackish coastal mudflats, and the Louisiana migrants that evidently bred on the prairies of Iowa, North Dakota and Minnesota and wintered, chiefly, on very similar prairies in southwestern Louisiana. Evidently, there was social segregation and geographic isolation in both cases, not only within each of these two groups of the population, but between them as well, the Texas birds apparently having no contact whatever, at

¹³⁵ Mayr (1942).

any time, with the prairie wintering birds of Louisiana.

The relationship of the smaller group of brackish coast wintering migrants in Louisiana to either of the other groups is not definitely known, but it seems probable that these may have joined with other Whoopers from the Port Arthur marshes in Texas and migrated towards the Platte River, making a junction there with other Texas birds. The fact that migrants existed on the Louisiana coast for many years after occurrence reports had ceased in Missouri, Iowa and Minnesota, suggests that this was the situation.

The isolated character of the winter life was noted long ago by McCall (1851) who, in the winter of 1845, observed the species near Corpus Christi, in pairs or in parties of three or four, but never in large flocks. In 1877, George B. Sennett, likewise on the Texas coast, saw them "always in pairs, and, as usual, very shy" (Sennett, 1878). Stevenson, who made the first detailed observations of definite territorial habits, wrote of them as follows (Stevenson and Griffith, 1946): "On the (Aransas) refuge, Whooping Cranes are retiring in nature. Ordinarily they do not associate with other species of birds nor do pairs (presumably mated birds) or family groups associate with each other. . . . On their feeding grounds, Whoopers, particularly pairs and families, set up more or less definite territories, the boundaries of which are more closely observed and guarded if the group contains a young bird." Craven, who followed Stevenson as manager at Aransas Refuge, stated (Craven, 1946): "Each family (two adults and one young) or pairs seem to prefer a large block of territory for its exclusive use."

During a period of almost daily observation of the cranes on the refuge, in the winters of 1946-47 and 1947-48, careful charts were kept of the exact location of every individual pair, "single" and group, whenever such record was possible to obtain. At the end of each winter

season, a compilation of the information on these charts, plus an intimate acquaintance with the identity, distribution and habits of each crane unit, was made use of in assembling a comprehensive map of approximate territorial limits. Finally, after combining the data obtained during these two seasons, the results were checked against an additional chart, supplied by James O. Stevenson, showing the location of 26 Whooping Cranes on the Christmas Census survey of December 17, 1940. From these sources the accompanying territory maps have been prepared. The boundaries, or limits, enclose the area, or probable area, in some instances, occupied by pairs or families of cranes during most of the winter season. In many cases the junctions of adjoining boundaries have been determined by observation of actual territorial friction and defense.

Although there are numerous and repeated exceptions, the claimants of a given territory, as a general rule, do not leave that territory from late October or early November, or shortly after their arrival on the refuge, until just prior to the spring migration. As described in the section on Migration, a breakdown of the rigid territorial system takes place towards the end of March. Cranes spending the winter in a territory at the east end of the salt flats never see those in territories at the west end. However, single birds (subadults or older individuals that have lost their mates) occupy no territory and wander at large. Subadults that remain together as "companions" may occupy a territory to which there are no adult claimants. They will not defend it, their attachment to it is weak and they may wander at will, restricted only by the defensive tactics of male birds on claims they may happen to invade. Thus, their occupation or use of the area is not true territorial behavior.

Approximately 400 acres of true salt flats, including ponds and estuaries, is evidently required, by the average pair or family of Whooping Cranes, as a wintering area in that environ-

ment. Actually, for the 14 territories described within the Aransas Refuge habitat, the total acreage is 6,105 and the average is 436 acres. As will be seen from the charts, not all of the land and water included in some of these territories is a salt flat environment. A percentage of it is what is popularly termed "oak brush" habitat, but is within the tension zone, from brackish to freshwater, and rainwater swales, runoff pockets, etc., are usually found in such portions of a territory, in addition to live oak and other upland vegetation. The true salt flats lie below the 3-foot contour and only two of the territorial limits reach beyond the 6-foot line. Some areas of spoil, from the dredging of the Intracoastal Waterway in 1940, appear in one-half of the territories, to a greater or lesser extent. These cover former salt flats and, in their present state, are of little value to the cranes. All territories have frontage on one or more of the inside bays and all include one or more types of the various kinds of salt flat ponds.

Ideal or optimum winter conditions may occur in the Middle Pond territory (No. 8), which is 100% salt flat environment. This area of slightly less than 400 acres includes a varied and well-balanced complex of ponds and connecting estuaries. There is about one mile of beach fronting on shallow Mullet Bay. Injured cranes that were unable to migrate invariably chose this territory as their summer home, and the pair that spent the winter of 1947-48 there were outstanding among all family groups in their zeal in defending it. This pair had brought a youngster with them to the wintering grounds and it is unquestionably true, as Stevenson noted, that the ability to claim and defend a definite winter territory is increased by the presence of young-of-the-year.

The male Whooper is the aggressor in defending the territory. He is also the acknowledged leader in all movements to feeding places, seldom or never being influenced by the whims of the female and offspring, who may wander in

an opposite direction from his route when feeding. The female and young remain close together through most of the winter, the mother spending considerable time each day in catching and breaking up food for the young, who learns to pick it out of the water or mud at her feet. Eventually, the young learns, by imitation, to probe in the mud and catch crabs or mud shrimps on its own. Occasionally the male will catch and prepare food for the youngster, but his chief occupation, in addition to feeding, is to act as guard and defender. His head is always snapping up to attention, his cold, yellow eyes scanning the complete arc of the horizon.

On the average, full-grown male Whooping Cranes are larger than females, but the characteristic male behavior is a more reliable index to sex than comparative size. This behavior is more apparent, of course, in the family group, where the interfamily and intrafamily relationships tend to accentuate the male's mannerisms. The female is more docile and less concerned with "guarding." She and the young bird go about the business of finding food, their manner quiet and what I can only describe as domestic. The male, on the other hand, seems to take his responsibilities quite seriously. Even his step, and the way he holds his head, are exaggerated. He reminds you of a certain type of old-time actor who dotes on heavy roles and fancies himself a *tragedian*. He is very solemn.

Territory Defense

The general location and approximate limits of the various territories may be more or less traditional, in the sense that the same areas may have been occupied and defended by cranes year after year for a considerable period. A basis for this would be the similar character and average size of the different segments, one territory breaking off and giving way to another as the normal combination of character and size is achieved. Of course, not all territories are

exactly alike, there being a variation from excellent to merely adequate, but before the dredging of the Waterway, and other artificial changes, it seems likely that all of the segments were nearly alike. Our studies suggest that the same pair and, later, their progeny, probably return to the same territory year after year, but although such behavior would seem logical, there is no actual proof that this is the case. As the cranes begin to return to the region in October there is a certain amount of shifting about for a few days, but it is the unmated birds and singles that contribute most to a sense of confusion, the paired couples, and especially the pairs with young, establishing their territorial claims without much delay. Nevertheless, weather conditions may upset the immediate cementing of a strong territorial bond, even for family groups.

On November 19, 1947, the family group on the Middle Pond territory seemed to be well established and all three of them flew into the edge of the adjacent oak brush to challenge the presence of the "Summer Pair," two injured birds that had spent the summer on the refuge, being unable to fly. The trio landed 40 or 50 yards from the intruders, who stood their ground, although their heads were high and their posture suggestive of contemplated retreat. Then the male of the family charged, running headlong towards the pair, neck extended, long bill forward like a spear, wings flapping and stride at maximum. The female and young watched, alert but inactive. As for the intruders, they started walking off with a curious, rather stiff and undeniably dignified posture. The charging male, calling loudly and obviously furious, never actually attacked them, stopping just short of contact, applying "the brakes" elaborately and, stretched to his full height, sounding his challenging *Ker-lee-oo* several times, his mate joining in on the first few calls, but just a fraction of a second late, so that the two calls together produced a vibrating, shrill, almost reed-like tone. The luckless intruders,

unable to fly, were more impressive in retreat than if they had taken wing. When they had marched, by stages, some distance beyond the limits of the Middle Pond territory, the female and young flew after their protector, all five birds moving on until nearly out of sight to the southwest.

On the 22nd of November, following, there was a heavy rain and, that night, a small "norther," the wind veering to northwest and the temperature dropping to 47° F. The rainfall measured 3.97 inches and the runoff, in a relatively brief period, was sufficient to flood the salt flats below the 2-foot contour. Most of the cranes, including the Middle Pond group, left their territories and sought shelter in the oak brush. On the 24th they were still there, but over the next few days they gradually returned and the territorial claims were occupied and strongly defended from that point on.

Numerous examples of territory defense could be cited. The pattern is fairly consistent. On some occasions the entire pattern is followed through; on others it may be broken off, abruptly, almost in the middle of a charge. On December 19, 1947, the Middle Pond family, after feeding, stood preening on a point of land in the center of the pond. At 1:45 p.m. they stretched, raising the wings part way over the back and bending the body forward. All then walked into the water and, quite suddenly, the male began to dance. He bowed towards the female, raised his wings to their full extent, leaped into the air and, still in the air, turned completely around. The female arched her neck in the stiff, formalized posture of dancing Whoopers, and duplicated his performance, although she did not leap as often as he. The young bird was definitely in the way. Once the female, leaping in a half turn, bumped against the youngster, who moved aside and resumed its foraging. The adults continued dancing. Twice both of them scooped the surface of the pond with a sidewise motion of the bill, tossing water over themselves. The male then leaped and pirouetted off to the left, until

he was some distance away. The female, followed by the youngster, walked to the right and resumed feeding.

At 2:07 p.m., after the male had quieted down and returned to his family, the pair occupying the Dike territory (#7), adjoining on the east, called. It was the usual challenging call, *Ker-lee-oo* repeated several times. The Middle Pond Male responded at once. Drawing himself to what seemed an amazing height, bill pointing straight up, he threw an answering challenge into the air. On the second call the female joined him, the young bird, although suddenly alert, making no sound. Abruptly all three took off, the male arching his neck and beginning his take-off a fraction of a second ahead of the other two. They flew about 50 yards to the east, which brought them into the buffer strip between the two territories. Then, with another

series of calls, they ran forward, launched themselves in a low, skimming flight and headed straight for the offending Dike pair. This carried them well inside the Dike pair's territory, but they seemed to feel that this was enough to satisfy their honor, for they landed again, nearly 200 yards short of where the two Dike birds were standing, their heads high and whole manner one of extreme alertness. Which ended the affair, as both groups soon resumed their endless feeding, the family gradually working back into their own bailiwick. This was a typical demonstration of the usual zeal and overpowering confidence of pairs with young, compared to a pair without young. However, there were exceptions to this, though infrequently.

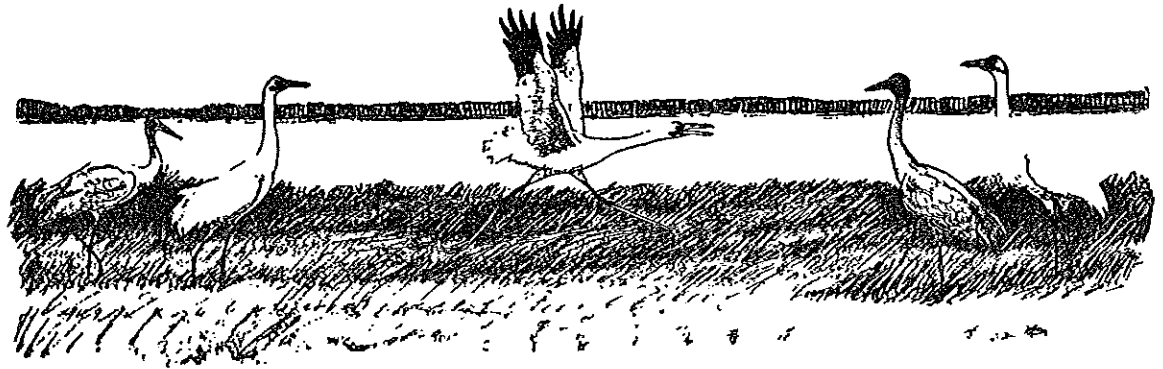
On January 5, 1948, when the blue flowers of the salt flat cranberry (*Lycium*) were in bloom, the Middle Pond family was observed walking very close to the Dike pairs' kingdom. The Dike pair walked toward them, calling, and the family retreated, with dignity and in silence, towards Middle Pond.

Sometimes two pairs, in adjoining territories, will feed towards each other and, as they reach the edge of their territories, both will call in a challenging manner. Usually, after a few calls, they slowly move away and let it go at that.

An interesting territorial situation occurred in December, 1948, when a lone adult, evidently a female, from her subsequent behavior, arrived on the area accompanied by one young-of-the-year. Apparently she had lost her mate along the migration route and from her late arrival (she and the youngster were first observed on December 10th) it was deduced that the male might have been badly wounded, but lingered long enough to keep his family at his side for some weeks and delay the completion of their journey south. At any rate, they arrived, and on this date all refuge territories, except the two abandoned sites on Mustang Lake and the two at Dunham Point and East Pocket, were occupied. Instead of resorting to one of these areas,

The Neck Is Arched Prior to Take-Off.





Male of Middle Family Chasing the "Extra Family."

however, this "Extra Family," as we termed them, insisted on trying to squeeze in between the Middle Pond group and the Dike pair, a boundary that was already jealously guarded. Again and again the two newcomers were chased, chiefly by the completely intolerant male of the Middle group. Sometimes, during these chases, he would bear down on the lone female on the wing, force her into the air, and then harry her mercilessly, flying close on her tail for a mile or more. The fatherless youngster would fly also, but the chase always passed it by and an hour or more was often required for the homeless female to join her offspring again.

Eventually, the Extra Family spent much of its time in wet swales in the oak brush, beyond the limits of regular territories, where they were seldom bothered by other Whoopers. From these observations we decided that the presence of the male of a pair is essential to normal establishment of a territory and, further, that the insistence of the Extra Family on a site between the Dike and Middle Pond might indicate that the female had family connections with one of those areas. Perhaps the irate male of the Middle group was her own father! Had the lost male of the Extra Family been present, his family ties might have been such that the business of claiming a territory would have been

carried through without difficulty in some other part of the area.

Apparently the intensity of territorial defense varies in relation to the date, the presence or absence of young-of-the-year, the individual vigor of the family male and, possibly, the existence of a close-knit, *kinship* unit within the whole interbred population. We noticed that marked exceptions in rigid adherence to the territorial code seemed to involve only family groups strongly entrenched on adjoining territories. For example, on January 10, 1947, I observed the two family groups occupying the Exclosure (#10) and Camp Pond East (#9) territories in a strange ceremony or display in which they engaged mutually (Allen, 1947b). "From the shelter of a live-oak thicket overlooking the flats I saw six Whooping Cranes close together in a bed of salt flat grass (*Monanthochloe littoralis*). They were about a half mile from us. The first look showed them to be . . . two pairs and their rusty-plumaged young-of-the-year. They were some twenty-five yards apart, but as we watched the two males (males from their behavior, which is more aggressive, more alert, more 'maleish') separated themselves from their families and strutted slowly towards each other. Their strides were exaggerated and stiff, the wings dragging slightly, the tibia brought up higher than necessary, their whole manner seemingly formal and

almost self-conscious. . . . They came on until only a yard separated them, then stopped and looked about them. One dropped his head in a feeding movement and the other did likewise. But whatever emotion it was that spurred them on was strong medicine. They came within less than two feet of each other and repeated the feeding movement. Then both retreated a couple of feet. Suddenly they were close together again, and simultaneously their heads came up, bills pointing skyward, wings drooped, plumes raised over tail and back. Across the gray, misty flats we heard the thrilling trumpet call of the Whooping Crane. . . . After the first blast, during which the two males had their heads almost together, the females joined in, their posture the same as that of the male. The two young birds, standing idly on the outskirts of this performance, seemed to have no interest at all in the proceedings. . . . The males repeated their performance without the females' cooperation, then drew away from each other in a curious circling walk, heads down as if feeding. After a little, the males came together again, bowing this time, in short, stiff little nods, not at all the same thing as the 'pumping' motion we had seen earlier in the day. They stood, finally, with their crimson crowns almost touching, bowing so low that their bills went back under the breast feathers and very nearly between the legs. . . ." This remarkable show lasted over a period of 50 minutes, after which the two families calmly separated, each withdrawing into its own territory. The location of the demonstration had been the exact boundary between the two territorial claims.

On March 20, 1947, Olaf Wallmo observed a similar performance between these same two families. On this date, however, the two groups did not actually join in a mutual display, although they came within 15 or 20 feet of each other. The two males again approached one another but there was a less cooperative sort of behavior. One male stood with head and neck outstretched while the other, facing him,

pumped his neck in and out, as they do during the prenuptial "dance." The plumes (i.e., tertails) of both birds were "ruffled up and very prominent." By this date adult birds are probably well advanced in their general gonadal cycle toward actual breeding condition.

In other instances, as cited by Stevenson (Stevenson and Griffith, 1946), males of different families are generally aggressive towards each other, even when they come together at a feeding location removed from their own territories. In the case of the two groups on territories 9 and 10, it would appear that some very close genetic kinship may exist that would account for the unusual tolerance between these two families.

Some forty other species of birds are more or less resident on the salt flats during the winter months. All of these are tolerated within established territories except Sandhill Cranes. However, the latter seldom leave the higher ground and actually invade the flats. If Whooping Cranes attack birds other than Sandhills it is not a gesture of territorial defense, but merely a desire to chase them from an immediate feeding place, or an attempt, usually by an inexperienced young crane, to catch them as food. On several occasions I observed young Whoopers attempting to catch ducks and smaller land birds, including boat-tailed grackles. They were never successful.

Mammals, including white-tailed deer, raccoons, red wolves, jack rabbits, pack rats, skunks, badgers, javelinas and armadillos are present, either on the edge of the flats or out along the brackish ponds, chiefly at night. The Whoopers usually roost at night in the center of a shallow pond, standing in water a few inches in depth. None of these mammals seem to interfere with them and the cranes show no interest, for example, when, at dusk, a group of busy raccoons appears on the shore and feeds on blue crabs or whole kernel corn, almost at the cranes' feet. Stevenson reported on interspecies relationships as follows (Stevenson and Griffith, 1946): "Ordi-

narily Whooping Cranes remain by themselves, in small groups, scattered over the east-shore flats of the Aransas Refuge. On these flats, we have seen cranes feeding in the company of Roseate Spoonbills, and Reddish and American Egrets, with apparent harmony. The young crane which remained on the refuge in the summer of 1941, once had the misfortune to walk into an area where Black-necked Stilts had their young. Six noisy stilts attacked the bird, worrying it until it would lunge, in vain, at them. The crane finally moved off and was left in peace. One autumn day we watched a coyote while it passed within 12 yards of an adult Whooper. The crane showed no noticeable reaction to the animal's presence, although it was aware of it. . . . At the Flowing Well . . . Whoopers often drove back geese or caracaras which attempted to drink alongside them, but did allow several turkeys to drink with them on one occasion. Late one afternoon we watched several deer drink water at a small pond, with three adult cranes. At times, Sandhills fought for drinking privileges with each other and with the Whoopers which dwarfed them in size. The latter won any argument."

Relationships at the Flowing Well during the dry spell of 1938-39 were not typical. Generally speaking the Whoopers drink brackish water in their normal feeding ponds. In these same ponds, where we had put out whole yellow corn as bait, the Middle Pond family, an aggressive group, was easily intimidated by cattle that walked across the pond and through the baited area where the cranes were feeding. The birds retired with protesting calls and stayed off by themselves for a full 15 minutes. On breeding grounds these interspecies situations are probably somewhat altered. The semi-captive pair of Whooping Cranes that nested on the Aransas Refuge in 1949, would not tolerate the proximity of deer or of any other animals, from red-winged blackbirds to Ward's herons.

According to Blyth (1881), Asiatic White Cranes, Sarus Cranes and other Gruidae return

each fall to the same winter quarters, and, as in *Grus americana*, separate into family groups. The subadults are said to associate together in small societies, and this may have been true of the Whoopers when they were more abundant. The Sandhill Cranes, however, remain gregarious throughout the winter, often in flocks of considerable size (Walkinshaw, 1949, pp. 113-117).

Ecological Relationships of the Salt Flat Environment

In terrestrial environments the boundaries of an animal community may be dictated by the limits of the dominant plant community, with which the animal population is associated. In marine communities, the freshness or salinity of the water, the water depth, character of bottom and bottom cover, presence and nature of currents and distance from shore may be major considerations governing the distribution and abundance of marine fauna. In the Whooping Crane's winter range in Texas, as we have seen, the most important environment is the salt flat habitat, a region that is neither terrestrial, in the full sense of that term, nor yet entirely marine. Its characteristics are such that the water environment determines the nature of both the animal and the plant marine life. Only those forms that are able to adapt themselves to extremes of salinity and temperature are found in the salt flat ponds in any abundance. Among the invertebrates, as we have noted, the Annelids of the Genus *Nereidae* are very abundant and, as Hedgpeth has stated (1950), marine worms apparently form the base of the food pyramid. These creatures, to quote Hedgpeth, are "obviously resistant to periods of low salinity and temporary droughts." The more abundant crustaceans, all of them decapods, are also highly resistant and, among the fishes, the abundant species are those notable for their ability to live in both fresh and salt water. The outstanding marine vegetation, muskgrass, *Chara* sp., wide-

on grass, *Ruppia maritima*, and several marine algae, are all varieties that can withstand wide extremes of water quality and depth.

Several ecological communities might be described within the winter range of the Whooping Crane. By far the most important of these is that which includes the salt flat habitat. The environment, already described in the preceding discussion, is confined essentially to shallow, semi-enclosed bodies of sea water having an extreme range of salinity (1.4°/00-28.5°/00) and temperature (0° C.-34.5° C.). Our observations indicated that the more important animals and plants of this community may be listed as follows:

Callinectes sapidus (blue crabs)
Callinassa jamaicensis (mud shrimp) var. *louisianensis*
Cyprinodon v. variegatus (sheepshead minnow)
Peneus aztecus (shrimp)
Crangon heterochaelis (pistol shrimp)
Palaemonetes sp. (grass shrimp)
Mugil cephalus (striped mullet)
Fundulus similis (long-nosed killifish)
Menidia beryllina peninsulae (Gulf silverside)
Procyon lotor ssp. (raccoon)
Grus americana (whooping crane)
Ardea herodias wardii (Ward's heron)
Casmerodius albus egretta (American egret)
Leucophoyx thula thula (snowy egret)
Dichromanassa r. rufescens (reddish egret)
Catoptrophorus semipalmatus (willet)
Squatarola squatarola (black-bellied plover)
Pelecanus erythrorhynchos (white pelican)

Of lesser importance are other herons, roseate spoonbills, white ibises, various pond ducks, several shorebirds, terns and gulls. Of these, only the ducks occur in very large numbers and their chief food connection is through marine plants like widgeon grass, muskgrass and algae. This vegetation appears to be of minor influence in the community, except as waterfowl food, since bottoms are generally soft and offer cover for the decapod crustaceans and even for some of the fishes, the sheepshead minnow for example. In some ponds there are stands of *Spartina alterniflora*, which also affords cover and shade for killifishes, crustaceans, molluscs and water snakes.

This environment extends from mean low tide on the open bays to the 3-foot contour. Although the marine habitat of the ponds, lakes, tidal estuaries and exposed mud flats is the dominant biotic area, intervening "salt flats," wet or partly submerged in winter to dry in summer, have a characteristic flora of typical salt-loving plants. Those of widest distribution and greatest abundance are the following:

1. *Distichlis spicata* (salt grass)
2. *Monanthochloe littoralis* (salt flat grass)
3. *Batis maritima* (saltwort)
4. *Borrchia frutescens* (sea ox-eye)
5. *Salicornia bigelovii* (glasswort)
6. *Salicornia europaea* (glasswort)
7. *Salicornia perennis* (glasswort)
8. *Spartina alterniflora* (popping cane)

Although six of these are listed among Whooping Crane food items, they are evidently of no great importance to the cranes in that habitat and can probably be assigned to a subordinate community of their own.

The marine beaches that form an *edge* to the salt flat community are doubtless, in that area, a sort of tension zone between the salt flats and the relatively shallow, partly sheltered bays or lagoons, such as Ayres Bay, Mullet Bay, Back Bay and Mud Bay. In former times these bays included extensive oyster communities, described by Galtsoff,¹³⁶ who conducted investigations of the oyster bottoms of the Texas coast in the winter of 1925-26. At that time the reefs in Mesquite Bay and nearby San Antonio Bay were among the most productive on the coast and a large fleet of oyster boats was fishing at Belden Dought, Gaston Reef and the Third Chain of Islands, during Galtsoff's visit there. In recent years these oyster beds have all but disappeared. According to Price,¹³⁷ "Deterioration in oyster farming along Gulf and Atlantic coasts for several decades past is attributed by marine biologists to a variety of unfavorable conditions and factors, including silting of bottoms and reef sur-

¹³⁶Galtsoff (1931).

¹³⁷Price (1947).

faces and the incidence of floods of fresh water. . . . Some of these adverse conditions have been accelerated by man's activities, including major engineering operations in the affected waters and acceleration of soil erosion due to cultivation and grazing. . . . The addition or aggravation of such unfavorable conditions brought about by man again reacts upon the oyster unfavorably by weakening it and its communities and making it and them more vulnerable to other unfavorable living conditions." The effect of this situation on the associated salt flat pond environment has not been measured, but since most of its marine animal forms must migrate to the bays to spawn, and since the bulk of its marine fauna reaches the salt flat waters from the bays, unfavorable conditions in the larger waters are probably reflected in the salt flat community, in one way or another.

There are likewise additional communities in the tension zone that lies between the salt flats and the upland area, towards the interior of the peninsula. The tension zone is fairly well outlined by contours and drainage swales and gullies. There are some salt flat plants present on the lower ground, chiefly one or more of the *Salicornias*, *Monanthochloe littoralis* and *Distichlis spicata*. Down to about the 5-foot contour there are heavy growths of stunted oak brush (*Quercus virginiana*), closely associated with grasses such as *Andropogon scoparius*, little blue stem or broom sedge, *Aristida purpurascens*, three-awn grass, and *Spartina spartinae*, needle cordgrass. In borrow ditches and along ponds and swales fed by sheet drainage or overflow from cattle wells, crayfish (*Cambarellus ninar* or *Cambarus hedgpethi*) are seasonally abundant. Oak brush is the most important plant.

Beyond the limits of tension, the plant community is dominated over considerable areas by one of the oaks, chiefly the live oak (*Quercus virginiana*), which grows to a fair size and forms isolated groves or mottes. Within the separate community of these mottes is found the horned

owl (*Bubo virginianus* ssp.) and such mammals as the javelina, skunk, badger, armadillo, white-footed mouse and pocket gopher. The last named are extremely abundant in nearly all other upland communities as well, and possibly are the dominant animal in a number of different plant associations. The Texas white-tailed deer, red wolf (*Canis rufus*), jack rabbit and raccoon are also present, the deer and raccoon in some numbers. Jack rabbits (*Lepus californica merriami*) are less abundant than formerly and tularemia has been found among them on the refuge area. In drier, sandier portions the roadrunner (*Geococcyx californianus*) occurs. The Sennett's white-tailed hawk (*Buteo albicaudatus hypospodius*) nests in or near the live oak mottes, as well as the caracara (*Polyborus cheriway auduboni*). Several pairs of bald eagles nest close to St. Charles Bay. In winter there is a temporary population of other hawks, including the marsh hawk, red-tailed hawk, American rough-legged hawk, sparrow hawk and, in limited numbers, the pigeon hawk and duck hawk. In winter the vermilion flycatcher and both pipits are seen, and, in summer the horned lark and nighthawk are prominent on open areas close to the salt flats and on portions of salt flat habitat that go dry at that season.

Winter Faunal Lists

We are chiefly concerned with the ecological relationships that exist during the winter season, when the Whooping Crane is established on its wintering territories. Although we can describe, from present knowledge, only a limited number of animals, and a minor collection of vegetable items, that are taken by the Whoopers as food, a wide array of faunal forms and a considerable list of plants may be assembled within the confines of the food chain with which the Whooper is associated. The more important plants have already been mentioned, and it has been remarked that their relationship to the Whooping Crane is of minor significance. The winter fauna

of the salt flats, however, is vitally connected with the existence of the cranes. In order that we may complete our picture of this existence, the outstanding species and forms in this fauna are listed.¹³⁸

a. Protozoa

aa. Mastigophora

(1) *Noctiluca (scintillans?)*

This large dinoflagellate is of common occurrence. It was collected by Hedgpeth at Cedar Bayou between Mesquite Bay and the open Gulf and may also reach the salt flat ponds at times. Phosphorescence along the shore of Mustang Lake was probably this form.

b. Coelenterata

bb. Ctenophora

(1) *Beroë* sp.

Another common form found in Cedar Bayou. May reach some of the ponds.

c. Annelida

cc. Chaetopoda

(1) *Neanthes succinea* (Frey and Leuckart)(2) *Laeonereis culveri* (Webster)(3) *Notomastus* sp.

L. culveri is the most abundant of these annelid worms in this environment.

d. Arthropoda

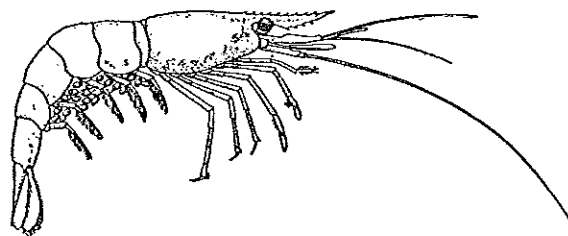
dd. Crustacea

(1) *Peneus aztecus* (Ives). Shrimp.(2) *Peneus setiferus* (Linn.). Common edible shrimp.

P. aztecus was the salt flat form, *P. setiferus* occurring only on the bay shore in May.

(3) *Crangon heterochaelis* (Say). Pistol shrimp.(4) *Palaemonetes* sp. Grass shrimp. An undescribed species, according to Dr. L. B. Holthuis, who is preparing a monograph on the American Palaemonidae. This form is "probably ubiquitous on the salt flat area" (Hedgpeth).(5) *Macrobrachium ohione* (Smith). River shrimp. One specimen taken by Hedgpeth on the bay shore on April 25, 1946, at a salinity of 8.6‰.(6) *Callinassa jamaicensis* var. *louisianensis* Schmitt. Mud shrimp.

An important food of the Whooping Crane in the salt flat ponds and, in the deeper bays off the mainland shore, is one of the chief food items of the hardhead catfish, *Galeichthys felis* (Hedgpeth).



The Grass Shrimp Found on the Aransas Salt Flats Is a Hitherto Undescribed Species, Allied with *Palaemonetes vulgaris*, shown here.

(Drawing by Joel W. Hedgpeth)

(7) *Clibinarius vittatus* (Bosc). Hermit crab. Found occupying the shells of *Littorina irrorata*, *Natica duplicata*, *Fasciolaria distans* and *Busycon perversum*. Occurs on the bay shores.(8) *Callinectes sapidus* Rathbun. Blue crab. A separate discussion of this important and dominant form is given beyond.(9) *Pinnixa cylindrica* (Say). Pinnixid crab. One specimen was taken by Hedgpeth in Long Pond.(10) *Sesarma cinereum* (Bosc). Mud crab. Collected on salt flats of St. Joseph Island.(11) *Uca pugnax* (Smith). Fiddler crab.(12) *Uca pugilator* (Bosc). Common fiddler crab.

ddd. Insecta

No systematic collection of insects was made. On the drier portions of salt flats, spiders, wasps and ants were noted. Grasshoppers, the praying mantis and several beetles occurred on higher ground. In the ponds there were various aquatic beetles, including corixids. Some increase in terrestrial forms was noted in February.

e. Mollusca

ee. Pelecypoda

(1) *Tagellus gibbus* (Spengler). Short razor clam.(2) *Solen (viridis?)*. Green razor clam.(3) *Rangia cuneata* (Gray).

None of these bivalves were found alive during the studies made between 1946 and 1948. Possibly conditions unfavorable to the nearby oyster communities have affected these animals as well.

eee. Gastropoda

(4) *Littorina irrorata* Say. Common periwinkle. Common seasonally on *Spartina alterniflora*.(5) *Melampus coffeus* (Linn.) Ear Snail. Found on "islands" of salt-flat grass and *Lycium carolinianum*.(6) *Cerithidea* sp. Horn shells.

Found in droppings but no specimens collected.

¹³⁸ Marine invertebrates as listed by Hedgpeth (1950), fishes by Gunter (1950a) and reptiles and amphibians by Russell Clapper (after Stevenson and B. P. Glass, Aransas Refuge files).

The empty shells of various other gastropods, including *Natica duplicata*, were picked up on the salt flats but might have been carried there by birds or hermit crabs.

f. *Chordata (Vertebrata)*
ff. *Pisces*

Dr. Gordon Gunter, Institute of Marine Science, University of Texas, studied the distribution of fishes on the area. The following discussion is from his report (1950a), as are the two tables listing species and numbers of fishes taken in salt flat ponds and at two bay stations just offshore from the flats.

"The fish fauna of the bay shores of the Texas Coast has been described (Gunter, 1945) and the data collected here at the two bay stations corresponds with what was expected. *Table Q* gives the numbers of fishes caught in the 10 minnow seine hauls in the order of their abundance. The number of species increased greatly in the spring. The mullet, *Mugil cephalus*, and the cyprinodontid, *Cyprinodon variegatus variegatus*, made up over 50 per cent of the numbers of specimens caught and 21 species made up only 10 per cent of the total catch. Fourteen species made up 3.4 per cent of the species taken. None of these species are particularly uncommon or rare and while their numbers are probably representative in many instances of their relative abundance, many are simply not commonly found on the bay beach, but live in other environments. For instance, *Mollienisia latipinna*, *Fundulus pulvereus* and *Lucania parva venusta* are more common in sheltered ponds and ditches in waters of generally lower salinity.

"Three stations in Long Lake Slough and an unnamed pond near the Refuge Headquarters were taken as typical of the salt flat ponds, which are usually not connected with the bay except at time of seasonal high tides in the spring and fall. *Table R* gives the species and numbers caught in 23 visits to the salt flat stations.

"Nine of the 17 species made up only 2.8 per cent of the numbers caught. The Cyprinodontes are overwhelming predominant in this environment. Eight species of this group made up 67.1 per cent of the total numbers. The first 8 species

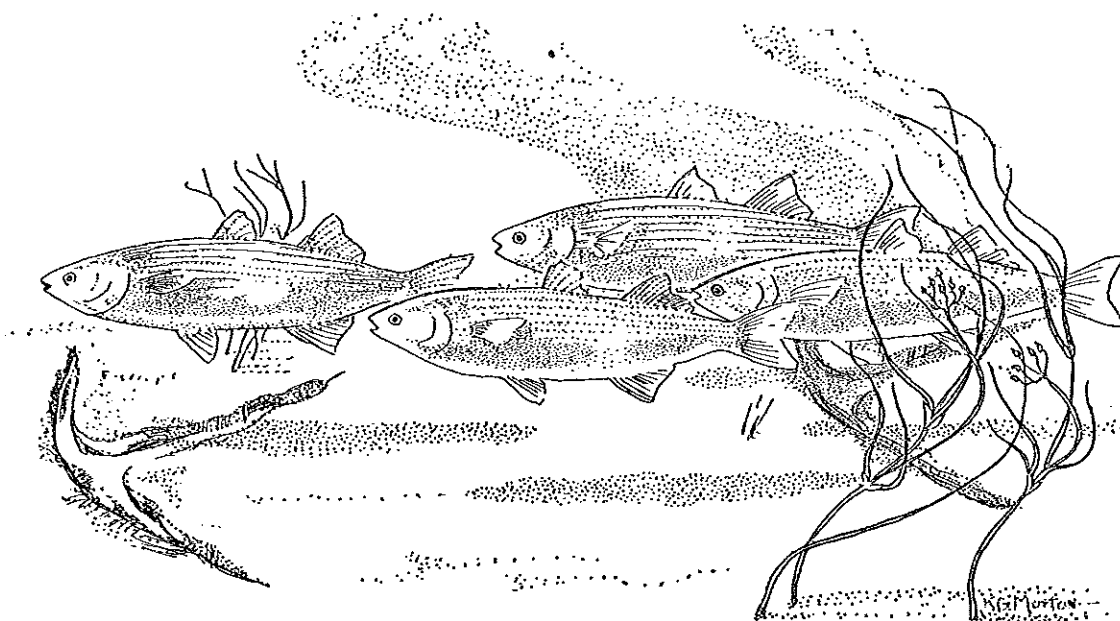
listed, with the exception of *Mugil cephalus*, *Menidia beryllina peninsulæ* and *Leiostomus xanthurus*, can probably all complete their life histories in the salt flat ponds. The cyprinodontids, *Lucania parva venusta* and *Fundulus pulvereus* and the peociliid, *Gambusia affinis affinis*, are probably strays from fresher waters. These two species were taken in the salt flat ponds, following very heavy rains when the whole flat was covered by interconnecting rivulets of sheet drainage. All the other species are

TABLE Q: *The Species and Numbers of Fishes Caught at the Two Bay Stations.*

<i>Mugil cephalus</i>	191
<i>Cyprinodon variegatus variegatus</i>	121
<i>Brevoortia</i> sp.....	95
<i>Leiostomus xanthurus</i>	43
<i>Fundulus grandis</i>	36
<i>Lagodon rhomboides</i>	30
<i>Fundulus similis</i>	23
<i>Bairdiella chrysura</i>	18
<i>Menidia beryllina peninsulæ</i>	17
<i>Elops saurus</i>	15
<i>Orthopristes chrysopterus</i>	11
<i>Spherooides marmoratus</i>	7
<i>Mugil curema</i>	6
<i>Paralichthys lethostigma</i>	5
<i>Micropogon undulatus</i>	3
<i>Strongylura marina</i> , <i>Lucania parva venusta</i> , <i>Caranx hippos</i> , <i>Sciaenops ocellata</i> , <i>Gobionellus</i> sp., <i>Citharichthys spilopterus</i> and <i>Symphurus plagiosa</i>	2
<i>Anchoa mitchilli diaphana</i> , <i>Mollienisia latipinna</i> , <i>Fundulus pulvereus</i> , <i>Eucinostomus</i> sp., <i>Cynoscion nebulosus</i> , <i>Pogonias cromis</i> and <i>Gobiosoma bosc</i>	1

TABLE R: *The Species and Numbers of Fishes taken in the Salt Flat Ponds*

<i>Cyprinodon variegatus variegatus</i>	609
<i>Mugil cephalus</i>	299
<i>Fundulus similis</i>	236
<i>Menidia beryllina peninsulæ</i>	128
<i>Fundulus grandis</i>	56
<i>Adinia multifasciata</i>	35
<i>Leiostomus xanthurus</i>	26
<i>Mollienisia latipinna</i>	15
<i>Brevoortia</i> sp.....	8
<i>Lagodon rhomboides</i>	7
<i>Lucania parva venusta</i>	6
<i>Fundulus pulvereus</i>	6
<i>Gambusia affinis affinis</i>	5
<i>Syngnathus</i> sp.....	3
<i>Bairdiella chrysura</i>	2
<i>Spherooides marmorata</i>	2
<i>Gobiosoma bosc</i>	1



School of Small Stripped Mullet Swimming Through Widgeon Grass and Over Tracks of *Grus americana*.

(Drawing by Kay G. Morton)

marine fishes which must return to the bays or perish. In all probability many of them do perish in these waters during the hot summers."

Additional studies of the pond complex demonstrated that "Long Lake Slough" and Headquarters Pond, mentioned by Dr. Gunter, are connected with the bay except at times of unusually low water. The entire pond system is discussed further along in this section of the report.

Dr. Gunter also describes other species of fishes found in a fresh water environment on the Aransas Refuge area. As this site is considerably removed from the normal Whooping Crane range the additional list is not included here.

fff. Amphibia

Frogs and toads occur in tension zone communities bordering the salt flats. These forms

have been identified from the refuge area:¹⁸⁹

1. *Acris crepitans*. Cricket frog.
2. *Rana pipiens berlandieri*. Leopard frog.
3. *Hyla cinerea cinerea*. Green tree frog.
4. *Hyla squirella*. Tree frog.
5. *Bufo* sp. (*valliceps?*). Toad.

ffff. Reptilia

A considerable list of reptiles has been identified from the refuge area, but only a few of these reach the salt flats. Since a number of them may occur on higher ground close to the salt flats, where they may come in contact with Whooping Cranes, we will give the entire list:

1. *Alligator mississippiensis* (Daudin). Alligator.
2. *Pseudemys scripta troostii* (Holbrook). Elegant turtle.
3. *Terrapene ornata* (Agassiz). Ornate box turtle.
4. *Kinosternon flavescens* (Agassiz). Yellow-necked mud turtle.
5. *Lepidochelys kempii*. Kemp's loggerhead turtle.
6. *Phrynosoma cornutum* (Harlan). Texas horned lizard.
7. *Leiopisma laterale* (Say) Brown-backed skink.
8. *Anolis carolinensis* Voigt. American chameleon.

¹⁸⁹ Lists of amphibians and reptiles by J. O. Stevenson, Russell Clapper and B. P. Glass, Aransas Refuge files.

9. *Ophisaurus ventralis* (Linnaeus). Glass "snake."
10. *Eumeces* sp. Skinks.
11. *Cnemidophorus* sp. Striped lizard.
12. *Sceloporus* sp. Spiny swifts.
13. *Heterodon contortrix* (Linnaeus). Black hog-nosed snake.
14. *Agistrodon piscivorus* (Lacépède). Cotton-mouth moccasin.
15. *Coluber constrictor flaviventris* (Say). Prairie racer.
16. *Coluber flagellum flagellum* (Shaw). Coachwhip snake.
17. *Natrix clarkii* (Baird and Girard). Clark's water snake.
18. *Natrix rhombifera* (Hallowell). Diamond-backed water snake.
19. *Elaphe laeta* (Baird and Girard). Emory's rat snake.
21. *Thamnophis sauritus proximus* (Say). Western ribbon snake.
22. *Thamnophis marcianus* (Baird and Girard) Marcy's garter snake.
23. *Lampropeltis getulus holbrooki* (Stejneger). Spotted king snake.
24. *Ophedryx aestivus* (Linnaeus). Keeled green snake.
25. *Micrurus fulvius tenere*. Texas coral snake.
26. *Sistrurus miliarius streckeri* Gloyd. Pigmy rattlesnake.
27. *Crotalus atrox atrox* (Baird and Girard). Western diamond rattlesnake.

ffff. Aves

Listed here are those birds that occur more or less regularly on the salt flats in winter, many of them in close association with the Whooping Crane. The coot, widgeon and pintail are probably the most numerous. Numbers in parenthesis are total counted on sample one day census (October 26, 1947).

- (1) White pelican (74).
- (2) Brown pelican. A few.
- (3) Double-crested cormorant.
- (4) Mexican cormorant.
- (5) Ward's heron (42).
- (6) American egret (36).
- (7) Snowy egret (29).
- (8) Reddish egret (3).
- (9) Louisiana heron (8).
- (10) Little blue heron.
- (11) Black-crowned night heron (2).
- (12) White-faced glossy ibis. Rare.
- (13) White Ibis. A few.
- (14) Lesser Canada goose (150).
- (15) Hutchins' goose. A few.
- (16) Lesser snow goose (50).
- (17) Mallard. A few.
- (18) Mottled duck (138).
- (19) Gadwall (12).
- (20) Widgeon (2500 to 5000).
- (21) Pintail (600 to 1500).
- (22) Green-winged teal. A few.
- (23) Blue-winged teal (50).
- (24) Cinnamon teal. Rare.
- (25) Shoveller (11).
- (26) Lesser scaup duck (3).
- (27) Buffle-head. A few.
- (28) Ruddy duck (2).
- (29) Turkey vulture. Ratio of about 3 to 1 over the next species.
- (30) Black vulture.
- (31) American rough-legged hawk. A few.
- (32) Bald eagle.
- (33) Marsh hawk.
- (34) Audubon's caracara.
- (35) Duck hawk. One or two may winter.
- (36) Pigeon hawk. Rare.
- (37) Rio Grande turkey. Common.
- (38) Sandhill crane (35 to 1200).
- (39) Coot (4500).
- (40) Killdeer (12).
- (41) Black-bellied plover (12).
- (42) Long-billed curlew (20).
- (43) Willet (20).
- (44) Greater yellow-legs.
- (45) Lesser yellow-legs.
- (46) Least sandpiper.
- (47) Red-backed sandpiper.
- (48) Dowitcher (58).
- (49) Semipalmated sandpiper.
- (50) Western sandpiper.
- (51) Herring gull. A few in first winter plumage.
- (52) Ring-billed gull.
- (53) Forster's tern.
- (54) Caspian tern.
- (55) Long-billed marsh wren.
- (56) American pipit.
- (57) Sprague's pipit.
- (58) Meadowlark. Probably both eastern and western forms are regular.
- (59) Boat-tailed grackle.
- (60) Common cowbird.
- (61) Savannah sparrow.
- (62) Vesper sparrow.

There are many additional winter birds in the immediate vicinity, but those listed are the forms that appear repeatedly in routine notes. A good many species that live on the uplands, in live oak mottoes for example, never move down on the salt flats and are not included in this list.

fffff. Mammalia

Strictly speaking, the only mammals that are of regular occurrence on the salt flats, in addition to range cattle, are those listed below:

- (1) *Procyon lotor* ssp. Raccoon.
- (2) *Canis nebracensis texanus*. Coyote.
- (3) *Canis rufus*. Red wolf.
- (4) *Odocoileus virginianus texanus*. Texas white-tailed deer.

Javelinas, badgers, skunks, jackrabbits, pack rats, white-footed mice, armadillos and other resident mammals come right to the edge of the salt flat habitat, within the tension zone towards fresh water ponds, but rarely, if ever, set foot on the flats proper.

These faunal lists are by no means complete, but the 152 items recorded are some of the more outstanding animal forms with which we have come in contact during our winter investigations on the area. Most of those that are regular residents of the salt flat environment are joined together by invisible biotic threads. Their entire winter existence, their distribution, relative numbers, food-getting and ultimate survival, are linked inseparably by interrelationships that have evolved over long periods of time, as both animals and plants have struggled, in a complicated web of mutual cooperation and ceaseless warfare, towards progress and survival.

Ponds, Lakes and Sloughs: the Water Habitat

We have described the water habitat of the wintering area on Aransas Refuge in a general way and have listed and discussed the animal and, to a limited extent, the plant inhabitants. It is equally important that we understand the various types of water that are included in the whole environment, if we are to appreciate the need for future conservation and management of these resources. Some of the water bodies in the pond complex are connected directly with the bay, others indirectly by means of tidal estuaries or bayous. Still others are of an ephemeral nature, having no connection with the bays or

with indirect sources of water from the bays, except on extreme high tides. Another category included ponds or sloughs, once isolated from direct connection with the bays, but now open to tidal flow through man-made devices such as canals or borrow ditches. The character of each of these types, particularly as reflected in its animal populations, is of considerable importance to the winter existence of the Whooping Crane.

Five types of water habitats can be described within the salt flat environment. These are as follows:

Type A: Permanent pond, lake, ditch or hayou open to bay tides at all seasons, flow depending on wind force and direction. Status and water source *natural*. Examples (see map):

Mustang Lake
Dunham Pond
Dunham Bayou
Mullet Bayou

Type B: Semi-permanent ponds connected by narrow bayous to permanent water areas (Type A). Contour lines are a factor in determining the form and limits of this type. Water levels rise or fall with changing wind conditions. Often go dry in summer. Sheet drainage is also important. These ponds lie in a northeast-southwest series and occupy the trough of a Pleistocene inter-beachridge depression. Status and water source *natural*. Examples:

Long Pond (Gunter: Long Lake)
Middle Pond
Camp Pond

Type C: Ephemeral ("yellow") ponds or sloughs having no connection, direct or indirect, with the other pond systems or with the bays, except during extreme high tides or prolonged winds from certain quarters. Otherwise these areas are merely salt flat depressions or mud holes. Winter evaporation results in stagnation, considerable red or yellow algae growth, gradual drying up. After high tides many marine organisms may be trapped in such ponds and temporarily they are superior feeding places. Status and water source *natural*. Examples:

Dunham Ponds
Fence Pond
1080 Pond

Type D: Former Type A pond or slough cut off from bay tides by artificial structure (concrete spillway). Value to Whooping Cranes, waterfowl and other birds fortuitous, depending on high tide or wind conditions. Present status and water source *artificial* and erratic. Example: Redfish Slough

Type E: Former Type C ponds now open to bay (on certain winds) by means of borrow ditch connection. Probable value to birds has been improved by artificial construction (borrow ditch open to bay). Condition may have been further improved by opening of Mustang Slough to bay, thereby preventing overflow of fresh water into these ponds. Status and water source *artificial* and uncertain. Example: Rattlesnake Ponds

It has been apparent in the course of our investigations that the relative value to the cranes of these various types of water areas is dependent on conditions. The Long Pond to Camp Pond series (Type B) is of first interest *provided* that water levels are at winter normal and the decapod population is abundant and available. Yellow ponds (Type C) may be of equal value *provided* that recent high tides have left behind an abundance of decapods, killifishes and other organisms, including, possibly, mullet or other bay fishes. Ordinarily these two types seem to contain the best combination of favorable conditions. But, when and if certain conditions are unfavorable, these types can fail utterly in providing the essentials of Whooping Crane existence. When widgeon grass is abundant these are the best duck ponds on the refuge.

Mustang Lake (Type A) formerly (until 1941) played host to a pair of adjoining territories (Stevenson and Griffith, 1946). After the Intracoastal Waterway was dug through the lower end of the lake, the environment was sufficiently altered so that these territories have become deserted. It is believed that the combination of a prevailing southeast wind and the wide opening at the lower end of the lake has resulted in rather heavy silting of the bottom.

Other Type A water (Dunham Pond, Dun-

ham Bayou and Mullet Bayou) pose other problems. Dunham Pond is often too deep for feeding and the possibility of a high population of bay fishes may reduce the abundance of smaller decapods and other forms normally taken by cranes. The two bayous are too deep and have banks that are too steep. The birds seem to prefer yellow ponds (Type C) that are scattered over the open flats between Dunham Pond and Mullet Bay or south of Dunham Bayou.

The chief value of Type A areas (aside from Mustang Lake) appears to be as supply basins and channels for water and for marine organisms without which the Long Pond-Camp Pond system would become a biotic desert.

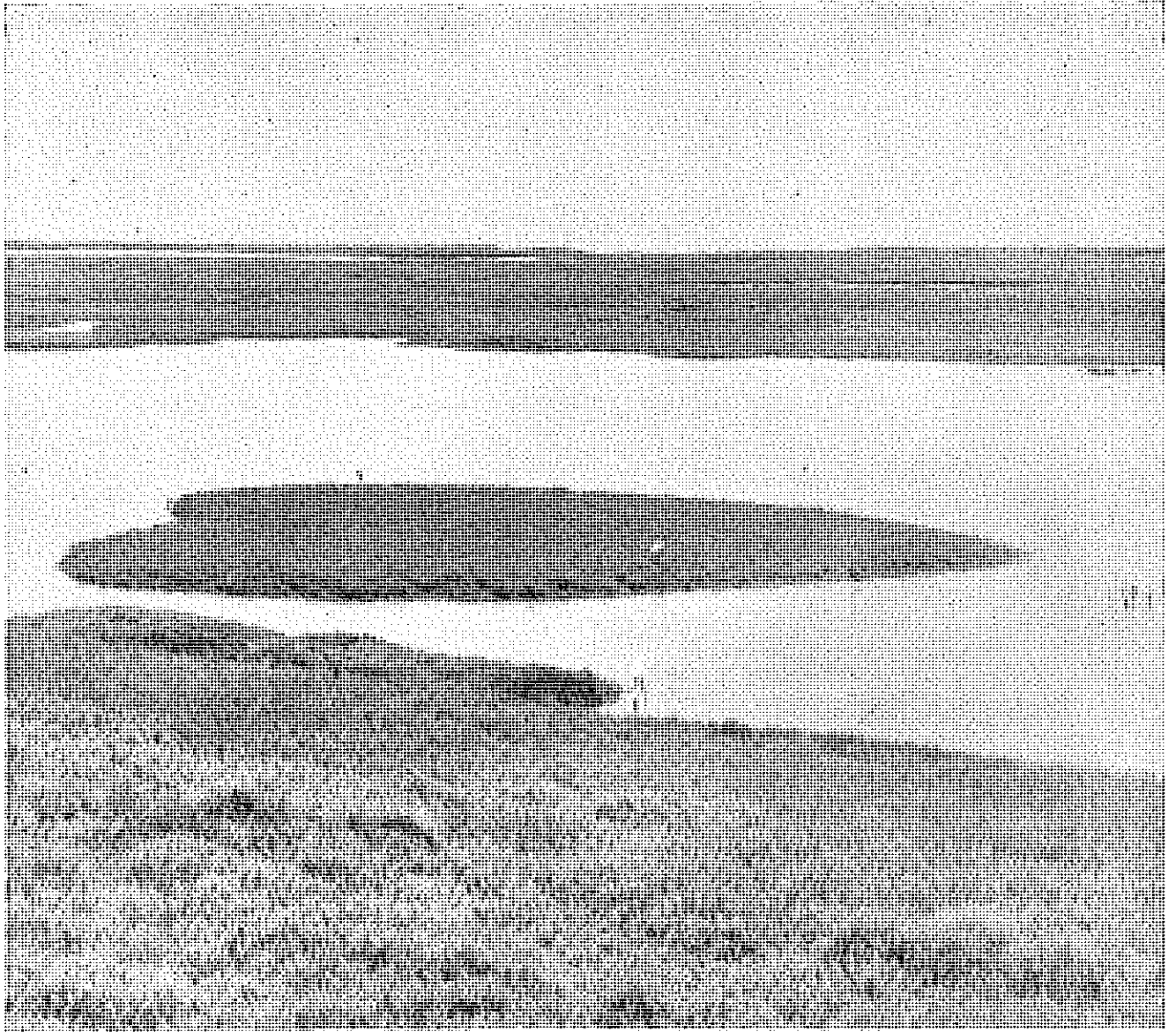
Redfish Slough (Type D) has been on occasion one of the major feeding areas, not only for Whooping Cranes, but for ducks and coots in great numbers. In this region there appears to be a definite connection between fresh supplies of bay water and the successful growth of widgeon grass (*Ruppia maritima*) and possibly *Chara* sp., muskgrass. However, lack of high tides or of prolonged easterly winds in the fall of the year, may leave Redfish Slough without either a healthy saline condition or a well-balanced population of marine animals, especially decapods and fishes.

The present status of Mustang Slough and of the Rattlesnake Ponds is not known. For several years the former was closed to the bay by an artificial dike, which prevented the ingress of bay water and the outgress of fresh water from the Flowing Well and other constant sources at the head of the slough. Overflow carried the excess into the Rattlesnake Ponds, but this rate of flow depended on wind and rainfall conditions. Thus, these ponds were sometimes heavily saline from the tidal flow of bay waters, at other times almost fresh from the Mustang Slough overflow. The intervals between these extremes were often too brief to be healthy. Now that Mustang Slough is once more open to the bay an improvement in both of these environments can be expected.

Most Losses in the Record Arc from Nebraska where this Photograph Was Taken in 1905.
(Courtesy Jack Kennedy)



The Salt Flat Habitat. Captive Pair on Brackish Tidal Pond within Enclosure
on Aransas Refuge, Texas.
(Photograph by Allan D. Cruickshank)



Future management practices will doubtless give full consideration to the varying character of these different types of water habitats. It is altogether possible that a further study of simple cause and effect will demonstrate that the salt flat environment can be permanently improved by a few basic changes. No question of interfering with the "balance of nature" is involved. In a hundred ways, the original balance was upset years ago. What is needed now is a recognition of the nature of the biotic situation that exists today, and the application of measures that will sustain and improve it.

Limiting Factors on the Winter Range

The important subject of limiting factors affecting the Whooping Crane on its winter range was summarized by Stevenson and Griffith (1946). It is a very adequate summary and, in certain instances, prophetic. Both decimating and welfare factors are discussed.

Decimating Factors

1. Unnecessary disturbance of the natural isolation of the cranes was considered the best policy. This meant that deliberate "management" of the habitat was avoided, on the premise that a large feeding and resting area is available and that this area provided all of the necessities of Whooping Crane existence during the winter months.

2. The danger of cranes ranging near the Intracoastal Waterway, with its increasing boat traffic, was considered. It was evidently felt that the birds might normally prefer the prairie-like spaces within the interior of the refuge if encroaching brush could be controlled.

3. "The increasing practices of oil exploration and drilling for oil in marshland and bay areas" was mentioned.

4. Harrying of cranes by airplanes, particularly during war time, and the obvious dangers posed by nearby bombing ranges, were listed.

5. Loss of migrating Whoopers along the migration route, especially in Nebraska, was considered, and the need for a general educational campaign and for a refuge in Nebraska was stressed.

6. The danger of the elimination of the cranes in the resident breeding colony in south-western Louisiana was mentioned, and it was pointed out that this colony presented "a totally unexpected opportunity to conserve the species."

7. Habits of the species that could be decimating factors but are "not controllable" were listed, as follows:

- (1) The species is migratory.
- (2) Vast areas of wild land are required for breeding purposes.
- (3) The adults are noisy and lively on the nesting grounds, rendering themselves conspicuous and, therefore, easily detected.
- (4) The species is monogamous.
- (5) It is likely that the birds do not breed until they are several years of age.
- (6) Usually only two eggs are laid.
- (7) Adults, presumably, are flightless for a period in summer during the post-nuptial molt.
- (8) Presumably the young, as in *G. canadensis* and other greids, cannot fly until they are several months of age.
- (9) The young are dependent for a considerable time on their parents for food.
- (10) If one member of a family is shot, the others remain close to the wounded or dead bird, placing themselves in a vulnerable position.

A more detailed study of the winter environment in Texas, especially the water habitat and its animal populations, makes it clear that some management is needed. As detected by the original work of Blakey, Gunter and Hedgpeth (unpublished progress reports), there can be a temporary failure of the normal food supply in the usual feeding ponds. Stevenson experienced such a failure during the extremely dry winter of 1938-39. There was additional evidence of such failure, to a lesser degree, towards the end of other winter seasons, after the supply of food animals had become exhausted in yellow ponds and greatly reduced or exhausted in Type

B ponds. Causes of failure are related to height of autumn tides, number of successive days of northerly winds, low points in cycles of major food animals and other natural phenomena.

The impression that Whooping Cranes will use open, prairie-like areas within the interior of the refuge in preference to the salt flats, if these interior areas are kept free of oak brush, has not been substantiated by our observations. The Waterway not only cut directly through typical salt flat habitat, creating an easy means of access by hunters, but destroyed the value of that original habitat over wide areas, through disposition of spoil and drainage of large portions of the flats bordering on the banks of the cut. Since the direct danger of the Waterway as a means of access was first mentioned, at least one Whooping Crane has been shot and killed from a boat or oil barge in the Waterway, and an injured crane, now in captivity, was probably wounded in the same manner.

Since the warning as to the dangers attending oil exploration and drilling, a test well has been drilled in the heart of the winter habitat near Camp Pond. This well proved to be a dry hole, but only the unusually high degree of cooperation on the part of the Continental Oil Company and the Western Natural Gas Company prevented serious disturbance of the biotic character of the environment. The drilling was done during the cranes' absence. Additional test wells are contemplated and the discovery of a field could be a fatal blow to the fortunes of *Grus americana*.

Even in peace times the wintering cranes have been harried by airplanes and only a regulation or order establishing a ceiling over the refuge area will provide a practical means of preventing this form of disturbance. The chief danger here lies in the possibility that cranes will desert the safety of the refuge for areas where they will be molested.

More individual Whooping Cranes were killed in Nebraska, according to our *Kill Record*, than in any other State, Province or District. The

need for a refuge along a strategic portion of the Platte River is apparent.

The habits of the species that were considered "not controllable" appear, for the most part, to be perfectly valid in the light of our recent investigations. Although passages in the literature suggest that the birds are "noisy and lively" on their nesting grounds, our observations of the captive pair that nested on Aransas Refuge in 1949 leads us to believe that, unless actually discovered and disturbed, nesting Whoopers are normally quiet and secretive, the incubating bird hiding itself in deep cattails and the free member of the pair leaving the nest, or approaching it, with extreme caution. Although it is probable that this 1949 nesting, in the cattail marsh, was typical, the captive pair nested on open salt flat the following year and were in plain view throughout incubation. However, it is our present feeling that the unknown breeding grounds are in an isolated spot that has remained undetected. No recent reports of "summer cranes" suspected of being nesting birds, have described behavior suggesting the proximity of a nest and an incubating partner. Further exploration of the North, by airplanes in search of minerals or of untried commercial or sport fishing locations, may in time uncover the hidden nesting sites. It is still to be hoped that wildlife officials will find them first.

The length of time required by the young in learning to fly has been discussed earlier in this report. It is not believed that this provides a valid decimating factor under normal conditions.

Other normal causes of decimation such as predation and disease can be mentioned. There is bound to be a certain annual loss, on the average, from natural causes. As was discussed earlier, if this annual average is 18.5% of the present total population (or 2 Whooping Cranes), there will be a steady improvement in total numbers. We do not know, just yet, how much of the present losses are from natural causes and how much from shooting and other unnatural causes.

No predation of adult cranes has been ob-

served on Aransas Refuge and it would seem more likely that this form of loss would take place on the nesting grounds, where young cranes, eggs and, perhaps, molting and temporarily flightless adults, would be more vulnerable than elsewhere. On September 24, 1949, Mrs. E. C. Boon, of Tulis, Saskatchewan, observed an eagle (apparently a golden eagle) swoop down on a flock of Sandhill Cranes and attack one of them. Mrs. Boon chased off the eagle and found that the crane, an immature Lesser Sandhill, was dead. Postmortem findings revealed three ribs broken and the liver torn (*Bluejay*, 1949). Bald eagles present in winter on Aransas Refuge do not appear to molest the Whoopers and the cranes' habit of roosting at night in the center of shallow ponds, would seem to be ample protection against wolves and coyotes attempting a sneak attack.

Walkinshaw (1949b, pp. 142-147) lists disease, predation by man and other animals, fire, drought and temperature extremes as decimating factors for various races of Sandhill Cranes. Cranes have died of "limberneck" (botulism), tuberculosis, enteritis, aspergillosis and chicken cholera. Predators are mentioned chiefly in connection with the cranes on the nesting grounds. The list included wolves, foxes, dogs, jaegers, hawks, eagles, owls, coyotes, raccoons, crows and ravens. There is some convincing evidence with regard to the predatory role of many of these animals.

Walkinshaw states further that "Shooting was probably the greatest factor in the reduction of the Greater Sandhill Crane." He also lists egg collecting, which may still menace the Florida Sandhill Crane. The Cuban race is still hunted.

Other decimating factors discussed are drainage of marshes; general lowering of water tables; fire; drought, frequently complicated by fire; shooting as a result of crop destruction.

Remedies suggested include the planting of grain crops adjacent to refuge areas, use of swinging mirrors on farm fences, early harvesting of grain crops, educational programs among

farmers, additional refuges in areas not already covered, special protection for the Florida roosts, controlled marsh burning, legal protection and establishment of refuges in Cuba.

Other diseases that have been discovered in cranes include swine erysipelas and coccidiosis (Morgan, 1944).

The Role of Cattle

Following suggestions that the presence of cattle on the Aransas Refuge, and especially on the salt flats, might react unfavorably on the habitat, directly or indirectly, so that cattle might have become a decimating factor or influence, resulted in the setting up of special study areas. Initially, two stake lines were established on two more or less identical sectors of salt flat and adjacent uplands. One of these lines (F line) was eventually (December 20, 1946) enclosed within a cattle-proof fence, while the other (G line) remained outside, where cattle had free access. The fenced area enclosed a salt flat and upland area of nearly one square mile. The F line was free from grazing, trampling and other effects of cattle use, and the G line would reflect any measurable results of such use.

Plant densities were estimated by the writer and Olaf Walimo on February 17-18, 1947. Samples were made at each stake along a 10-meter chain by the line intersection method.¹⁴⁰ There were seven stakes on each line and densities were estimated for each species of vegetation and the total density averaged for each stake location. After one year (in March 1948) the densities and general condition of vegetation were checked again. Although no cattle had been present within the enclosure, densities were reduced, after one year, on the salt flat portion of the F line as a result of high tides and prolonged flooding by salt water. On the upland portion the only outstanding change was in the unchecked growth of grasses like *Andropogon*, *Pas-*

¹⁴⁰Canfield (1944).

palum and *Aristida*, where these were present in scattered abundance.

On the G line, outside the enclosure, four out of seven densities increased, in spite of the presence of cattle, and it was thought that a greater amount of precipitation was probably the responsible factor. High water levels through much of the previous winter did not keep cattle away from the stake line, however, and where trails had been followed there was excessive trampling. In general, the dominant salt flat plants were not heavily browsed, the cattle seeming to prefer the vegetation of the higher ground. Nevertheless, with a bovine propensity for aimless wandering, cattle struggled through the soft mud of most of the ponds in order to reach other trails along the rim of the bay, and continue their endless peregrinations. A few of them stuck in the mud and one unfortunate beast, unable to extricate herself, died in the muck at the eastern end of Dunham Pond, to the delight of the blue crabs.

Since none of the vegetation concerned is of any major value to the Whooping Cranes, as either food or cover, it is not felt that our density studies were very useful and the detailed results are omitted. In clambering through feeding ponds the cattle undoubtedly do some damage to crab burrows, mud shrimp burrows, Nereid worm habitat, and so on, but it is not particularly serious. As already mentioned elsewhere, cattle sometimes forced cranes to leave feeding places that had been baited, but the birds returned soon after the cattle had moved on. No apparent harm was done.

In the salt flat habitat, below the 3-foot contour, water and the elements—wind, precipitation and tide—are the dominant influences and their interaction determine plant densities and distribution, regardless of the presence, or absence, of cattle.

Nevertheless, the fact that cattle roam at large over the salt flat portion of the refuge creates circumstances that cannot be interpreted as anything but unfavorable to the cranes. The pres-

ence of the cattle requires a certain amount of activity in rounding up yearlings for branding, in searching for small herds that have become isolated on beach ridges near the bay and in feeding them their occasional ration of cottonseed cake, as is done in winter in brush country like that on Aransas. The security and isolation of the Whoopers is broken into by these and kindred activities and because of them pairs and family groups of cranes have been driven from favorite feeding places, to seek refuge on the shore of the Waterway or elsewhere, where they may be vulnerable to illegal shooting. Disturbance of this kind is exactly the sort of thing the birds should be spared because they are within the confines of a refuge.

According to the figures on acreages listed earlier in this discussion of *Winter Life*, some 72% of the total refuge area is already assigned to grazing. It should not interfere with the operation of the grazing program if the 5,000 acres, more or less, of the East Shore Flats were fenced to keep out cattle. Such a move might even simplify cattle management and, at the same time, benefit the Whoopers by increasing the highly important isolation factor.

The Food Supply: Possibilities of Study and Management

When the environment of the salt flats and their immediate and adjoining water habitats were still completely undisturbed by man and his works, there was doubtless little possibility of a failure in the food supply, except during extreme drought. Even then the cranes and other wildlife could range far and wide in search of food without serious molestation from the aboriginal inhabitants of the coast. Drying up of the feeding ponds that we have classified as Type B (Long Pond, Middle Pond, etc.) was probably an infrequent occurrence, however. Price and Gunter,¹⁴¹ in discussing geological and

¹⁴¹Price and Gunter (1942).

other changes on the Texas coast, have commented, ". . . Man's occupancy of territory suitable for grazing and farming has often led to depletion of vegetational cover of the land and locally resulted in gulying, loss of soil water and lowering of the water table." While the mean level of the bay waters has not changed significantly (delineation of Texas shorelines, drawn by Cardenas and Siguenza in 1689 and 1690, show almost no change from present outlines), the water table of the peninsula (mainland) was evidently higher, the runoff more gradual and the level in the sheltered ponds more constant in earlier times, prior to settlement, than they are today.

Apparently the first serious disturbance of the biotic equilibrium occurred in the 1840's. In that decade, numbers of immigrants arrived on the Texas coast and spread over the adjacent country, several families farming and grazing cattle on the Blackjack Peninsula. During the last three decades of the 19th century, there was considerable human activity along that part of the coast, with large scale hunting of waterfowl, including, Whistling Swans, once present in great numbers. For example, in April 1895, a party of sportsmen from Chicago, San Antonio and Rockport, guided by Johnny Bludworth, journeyed to the mouth of the Guadalupe River to hunt canvas-backs. An account of the hunt, which appeared in *Forest and Stream* that same spring (Hough, 1895), presents an unusual picture of the abundance of ducks, geese and swans on the salt flats of the Blackjack Peninsula. This was one of the drought years, and the party found so little fresh water coming down the Guadalupe that the "wild rice" (*Zizania?*) had failed. They were much disappointed and bagged only "about a dozen and a half in our one night stand there." They also expected to shoot snipe, but found none.

The party left Hynes Bay for Rockport, stopping on oyster reefs, where the "opening and eating occupied a good part of the evening." That night, under sail, they reached a location

off False Live Oak Point, now part of the Aransas Refuge. The sounds made by multitudes of feeding ducks and geese were so loud as to "represent a great body of fowl, perhaps the very location we had been feeling around for on the coast." Accordingly, they dropped anchor and spent the next morning shooting.

The following passage describes the scene that lay before them when they went ashore at Mustang Lake at daybreak. "We did have a good time, perhaps the best time of the whole trip so far as the shooting was concerned, for certainly at no other point did we see such abundance and variety of wildfowl, and had we stayed for a day or so at this point we could surely have shot to our heart's content. We found that there was a long expanse of water about a quarter of a mile inland from the shallow salt water bay, and this lake or arm of water we at first took to be fresh, though we found later that it was connected with the salt water by a narrow channel at each end. This inland lagoon was nearly two miles in length and was perhaps a half mile across at its widest point. On each side of it there ran many ponds and pools of shallow water. All these connected waters, as well as the shoal water of the bay in which we had come to anchor, bore innumerable thousands of fowl which were evidently finding plenty of feed, for they were all very fat and heavy, as we found later. I have never in my experience seen so royal a sight as that uncovered by the morning sun as it rose above these favored water. There were long lines of honkers riding out at sea and passing inland to the lakes; there were ducks in strings and clouds coming and going along the coast and over the ends of the inland arm; hundreds of silver gray herons stood in gaunt profile along the sedgy flats inshore, and there came to us often the wild trumpeting of the great bugler cranes."

At that date, most of the "honkers" were probably the common Canada goose (*Branta c. canadensis*), now almost entirely depleted on that part of the Gulf Coast. The "silver gray

herons" were Ward's herons, nesting on the nearby Second Chain and feeding along the shore of Mustang Lake. The "great bugler cranes," of course, were Whooping Cranes.

Whistling swans, now virtually extirpated on that coast, were likewise present. "Out on the bay, in great white squadrons of many acres in extent, floated the greatest birds of all our wildfowl, the big white swans . . . we were ready to admit that on this, our last day in the country, the gulf coast of Texas had massed its attractions to show what it could do."

The shooting began in the early morning light. "Dick Merrill killed so many geese that he could hardly lug them over from the lake to the boat landing. Wilbur Dubois and Bob Burton had geese and ducks both in their string, and Mr. Peabody was regularly cutting down the mallards in the finest bit of decoy shooting he ever had in his life. Jimmie shot up all his shells and Johnnie used up the last of his rifle cartridges, getting a fine honker and a splendid specimen of the white bugler crane (*Note: Whooping Crane*) before he was compelled to cease firing. It was about 11 o'clock when we first rounded up on the beach off the anchorage, and when we piled up all our game we had a magnificent showing—nearly four dozen ducks, a dozen of the largest and fattest geese I ever saw, all Canadians, besides some white fellows not enumerated, the big white crane and also a fine great swan."

An environment that could support this vast assemblage of waterfowl and other wildlife must have been (perhaps we should say, must *still* have been) in a fine state of balance. Flocks of swans "many acres in extent" required a huge supply of underwater vegetation for most of their feeding, not to mention the "innumerable thousands" of ducks and geese, which divided their diet between vegetable matter and certain forms of animal life, including the tender razor clams now extirpated from that same area. Fifty-five years later the vicinity of False Live Oak Point and Mustang Lake is still one of the best

wildlife habitats on the Gulf Coast, but, in the passing of these years, the environment has been altered in many ways and from many causes.

The removal of vast numbers of waterfowl and other birds has, in itself, been a serious blow to the biotic balance. In the winter of 1947, on an average day, I counted 913 ducks and 172 geese on Mustang Lake and the adjacent salt flat ponds, including Redfish Slough. There was one whistling swan in the area, but it was on a fresh water lake a couple of miles away. The erosion, silting and general lowering of water tables as a result of drainage, farming and, especially, over-grazing on lands up the nearby Guadalupe River and elsewhere in the interior, have had a gradual and destructive effect on the water environment, including oyster beds and marine organisms in general. The dredging of the old channel through the oyster reefs at Ayres Dugout and beyond, not only made the bays more accessible, thus reducing the isolation factor, but probably altered the normal equilibrium throughout those bays. Construction of earth and shell dikes on the shore of the peninsula and of a concrete dam across the natural opening of Redfish Slough have been other disturbing elements, while the dredging of the Intracoastal Waterway, right through portions of the salt flat habitat, and the destruction of large areas of salt flat that was smothered by spoil from the dredging, all of these more or less recent activities have so changed the original environment that it is more than possible it can never be restored to anything vaguely approaching its primitive condition.

Today, when we speak of maintaining "the balance of nature," even in a relatively remote and relatively unspoiled habitat like the Aransas Refuge salt flats, it should be borne in mind that the natural balance was upset many years ago. It is being further disturbed and altered every day. Thus, any artificial measures designed to *arrest* further disturbance of the remnants of the normal habitat, or any effort to *restore* original conditions, are not attacks on a

mythical "balance of nature," but commendable attempts to prevent more chaos, to forestall ultimate and complete disaster. Besides, "balance" is actually a changing, delicate, dynamic state. Hedgpeth has applied the term "precarious equilibrium" to the salt flat situation and, doubtless, this has always been an applicable term, even under original conditions.

It is our business to understand the nature of such an environment, to measure the changes it is undergoing, and their causes, and then to arrest unfavorable factors and influences and restore what we can of the original conditions. When purely artificial measures and activities have been responsible for the sapping of the various streams of life blood in a broad complex of plant and animal communities, these destructive forces must be met by opposing measures and activities of artificial source.

If normal sheet drainage is insufficient, wells can supply runoff water from greater depths. If autumn tides bring in much needed stocks of crustaceans, fish and other marine organisms, control gates can be installed to trap these basic food animals in depleted ponds and estuaries where they will be utilized by Whooping Cranes and other birds. Killifishes are easily netted and placed in depleted water habitats, just as aquatic vegetation is artificially planted. If the basic food stock, the blue crab, is cleaned out of the ponds before the end of the winter, they can be obtained by the barrel from shrimp trawlers operating in the nearby bays and the ponds restocked in a few days.

Considerable study has already been made of the biology of the Whooping Crane's winter habitat and it is believed that the existing possibilities for improvement and restoration work through management are of a thoroughly practical nature. It is also felt that management of the environments concerned has become a necessary step. From this point on, it may be more important, for instance, to investigate the life history of *Callinectes sapidus* in that area, than to obtain further data on the behavior of *Grus*

americana. Food is essential, and the Whooping Crane is not as omnivorous as one might be led to think. At least half their day is given to feeding. I once watched a family of Whoopers from a blind, at close range (100 to 200 feet) for a period of 6 hours and 56 minutes. They fed for a total of 212 minutes, preened and rested for 143 minutes, defended their territory for 46 minutes and were idle for 15 minutes, while a herd of cattle splashed through their feeding place. Thus, about 50% of their time was spent in feeding. Other observations indicate that some pairs spend better than 50% of their day actually feeding and something like 25% walking from one feeding place to another. As Stevenson observed in the winter of 1938-39, when the food and water supply fails it presents an extremely serious situation. We must profit by these lessons and prepare for emergencies. The death blow to the Louisiana population was a heavy fall of rain that flooded their native marsh and drove them into an inhospitable and unfamiliar world.¹⁴² It happened very quickly.

Welfare Factors

Stevenson and Griffith (1946) list factors that operate in favor of the Whooping Crane's survival. These are (a) protection by federal and state laws, (b) the retiring and wary nature of the species, (c) parental care until young are fully grown, (d) ability of adult Whoopers to "hold their own" with most predators, except man, (e) the possibility of a natural longevity, (f) lack of any record of critical or fatal diseases in wild Whooping Cranes.

Only one of these, protection by law, is within our ability to control. Until 1918 protection by

¹⁴²Annual rainfall in this area is 57 inches (average). In five days during early August, 1940, there was a fall of 22 inches. At White Lake the flood waters were 5 feet above normal Gulf level. Normal levels throughout the region were not regained until about September 15 (see *Senate Document 94*, 77th Congress, 1st Session, for full report on the flood conditions).

Federal Law was chiefly "on paper." The continental population, by that year, had already been reduced by an estimated 95% and our *Kill Record* shows that, in 1918, 14 Whooping Cranes were known to have been shot. In the years since, the known kill totalled 46 birds. From an overall point of view, there are some 29 Whoopers less today than the total estimated for 1917. Yet, without the restraint of protective laws, and, especially, the discontinuance of legal spring waterfowl shooting, the species would probably have been extinct by this year of 1950. Or long before this.

There are other welfare factors and influences within our control. Education of the general public, particularly of the man and boy who is out in the open, with a gun over his arm, along the migration route, is perhaps the field in which most can be accomplished, over a long period, towards preserving the Whooping Crane. Public sentiment has already been interested, if not aroused, but it would be very foolish to be satisfied with the interest of a few thousand ordinary citizens, residents of cities a thousand miles from the Whooping Crane's migration highway. We must seek to reach the male population of small towns and farms throughout the critical States and Provinces. Articles in hunting magazines, conservation department periodicals and farm journals are an obvious medium. Though the immediate need for education is too pressing to depend entirely on work in the schools, this, in the long run, is the most fertile field of all, and should not be neglected. What material on the Whooping Crane and other threatened species is being provided members of Junior Audubon Clubs? Or Boy Scout groups, 4-H Clubs, and Future Farmers of America?

In 1901, before the Junior Audubon Club idea had been developed, Wilson Tout, then a school teacher in Nebraska, spoke before the Nebraska Ornithologists' Union on the subject of "Ornithology in the Schools." He ended his remarks with these words: "The time is passing rapidly. Every year hundreds of boys and girls

are finishing their courses and leaving the schools of Nebraska. They know nothing of the value of our bird fauna and in their strivings to become real men and women they imitate their vices as well as their virtues and join the ranks of bird destroyers, the men for sport and pleasure, the women for decoration. As students of bird life and champions of its protection our duty is plain and if future generations blame us and we attempt an excuse, they will mock us by repeating our big words and showing our little deeds.

"The school is the field and we are responsible for the harvest. What shall it be?" Great strides have been made since that day in improvement of protective laws, in enforcement, in public opinion and in the general status of most species in our North American avifauna. But the job is not finished. There are still weak spots and the challenge has broadened to include an understanding of the whole complex of soil, water, animal and plant resources, and the ultimate welfare of Man himself. One of the weak spots is the status of the Whooping Crane. If we fail and if the last Whooping Crane is finally shot, by an unidentified man or boy out for a little "sport" we can be very sure of one thing; that man or boy was never an active member of a Junior Audubon Club. The present challenge is to reach this individual, and to reach him *now*. His hand will be raised to salute or to destroy. "What shall it be?"

Basic welfare factors are contained in the species' natural environment. On the breeding grounds, at points along the migration route and on the winter range, these habitats must remain as natural and as free from disturbance as possible. Refuge status, as on the wintering grounds, should be obtained for at least one strategic stopping place on the migration route, preferably on the Big Bend of the Platte River, in Nebraska. The nesting area, when located, should be set up as an inviolate refuge. Other forms of wildlife will benefit from these moves, particularly waterfowl. Where needed, study

and management of the environment should be undertaken.

It is difficult to speak on a broad subject like "welfare factors" without bogging down in equally broad generalities. It is one thing to suggest that the problem requires educational efforts, more refuges at strategic locations, or management of outstanding environments, but quite another to make specific suggestions, based on actual experience. It is our feeling that phases of this restoration program dealing with education and acquisition of additional refuge areas should be outlined and carried through by specialists in those two fields. We can see the need and we can urge the action, but others are better trained to handle the details. More within the province of this report is the matter of management of wildlife resources. Here we are more at home and have had the advantage of special study in the field.

Perhaps the best example of the many possibilities of subjects for management on the winter range is the blue crab, *Callinectes sapidus*. Without this lively decapod the winter environment of the Whooping Crane, as such, would deteriorate very quickly. The crab is

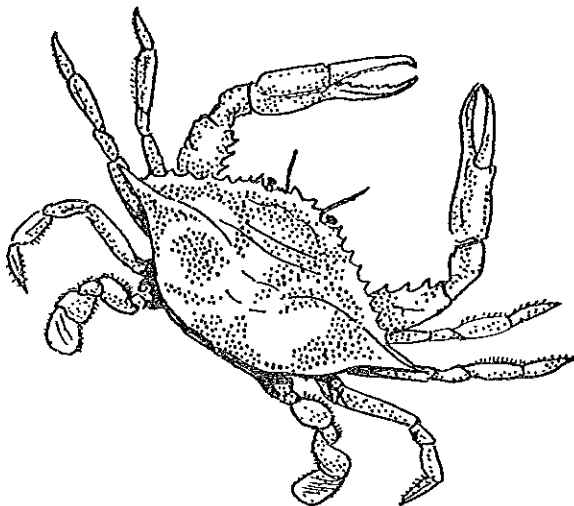
obviously a key species and, if we are to plan for the future welfare of *Grus americana*, it behooves us to learn all we can about the equally important welfare of *Callinectes* in that region.

The Blue Crab as a Basis for Management

What do we know of *Callinectes sapidus* and its pattern of existence in the feeding ponds of the Whooping Crane on Aransas Refuge? We cannot afford to take this important crustacean for granted. There are a number of profound questions that should be answered concerning its abundance at different seasons, the causes of any fluctuations in numbers, size range and availability through the winter months, and a host of others. Joel Hedgpeth (1950), who studied their relation to the Aransas salt flat habitat, summarized his investigations as follows:

"The blue crab is one of the dominant elements in the food chain cycle of the Aransas Refuge salt flats, comparing in bulk if not in numbers with some of the fish. It is the most ubiquitous and conspicuous invertebrate member of the salt flat fauna and one of the important elements in the diet of the Whooping Crane."

It was found that the blue crab is present, in greater or lesser numbers, throughout the entire year in the salt flat ponds. There is, however, a pattern of distribution that is chiefly influenced by the advent of the spawning season and by weather conditions, particularly in winter. The salinity factor is of great importance with relation to egg-bearing females and hatching eggs, but evidently less important in other phases of the life history. Hedgpeth found crabs on Aransas Refuge in salinities ranging from 2.0 ‰ to 18.6 ‰ and it is well known that the species is no stranger to fresh water, sometimes traveling up rivers for considerable distances.¹⁴⁸ Aside from definite environmental requirements during spawning, the blue crab is an extremely adaptable and successful crustacean.



(Drawing by Kay G. Morton)

¹⁴⁸Gunter (1938).

On the Texas Gulf coast in general, Gunter (1950b) reports that "Females carrying eggs were taken from March 22 to August 25, 1942. . . . the egg-bearing females range from 110-185 mm. in width across the carapace. The average width was 155 mm. . . . The salinity range for the egg-bearing blue crabs caught ranged from 22.9 to 32.4." Most spawning takes place in the open Gulf.

So far as the salt flat ponds at Aransas Refuge are concerned, the average pattern of abundance, dispersal and availability to Whooping Cranes is more or less understood, but under certain conditions there may be a complete lack of active and, therefore, *available* crabs (as well as of other motile organisms) and it is these conditions that require our special attention in this report. The percentage of females in the total blue crab population on Aransas Refuge begins to drop off during March and continues to a low point that may be reached in September. This period from March through September coincides with the overall spawning time. From this cause of normal spawning dispersal alone there is some loss in available numbers that begins in March and continues at an increasing rate through the first weeks of April, after which the cranes have migrated towards their breeding grounds in the North. It is doubtful if this dispersal by itself creates anything in the nature of a food shortage, so far as the cranes are concerned. Up to mid-April there may still be large numbers of male crabs in the ponds, as well as a growing influx of young crabs, depending on climatic conditions, success of late hatches of the previous season and other factors.

In his same paper on the marine invertebrates of the Aransas area, Hedgpeth (1950) says, "Because of the blue crab's protracted spawning season in Texas waters, there is always a reservoir of potential emigrants to the salt flats in the bays at all times of the year except during cold periods when the crabs do not move about. . . ." In general, according to Hedgpeth, there is probably a steady supply of small crabs entering

the salt flat area from early summer to nearly mid-winter. Small crabs that may appear in the catches in February and March, in the opinion of Hedgpeth, were probably "the last of the previous year's hatch." If mating occurs in March and eggs hatch two months later, in May, then it may be early July before many young crabs of the new hatch can begin appearing in the bays and ponds in any numbers. There is evidence of some movement of young crabs of the current hatch on the Texas coast in late June, however.

The movement and arrival of small crabs can be very irregular. In 1946 Hedgpeth reported an influx of young blue crabs in February and March, but the following year the peak for the 20-30 mm. class was noted in April. These irregularities have an important bearing on the food supply of wintering Whooping Cranes and it will be of value to understand something of the general life history of the blue crab with reference to spawning and the dispersal of the young.

According to Hopkins:¹⁴⁴ "Mating of the female crab occurs only once, and this is always at the time of the last molt. After mating the females, at least in the Chesapeake Bay, begin to move back towards saltier and deeper water." There are believed to be about 14 molts between the first crab stage and the mature crab. If mating occurs in spring or early summer the eggs are laid about two months later, but if cold weather follows shortly after mating the eggs are not laid until the following spring.

Hatching takes place about 15 days after egg laying and the egg mass or "sponge" may contain from 1,500,000 to 2,000,000 eggs. If conditions of salinity and temperature are favorable a female may spawn two or three times in the same season. Hopkins (*in litt.*) states that, "Where salinities are high enough, nearly all eggs hatch; in low salinities, eggs fail to hatch or hatch abnormally. A very small percentage of

¹⁴⁴Hopkins (1942).

the crab larvae survive," through the first month or so (zoal stages). Thus at this phase in the life history, precipitation, winds and other climatic conditions have an important bearing on blue crab abundance and, on portions of the Texas coast, on the welfare of the Whooping Crane.

From the next (megalops) stage on, crabs are "extremely tolerant of wide ranges of environmental conditions and can eat almost any kind of food. . . . Young crabs in the early instars migrate long distances in a relatively short time, especially where tidal currents are strong, and become distributed to all parts of a bay system, including fresh water streams." (Hopkins, *in litt.*).

Normally, a period of high tides is recorded along the coasts in September. At this time the number of young crabs on the move may be fairly high, possibly at peak in certain years. But even these tidal conditions may vary and such an item as prolonged wind from quarters that are favorable for depositing large numbers of small crabs in the Whooping Crane ponds, cannot be predicted. On the other hand, we should be able to learn to anticipate both favorable and unfavorable conditions and thus to estimate the nature of this major item in the food supply at the outset of any given season.

The dispersal of mated females and the uncertain influx of small crabs, as important as these matters are in their relation to the food availability of the Whooping Crane, are less serious than the impact of winter "northers." In his recent marine invertebrate paper, Gunter (1950b) notes that when these northers are extreme and prolonged there is a general exodus of nearly all motile organisms from shallow to deeper waters. When the "hard cold" spells come, all kinds of marine animals in the shallows may be killed. These facts point to the conclusion that the low point of the blue crab population in the Aransas Refuge ponds may come in mid-winter and in some years the reduction in numbers of crabs and other marine forms

may be drastic. Obviously, it is at such times that the Whooping Cranes may be faced with a virtual failure of their normal food supply.

Under "original" or undisturbed conditions the cranes probably were able to meet an occasional crisis like this by moving to other areas, such as nearby river deltas and marshes that were less drastically affected by the cold. But today there is no safe place for them to go. If they retreat to locations beyond the limits of the refuge they are in constant danger of being shot and will certainly be disturbed, as few places on that coast remain isolated. Today we must devise means for keeping these birds on the refuge, even in the face of temporary failure of the food supply. There are a number of measures that can be taken and these are discussed in the recommendations at the end of this report. In a sudden emergency it might be possible, for example, to introduce live crabs, obtaining them on order from trawlers or from stock ponds of sufficient depth to carry a large supply through cold weather. These deep ponds could be prepared and stocked in early winter against the possibility of a cold snap and failure of the normal supply. The number of crabs involved would not be large enough to disturb the balance of the crab population,¹⁴⁵ being quickly disposed of in the feeding ponds by various birds and mammals in addition to the Whooper. In this manner, and in other ways, it should be possible to create our own welfare factors. The Whooping Crane has suffered at our hands and it must be these same hands that will reach out and help it to recovery.

Winter Life: Summary

1. The original winter range of the Whooping Crane was confined chiefly to a coastal strip

¹⁴⁵ The total number of blue crabs must be immense, under suitable conditions. 200,000,000 are reported as caught annually in the Chesapeake Bay area (Newcombe, 1945). The crab industry is relatively small in Texas yet there are records of more than 1,000,000 pounds of blue crabs being marketed in that state in a single year.

extending from Marsh Island, and adjacent interior prairies, in Louisiana, southwestward through Texas to the vicinity of Matamoros, Tamaulipas (Mexico). There were smaller wintering groups on the Atlantic seaboard, prior to 1858, and on interior tablelands near San Angelo and San Antonio, Texas, and in central Mexico, this last prior to 1904. Five major types of habitat were included.

2. The present winter range is confined to a coastal region of approximately 10,000 acres of salt flats and brackish water areas, midway along the southeast Texas coast. One-half of the region is within the Aransas National Wildlife Refuge and normally some 85% of the migrant Whoopers winter in the refuge sector.

3. In origin, the refuge area on the Blackjack Peninsula is a relict of the Pleistocene Ingleside offshore bar. From its geological and other physical characteristics it is apparent that the present Whooping Crane habitat has been duplicated, with only slight differences in location and conditions, since Pleistocene times.

4. The vegetation of the entire peninsula has been described. The higher ground of the interior is dominated by oaks, chiefly live oak, myrtleleaf oak and blackjack. Below the three-foot contour the salt-loving plants take over and the dominant forms include salt grass, saltwort, salt-flat grass and at least three varieties of glassworts.

5. The pond complex of the salt flat area is described and salinity, temperature and other factors are considered. The importance of wind force, direction and duration, and of rainfall, is discussed in relation to the animal populations in the ponds and other water areas.

6. The marine fauna is discussed and it is indicated that 67% of the fishes taken in the salt flat ponds were killifishes, while, among the invertebrates, the decapod crustaceans were the dominant forms, the blue crab being outstanding.

7. The entire salt flat environment is considered a transitional area, between the sea and

fresh water, yet the dominant fauna is marine in character. Due to fluctuations of tide, wind and rainfall the situation is one of precarious equilibrium, rather than that of a typical tension zone. The tension zones are found between the salt flats and the fresh water ponds and on the maritime beaches that separate the salt flats from the sea (i.e., the bays). The relation of the Whooping Crane to these and adjacent habitats is discussed.

8. The role of winter territories in the life of the species is considered, and the manner in which pairs and family groups segregate themselves on these territories is described. It is believed that approximately 400 acres of salt flats, including water areas, are required by each family or pair in that environment, as winter quarters. Fourteen territories on the Aransas Refuge are illustrated on maps that show the major habitats of each.

9. Territory defense is described and examples quoted from field notes. It is suggested that the intensity of defense varies according to the date, the presence or absence of young-of-the-year, the individual vigor of the family male and, possibly, the existence of a kinship within certain segments of the population.

10. The ecological relationships of the salt flat environment are discussed. It is considered that the decapods and the Cyprinodontidae (killifishes) are probably the key animal forms. Other important animals are listed as the blue crab, mud shrimp, sheepshead minnow, penaeid shrimp, pistol shrimp, grass shrimp, striped mullet, long-nosed killifish (black chub), Gulf silverside, raccoon, Whooping Crane, Ward's heron, American egret, snowy egret, reddish egret, willet, black-bellied plover and white pelican. Animal and plant forms in adjoining communities are discussed briefly.

11. The winter faunal list of the environment is given, including 152 outstanding forms.

12. The water habitat of the environment is discussed in detail and it is shown that there are five different water types, each of which

varies in its value to wildlife, depending on the action of certain natural and artificial conditions. It is considered that a working knowledge of the nature and biotic character of these water types will be essential to wise management of the whole environment in the future.

13. Limiting factors affecting the Whooping Crane are listed and discussed. The two major decimating factors on the winter range are believed to be (1) shooting and (2) periodic failure of the natural food supply. Remedies for both problems are discussed.

14. The role of cattle on the Whooping Crane area is discussed. After intensive studies it is considered that wind, precipitation and tide are dominant influences on the whole salt flat environment, and that their interaction determines plant density and distribution, regardless of the presence or absence of cattle. Disturbance of the marine fauna by cattle is considered negligible. However, it is felt that the presence of cattle on the salt flat area is unfavorable to the

welfare of the cranes for other reasons and these are discussed.

15. The status of the biotic equilibrium on the area is discussed and it is considered that this "balance" was upset at least a century ago, with progressively unfavorable changes taking place ever since. It is felt that the only solution to the problem of steady environmental deterioration is *management*.

16. Of the welfare factors listed, several are within our ability to control: protection by law and protection on refuge areas; education, immediately through articles aimed at the hunting group, long range through the schools and children's organizations; management of endangered environments essential to the species' survival.

17. The blue crab as a basis for management is discussed. It is pointed out that, by the means described, as well as in other ways, it is possible to create our own welfare factors. It is believed that something along this line must be done if we are to restore species like *Grus americana*.

Part VI. The Breeding Cycle

A century ago the coming of March saw high, circling flocks of Whooping Cranes beginning their northward migration from points separated by the width of the North American continent. The great flights were from the Gulf of Mexico, from northeastern Tamaulipas, Texas and the coasts and prairies of Louisiana; but other flocks began their long journey on Mexican lakes, only 100 miles from the Pacific Ocean, while still other migrant groups set out across the Appalachians, from wintering grounds on the Atlantic seaboard.



Today, the first signs of the beginnings of a new breeding cycle are observed on the Texas coast, the last of the wintering areas, in late December or early January. At the start, only one bird of a pair is seen leaping into the air,

springing several feet off the ground, wings flapping. This solo demonstration has been observed as early as December 18 and 19 (1946). However, the following winter we saw both the male and the female of the family at Middle Pond dancing on December 19. This dance, described previously, in our discussion of territory defense, was begun by the male. On January 10, 1947, a solo was observed, the one member of a pair suddenly pumping its head up and down in a series of bows, at the same time flapping its wings slowly and leaping lightly off the ground. In pumping, the bill almost touched the ground, coming up again to about one-half the distance between the ground and standing posture. All at once this bird flew, its mate following.

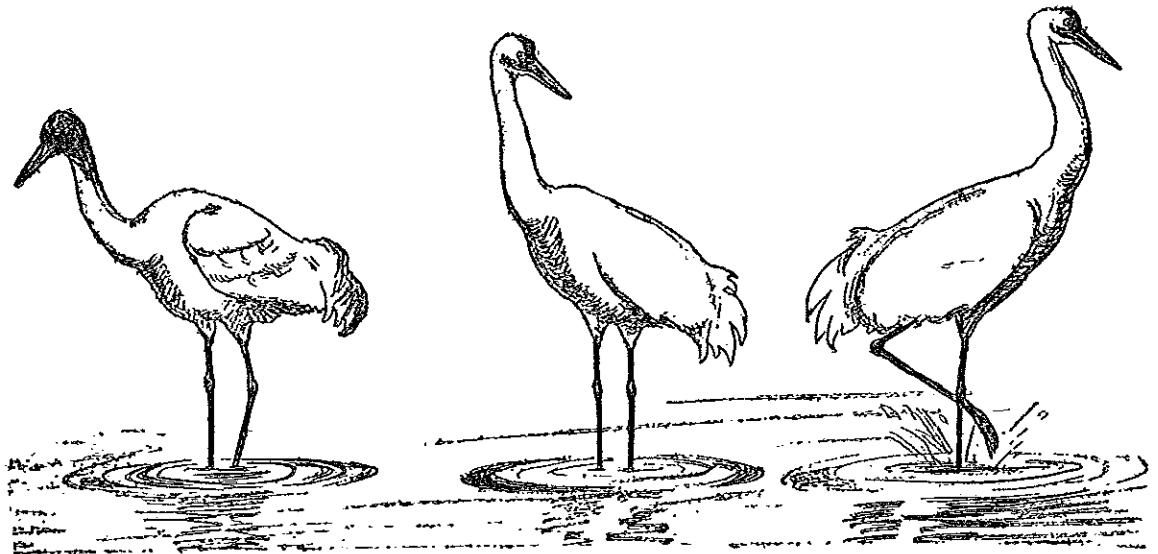
A brief but complete dance was seen on January 26, as described in a previous article (Allen, 1947b): "The 26th was warm and clear, in contrast to the wet and chilly weather of January 10. The same pair that we had watched in a partial dance on the earlier date were observed moving slowly along the far bank of Middle Pond. Suddenly one bird (the male?) began bowing his head and flapping his wings. At the same time he leaped stiffly into the air, an amazing bounce on stiffened legs that carried him nearly three feet off the ground. In the air he threw his head back so that the bill pointed skyward, neck arched over his back. Throughout this leap the great wings were constantly flapping, their long black flight feathers in striking contrast to the dazzling white of the rest of the plumage. The second bird (the female?) was facing the first individual when he reached the ground after completing the initial bounce. This second bird ran forward a few steps, pumping her head up and down and flapping her wings. Then both birds leaped into the air, wings flapping, necks doubled up over their backs, legs thrust downward stiffly. Again they

leaped, bouncing as if on pogo sticks. On the ground they ran towards each other, bowing and spreading their huge wings. Then another leap! The climax was almost frantic, both birds leaping two and three times in succession. Quickly it was all over, after about four minutes, and an extended period of preening followed."

As the migration departure date draws near, the dance can be released quite readily. On March 23, 1948, the family at Middle Pond was walking, single file, across an arm of the pond and in so doing came upon a small group of ducks. The male, who was in the lead, raised his wings and threatened the ducks, leaping towards them. This movement seemed to excite him and he immediately began a series of dance leaps, in a form that carried him around in a complete circle. The female, who was in the center of the circle, leaped two or three times, as if involuntarily, and began searching for food. The male's emotions seemed to be set on a hair trigger.

On April 3, 1948, just a few days prior to

migration, this same family group was again standing in the water at Middle Pond. On this particular day the female was more interested in dancing than the male. While he fed, she and the now well-grown youngster were bathing, the offspring imitating the movement of the female. They were standing in water about 15 inches deep. The female would crouch hesitantly, like a bather cautiously feeling the water with an exploratory toe. Then she would dip all the way under, except for her head and neck, splashing up and down, shaking her partly open wings, wiggling her tail and throwing her head about so that her crown stroked the feathers of her back. The immature Whooper imitated all this awkwardly. Then both birds stood and shook themselves vigorously, flapped their wings, wiggled their tails, ran their bills through their dripping primaries and began jumping up and down. The male kept on with his feeding. Then the female began leaping and flapping in a wide circle, running as she leaped. The immature watched and started to follow suit. The female

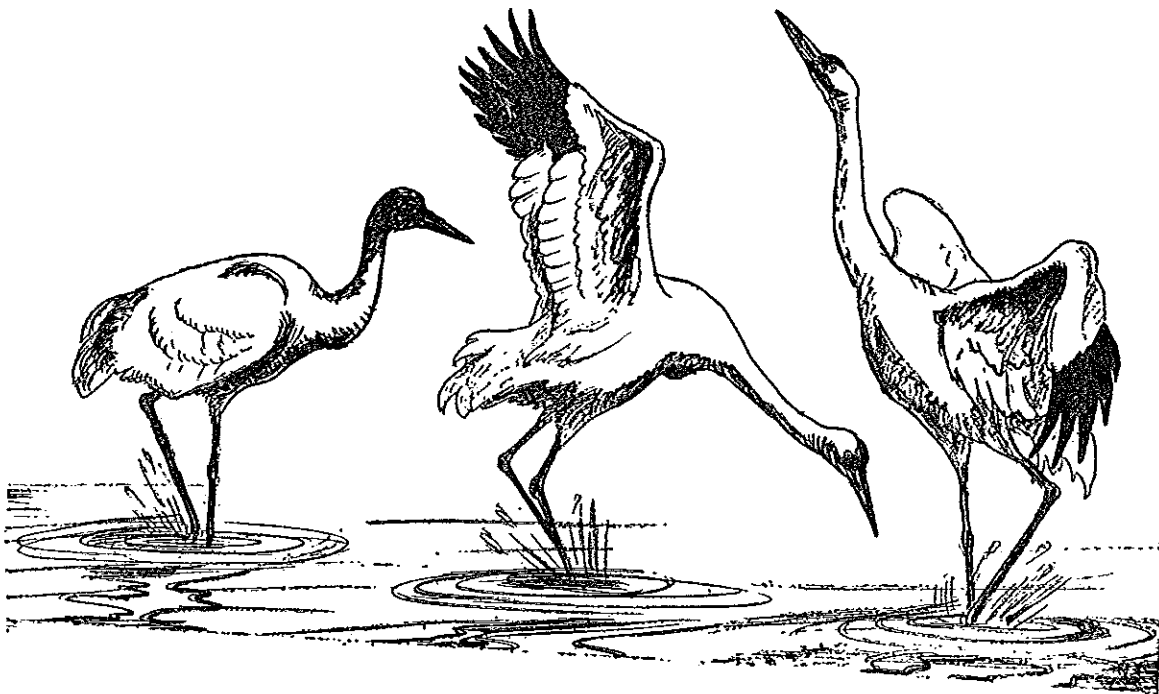


Family Group—Young, Female and Male—at Start of Dance.

turned and, with head lowered as in an attack, chased the youngster. She chased it repeatedly. Though obviously bewildered, the youngster continued following her and attempting to leap and circle as she did, wings flapping. After a little, the male, looking up from his searching, walked towards the female, leaped and beat his wings a few times. But no complete dance resulted. The routine of the long winter months was nearly broken. There was an air of excitement, of impending change. The cranes seemed almost as if poised, ready, waiting for the sound of a starting gun.

In general, the form of these "dances" is essentially like that of other cranes. Walkinshaw writes (1949b, p. 34): ". . . he was bowing, almost touching the ground with his bill, then raising and pointing the bill into the air at a steep angle. He did this several times, then

began bowing while at the same time rotating, slowly at first, then faster and faster, sometimes in a complete circle, sometimes in a half circle and then back, usually with head up, wings half-spread and drooping. When he stopped, he acted as if he were a little off balance, possibly a little dizzy. He continued to bow, holding his head near the ground, and sometimes swinging it from side to side. Again, he would spring into the air, rising five or six feet, very light-footed, with wings half-spread and legs dangling, partly bent, then drop gracefully and easily to the ground. Many times this crane leaped and whirled at the same time, hut not always to the same height. Occasionally he fanned the air gracefully and slowly with his wings as he whirled." This was a Greater Sandhill Crane, feeding near the nesting site in Calhoun County, Michigan. The date was April 3 (1941). The



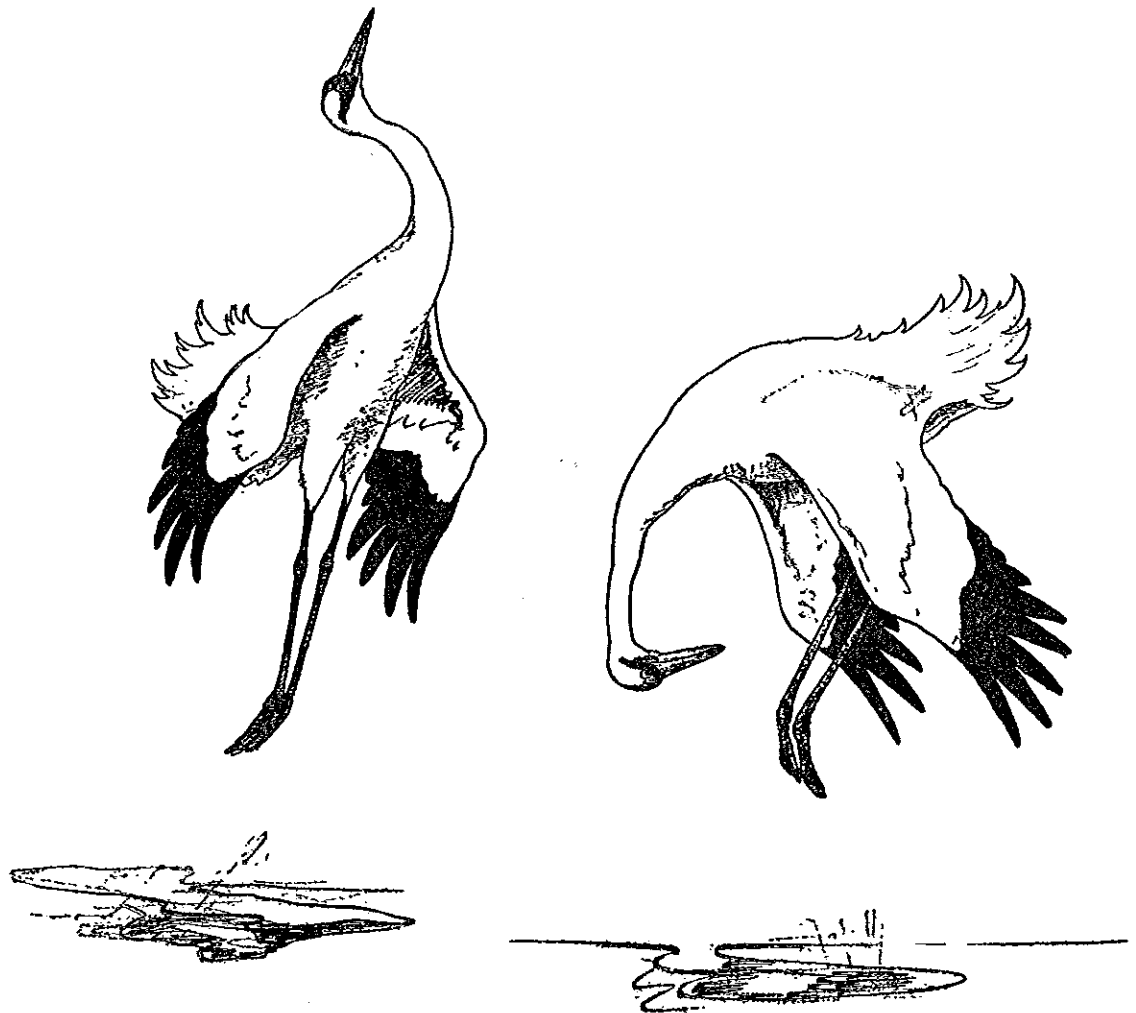
Male and Female in Initial Dance Postures.

bird's mate was with it, but, except for a few head bows it did not dance.

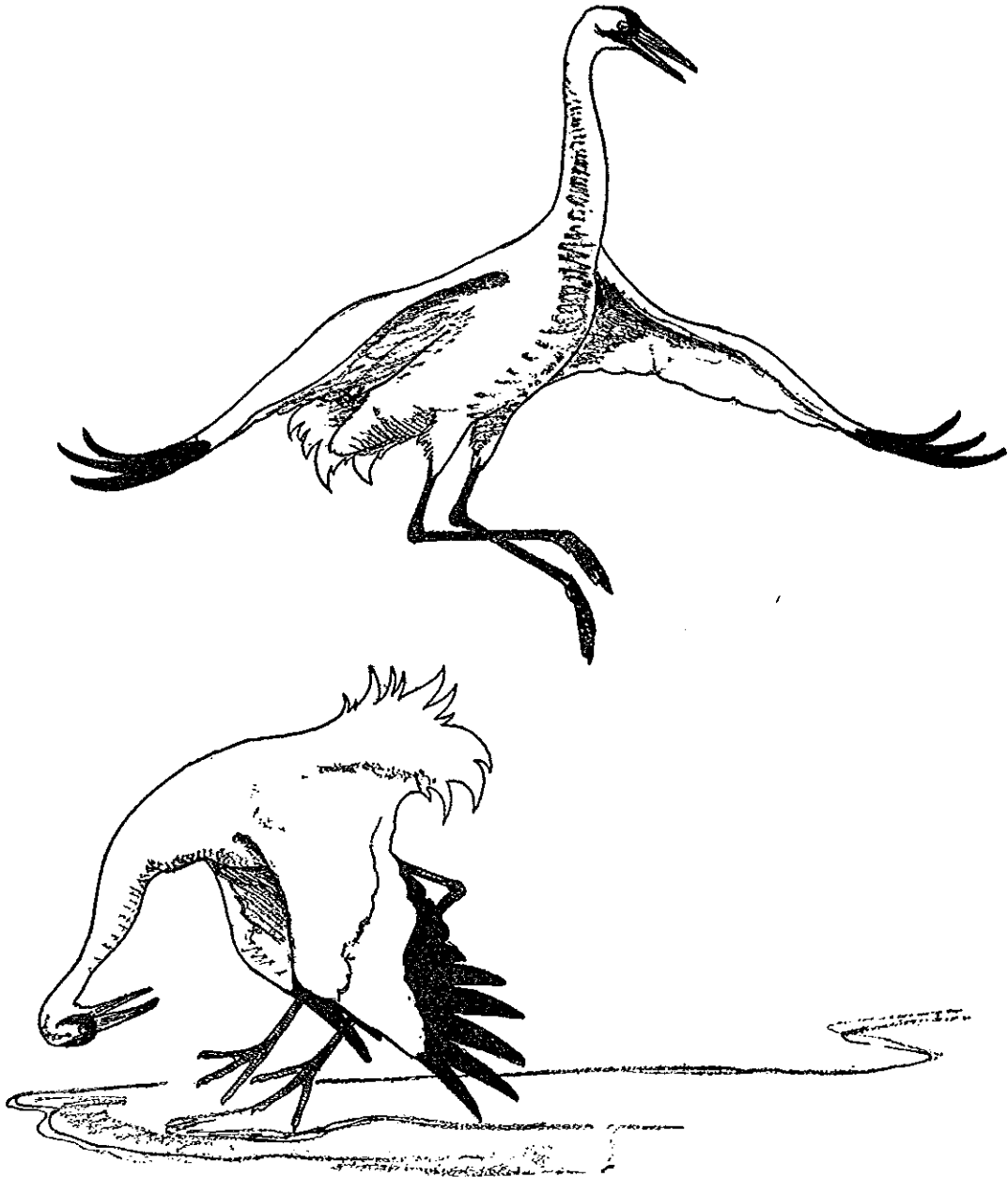
It should be noted that the Sandhill leaps higher in the air than the Whooper has been observed to do, and that its leap is "very light-footed," the legs dangling, partly bent. The Whooper springs stiff-legged, like a bird on a pogo stick, and while its performance is graceful

enough, we see in it also a ponderous sort of dignity that is evidently lacking in the dance of the smaller crane. Walkinshaw (1949b, p. 33) describes a stiff-legged leap by pairs of Florida Sandhills in March.

Another major difference between the dances of the Whooping Crane and several other gruins, including the Sandhills, is the mass perform-



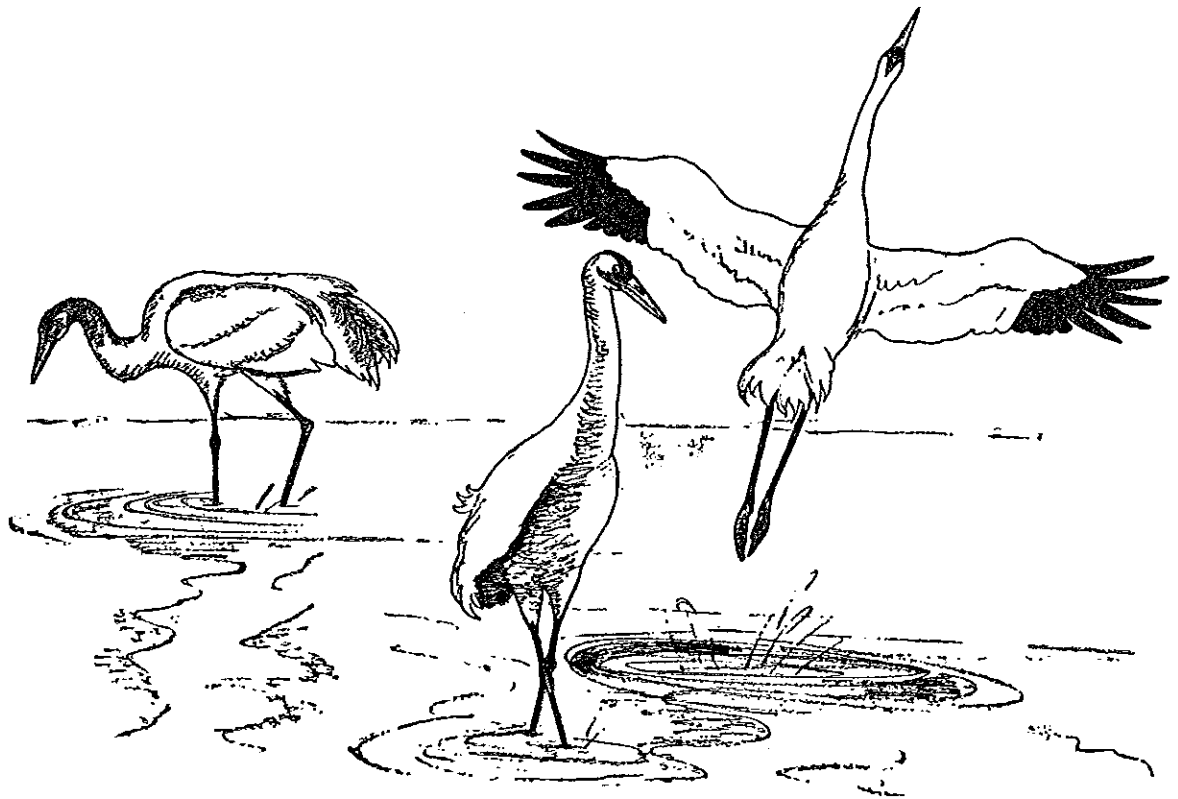
Leaps and Head Bows of a Full Dance.



The Male Leaps High Over Her Posturing Figure.

ance of these other races. In Nebraska, in April, I have seen several hundred Sandhills in a corn stubble field, leaping and flapping in an excited, quarrelsome, animated confusion that seemed without pattern or purpose. Whoopers are silent while dancing, but this jittery mass of birds was "talking" and uttering the guttural *garooo-a-a-a* notes without ceasing. Walkinshaw (1949b, p. 32) remarks, "The dance of the Sandhill Crane has long been considered a courtship display, but although cranes do dance more often in the spring than at other seasons, I have observed the

dance all through the year. . . ." Among the flock of Sandhills in April, in Nebraska, I could detect no evidence that any of them were paired. The leaping seemed almost involuntary, like blinking the eyelids or nervously drumming on a table top with the fingers. As one bird leaped and jostled its neighbor, the neighbor protested vocally and leaped, too, going up as the other bird was coming down. Possibly, as the gonadal development nears its peak, these birds are in an unusually nervous, highly emotional condition, and the constant jumping, wing-flapping and



Young Bird Bored, Female Through Dancing, Male Continues a Series of Solo Leaps.

protesting, is a means of keeping these combined physical and psychological forces at the right temperature, as it were, until they can be released in the actual courtship dance on the nesting grounds. Thus, this mass performance may be a sort of pre-nuptial display, at least in its origin and purpose, but carried out in chorus by a highly gregarious species.

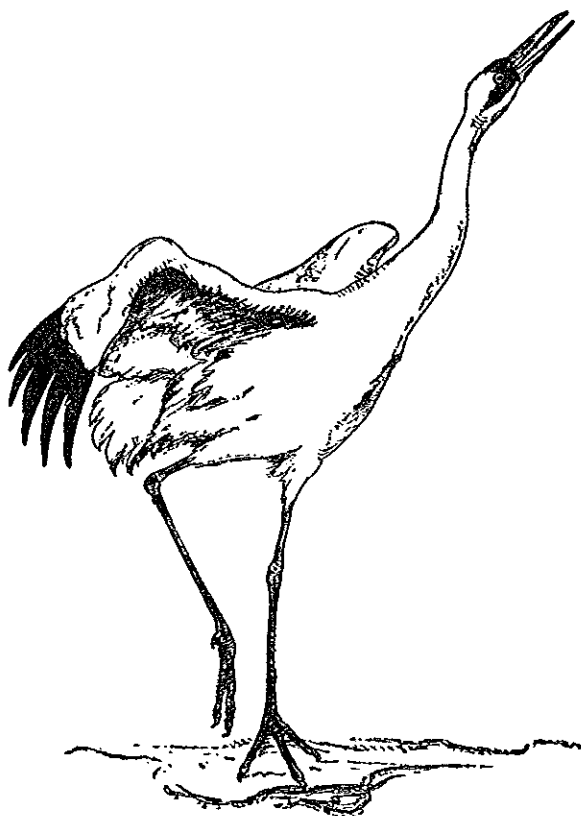
There may be a second stage in which several potential pairs take part, more or less as partners, and sort themselves out, so to speak, emerging eventually as distinct pairs. A third stage would be the mutual performance of mated pairs at or near their nest site. Since the Whooping Crane is joined to its mate in a permanent bond, only the third stage is normally observed in this species.

In her novel *The Yearling* (1938) Marjorie Kinnan Rawlings describes what is supposedly the dance of the Whooping Crane. I have never seen anything quite like it among the Whoopers in Texas and, since it was narrated to Mrs. Rawlings by "an oldtimer," (Rawlings, *in litt.*), a lively imagination may have supplied some of the details. There is serious doubt, of course, that Whooping Cranes occurred in Florida around 1880, when this scene was witnessed. But, although there is no real evidence as to the presence of the species in Florida at that time, even if these birds were *Grus americana*, the pattern of the dance, as described, is completely out of character.

The dance, then, has an emotional basis and, in the Whooping Crane at least, may serve to strengthen and cement the sexual bond between the pair. Its frequency and intensity may be correlated with the development of the various gonadal stages towards full breeding condition. The dance form may also be simply, at times, an emotional and physical outlet, a means of relaxing. With the powerful bond of nest and eggs to hold them together, the captive pair that nested on Aransas Refuge in 1949, did not engage in a mutual form of dance. In fact, they could not, since one member of the pair was

always on the eggs. But, after a long spell on the nest, the free bird would often stand on a slight mound, some 150 yards from the nest site, and silently whirl and leap in a partial dance. On occasion, this partial dance was undertaken on the nearby salt flat or in the shallow brackish water of the adjacent pond.

Whether or not the Whoopers dance while on the spring migration route is uncertain. Perhaps their singleness of purpose, their urge to reach the nesting area is so great, at this time, that there is no need for additional stimuli or outlet. Unquestionably they dance on arrival at the nest site, and throughout the initial phase of nest-building and copulation. Probably the picking up, presentation and application of nest material becomes a part of the dance ritual dur-



Josephine Searching for Grasshoppers on Ridge near Nest Site. Aransas Refuge, Texas.
(Photograph of Captive Bird by U. S. Fish and Wildlife Service)



coil of hay." Its flat surface was slightly concave toward the center.

Near Baliol, 20 miles north of Davidson, Saskatchewan, May 19, 1922 (account of Neil Gilmour quoted by Bent, 1926).

f. A "heavy marsh" with water depth of 2 feet. Nest in an open area cleared by the birds gathering nest material. "The nest was made of rushes, three-sided sedge grass, pulled up by the roots. I found it very difficult to uproot, it having adventitious roots." Diameter of nest 4-5 feet. Height above water 15-18 inches. Nest lining "the finer outside covering of the old dry grasses, the seed of which is a brownish color and pear-shaped." A very slight depression in the center of the nest. Muddy Lake, 7 miles south of Unity, Saskatchewan, May 28, 1922 (account of Fred Bradshaw quoted by Bent, 1926).

There are additional notes, but the details are not very complete. One nest, found near Battleford, Saskatchewan, in 1884, was "a flat mass of rushes and grass" and 3 feet in diameter (Raine, 1892). Another, located "near an old barn" was discovered at Lake Mills, Winnebago County, Iowa, by John Krider. The date was May 12, 1879, and the two eggs are now in the Natural History Museum at San Diego.

In Minnesota, Iowa and Saskatchewan, the nesting site was a wet prairie, slough, swale or marsh. Vegetation mentioned included rushes (*Juncus*?), three-sided sedges (*Cyperus*?) and "flags" (*Typha*?). Details are lacking, but each of the sites mentioned could have had a common biotic relationship and probably did. Nests measured from 2 feet in diameter to 4 or 5 feet. The top of nests were described as being from 8 to 10 inches to 15 or 18 inches above the surface of the surrounding water. Water depths near the nests were evidently from 8 to 10 inches to about 18 inches.

The nest that was built by semi-captive Whooping Cranes within the large (150 acre) enclosure on the Aransas Refuge in Texas, was examined by the writer on May 23, 1949, in

company with Dr. L. H. Walkinshaw, Charles A. Keefer and Guy Colbath. Dr. Walkinshaw very kindly prepared the following detailed description.

"It was a flat mound of surrounding plants, mostly *Distichlis spicata*, some *Typha angustifolia* and a little *Borrchia frutescens*. It was well packed down with an outside diameter of 180 x 184 cm. to the edges. In one place where a cattail (*Typha*) grew against it, it measured 149 cm. across, with a sloping runway to the water. There were at least three distinct trails through the surrounding vegetation, working in to the nest. On the top of the nest the main platform measured 96.5 x 104.1 cm. in diameter. There was no concavity. The nest was 25.4 cm. in height and the water depth on May 23 was 2.5 to 5.0 cm. in the immediate vicinity. On April 30 this depth had been about 30 cm.

"The nest was placed in a group of cattails (*Typha*) that were rather sparsely scattered about and from four to nine feet in height on May 23. There was a small clearing just to the west covered with *Distichlis spicata* and *Borrchia frutescens*. This open area was about 20 x 30 meters in diameter. It was bordered with cattails (*Typha angustifolia*) which surrounded the nest, growing in thick clumps and affording good places for concealment when the birds rested and preened during mid-day. To the west of the small clearing was a stand of *Scirpus americanus* bordering a ridge. To the southeast was a wide clearing extending about 75 meters to another ridge toward the bay. Beyond this was the salt flat facing on San Antonio Bay. The *Typha* growth at the nest was about 10 meters in width."

Apparently the nest had at first been built high enough to rise above the water depth of April 30, which was about one foot. A falling water level, and the weight of the incubating birds, had resulted in the May 3rd height of 25.4 cm. (about 10 inches). Thus the outside diameter of about 6 feet was probably greater than it had been at the start. Otherwise, these figures

compare very well with the average measurements obtained from the existing records. The 1950 nest of the other captive pair was approximately the same size but was built chiefly of *Distichlis spicata* in an open site covered by this grass and bordered by *Borrchia frutescens*.

The nests of other cranes vary from no material whatever to bulky structures as much as 205 x 93 cm. (about 61½ feet by 3 feet) in diameter at the base (Walkinshaw, 1949b, pp. 66-67; 80-82). Both the Lesser and Greater Sandhill Cranes use twigs and branches, as well as various grasses, in the construction of their nests. A very complete list of types of nest sites and of materials used in nest building, for each of the races of Sandhill Cranes, is contained in Dr. Walkinshaw's excellent study of these birds (Walkinshaw, 1949b). In general, it would seem that the greater adaptability of the Sandhill Cranes can be further demonstrated by a comparison of the variety of habitats in which they have been found nesting and their ready use of the handiest nest material, with the far more limited range in these respects that we see in *Grus americana*.

We have two descriptions of the nest sites and nests of the former resident breeding group in southwestern Louisiana. Mrs. Gaspard, who was born in 1873, lived on Pine Island, adjacent to the White Lake marshes, as a girl. She recalls seeing a few Whooping Crane nests and heard much talk about them. They were always built in the paille-fine (*Panicum hemitomen*) and "fouets" (lit. whips) or bulrush (*Scirpus californicus*). To quote John Lynch, of the U. S. Fish and Wildlife Service, who obtained these notes from Mrs. Gaspard, the bulrush "must have been used extensively, since she spoke of the birds breaking down and piling the whips in the middle of a stand, leaving the periphery of the stand as a shield for the nest. She claims all the nests were capable of floating, and would do so with every south wind that drove the waters of White Lake over the marsh west of Pine Island."

On this point, Walkinshaw (1949b, p. 82) writes, "During heavy rains, nesting material is often added to nests, but even then they are apt to be flooded or, if they float, are sometimes not strong enough to support the adult cranes. Preston (1893, p. 81) reported cranes incubating eggs in floating nests, but I have never observed this."

Our distribution discussion showed that nearly all of the Canadian nesting sites of the Whooping Crane were in aspen parkland or the transitional zone lying between that type and the true prairie. All U. S. sites were in prairie habitats. When we reduce these three types into their lesser parts, and set aside the marsh and slough portions having standing surface water, we isolate the nesting sites of the Whooper. As already suggested, these shallow water habitats, whether they are in prairie, transition or parkland types, will have, in all probability, a marked biotic similarity.

In Ralph Bird's study of the biotic communities of the aspen parkland of central Canada (Bird, 1930), which we have already referred to on several occasions, the description of the *Salix-Chrysomellidae* communities seems to fit in with our general concept of the average nesting site of the Whooping Crane. Much of the area occupied by aspen parkland is covered by sloughs, a majority of which are grown to willows (*S. petiolaris* Sm.), but this willow is absent if the soil shows a high percentage of alkaline salts, as at Quill Lake and elsewhere in Saskatchewan, in which case the succession is direct to prairie. This variety is the rosemary willow. The river bank or sandbar willow (*S. longifolia* Muhl. = *S. interior* Rowlee), on the other hand, "develops if there is an abundant water supply and denuded soil (sometimes running water)."

Small¹⁴⁰ (1933) describes the habitat of the rosemary as "swamps and low grounds," and of the sandbar willow as "alluvial soil, river-banks and islands."

¹⁴⁰Small (1933).

The animals of both these willow sub-climax communities (*presocieties*) are similar. Subdominants are mostly sedges such as *Carex*, which are typical of moist meadows, bogs and marshes. Biotic succession proceeds in three directions, from a purely aquatic community through (1) lake, (2) river or (3) slough. Succession is initiated on lakes by various species of pondweeds (*Potamogeton*), followed by soft-stem bulrushes (*Scirpus validus* Vahl.), common cattail (*Typha latifolia* L.) or sedge (*Carex*). Succession from sloughs is also initiated by pondweeds. The next stage is spike rush (*Eleocharis palustris* [L.]), followed by bulrush or cattail, with sedges and water plantain (*Alisma brevipes*) as subdominants.

The animal population of the sub-climax willows is characterized by ducks, coots and other aquatic birds. Also common are red-wings, bronzed grackles, Maryland yellowthroats, yellow warblers and song sparrows. Muskrats and field mice are typical mammals. There are spiders and frogs and a large insect group, including Diptera, Coleoptera, Homoptera and Collembola. In the swamp or rosemary willow community the large invertebrate population is chiefly surface-dwelling and reaches a numerical peak in March, when Bird estimated 9.5 million per acre. Among the sandbar willows, the invertebrates are found chiefly in the soil and reach a peak in June, when they were estimated at 6.75 million per acre.

The animal populations change slightly as the succession moves one way or another. On lakes the characteristic birds are pied-billed grebe, red-wing, yellow-headed blackbirds and long-billed marsh wren. Snow geese, Canada geese and cranes were once (as late as 1900) abundant during migration and some remained to breed. Now these larger birds are rarely seen.

Sloughs are populated by coots, horned grebes, pied-billed grebes, red-wings, blue-winged teal, mallards and other ducks. The coot was the predominating animal at the time of the study

(1930) and the muskrat was listed as a sub-influent.

Incidentally, the *Chrysomellidae* are protozoa of the Mastogophora group (Class), and live in small bodies of fresh water.

It is interesting that of the 21 invertebrate groups listed, 8 have already been established as containing actual or potential Whooping Crane food items. Of the four categories—prairie, rosemary willow, sandbar willow and mature aspen—the heaviest density of invertebrates was found in the rosemary willow community. These particular sloughs may also have been, especially at the bulrush and cattail stage, one of the most suitable nesting sites for *Grus americana*.

Eggs and Egg Collecting

The appearance and size of the eggs of the Whooping Crane are summarized by Bent (1926) as follows: "The Whooping Crane lays ordinarily two eggs, occasionally only one and very rarely three; in the set of three, referred to above, one egg proved to be infertile. The shape is elliptical ovate. The shell is smooth, but more or less pimpled and slightly glossy. The eggs are usually, if not always, darker colored and more heavily marked than those of the sandhill crane. The ground color varies from 'cream buff' to 'olive buff.' This is clouded and blotched, quite heavily near the larger end and more sparingly elsewhere, with dull browns, 'wood browns' or 'buffy brown,' overlaid with blotches of darker and brighter browns, 'Verona brown' or 'hazel.' The measurements of 38 eggs average 98.4 by 62.4 millimeters; the eggs showing the four extremes measure 107.5 by 63.5, 98 by 67.5 and 87.4 by 50.2 millimeters."

Data on the eggs of the Whooping Crane was very kindly contributed to the present study by sixteen museums and private collectors, for which acknowledgements are made elsewhere. These combined collections total 121 eggs, of which 54 are in sets of two, or, in other words, there are 27 sets of two eggs each, and 67 single

eggs. In general, important information such as the exact nesting location, description of the nest and nesting site, date, etc., is lacking. Of 94 possible items, only 41 give the State or Province where the eggs were collected, 19 list the county or general locality. There are only a half dozen descriptions of nests and nesting sites containing anything in the way of useful details, and these are limited. Of the 94 possibilities, only 34 list the year or month and year. It seems fairly obvious that both the commercial and private, childishly competitive aspects of egg collecting were responsible for this dearth of basic information. Valuable data that might have contributed to our knowledge of this bird was withheld for purely selfish purposes, reducing a potential science to a mere sport, at best.

The available data gives the following geographic divisions where eggs were taken, and the number of items listed for each. Some of these represent egg sets, some single eggs attributed to the division in question.

Iowa	23	Saskatchewan	2
Manitoba	11	North West Territories	2
Minnesota	2	North Dakota	1

By years, the following number of similar items are listed:

1864	2	1880	2
1866	1	1881	1
1867	1	1883	1
1868	1	1885	1
1870	1	1893	1
1871	11	1894	1
1874	2	1896	1
1877	4	1900	2
1879	1		

Of the sixteen collections contributing data to our present study, nine included egg measurements. In all, 62 Whooping Crane eggs are represented in these measurements and the average figures are 99.6 by 63.3 millimeters, which is slightly larger than Bent's average for 38 eggs (98.4 by 62.4 mm.). Extremes are as follows: 108.0 by 59.3, 98.0 by 67.5, 87.0 by 59.0 and

87.4 by 50.2. There does not appear to be any relation between size and period (year), and there are not enough examples from the different geographic areas to determine whether there is a size difference in this category. Walkinshaw (1949, p. 82), writing of the eggs of the Greater Sandhill Crane, found that "eggs from the Prairie Provinces of Canada are smaller than those from Oregon, Idaho, and Iowa. Those from Michigan are a little smaller than those from Idaho and Oregon."

No weights are given for Whooping Crane eggs, but Max Schönwetter, a private collector in Germany, who measured and weighed the empty shells of 14 eggs of *Grus americana* in various European collections, writes me that he estimates by calculation the average weight of a fresh egg as 212 grams. Thickness of the shell he gives as .58 millimeters. Walkinshaw (1949b, p. 69) lists average egg weights for three races of Sandhill Cranes. Average extremes are 183.0 grams (for Greater Sandhills in Michigan, start of incubation) and 119.1 grams (for Lesser Sandhills in Alaska, late in incubation period). There are large extremes of 216.3 grams (Greater Sandhill in Michigan at start of incubation) and 207.1 grams (Florida Sandhill in Georgia, probably a fresh egg).

A presumably infertile Whooping Crane egg from the aviary of Lord Lilford, in England, measuring 97.0 by 66.0 millimeters and the weight of the shell, as given by M. Schönwetter (*in litt.*) is 24.7 grams, which is greater than the average weight of 14 eggs, 20.75 grams.

There is evidently some variation in the color and markings of the eggs, as well as in shape, size and weight. Sometimes, however, a seeming difference as to color may exist only in the terms of the description. The ground color is described by Bent (1926) as "cream buff to olive buff." Coues (1874a) gives it as "light brownish-drab." Anderson (1894) noted a different ground color in two eggs from the same clutch. He described one as "a light greenish brown" and, the other, "a light brownish color,

without a decided greenish tinge." Bent found the markings clouded and blotched, quite heavily near the larger end. Anderson's two eggs were "spotted quite thickly and evenly over the whole surface," the spots "confluent at the larger end" in one egg. Those examined by Coues had markings that were "rather sparse, except at the great end." The shade and color of these markings are variously described as *dull browns*, *wood browns*, *buffy brown*, *brown and buff*, and *pale dull chocolate-brown*. An overlay of blotches of darker and brighter browns is described by Bent. Anderson noted "purplish shell markings." Goss (1891) mentioned "obscure shell stains of sepia."

The surface of the shell is "smooth, but more or less pimpled and slightly glossy" (Bent, 1926). Coues (1874a) described them as "much roughened with numerous elevations, like little warts, and is, moreover, punctulate all over." Walkinshaw (1949b, p. 83) states that the surface of Greater Sandhill Crane eggs "as a rule, is smooth, and of hard, strong texture, with, on some, a few irregularly-shaped granulations of shell material. Most of the eggs are marked over the entire surface with very narrow, barely perceptible pits, about 1 mm. in length, usually occurring in rows along the long axis of the egg." Romanoff and Romanoff (1949) speak of the eggs of crane's as "dull and chalky" rather than "smooth and lustrous," and consider that this appearance is due to the nature of the cuticle, the thin, transparent coating of protein. According to these authors, the cuticle on the eggs of cranes is thick, as it is also on the eggs of the cassowary and the pelican, for example. They state that it is thin on the eggs of the kiwi and lacking on the eggs of gulls and certain small birds.

By comparison with the eggs of Sandhill Cranes the shape of these of the Whooper is described as "oval to elliptical oval" (Goss, 1891) or "elliptical ovate" (Bent, 1926), while the Sandhill's are "usually ovate to elongate ovate," according to Walkinshaw (1949b, p. 83).

Anderson (1894) described the eggs of the Whooper as "proportionately longer and narrower," with a "somewhat rougher shell" than those of the Sandhill observed by him. In color, Walkinshaw told me that the fragments of eggs of the Whooping Crane that he saw in Texas, and that were laid by a captive female in 1949, were "colored much like Sandhill Crane eggs." The detailed descriptions in his book on the Sandhill Cranes bears this out.

It is of interest that Walkinshaw (1949b, p. 38) found similarities between the markings and ground color of Sandhill Crane eggs and those of sora and yellow rails. We have already remarked on the similar food items consumed by many of the rails and their largest relative, *Grus americana*.

Forbush is quoted by Worth (1940) as stating that in his belief the incubation period of the Whooping Crane is "at least 33 days." Dr. Worth, obtaining the egg volume by use of a formula, calculates the incubation period as 34.5 days. Incubation periods for different cranes, quoted from various sources, are given by Walkinshaw (p. 85) as follows:

Greater Sandhill Crane	29-30 days
Manchurian Crane	30 days
Common Crane	28-30 days
Saras Crane	35-36 days
Saras Crane	32 days
White-necked Crane	30-32 days
Wattled Crane	36 days
Stanley Crane	33 days

Walkinshaw remarks, "It is evident that the incubation of crane eggs requires between 28 and 36 days and that the second egg is usually laid two days after the first one. Both parents incubate."

Behavior at the Nest

Cranes are extremely attentive to their nests, once incubation has started. Walkinshaw (1949b, p. 85), notes however that although Greater Sandhill Cranes rarely "leave the eggs

nncovered; yet, occasionally at midday, I have found both male and female some distance from the nest." The pair of semi-captive Whooping Cranes that nested within an enclosure on the Aransas Refuge in Texas in 1949 were more cautious than this, according to continuous observations over an 11-day period. Except for momentary lapses, during nest relief, one of the pair was always on the nest. At such times the setting bird might walk off the eggs before the relieving bird had approached to take over. However, one or both members of the pair was always standing close to the nest in such a situation.

Apparently, as a general rule, Whooping Cranes are less noisy at nesting time than Sandhill Cranes; but it should be remarked that this comparison is true at other times as well. Sandhill Cranes may call as other birds sing, to announce territorial claims, and they surely call as other birds do when flying or feeding in flocks, in order to keep together, or to warn of danger. Whooping Cranes, much less gregarious, except possibly during migration, only call in alarm, or as a territorial challenge, so far as my experience goes. Stevenson and Griffith (1926) also describe a "recognition call or greeting," suggesting that these notes may indicate "safe feeding," but I did not discern this type of call. Walkinshaw noted that Sandhill Cranes nesting in wilderness areas were less cautious than those nesting in farming communities, the former calling more or less frequently, at daybreak and during nest reliefs. In farming areas, on the other hand, Sandhills "are exceedingly quiet during nesting time except early in the morning and, rarely, late in the evening" (Walkinshaw, 1949b, p. 88). Our experience with the nesting captives indicates that nest relief in the Whooper is a silent affair. In 11 days of continuous daytime observation, the cranes called only six times, each time very briefly. On each occasion another bird or a deer had approached the nest. Only one bird called, except twice when Ward's herons were the cause of an alarm. Then both

birds called, very briefly (from two to five notes each).

Seton (quoted by Bent, 1926) believed that Whooping Cranes danced and sounded "their raucous and daily trumpeting" while nesting, but it is my belief that what he described must have been a prenuptial courtship display. After incubation gets underway they appear to be silent, except when alarmed. Although, when undisturbed, they are faithful to the nest, never leaving it together, it is another matter when the vicinity is approached by a human intruder. On May 21, 1876, George B. Sennett, the inveterate collector from Erie, Pennsylvania, was hunting at Elbow Lake, Grant County, Minnesota. On the previous day his companion had killed two Whooping Cranes nearby and Sennett was determined to secure a specimen. He located a pair at their nest, which was built on top of a muskrat house in a burnt slough, with only short grass clumps for cover. As he approached to a point close to the nest the birds left, and Sennett concealed himself as best he could, piling grass over himself as he lay prone behind a clump. "Fully half an hour went by and I began to cramp and feel uneasy and was on the point of changing my position at the risk of losing my covering by the wind, when one noble fellow flew over the slough and lit on the opposite side from me about two shots off. Cautiously he began to survey the situation and shortly his mate came swooping down to his side. They kept their eyes well on my bunch of grass and remained at a safe distance, yet I could see they knew their eggs were safe. Some fifteen minutes of strutting back and forth when she boldly walked out into the water, some eight or ten inches deep, directly towards me, mounted the rat house and sat down on her two eggs, some twenty-five yards from me in plain sight. I could see her wink her eyes watching me and her mate constantly. Her eyes gleamed like fire. How anxious and how handsome, was ever a sight so grand. . . . The male stood on the ridge watching her closely for a few minutes,

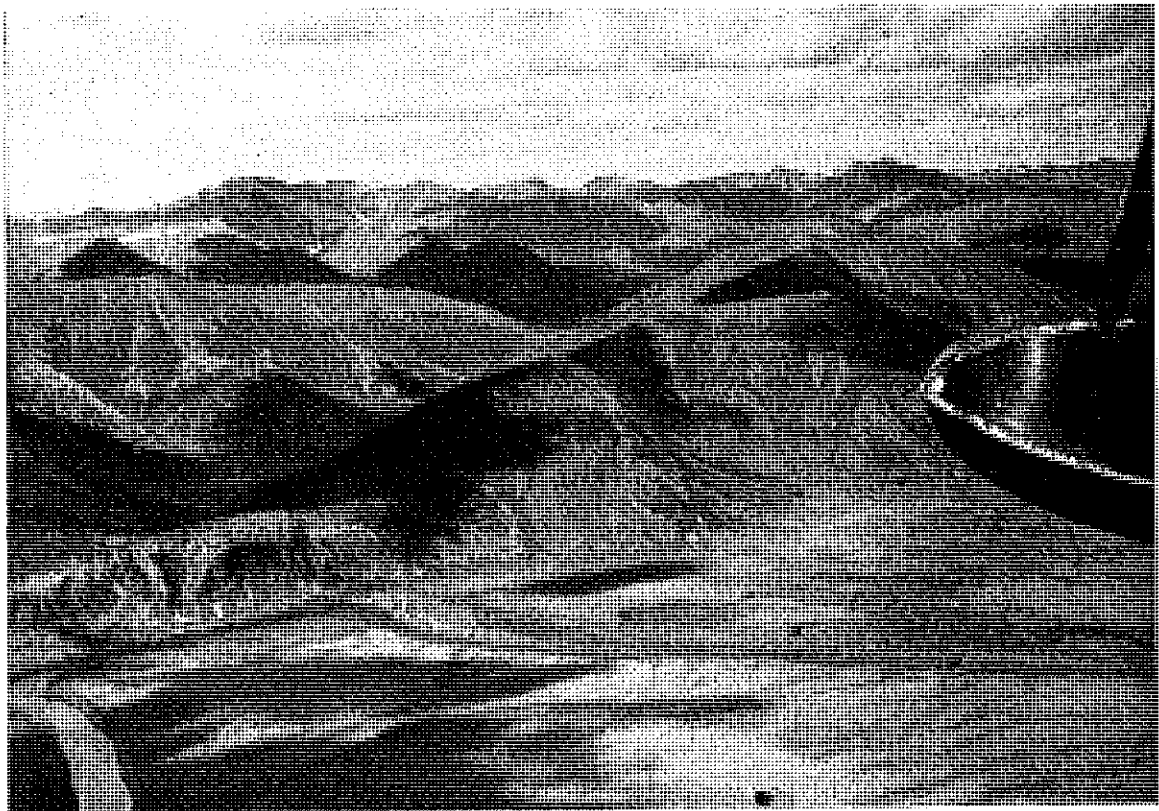
Captive Whooping Crane Nest, Enclosure, Amazon National Wildlife Refuge. Nest
Located 1/2 mile West N. entrance of Enclosure Observation Tower and 1/2 mile North
of Enclosure Fence. Nests are Nest in Photo.
(Photograph by Charles A. Forster, George H. E. Fish and Wildlife Service)





The Search for the Northern Breeding Grounds Was Extended to the Arctic Shores.
Ice Breaking in Beaufort Sea, July, 1948.
(Photograph by Robert P. Allen)

Mountains Bordering the Mackenzie Delta Country on the West Halted Our
Search in That Direction.
(Photograph by Robert P. Allen)



when feeling all was safe he calmly commenced to plume himself in grand style and shortly walked off away from me the proudest of birds. . . . I slowly arose, turned and gave her one barrel as she was rising from the nest and the next before she had gone six feet and dropped her in the water. . . ." (Deane, 1923).

When Ernest L. Brown approached a Whooping Crane nest at Thief Lake, Marshall County, Minnesota, June 19, 1889, both birds left the vicinity, calling loudly (Nute, 1945). On May 4, 1883, J. W. Preston found Whoopers nesting in marshes near Eagle Lake, Hancock County, Iowa. These birds behaved in an entirely different fashion. Preston first spotted one of the pair at a distance of about one mile. As he started towards it the crane saw him and called, whereupon both birds made their appearance (the hidden one was probably on the eggs) and flew beyond sight. For several hours Preston wandered about the marsh, amid the rushes and shallow water, seeing pairs of geese, rails and flocks of "sand-peeps" that whistled by him. Late in the afternoon he sighted "the snowy form of a pair of White Cranes flying slowly toward me. Immediately I fell flat, the birds alighted far in the swamp, my presence was detected at once and away they went. However, I concealed myself well and watched their return, which occurred in about twenty minutes. This time one of the birds walked to a certain point and stopped; as she remained so long I concluded to make my way to where she was. To my delight she was sitting on her heavily marked drab egg, which lay in a neat cavity in the top of a well-built heap of tough, fine marsh grass $1\frac{1}{2}$ feet high on firm sod. The eggs were the first I had seen and were a rare prize to me. When I approached the nest, the bird, which had walked some distance away, came running back within a few rods, trotting awkwardly around, wings and tail spread drooping, with head and shoulders brought to a level with the water; then it began picking up bunches of moss and sticks which it threw down in a defiant way; then with pitiable

mien it spread itself on the water and begged me to leave its treasure, which, in a heartless manner, I didn't do. At one time she was within twenty feet of me, but showed no inclination to fight, though they are said to defend their young with courage" (Preston, 1886). On May 4, 1949, Charles A. Keefer, then Refuge Manager of the Aransas Refuge in Texas, approached the nest of the captive birds in order to photograph the eggs. Both birds "raised an awful fuss, whooping and scolding." The female pecked at his right thumb until she drew blood, then grabbed his sleeve and tried to pull him away. She finally pecked him hard on top of the head. After securing his pictures Keefer was glad to retreat. The male stood on the nest during all this, hovering excitedly over the two eggs. However, this behavior on the part of the male may not have been typical, as this individual may have been old enough to be senile. He died of natural causes the following July, after 13 years of captivity.

When Rudolph M. Anderson and "a boy" walked towards a Whooping Crane nest in the Eagle Lake marshes, May 26, 1894, the two cranes rose "with slow, heavy flaps of their great wings" and moved to the far side of the marsh. There they stalked along with "long strides as fast as a man could walk," and called occasionally. This was the last wild pair found nesting in the United States. The fight was all out of them.

Neil Gilmour's account of finding the Baliol nest, May 19, 1922, which is quoted by Bent (1926), describes the sudden appearance of one of the pair "where a moment before I thought no bird had been." Apparently this crane had left the nest to feed nearby, its mate being off at that time, feeding in a stubble field a half mile beyond the edge of the marsh. Gilmour then played a sort of hide-and-seek with the pair. Each time that he concealed himself the one bird returned to the nest. Eventually, by lining up an object on higher ground with the head of the sitting bird, he was able to walk to the

spot, by degrees. "The distressed whooping cries of the birds, as I tarried at the nest, I shall never forget."

The pair at the "last" nest, discovered on May 28, 1922, at Muddy Lake, by Fred Bradshaw, attempted to lead him away, one moving to the right, the other to the left. As he came up to the nest they moved closer and closer, "feigned many times to be on the nest and went through antics of covering eggs." One bird circled within 100 yards radius on two occasions, while Bradshaw was taking a photograph.

Walkinshaw (1949b, p. 88) describes nesting behavior of the Greater Sandhill Crane that indicates they are not as wary as the Whooper. He was able to watch a nesting pair of Greater Sandbills in Michigan, in plain sight, without alarming them. He could walk away from them without disturbance and "they did not call or show alarm until I waded out to them." However, another pair deserted a nest when he walked from the blind (p. 104).

Some remarkably accurate observations have been contributed, entirely from memory, by older residents of southwestern Louisiana, who were interviewed by John Lynch. O'Neil Nunez said that one Whooping Crane of a nesting pair wandered about feeding while the other was on the eggs. Both would stay by the nest when an intruder approached, but would take wing before he came too close, unless young were already hatched. In that case the female (i.e., the smaller one of the pair) would stay and often threaten the intruder. On the White Lake marshes, according to Mr. Nunez, most Whooping Crane eggs were found in May or early June, although Mrs. Nunez recalled that two young, newly hatched, were picked up by her father in April. Duncan Crain of Grand Chenier told Lynch that the Whoopers in Louisiana started nesting shortly after the Ward's herons, or in late March. On May 15, 1939, Lynch saw a pair with two well grown young. These were the last Louisiana young definitely observed.

Nesting Behavior of Captive Birds

When the Cooperative Whooping Crane Project got underway in 1945 it was learned that two birds of this vanishing species were being held in captivity, one in Nebraska and the other in Louisiana. It immediately occurred to us that since both individuals had been captured as a result of injuries, so that neither could be released among wild birds of their own kind, they might prove to be male and female and mate in captivity. Accordingly, plans were laid for bringing these two birds together under favorable circumstances. Many persons helped in accomplishing this purpose, notably J. P. Kennedy and other members of the Gothenburg, Nebraska, Gun Club; George P. Vierheller of the St. Louis Zoo; George Douglass and fellow members of the Audubon Park Commission in New Orleans; Fred Stark of the San Antonio Zoo and officials and personnel of the U. S. Fish and Wildlife Service, on whom fell most of the actual labor and responsibility.

A suitable marsh on the Aransas National Wildlife Refuge, in Texas, part brackish and part fresh, was designated and approximately 150 acres were fenced. Finally, in October, 1948, the two birds were placed in this enclosure, having first been rested and conditioned by Fred Stark, of San Antonio, whose success in breeding and rearing cranes has been remarkable. In early December they were observed in a mutual dance display. By March and April these displays had become more frequent and more intense. In late April a distinct change in their usual behavior was noted. Both had been accustomed to come to the fence for small quantities of yellow corn, a practice that was more of a means of keeping a close watch on the two birds than a supplement to their natural feed, which is abundant within the enclosure. On April 27 the male bird remained in the cattails, the female coming to the fence alone. On the following day only the male came to the fence. On the 29th the male was definitely "setting" and

the female came in alone for corn.

Refuge Manager Keefer investigated and, on April 30, discovered that the nest contained a single egg. It had evidently been laid the previous day. On May 1, it was estimated, a second egg was deposited.

The immediate question then was—are the eggs fertile? The answer did not come until May 23, when the pair, after some 23 days of the most faithful devotion to the eggs and to the arduous duties of incubation, voluntarily broke them up. They were mere empty shells, the infertile contents dried up and utterly futile.

There is a long history of Whooping Cranes in captivity, going back, no doubt, before Audubon's time, although early records are confused by indefinite references as to the actual species concerned. Nevertheless, we have reliable evidence on the captivity of some 38 Whoopers, dating from 1864 to the present. Attempts were made to breed the species in aviaries and zoos, without success, although several other cranes mate quite readily and rear their young without apparent difficulty (see Walkinshaw, 1949, p. 85). Some years ago there was a fashion for keeping various species of cranes on the grounds of large estates. There were several tame Whoopers at the Mexican Hacienda El Molino of Senor Jose Maria Negrete, kept "as one of the attractions of the place" (Jouy, 1894). Another lived for some years at the Hacienda Buena Vista, also in Mexico (Goldman, U. S. Nat. Mus. records). Early in the present century, the Duchess of Bedford had 11 species of cranes on her estate in England (Bedford, 1907). Four species nested and hatched their eggs (*Common Crane*, *Saras Crane*, *Demoiselle Crane*, *White-necked Crane*). Two species nested but never hatched (*Australian Crane*, *Stanley Crane*). Five species did not nest (*Whooping Crane*, *Sandhill Crane*, *Wattled Crane*, *Asiatic White Crane*, *Manchurian Crane*).

Lord Lilford, at Lilford Hall, kept as many as 30 cranes of various species. His Sandhills nested and hatched twice and his Asiatic White Cranes

laid eggs but never hatched them (Cosgrave, 1911). The Lilford Whooping Crane, a female, was purchased in 1892 and died August 19, 1930, aged at least 40 years (Moody, 1931). For a number of years this bird laid infertile eggs, one of which is now in the British Museum. According to Astley (1907), in general "style and size" the Whooping Crane resembles the Manchurian Crane (*Grus japonensis*). In the Lilford aviary, the female Whooper and a female Manchurian Crane shared the same nest and, after she had stopped laying eggs, the Whooper guarded and brooded the infertile eggs of *G. japonensis*.

There were several Whoopers and other cranes on estates in this country, including that of the late John C. Phillips at Wenham, Massachusetts (Phillips, 1912a, 1912b) and G. D. Tilley at Darien, Connecticut. In 1913, Dr. William T. Hornaday of the Bronx Zoo, had a captive Whooper and advertised widely for a mate. Conservation organizations of that period were interested in the possibility of breeding the species in captivity. But nothing came of the project.

There are numerous references in the literature on the breeding and rearing of cranes in captivity, but, while some discussion of management problems is presented, there is little or nothing on the nesting behavior. Although it is to be expected that cranes that are pinioned and otherwise restrained, and living under more or less artificial conditions, will not behave altogether normally, much can be learned by observing them at a nest. This was particularly true of the Aransas pair, which were, in fact, a male and female, and which lived in semi-captivity, within a large enclosure, under natural conditions for the most part, feeding on natural foods in adjacent biotic communities identical with their normal environment. Possibly the only serious abnormality was the age of the male bird, which may have been responsible for the infertility of the eggs.

The nest and nest site, already described, were definitely within the limits of size and character

to be expected of a normal pair of Whooping Cranes. There is no way at present that we can compare the various nest-side activities such as nest relief, territory defense, etc., with those of wild Whoopers, but most of these involve basic reactions and were probably quite normal.

Nest Relief

A careful record was kept of all exchanges on the nest between male and female. It was possible to begin observations at 5:00 a.m. and continue without a break until 7 or 7:30 p.m., a period of 14 to 14½ hours. At first (May 12) there were usually 6 nest reliefs during the day, 3 by the male and 3 by the female. As the temperature rose (from May 19th on) the number of nest reliefs increased. On the average there were 7.6 nest reliefs per day and the average by sex was 3.6 by the male and 4 by the female. However, the male spent more time on the eggs than the female.

The six normal diurnal relief periods were spaced as follows: (1) before dawn to 6:30 a.m., (2) 6:30 a.m. to 8:00 a.m., (3) 9:00 a.m. to 10:30 a.m., (4) 12:00 m. to 1:00 p.m., (5) 2:00 p.m. to 4:30 p.m., and (6) 6:00 p.m. to 8:00 p.m. These periods are the approximate extremes noted and relief might take place at any hour between the times cited. Actual time on the eggs before the free member of the pair took over varied from a minute or less to one example that exceeded 8 hours. On the average the male spent slightly over 2 hours on the eggs between reliefs, the female slightly less than 1½ hours. However, the male assumed in excess of 70% of diurnal incubation duties during the total period under observation. Towards the end of the period the female began to increase her total time on the eggs and the frequency of her nest reliefs.

According to data presented by Walkinshaw (1949, p. 87), the nest relief pattern of the Greater Sandhill Crane may be very similar to that observed in the captive Whoopers. One

pair of Greater Sandhills engaged in four reliefs between daylight (approx. 5:00 a.m.) and 12:30 p.m. The Whoopers pattern shows four reliefs between daylight and the noontime period (extremes for the noon relief were actually 12:00 m. to 1:15 p.m.). The male Sandhill was on the nest for a total of 282 minutes and the female 166 minutes. The male, during these morning observations, assumed nearly 63% of the incubation duties.

Cosgrave (1911), writing of the nesting habits of the White-necked Crane, states that the *male* begins incubating the first egg as soon as it is laid, so that it hatches before the second egg, usually a difference of two days. About four hours after hatching, the young is given food by the *male*, generally small insects. The young leaves the nest when one day old and is cared for by the *male*. Later on, in the Whooping Crane, the care of the young becomes the duty of the female, for the most part. This may be the case after arrival on winter quarters, where the male is occupied with territory defense, search for food, etc.

Behavior of the Incubating Bird

Some of the notes on the Aransas captive pair are revealing as to behavior of male and female during incubation. The nest platform or mound was well concealed among the cattails, although observations were made from a 20-foot tower 150 yards away. When the incubating bird stood on the nest it was in plain view, from this vantage point, but when it settled on the eggs it was extremely difficult to see and was often out of sight completely. However, with the aid of a 19.5x spottingscope its movements generally could be followed without much loss of detail.

The male was sometimes extremely restless and particular about his position on the eggs. On May 12th, after relieving the female at 8:12 a.m., he did not stir until 9:04 a.m. Then he stood and rearranged the position of his feet and of the eggs four times in the next 45 min-

utes. At 9:55 a.m., with the female standing close by, he walked off the nest, possibly to drink, and was back again within a few seconds. Although he stayed on the nest, except for momentary excursions of a few seconds each, until 12:55 p.m., the male rose and fussed with the eggs and the nest five more times. Once he added more nesting material. Some of the excursions were evidently for water.

Also on May 12th, at dusk (7:10 p.m.), the male was on the eggs and the female, standing near the nest, raised her wings and jabbed with her bill at something in the cattails. The male remained motionless. Four minutes later the female sounded an alarm note and ran, wings partly opened, towards something in back of the nest. The incubating male never moved. Then we saw a large doe (*Odocoileus virginianus texanus*) retreating rapidly with the enraged female in pursuit. The male, low on the nest, sat like a statue.



The Eggs Are Turned and Rearranged Frequently.

"When the Incubating Bird . . . Settled on the Eggs It Was Extremely Difficult to See . . ."

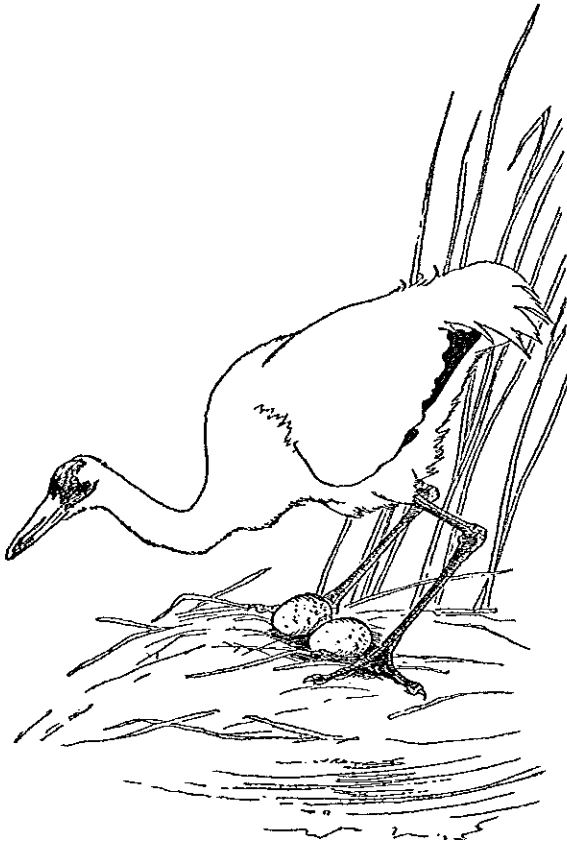


On occasion the incubating bird seemed to grow extremely weary. On May 14th, after the usual noontime relief, during which the two birds might exchange places on the eggs twice, or even three times, within a half hour, the male resumed his incubation at 1:30 p.m. It was a warm afternoon and when the female did not come near the nest by 4:20 a.m., the male simply stood and with bill open, as if very hot and tired, walked off. The female, who was perhaps 20 yards off, immediately started directly towards the nest, covering the eggs two minutes later, after arranging them to suit her.

It was noted that whereas the incubating bird was quiet when a deer came near the nest, allowing the free or "guard" bird to handle the situation, both birds might call an alarm if turkey vultures, Ward's herons or other birds flew over, close to the nest.

In general, the female was more restless and impatient on the eggs than the male, at least during the daytime. It is quite possible that the female does most of the incubating at night. Walkinshaw's data seems to indicate that this is the case with the Greater Sandhill Crane. With our captive birds the female seldom spent any length of time on the nest in the middle of the day. This seemed to be the male's job. On the other hand, she did not wander as far from the nest area during her free time as did the male. On him seemed to rest the chief responsibility for establishing the territorial limits beyond the immediate precincts of the nest.

The Feet Are Placed Alongside the Eggs with Great Care.



Behavior of the Guard Bird

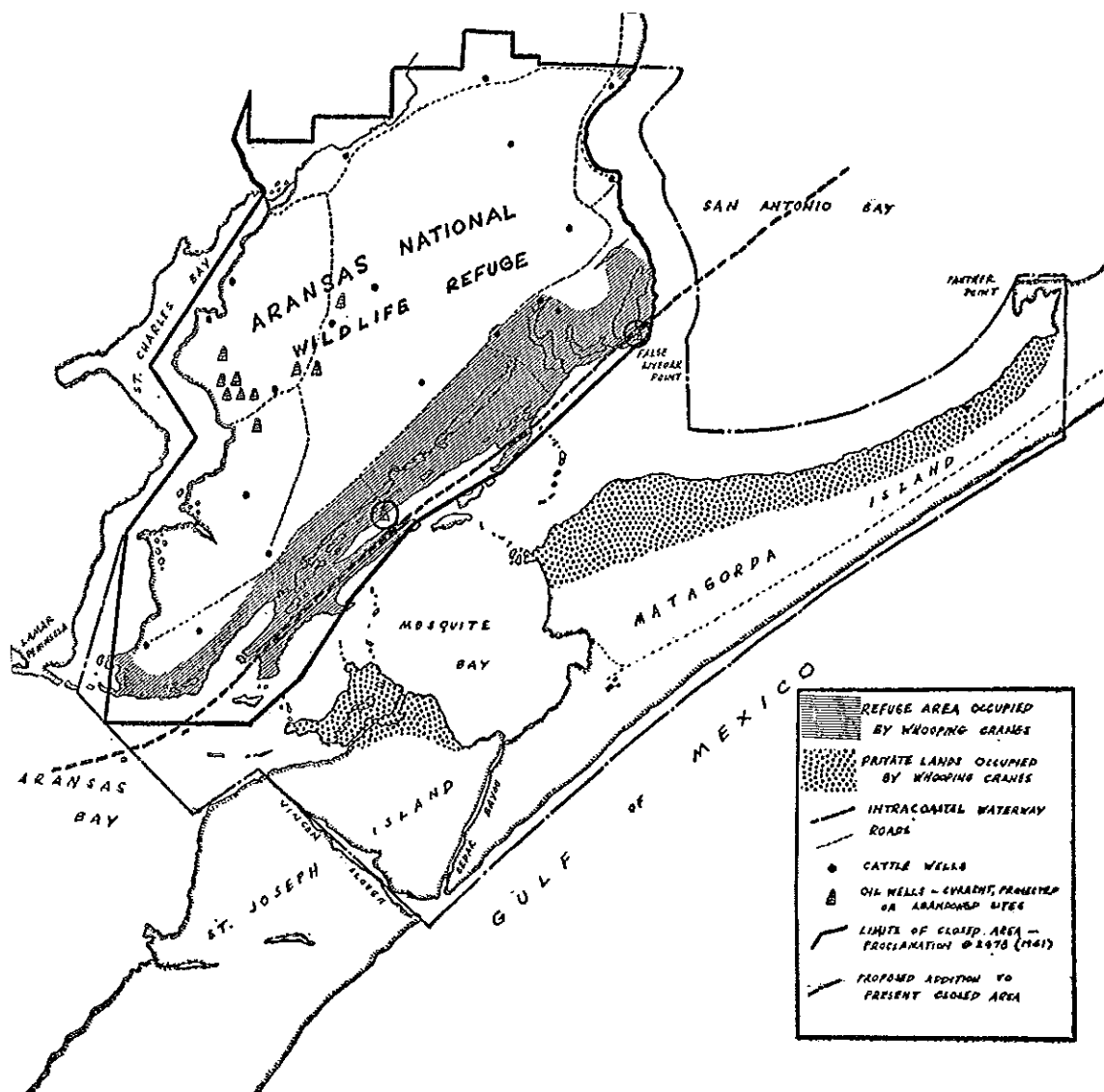
In both leaving and approaching the nest, the free bird nearly always followed a devious route through the cattails, disappearing for a space and then emerging 40 or 50 yards to one side. Once in the open, this caution diminished and when 150 yards or more from the nest the bird might dance briefly, but silently, or relax enough to bathe in a pool of fresh water. The male was less tame than the female, but how much of this was typical male behavior and how much the result of experience we had no way of knowing.

The surrounding area comprised both salt and fresh marsh and each had its peculiar animal and plant communities and transients. On the salt marsh side the following bird species were noted, some of which were a source of constant annoyance to the male Whooper.

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|--------------------------------------|------------------------------|
| 1. Willet | 14. Black Tern (flying) |
| 2. Gull-billed Tern | 15. Lesser Scaup |
| 3. Caspian Tern | 16. Black-bellied Plover |
| 4. Forster's Tern | 17. Red-backed Sandpiper |
| 5. Black Skimmer | 18. Mottled Duck (nesting?) |
| 6. Mexican Cormorant | 19. Yellowlegs |
| 7. Roseate Spoonbill | 20. Black-necked Stilt |
| 8. Louisiana Heron | 21. Clapper Rail (nesting?) |
| 9. American Egret | 22. White Pelican |
| 10. Snowy Egret | 23. Boat-tailed Grackle |
| 11. White Ibis | 24. Man-o'-war-bird (flying) |
| 12. White-faced Glossy Ibis (flying) | 25. Ward's Heron |
| 13. Laughing Gull | |

Of these the male would not tolerate the roseate spoonbill, Ward's heron, American egret, Louisiana heron or snowy egret within several hundred yards of the nest location. The Ward's heron and American egret were a particular anathema to him. At times the male would chase egrets the entire length of the enclosure salt pond, or nearly a mile. He seemed more cautious in attacking Ward's herons, but never failed to evict them, no matter how long or how far from the nest the chase carried him.

On May 21st, the male was relieved at 2:52 p.m. and walked immediately to the salt pond,



The Future of the Winter Range Poses Several Vital Problems.

where he chased a group of American egrets. When they simply flew to the far side of the pond he charged after them again. At this juncture a Ward's heron flew across the pond and came down on the west shore. The male turned from the egrets and gave his full attention to the Ward's. He actually *whooped* at it several times,

strutting very stiffly and with an air of great dignity. Then he lowered his spear-like head and neck and charged, running with huge strides and flapping his wings rapidly, fairly skipping across the surface of the water. The heron, glaring at the male in what seemed a very disconcerted manner, stood his ground until the

juggernaut was almost upon him. Then he rose and flew. The male, with only one complete wing, usually ended his charge at this point, slowing and shortening his stride, using his wings as a brake, arching his neck until it looked like that of a swan, and coming to a rather abrupt but wholly dignified stop. Two hapless egrets were standing nearby, uncertain whether to stay or fly, and the male settled the issue for them by walking towards them, his head high, his manner aggressive. The Ward's heron, discouraged, flew out of the enclosure. After another moment, the male charged the two egrets, and they quickly followed the Ward's. When every last intruder had been sent packing and the entire pond and salt flat were his, the male strutted back towards the nest, his solemn grandeur a joy to behold.

There were pied-billed grebes, red-wings, yellow-throats and killdeer in and around the cattail marsh, while many other birds passed over in flight or appeared on the nearby wooded ridges. The song of the painted bunting was constantly on the air, one pair evidently nesting inside the enclosure, on the low ridge that divided the cattail marsh from the salt flat, the other on the same ridge outside the fence. The only territorial enemies challenged by the cranes were soaring vultures, flapping herons and inquisitive deer. There were raccoons in the area, a few of them being observed inside the fence, but they did not appear to come near the nest.

Both birds did all of their feeding when relieved from incubation. They searched through the cattails, apparently for frogs, crayfish and aquatic insects. In a meadow of *Borrchia frutescens* between the *Typha* and the salt flat, grasshoppers and dragon-flies were stalked and caught. Leopard frogs in wet depressions on the edge of this meadow were stalked with wonderful patience. On the salt flats the cranes seemed to find small molluscs and grass shrimps in the rim of *Distichlis spicata* along the shore of the large pond. Blue crabs were rather scarce at this time but small examples were caught occasionally.

The female, a younger bird and in finer plumage, always looked clean and neat. The old male, from so much chasing through mud and water, was usually dirty and ruffled-looking. Sometimes, after a series of exhausting chases, he walked back towards the nest dripping wet and black underneath from the splashing mud. He was a game old warrior and did the best he could.

After the infertile eggs had been broken up, the pair resumed their former routine, walking out of the cattails together (for the first time since April 26), shoulder to shoulder, and even dancing a little, as if relieved at escaping the rigorous joys of parenthood. On the 26th of May, three days later, both were observed near the observation tower. The female was picking up loose particles of oyster shell when an airplane was heard. Both cranes raised their heads and made a low, protesting, guttural sound. The female then spread her wings and crouched slightly. At once the male leaped on her back as if to attempt copulation, his weight causing the female's legs to bend. Both birds waved their wings up and down during this brief interlude, but copulation did not actually occur. The male jumped or fell to the ground and both cranes preened for several minutes.

The male was last seen alive, and apparently in good health, mid-morning on July 21 (1949). Early on the following morning, Refuge Manager Julian A. Howard and Clerk Russell W. Clapper heard calls from inside the enclosure. It was noted that only one crane was calling. At 6:15 a.m. Clapper went to the fence and could see only the female. Returning with Howard, they searched the vicinity and soon came upon what remained of old Pete. He lay on his back in about three inches of water and was very dead. Subsequent examination resulted in the conclusion that he had simply toppled over from natural causes.

At this writing another male, a larger and presumably more vigorous individual than Pete, has been secured and placed in the enclosure

with the female. At last report they were engaging in the mutual dance display that is the beginning of the breeding cycle. (*Note:* Eventually this pair produced a single fertile egg which hatched after 33 or 34 days of incubation. The chick "Rusty," was lost at the age of four days).

The Young

Information on the first days, weeks and months of the Whooping Crane's life is extremely limited. O'Neil Nunez, in Louisiana, told John Lynch that downy young "took about 12 hours to dry, and left the nest the day after hatching." Walkinshaw (1949b, p. 103) says that the eggs of Sandhill Cranes are pipped "13 to 48 hours, but usually a little more than 24 hours, before hatching. After circling the egg with its white egg tooth, the young crane breaks out, a wet, weak form of tawny-colored down. In about two or three hours it becomes dry and fluffy. . . . At hatching, the young are quite sensitive to cold and are brooded considerably by the parents. If a human approaches, the adults trumpet loudly, and the young leave the nest to hide in nearby vegetation. At first the young crane is too weak to hold itself erect, but within 24 hours it can stand briefly on wobbly legs."

"Rusty," the Whooping Crane chick hatched on the Aransas Refuge in May 1950, was quite active within less than 24 hours after hatching and particularly so on the third day. It ran across the feet of the parent birds, so that they had to step back with great care and then hurry after it as it dodged this way and that. By the fourth day it was being brooded more than 100 yards from the nest.

As quoted by Bent (1926), Fred Bradshaw told of hearing "a strange piping whistle" which he discovered to be "that of a young crane just breaking through the shell. The call was very vigorous for an unhatched bird." This was a young Whooper making his start in the world. After hatching, the young bird called "almost

constantly, by a whistle resembling that of the red-winged blackbird, but fainter; occasionally it would be louder or more pathetic." On the next day the young bird left the nest at Bradshaw's approach and started swimming towards the cover of the rushes. Mr. Nunez claimed that the Whooping Crane family group remained for many weeks in the same swale where the young had hatched. At night, however, the young Whoopers were led to roost on small ridges or prairie knolls in the marsh, according to Nunez. Walkinshaw mentions that soon after hatching, young Sandhills are led to the nearest dry meadow or field, usually close to water but sometimes at some distance from water. In the Okefenokee Swamp, in Georgia, where there is no high land near their nests, the families stay in the less thickly vegetated parts of the marsh until the young are on the wing (Walkinshaw, 1949b, pp. 107-108).

When the young Whooping Cranes arrive in Texas, to spend their first winter on the Aransas Refuge, they are approximately 5 months old. They have been flying for only a matter of five or six weeks, with anything like strength and confidence, and for the previous two to three weeks have been traveling across strange and alien territory, covering a distance of perhaps 1,800 to 2,000 miles, following in the wake of their able and fearless parents.

Usually the family groups are the last Whoopers to arrive at Aransas and anxious days are passed waiting and watching for them. Then, at the very tag end of October or in the first few days of November, in they come, all adults with young-of-the-year generally arriving within a period of three or four days. No experience of this sort could be half as exciting, for these buff, cinnamon and russet plumaged youngsters are not only one of the rarest birds to be seen anywhere, but the last of their line and the hope of their race. On the ground, trailing closely behind the alert adults, they seem small, awkward and puerile. Their wings, pinkish buff or cinnamon splotched with dull white, appear too big

for the rest of them. Their heads, bristly with the rusty-looking feathers of their youth, give them a gawky, callow appearance, like an over-tall twelve-year-old boy whose hair needs brushing. But on the wing they seem suddenly as large and as capable as their parents. Without difficulty they keep up with the old birds and follow them out across the salt flats, the winter home of unknown generations of their ancestors, landing with at least a simulation of dignity, to explore, with expert and solicitous guidance, the many wonders of their new habitation.

The young, almost immediately upon arrival, are right in the middle of the territorial battles of the adult birds. It is then that we see the female and the offspring in close association, while the fierce male struts and whoops, challenging the right of all other Whooping Cranes to remain within hearing distance. When the male attacks other cranes, the female and young may stand idly aside, but more often they join him in his forays, keeping carefully in his wake and letting him serve as the spearhead of the charge. The young crane, its voice not yet developed, seems only mildly interested in these exciting events, acting much as it does when, in December, the parents begin dancing in their first prenuptial displays of the new season. The youngster's behavior at such times is a combination of boredom and indifference. It is interested chiefly in eating.

An excellent and sympathetic picture of the winning nature of a young Whooping Crane will be found in S. W. Oliver's story, *A Whooping Crane Named Bill* (Oliver, 1948). Dr. Lawrence H. Walkinshaw obtained valuable data on the growth and behavior of the Greater Sandhill Crane from the downy chick that he carried home and cared for to maturity. His account will be found in his book on the Sandhill (Walkinshaw, 1949b).

Young Whoopers are fed by the parents, chiefly the female, for some weeks after their arrival on winter quarters. Most of this feeding is concerned with searching for and obtaining food

items and breaking them up in a place where the youngsters can pick up and eat them. By January the young are learning to search for their own food and for a few weeks the *weaning* process is evident. At the same time the young gain in confidence, feeding farther from the female and experimenting on their own. By February the youngster is feeding itself almost entirely, and begins to look like an adult. Until the prenuptial dances of the parents become more intense, in March or April, family life moves along on an even keel. Then, one day, the young hopeful who has been so carefully guarded and nurtured for so many weeks, suddenly becomes a source of annoyance. Its own mother turns on the bewildered creature and drives it from her presence. The male, in his turn, chases it too, sometimes flying after the poor youngster for a mile or so before leaving it to its own, uncertain devices. In spite of this final and wholly necessary *weaning*, the young crane appears to return to the family circle, perhaps with a new understanding all around, and evidently makes the northward migration in company with its parents. What happens when they reach the breeding grounds we can only conjecture. Eventually groups of non-breeders are formed, but we do not know the details of the formation of these societies.

Other cranes behave in a similar manner towards their young. Walkinshaw (1949b, p. 58) presents evidence indicating that Greater Sandhills reach the breeding grounds accompanied with their young of the previous year. The "extra cranes," presumably yearlings, are driven away a few days after a pair arrives at the nest side. Fred Stark, as quoted by Walkinshaw, found that young Sarus Cranes, reared in the San Antonio Zoo in 1944, 1945 and 1946, were "taken care of assiduously up to the time of nesting the following year, when they were attacked by the parents and had to be removed from the nesting pen."

The existence of the subadults is little known. Our discussion of the role of summer wanderers

deals for the most part with this group, but there is not much available on the relationship of these youthful nonbreeders to each other or to older, unmated individuals with which they may associate. Walkinshaw (1949b, p. 58) states that "the Sandhill Crane does not breed until at least two years of age." It is my belief that the Whooping Crane does not breed before its third spring, at which time it is approximately two years old. The same is apparently true of Saras and Asiatic White Cranes (Blyth, 1881). In the present Whooping Crane population, it is even possible that some two-year olds are unable to find mates and must wait until they are three years of age or older. Many of these problems might be solved by the observation of banded individuals that have been hatched, reared and kept as breeding stock in large, natural enclosures such as the one at Aransas Refuge.

The Present Breeding Area

For more than a quarter of a century a few pairs of Whooping Cranes have been nesting somewhere in the Canadian wilderness and, in the last decade, rearing an average of four young annually. The location of the nesting site is unknown and has been the object of intensive search since the summer of 1945. In one sense it is encouraging that the location of the nesting area resists all efforts to find it, for this means that it is safe, for the present at least, from disturbance by irresponsible and destructive human elements. On the other hand, it is important that wildlife service or other thoroughly responsible personnel are the first to discover the area, so that the exact site will not be made public, and in order that the necessary steps may be taken to set the region aside as an inviolate sanctuary, before it is too late.

In speculating as to where these birds may be nesting we now have these advantages: (1) we know something as to the biotic character of the former nesting sites and, (2) as a result of previous searching, we know where the Whooping

Crane does *not* nest. Both categories of information should be helpful in narrowing the search to the more likely areas that remain to be investigated. Long ago it was a habit of the late Dr. Frank M. Chapman to list localities where he did *not* see certain species. Such negative data can be as useful, in this instance, as positive information on recent occurrence that may show us the trend of the migrant birds.

The biotic niche of the nesting Whooper in Canada is probably shared by species like the pied-billed grebe, coot, mallard, pintail, widgeon, shoveller, teal, red-winged blackbird, long-billed marsh wren and rails. The muskrat would be a typical mammal. Cattails, sedges and bulrush would be present, along with pondweeds, spike-rush and similar aquatics. It is a shallow water region of ponds and sloughs, if our information derived from past performance has any meaning, a region such as was found in the prairie marshes of western Minnesota and northern Iowa, and in the aspen parklands and adjacent habitats of the central Canadian Provinces. It is vastly significant that these very environments—those that remain in some of our north central States and in Canada—are still among the major breeding grounds for the pond ducks. In recent years, waterfowl breeding ground inventories have become increasingly thorough, and it is these same areas of shallow ponds, potholes and sloughs that have been given the most painstaking attention. One has only to study the data and maps in the Special Scientific Reports, issued each year by the U. S. Fish and Wildlife Service and the Dominion Wildlife Service, to appreciate the coverage now undertaken by air and ground crews engaged in sampling our continental waterfowl supply. Furthermore, these inventories are made while the ducks are still on their breeding areas, usually in early May and early June. It is at this time that Whoopers are incubating their clutches, and later, when waterfowl brood counts are made, in July, the family groups of Whooping Cranes, with young-of-the-year in tow, should be particularly conspicuous. Never-

theless, the only authentic reports received from aerial or ground crews engaged on inventory work, have been of summer wanderers, such as the "single" that spent the summer of 1947 in parkland areas east of Regina.

All of the old nesting sites that are known to us have been investigated. Some have been drained, others are now comfortable summer resorts, a few others continue to provide sufficient water, isolation and natural food to raise ducks. But none of them harbor nesting Whooping Cranes. The last observed nesting location, Muddy Lake, Saskatchewan, is typical of most of the former Provincial sites. No longer is there enough water, nor enough solitude. It is almost 30 years since Whoopers nested in the parklands of the central Provinces, and, in that time, many changes have been made, all of them unfavorable to a large, conspicuous, wilderness-seeking species like *Grus americana*.

Since 1948 the waterfowl counts have been extended into the Far North, to the shores of the Arctic seas, bays and gulfs. In so doing it has been essential to search out the habitats—river deltas, wet plateaus, tundra marshes, etc.—where nesting waterfowl might be found. Again, it is these same environments in which we would expect to see nesting Whoopers. But none have been found. To the west lies the Canadian Cordillera, extending from just west of Fort St. John and Fort Nelson to Camsell Bend on the Upper MacKenzie, swinging around Fort Norman and west to the Peel Plateau, the Richardson Mountains and the Arctic Plateau facing the Beaufort Sea. It is a rugged, forbidding region and, except for a few oases like the Old Crow Basin, is *not* Whooping Crane country. The Old Crow area was searched in both 1948 and 1949 without results, so far as Whooping Cranes were concerned.

From the Cordillera eastward to the barrenness of the Precambrian rock area, the terrain is rough, deeply etched and scoured by networks of

streams and, except for occasional stretches of open or thinly treed muskegs and the rolling tundra of the coast, it is heavily forested. Reduced to its practical dimensions, from the point-of-view of waterfowl and Whooping Crane use, it is a surprisingly narrow belt, considering the immense width of the whole of Canada. From a base 400 miles or so in width, along the 58th parallel, it narrows to about 325 miles at Great Slave Lake, 200 miles at Great Bear Lake and then broadens to approximately 350 miles along the Arctic Coast. In the two previous years the waterfowl habitats of this entire area have been carefully surveyed. No Whooping Cranes have been seen, but somewhere in that 300,000 square miles of wilderness they may be found.

Since the waterfowl inventories are based on transect samples, it is always possible that a corner of one of these habitats has been overlooked. But it would have to be a very small corner. Another possibility is that nesting Whoopers, hidden in deep cattails or bulrushes, might not be easily spotted from a fast-moving airplane. Or perhaps the search period has been too early and should be advanced to June 15–July 15, when the young are certain to be hatched and walking around, and the entire family group more readily observed than while incubation is under way. July brood counts have not been made in most of this northern area.

It is still our considered belief that these six or seven breeding pairs that remain are nesting north of 58° and in the relatively narrow strip between the foothills of the Cordillera on the west and the Precambrian Shield on the east. Below 58° the country is either too settled or it is unsuited from a biotic standpoint. Historically, the species has never been found nesting on mountains, in mixed or coniferous forest or on tundra. There are almost no occurrence records from the Precambrian region. From what we know of its life history we would not expect it to occur in any of these areas, except as a transient wanderer.

The Breeding Cycle: Summary

1. The first prenuptial displays are observed on the Texas wintering grounds in late December or early January. The nature and progress of these displays is described and they are compared with similar displays and "dances" in other cranes.

2. Existing knowledge as to the appearance and character of typical Whooping Crane nest sites is summarized, from data in the literature. The nest built by captive Whoopers in 1949 is described and comparisons are made with nest structures built by other cranes. It is concluded that the Whooping Crane normally selects a nesting site closely allied, from a biotic point of view, with the *Salix* communities of the aspen parkland habitat. The nature of these is described.

3. The appearance of the eggs is summarized from the existing literature and average and extreme measurements are given. Limited data is presented as a result of information supplied with 121 Whooping Crane eggs reported on by museums and private collectors. Egg weights are discussed briefly and comparisons made with the eggs of Sandhill Cranes.

4. The incubation period has been calculated at 34.5 days and this is compared with the period observed for other cranes, which varied from 28 to 36 days.

5. The behavior at the nest is described in quotations from the literature. Some individual

variation is noted. The nesting behavior of a captive pair is described in some detail. It was observed that, as in other cranes, incubation of the first egg is started by the male. In general, the female appears to incubate at night, the male by day. However, there was an average of 7.6 diurnal nest reliefs in the captive pair, 4 by the female and 3.6 by the male, as an average (11 days). Much of the nest-side behavior in the Whooper appears very similar to that of other cranes, although Whoopers may be more quiet at nesting time than Sandhill Cranes.

6. It was observed that one member of the pair remained on the nest at all times, except for very brief lapses, chiefly for the purpose of drinking. The free or "guard" bird divided its time between guarding close to the nest, feeding, bathing and chasing other species from the vicinity of the nest. The male was more attentive to chasing than the female. These activities are described.

7. The appearance and behavior of the young, from wet nestling to one year of age, is described. The detailed existence of sub-adults, from one year of age to breeding age, is little known.

8. The present breeding area, which remains unknown, is believed to be within a 300,000 square mile segment of Canadian wilderness north of latitude 58° and between the Canadian Cordillera on the west and the Precambrian Shield on the east.

Part VII. Molts, Plumages and Anatomy

THE adult, juvenal and downy plumages of the Whooping Crane are described by Ridgway and Friedmann (1941). Bent (1926) discusses the plumages of the downy young and the immature bird and Stevenson and Griffith (1946) mention the individual variation to be observed in certain adult plumage features and describe the progressive nature of the changes in the appearance of the young. Bent states, "At the seasonal molts of adults we can only guess, for lack of material." Ridgway and Friedmann mention that "The length of time required to attain adult plumage is not known. It is similarly not definitely known whether there are any progressive changes in young birds or whether the adult plumage is acquired by a post-juvenal molt at the end of the first year." On this point, Bent had noted that there was apparently "a partial molt of the contour feathers" in winter and spring, advancing the young towards maturity, and Stevenson observed an immature individual, whose age he estimated as "not more than 15 months," which was indistinguishable in the field from its parents. His notes present details that suggest gradual and progressive changes during the first year to year and a half. Some of our data obtained in the field adds to the information on this subject.

Adult Plumage

The body plumage of the adult appears entirely white, except for the region of the head. The wings are also white, except for the alula and the ten primaries and their ten greater upper coverts, which are chiefly a slate black. Ridgway and Friedmann state that these feathers are "uniform slate black," but a specimen examined at Aransas Refuge, in March, 1948, showed some white towards the base of some primaries, a brownish cast in others and considerable white brown in the five smaller feathers of the greater coverts. The last two covert

feathers were completely white except for a few minute black spots near the tip of the smaller. Of the four feathers of the false wing, three were slate black towards the terminal end, one was washed with gray. The age of this bird was not known. It was presumed to be a female.

The "whiteness" of the plumage, while often appearing satiny in texture, is not a brilliant white as in the white pelican, but gives the impression of being basically gray. The plumage of the sexes is presumably alike.

The forehead, crown and anterior part of occiput are bare, except for sparse, black, hair-like feathers, heavier on the forehead than anteriorly. The skin is "warty or granulated carmine reddish" (Ridgway and Friedmann, 1941). These same authors say that the space between the eyes and bill (lores) and the cheeks (malar regions), "including a narrow angular strip extending from the latter down each side of the throat, also naked, carmine, and similarly bristled, the bristles denser anteriorly." There is a wedge-shaped patch of dark feathers ("dark plumbeous:" Ridgway and Friedmann) on the nape or post-occipital region. In close range observations of both captive and wild birds a variation was noted in the extent of this plumbeous patch. There was also variation in the growth of the black, hairlike feathers of the face and in the color of the bare skin. Two captive individuals that had been in close confinement and on an inadequate diet for some months were noticeably pallid in the shade of the skin and the bristles of the face were lacking in thickness and gloss. After some weeks of natural foods and the freedom of a large enclosure, both birds showed a deeper carmine, particularly on the crown, as well as a definite richness and gloss to the black, hair-like bristles. There is probably a direct connection between both general physical condition and gonadal stage in the appearance of these bodily characters, and this last may have contributed to the improvement noted.

The iris is "lustrous yellow" (Stevenson and Griffith, 1946) in the adult bird. To this observer it always has a certain bright coldness, more of a "white yellow" than a golden or warm yellow.

The color of the bill varies according to general physical condition of the individual, age or gonadal stage. Stevenson and Griffith state, "The bill is olive-gray, tipped with dark gray. In certain lights the bill appears dull yellow in color. The base of the bill, contrary to the portraits by bird artists, including Audubon, is pink or rosaceous which color is more extensive on the upper mandible. The small area of bare skin between the rami is also red." A wild adult observed at close hand, December 28, 1947, showed the base of the bill dull pink or flesh color, the middle portion of the bill dull brownish black and the tip dirty yellow. On May 20, 1948, a captive female, then incubating infertile eggs in the first Aransas nest, showed a pinkish, flesh-colored base to the bill, a middle portion, to the nostril openings, that was dark olive on the upper mandible and medium dark olive green on the entire lower and tip of the upper mandibles. The lining of the bill, as seen through the large nostrils, was dark flesh-color. Ridgway and Friedmann describes the bill as "wax yellow tipped with dull greenish or yellowish," which may apply only to the bill of a dried study skin.

The same authors point out that the eye is "surrounded above and below and in front, but not behind, by bare skin, the lower eyelid feathered, the upper nearly bare." The bare skin, however, may be more or less heavily covered by the black, hair-like feathers, especially in front and below.

There is a diamond-shaped area of bright pinkish or flesh-color in the gular region or throat.

It is a generic character that the tertails are longer than the primaries and decurved. In the adult *Grus americana* these feathers are exquisite and plume-like and can be raised over

the back at will, as is done in certain displays. Stevenson and Griffith note that "When the wings are in normal folded position, the black primaries, upper primary coverts and alula are hidden." However, the birds frequently stand or walk with the wings drooping slightly, so as to expose the tips of the primaries, the edge of the coverts and the alula. In some attitudes the tips of the primaries may protrude above the tail, unless hidden by the drooping, decurved tertails. The legs and feet (tarsi and toes) are black, brighter on the anterior side. The pads of the feet and toes are dull flesh color.

Juvenal Plumages

The young of the Whooping Crane are first observed moving south in the fall and arriving on the Texas coast when they are approximately five months of age. Apparently they are not as tall as the female adults, on the average, but their wing spread appears to be almost as great. At first glance, on the ground, they appear to be quite uniformly buff or brownish, but some individuals may show a good deal of white, especially on the lower breast, belly and back. There may also be considerable white in the wings, as is evident when the young bird is in flight. However, there is wide variation among immature Whooping Cranes of approximately the same age, not only in the amount and distribution of white feathers, but in the shade of buff or brown retained in the plumage.

Bent (1926) suggests that "a young bird collected in October probably represents the juvenal or first winter plumage." He then describes an immature plumage that is mainly white, heavily mottled, variegated and mixed with various shades of "pinkish cinnamon," "cinnamon buff" and "saya brown." By February this same bird may be almost entirely white, and, by the end of March, may be difficult to distinguish from an adult, except at close range. Some young individuals arrive in Texas with more white in the plumage than others and

could be as much as two weeks older than the darker birds. Also, some young seem to progress towards the adult (or sub-adult) plumage more rapidly than others. In general, what may be termed the first year or sub-adult plumage, attained by the time the young are approximately one year old, is nearly identical with that of the adult. As in all juvenal or immature plumages, the sexes are apparently feathered alike and no difference has been detected in color or form of the soft parts.

The appearance of the first winter young, in various stages of their plumage development, shows many differences. Individual variation is obvious in the November group. This continues to be marked in December examples, but is usually less so thereafter. By the time the adults are ready for the spring migration, in April, there are still ample signs of immaturity, but the attainment of white feathers seems to be more rapid and there are probably few obvious outward signs left by the time the migrants reach Canada in May.

Ridgway and Friedmaun's description of the juvenal plumage is not necessarily average, even for an early winter individual, which it appears to represent. They state that the entire head is "feathered, including forehead and lores, the feathers on the parts that become bare in the adults short and somewhat dusky." In general, young observed in the field (in winter in Texas) appeared to vary between a rather dark, russet brown or sayal brown on the head to a light buff, either yellowish, saffron or orange-tinged or pinkish buff. Ridgway and Friedmann say that sayal brown may be a solid color on top of the head.

The same authors describe the rest of the juvenal plumage—except primaries, greater upper coverts and alula—as "whitish" (frequently given in our notes as "a dirty or smudgy white"), "heavily washed, mottled, and blotched with pinkish cinnamon to cinnamon buff." Again, these areas may be quite dark and brownish or a very light pinkish or saffron buff. "The

upperparts of the body and the wings much mixed with white feathers and cinnamon-buff ones, the latter more numerous on the scapulars, interscapulars, and back, and less so in the wings; the darkest of the colored feathers are in the scapulars as a rule" (Ridgway and Friedmann, 1941). In some individuals the short feathers of the head are darker than any others.

According to the same authors, the primaries in the juvenal are dull blackish, alula and greater upper primary coverts "dull blackish washed with buffy or ochraceous." They describe the bill of the young bird as darker than the adult's and more blackish at the tip. Study skins do not show areas that are flesh-colored in life. Stevenson and Griffith (1946) record that the juvenal bill is darker than in the adult and add that "the pink patch at the base of the upper mandible is more extensive." A young bird observed at close range on February 15, 1948, when approximately 8½ months of age, had a bill that was flesh-colored at the base, but not exceptional in extent. The major portion of the bill was dark brown with a background of dull yellow that was not very apparent. The tip was blackish.

Stevenson and Griffith (1946) speak of a young bird observed January 30, 1941, when approximately 8 months of age, that "had a crescent area in front of each eye (lores and malar region) which was darker than the rest of the head and becoming black. The head, apparently, is still entirely feathered. The head and upper neck are cinnamon, the crown, lores and malar stripe much darker." My February 15th youngster was definitely blackish on the areas that are semi-bare in the adult, but the sketchy nature of the feathers suggested that some juvenal plumage still remained and the hair-like feathers of maturity were just appearing. The rest of the head, the nape and a portion of the neck below the nape, were light orange. The remainder of the plumage, as a whole, was a grayish or dirty white.

The young bird that remained on the Aransas

Refuge through the summer of 1941 retained "a few brown wing coverts and a few cinnamon-tipped tertails," as well as some brown-tipped tail feathers, until at least June 30th, according to Stevenson and Griffith. By August 25th it was "pure white," with no cinnamon on the wings. The bare skin had appeared on the crown and cheeks as early as the end of June.

While it is not yet possible to be certain on this point, it seems likely that the average sub-adult retains some brownish or cinnamon feathers through the second summer, and does not attain full adult plumage until after partial molts that may, as in the Sandhill Cranes (Walkinshaw, 1949, pp. 9-11), occur (a) between August and October, for feathers involving body, neck, head and part of the wing, and (b) early the following summer for the primaries, secondaries and a few of the tertails. If this is the case, then adult plumage is not complete until the individual is in its third summer, aged approximately 25 or 26 months. Possibly this is also the period when the breeding age is reached.

Natal Down

The description of Ridgway and Friedmann (1941) is the most complete: "General color of upperparts dull cinnamon to sayal brown, deepening into mikado brown or russet on rump, where still darker (liver brown or bay) along median line, continued along median line of back, paler and grayer on neck, still paler behind wings; underparts pale dull grayish buffy or dull brownish whitish, tipped or suffused with pale cinnamon; bill pale buffy brown, flesh color basally, with a small whitish spot on the upper mandible; tarsi and toes light brownish." Fred Bradshaw, quoted by Bent (1926), describes the young bird in the Muddy Lake, Saskatchewan, nest as "for the most part of a buff color; from the neck to the rump on the back it is somewhat darker, while the under parts are

much paler than the color of the head. The bill is about three-fourths inch long, upper half flesh color, lower half darker or horn color, a small white spot on the upper mandible." It seems possible that the small white or whitish spot on the upper mandible is the remains of the egg tooth, which is white in the Sandhill Cranes, as mentioned by Walkinshaw (1949b, p. 103).

Molts

It has already been suggested that the Whooping Crane may molt once a year, in two stages: a partial molt of most of the plumage between August and October and a partial molt involving the primaries, secondaries and possibly a few of the tertails, in early summer. This pattern follows that of the Sandhill Cranes, as described by Walkinshaw (1949b, pp. 9-11). Blaauw (1897) stated that cranes "moult only once a year," also describing two periods or stages, the wing and tail feathers being dropped at one time and the body feathers at another. The same authority, from data and observations of both wild and captive cranes of many species, believed that certain cranes molt all of the primaries and some of the secondaries at once, "so that the birds for a time are unable to fly." *Grus americana* is included in this group.

It is therefore possible or even probable that the adults molt the primaries and some, at least, of the secondaries in early summer, after the young have been hatched. Thus, for a time in late June or July the parent birds may be flightless.

The additional molting may occur in September, just prior to departure on the fall migration. We did not pick up any number of dropped feathers on the wintering grounds, or detect any signs of molting during that period. Ultimately, careful observations of captive birds living under more or less natural conditions, should establish the pattern of these molts.

Anatomy

In the museums and private collections of this and, in a more limited way, of several European countries, there is a fairly large and quite representative number of study skins of *Grus americana*. The amount of skeletal material is less satisfactory and complete skeletons are a rarity. There are at least two trachea preserved and a carcass, nearly complete, has recently been made available for anatomical and osteological study. A synopsis of the osteological characters of *Grus americana* was published many years ago by Robert W. Shufeldt (1894) and there are descriptions of the convolution of the trachea by both Dr. Elliot Coues (1874a) and Dr. T. S. Roberts (1880). At the present time, Dr. Harvey I. Fisher of the Department of Zoology and Physiology at the University of Illinois, is making a study of the anatomy and skeletal characters and publication of his paper is looked for in the near future. Dr. Fisher's report should be more complete than any that has been available up to this time.

A number of museums have very kindly provided us with measurements taken from skins in their collections. In addition, there is some data on measurements in the literature and Dr. Walkinshaw's recently published book on the Sandhill Cranes provides us with summaries of similar data on that group of cranes, which is thus available for comparative purposes. However, there has been no opportunity for a thorough and comprehensive study of all this material and it is, therefore, quite impossible to discuss it in this report. It is hoped that it can be prepared at some future time and published as a separate contribution.

Meanwhile, the present standard with regard to extreme and average measurements of the species will be found in Ridgway and Fried-

mann (1941). These data are based on the examination of 15 male specimens from Canada, Minnesota, Kansas, Illinois, South Dakota and Texas, and of 7 female specimens for Minnesota, Nebraska, South Dakota and Texas.

Molts, Plumages and Anatomy: Summary

1. The adult plumage is described, the remarks of various authorities being supplemented with observations of both wild and captive birds, particularly as to the color of "soft parts."

2. The considerable variation in the plumage of juvenals is discussed. It is believed that the first year or sub-adult plumage, which resembles the adult plumage superficially, is attained at approximately one year of age. It seems probable that the full adult plumage is not attained until the age of about 25 or 26 months.

3. The appearance of downy young is quoted from sources in the literature. The small white or whitish spot on the upper mandible is thought to be the remains of the egg tooth, which is white in Sandhill Cranes.

4. It is suggested that Whooping Cranes may molt twice each year, following a pattern similar to that described for the Sandhill and other cranes. It seems likely from existing evidence that the adults molt their primaries, some of the secondaries and possibly some of the tertails after the breeding season, in late June or early July, and are temporarily flightless. Additional molting may occur in September just prior to the fall migration, involving the remainder of the plumage. No evidence of molting was observed on the wintering grounds.

5. References are given for available material on certain osteological and anatomical characters and on measurements. There was no opportunity for a complete anatomical report, although data is being studied.

Part VIII. Survival: Protection and Conservation

IN this report we have considered in some detail our knowledge of the distribution, abundance, migration, food habits and other phases of the Whooping Crane's existence. We have assembled this considerable volume of background material, not only to place it on record and familiarize ourselves with the entire story, but to put ourselves in a position to evaluate all available data and draw conclusions as to effective measures of protection and conservation. Only thus may we understand the full significance of the Whooping Crane's present predicament. It is still faced with the threat of extinction. What are we going to do about it?

The fate of the Whooping Crane has become of public concern. The struggle of these great birds to survive the dangers and difficulties that threaten to engulf them is dramatic, appealing and challenging. When the remaining migrants, now only 33 in number, return, with their young of the year, to winter quarters on the Texas Gulf coast, it is an event of national interest. When Josephine, the female of the captive pair in an enclosure on the Aransas National Wildlife Refuge in Texas laid an egg, the possibility of the advent of "Whooping Crane No. 37" was heralded, with double-page spread of pictures, in a leading national weekly. The ultimate hatching and tragic end of the ill-fated chick, "Rusty," was featured in newspapers and on national radio hook-ups the country over.

An editorial in the Greenville (S. C.) *News* expressed consternation over the fact that the newspaper-reading public followed avidly the story of Rusty and then, presumably, forgot about it as soon as the little chick, and the story, died. The editorial said, in part:

"What we ought to be doing is continuing our interest in the 30-odd specimens still left to help make sure they have sufficient natural habitat to attempt a real comeback . . . we read and exclaim about the little whooper, forget him the minute he disappears and all the while the National Audubon Society is

struggling to provide sanctuaries in appropriate places where not only whooping cranes but other birds, threatened with extinction, may have some natural privacy and protection to make comebacks. . . ."

The story of Rusty even appeared in the Western Berlin edition of the *Stars and Stripes*, the U. S. Army newspaper, recalling another editorial, in the *Toronto Globe and Mail* a couple of years ago, when we were asking for information on the migration of the Whooper:

". . . The very fact that in these troubled times people should actually be devoting their energies to something quite removed from politics, atomic bombs, making money and other such mundane activities, is refreshing. For the past week or so hundreds, or it may be thousands, of farmers in Southern Saskatchewan have been peering into the spring sky for signs of whooping cranes on their way to summer nesting grounds. Now surely this is better fun, certainly less nerve-wracking, than watching for buzz bombs at the North Pole. . . ."

Nowadays, the threatened extinction of a bird is news and the public wants to know about it. Every typical American, the man in the street, or on the farm, is full of suggestions and advice. He wants to help. In Canada, Nebraska, Texas or New York it is the same. As I was picking up some spare parts at an auto supply store in a small Texas town, the proprietor said, "Now, about those Whoopin' Cranes down there at Aransas. I was just sayin' to the wife last night, I said, what they oughta do . . ." This advice is well meant, earnest and often it hits the nail squarely on the head. Those of us who are responsible for the details of the job cannot always make the move that seems so obvious and so right. Some of the obstacles are inherent in a job that deals with a shy, wilderness-seeking bird that migrates halfway across North America to breeding grounds as yet unknown. Others are a result of the need for moving cautiously, and of planning carefully as we go. We should not take unnecessary chances with a species that numbers less than 40 individuals.

This has been a cooperative project under the joint sponsorship of the U. S. Fish and Wildlife Service and the National Audubon Society. Action on suggestions that follow is primarily for consideration by these two responsible agencies. In the course of the last four years, during the progress of our investigations in the field, from the Mexican border to the Arctic Coast, it has been possible to make urgent recommendations as we went along. Many of these have already been acted upon, to the unquestionable advantage of the Whooping Crane. Others are still "in the mill."

The average layman will be rather impatient with caution and delay. I can sympathize most heartily with that attitude, but, on the other hand, I believe that the situation with regard to both planning and action will be clarified by the detailed discussion further along in this chapter. For almost a century the Whooping Crane has been listed as a rare species. For much of that period it has been considered on the verge of extinction. About thirty years ago it was actually, if unofficially, pronounced as extinct! It still lives on, and, as long as some progress can be made, however, slow, our hopes are high. As pointed out in our discussion of the abundance of the species through the years, there is a good chance that *Grus americana* was never very numerous. There appear to be sound reasons for this belief. We cannot overlook the fact that Nature is a relentless mistress and, to survive, a species must adapt itself to change. Nearly all of the extinct and currently threatened species of birds that come to mind have, in part, suffered because of an inherent lack of adaptability. As has been noted by others, the California Condor has become seriously depleted within a habitat in which the Turkey Vulture thrives; the Ivory-billed Woodpecker has disappeared in forests where the Pileated has prospered.

It is worthy of consideration that these and other species, including the Whooping Crane,

may have been for some time on the list of Nature's cast-offs. In certain cases there may be a very gradual process of elimination, through the slow action of natural selection over centuries of time. If man comes along and brings into play additional decimating factors, then the process may be tremendously accelerated and it is possible that extinction may follow very quickly. On the other hand, if man recognizes the realities and the possibilities of such a situation it may be within his power to stave off the threat of extinction and even restore a species to relative abundance, turning the tide against the trend that Nature may have set in motion.

Applying these thoughts to the Whooping Crane we see at once the need that has long existed for a careful study, followed by a course of direct action that is based on the facts at hand. Once we know what these facts are, it is clear that our actions must be translated into tangible assets favoring the practical welfare of this great bird and aimed straight at its protection and conservation. This is the approach that will be found in these recommendations. They are based on the assumption that we have singled out the Whooping Crane for survival for reasons that are peculiarly our own, in the face of the possibility that Nature had already greased the skids that would lead to its ultimate destruction. We cannot identify ourselves with Nature to the extent of assurance that our personal wishes are Nature's also. It seems far more reasonable and much more practical to recognize the full extent of the danger that exists and to overlook no step, direct or indirect, that may contribute to survival. The decimating factors may far outweigh the welfare factors. What we must do is go beyond routine and the usual practices, even to creating welfare factors. If Nature fails to provide suitable conditions somewhere along the line, we must step in and try to improve the situation through our own efforts. Only by alert and resourceful action, based on a sound and detailed knowledge of the prob-

lems, can we hope to insure the survival of *Grus americana*.

SURVIVAL: (1) RESULTS TO DATE

The establishment of the Aransas National Wildlife Refuge in 1937 may very well have saved the Whooping Crane. Today, an area of about 5,000 acres of salt flats on the Refuge, and a like acreage on nearby Matagorda and St. Joseph Islands, comprise the only remaining wintering grounds. The species has gradually disappeared from all other wintering areas. Although the purchase of the refuge lands was undertaken primarily in order to provide safe wintering habitat for waterfowl, it was not without full cognizance of the fact that Whooping Cranes were using it.

The presence of the Cranes on the lower end of St. Charles Ranch evidently clinched the matter. It seems possible that this decision alone may have been the determining move that weighed the scales in favor of survival for *Grus americana*. Because of the adaptability of the area to waterfowl refuge purposes (acquisition funds are only available on that basis) it was possible to benefit many other wildlife forms, some of them, like the Whooping Crane, in grave need of refuge protection.

Alertness in a situation of that kind is important in halting further depletion of valuable natural resources and is the type of intelligent administration, moving boldly and looking beyond the minimum requirements ordained by laws and regulations, that we must have if wildlife species like the Whooping Crane are to be preserved.

Since 1937 a number of moves have been made to improve the condition of the species. Most of these have been undertaken on the Aransas Refuge, where the results to date, while not outstanding, have been encouraging.

By contrast, little direct action was taken to improve the situation for the group of Whoopers that then survived in Louisiana and today, thir-

teen years after the establishment of Aransas, one wild Louisiana Whooper is still alive and was recently transferred to the Texas area (Allen, 1950). Before discussing future plans, it will be appropriate to mention other major steps that have been taken, to date, for the greater security of this bird.

Initial studies of the Texas population and of the winter habitat were begun in the winter of 1938-39 by the personnel of Aransas Refuge. Much new and valuable knowledge was accumulated and highlights published in ornithological and conservation periodicals, notably the excellent paper on the winter life of the species, based on the field work of James O. Stevenson, who was refuge manager at Aransas from 1938 through most of 1941 (Stevenson and Griffith, 1946). The summary of limiting factors contained in this paper furnished a brand new basis for action. These have been discussed in the section of this present report on the winter life.

With the coming of World War II, due to curtailment of funds and personnel, it was necessary for the government to resort to holding or delaying action so far as the Whooper was concerned. The refuge was maintained and the Cranes counted regularly, but no studies were made and no special action proposed or undertaken in their behalf.

Before the end of the conflict, however, in 1945, as a result of reports from both Texas and Louisiana as to the uncertain status of the species, the U. S. Fish and Wildlife Service and the National Audubon Society joined forces in a cooperative project the purpose of which has been to investigate the condition of the Whooping Crane thoroughly and find ways and means of halting its decline and favoring its increase in numbers.

One of the initial efforts was concerned with locating the unknown Canadian breeding grounds of the few nesting pairs that survive. Fred Bard, Jr., now Director of the Provincial Museum in Regina, Saskatchewan, handicapped by the wartime restrictions still in effect in that

summer of 1945, nevertheless made a number of investigations, by airplane and automobile, without turning up a clue of consequence. Negative information obtained by him, however, was extremely useful to future searchers. At the same time, Mr. Bard began a campaign designed to interest the Canadian public in the welfare of the Whooping Crane; spreading out on a continent-wide basis in the last four years, the educational campaign has obtained results far exceeding any previous experience. By radio, news stories, correspondence and personal interviews, Bard soon found that the public, too often accused of complete apathy in such matters, was not only interested but fired with an enthusiastic desire to help in any way that it could. Migration reports, many of them accurate and of great value, poured into his office. Old timers in the parklands and in the "bush" wrote wishing him well and contributing old, almost forgotten records. Conservation agencies and organizations, the Royal Canadian Mounted Police, the far-reaching Hudson's Bay Company and many others offered their assistance. Editorials lauding the effort and praying for favorable results appeared in the newspapers. Still, the location of the breeding grounds remained undiscovered.

From September 1945 until that same month one year later, the project was in the capable hands of Dr. Olin Sewall Pettingill of Carleton College. Dr. Pettingill made valuable observations and inventories on the Aransas Refuge, searched other Gulf Coast areas and called attention to the two captive Whooping Cranes in isolated enclosures in Nebraska and New Orleans. He also began a study of the literature and a card file of Whooping Crane titles.

During the summer of 1946 Dr. Pettingill, with the aid of Terris Moore, flew out of Fort Chipewyan, at the western tip of Lake Athabaska, in another effort to locate the breeding grounds. Once more, while the nesting pairs were not located, information of much value, in a negative sense, was secured. Meanwhile, Fred

Bard and others voluntarily continued the splendid work of obtaining and screening migration reports, in addition to keeping up an increasingly high level of public interest.

The writer was assigned to the project in October 1946 and has given practically full time to the study up to now. It was possible, with the help of many persons, to launch a number of specific plans to improve the status of the Whooping Crane. Some of these now show signs of bearing fruit, others, for one reason or another, hang fire and must be pushed with greater vigor. They make up a varied list, touching on many phases and problems of the Whooping Crane's existence. Following is a summary of the more important items that have been undertaken or proposed up to this time:

(a) *Habitat and Food Resources Studies*

These have been confined chiefly to the winter range in Texas (Aransas Refuge). Less detailed work was done in Louisiana, Nebraska and Canada. Initial studies at Aransas Refuge were made by Stevenson, Beaty, Lynch and others, all personnel of the U. S. Fish and Wildlife Service. The paper already cited, by Stevenson and Griffith (1946), summarizes the habitat and the types of food available to the Cranes in that environment. In the summer of 1946, following the visit to Aransas by Dr. Pettingill, a formal study of the food resources was arranged through the cooperation of Dr. Gordon Gunter and Joel W. Hedgpeth of the Institute of Marine Science, University of Texas. They were assisted by Harold L. Blakey, refuge biologist. The scientific results of this investigation have been published as separate papers, one on the fishes (Gunter, 1950) and the other on the marine invertebrates (Hedgpeth, 1950). Both Dr. Gunter and Mr. Hedgpeth had previously turned over their results to the project and the writer has, with their permission, made free use of their material in his discussion of the food of the species and those problems on the winter-

ing grounds having to do with food availability. Dr. Gunter likewise assisted with determinations of food specimens collected in the South Platte River, Nebraska, and obtained various opinions as to potential food animals of other kinds along the migration route in that general location. Joel Hedgpeth continued to assist the writer in many ways, both in the field and in our subsequent studies of the important invertebrate group among marine animals present in the feeding ponds of the Aransas winter range. As an interesting sidelight to studies such as these, two species of crayfish new to science were unearthed on the Whooping Crane area at Aransas Refuge, *Cambarus hedgpethi* and *Cambarellus ninae*, both described and named by Dr. Horton H. Hobbs of the Miller School of Biology, University of Virginia, to whom we sent specimens. Both varieties are taken by the Cranes as food.

The results of habitat and food resources studies conducted during the winters of 1946-47 and 1947-48 on the Aransas Refuge are contained in the present report.

(b) Accurate Counts and Observations

Techniques for obtaining accurate counts and observations of Cranes in the areas occupied by them on the Texas range have been developed. This has proved of considerable importance because of the need for detecting quickly and accurately the number of individual birds returning each fall, winter population shifts, relation of family groups or pairs to territories, presence of birds on outlying islands, use of burns and agricultural lands, behavior during "northers," departure in spring and all of the many vital details that make up the winter life of the species. For inventory purposes alone the need for reliable counts is essential.

It was found that a small, slow-flying monoplane cruising at an average altitude of 300 feet is about right for making counts where the Cranes are in the open and both pilot and observer know the area and the approximate limits

of Crane territories. If care is exercised, most of the Cranes will not flush during the progress of such counts. The usual pattern consisted of zigzag courses, one leg of which placed the sun on the plane's tail, and the other leg being merely a swing back into position for favorable observation.

Ground counts, while not as thorough as aerial counts, can be conducted with accuracy if certain precautions are taken. There are two chief difficulties: (1) duplications and (2) the missing of certain groups entirely. It is necessary to make a number of test runs first to learn the distribution of the Cranes on the various territories. Some of the territorial limits or boundaries are more fluid than others and some individual Cranes, probably sub-adults, have no fixed territory but wander through several "claims." A working acquaintance with the different pairs, family groups and occasional "singles" is a prerequisite for making accurate ground counts. A jeep is the proper equipment.

Counting from a boat is difficult because of the low level of visibility. The Cranes that sometimes occur on St. Joseph and Matagorda Islands can best be counted by the use of an airplane.

(c) Warning Signs

Good-sized warning signs, with large lettering, so that they can be easily read from boats in the Waterway, were placed in 1947 at each end of the canal where it enters refuge property at False Liveoak Point and at Bloodworth Island between Dunham Bay and Cape Carlos. Although the Waterway constitutes navigable water, it is, at this point, within the limits of the area closed to the hunting of migratory birds by Presidential Proclamation No. 2478 (April 17, 1941). The signs warn that all guns must be cased while passing through the ten-mile sector. There have been violations in the past but not as many since the signs were put in place.

In addition, the names of tugboat and barge companies using the Intracoastal Waterway were

obtained from the office of the U. S. Engineers in Port Lavaca and forwarded to the Washington office of the U. S. Fish and Wildlife Service with the suggestion that letters be sent to each of them explaining the special importance of seeing to it that there be no shooting within that particular closed area. The crews of shrimpers and other fishing boats, and of pleasure craft, are most difficult to reach and influence (some come into these waters from other states).

(d) Oil Drilling

In 1941 a wildcat well was drilled at Panther Reef, which lies in San Antonio Bay off False Liveoak Point. In June of that year, when Whooping Cranes were absent from the area (with the exception of a family group that unaccountably remained for the summer), but Roseate Spoonbills were just learning to fly, scattered out along the rim of Carroll Island and other islands in the Second-Chain group, leaky barges and other equipment sent a long and a fairly wide oil slick out across the bay. The slick traveled towards False Liveoak and the Second-Chain. It moved close to Mustang Lake and the open Waterway below Redfish Slough, where Whooping Cranes live through the winter. Then it veered off towards the north and headed in the direction of Hynes' Bay. It was a close call.

With James O. Stevenson, then refuge manager, the writer drove to Houston and discussed the matter with the president of the company responsible for the wildcatting. He turned up the palms of his hands. All sorts of precautions were taken to avoid such unfortunate occurrences but there was always the weakness of the human equation. These things happened, in spite of precautions. He was sorry. "Let us trust, gentlemen, that this does not happen again." He was very sympathetic.

If that oil slick had landed on the shore of the Second-Chain and had reached the Waterway and traveled into ponds and sloughs where the Whooper feeds in winter there is no telling how disastrous the results might have been. It

would have done little good to be sorry about it, after the event.

When the Aransas National Wildlife Refuge was set up, it was burdened with a mineral lease to the Continental Oil Company, which provided that the lease would not terminate on the entire refuge acreage as long as any activities or operations were being carried out on any part of the acreage. Early in 1948 it was learned that the company had sub-leased its mineral rights to the Western Natural Gas Company of Houston, which planned to drill in the very heart of the Whoopers' winter range, between Mullet Bay and Camp Pond. Immediately, John H. Baker, President of the National Audubon Society, sought and obtained conference with L. F. McCollum of the Continental Oil Company of New York. In Houston, as a consequence, the writer met with Charles A. Perlitz, Vice-President and Regional General Manager of Continental; Dr. J. A. Culbertson of its Geological Department, and H. O. Weaver, Secretary-Treasurer of the Western Natural Gas Company. Soon thereafter, Mr. Baker met with the Secretary of Continental and the heads of its Sales and Advertising Departments from Ponca City, Oklahoma.

These meetings were very friendly and the officials of the oil and gas companies expressed every desire to cooperate to the fullest feasible degree, and exhibited great personal interest in the protection and survival of the Whoopers. It was agreed that activities of the Western Natural Gas Company in the area would be limited to the months between May 1st and September 30th, when the Whoopers would not be there; this whether these activities involved road-building, pipeline-laying or drilling operations. It was agreed that conduits would be placed under roads or pipelines to permit continuance of natural flow of water between the ponds on the marsh. It was agreed that gas flares would not be permitted. It was, furthermore, agreed that representatives of the U. S. Fish and Wildlife Service and the Society would be consulted before final

decision as to the exact location of drilling operations and the possibility was granted that the location might be somewhat shifted, if need be, for the better protection of the cranes.

As a matter of fact, no operations were attempted until June of 1949, at which time the writer met on the spot with W. K. Davis, Vice-President, Paul Wright, Geologist, and Harry E. Russell, Field Superintendent of the Natural Gas Company. Agreements were reached by the Refuge Manager, myself and these men as to the route and character of access roads to prospective drilling sites. Later we were in direct contact with the tool-pusher on the rig who, as oil men know, is the boss on the job. Still later Mr. Baker met with these same men on location, after the road was nearly completed.

Meanwhile, in a fine demonstration of cooperation and recognition of responsibility, the Continental Oil Company published an article, in the March-April (1949) issue of their trade paper *The Red Triangle* entitled, "Conoco Turns an Ear to the Plight of the Rare Whooping Crane." The following excerpts demonstrate the level of understanding and cooperation that is possible in such situations, at the present time:

"The endless quest for oil has crossed paths with a fascinating saga in the modern realm of wildlife. The two forces—the probing search for petroleum and a struggle for survival in the world of super birds—transect in a lonely stretch of marshland along the coast of Texas Continental Oil Company..... will do its best to see that (the Texas habitation) remains safe for the vanishing super bird, which unjustly appears to have been doomed to extinction. Continental, through its cooperation in keeping the southern habitat unmolested, hopes this will mean a permanent reprieve for the great Whooper and that once again his legions may fill the sky."

This well went 8,512 feet without finding production and, in August 1949, was plugged and abandoned as a dry hole. As of the present, no further drilling has been undertaken on the Whooping Crane range. However, in the waters surrounding the Aransas Refuge, in San An-

tonio Bay on the one hand and St. Charles Bay on the other, seismograph tests were run during the summer of 1950 by at least two of the larger oil companies.

(e) *The Role of Cattle*

During the course of field investigations of available food resources the question of the relationship of cattle to the Whooping Crane environment was raised. As has been described in the chapter on Winter Life, an average of 3,000 head of adult cattle graze on the Aransas Refuge under the terms of a Special Use Permit. An area of approximately one square mile, embracing typical Whooping Crane range, was fenced early in 1947 so as to exclude cattle. Study plots were set up within this fenced area and similar plots on more or less identical range outside the enclosure, where cattle were present. Observations were extended over more than a year and the results, already summarized in the body of this report, indicate that cattle are not responsible for direct damage to Whooping Crane food items, including plant life, which forms a very minor part. It was demonstrated that the vegetation of the salt flats, where the Cranes spend at least 95% of their time, responds to the direct or indirect influence of the elements—wind, tide and rainfall playing the most significant roles—regardless of the presence or absence of cattle. There were examples of the vegetation improving in size and condition where cattle were present and dying out in the closed area where cattle were absent. In this instance, the influencing factor was salt water, which did not reach the area in which cattle were present, but flooded the other.

On the other hand, there appeared to be little realistic evidence that the presence of cattle is beneficial to Whooping Cranes. There seems to be no question but that cattle can be demonstrated as beneficial to certain wildlife in certain environments, but not necessarily in all environments. Extensive observations suggest that *Ruppia maritima*, or widgeongrass, grow-

ing in the bottom muck of such water areas as Long Pond, is the most attractive duck food of the Aransas salt flat habitat. It is difficult to see how the presence of cattle would improve the widgeongrass crop.

One cannot fail to note, however, that regardless of their possible value in the upland portions of the refuge, cattle do not improve the appearance of the salt flats and, in certain respects, constitute a foreign element that might, in time, be demonstrated as detrimental to the normal flow of interrelated life cycles in that habitat. One has only to look at a dry, open stretch of salt flat, where autumn tides will bring a succession of brackish water animals—marine worms, pistol shrimps and, at times, two or three varieties of fiddler crabs—and see it covered with several tons of cow dung, to appreciate the possibilities. While there has been, as stated, no evidence of direct damage to Whooping Cranes, there may well be a long range effect that is *not* beneficial to this particular environment. Although considerable attention has already been given to this relationship, more study is needed.

(f) *Low-flying Airplanes*

Low-flying planes are sometimes a hazard. The danger is that they will drive the Whoopers away from the refuge so that, in temporary confusion, they settle down in outside areas where they may be molested or even shot. During World War II, and recently, both Army and Navy planes on training missions used their machine guns and dropped small practice bombs, each equipped with a 10-gauge shotgun shell, on target ranges on nearby Matagorda Island and frequently flew at low altitudes over the refuge. Previously, refuge personnel has found it effective to call in person on the commanding officer at the various airfields concerned and secure his cooperation. There seems to be no trouble about obtaining an order declaring the refuge area restricted to Service planes and/or establishing a ceiling. However, these calls must be repeated from time to time.

Messrs. Howard, Beaty and others at the refuge have given this problem much thought, based on experience, and it is their feeling that, in addition to the necessity for personal calls on airfield commanders with regard to Service planes, it may be desirable to request the Civil Aeronautics Administration to officially establish a ceiling over the Aransas Refuge. This altitude would have to be determined, but could coincide with that normally flown by commercial airlines passing over this sector on the flight from Corpus Christi to Houston and return. It is probably in the neighborhood of 3,000 feet.

(g) *Captive Cranes*

In the chapter on the Breeding Cycle we outlined our initial efforts to bring together the two captive Whooping Cranes then living in Gothenburg, Nebraska, and New Orleans. Both birds had been secured as a result of injuries received from being shot, but appeared to be in good condition. The larger of the two, kept in a fenced area near Gothenburg on the Platte River and cared for by members of the Gothenburg Gun Club, had been in captivity since May 1936. When it was finally placed in the same enclosure with the New Orleans bird, it was no less than 14 years old, and possibly somewhat older. The New Orleans bird, a smaller and younger-appearing individual, was evidently one of the former resident colony from near White Lake, Vermilion Parish, Louisiana. In August 1940 a cloudburst and flood had driven the remaining Cranes of this colony to higher ground from which some of them never returned. The New Orleans bird, which had been shot in 1940 and brought to the zoo in Audubon Park when it recovered, was apparently one of the "missing" members of that group. When placed with the other captive it was at least 10 or more years of age.

It was obvious that these two individuals could make no contribution to the future of their race if they remained in isolated enclosures. In the hope that they would turn out to

be male and female, and that they might prove compatible and eventually pair and produce offspring, they were brought together in the Audubon Park Zoo in New Orleans. This was accomplished through the unselfish cooperation of a number of persons, notably J. P. Kennedy of Gothenburg, who agreed to turn the Nebraska bird over to the National Audubon Society; George P. Vierheller of the St. Louis Zoo, who assisted in transporting the bird to New Orleans via St. Louis; George Douglass of the Audubon Park Commission in New Orleans, which generously contributed its captive Crane to the experiment on a loan basis and provided special quarters for the pair within the confines of its zoo. Later on the pair was transferred to a large natural enclosure on the Aransas National Wildlife Refuge in Texas, where they were released in October 1948. This transfer was arranged through the further cooperation of Mr. Douglass and was carried out by personnel of the U. S. Fish and Wildlife Service under the direction of Aransas Refuge Manager Charles A. Keefer. Before being released within the new enclosure, the birds were cared for temporarily by Fred Stark of the San Antonio Zoo, who has had great success in hatching and rearing various Cranes in captivity, and who rested and conditioned the two Whoopers until habitat conditions at Aransas were ideal for the support of the two captives.

As described in the chapter on the Breeding Cycle, this first pairing of the Nebraska bird, which proved to be a male, and the New Orleans bird, a female, resulted in the normal laying of two eggs. However, both eggs were infertile and, after 23 days of futile incubation, they were broken up by the birds themselves. Following this, in July 1949, the male bird (*Pete*) died, presumably of natural causes.

However, there was another injured Whooper in the refuge, an individual that appeared, from his great size and general demeanor, to be another male. At the end of the summer this bird (*Crip*), being unable to fly more than a few yards because of an injured wing, was captured

and placed in the enclosure with the female (*Jo*). This second pairing was more successful and on the night of May 24, 1950, the first Whooping Crane ever hatched in captivity made his way into the world.

At this time Julian A. Howard was refuge manager at Aransas and he and his staff set up a daylight-to-dark watch until the moment of hatching. The chick, which was quickly named *Rusty*, appeared lively and well. However, on its fourth day, when the parents had wandered as much as 200 yards from where the chick lay hidden, it suddenly disappeared. The tragic loss was first noted when the parent birds returned to the area where they had last brooded their youngster and seemed unable to find it. Watching from a 20-foot tower over 1,200 feet away, the observers could not determine exactly what had happened. The cover, chiefly *Borrchia frutescens* and *Distichlis spicata*, was some 12 to 18 inches in average height and the little chick, no more than six inches tall, was completely hidden from view most of the time. Whether it died of natural causes and was taken by a Turkey Vulture that settled on the ground near the last brooding site, or fell prey to a wandering raccoon, is not known. Because of the excellent possibility that *Crip* and *Jo* will produce more young in the future, every precaution against a similar loss will be fully considered and put into operation well ahead of nest-building time in late April. Specific recommendations in this regard are given at the end of this chapter.

(h) Reopening Mustang Slough

An ill-advised plan to throw up dikes around a portion of the Aransas salt flat and flood it with fresh water, in which it was hoped to start waterfowl food plants, resulted in the closing off of Mustang Slough, which originally had been connected with the open water of the bay. This closure prevented blue crabs, shrimp and other Whooping Crane food animals from getting into the slough from the bay and the value of the

area to the Cranes dropped perceptibly. A drag-line was moved to the dike late in the summer of 1949 and an opening dug between the slough and the bay. During the winter that followed a considerable number of Whoopers found the shores of Mustang Slough of interest to them and the improvement was an outstanding success, according to Julian A. Howard, the refuge manager. This would appear to be a good example of the possibility of taking steps that result in the partial restoration of "original" conditions.

(i) *Education of the Public*

In the paper by Stevenson and Griffith (1946) the need for a general educational campaign, particularly along the migration routes, was stressed. The same need applies to other portions of the species' range, and Texas is no exception. It has already been noted that this research project has caught the public fancy, with a remarkable demonstration of interest by the press. The laying of *Josephine's* 1950 egg and the hatching of *Rusty* were probably the high points of public interest. Several hundred persons had traveled to the fenced enclosure on Aransas Refuge the first season to see the original captive pair, and the following season, from January 1, 1950 until April 30, 1950, a total of 1,694 persons registered at refuge headquarters, most of them coming there (from many States and Canadian Provinces) to see the Whooping Cranes.

This show of interest is heartening and evidences the educational value of publicity.

SURVIVAL: (2) OTHER REGIONS
AND OTHER PROBLEMS

In addition to steps taken on the winter range on the Aransas Wildlife Refuge and nearby areas, our investigations and contacts extended into Oklahoma, Kansas, Nebraska, North Dakota, South Dakota, Saskatchewan, Alberta and the Northwest Territories. We gathered infor-

mation as to the migration routes of the remaining wild birds, the distribution and behavior of nonbreeding summering individuals, habitat characteristics, status of former breeding sites, need for education and conservation efforts at various points, need for refuges at such locations as the Big Bend of the Platte River in Nebraska and many other items. Most of this large store of information has been incorporated, in one way or another, in this report. Without this first-hand experience the records of the past could not have been analyzed with any degree of confidence as to conclusions. It was as essential to an understanding of the Whooping Crane's status as our intimate contact with the birds on their winter range.

A little more than a year ago a recommendation in detail was made as to the most beneficial site for a Nebraska refuge. The Platte River has long been a major stopping place for the Whooper migrants, yet no safe resting place has been provided for them. Since the river bottom would also provide a haven for waterfowl, a practical waterfowl refuge could be set up by including a considerable stretch of river most suitably located with regard to migrating Whoopers. No conclusive action has as yet been taken on this important matter.

It has been an efficient plan to combine the crane search with waterfowl counts. The former nesting sites of the Whooper were also favored breeding grounds for pond ducks. Some of them still are good waterfowl areas, although the depleted Whooper has long been absent. In every instance the dates of the search have been, of necessity, governed by the estimated dates on which it could be expected that ducks and geese would be established on their breeding locations, preferably with most nesting pairs still intact. North of the settled portions of the Canadian Provinces, beyond which careful investigation has indicated the Cranes are probably nesting, these dates are approximately the last week of May through June on the Mackenzie Delta and the Arctic Coast, somewhat earlier

farther south. Whooping Cranes deposit their eggs close to the end of April, as a rule, and hatch their chicks around the first of June. Most of our actual search for nesting Whoopers was made in early June, at which time Whoopers could be expected to be just hatching or tenderly brooding and caring for very small young. In the light of our experience, intensive coverage at a somewhat later date, possibly mid-July, might be more profitable since the young would be well-grown and active and the entire family group more conspicuous. On the other hand, based on records of captive birds, this would be apt to be the period of post-nuptial molt for the adults, when they drop all of their primaries and are flightless for two to three weeks. At this time they might be less active than when fully equipped for flight. Someday we may know the entire story.

It is still of considerable importance that we locate the unknown breeding grounds of the Whooping Crane. There is much of significance to be learned there, by cautious observation, as to the conditions under which the wild pairs are rearing their young and as to causes of any losses that might be preventable, if we knew the situation. Also, the continued isolation and security of the breeding area must be carefully guarded.

Aside from personal contacts and radio, newspaper and magazine coverage, there has been no formal and continuous educational campaign along the U. S. migration route of the Whooping Crane, or in Canada. A very good leaflet, showing the appearance of the Whooper compared with birds with which it might be confused, was distributed, chiefly in Canada. There were two other leaflets, one of them illustrated, giving information about the species. Photographs published in magazines, such as *Life*, have given the lay public a clear idea of the Whooping Crane's appearance. Information in the press, and in magazine articles, has been quite accurate, as a rule. So the public, in general, is fairly well informed.

Practical education, of course, is another

thing altogether. For example, we are more concerned as to the attitude of a farm boy living along the Platte River in Nebraska, let us say, than with the interest of a hundred people along the eastern seaboard, where Whooping Cranes have not been seen in almost a century. Besides, the farm boy has a gun, probably a 12-gauge loaded for geese. It is pleasing to know that thousands of people may have known the answer, in a recent Double-Crostic in the *Saturday Review*, to the question, "The name of the first bird, in Word K above, born in captivity recently in Texas." But none of these good people will ever shoot a Whooping Crane. The farm boy in Nebraska—or Oklahoma, or Kansas, or Saskatchewan—might.

In the long run there is no more powerful weapon in the hands of the wildlife conservationist than Education. The trouble is it takes time, and the Whooping Crane needs help now. To reach the men and boys on the farms along the migration route of the species, and within the region over which summer wanderers may occur, we must take immediate action. Articles, preferably with good clear, pictures of the Whooping Crane, should be prepared from time to time for publication in the numerous farm magazines. Within the critical areas, County Agents should be provided with similar material. Items in such mediums as the *County Farm Bureau News* would be of great help in reaching those most likely to come in contact with migrating or wandering Whoopers.

SURVIVAL: (3) FUTURE PLANS

In discussing activities in the recent past, or still underway, on behalf of the Whooping Crane, we have made some suggestions with regard to continued or future plans. We now come to specific recommendations touching on topics not yet brought forward. Many of these concern the management and protection of the species on the Aransas Refuge. It may be well to mention that regardless of the seeming merits

of a suggestion or recommendation, it must pass through many hands and meet many requirements as to established policy, practicality, cost, present need, and so on, before it is put into effect. The writer has worked with the cooperating agencies for a fairly long period now, and under many different and often difficult circumstances and conditions. It is apparent to him that what most persons impatiently consider "red tape" is very often a necessary and even essential delay occasioned by the need for study, critical analysis and various practical estimates.

A number of activities and plans are now in process. In spite of the urgency that we feel in this matter, we will be a long time saving the Whooper. In other words, it is not expected that all of these suggestions will be put into effect tomorrow. These are ideas to consider. Some of them may be employed as we go along and may benefit the Whooper. Others may be passed over in favor of new ideas. By all means let there be new ideas! This report is intended to be a record of what has happened up to this time, and as a starting point for future action.

(a) Status of Mustang Lake

Mustang Lake lies at the extreme eastern end of the salt flat-brackish water habitat of the Whooping Crane on Aransas Refuge. It is approximately $1\frac{1}{2}$ miles long and from a quarter to a half mile wide. Before the dredging of the Intracoastal Waterway through its lower end in the spring of 1940, it was open to San Antonio Bay only at the upper or north end. A narrow layou, choked with *Spartina alterniflora* meandered from the lower end into the bay. From its position, with the long axis facing the direction of prevailing or southeast winds, it is obvious that the lake, with both natural and aboriginal shell mounds and ridges along its western shores, is a product of wind action. When the writer first investigated this lake (in June, 1940) the bottom in most places was firm. There was

a considerable population of mud shrimps (*Calinassa*) and razor clams (*Tagellus* and *Solen*), in addition to other marine animals. The mud of the bottom was fairly firm and contained some sand, in which marine worms (*Polychaeta*) were abundant.

The Waterway cut through the lower end of Mustang Lake, leaving an opening into the 12 ft. depth of the canal itself. There is no record as to changes in currents and tidal flow, but since that event the bottom of the lake has been covered with soft mud or silt to a considerable depth. That the biotic structure of the lake has been altered is demonstrated by the fact that the communities of mud shrimps have virtually disappeared, while razor clams seems to have gone entirely. Of course marine worms cannot live beneath a couple of feet of soft mud, so they are gone too.

These changes have affected other species. When the refuge area was established there were two pairs of Whooping Cranes living on Mustang Lake. One pair claimed the north end as a winter territory, the other pair the south end. The birds would meet at the invisible boundary line, somewhere in the middle of the lake, and go through their feints and mock attacks. There have been no regular Whooping Crane territories established on those sites since the Waterway was constructed. We have outlined one possible cause—a drastic change in the biotic communities of the lake bottom, apparently brought about by the opening of the lower end of the lake—and there are other factors that may contribute to the situation.

One of these factors is that Mustang Lake was not included within the original boundaries of Aransas Refuge. It should be. Now it is State property and, by present State Law, remains open to netting by commercial fishermen.

We must look ahead to the problem of available space to take care of the desired increase in cranes. In view of the rigid territorial habits of the species in winter, this will not be easy to solve. Obviously we cannot afford to do

without potentially useful areas like Mustang Lake.

The next time that this sector of the Intra-coastal Waterway is cleaned by the U. S. Army Engineers it might be feasible for the dredge to close off the lower end of Mustang Lake, thus restoring it to its original condition with respect to outside openings. The bayou is still intact, I believe. It might take a long time for the lake bottom to change again, and the silt might be there to stay, but it seems worth the experiment.

Pending possible inclusion of Mustang Lake in the Aransas Refuge, the State Land Office and the Texas Game, Fish and Oyster Commission should be approached with regard to closing Mustang Lake to netting or other fishing. I believe it could be demonstrated that only two or three individual fishermen net this lake with any regularity and that there are plenty of other places to which they could go. Personal talks with these fishermen might have favorable results.

(b) Auxiliary and Emergency Feeding Ponds

Under certain adverse conditions, the normal feeding ponds and sloughs on Aransas Refuge may become seriously depleted of nearly all food animals. The factors and influences concerned may include the height and duration of fall tides, occurrence of hurricanes, amount of rainfall in the fall and winter months and degree of previous deficiency, degree and period length for "northers," degree of evaporation and transpiration through the winter and other similar factors. The relative success of new crops of blue crabs is probably important, and this success is related to many factors. Some of these relationships have already been discussed in this report.

Primarily, we are interested in understanding what causes the temporary failure of the food supply. We should experiment with auxiliary and emergency methods of preventing this failure, to some extent at least, and with other sources of food supply.

The basic situation is this: nearly all of the important food animals in the ponds must return to the open bays to spawn. The immature forms, struggling to survive, then make their way to estuaries and shallow coastal ponds and protected lagoons, where they grow to maturity. Meanwhile, there are apparently two major motivations for leaving the ponds: in March the females start moving out of the ponds on their way to spawning waters (there are definite limits of both salinity and temperature that govern successful hatching). The departure of mated females proceeds at an increasing rate through April, which is the month when Whooping Cranes leave Texas for the northern breeding grounds.

A second cause of dispersal may occur in January and February. Sudden "northers" bring a rapid drop in temperatures and low temperatures cause blue crabs, to continue with that convenient example, to seek deeper water. The level of ponds drops also. If they can find their way out of shallow ponds and sloughs to the deeper bay waters they may do so. Otherwise, normal activity is more or less restricted, growth rate slows down and crabs burrow into the bottom mud of the deepest holes they can find. If the "norther" is short-lived, the temperature may rise before the day is out; but prolonged and repeated "northers" are another matter. When these occur, beginning in January and continuing into March, you can be sure that many crabs have escaped from the ponds or become inactive, and the usual results, so far as Whooping Cranes are concerned, is a temporary but often critical shortage of normal food items.

What do the cranes do about it? They may find the acorn crop a good one (it isn't always) and a recent "burn" may have made this food more available than ordinarily, by removing the heavy growth of dead grasses that often surround liveoak brush. Or, in February, the crayfish along the borrow ditches that line East Shore Road, may have burgeoned, thus providing a welcome new food item. But the crayfish

may be delayed by a low water level, or some other factor.

Generally, however, the Whoopers move to the beaches, the shores of the bays, where they fish for mullet and other marine forms. At such time many of them may move across the bays to the barrier islands, or to the shores of such islands as Roddy or isolated beaches like that near Cedar Point. In any event, it is obvious that the birds become more vulnerable due to these moves and the refuge area, temporarily without food resources, is of little protection to them.

What can be done? It may be possible to develop methods of controlling the inlets and outlets to the ponds by means of one-way tide gates in the bayous that reach the bay. Such structures could be so built as to permit control, within reason, of the movement of marine animals into and out of the feeding ponds. These gates could be in operation until the last migrant Whoopers had departed in April and then opened to allow mated female blue crabs to find their way out to the spawning grounds.

An experimental structure might be installed in the ditch cut into Mustang Slough, and the ditch, at the same time, lengthened and deepened at its inside end, where it joins the natural course of the old bayou. Other points at which gates would be helpful are the deep bayou running into the interior pond system at the western end of Mullet Bay (1080 Bayou) and the narrow, twisting bayou that extends from the pond system into Dunham Bay (Dunham Bayou).

Redfish Slough is another problem. The dike and spillway have cut off contact with the bay except on very high tides. A ditch through the dike at the location of the original connecting bayou (which shows up on old aerial maps or black and white compilations of aerial photographs) could be equipped with both a culvert under the patrol road on the dike, and with a one-way tide gate.

This discussion assumes that the fundamental

biology of these pond systems and sloughs is based on contact with the open waters of the bays. There is sound reason for believing that this conception is the correct one.

Although the Whooping Cranes that winter on Aransas Refuge spend most of their time in brackish and salt water areas, they will feed in fresh water as well. Another possibility for providing a food supply in late winter is the artificial fresh-water pond, dug by dragline and filled by runoff and underground water pumped by windmill, as is done at the cattle wells. It has been noted that some cattle wells have a sufficient supply of water so that the tanks, from which cattle drink, have enough over-flow to create a small pond. Examples are Salada, Carlos and Sierritos. In these ponds there is a lively community of killifishes and aquatic insects. At times, frogs and crayfish show up, often in abundance.

The natural drainage could be studied and fairly large ponds constructed, with a few deep holes to provide winter shelter for the animal inhabitants, shallow stretches for waterfowl plants and shelving beaches for crayfish communities. Except in dry periods it might not be necessary to use a windmill, in every case. Killifishes, frogs and even crayfish could be stocked. We feed game birds in winter, why not Whooping Cranes? It might be a good plan to try fencing cattle out of some of these ponds, and, perhaps, eventually, out of all of them. The best location, for the benefit of Whooping Cranes, would be the gently sloping ground lying between the East Shore Road and the first large mottes, or north beyond the road to about the distance of Carlos Well on the far side of Carlos Field.

Another possibility for winter feeding, when necessary, is the blue crab. These important food animals might be secured by the barrel, alive, by arrangement with local shrimpers and released in ponds where they are unable to escape to the bay (see earlier discussion of this

possibility under *The Blue Crab as a Basis for Management*).

In road-building work, as along the route of the East Shore Road, it would be helpful to give some attention to the form of borrow ditches. The side next to the road could be as steep as necessary, but the outer side, away from the road, ought to slope rather flat, so as to provide suitable environment for crayfish communities. If a deep hole is included here and there in the course of a borrow ditch, these water areas, in certain seasons, could also be stocked with crabs and killifishes. The hole would help them to survive cold snaps and a lowering water table.

There are fairly well defined indicators that may foretell a winter food scarcity. The refuge staff could be alert to these signs—especially to such outstanding indicators as a lack of high autumn tides, or prolonged periods of “northers”—and plan to take steps accordingly. It will require an alert staff and a good deal of experiment and planning and hard work to improve conditions as suggested. But it can probably be done, and if there is any chance that such efforts as these will be of real benefit to the Whooping Crane, and to other wildlife species at the same time, they ought to be given consideration.

(c) Enlargement of Closed Area Boundaries

When the boundaries of the area closed to the hunting of migratory birds by proclamation were set up in 1941, certain locations, that have since become of importance in the job of protecting the Whooping Crane, were shaved off too closely. One of these is the vicinity of the East Pocket, from Blackjack Point to Bird Point, on the St. Charles Bay side. Under the present limits it is perfectly legal to build a duck blind on the shore of these points and shoot there during the legal hours on open season days. Whooping Cranes have been seen feeding along the shore or flying by within 200 yards of such blinds. This seems like a needless risk and it would remove the danger if the closed boundary

at this point were moved out into St. Charles Bay, possibly as far as the eastern tip of Bartell Island.

The other location is the San Antonio Bay shore of the refuge, from the northeast corner to False Liveoak Point. As it now stands, it is legal to shoot right up to the low water mark. The limits should be extended, possibly one mile offshore.

If these extensions were included in the officially closed area before efficient patrol were established by the government, enforcement would be ineffective. Moreover, it is important to the survival of the Cranes that the sincere interest and good-will of the people in the local communities be enjoyed. If, in advance of closing of hunting grounds favored by many of them, there not be clear and adequate explanation of the need, there might be considerable opposition and antagonism. The situation calls for friendly handling. A happy solution will surely be found.

(d) Patrol

Our partner, the U. S. Fish and Wildlife Service, would be the first to admit that patrol of the refuge for efficient protection of the Cranes has been inadequate in both quality and quantity. The ten miles, more or less, of the Intracoastal Waterway passing through the major portion of the Whooping Crane range within the refuge is the chief danger point. The vicinity of East Pocket on the St. Charles Bay side and Mustang Lake on the San Antonio Bay side need more or less constant patrol. The Cranes also resort at times to locations such as Roddy Island, a spot difficult to reach quickly by boat. Bloodworth Island also presents a patrol problem, especially when the Cranes use the beach near Cedar Point or Cape Carlos, or the spoil areas near Dunham Island. Constant patrol by a deeply interested and able warden would do immeasurable good.

Patrol of the marsh areas used by the Whoopers on portions of Matagorda and St. Joseph Islands, outside the limits of the refuge, presents a different problem. Although the State of

Texas claims to own a portion of the former, the great bulk of these areas is privately owned—largely by two individuals. Each of these men employs his own patrolmen, equipped with jeeps and boats; this primarily, perhaps, for the purpose of keeping an eye on the cattle that graze on both islands; secondarily, for the protection of deer and quail. Hunting by others than the owners and their guests is firmly discouraged, with some resulting ill-will on the part of people living in the mainland towns just across the water. Mr. Toddie L. Wynne, the owner of the bulk of the private lands used by the Cranes on Matagorda Island, has cooperated with the Society by authorizing it to patrol and place no-hunting signs thereon.

The closure to hunting of the state-owned land on Matagorda Island would require official action by the State Game, Fish and Oyster Commission, establishing the area as a state refuge. Up to this writing, the Commission has not taken such official action.

Mr. Sid Richardson, owner of St. Joseph Island, has expressed sympathy and a desire to cooperate, but up to the time of this writing no lease or authorization has been forthcoming. It is hoped and believed that when all parties involved in this complicated situation are fully conversant with the facts and the needs, a happy outcome will result.

(e) "Burns" for Whooping Cranes

Under current policy, "burns" on Aransas Refuge are limited to brush control projects. Previously, various pastures, including brush pastures, were given light burns to bring out fresh grass for cattle grazing. It was noted that some of these, on brush pastures adjacent to the Whooping Crane territories, were very attractive to the Cranes, as they spent a considerable total of hours there, feeding. It was established, by droppings examinations, that the chief food item under these circumstances was acorns (*Quercus virginiana*). Some insects and insect egg masses, a few frogs and crayfish were

also taken. It was demonstrated that a light, quick fire burned off the dead grasses that cluster in a thick, dry mass around stands of oak brush. With the screening of grass removed, the acorns are exceedingly easy to obtain.

This environment cannot be burned year after year and if any deliberate use were to be made of burns for the benefit of Whooping Cranes, plots would have to be designated and rotated. The major use of such plots would be late winter emergencies when the normal food supply is low.

(f) On the Migration Route

We have already suggested the need for further educational efforts along the migration route, concentrating realistically on a program in the communities near the route rather than in less fruitful activity elsewhere. There are many ways in which such a campaign can be carried out. While personal contacts are the most effective it is impossible to be everywhere and interview everyone. It might be very helpful if photo mats and copy were prepared each year and sent to newspapers, State Conservation Department publications and sporting magazines, including selected lists of individuals from Texas north through Saskatchewan and Alberta.

A Federal refuge on the Platte River, and possibly others at points north or south of the Platte, is still a necessity. Progress on this part of the program ought to be made soon.

SURVIVAL: (4) SUMMARY OF RECOMMENDATIONS

Here, then, are the suggestions that we believe, at this time, will help to improve the status of the Whooping Crane and assist in securing the gradual recovery and ultimate increase of this species.

1. Refuge status for all areas outside present refuge boundaries on which Whooping Cranes winter. Meanwhile it is important to have a cooperative and friendly understanding and contact with owners, foremen and patrolmen of all

private and state lands where Whooping Cranes may occur in winter.

2. Improved patrol of the winter range, including regular assignment of patrol personnel, workable arrangements for Saturday and Sunday patrols and upkeep of jeep and boat equipment.

3. A Federal refuge for waterfowl and Whooping Cranes should be established along no less than 50 miles of the Platte River in Nebraska, as already recommended.

4. An educational plan should be drawn up for the sole purpose of reaching hunters, farm boys and others in strategic locations along the migration route of the Whooping Crane, from Texas to Canada. Mediums for the application of this plan might include radio, newspapers, sporting, hunting and farm magazines, 4-H clubs and other similar organizations, public schools and County Farm Bureaus.

5. Mustang Lake should be closed at its lower end, possibly by the U. S. Engineers' dredge when next engaged in "cleaning" that section of the Intracoastal Waterway. This same lake should be given "closed" status, as regards trespass, including hunting and fishing, both sport and commercial. It should be added to the Aransas Refuge.

6. The closed area boundaries bordering Aransas Refuge should be enlarged on at least two points—off East Pocket on the St. Charles Bay side and along the east shore from the northeast boundary corner to a location off False Liveoak Point.

7. Continuance of the experiment with captive Whoopers in the Aransas enclosure until it can be demonstrated that these birds will successfully hatch and rear young. As a result of recent experience it is recommended that the size of the area in which the cranes nest be reduced by additional fencing as a means of assuring that the parents attend the young more closely and as an aid to more adequate supervision and control of conditions. Plans with regard to release of young or their retention as

future captive breeding stock can be made when and if the present pair is successful.

8. The new ditch from Mustang Slough to the bay should be lengthened and, experimentally, a one-way tide gate installed, as described.

9. Definite arrangements with Armed Service's airbases as to boundaries of target ranges in relation to Whooping Crane territories on Matagorda and St. Joseph Islands and in the Mesquite Bay region. Definite understanding with Armed Service's airbases as to low-flying planes over Aransas Refuge and establishment of a practical ceiling for Armed Service's planes. Similar arrangements through the C.A.A. as to a ceiling for private airplanes when flying over the area.

10. Continued contacts with oil companies holding subleases or leases on land or water areas within and adjacent to the winter range of the Whooping Crane.

11. Careful consideration, over a period of time, of the long term relationship of cattle to the salt flat environment as a biotic complex.

12. Upkeep of large warning signs at the two entrances to the Intracoastal Waterway where it passes through Aransas Refuge.

13. Continued employment of a careful and standardized technique for obtaining accurate counts and observations of the Cranes on winter quarters and alertness to population trends and shifts, as a means of keeping up-to-date on winter distribution at all times.

14. A leaflet containing information about the Whooping Crane, and the purposes of the cooperative project, should be made available for distribution to visitors at Aransas Refuge.

15. Renewed attention, by U. S. and Canadian authorities, to the job of locating the northern breeding grounds.

Additional problems will arise, no doubt, even before this report is in print. Situations change from day to day. As a final suggestion it is the hope of the writer that the partners in this

project will continue their efforts until the Whooping Crane is not only released from the threat of early extinction but reasonably restored in numbers. This will not be for some years.

During this anxious period it should be possible to enlist the active interest and participation of many other groups and organizations.

Sympathy for the species is widespread and there seems no reason to doubt that many others would be glad to assist in the efforts towards its survival. The Whooping Crane, in its fight for existence, has an appeal for all of us. What could be more fitting than that many hands be raised to save it?

Appendix

A. LOCAL AND FOREIGN COMMON NAMES FOR THE WHOOPING CRANE

According to McAtee (1923) the following names for the Whooping Crane (*Grus americana*) have been in local use:

- Big White Crane (Fla.).
- Flying Sheep (Manitoba).
- Grue Blanche (La.).
- Stork (Fla., La., N. J.).
- White Crane (Alberta, Fla., Iowa, Ky., Manitoba, Nebr., So. Dak.).
- Whooper (Fla.).
- Whooping Crane (Alberta, Ariz., Fla., Miss., So. Car., Texas).

Stevenson and Griffith (1946) add these local names, chiefly from Refugio, Aransas and Calhoun Counties, Texas:

- Bugle Crane
- Trumpet Crane
- White Stork

In the same section of Texas these local names are applied to the young-of-the-year:

- Pink Crane
- Red Crane

Stevenson and Griffith (1946) also report the following common names in use in parts of Mexico:

- Grulla Blanca (coastal Tamaulipas and south Texas).
- Viejo del Agua (coastal Tamaulipas).

Other local and foreign common names for the Whooping Crane include the following:

- Great White Crane (Edwards, 1750; Ridgway, 1895).
- Hooping Crane (various early authors).
- White Sandhill Crane (Woodruff, 1907).
- Garoo (*Birds of America*, all editions).
- Turkey, Wild Turkey (Saskatchewan).
- Mal Ojo (Mexico).
- Wapow Oocheehawk (Cree; Richardson and Swainson, 1831).
- Wapaw-uchehawk (Cree; Latham, 1824).
- Tutteeghuk or Teteeghuk (Eskimo, west coast of Hudson's Bay; Sutton, 1931).
- Amerikaansche Kraanvogel (Dutch).
- Weisse Amerikanische Kranich (German).
- Grue d'Amérique (French).

B. LIST OF SCIENTIFIC NAMES OF PLANTS AND ANIMALS MENTIONED IN THE TEXT.

1. PLANTS

- Algae *Algae*
- Arrowhead *Sagittaria* sp.
- Ash, prickly *Fraxinus caroliniana* Mill.
- Aspen *Populus* sp.
- Barley *Hordeum* sp.
- Bay, sweet *Tamala Borbonia* (L.) Raf.
- Beakrush *Rynchospora* sp.
- Beech *Fagus* sp.
- Bluestem, little *Andropogon scoparius* Michx.
- Broom-grass, broomsedge *Andropogon* sp.

- Broomsedge *Andropogon scoparius* Michx.
- Bulrush *Scirpus* sp.
- Bulrush (coco) *Scirpus robustus* Pursh.
- Bulrush, soft-stem *Scirpus validus* Vahl.
- Bulrush, southern *Scirpus californicus* (Meyer) Britt.
- Bulrush (Three-corner) *Scirpus olneyi* Gray.
- Bulrush, (Three-square) *Scirpus americanus* Pers.
- Cane *Phragmites communis* Trin.
- Cane, popping *Spartina alterniflora* Loisel.
- Cattail *Typha* sp.
- Cattail, narrow-leaved *Typha angustifolia* L.
- Coco *Scirpus robustus* Pursh.
- Cordgrass, needle *Spartina spartinae* (Trin.) Merr.
- Cordgrass, smooth *Spartina alterniflora* Loisel.
- Corn *Zea Mays* L.
- Cranberry, salt flat *Lycium carolinianum* Walt.
- Croton *Croton* sp.
- Cutgrass, giant *Zizaniopsis miliacea* (Michx.) Doell. & Aschers.
- Duck potato *Sagittaria platyphylla* (Engelm.) J. G. Smith.
- Fir *Abies balsamea*.
- Glasswort *Salicornia* sp.
- Glasswort *Salicornia bigelovii* Torr.
- Glasswort *Salicornia europaea* L.
- Glasswort *Salicornia perennis* Mill.
- Grass, Bermuda *Capriola Dactylon* (L.) Kuntze.
- Grass, goose *Monanthochloe littoralis* Engelm.
- Grass, gramma *Bouteloua* sp.
- Grass, salt flat *Distichlis spicata* (L.) Greene.
- Grass, three-awn *Aristida purpurascens* Poir.
- Jointgrass *Paspalum distichum* L.
- Lily, prairie *Nothoscordum bivalve* (L.) Britton.
- Lily, water *Castalia* sp.
- Maiden-cane *Panicum hemitomom* Schult.
- Manna-grass *Panicularia* sp.
- Marsh-onion *Crinum americanum* L.
- Mulberry *Morus* sp.
- Muskgrass *Chara* sp.
- Oak, blackjack *Quercus marilandica* Muench.
- Oak, live *Quercus virginiana* Mill.
- Oak, pin *Quercus myrtifolia* Willd.
- Oats *Avena* sp.
- Palmetto *Sabal* sp.
- Peanut *Arachis* sp.
- Pickelweed *Pontederia* sp.
- Plantain, water *Alisma* sp.
- Pondweed *Potamogeton* sp.
- Potato, sweet *Ipomoea Batatas* Poir.
- Reed *Phragmites communis* Trin.
- Rice *Oryza* sp.
- Rice, wild *Zizania* sp.
- Rush *Juncus* sp.
- Saltwort *Batis maritima* L.
- Sawgrass *Mariscus jamaicensis* (Crantz) Britt.
- Sea oxeye *Borrchia frutescens* (L.) DC.
- Sedge *Carex* sp.
- Sedge, three-sided *Cyperus* sp.
- Shoalgrass *Halodule wrightii* Aschers.
- Smartweed *Polygonum* sp.
- Sorghum *Holcus Sorghum* L.
- Spikerush *Eleocharis palustris* (L.)
- Spruce *Picea* sp.
- Widgeongrass *Ruppia maritima* L.

- Trout, speckled *Cynoscion nebulosus* Cuvier & Valenciennes.
 Yellowtail *Bairdiella chysura* (Lacépède).
 (Amphibia)
 Frog *Rana catesbiana* Shaw.
 Frog *Pseudacris triseriata* Wied.
 Frog, cricket *Acris crepitans* Baird.
 Frog, green tree *Hyla cinerea cinerea*.
 Frog, tree *Hyla squirella*.
 Toad *Bufo* sp.
 Toad *Bufo woodhousii woodhousii* Girard.
 (Reptilia)
 Alligator *Alligator mississippiensis* (Daudin).
 Chameleon, American *Anolis carolinensis* Voigt.
 Lizards Sauria.
 Lizard, striped *Cnemidophorus* sp.
 Lizard, Texas horned *Phrynosoma cornutum* (Harlan).
 Moccasin,
 cotton-mouth *Aghistrodon piscivorus* (Lacépède).
 Racer, prairie *Coluber constrictor flaviventris* (Say).
 Rattlesnake, pigmy *Sistrurus miliarius streckeri* Gloyd.
 Rattlesnake,
 western diamond *Crotalus atrox atrox* (Baird & Girard).
 Skink, brown-backed *Leiopisma laterale* (Say).
 Skinks Eumeces sp.
 Snake, black hog-nosed *Heterodon contortrix* (Linnaeus).
 Snake, Clark's water *Natrix clarkii* (Baird & Girard).
 Snake, coachwhip *Coluber flagellum flagellum* (Shaw).
 Snake, common water *Natrix sipedon sipedon* (Linnaeus).
 Snake, diamond-back
 water *Natrix rhombifera* (Hallowell).
 Snake, Emory's rat *Elaphe laeta* (Baird and Girard).
 "Snake," glass *Ophisaurus ventralis* (Linnaeus).
 Snake, gray rat *Elaphe obsoleta confinis* (Baird and Girard).
 Snake, keeled green *Ophiodryx aestivus* (Linnaeus).
 Snake, Marcy's garter *Thamnophis marcianus* (Baird & Girard).
 Snake, plains garter *Thamnophis radix* (Baird and Girard).
 Snake, red-barred garter *Thamnophis sirtalis parietalis* (Say).
 Snake, spotted king *Lampropeltis getulus holbrooki* (Stejneger).
 Snake, Texas coral *Micrurus fulvius tenere*.
 Snake, western ribbon *Thamnophis sauritus proximus* (Say).
 Swift, spiny *Sceloporus* sp.
 Turtle *Chrysemys bellii bellii*.
 Turtle, common
 snapping *Chelydra serpentina* (Linnaeus).
 Turtle, elegant *Pseudemys scripta troostii* (Holbrook).
 Turtle, Kemp's
 loggerhead *Lepidochelys kempii*.
 Turtle, ornate box *Terrapene ornata* (Agassiz).
 Turtle, yellow-necked
 mud *Kinosternon flavescens* (Agassiz).
 (Aves)
 Albatross, short-tailed *Diomedes albatrus* Pallas.
 Avocet, American *Recurvirostra americana* Gmelin.
 Bittern Botaurinae.
 Blackbird,
 yellow-headed *Xanthocephalus xanthocephalus* (Bonaparte).
 Brant *Branta* sp.
 Bunting, painted *Passerina ciris* (Linnaeus).
 Bustard Otidae.
 Caracara, Audubon's *Polyborus cheriway auduboni* Cassin.
 Condor, California *Gymnogyps californianus* (Shaw).
 Coot, American *Fulica americana americana* Gmelin.
 Cormorant *Phalacrocorax* sp.
 Cormorant,
 double-crested (Lesson).
 Cormorant, Mexican *Phalacrocorax olivaceus mexicanus* (Brandt).
 Cowbird *Molothrus ater* subsp.
 *Crane *Grus conferta* Miller and Sibley.
 *Crane *Grus nandeos* Wetmore and Martin.
 *Crane *Grus nobilis* Marsh.
 *Crane *Grus primigenia*.
 *Crane *Grus proavus* Marsh.
 Crane, Asiatic white *Grus leucogeranus* Pallas.
 Crane, Australian *Grus rubicunda rubicunda* (Perry).
 Crane, common *Grus grus grus* (Linnaeus).
 Crane, Cuban sandhill *Grus canadensis nesiotis* Bangs and Zappy.
 Crane, demoiselle *Anthropoides virgo* (Linnaeus).
 Crane, Florida *Grus canadensis pratensis* F. A. A. Meyers.
 Crane, Greater Sandhill *Grus canadensis tabida* (Peters).
 Crane, "Hoy's" *Grus hoyianus* Dudley.
 Crane, lesser sandhill *Grus canadensis canadensis* (Linnaeus).
 Crane, Manchurian *Grus japonensis* (P. L. S. Muller).
 Crane, Saras *Grus antigone antigone* (Linnaeus).
 Crane, Stanley *Anthropoides paradisea* (Lichtenstein).
 Crane, wattled *Bugeranus carunculatus* (Gmelin).
 Crane, white-naped *Grus vipio* Pallas.
 Crane, whooping *Grus americana* (Linnaeus).
 Crow *Corvus* subsp.
 Curlew, Eskimo *Phaeopus borealis* (Forster).
 Curlew, long-billed *Numenius americanus americanus* Beckstein.
 Dowitcher *Limnodromus griseus* subsp.
 Ducks Anatidae.
 Bufflehead *Glaucionetta albeola*
 Gadwall *Chaulelasmus streperus* (Linnaeus).
 *Labrador *Camptorhynchus labradorius* (Gmelin).
 Lesser scaup *Nyroca affinis* (Eyton).
 Mallard *Anas platyrhynchos platyrhynchos* Linnaeus.
 Mottled *Anas fulvigula maculosa* Sennett.
 Pintail *Anas acuta tritzihoa* Vieillot.
 Ruddy *Oxyura jamaicensis rubida* (Wilson).
 Shoveller *Spatula clypeata* (Linnaeus).
 Teal, blue-winged *Anas discors* Linnaeus.
 * Extinct.

- Teal, cinnamon *Anas cyanoptera cyanoptera* Vieillot.
 Teal, green-winged .. *Anas carolinensis*.
 Widgeon *Mareca americana* (Gmelin).
 Eagle Buteoninae.
 Eagle, bald *Haliaeetus leucocephalus leucocephalus* (Linnaeus).
 Eagle, golden *Aquila chrysaetos canadensis* (Linnaeus).
 Egret, American *Casmerodius albus egretta* (Gmelin).
 Egret, reddish *Dichromanassa rufescens rufescens* (Gmelin).
 Egret, snowy *Egretta thula thula* (Molina).
 Geese Anserinae.
 Goose, common Canada. *Branta canadensis canadensis* (Linnaeus).
 Goose, Hutchin's *Branta canadensis hutchinsii* (Richardson).
 Goose, lesser Canada ... *Branta canadensis leucoparsia*.
 Goose, lesser snow *Chen hyperborea* (Pallas).
 Grackle, boat-tailed ... *Cassidix mexicanus major* (Vieillot).
 Grackle, bronzed *Quiscalus quisqualis aeneus* Ridgway.
 Grebe, eared *Colymbus nigricollis californicus* (Heermann).
 Grebe, Holboell's *Colymbus griseogen holboelli* (Reinhardt).
 Grebe, horned *Colymbus auritus* Linnaeus.
 Grebe, pied-billed *Podilymbus podiceps podiceps* (Linnaeus).
 Grebe, western *Aechmophorus occidentalis* (Lawrence).
 Gull, great black-backed *Larus marinus* Linnaeus.
 Gull, herring *Larus argentatus smithsonianus* Coues.
 Gull, laughing *Larus atricilla* Linnaeus.
 Gull, ring-billed *Larus delawarensis* Ord.
 Gulls Laridae.
 Hawk, American rough-legged *Buteo lagopus s. johannis* (Gmelin).
 Hawk, duck *Falco peregrinus anatum* Bonaparte.
 Hawk, marsh *Circus hudsonius* (Linnaeus).
 Hawk, pigeon *Falco columbarius columbarius* Linnaeus.
 Hawk, red-tailed *Buteo borealis* subsp.
 Hawk, Sennett's white-tailed *Buteo albicaudatus hypospodius* Gurney.
 Hawk, sparrow *Falco sparverius sparverius* Linnaeus.
 *Heath hen *Tympanucus cupido cupido* (Linnaeus).
 Heron, black-crowned night *Nycticorax nycticorax hoactli* (Gmelin).
 Heron, little blue *Florida caerulae caerulea* (Linnaeus).
 Heron, Louisiana *Hydranassa tricolor ruficollis* (Gosse).
 Heron, Ward's *Ardea herodias wardi* Ridgway.
 Herons Ardeidae.
 Ibis, white *Guara alba* (Linnaeus).
 Ibis, white-faced *Plegadis guarauna* (Linnaeus).
 Ibis, wood *Mycteria americana* Linnaeus.
 Jabiru *Jabiru mycteria* (Lichtenstein).
 Killdeer *Oxyechus vociferus vociferus* (Linnaeus).
 Limpkin *Aramus scolopaceus pictus* (F. A. A. Meyers).
 Man-o'-war-bird *Fregata magnificens* Mathews.
 Meadowlark *Sturnella magna* subsp.
 *Moas *Dinornis* sp.
 Owls Strigiformes.
 Pelican, brown *Pelecanus occidentalis occidentalis* Linnaeus.
 Pelican, white *Pelecanus erythrorhynchus* Gmelin.
 Phalarope, Wilson's ... *Steganopus tricolor* Vieillot.
 *Phororhacos *Phororhacos* sp.
 Pipit, American *Anthus spinoletta rubescens* (Tunstall).
 Pipit, Sprague's *Anthus spraguei* (Audubon).
 Plover, black-bellied ... *Squatarola squatarola* (Linnaeus).
 Puffin *Fratercula artica artica* (Linnaeus).
 Rail, clapper *Rallus longirostris* subsp.
 *Rail, wood *Aramides cajanea* (Muller).
 Rail, yellow *Coturnicops noveboracensis* (Gmelin).
 Rails Rallidae.
 Raven *Corvus corax* subsp.
 Red-wing *Agelaius phoeniceus* subsp.
 Roadrunner *Geococcyx californianus* (Lesson).
 Sandpiper, least *Pisobia minutilla* (Vieillot).
 Sandpiper, red-backed. *Pelidna alpina sakhalina* (Vieillot).
 Sandpiper, semipalmated *Ereunetes pusillus* (Linnaeus).
 Sandpiper, western ... *Ereunetes mauri* Cabanis.
 Shearwater, Manx *Puffinus puffinus puffinus* (Brünnich).
 Shorebirds Charadriidae; Scolopacidae.
 Skimmer, black *Rynchops nigra nigra* Linnaeus.
 Snipe Scolopacidae.
 Sora *Porzana carolina* (Linnaeus).
 Sparrow, Savannah ... *Passerculus sandwichensis* subsp.
 Sparrow, song *Melospiza melodia* subsp.
 Sparrow, vesper *Poecetes gramineus* subsp.
 Spoonbill, roseate *Ajaia ajaja* (Linnaeus).
 Stilt, black-necked *Himantopus mexicanus* (Muller).
 Sun-bitterns Eurypygidae.
 Swan, trumpeter *Cygnus buccinator* Richardson.
 Swan, whistling *Cygnus columbianus* (Ord).
 Swans Cygninae.
 Tern, black *Chlidonias nigra surinamensis* (Gmelin).
 Tern, Caspian *Hydroprogne caspia imperator* (Coues).
 Tern, Forster's *Sterna forsteri* Nuttall.
 Terns Sterninae.
 Trumpeters *Psophia* sp.
 Turkey, Rio Grande .. *Meleagris gallopavo intermedia* Sennett.
 Vulture *Cathartes aura aura* (Linnaeus).
 Vulture, black *Coragyps atratus atratus* (Meyer).
 Vulture, turkey *Cathartes aura septentrionalis* Wied.

* Extinct.

* Extinct.

Bibliography

(Many authorities have been given a complete reference in the body of the text or in the form of a footnote. Otherwise the author's last name and the publication date appear in the text in parentheses and refer to the following bibliography).

- A.A.M.
1886. Spirit and Okoboji Lakes. Attraction Offered to Sportsmen in the Lake Region of Iowa. *Western Sportsman*, 1:1:5.
- ABBOTT, WILLIAM L.
1880. List of Birds Taken at Pembina, Dakota, July, 1879. *Forest and Stream*, 13:24:984-985.
- ADDISON, RICHARD
1931. Curious Creatures. *Nature Magazine*, 17:4:217.
- AGERSBORG, G. S.
1885. The Birds of Southeastern Dakota. *Auk*, 2:3:287.
- AIKEN, C. E.
1873. Notes on the Birds of Wyoming and Colorado. *Proc. Boston Soc. Nat. Hist.*, 15:209.
- ALEXANDER, W. B., B. A. SOUTHGATE AND R. BASSINDALE
1932. The Salinity of the Water Retained in the Muddy Foreshore of an Estuary. *Jour. Marine Biol. Assoc.*, 18:1:297-298.
- ALLEN, ARTHUR A.
1937. The Shore Birds, Cranes and Rails; Willets, Plovers, Stilts, Phalaropes, Sandpipers and their Relatives Deserve Protection. *The Book of Birds*, vol. 1:261,294-295. National Geographic Society, Washington, D. C.
- ALLEN, FRANCIS H.
1941. Conservation Notes. *Auk*, 58:2:288.
- ALLEN, JOEL ASAPH
1871. On the Mammals and Winter Birds of East Florida, etc. *Bull. Mus. Comp. Zool.*, 3:3:357.
- ALLEN, JOEL ASAPH
1876. Decrease of Birds in Massachusetts. *Bull. of the Nuttall Ornith. Club*, 1:3:53-58.
- ALLEN, JOEL ASAPH
1886. A Revised List of the Birds of Massachusetts. *Bull. Am. Mus. Nat. Hist.*, 1:7:263.
- ALLEN, ROBERT P.
1942. The Roseate Spoonbill. *Research Report No. 1* New York, Nat. Audubon Soc.
- ALLEN, ROBERT P.
1947a. Status of the Whooping Crane. *Wilson Bull.*, 59:2:127-128.
- ALLEN, ROBERT P.
1947b. The Whooping Cranes Still Dance. *Audubon Magazine*, 49:3:136-139.
- ALLEN, ROBERT P.
1947c. Quotations from Bob Allen's Field Reports, Mailed from North Platte, Nebraska. *Audubon Magazine*, 49:3:174-175.
- ALLEN, ROBERT P.
1948a. Lost: Part of a Continent. *Audubon Magazine*, 50:1:28-35.
- ALLEN, ROBERT P.
1948b. An Editorial Comment. *Audubon Magazine*, 50:4:231.
- ALLEN, ROBERT P.
1948c. Field Notes. *Audubon Magazine*, 50:5:296-298.
- ALLEN, ROBERT P.
1950a. The Whooping Crane and its Environment. *Audubon Magazine*, 52:2:92-95.
- ALLEN, ROBERT P.
1950b. The Unique Drama of a Wild Whooper. *Audubon Magazine*, 52:3:194-195.
- AMERICAN GAME PROTECTIVE AND PROPAGATION ASSOC.
1916. Whooping Crane Might be Saved. *Bull.*, 5:2:2.
- AMERICAN GAME PROTECTIVE AND PROPAGATION ASSOC.
1918. Game in the Province of Saskatchewan. *Bull.* 7:1:22.
- AMERICAN ORNITHOLOGISTS' UNION
1886. The Code of Nomenclature and Check-list of North American Birds. N.Y., Am. Ornith. Union.
- AMERICAN ORNITHOLOGISTS' UNION
1895. Check-list of North American Birds. 2nd Rev. Ed. N. Y., Am. Ornith. Union.
- AMERICAN ORNITHOLOGISTS' UNION
1910. Check-list of North American Birds. 3rd Rev. Ed. N. Y., Am. Ornith. Union.
- AMERICAN ORNITHOLOGISTS' UNION
1931. Check-list of North American Birds. 4th Rev. Ed. Lancaster, Amer. Ornith. Union.
- AMERICAN ORNITHOLOGISTS' UNION. COMMITTEE ON BIRD PROTECTION
1940. Report for 1939. *Auk*, 57:2:280 and 289.
- AMERICAN ORNITHOLOGISTS' UNION. COMMITTEE ON BIRD PROTECTION
1941. Report for 1940. *Auk*, 58:2:294.
- AMERICAN ORNITHOLOGISTS' UNION. COMMITTEE ON BIRD PROTECTION
1942. Report for 1941. *Auk*, 59:2:295.
- AMERICAN ORNITHOLOGISTS' UNION. COMMITTEE ON BIRD PROTECTION
1943. Report for 1942. *Auk*, 60:1:159.
- AMERICAN ORNITHOLOGISTS' UNION. COMMITTEE ON BIRD PROTECTION
1944. Report for 1943. *Auk*, 61:4:622-635.
- AMERICAN ORNITHOLOGISTS' UNION. COMMITTEE ON BIRD PROTECTION
1950. Report for 1949. *Auk*, 67:3:321-322.
- AMERICAN SPORTSMAN
1873. Some Western Birds. 2:4:51.
- ANDERSON, R. M.
1894. Nesting of Whooping Cranes. *Oologist*, 11:8:263-264.
- ANDERSON, R. M.
1907. The Birds of Iowa. *Proc. Davenport Acad. Sci.*, 11:201-204.
- ANTHONY, A. W.
1886. Field Notes on the Birds of Washington County, Oregon. *Auk*, 3:2:162 and 164.
- ARMSTRONG, EDWARD A.
1942. Bird Display: an Introduction to the Study of Bird Psychology. London, Cambridge Univ. Press.
- ARTHUR, STANLEY C.
1918. Birds of Louisiana. *Bull. No. 5, Louisiana Dept. Conserv.*
- ARTHUR, STANLEY C.
1929. Winter Requirements of Migratory Waterfowl. *Trans. 16th Am. Game Conf.*, p. 101.

- ARTHUR, STANLEY C.
1931. The Birds of Louisiana. *Bull. No. 20, Louisiana Dept. of Conserv.*
- ASTLEY, HUBERT D.
1901. Cranes in Captivity. *Avicultural Magazine*, 7:4: 65-69.
- ASTLEY, HUBERT D.
1907. The Cranes. *Avicultural Magazine, New Series*, 5:12:347-353.
- AUDUBON, JOHN JAMES
1827-38. The Birds of America. 4 vols. (double elephant folio). Pl. CCXXVI, London, Author.
- AUDUBON, JOHN JAMES
1835. Ornithological Biography. III:202-213, 441. Edinburgh, Adam and Charles Black.
- AUDUBON, JOHN JAMES
1839. A synopsis of the Birds of North America. Edinburgh, Adams and Charles Black. London, Longman.
- AUDUBON, JOHN JAMES
1941. The Birds of America. Edited by William Vogt. New York, Macmillan.
- AUCHEY, SAMUEL
1878. Notes on the Nature of the Food of the Birds of Nebraska. *1st Report U. S. Entom. Comm. for 1877*, appendix 2, p. 13-62.
- AVERY, W. C.
1890. Birds Observed in Alabama. *American Field*, 34: 25:584.
- BAERG, W. J.
1931. Birds of Arkansas. *Bull. 258, Ark. Agr. Exp. Sta.*, p. 56.
- BAILEY, ALFRED M.
1928. Notes on the Winter Birds of Chenier au Tigre, Louisiana. *Auk*, 45:3:277.
- BAILEY, ALFRED M.
1934. Additional Notes on the Wintering Birds of Chenier au Tigre, Louisiana. *Auk*, 51:3:399.
- BAILEY, ALFREDO M. AND E. G. WRIGHT
1931. Birds of Southern Louisiana. *Wilson Bull.*, 43: 3:193.
- BAILEY, FLORENCE MERRIAM
1928. Birds of New Mexico. Santa Fe, N. M. Dept. of Game and Fish.
- BAILEY, HAROLD H.
1925. The Birds of Florida, p. 39, pl. 20. Baltimore, author.
- BAILEY, WILLIAM L.
1869. Our Own Birds. Phila., Lippincott.
- BAIRO, S. F., J. CASSIN AND G. N. LAWRENCE
1858. U. S. War Department Reports of Explorations and Surveys to Ascertain . . . the Route for a Railroad from the Mississippi River to the Pacific Ocean, Made . . . in 1853-6. Vol. 9, Part 2. General Report upon the Zoology of the Several Pacific Railroad Routes. *Birds*. pp. 653-655. Washington.
- BAIRD, S. F., T. M. BREWER AND R. RIDGWAY
1884. The Water Birds of North America. *Mem. Mus. Comp. Zool.*, Vol. 1, 404-407.
- BAKER, JOHN H.
1945a. Whooping Crane Project Gets Under Way. The President Reports to You. *Audubon Magazine*, 47:3:179-180.
- BAKER, JOHN H.
1945b. Search for Whooping Crane. The President Reports to You. *Audubon Magazine*, 47:4:245-246.
- BAKER, JOHN H.
1946a. Progress Report on Whooping Cranes. The President Reports to You. *Audubon Magazine*, 48:1:55.
- BAKER, JOHN H.
1946b. Progress Report on Whooping Cranes. The President Reports to You. *Audubon Magazine*, 48:5:311.
- BAKER, JOHN H.
1947a. Bob Allen Looks for Whooping Cranes. The President Reports to You. *Audubon Magazine*, 49:1:55-56.
- BAKER, JOHN H.
1947b. Whooping Cranes. The President Reports to You. *Audubon Magazine*, 49:2:115-116.
- BAKER, JOHN H.
1947c. On the Trail of the Whooper. The President Reports to You. *Audubon Magazine*, 49:3:173-175.
- BAKER, JOHN H.
1948a. Oil Companies and Cranes. The President Reports to You. *Audubon Magazine*, 50:3:177-178.
- BAKER, JOHN H.
1948b. The Mystery Deepens. The President Reports to You. *Audubon Magazine*, 50:5:303.
- BAKER, JOHN H.
1949a. The President Reports to You. *Audubon Magazine*, 51:3:178-180.
- BAKER, JOHN H.
1949b. New Attitude Toward Wildlife Conservation. The President Reports to You. *Audubon Magazine*, 51:4:251-252.
- BAKER, JOHN H.
1950a. Whooping Cranes Show Increase. The President Reports to You. *Audubon Magazine*, 52:1:50.
- BAKER, JOHN H.
1950b. Whooping Crane Tragedy. The President Reports to You. *Audubon Magazine*, 52:4:256.
- BARNARD, VINCENT
1861. A Catalogue of the Birds of Chester County, Pennsylvania. *Ann. Rep. Smiths. Inst. for 1860*, p. 438.
- BARROWS, W. B.
1912. Michigan Bird Life. *Special Bull. of Mich. Agr. College, Lansing*, p. 148-149.
- BARTRAM, WILLIAM
1791. Travels through North and South Carolina, Georgia, East and West Florida, etc. Phila., printed by James and Johnson.
- BARTSCH, PAUL
1900. A Trip to the Zoological Park. *Osprey*, 5:2:20.
- BATES, FRANK A.
1896. The Game Birds of North America, Boston, Whidden.
- BECKHAM, CHARLES W.
1885. A List of the Birds of Nelson County (Kentucky). *Kentucky Geol. Surv.*
- BECKHAM, CHARLES W.
1887. Observations on the Birds of Southwest Texas. *Proc. U. S. Nat. Mus.*, 10:633-696.
- BEDFORD, DUCHESS OF
1907. Cranes at Woburn Park. *Avicultural Magazine, New Series*, 6:1:26.

- BEEBE, C. WILLIAM
1902. Rare Birds in the Zoological Park. *N. Y. Zool. Soc. Bull.*, 7:38.
- BEEBE, C. WILLIAM
1906. *The Bird, Its Form and Function*, New York, Holt.
- BELDING, L.
1891. Notices of Some California Birds. *Zoe*, 2:99.
- BENNETT, G. B.
1887. A Collecting Trip in Texas. *Ornith. and Oologist*, 12:6:83.
- BENNETT, RUDOLF
1932. Check-list of the Birds of Missouri. *Univ. of Mo. Studies*, 7:3:27.
- BENNETT, RUDOLF
1938. Whooping Cranes in Southwestern Missouri, 1937. *Wilson Bull.*, 50:1:61-63.
- BENT, ARTHUR CLEVELAND
1926. Life Histories of North American Marsh Birds. *Bull. 135, U. S. Nat. Mus.*, p. 219-231.
- BERGTOLD, W. H.
1931. The Season. Denver Region. *Bird-Lore*, 33:5:339.
- BEVERLY, FRED
1874. The Okeechobee Expedition. *Forest and Stream*, 2:4:50.
- BEYER, GEORGE EUGENE
1900. The Avifauna of Louisiana. Reprinted from *Proc. Louisiana Soc. Nat. Hist. for 1897-99*, p. 19.
- BEYER, GEO. E., A. ALLISON AND H. H. KOPMAN
1908. List of the Birds of Louisiana. Part IV. *Auk*, 25:2:176.
- BIRDS OF AMERICA
1940. Editor-in-Chief, T. Gilbert Pearson . . . Garden City, N. Y., Garden City Publ. Co.
- BLAAUW, FRANS ERNEST
1897. A Monograph of the Cranes. Leiden and London, E. J. Brill, R. H. Porter.
- BLACK, CYRUS A.
1922. Some Bird Notes from Central and Western Nebraska. *Wilson Bull.*, 34:1:43.
- BLACK, CYRUS A.
1933. Nebraska Records of the Whooping Crane for 1932 and 1933. *Nebr. Bird Rev.*, 1:3:61-62.
- BLACK, CYRUS A.
1934a. A Nebraska Record of the Whooping Crane for the Fall of 1933. *Nebr. Bird Rev.*, 2:1:6-7.
- BLACK, CYRUS A.
1934b. The Whooping Crane in the Spring of 1934. *Nebr. Bird Rev.*, 2:3:117-118.
- BLACK, CYRUS A.
1934c. The Whooping Crane in the Spring of 1934. *Nebr. Bird Rev.*, 2:4:118.
- BLACK, CYRUS A.
1935. Whooping Cranes Seen in the Fall of 1934. *Nebr. Bird Rev.*, 3:1:26.
- BLACK, CYRUS A.
1936. Records of the Whooping Crane for the Spring of 1936. *Nebr. Bird Rev.*, 4:4:81.
- BLACK, CYRUS A.
1937a. Whooping Cranes and Whistling Swans Seen in the Fall of 1936. *Nebr. Bird Rev.*, 5:1:10.
- BLACK, CYRUS A.
1937b. Some Observations of the Whooping Crane in the Spring of 1937. *Nebr. Bird Rev.*, 5:2:33.
- BLACK, CYRUS A.
1937c. The Whooping Crane near Kearney, Buffalo County. *Nebr. Bird Rev.*, 5:4:106.
- BLACK, CYRUS A.
1938. Some 1937 Notes on Whooping Cranes and Other Birds. *Nebr. Bird Rev.*, 6:1:12.
- BLACKLY, C. P.
1884. Whooping Crane (Correspondence). *Ornith. and Oologist*, 9:2:24.
- BLAKISTON, THOMAS
1863. On the Birds of the Interior of British North America. *Ibis*, 5:17:128.
- BLANCHAN, NELTJE (Doubleday, Mrs. Nellie Blanchan)
1902. Birds that Hunt and Are Hunted. New York, Doubleday and Page.
- BLINCOE, BENEDICT J.
1925. Birds of Bardstown, Nelson County, Kentucky. *Auk*, 42:3:404-420.
- BLUE JAY
1949. Cranes and Eagles. 7:4:16.
- BLYTH, EDWARD
1881. The Natural History of the Cranes. A Monograph . . . greatly enlarged and reprinted with numerous illustrations by W. B. Tegetmeier. London, Cox and Porter.
- BONAPARTE, CHARLES LUCIEN JULES LAURENT
PRINCE DE CANINO
1825. Observations on the Nomenclature of Wilson's Ornithology. *Jour. Acad. Nat. Sci. Phila.* 5 (Part 1):66.
- BONAPARTE, CHARLES LUCIEN JULES LAURENT
PRINCE DE CANINO
1827. Contributions of the Maclurian Lyceum to the Arts and Sciences, 1:24.
- BRADSHAW, FRED
1923. Saskatchewan. *Report of the Chief Game Warden for 1923*, p. 14-15.
- BRISSON, MATHURIN JACQUES
1760. Ornithologie ou Méthode contenant la division des oiseaux en ordres, sections, genres, espèces, et leur variétés . . . tome V., Paris, C. J.-B. Bauche.
- BROOKING, A. M.
1934. The Whooping Crane in the Spring of 1934. *Nebr. Bird Rev.* 2:4:117-118.
- BROOKING, A. M.
1942. The Vanishing Bird Life of Nebraska. *Nebr. Bird Rev.*, 10:2:45.
- BROOKING, A. M.
1943a. The Present Status of the Whooping Crane. *Nebr. Bird Rev.*, 11:1:5-8.
- BROOKING, A. M.
1943b. Additional Records of the Whooping Crane. *Nebr. Bird Rev.*, 11:2:47.
- BROOKING, A. M.
1944. Additional Records of the Whooping Crane. *Nebr. Bird Rev.*, 12:1:7.
- BROOKING, A. M. AND J. J. HICKEY
1944. Status of the Whooping Crane. *Wilson Bull.*, 56:3:180.
- BROOKING, MRS. A. M.
1934. Report in 1934 Migration Season. *Nebr. Bird Rev.*, 2:2:48.
- BROOKING, MRS. A. M.
1946. Whooping Cranes in Hall and Buffalo Counties. *Nebr. Bird Rev.*, 14:2:46.
- BROOKS, WINTHROP S., AND S. COBB
1911. Notes from Eastern Alberta. *Auk*. 28:4:466.
- BROWN, EDDIE
1942. The Whooping Crane at Lexington, Dawson County. *Nebr. Bird Rev.*, 10:1:30.

- BRYANT, HENRY
1853. Paper on the Sandhill Crane. *Proc. Boston Soc. Nat. Hist.*, vol. 4, p. 303-305.
- BUCK, PETER H.
1938. Vikings of the Sunrise. Phila., Lippincott.
- BUFFON, GEORGE LOUIS LECLERC
1780. *Histoire Naturelle des Oiseaux*. Vol. 7. Paris, Imprimerie Royale.
- BURLEIGH, THOMAS D.
1944. The Bird Life of the Gulf Coast Region of Mississippi. Louisiana Univ., *Occasional Papers Mus. Zool.*, 20:363.
- BURMOOD, MRS. WILL
1934. Whooping Cranes near Wood River, Hall County. *Nebr. Bird Rev.*, 2:4:117.
- BURNS, FRANK L.
1932. Charles W. and Titian R. Peale and the Ornithological Section of the Philadelphia Museum. *Wilson Bull.*, 44:1:26,28.
- BURRAGE, H. S.
1906. *Early English and French Voyages, 1534-1608*. New York, Scribner.
- BUTLER, AMOS W.
1898. The Birds of Indiana. *Twenty-second Ann. Report, Ind. Dept. Geol. and Nat. Resources (1897)*, p. 669.
- CANFIELD, R. H.
1944. Measurement of Grazing Use by the Line Intersection Method. *Journ. Forestry*, 42:3:192.
- CARROLL, JAMES J.
1900. Notes on the Birds of Refugio County, Texas. *Auk*, 17:4:340.
- CARY, MERRITT
1900. Some Bird Notes from the Upper Elkhorn. *Proc. Nebr. Orn. Union*, for 1st Annual Meeting, 1899, p. 22.
- CATESBY, MARK
1771. *The Natural History of Carolina, Florida, and the Bahama Islands*. London, printed for B. White.
- CHAMBERLAIN, MONTAGUE
1887. *A Catalogue of Canadian Birds*. St. John, N. B., J. and A. McMillan.
- CHAMPLAIN, SAMUEL DE
1604-1610. *Voyages of Samuel de Champlain*. Otis transl. Boston, the Prince Society (1878-82).
- CHAPMAN, FRANK M.
1891. On the Birds Observed Near Corpus Christi, Texas, During Parts of March and April, 1891. *Bull. Am. Mus. Nat. Hist.*, 3:2:328.
- CHARLEVOIX, PIERRE FRANÇOIS XAVIER DE
1721. *Histoire de la Nouvelle France; Journal d'un voyage fait par ordre du roi dans l'Amérique Septentrionale*. Paris, Nyon, 1744.
- CHRISTY, MILLER
1885. Notes on the Birds of Manitoba. *Zoologist*, 3rd series, 9:160:121-133.
- CLARKE, C. H. D.
1940. A Biological Investigation of the Thelon Game Sanctuary. *Bull. 96, Biol. Ser. 25, Nat. Mus. Canada*, p. 49.
- CLARKE, FRANCIS E.
1940. *Great Wings and Small*. New York, Macmillan.
- COBEAUX, EUGENE
1900. Contributions to the Natural History of the North West Territories. 1. The Birds of Saskatchewan. *Ottawa Naturalist*, 14:12:26.
- CONOVER, H. B.
1922. *Anas diazi novimexicana* and *Crus americana* in Nebraska. *Auk*, 39:3:412.
- COOKE, W. W.
1888. Report on Bird Migration in the Mississippi Valley in the Years 1884 and 1885. *U. S. Bureau of Biol. Surv., Bull. No. 2*: 84-85.
- COOKE, W. W.
1897. Birds of Colorado. *Colo. State Agr. College, Ft. Collins, Bull. No. 37*: 62.
- COOKE, W. W.
1914. Distribution and Migration of North American Rails and their Allies. *U. S. Dept. Agr. Bulletin* 128:1,4-7.
- COAY, C. B.
1909. The Birds of Illinois and Wisconsin. *Field Mus. Nat. Hist., Publ. 131, Zool. Series*, 9:375-376.
- COSGRAVE, R.
1911. Notes on the Cranes at Lilford Hall. *Avicultural Magazine, New Series*, 2:5:147-150.
- COSGRAVE, R.
1912. The Whooping Crane. *Avicultural Magazine, New Series*, 3:10:312.
- COUES, ELLIOTT
1868a. A List of the Birds of New England. *Proc. Essex Inst.*, 5:289.
- COUES, ELLIOTT
1868b. Synopsis of the Birds of South Carolina. *Proc. Boston Soc. Nat. Hist.*, 12:123.
- COUES, ELLIOTT
1874a. Birds of the Northwest: A Handbook of the Ornithology of the Region Drained by the Missouri River and Its Tributaries. *U. S. Geol. Surv. of the Territories, Miscel. Publ. 3*: 530-532.
- COUES, ELLIOTT
1874b. The Cranes of America. *Forest and Stream*, 3:2: 20-21.
- COUES, ELLIOTT
1878. Field Notes on Birds Observed in Dakota and Montana along the 49th Parallel During the Seasons of 1873 and 1874. *U. S. Geol. Surv. of Terr. Bull. 4*: 545-661.
- COUES, ELLIOTT
1882. Coues' Check List of North American Birds. Boston, Estes and Lauriat.
- COVERT, A. B.
1876. Birds of Lower Michigan. *Forest and Stream*, 7: 10:147.
- GRAVEN, EARL
1946. The Status of the Whooping Crane on the Aransas Refuge, Texas. *Condor*, 48:1:37-39.
- CUTTING, HIRAM A.
1884. Lectures on Milk, Forestry, Our Bird Catalogue. Insects, How to Foretell Storms, Fertilization, etc. Montpelier (Vt.) Watchman and Journal Press.
- "D. O. OF B."
1876. A Hunt in Western Iowa. *Chicago Field*, 6:14: 226.
- DAVIE, OLIVER
1889. Nests and Eggs of North American Birds. 4th ed. Columbus, Hahn and Adair.
- DAVIS, EDWIN C.
n. d. Reduced Price List of North American Birds' Eggs. Gainesville, Texas.

- DAVIS, JOHN H., JR.
1943. The Natural Features of Southern Florida. Tallahassee, *Fla. Geol. Surv. Bulletin* 25.
- DAWSON, WILLIAM LEON
1903. The Birds of Ohio. Columbus, Wheaton Publ. Co.
- DAWSON, WILLIAM LEON
1908. New and Unpublished Records from Washington. *Auk*, 25:4:484.
- DAWSON, WILLIAM LEON AND J. H. BOWLES
1909. The Birds of Washington. Vol. II. Seattle, Occidental Publ. Co.
- DEANE, RUTHVEN
1923. Extracts from the Field Notes of George B. Sennett. *Auk*, 40:4:627, 629-631.
- DEKAY, JAMES E.
1844. Zoology of New York or the New York Fauna. Part II, *Birds*. Albany, Carroll and Cook.
- DEMAV, I. S.
1941. Quaternary Bird Life of the McKittrick Asphalt, California. *Carnegie Inst. Washington, Publ.* 530: 35-60.
- DOUTHITT, BESSIE PRICE
1918. Migration Records for Kansas Birds. *Wilson Bull.*, 30:4:108.
- DRESSER, H. E.
1866. Notes on the Birds of Southern Texas. *Ibis*, 2nd Ser., 2:30.
- DRURY, CHARLES
1900. Random Notes on Natural History. *Jour. Cincinnati Soc. Nat. Hist.*, 19:5:174.
- DUDLEY, WILLIAM
1854. Description of a species of Crane (*Grus hoyanus*) found in Wisconsin. Presumed to be New. *Proc. Acad. Nat. Sci. Phila.*, 7:64.
- DUGES, ALFRED
1870. Catalogo de Animales Vertebrados Observados en la Republica Mexicana. *Naturaleza*, 1:142.
- DUMONT, PHILIP A.
1933. A Revised List of the Birds of Iowa. *Univ. Iowa Studies in Nat. Hist.*, 15:5:59-60.
- EATON, ELON HOWARD
1901. Birds of Western New York. *Proc. Rochester Acad. Sci.*, 4:25.
- EATON, ELON HOWARD
1910. The Birds of New York. *Memoir 12, N. Y. State Mus. Part I*. Albany, Univ. of the State of N. Y.
- EDWARDS, GEORGE
1750. A Natural History of Birds the Most of Which have not Hitherto been Figured or Described. Part III, vols. 3 and 4 (original ed. 1743-51). London, W. Gardener (1802).
- "ELANOIDES"
1890. A List of the Birds of McLennan County, Texas. *Ornith. and Oologist*, 15:4:57.
- EMMONS, EBENEZER
1835. Birds (in Edward Hitchcock's *Catalogue of the Animals and Plants of Massachusetts* "Copied from his 'Report on the Geology, Botany and Zoology of Massachusetts'"). Amherst, J. S. and C. Adams.
- EVANS, A. H.
1909. Birds. London, Macmillan.
- EVERTS, HAL G.
1923a. The Last Straggler. *Saturday Evening Post*, 196: 2:48.
- EVERTS, HAL G.
1923h. The Passing of the Old West. Boston, Little, Brown.
- FARLEY, FRANK L.
1932. Birds of the Battle River Region. Edmonton, Alberta. Institute of Applied Art.
- FAXON, WALTER
1915. Relics of Peale's Museum. *Bull. Mus. Comp. Zool.*, 59:3:131.
- FEDERAL MIGRATORY BIRD LAW
1916. Open Seasons Effective August 21, 1916. *Bull. Am. Game Prot. Assoc.*, 5:3:36.
- FENTON, CARROLL LANE
1916. Preliminary List of the Birds of Floyd County (Iowa). *Wilson Bull.*, 28:3:133-134.
- FERRY, JOHN F.
1910. Birds Observed in Saskatchewan During the Summer of 1909. *Auk*, 27:2:195.
- FISHER, ALBERT KENRICK
1893. The Death Valley Expedition. *U. S. Biol. Surv. N. Amer. Fauna No. 7*.
- FISHER, JAMES
1939. Birds as Animals. London and Toronto, W. Hineinann.
- FLEMING, JAMES H.
1901. A List of the Birds of the Districts of Parry Sound and Muskoka, Ontario. *Auk*, 18:1:36.
- FORDUSH, EDWARD HOWE
1912. A History of the Game Birds, Wild-Fowl and Shore-Birds of Massachusetts and Adjacent States. Boston, Mass. State Board of Agr.
- FORDUSH, EDWARD HOWE
1925. Birds of Massachusetts and Other New England States. Boston, Mass. Dept. of Agr.
- FOREST AND STREAM
1876. In Invitation. *Forest and Stream*, 6:2: 19,20.
- FOREST AND STREAM
1881. An Intelligent Crane. *Forest and Stream*, 16:4:67.
- FRIEDRICH II, Emperor of Germany (1194-1250)
The Art of Falconry, being the *De Arte Vanandicum Avibus* of Frederick II of Hohenstaufen; transl. and ed. by Casey A. Wood and F. Marjorie Fyfe. Book IV. Stanford Univ. Press; London, Oxford Univ. Press (1943).
- FUERTES, LOUIS AGASSIZ
1923. Whooping Crane in Nebraska. *Auk*, 40:1:121.
- "G. M."
1876. The Game of Manitoba. *Forest and Stream*, 6: 14:212-213.
- GABRIELSON, I. N.
1917. A List of Birds Observed in Clay and O'Brien Counties, Iowa. *Proc. Iowa Acad. Sci.*, 24:264.
- GABRIELSON, I. N., AND S. G. JEWETT
1940. Birds of Oregon. *Ore. State Monographs, Studies in Zool.*, No. 2, Ore. State College.
- GALTSOFF, PAUL S.
1931. Survey of Oyster Bottoms in Texas. *Investigational Rep. No. 6*, U. S. Bureau Fisheries, Washington.
- GILLESE, JOHN P.
1948. I Shot a Whooping Crane. *Forest and Outdoors*, 44:9:29.
- GIRAUD, JACOB P., JR.
1844. The Birds of Long Island. New York, Wiley and Putnam.

- GLANDON, MR. AND MRS. EARL W.
1934. Notes on Some Logan County Birds. *Nebr. Bird Rev.*, 2:2:31-36.
- GLISAN, RODNEY
1874. *Journal of Army Life*. San Francisco. A. L. Bancroft and Co.
- GOLSAN, L. S. AND E. G. HOLT
1914. Birds of Autauga and Montgomery Counties, Alabama. *Auk*, 31:2:218.
- GOODRICH, ARTHUR L., JR.
1946. Birds of Kansas. *Report of the Kansas Board of Agr.* 64:267:190.
- GOSS, NATHANIEL S.
1886. A Revised Catalogue of the Birds of Kansas, Topeka, Kansas Publ. House: T. D. Thacher, state printer.
- GOWANLOCK, JAMES NELSON
1939. Vanished Americans. *La. Conserv. Review*, 8:1:49.
- GRAHAM, EDWARD H.
1947. *The Land and Wildlife*. New York, Oxford Univ. Press.
- GRAVE, B. H. AND E. P. WALKER
1913. *The Birds of Wyoming*. Laramie, Univ. of Wyoming.
- GREENE SMITH MUSEUM, Peterboro, N. Y.
1881. *Catalogue of Birds, Eggs and Nests*. Morrisville, N. Y., Madison Observer office.
- GRINNELL, GEORGE BIRD
1917. Dr. Grinnell Writes of Native Cranes. *Bull. Am. Game Protective and Propagation Assoc.*, 6:1:9-10.
- GRINNELL, JOSEPH
1900. Birds of the Kotzebue Sound Region, Alaska. Cooper Ornithological Club of Calif., *Pacific Coast Avifauna No. 1*.
- GRINNELL, JOSEPH, H. C. BRYANT AND T. I. STORER
1918. *The Game Birds of California*. Berkeley, Univ. of California Press.
- GRINNELL, JOSEPH AND A. H. MILLER
1944. The Distribution of the Birds of California. Cooper Ornithological Club of Calif., *Pacific Coast Avifauna No. 27*.
- GRISCOM, LUDLOW
1945. *Modern Bird Study*. Cambridge, Harvard Univ. Press.
- GRISCOM, LUDLOW AND M. S. CROSBY
1925. Birds of the Brownsville Region, Southern Texas. *Auk*, 42:3:437 and 42:4:526.
- GUNTER, GORDON
1938. The Common Blue Crab in Fresh Waters. *Science*, 87:2248:87-88.
- GUNTER, GORDON
1943. Remarks on American Bison in Louisiana. *Jour. Mammalogy*, 24:3:398-399.
- GUNTER, GORDON
1945. Studies on Marine Fishes of Texas. *Publ. Inst. Marine Sci.*, 1:1.
- GUNTER, GORDON
1947. Paleocological Import of Certain Relationships of Marine Animals to Salinity. *Jour. Paleontology*, 21:1:77-79.
- GUNTER, GORDON
1950a. Distribution and abundance of Fishes on the Aransas National Wildlife Refuge, with Life History Notes. *Publ. Inst. Marine Sci.*, 1:2:89-101.
- GUNTER, GORDON
1950b. Seasonal Population Changes and Distributions as Related to Salinity, of Certain Invertebrates of the Texas Coast, Including the Commercial Shrimp. *Publ. Inst. Marine Sci.*, 1:2:7-51.
- GURNEY, J. H.
1921. *Early Annals of Ornithology*. London, Witherby.
- GUTHRIE, J. E.
1932. Snakes versus birds; birds versus snakes. *Wilson Bull.* 44:2:102.
- HAKLUYT, RICHARD
1589. *The Principall Navigations Voiges Traffiques & Discoveries of the English Nation, Made by Sea or Over-land to the Remote and Farthest Distant Quarters of the Earth at any time within the compass of these 1600 Yeeres*. Glasgow, Jas. MacLehose and Sons (1903-05).
- HALL, F. S.
1933. Studies in the History of Ornithology in the State of Washington (1792-1932) with Special Reference to the Discovery of New Species. *Murrelet*, 14:3:70.
- HARRIS, HARRY
1919. Birds of the Kansas City Region. *Trans. Acad. Sci. of St. Louis*, 23:8:244-339.
- HATCH, P. L.
1892. Notes on the Birds of Minnesota. *Minn. Geol. and Nat. Hist. Surv. Zool. Ser.* 1:98,99.
- HEARNE, SAMUEL
1795. A Journey from Prince of Wales's Fort in Hudson's Bay to the Northern Ocean Undertaken by Order of the Hudson's Bay Company for the Discovery of Copper Mines, a North West Passage, &c. in the Years 1769, 1770, 1771 & 1772. London, printed for A. Strahan and T. Caddell and sold by T. Caddell, Jun and W. Davis.
- HEDGPETH, JOEL W.
1950. Notes on the Marine Invertebrate Fauna of Salt Flat Areas in Aransas National Wildlife Refuge, Texas. *Publ. Inst. Marine Sci.*, 1:2.
- HENNINGER, W. F.
1902. A Preliminary List of the Birds of Middle South-ern Ohio. *Wilson Bull.*, 9:3:81.
- HENRY, THOMAS CHARLTON
1855. Notes Derived from Observations made on the Birds of New Mexico during the Years 1853 and 1854. *Proc. Acad. Nat. Sci. Phila.*, 7:306.
- HENRY, THOMAS CHARLTON
1859. Catalogue of the Birds of New Mexico as compiled from notes and observations made while in that Territory, during a Residence of Six Years. *Pro. Acad. Nat. Sci. Phila.*, 11:108.
- HENSHAW, HENRY W.
1915. American Game Birds. *Nat. Geog. Magazine*, 28:2:122-123.
- HERSEY, L. J. AND R. B. ROCKWELL
1909. An Annotated List of the Birds of the Barr Lake District, Adams County, Colorado. *Gondor*, 11:4:114.
- HEWITT, C. GORDON
1921. *The Conservation of the Wildlife of Canada*. New York, Scribner.
- HIND, HENRY YOULE
1860. *Narrative of the Canadian Red River Exploring Expedition of 1857 and of the Assiniboine and Saskatchewan Exploring Expedition of 1858*. London, Longman, Green, Longman and Roberts.

- HOFFMAN, W. J.
1882. List of Birds Observed at Fort Berthold, Dakota Territory during the Month of September 1881. *Proc. Boston Soc. Nat. Hist.*, 2:404.
- HOPKINS, SEWELL H.
1942. The Crab Fishery, with Suggestions for its Improvement in Texas. *Texas Game and Fish*, reprinted from Feb. issue.
- HORNADAY, WILLIAM T.
1913. Our Vanishing Wild Life. N. Y. Zool. Society.
- HOUGH, E.
1895. Round Rockport Way in Texas. *Forest and Stream*, 44:19:366-367.
- HOUSTON, C. STUART
1949. The Birds of the Yorkton District, Saskatchewan. *Canadian Field Naturalist*, 63:6:225.
- HOWARD, HILDEGARDE
1930. A Census of the Pleistocene Birds of Rancho La Brea from the Collections of the Los Angeles Museum. *Condor*, 32:2:81-88.
- HOWELL, ARTHUR H.
1911. Birds of Arkansas. *U. S. Biol. Surv. Bull.*, 38.
- HOWELL, ARTHUR H.
1928. Birds of Alabama, 2nd ed., Birmingham, Birmingham Printing Co. (U. S. Biol. Surv.).
- HOWELL, ARTHUR H.
1932. Florida Bird Life, New York, Coward-McCain.
- HOY, PHILO ROMAYNE
1844. (An account of the former and present status of 26 species.) *Racine Advocate*, June 4, 1844.
- HOY, PHILO ROMAYNE
1864. Journal of an Exploration of Western Missouri in 1854. *Ann. Report Smith, Inst. for 1864*, p. 437-438.
- HOY, PHILO ROMAYNE
1874. Some of the Peculiarities of the Fauna near Racine. *Trans. Wis. Acad. Sci.*, 2:120-122.
- HOY, PHILO ROMAYNE
1885. Man's Influence on the Avifauna of Southeastern Wisconsin. *Proc. Wis. Nat. Hist. Soc.*, March (1885):4-9.
- HOY, PHILO ROMAYNE
1886. (Record of Whooping Crane shot in Nebraska and mounted by Hoy.) *Racine Journal*, April 21, 1886.
- HUBBARD, WILLIAM
1610. General History of New England from the Discovery to MDCXXX. *Coll. Mass. Hist. Soc.*, 2nd ser., 6:672.
- HUNTER, J. S.
1900. The Bird Fauna of the Salt Basin near Lincoln. *Proc. Nebr. Ornith. Union*, for 1st Annual Meeting, 1899, p. 20.
- HUNTINGTON, DWIGHT W.
1911. Our Feathered Game. New York, Scribner.
- IMLER, RALPH H.
1936. An Annotated List of the Birds of Rooks County, Kansas, and Vicinity. *Trans. Kans. Acad. Sci.* No. 39, p. 301.
- INGERSOLL, A. M.
1887. Eggs! Eggs!! Eggs!!! (Classified advertisement). *Oologist*, vol. 4, nos. 3-4.
- ISLEY, DWIGHT
1912. A List of the Birds of Sedgwick County, Kansas. *Auk*, 29:1:40.
- J. F. L.
1887. Whooping Cranes. *Forest and Stream*, 28:2:27.
- JACKSON, H. H. T.
1946. Conserving Endangered Wildlife Species. *Ann. Report Smiths. Inst. for 1945*, p. 261.
- JAMES, EDWIN (compiler)
1823. Account of an expedition from Pittsburgh to the Rocky Mountains performed in the years 1819, 1820 . . . under the command of Maj. S. H. Long. . . . Comp. from the Notes of Major Long, Mr. T. Say, and other gentlemen of the party. . . . London, printed for Longman, Hurst, Rees, Orme, & Brown.
- JOB, HERBERT K.
1923. Propagation of Wild Birds. New York, Garden City.
- JOHONNOT, JAMES
1885. Neighbors with Wings and Fins and some others. For Young People. New York, D. Appleton.
- JONES, JOE
1946. Letters. *Audubon Magazine*, 50:5:321.
- JOUV, P. L.
1894. Notes on Birds of Central Mexico, with Descriptions of Forms Believed to be New. *Proc. U. S. Nat. Mus.*, 16:975-790.
- JUDD, ELMER T.
1891. Dakota Game Birds. *Forest and Stream*, 36:9:169.
- JUDD, ELMER T.
1917. List of North Dakota Birds Found in the Big Coulee, Turtle Mountains, and Devil's Lake Region . . . 1890 to 1896 . . . Cando, N. D. Author.
- KALMBACH, E. R.
1942. Whooping Cranes in Eastern Colorado. *Auk*, 59:2:307.
- KELLOGG, VERNON L.
1900. A List of the Biting Lice (*Mellophaga*) Taken from Birds and Mammals of North America. *Proc. U. S. Nat. Mus.*, 22:1183:72,86.
- KELSEY, CARL
1891. Birds of Poweshiek County, Iowa. *Ornith. and Oologist*, 16:9:131.
- KEMIES, EMERSON
1930. Birds of the Yellowstone National Park, with some Recent Additions. *Wilson Bull.*, 42:3:198, 203.
- KENNEDY, JOHN P.
1934. The Whooping Crane in Nebraska in Forty Years of Observation. *Nebr. Bird Rev.* 2:4:117.
- KENNICOTT, ROBERT
1853-54. *Transactions of the Illinois State Agricultural Society*, 1, 587.
- KEYES, C. R. AND H. S. WILLIAMS
1888. Preliminary Annotated Catalogue of the Birds of Iowa. *Proc. Davenport Acad. Nat. Sci. Pub. Mus.*, vol. 5.
- KIMBALL, H. H.
1923. Bird Notes from Arizona and California. *Condor*, 25:3:109.
- KING, RICHARD
1836. Narrative of a Journey to the Shores of the Arctic Ocean in 1833, 1834 and 1835; under the Command of Capt. Back, R.N. Vol. 2. London, Richard and Bentley.
- KINGSLEY, F. R.
1935a. Whooping Cranes in Kearney County, Nebraska. *Nebr. Bird Rev.*, 3:2:57.

- KINGSLEY, F. R.
1935h. More Whooping Cranes Seen in Kearney County, Nebraska. *Nebr. Bird Rev.*, 3:3:84.
- KINGSLEY, F. R.
1937. The Whooping Crane in Northeastern Gosper County. *Nebr. Bird Rev.*, 5:3:57-58.
- KNIGHT, WILBUR C.
1902. The Birds of Wyoming. *Wyoming Agr. Experimental Sta., Laramie, Bull.* 55.
- KNOWLTON, FRANK H.
1909. Birds of the World. New York, Holt.
- KRIDER, JOHN
1873. Game in Season for November (Shot Gun and Rifle). *Forest and Stream*, 1:15:235.
- KRIDER, JOHN
1879. Forty Years' Notes of a Field Ornithologist. Philadelphia, Jos. H. Weston.
- KUMLIEN, LUDWIG
1879. Contributions to the Natural History of Arctic America. *U. S. Nat. Mus. Bull.* 15.
- KUMLIEN, LUDWIG AND N. HOLLISTER
1903. The Birds of Wisconsin. *Bulletin Wis. Nat. Soc.*, vol. 3 (New Ser.) nos. 1, 2, 3, p. 36-37.
- KUMLIEN, L. AND N. HOLLISTER
1948. The Birds of Wisconsin; with Revisions by A. W. Schorger. *Passenger Pigeon*, 10:3:111-112.
- LAET, JOANNES DE
1640. L'Histoire du Nouveau Monde; ou description des Indes Occidentales. . . Leyde, B. and A. Elseviers.
- LANGDON, FRANK W.
1877. A Catalogue of the Birds of the Vicinity of Cincinnati, with Notes. Salem, Mass., The Naturalists' Agency.
- LANGILLE, J. HIBBERT
1884. Our Birds in their Haunts. Boston, S. E. Cassino and Co.
- LANTZ, DAVID E.
1896-97. Review of Kansas Ornithology. *Proc. Kansas Acad. Sci.*, 16; 224-276.
- LANTZ, DAVID E.
1907. An Economic Study of the Field Mice (Genus *Microtus*). *U. S. Biol. Surv. Bull.* 31, p. 53.
- LARSON, ADRIAN
1907. A Preliminary List of the Birds of Western Lyman County, South Dakota. *Wilson Bull.*, 19:3:114.
- LARSON, ADRIAN
1925. The Birds of Sioux Falls, South Dakota, and Vicinity. *Wilson Bull.*, 37:1:24.
- LATHAM, J.
1824. General History of Birds. Vol. 9. Winchester, author.
- LATROBE, CHARLES J.
1836. The Ramhler in North America. 2nd ed. London, Seeley and Durnside.
- LAWSON, JOHN
1709. The History of Carolina, Containing the exact Description and Natural History of that Country . . . Raleigh, N. C., printed by Strother and Marcom (1860).
- LESSON, RENE PRIMEVERE
1831. Traité d'Ornithologie, ou Tableau méthodique, etc., Paris, F. G. Levrault.
- LEWIS, HARRISON F.
1946. Management of Canada's Wildlife Resources. *Trans. 11th N. Amer. Wildlife Confer.*
- LEWIS, MERIWETHER
1804-05-06. History of the Expedition under the Command of Lewis and Clarke to the sources of the Missouri River . . . Performed during the years 1804-05-06 . . . New ed. . . with copious critical commentary . . . by Elliott Cones. New York, Harper. (1893).
- LEWIS, WALTER E.
1930. Water Birds in a Dry Land. *Wilson Bull.*, 42:1:41.
- LICKING, CLYDE L.
1940. The 1939 Spring Flight of Migratory Birds in Nebraska. *Nebr. Bird Rev.*, 8:1:10,11.
- LLOYD, HOYES
1922. Some of Captain Henry Toke Munn's Observations on the Birds of Baffin Island and Vicinity. *Canadian Field-Naturalist*, 36:3:49-50.
- LLOYD, WILLIAM
1887. Birds of Tom Green and Concho Counties, Texas. *Auk*, 4:3:185.
- LONG, W. S.
1940. Check-list of Kansas Birds. *Trans. Kansas Acad. Sci.*, 43:441.
- LOUISIANA, DEPT. OF CONSERVATION
1914-16. Report of the Conservation Commission of Louisiana, p. 19.
- LOUISIANA, DEPT. OF CONSERVATION
1921. Wild life resources of Louisiana; their nature, value, and protection. New Orleans. *Bull.* 10:151-152.
- LUDLOW, CHARLES S.
1935. A Quarter Century of Spring Bird Migration Records at Red Cloud, Nebraska. *Nebr. Bird Rev.* 3:1:3-25.
- MCATEE, WALDO LEE
1923. Local Names of Migratory Game Birds. *U. S. Dept. Agr. Miscel. Circ. No. 13.*
- MCCALL, GEORGE A.
1851. Some Remarks on the Habits, etc., of Birds Met with in Western Texas between San Antonio and the Rio Grande and in New Mexico. . . *Proc. Acad. Nat. Sci. Phila.*, 5:223.
- MCCHESENEY, CHARLES E.
1877. Birds of the Coteau des Prairies of Eastern Dakota. *Forest and Stream*, 8:16:241.
- MCCHESENEY, CHARLES E.
1879. Notes on the Birds of Fort Sisseton, Dakota Territory. Extracted from *Bull. U. S. Geod. and Geog. Survey*, 5:1:94.
- MCCOLLUM, C.
1884. Wisconsin Birds. *Young Oologist*, 1:6:93.
- MCCREARY, OTTO
1937. Wyoming Bird Life. Minneapolis, Burgess Publ. Co.
- MACFARLANE, R. R.
1891. Notes on and List of Birds and Eggs Collected in Arctic America, 1861-1866. *Proc. U. S. Nat. Mus.*, 14:413-466.
- MCILHENNY, EDWARD AVERY
1938. Whooping Crane in Louisiana. *Auk*, 55:4:670.
- MCILHENNY, EDWARD AVERY
1943. Major Changes in the Bird Life of Southern Louisiana During Sixty Years. *Auk*, 60:4:544.
- MCLWRAITH, THOMAS
1894. The Birds of Ontario. Toronto, Wm. Briggs.

- MACCOUN, JOHN
1882. Manitoba and the Great North-West. Guelph, Ontario, World Publ. Co.
- MACCOUN, JOHN
1900. Catalogue of Canadian Birds. Part I. Ottawa (Can. Geol. Surv.).
- MAIR, CHARLES AND R.R. MACFARLANE
1908. Through the Mackenzie Basin. Toronto. Wm. Briggs.
- MANN, WILLIAM M.
1938. Wild Animals in and out of the Zoo. New York. Smithsonian Inst. Series Vol. 6.
- MAYNARD, C. J.
1896. The Birds of Eastern North America, with Original Descriptions of all the Species which occur East of the Mississippi River between the Arctic Circle and the Gulf of Mexico, rev. ed., Newtonville, Mass., C. J. Maynard.
- MAYR, ERNEST
1942. Systematics and the Origin of Species. New York, Columbia Univ. Press.
- MEASE, JAMES
1811. The Picture of Philadelphia, Giving an Account of its Origin, Increase and Improvements . . . with compendious Views of its . . . Museum. Phila., publ. by B. and T. Kite . . . for sale by them and Joseph Delaplaine.
- MEINERTZHAGEN, R.
1920. Some Preliminary Remarks on the Altitude of Migratory Flight of Birds, with Special Reference to the Palaearctic Region. *Ibis*, Ser. XI, 2:920-936.
- MERRIAM, CLINTON HART
1891. Results of a Biological Reconnaissance of South-central Idaho. *U. S. Bureau of Biol. Surv., North American Fauna No. 5*.
- MERSON, WILLIAM B.
1923. Recollections of My Fifty Years Hunting and Fishing. Boston, Stratford.
- MERSON, WILLIAM B.
1928. Whooping Crane in Saskatchewan. *Auk*, 45:2:202-203.
- MERSON, WILLIAM B.
1934. A Recent and Former Occurrence of the Whooping Crane in Saskatchewan and North Dakota. *Nebr. Bird Rev.*, 2:2:39.
- MILLER, A. H. AND C. G. SIBLEY
1942. A New Species of Crane from the Pliocene of California. *Condor*, 44:3:126-127.
- MILLER, LOYE
1925. The Birds of Rancho La Brea. *Carnegie Inst. Washington Publ.*, 349:63-106.
- MILLER, LOYE
1944. Some Pliocene Birds from Oregon and Idaho. *Condor*, 46:1:26,30.
- MILLER, LOYE AND I. DEMAY
1942. The Fossil Birds of California. An Avifauna and Bibliography with Annotations. *Univ. Calif. Publ.*, 47:4:109.
- MILNE EDWARDS, ALPHONSE
1867-71. Recherches Anatomiques et Paléontologiques pour servir à l'Histoire des Oiseaux Fossiles de la France. Vol. 2. Paris, Masson.
- MILWAUKEE JOURNAL
1940. (Mention of Whooping Crane specimens in the Hoy Collection.) *Milwaukee Journal*, Sept. 10, 1940.
- MITCHELL, H. HEDLEY
1924. Birds of Saskatchewan. *Canadian Field-Naturalist*, 38:6:106.
- MOODY, A. F.
1931. Death of an American Whooping Crane. *Avicultural Mag.*, 4th Ser., 9:1:8-11.
- MOOS, LOUIS L.
1937. Interesting Records of Birds of Western South Dakota. *Jour. Minn. Ornith.*, 1:2:11-12.
- MORGAN, BANNER BILL
1944. Bird Mortality: a Detailed Resumé of Many Known Bird Diseases. *Passenger Pigeon*, 6:2:27-34.
- MORRISON, CHARLES F.
1888. A List of the Birds of Colorado. *Ornith. and Oologist*, 13:11:166.
- MORTON, THOMAS
1632. New England Canaan. *Publ. Prince Soc.*, (1883). "NARRAGANSETT"
1872. Whooping Crane. *Turf, Field and Farm*, 15:8:114-115.
- NATURE MAGAZINE
1930. Michigan Protection. 16:3:190.
- NAUMAN, E. D.
1931. Birds of Early Iowa. *Iowa Bird Life*, 1:1:3.
- NEHRLING, H.
1882. List of Birds Observed at Houston, Harris County, Texas, and Vicinity and in the Counties Montgomery, Galveston and Fort Bend. *Bull. Nuttall Ornith. Club.*, 7:3:223.
- NELSON, E. W.
1877. Birds of North-eastern Illinois. *Bull. Essex Inst.*, 8:9-12, p. 133.
- NELSON, E. W.
1929. The Whooping Crane Continues to Visit Louisiana. *Condor*, 31:4:146-147.
- NELSON, THOMAS HUDSON
1882. Small Birds Carried by Cranes in their Migrations. *Zoologist*, 3rd Ser., 6:73.
- NETTING, M. GRAHAM
1927. Amphibians and Reptiles in Relation to Birds. *Cardinal*, 2:2:28.
- NEWCOMBE, CURTIS L.
1945. The Biology and Conservation of the Blue Crab, *Callinectes sapidus* Rathbun. *Educ. Ser. No. 4. William and Mary College, Fisheries Lab. and Va. Comm. of Fisheries, Richmond*.
- NEW JERSEY STATE MUSEUM, TRENTON
1903. Annual Report (List of the Birds of N. J.). p. 66. Camden (1904).
- NEWTON, ALFRED
1893-96. A Dictionary of Birds. London, Adams and Chas. Black.
- NICE, MARGARET MORSE
1931. The Birds of Oklahoma. Rev. Ed. *Okla. Biol. Surv.*, 3:83-84. Norman, Okla., Univ. Press.
- NUTE, GRACE LEE
1945. A Bird-loving Taxidermist of the 1890's. *The Conservation Volunteer*, 8:29-34.
- NUTTALL, THOMAS
1834. A Manual of the Ornithology of the United States and of Canada. *Water Birds*. Boston, Hilliard and Brown.
- NUTTING, C. C.
1893. Report on Zoological Explorations on the Lower Saskatchewan River. *Bull. Lab. Nat. Hist.*, Iowa State Univ., 2:235-293.
- OBERHOLSER, HARRY C.
1938. The Bird Life of Louisiana. *La. Dept. of Conservation Bull.* 28.

- OBERHOLSER, HARRY C. AND W. L. MCATEE
1920. Waterfowl and their Food Plants in the Sandhill Region of Nebraska. *U. S. Dept. Agr. Bull.* 794: 28.
- OLIVER, S. W.
1948. A Whooping Crane Named Bill. *Audubon Mag.*, 50:4:226-231.
- OLIVER, S. W.
1949. "A Whooping Crane Named Bill." *Audubon Magazine*, 51:6:403.
- OOLOGIST
1889. A Complete List of the Birds of North America arranged according to the A.O.U. Check List; with values for 1890, given for the Eggs of each Species as far as Known. . . . 6:11:214.
- OOLOGIST
1890. A complete List of the Birds of North America arranged according to the A.O.U. Check List; with Values for 1890 given for the Skins of Each Species as far as Known. . . . 7:2:32.
- OOLOGIST
1894. Bird Skins; with a Complete List of the Birds of North America arranged according to the A.O.U. Check List . . . Prices are Quoted for the Poorest and Best Specimens . . . 11:6:220.
- ORNITHOLOGIST AND OOLOGIST
1890. A List of the Birds of Minnesota. 15:9:130.
- PALMER, THEODORE SHERMAN
1902. Legislation for the Protection of Birds other than Game Birds. *U. S. Bureau of Biol. Surv. Bull.* 12, rev. ed., p. 22.
- PARKER, H. W.
1871. Iowa Birds. *American Naturalist*, 5:3:169.
- PEARSE, A. S.
1936. The Migrations of Animals from Sea to Land. Durham, N. C., Duke Univ. Press.
- PEARSON, THOMAS GILBERT
1922. Whooping Cranes (*Grus americana*) in Texas. *Auk*, 39:3:412-413.
- PEARSON, THOMAS GILBERT
1932. Notes on Some Extinct, Rare and Vanishing Birds. *Maryland Conservationist*, 9:4:9.
- PENNANT, THOMAS
1785. Arctic Zoology. Vol. 2. London, printed by Henry Hughs.
- PETERS, JAMES LEE
1934. Check-List of the Birds of the World. Vol. 2. Cambridge, Harvard Univ. Press.
- PETERSON, ROGER TORY
1948. Birds over America. New York, Dodd, Mead.
- PHILLIPS, JOHN CHARLES (given as J. L. Phillips)
1912a. Wintering Cranes in New England. *Avicultural Magazine*, 3rd ser.; 3:8:222-224.
- PHILLIPS, JOHN CHARLES
1912b. The Whooping Crane. *Avicultural Magazine*, 3rd ser.; 3:10:288.
- PHILLIPS, JOHN CHARLES
1926. An Attempt to List the Extinct and Vanishing Birds of the Western Hemisphere with some Notes on Recent Status, Location of Specimens, etc. Reprinted from *Proc. VI Internat. Ornith. Congress*, p. 510. Copenhagen.
- PICKET
1883. The Whooping Crane. *Forest and Stream*, 21:21:407.
- PINDAR, L. OTLEY
1887. A List of the Birds of Fulton County, Kentucky. *Ornith. and Oologist*, 12:4:55.
- PINDAR, L. OTLEY
1924. Winter Birds in Eastern Arkansas. *Wilson Bull.*, 36:4:204.
- PINDAR, L. OTLEY
1925. Birds of Fulton County, Kentucky. *Wilson Bull.*, 37:2:82.
- PITELKA, FRANK A.
1942. Summary of Ecological Studies of Intertidal Flats in California. *Nat. Research Council Report, Comm. Marine Ecology*, 2:18-19 (mimeo.).
- PORSILD, A. E.
1943. Birds of the Mackenzie Delta. *Canadian Field-Naturalist*, 57:2 and 3:27.
- POUGH, RICHARD HOOPER
1938. How Shall We Approach the Pollution Problem? *Trans. 3rd N. Amer. Wildlife Confer.*
- PREBLE, EDWARD A.
1902. A Biological Investigation of the Hudson Bay Region. *U. S. Bureau of Biol. Surv., N. Amer. Fauna No.* 22.
- PREBLE, EDWARD A.
1908. A Biological Investigation of the Athabaska-Mackenzie Region. *U. S. Bureau of Biol. Surv., N. Amer. Fauna No.* 27.
- PRESTON, J. W.
1886. My First White Crane's Nest. *Oologist*, 3:4:43-44.
- PRESTON, J. W.
1893. Some Prairie Birds. *Ornith. and Oologist*, 18: 6:81.
- PRICE, W. ARMSTRONG
1947. Equilibrium of Form and Forces in Tidal Basins of Coast of Texas and Louisiana. *Bull. Amer. Assoc. Petroleum Geologists* 31:9.
- PRICE, W. ARMSTRONG AND G. GUNTER
1942. Certain Recent Geological and Biological Changes in South Texas, with Consideration of Probable Causes. *Proc. and Trans. Texas Acad. Sci.*
- PUTNAM, F. W.
1856. Catalogue of the Birds of Essex County, Mass. *Proc. Essex Inst.*, 1:229.
- RAINE, WALTER
1892. Bird-Nesting in North West Canada. Toronto, printed by Hunter, Rose and Co.
- RANDOM NOTES ON NATURAL HISTORY
1885. Exchange . . . skins wanted . . . eggs wanted, skins for exchange . . . eggs for exchange (advertisement). 2:2:vii.
- REAGAN, ALBERT B.
1908. The Birds of the Rosebud Indian Reservation, South Dakota. *Auk*, 25:4:463.
- RED TRIANGLE
1949. Conoco Turns an Ear to the Plight of the Rare Whooping Crane. March (1949).
- REED, CHESTER ALBERT
1904. North American Bird Eggs. New York, Doubleday, Page.
- REID, D. M.
1932. Salinity Interchange between Salt Water in Sand and Overflowing Fresh Water at Low Tide. *Jour. Marine Biol. Assoc.*, New Ser. 18:299-306.
- REID, RUSSELL
1946. The Whooping Crane. *N. Dak. Outdoors*, 8:10: 12-13.
- RICHARDSON, SIR JOHN AND W. SWAINSON
1831. Fauna Boreali-Americana, or the Zoology of the Northern Parts of British America. 2:372. London, Murray.
- RIDGWAY, ROBERT
1873. Birds of Colorado. *Bull. Essex Inst.*, 5:11:177.

- RIDGWAY, ROBERT
1895. The Ornithology of Illinois. Vol. II, Part 1. Springfield, H. W. Rokker, printer.
- RIDGWAY, ROBERT
1915. Bird-Life in Southern Illinois; Part IV. Changes Which Have Taken Place in Half a Century. *Bird-Lore*, 15:3:192-195.
- RIDGWAY, ROBERT AND H. FRIEDMANN
1941. The Birds of Middle and North America. *Bull. 50, Part IX. U. S. Nat. Mus.*
- ROBERTS, THOMAS S.
1880. The Convolutions of the Trachea in the Sandhill and Whooping Cranes. *American Naturalist*, 14:1:108-114.
- ROBERTS, THOMAS SADLER
1919a. Water Birds of Minnesota, Past and Present. *Min. Game & Fish. Comm., Bienn. Report Period Ending July 31, 1918*, p. 70-71.
- ROBERTS, THOMAS SADLER
1919b. A Review of the Ornithology of Minnesota. *Research Publ. Univ. Minn.*, 7:31.
- ROBERTS, THOMAS SADLER
1936. The Birds of Minnesota. 2nd Ed. Rev., Vol. I. Minneapolis, Univ. of Minn. Press.
- ROBERTS, THOMAS S. AND F. BENNER
1880. A Contribution to the Ornithology of Minnesota. *Bull. Nuttall Ornith. Club*, 5:1:19.
- ROLFE, EUGENE S.
1836. The Passing of Species. *Oologist*, 13:5:42-44.
- ROMANOFF, ALEXIS L. AND A. J. ROMANOFF
1949. The Avian Egg. New York, Wiley.
- ROSS, ALEXANDER MILTON
1872. The Birds of Canada. Toronto, Rosswell and Hutchinson.
- ROSS, BERNARD H.
1862. On the Mammals, Birds, etc., of the Mackenzie River District. *Nat. Hist. Rev., 2nd Ser.*, 2:284.
- ST. QUINTIN, W. H.
1906. Rough Notes on the Birds at Scampston Hall. *Agricultural Mag., New Ser.*, 4:9:284.
- SALVIN, OSBERT AND F. D. GODMAN
1903. *Biologia Centrali-Americana. Aves*, 3. London, Taylor and Francis.
- "SANDPIPER"
1877. Sport in Iowa. *Forest and Stream*, 9:15:288.
- SANDYS, EDWIN AND T. S. VAN DYKE
1904. Upland Game Birds. New York, Macmillan.
- SAUNDERS, AETAS A.
1921. A Distributional List of the Birds of Montana. Cooper Ornithological Club of California, *Pacific Coast Avifauna* No. 14.
- SAUNDERS, W. E.
1910a. Birds of Central Alberta. *Auk*, 27:1:89.
- SAUNDERS, W. E.
1910b. Birds of Alberta. *Ottawa Naturalist*, 24:1:22.
- SCARSDALE AUDUBON SOCIETY
1948. Letters. *Audubon Mag.*, 50:5:321-322.
- SCHORGER, A. W.
1944a. Philo Romaine Hoy: Wisconsin's Greatest Pioneer Zoologist. *Passenger Pigeon*, 6:3:55-59.
- SCHORGER, A. W.
1944b. Benjamin Franklin Goss. *Passenger Pigeon*, 6:4:85.
- SENNETT, GEORGE B.
1878. Notes on the Ornithology of the Lower Rio Grande, Texas, from Observations Made During the Season of 1877. *Bull. U. S. Geol. and Geog. Surv. of the Terr.*, 4:1:61.
- SENNETT, GEORGE B.
1879. Further Notes on the Ornithology of the Lower Rio Grande of Texas, from Observations Made During the Spring of 1878. *Bull. U. S. Geol. and Geog. Surv. of the Terr.*, 5:371-440.
- SETON, ERNEST E. T.
1886. The Birds of Western Manitoba. *Auk*, 3:2:150.
- SETON, ERNEST THOMPSON (ERNEST E. THOMPSON)
1891. The Birds of Manitoba. *Proc. U. S. Nat. Mus.*, 13:841:457-643.
- SETON, ERNEST THOMPSON
1911. The Arctic Prairies. New York, Scribner.
- SETON, ERNEST THOMPSON
1940. Trail of an Artist-Naturalist. The Autobiography of Ernest Thompson Seton. New York, Scribner.
- SHAW, GEORGE AND J. F. STEPHEN
1819. General Zoology, or Systematic Natural History Commenced by the late Geo. Shaw. . . . Vol. XI, Pt. 2, *Aves*, by J. F. Stephens. London, printed for J. Walker, Longman and Co., etc.
- SHELFORD, VICTOR E.
1945. Map of North American Biomes. *Wilson Bulletin*, 57:4:249.
- SHUFELDT, R. W.
1894. On the Osteology of Certain Cranes, Rails and their Allies, with Remarks upon their Affinities. *Jour. Anat. and Phys.*, 29:21,29,31.
- SIMMONS, ALBERT DIXON
1937a. Letter. *Bird-Lore*, 39:3:220.
- SIMMONS, ALBERT DIXON
1937b. A Trumpeter of the Marshlands. *Nature Mag.*, 30:3:142-143.
- SIMMONS, GEORGE FINLAY
1925. Birds of the Austin Region. Austin, University of Texas.
- SLACK, J. H.
1872. Natural History Department. *Turf, Field and Farm*, 15:10:151.
- SMALL, JOHN K.
1933. Manual of the Southeastern Flora. New York, author.
- SMITH, ROBERT H. AND R. P. ALLEN
1948. An Aerial Waterfowl Reconnaissance in the Far North. *U. S. Fish and Wildlife Service, Spec. Scientific Report* No. 60, p. 5-12.
- SNOW, FRANCIS HUNTINGTON
1875. A Catalogue of the Birds of Kansas. 3rd Ed. Kansas City, author.
- SNOW, FRANCIS HUNTINGTON
1903. Notes on the Birds of Kansas and a Revised Catalogue. 5th Ed. *Trans. Kansas Acad. Sci.*, 18:154-176.
- SOPER, J. DEWEY
1928. A Faunal Investigation of Southern Baffin Island. *Bull. 51. Canada Nat. Mus.*, p. 95.
- SPRUNT, ALEXANDER, JR.
1929. The White Legions. *Nature Mag.*, 14:3:168-170.
- SPRUNT, ALEXANDER, JR.
1941. Wings Along the Coast of Texas. *Audubon Mag.*, 43:3:243-244.
- SPRUNT, ALEXANDER, JR.
1945. The Vanished Legions. *Audubon Mag.*, 47:3:130-133.
- SPURRELL, J. A.
1917. Annotated List of the Water Birds, Game Birds and Birds of Prey of Sac County, Iowa. *Wilson Bull.*, 29:3:152-153.

- STANSELL, SIDNEY S. S.
1909. Birds of Central Alberta. *Auk*, 26:4:392.
- STEARNS, R. E. C.
1869. Rambles in Florida. *American Naturalist*, 3:8:401.
- STEARNS, WINFRID A.
1883. New England Bird Life. Ed. by Elliott Coues. Part II. Boston, Lee and Shepard; New York, Chas. T. Dillingham.
- STEPHENS, T. C.
1943. Early Bird Life in Clay County, Iowa. *Iowa Bird Life*, 13:4:65.
- STEPHENS, T. C.
1944. The Makers of Ornithology in North-western Iowa. *Iowa Bird Life*, 14:2:25
- STEVENSON, JAMES OSBORNE
1942. Whooping Cranes in Texas in Summer. *Condor*, 44:1:40-41.
- STEVENSON, JAMES OSBORNE
1943a. Will Bugles Blow No More? *Audubon Mag.*, 45:3:134-139.
- STEVENSON, JAMES OSBORNE
1943b. Will Bugles Blow No More? *Texas Game and Fish*, 1:11:5, 17-19.
- STEVENSON, JAMES OSBORNE
1946. An Old Account of the Whooping Crane in Nebraska. *Nebr. Bird Rev.*, 14:1:21-22.
- STEVENSON, JAMES OSBORNE AND R. E. GRIFFITH
1946. Winter Life of the Whooping Crane. *Condor*, 48:4:160-178.
- STILLWELL, JERRY EDWARD
1939. Check List of Birds of Dallas County, Texas. 3rd ed. Dallas, printed by the Boyd Printing Co.
- STIMPSON, WILLIAM
1867. Illustrations of North American Birds in the Museum of the Chicago Academy of Science. *Trans. Chi. Acad. Sci.*, 1, pt. 1, spp. pl. xix.
- STONE, WITMER
1894. The Birds of Eastern Pennsylvania and New Jersey. Philadelphia, Delaware Ornith. Club.
- STONE, WITMER
1908. The Birds of New Jersey. *N. J. State Mus. Ann. Rep.*, Pt. I, p. 108-109.
- STRECKER, JOHN K., JR.
1912. The Birds of Texas. *Baylor Univ. Bull.*, 15:1:18.
- STRECKER, JOHN K., JR.
1927. Notes on the Ornithology of McLennan County, Texas. *Baylor Univ. Special Bull.* 1:27.
- STREET, MAURICE
1946. Whooping Crane Records. *Blue Jay, Bull. Sash. Nat. History. Soc.*
- STUDER, JACOB HENRY
1881. Birds of North America; Studer's Popular Ornithology. New York, and Columbus, Studer and Co.
- SUTTON, GEORGE MIKSCHE
1931. Notes on the Birds Observed Along the West Coast of Hudson's Bay. *Condor*, 33:4:57.
- SUTTON, GEORGE MIKSCHE
1932. The Exploration of Southampton Island, Hudson Bay. Part II, Zool., Sec. 2, The Birds of Southampton Island. *Memoirs Carnegie Mus.*, Vol. XII, Part II, Sec. 2.
- SWENK, MYRON H.
1913. The Whooping Crane (*Grus americana*) in Nebraska. *Auk*, 30:3:430.
- SWENK, MYRON H.
1921. The Present Status of the Whooping Crane. *Wilson Bull.*, 33:1:37-38.
- SWENK, MYRON H.
1933. The Present Status of the Whooping Crane. *Nebr. Bird Rev.*, 1:4:111-129.
- TAVERNER, PERCY ALGERNON
1919a. The Birds of the Red Deer River, Alberta. *Auk*, 36:2:264.
- TAVERNER, PERCY ALGERNON
1919b. The Birds of Shoal Lake, Manitoba. *Ottawa Naturalist*, 32:9:157.
- TAVERNER, PERCY ALGERNON
1939. Canadian Water Birds. Phila., McKay.
- TAVERNER, PERCY ALGERNON
1949. Birds of Canada. New and Rev. Ed. Toronto, Musson Book Co.
- TAVERNER, PERCY ALGERNON AND G. M. SUTTON
1934. The Birds of Churchill, Manitoba. *Ann. Carnegie Mus.*, 23:31-32.
- TAYLOR, W. EDGAR AND A. H. VANVLEET
1888. Notes on Nebraska Birds. *Ornith. and Oologist*, 13:11:170.
- THOMPSON, ZADOCK
1842. History of Vermont, Natural, Civil and Statistical, in Three Parts with a New Map of the State . . . Burlington, publ. for the author by Chauncey Goodrich.
- THORNTWAITE, C. W.
1941. The Climates of the U. S., pt. 2, pl. 3, of Atlas of Climatic Types in U. S., 1900-1939. *U. S. Soil Conservation Service, Misc. Publ. No. 421.*
- TOUT, WILSON
1901. Ornithology in the Schools. *Proc. Nebr. Ornith. Union*, 2:30-33.
- TOUT, WILSON
1947. Lincoln County, Birds; Lincoln County, Nebraska. North Platte, author.
- TOWNSEND, JOHN KIRK
1899. Narrative of a Journey Across the Rocky Mountains to the Columbia River . . . Philadelphia, Henry Perkins.
- TRINE, MRS. GEORGE W.
1935. Whooping Cranes Present and Lingering Near Red Cloud. *Nebr. Bird Rev.*, 3:3:84.
- TRIPPE, T. MARTIN
1871. Notes on the Birds of Minnesota. *Proc. Essex Inst.*, 6:6:118.
- TRIPPE, T. MARTIN
1872. Notes on the Birds of Southern Iowa. *Proc. Boston Soc. Nat. Hist.*, 15:240.
- TURF, FIELD AND FARM
1872. The Whooping or Sandhill Crane (*Grus americana*). 15:6:89.
- TURNBULL, WILLIAM PATTERSON
1869. The Birds of East Pennsylvania and New Jersey. Glasgow, printed for private circulation.
- TURNER, WILLIAM
1544. Turner on Birds: a Short and Succinct History of the Birds Noticed by Pliny and Aristotle. Ed. by A. H. Evans. Cambridge, Univ. Press. (1903).
- U. S. NATIONAL PARK SERVICE
1942. Fading Trails. The Story of Endangered American Wildlife. New York, Macmillan.
- VAN DYKE, THEODORE S.
1895. Game Birds at Home. New York, Fords, Howard and Hulbert.
- VAUGHN, THOMAS WAYLAND
1914. Building of the Marquesas and Tortugas Atolls and a Sketch of the Geologic History of the Florida Reef Tract. Washington, *Carn. Inst., Publ. 182.*

- VIEILLOT, LOUIS JEAN PIERRE
1817. Nouveau Dictionnaire d'Histoire Naturelle appliquée aux Arts, à l'Agriculture, à l'Economie Rurale et Domestique, à la Médecine etc., par une Société de Naturalistes et d'Agriculture. Tome XIII. Paris, Déterville.
- VISHER, STEPHEN SARGENT
1911. Annotated List of the Birds of Harding County, Northwestern South Dakota. *Auk*, 38:1:9.
- VISHER, STEPHEN SARGENT
1913. An Annotated List of the Birds of Sanborn County, Southeast-Central South Dakota. *Auk*, 30:4:565.
- VISHER, STEPHEN SARGENT
1915. A List of the Birds of Clay County, Southeastern South Dakota. *Wilson Bull.*, 37:2:325.
- VOGT, WILLIAM
1948. Road to Survival. New York, Sloane.
- VRIES, DAVID PIETERSZ DE
1642. Korte Historiæ Ende Journaels Aenteyckeninge (1633-43). Ed. by J. Franklin Jameson in his *Narratives of New Netherland*, 1609-1664. (Original Narratives of Early American History). New York, Scribner, (1909).
- W. L. B.
1887. Whooping Cranes. *Forest and Stream*, 28:2:27.
- WAILES, B. L. C.
1854. Report on the Agriculture and Geology of Mississippi. . . . n.p. Lippincott, Grambo and Co. for E. Barksdale, State Printer.
- WALKER, ERNEST P.
1941. Care of Captive Animals. *Ann. Rep. Smithsonian Inst. for 1941*, p. 351.
- WALKINSHAW, LAWRENCE H.
1949a. Apparent Observations of the Whooping Crane in Central Saskatchewan. *Canadian Field-Naturalist*, 63:2:78-80.
- WALKINSHAW, LAWRENCE H.
1949b. The Sandhill Cranes. *Cranbrook Institute of Science, Bull.* 29.
- WARD, F. C.
1943. Whooping Cranes at Shoal Lake, Manitoba. *Wilson Bull.*, 55:4:245.
- WAYNE, ARTHUR TREZEVANT
1910. Birds of South Carolina. *Contributions Charleston Mus.*, 1.
- WEAKLY, HARRY E.
1937. The Whooping Crane in North Platte, Lincoln County. *Nebr. Bird Rev.*, 5:3:58.
- WEAKLY, HARRY E.
1939. The Whooping Crane and other Birds Seen in Lincoln County in the Spring of 1939. *Nebr. Bird Rev.*, 7:1:30.
- WEAKLY, HARRY E.
1940. Some Recent Nebraska Records of the Whooping Crane. *Nebr. Bird Rev.*, 8:1:32.
- WEAKLY, HARRY E.
1945. Whooping Cranes Again Seen in Lincoln County. *Nebr. Bird Rev.*, 13:1:43.
- WELLS, C. S.
1887. White Crane. *Forest and Stream*, 27:25:487.
- WETMORE, ALEXANDER
1931. The Avifauna of the Pleistocene of Florida. *Smiths. Miscel. Coll.*, 85:2:35-36.
- WHEATON, JOHN M.
1882. Report on the Birds of Ohio. (Ohio Geol. Surv.) Columbus, Nevins and Myers.
- WHITNEY, H. H.
1948. Letters. *Audubon Mag.*, 50:5:322-323.
- WIDMANN, OTTO
1907. A Preliminary Catalogue of the Birds of Missouri. *Trans. Acad. Sci. St. Louis*, 17:56-57.
- WIED-NEUWIED, MAXIMILIAN ALEXANDER PHILIPP, PRINZ VON
1840-43. Voyage dans l'intérieur de l'Amérique du Nord, exécuté pendant les années 1832, 1833 et 1834. . . . Paris, A. Bertrand.
- WIER ("BYRNE")
1882. On the "Ar-Kan-Saw" Prairies. *Forest and Stream*, 19:16:308.
- WILLIAMS, GEORGE C.
1941a. Texas Coastal Region. *Audubon Mag.*, Sec. II, The Season, 138:398.
- WILLIAMS, GEORGE C.
1941b. Texas Coastal Region. *Audubon Mag.*, Sec. II, The Season, 139:478.
- WILLIAMS, GEORGE C.
1941c. Texas Coastal Region. *Audubon Mag.*, Sec. II, The Season, 140:576.
- WILLIAMS, H. V.
1926. Birds of the Red River Valley of Northeastern North Dakota. *Wilson Bull.*, 38:1:24.
- WILSON, ALEXANDER
1814. American Ornithology; or the Natural History of the Birds of the U. S. vol. 8 (ed. by Geo. Ord). Phila., Bradford and Inskeep.
- WILSON, ALEXANDER
1829. American Ornithology. vol. 3. New York. Collins and Co.; Phila., Harrison Hall.
- WILSON, ELLIS E.
1933. A Wounded Whooping Crane. *Iowa Bird Life*, 3:2:25-26.
- WILSON BULLETIN
1945. Ornithological News. 57:2:134-135.
- WOLCOTT, ROBERT H.
1909. An Analysis of Nebraska's Bird Fauna. *Proc. Nebr. Ornith. Union*, 4:2:35.
- WOLLEY, JOHN, JR.
1859. On the Breeding of the Crane (*Grus cinerea*) in Lapland. *Ibis*, 1:2:191-198.
- WOOD, NORMAN A.
1923a. A Preliminary Survey of the Bird Life of North Dakota. *Univ. Mich. Mus. Zool., Miscel. Publ.* 10:10,24-25.
- WOOD, NORMAN A.
1923b. Whooping Crane in North Dakota. *Auk*, 40:4:692.
- WOOD, NORMAN A.
1925. New and Rare Birds in North Dakota. *Auk*, 42:3:452.
- WOOD, WILLIAM
1629-34. New England's Prospect. *Publ. Prince Soc.* (1865).
- WOODRUFF, FRANK MORLEY
1907. The Birds of the Chicago Area. *Chicago Acad. Sci., Nat. Hist. Surv. Bull.* 6:56-57.
- WORTH, C. BROOKE
1940. Egg Volumes and Incubation Periods. *Auk*, 57:1:53.
- WRIGHT, MURIEL H.
1929. Some Geographic Names of French Origin in Oklahoma. *Chronicles of Okla.*, 7:2:191-192.
- WYMAN, L. E.
1922. Notes from Imperial Valley. *Condor*, 24:5:182.
- YOUNGORTH, WILLIAM
1931. Notes from Sioux City. *Iowa Bird Life*, 1:1:11.
- YOUNGORTH, WILLIAM
1935. The Birds of Fort Sisseton, South Dakota: a Sixty Year Comparison. *Wilson Bull.*, 47:3:217.

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