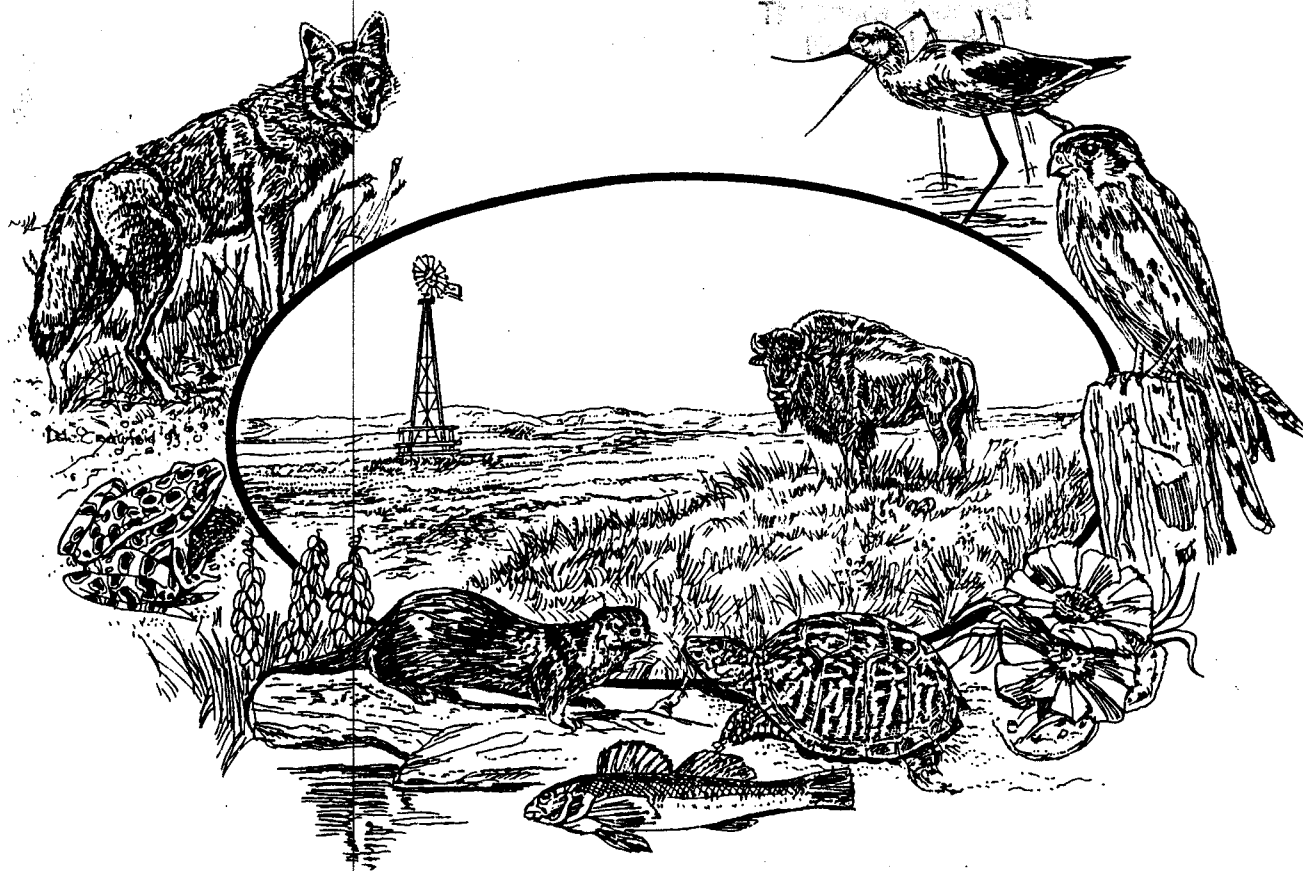


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A BIOLOGICAL SURVEY OF FORT NIOBRARA AND VALENTINE NATIONAL WILDLIFE REFUGES

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Final Report
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**A BIOLOGICAL SURVEY OF FORT NIOBRARA AND
VALENTINE NATIONAL WILDLIFE REFUGES**

edited by

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EXECUTIVE SUMMARY

Pursuant to an agreement reached between the Assistant Regional Director, Refuges and Wildlife, Region 6, Fish and Wildlife Service, and the Director, National Ecology Research Center, Fish and Wildlife Service, a Biological Survey of the Vertebrates of Fort Niobrara and Valentine National Wildlife Refuges was conducted. Field work commenced April 1991 and concluded September 1992. This is the Final Report on this work.

The objectives of the study were to: (1) summarize vegetation and landscape alterations occurring since about 1850; (2) determine what vertebrates historically inhabited the areas of the refuges; (3) conduct biological surveys to confirm current presence or absence of vertebrates, excluding fishes; and (4) identify changes that may have caused extirpation or invasion of species and provide management recommendations. At the request of Region 6, the bird portion of the study was expanded in the second year to allocate more effort to species composition, habitat relationships, and timing of migration of birds, especially Neotropical migrants.

The Final Report includes an Introduction, followed by five chapters that discuss faunal and floral change in the Sandhills since 1850; historical distribution of fishes; and historical distribution, faunal changes, and current status of amphibians and reptiles, birds, and mammals. A summary of management concerns and suggestions for further study concludes the report.

The vertebrate groups differ considerably in relative ease of observation, in the completeness of each group's historical record, relative importance to early explorers and naturalists, and extent and refinement of current scientific knowledge. These differences are clearly reflected in the individual chapters, with certain kinds of information differing from group to group. In general, amphibians are most poorly known and difficult to study, birds are somewhat better known historically and quite well understood in terms of present-day distribution and abundance, and mammals tend to be well known in an historic sense yet more like the herpetofauna in terms of our modern-day understanding.

We found no crises requiring immediate attention or change. Our recommendations are suggestions for further study and thus serve to identify potential long-term problems that can be influenced with the acquisition of new data and development of new management plans. We suggest specific ideas for studies of upland Sandhills, wet meadows, ponds and lakes, and woody habitats to elucidate how they can be maintained, enhanced, or managed to help preserve biological diversity. Some of our habitat concerns suggest opportunities for experimental studies of the use of grazing as a management tool in the Sandhills. Aquatic habitats are being well managed for turtles, which need to be protected from commercial collectors, but are not so well-managed for amphibians.

We also recommend: additional inventory/monitoring of nongame species, especially those which we were unable to verify on the refuges; further assessments of Blanding's and Yellow Mud turtles; monitoring of several high-priority avian species that are experiencing declines regionally and for which we have specific habitat concerns; experimental studies of grazing by elk, bison, and longhorn at Fort Niobrara National Wildlife Refuge and a re-evaluation of management objectives for those species and where they graze on the refuge; and, finally, an assessment of predator control on the refuges that could include evaluating existing data and assessing faunal changes as a result of predator control.

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INTRODUCTION

by

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In the summer of 1990, W. N. (Skip) Ladd, Jr., Assistant Regional Director, Refuges and Wildlife, Fish and Wildlife Service, Region 6, Denver, and Rey Stendell, Director, National Ecology Research Center (Now Midcontinent Ecological Science Center), Fort Collins, discussed the desirability of initiating a study of biological diversity on one or more refuges in the Rocky Mountains-Great Plains Region. By compiling historical data and assessing the current status of refuge vertebrates they hoped that overall faunal changes could be evaluated. Subsequently, F. L. Knopf prepared a preliminary proposal for the Region's consideration; the proposal was then refined by myself and others and was ultimately accepted by Region 6 as a working document. There was general agreement that this approach to assess historical and current refuge biological diversity was a pilot program that, depending upon evaluation and funding, might be continued.

The objectives of the proposal entitled "A Biological Survey of Valentine National Wildlife Refuge" (VNWR) were to: (1) use historic accounts and photographs to summarize the vegetation and landscape alterations that have occurred since settlement of northern Nebraska by Europeans (circa 1850); (2) determine what vertebrates, including fishes, historically inhabited the refuges; (3) conduct biological surveys and studies to confirm current presence or absence of vertebrate species (excluding fishes); and (4) to the extent possible, identify changes that may have caused extirpation or invasion of species and suggest actions to restore or enhance the native fauna. Final discussions resulted in Fort Niobrara National Wildlife Refuge (FNNWR) being added to the proposal; the two refuges are managed as a complex by the Service and provide both similarities and differences in aspects of their geology, biology, and other features.

A study plan for the work was developed and approved by the Center with a copy sent to Region 6. Although we originally hoped that some or all data could be provided in a Geographic Information Systems-compatible format, funding was not available for this refinement. We agreed that field studies on amphibians, reptiles, birds, and mammals would commence in spring 1991 and continue through summer/fall 1992 with a final report to be provided approximately two years after initiation of work. Specimens collected during the study were deposited in the Service's Biological Surveys Collection in Fort Collins (BS/FC), since re-located to Albuquerque, New Mexico.

Funding for travel, some supplies, and temporary technician salaries was provided by Region 6, whereas the Center funded permanent salaries and provided non-expendable equipment and vehicles. Funding in FY91 was \$53,500 from Region 6 and approximately \$34,800 from the Center. Following discussions after the first year's efforts, and due to regional funding adjustments, it was agreed that in FY92 increased efforts would be made on Neotropical migrant birds to reflect Service priorities, with a slight reduction made in field efforts on herptiles and mammals. However, FY92 regional funding still totaled \$50,000 and the Center's contribution was about \$30,000. Costs in FY93 were borne by the Center and although some travel expenses were incurred, most costs were permanent salaries associated with data analysis and report writing. We estimate those costs at approximately \$40,000. Thus total costs for this effort were about \$103,500 from regional funds and about \$105,000 from Center funds. These estimates do not include Center costs for staff time incurred in revising the Preliminary Draft to Final.

This report begins with a chapter describing the landscape of the Great Plains and northern Sandhills in the mid-1800s. Early travelers to the West tended to comment on large and impressive forms of wildlife (e.g., elk and bison) and often showed little interest in the smaller or more secretive forms, especially of amphibians and reptiles. Thus, our description of the early landscape and its fauna is dominated by accounts of large mammals. Perhaps this is appropriate for, outside of climate and geology, it was these forms that were pre-eminently responsible, in many ways, for shaping both the floral and faunal elements of the Great Plains. At the least, these large, distinctive forms were the very essence of the plains to European eyes unaccustomed to animals of such size and numbers.

As agreed to with the Region and refuges, we present a brief chapter on the historical distribution of fishes in northcentral Nebraska, with an emphasis on the Sandhills. As we did no field work on fishes, the information in this chapter comprises a literature review and specimen compilation. This chapter provides an historical overview of the Sandhills ichthyofauna and documents the occurrence of 21 species in or near the refuges.

The chapter on amphibians and reptiles exemplifies some of our frustrations in attempting to construct an historic image of early vertebrate communities. Although small "varicolored" turtles were mentioned in one of the earliest accounts (Mackey's 1795 trip *in* Diller 1955) we found, in general, there was little historic information on herptiles. Our work on Sandhills herptiles thus relies more on recent compilations, supplemented by our own field work. We were able to confirm the existence of 22 species of amphibians and reptiles on the refuges. One particularly interesting group is the turtles, comprising six species of generally unexploited populations on Valentine National Wildlife Refuge (VNWR). We used a variety of techniques to sample herptiles but many species appear to be thinly scattered; for example, our pitfall arrays captured a total of 96 amphibians, 32 lizards, and 210 snakes. Opportunistic sampling augmented our information, but relative to the bird and mammal work, samples were small. Nonetheless, our work provides a baseline inventory for herptiles on the refuges, identifies important resources, and suggests some management issues relative to amphibians and reptiles.

In contrast to herptiles, birds represented the opposite extreme in numbers of data points with over 20,000 individuals of 148 species identified in over 3,200 point surveys in the 2-year effort. Furthermore, this primarily diurnal, visible group of vertebrates is generally well-known on the Great Plains and considerable information is available on historic occurrence and population trends. Our study approach to birds was strongly influenced by these factors and reflects a strong habitat orientation to the study of birds on the refuges. The decision in the second year of study to allocate increased resources to species composition, timing of migration, and habitat relationships of birds, especially the Neotropical migrants, resulted in a large complex database containing much information on status and relationships of birds on the refuges. Although such studies are perhaps too time-consuming to be continued by refuge staff, they have provided a wealth of detail on birds of the two refuges. We initiated two Breeding Bird Survey routes, one at each refuge, that will be used by refuge staff to continue to monitor birds in the future. A similarity between birds and herptiles is the general paucity of early observations in the Sandhills,

but available information strongly suggests that most species we recorded were present historically. There have been some changes, some perhaps related to vegetation changes, but in general the avifauna is intact and healthy.

Mammals, as a group, are more like herptiles in terms of number of species (about 55 as compared to 22 confirmed species) and somewhat more like birds in our knowledge of their past distribution, abundance, and status today. As noted above, our knowledge is particularly good for large mammals and their population trends over time. However, small mammals are often poorly known, their habitat relationships incompletely understood, and they are difficult to study due to their generally nocturnal habits. Nonetheless, it is perhaps for mammals that we have been able to best document faunal changes over time. This is partly due to the conspicuousness of some forms, but perhaps also due to happenstance because early naturalists obtained both specimens and observations of some smaller forms. Because of the moderately good historical record for mammals we chose to present much of the information in the form of species accounts and to allocate the current and historic species to extant, extirpated, invading, and introduced categories.

Finally, in the closing chapter, we present a summary of vertebrate resource issues on the refuges as identified by us, and, wherever possible, management recommendations. Our work on the refuge was both privilege and responsibility, and both our time and data suggested that native Sandhills habitats and vertebrate fauna are generally in good health and being appropriately maintained for posterity on the refuges. Many dramatic changes in the fauna predate either preserve or refuge establishment. Other changes have occurred because of political and real-world constraints, such as the need to control fires to prevent loss of human life or property. In many cases the specific answers to resource issues and how to address them from a management perspective may continue to elude us.

I thank the curators and staff of the following institutions for providing records of vertebrates from Cherry County: American Museum of Natural History (AMNH); California Academy of Sciences (CAS); Carnegie Museum of Natural History (CM); Chicago Academy of Sciences (CHAS); Cornell University (CU); Field Museum of Natural History (FMNH); James Ford Bell Museum of Natural History, University of Minnesota at Minneapolis (MMNH); Museum of Comparative Zoology, Harvard University (MCZ); Museum of Natural History, University of Kansas (KU); Museum of Natural History, Wayne State University (WSMNH); Museum of the High Plains, Fort Hays State University (MHP); Museum of Vertebrate Zoology, University of California at Berkeley (MVZ); Natural History Museum of Los Angeles County (LACM); Peabody Museum of Natural History, Yale University (YPM); Philadelphia Academy of Natural Sciences (ANSP); San Diego Natural History Museum (SDNHM); Southern Illinois University at Carbondale (SIUCM); Southern Illinois University at Edwardsville (SIUE); United States National Museum of Natural History (USNM); University of Colorado Museum, University of Colorado (UCM); University of Illinois Museum of Natural History, University of Illinois (UIMNH); University of Michigan at Ann Arbor (UMMZ); University of Nebraska at Kearney (UNK); University of Nebraska State Museum, University of Nebraska at Lincoln

(UNSM); University of Nebraska at Omaha (UNO); and Western Foundation of Vertebrate Zoology.

I wish to thank Wayne King, without whose support and patience this study would not have been possible. Throughout our tenure on this project, Wayne assisted in the myriad of details attendant to such a study, ran interference with others as necessary, and always believed in what we were trying to do. I appreciate the support of R. L. McCue and the Service's Grand Island office for additional financial assistance in 1992. The support of Skip Ladd and Rey Stendell was essential to conducting the study and I appreciate their willingness to proceed, often in the face of daunting financial obstacles, and their forbearance as the study neared completion. Finally, I appreciate the assistance and support of staff at FNNWR and VNWR. It is always awkward and inconvenient to adjust to the "invasion" of one's domain by outsiders. Yet, staff of the two refuges not only tolerated us, but frequently went out of their way to assist us, accompanied us on our rounds, brought us the occasional specimen, and shared their intimate knowledge of this unique area with us. I especially appreciate the support, assistance, and knowledge of Len McDaniel, Bob Ellis, Mark Lindvall, Kathy McPeak, and Jim Sellers.

Production of the Draft Final Report and this Final Report would not have been possible without cooperation from the various authors and I appreciate their continued willingness to participate in this venture. Three people have been especially important in producing the two reports; Mike Jennings and Cindy Ramotnik oversaw virtually all aspects of collating chapters, figures, and tables into the Draft Final Report and I appreciate their contributions. Cindy also helped with the Final Report. Dora Ibarra Medellin produced the preliminary draft report and assisted with the final version and I am grateful for her assistance. Dale Crawford provided the fine original cover art for both reports.

**A PORTRAIT OF FAUNAL AND FLORAL CHANGE
IN THE SANDHILLS OF NORTHERN NEBRASKA**

by

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THE NORTHERN AND CENTRAL GREAT PLAINS IN 1850

Zoological study of the Great Plains and West generally commenced in 1832 when John Kirk Townsend and Thomas Nuttall became the first biologists to cross the continent with the Wyeth Expedition. Townsend's travel log (Townsend 1839) plus the writings of nineteenth century explorers (Frémont 1845; Stansbury 1852), adventurers (e.g., Irving 1835), and travelers along the Platte River Road (Mattes 1988) provide some insights into the native fauna of the Great Plains that have relevance to the Sandhills.

Heavily wooded stream bottoms and uplands of fire-maintained tall grasses characterized eastern Oklahoma, Kansas, and Nebraska. Wapiti, pronghorn, and deer were abundant, as were wolves, mountain lion, and black and grizzly bears. Extensive herds of bison were not seen until travelers were further west, with only straggler bison generally seen east of a line from El Reno, Oklahoma through Hays, Kansas, and North Platte, Nebraska. Because tall and mid-grasses do not cure well (i.e., retain their nutritive quality) bison generally moved eastward into the mid-grass region with greening of grasses each spring, then returned to the short-grass prairie later in the season.

Probably the best historical evidence of these annual movements are Woodhouse's (1853:57) comments recorded during Woodruff's surveys of the Creek Reservation northern boundary in Oklahoma. Early travelers often comment on seeing small groups of very old bull bison first as they moved westward. These bison were effectively "stranded" in these eastern, marginal grasslands where they would die. The historical scarcity of bison in the mid-grass region of central Nebraska is manifest in records that hunters from the Pawnee villages on the Loup River journeyed semi-annually to hunt on the short-grass prairie between the Republican and Smoky Hill rivers of northwestern Kansas (Hyde 1974). In contrast to the bison, large cervids were better suited to survive winters on the eastern plains by browsing deciduous vegetation.

Observations on the status of large animals on the Upper Missouri as of 1855-57 were made by Hayden (in Warren 1875:90-91), who noted that many of them are "fast passing away, and in a few years must become extinct." He said buffalo were gathering into a smaller area and were annually decreasing at a rapid rate but that they were still quite abundant in the Platte River Valley. Warren (1875), in a footnote, noted the propensity of buffalo to move annually and seasonally. Hayden believed that all larger animals (buffalo, elk, deer, pronghorn, bighorn, and beaver) were more abundant in the Yellowstone valley than in any other portion of the Upper Missouri. He said beaver were increasing rapidly now that major trapping had ceased and that many mountain streams literally swarmed with them. Regarding the distribution of raccoons, he said they were seldom seen beyond the frontier (i.e., the Missouri River in eastern Nebraska). Hayden saw skins of bobcats, wolves ("most abundant where the buffalo range"), coyote ("exceedingly abundant"), and foxes.

In 1873 General D.S. Stanley led the North Pacific Railroad Expedition to the Dakota and Montana territories and was accompanied by the naturalist J.A. Allen. Although this expedition

was well north of the Sandhills his observations shed light on the general nature of the northern plains at this time. Allen (1874) noted that although this region was little frequented by white men, considerable changes in the relative abundance of the larger mammals had already been effected by human agency. He believed that bison had disappeared east of the Yellowstone, as far up as at least the Tongue River, and with it the coyote and wolf. The grizzly bear and beaver were sparsely distributed, the bighorn occurred sparingly in the Badlands, and the pronghorn was the most numerous large mammal and the only herbivore still generally distributed. Allen's narrative suggests several animals were showing population decreases including coyote, wolf, elk, mule deer, bighorn sheep, prairie dog, and "striped gopher" (probably the thirteen-lined ground squirrel). House mice, introduced from Europe, were already common in a one-year-old fort.

THE HISTORICAL SANDHILLS LANDSCAPE (1850-1900)

The above image of the more conspicuous Great Plains elements seems consistent with fragments of information from the Sandhills, although the sparse written record precludes an accurate historical list of native species in the Niobrara/Valentine region circa 1850. The absence of information may be explained partly by the fact that the Niobrara River was not used as a major overland passage by early western explorers (Fig. 1). Rather, the Missouri to the north (which permitted boat travel and was key to the beaver trade) and the Platte to the south, whose broad, flat ("Platte" is from the French for "flat") floodplain favored overland travel, were the major avenues of early movements to the west. However, some insights into the native vertebrate diversity can be gleaned from observations of early explorers and from limited information in the writings of early naturalists who ventured near the Sandhills (Fig. 2).

Historical vertebrate diversity in the Sandhills of northern Nebraska varied from that which is now present. The most difficult task in developing comparisons between 1850 and the present is recreating the historical image of a Great Plains fauna, dominated by large mammals, against which the contemporary fauna can be evaluated. Observations of otherwise reliable travelers may have been biased towards the more conspicuous life forms. Early collections and museum records are often inadequate due to a tendency towards opportunistic rather than systematic collecting by early naturalists. For example, most early travel (and, thereby, collecting) west of the 99th meridian was along river courses, resulting in a disproportionate sampling of riparian versus upland landscapes (cf. Allen 1874).

Further, early naturalists tended to look for the new and unique specimens, often represented by geographically marginal individuals, rather than local faunal elements. Finally, place names, boundaries, and actual landscapes have changed, often making it difficult to reconstruct routes of early travelers and determine the location of specimens collected. To some extent, insight into the historical fauna of a site must be developed through inference. In the case of the northern Sandhills, such inference is based upon early historical statements about the landscape, its more conspicuous faunal elements, pre-settlement history, and early photographs of the area.

The first group to record their observations of what is now Nebraska were early explorers, fur traders, and missionaries who visited the area in the 1700s and early 1800s. Diller (1955) names several early explorers but notes that their routes are very uncertain. One route that is more certain is that of Mr. J. Mackay, who was the leader of the second expedition sent out by the Upper Missouri Company of St. Louis in 1795. It seems as though Mackay's written account and some maps have not survived, but Diller (1955) attributes other annotated maps in manuscript and print to Mackay. According to Diller, Mackay, during part of his journey, traveled westward north of the Niobrara River, crossing that river "a little below Valentine," and continuing southward past the lakes of Cherry and Thomas counties, and then on south and east. Mackay observed that white bears (perhaps "silvertip" grizzlies, although Smith [1958] attributes the observation to bighorn sheep) were common (Todd Co., South Dakota), described a "great desert of drifting sand without trees, soil, rocks, water, or animals of any kind, excepting some little varicolored turtles, of which there are vast numbers" (Cherry County); and said there are many wild oxen (buffalo) in summer and autumn (Loup County) and many beaver in the Elkhorn River. Smith (1958) and Miller (1990) recount additional details of Mackay's travels.

Captains Lewis and Clark passed through Nebraska in 1804 and 1806 followed by Major Stephen H. Long in 1819-1820 (Jones 1964); neither expedition passed through the Sandhills. Following the discovery of gold in California in 1849 and the subsequent rush of settlers to the West, the United States War Department was assigned dual tasks of surveying the area for wagon, and later railway, routes and protecting those who travelled West (Jones 1964). Of the many reports that emanated from these military surveys, apparently only one discusses the Sandhills. During the period 1855-57, Lieutenant G. K. Warren passed through the Sandhills on two of his three northern plains expeditions. In 1855 Warren traveled from Fort Pierre (South Dakota) to Fort Kearney (Nebraska), which took him directly through the unexplored Sandhills region. In 1857 Warren returned to Nebraska and travelled up the Loup Fork (Middle Loup River?), through the Sandhills north to the Niobrara River, then west to Fort Laramie. Later that year his party returned east along the Niobrara River to its junction with the Missouri (Warren 1875).

Warren (1875:40) described the Niobrara River valley as they moved eastward as destitute of wood, with not even enough to build a campfire. This paucity of timber may have been due to wildfires sweeping across the river valley. Except for occasional pines on distant hills to the north, the valley was described as treeless until near longitude 102°30' (near Rushville), at which point the river entered between high steep banks. Here, wood became more abundant and continuous with pine on the bluffs and small clusters of cottonwood, elm, and ash along the river. Where the river was walled in by high bluffs, Warren (p. 40) described small, deep valleys with luxuriant grass, abundant pine, ash, and oak, and gushing springs of clear cold water. Warren suggested that agriculture would be more productive to the east of 99°20' (western Boyd County), where the valley bottoms are wider with abundant timber. He described (p. 41) Minnechadusa (or Rapid) Creek at its mouth as being about eight yards wide, with a valley about a quarter to half a mile wide with a very fertile soil. The banks were said to be "scantily fringed with small trees."

The Niobrara River likely flowed throughout the year as evidenced by the historical presence of Ponca Indian villages (Brown 1970). The presence of continuously running water suggests that the banks of the Niobrara were historically wooded in the Valentine vicinity. This is in contrast to areas further west where prairie streams, such as the North and South Platte rivers, often dried completely in the summer and then were also subjected to periodic, annual "flushes" from snowmelt in the spring. Those latter streams lacked woody riparian vegetation historically (Knopf and Scott 1990). Comparatively, the Niobrara and Loup rivers are spring-fed streams that do not have high-elevation headwaters.

Early photographs demonstrate the historical presence of woody riparian vegetation along the Niobrara and reveal relatively rank deciduous vegetation (Fig. 3). Photographs from drainages just northwest and southeast of old Fort Niobrara (Fig. 4) also support the image of deciduous vegetation, dominated by cottonwood, occurring this far west along streamcourses in this vicinity. The presence of timber, especially pines, was fundamental to the establishment of a military fort in the vicinity (Buecker 1982) as it also was at Fort Robinson on the White River near Crawford, Nebraska, and at Fort Laramie in Wyoming. Fort Niobrara was established in 1880 to protect white settlers, gold seekers, and fur traders from the Rosebud Sioux (Beed 1936); by 1907 the fort was abandoned but used as a supply depot for five years. Tolstead (1942) discusses the historical presence, cutting, and regeneration of this riparian vegetation in the Valentine area.

Warren (1875:25) described the Sandhills as an area comprising no less than 20,000 square miles (19,300 according to Bleed and Flowerday 1990), "covered with barren sand, which, blown by the wind into high hills, renders this section not only barren, but in a measure impracticable for travel." Warren (p. 26) said the hills varied in height from 10 to 200 feet, often arranged in ridges running east and west. Near the sources of the Loup Fork he found many of the lakes impregnated with salts and unfit to drink (although he notes on p. 18 that some of their animals drank without injury). He noted (p. 26) that the present form of the hills is mainly due to wind and that where grass protects the surface the sand did not drift, but where grass is removed the wind "whirls the sand in the air, and often excavates deep holes."

As he passed through the Sandhills in 1857, Warren noted (1875: 18) that they had been "very much disappointed in the amount of game" and though there was evidence of the country having recently been occupied by large herds of buffalo, "only a few bulls were seen." Warren (1856) found only scattered buffalo chips (to build fires with) and noted that pronghorn were very abundant in the Sandhills proper. The trip must have been uncomfortable given comments on "abundant mosquitoes" and "immense numbers of flies." Although it is unclear if Warren actually saw them, he also referred (p. 28) to clouds of grasshoppers that "occasionally destroy the vegetation." His comments on big game are probably strongly influenced by the wildlife he saw the previous year, 1856, on the Yellowstone River, about which he said (p. 16) they "enjoyed the greatest abundance of large game of all kinds"

Less seems to have been written of the interspersed lakes within the Sandhills, most of which are subterraneanly recharged rather than dependent upon runoff for a water source. Warren (1856) noted that some lakes contained native fishes and this suggests they were permanently watered. Unlike the river bottom of the Niobrara, the lakes (Fig. 3) were sandy bottomed with sedge (*Carex* spp.) shorelines and woody vegetation restricted primarily to scattered willows (Warren 1856; Smith and Pound 1892; Pound and Clements 1900). Grasses were relatively thick around the lakes and provided nesting habitats for many species of water birds (Wolcott 1906).

Fire frequency likely played an important role in determining vegetative components in the riparian habitats of these lakes. An analysis of ponderosa pine fire scars indicated a 5- to 10-year fire "return" interval in the middle Niobrara Valley before settlement (Bragg 1984). Such frequent, historic fires likely precluded significant deciduous, at least cottonwood, establishment around the lakes, although growth of willows might have been promoted.

The paleontologist O. C. Marsh made a series of annual trips from 1870 to 1873 to the West in search of fossils and on the first of these one of his assistants was G. B. Grinnell, whose papers have been edited by Reiger (1972). The first expedition went north from Fort McPherson, near the present town of Maxwell, through the Sandhills past Cody Lake, crossed the Dismal River, and on to the middle fork of the Loup. From here they traveled west past the forks of the Middle Loup and then turned south and proceeded past Dry Lake and into Birdwood Creek. According to Grinnell, he saw big game everywhere along his trip. One herd of elk on the north bank of the Loup numbered from 200 to 250 animals. By far the most abundant big game was the pronghorn, and Grinnell (*in* Reiger 1972: 37) characterized them as being "still nearly in their primitive numbers." Northeast of Cheyenne, Wyoming, later in the trip, Grinnell saw a herd of over 500 pronghorn.

In the summer of 1872 Grinnell and others made a hunting trip south of the Republican River and he noted that the streams south of the Republican were rich with wildlife including elk, deer, turkey, wolves, bald eagles, and "buffaloes ...by thousands." By 1872 buffalo rarely advanced as far north as the Platte, but south of the Republican they were abundant and could still (p. 59) "blacken the plains." On a hunt in 1873, somewhere on the Loup, Grinnell's party saw a herd of 20 elk and Grinnell killed one. They found and killed elk on several occasions over the next five days. In 1874 Grinnell traveled with Custer through the Black Hills where big game likewise was still abundant.

In 1873 Marsh made another paleontological expedition through the Sandhills and clearly reached what is now Cherry County. This trip is recounted in the diary of Dr. Maghee (or McGhee; Lindsey 1929; Smith 1958). The 1873 party left North Platte and travelled up the North Platte River to Birdwood Creek where they turned north, crossed the head of the Dismal River and proceeded across the Sandhills to the Niobrara River south of Gordon. They then traveled down the Niobrara and near Valentine they turned south and took a route not unlike the present route of Highway 83 to North Platte.

In general, Marsh's party saw large numbers of pronghorn, elk, and (mule?) deer throughout their journey. They also comment on seeing beaver (or sign), coyote, and "red deer" (white-tailed deer?). Maghee described the valley of the Niobrara as winding and fertile, with cedar trees of great size, and large pines in the canyons. It appears they spent several days near the confluence of the Minnechaduza and Niobrara, an area described as a magnificent camp with a swift clear stream, wooded at its mouth, with a beautiful grove of timber to the north. Bear hunting was mentioned, but there is no record that they were successful. Fish were caught occasionally, as was a beaver kitten. Although the party must have traveled near VNWR (Lindsey's map depicts their route as being just east of Marsh Lake), it is a severe hailstorm that fills most of the Doctor's diary at this point. He commented on the most "ellegant scope of country" with a well watered "lake and pond valley" of "surpassing beauty and fertility" as they passed through the area.

The fauna of the Sandhills was changing by the 1870s and 1880s as shown in some of the recollections published in Beel (1986). A cowboy named Rowley saw a buffalo bull south of the Snake in the early 1880s and claimed that the next spring hunters killed two buffalo 75 mi south. These were the "last wild buffalo he heard of." Around 1882 near Bull Lake (west of Valentine NWR), Rowley shot a "spike-horn buck elk, the only one he ever saw there." Other recollections state that in the early 1870s gray wolves were scattered thickly through the Sandhills, but became scarce as their prey, deer and pronghorn, were killed by advancing settlers. At this time wolves apparently turned to livestock and were said to prey on yearling heifers, steers, horses, and mules.

In the spring of 1894, ranchers organized a hunt to kill as many wolves as possible. It was the area between the North Loup and Snake rivers that was most thickly populated with wolves, and the lake country around Hackberry (VNWR) marked the eastern boundary of this area. After several days on the hunt, more than two dozen wolf "scalps" were secured. County records show that in the spring of 1894 a trapper named Pratt collected bounty on 94 wolves. He was required to swear on the bible that the wolves all came from Cherry County. In 1908 the Valentine Reporter said wolf numbers were increasing and a hunt was being organized. Beel (1986) includes an account of a wolf kill as late as 1915 in Cherry County.

Apparently beaver were trapped along the Niobrara for years but by 1901 they were protected in the state. That other wildlife was becoming scarce is shown by a Game and Fish Commission report that indicated there were only 50 deer present in the entire state in 1901-02 (Beel 1986). By the early 1900s, when reports were made of large numbers of animals killed by hunters, the reports were of waterfowl and not large or furbearing mammals.

Some habitat information, gathered in connection with nongame wildlife surveys, is in the journals of several biologists with the Bureau of Economic Ornithology and Mammalogy (later the Bureau of Biological Survey) who worked in the Valentine area from 1888-1890. Vernon Bailey worked near Kennedy, just west of the Headquarters of Valentine NWR, from 9-14 June 1888. He described the immediate area as "high, very sandy hills, grassy valleys, creeks and a few sloughs and lakes, no timber or brush for miles The hills are of clear, white sand, (no

pebbles) but scantily covered with vegetation The tops of some hills are being scooped out into great holes and the sand piled up in some other place The hills seem to me to be formed almost wholly by the wind." On a subsequent trip in April 1890 he elaborated on the nature of the country, noting that "the Gordon Valley has dark fertile soil and produces a fine growth of grass, that of the hills is light sand and the grass is thin and in bunches." He commented that the water in the shallow ponds is strongly alkaline. He apparently found trees and brush only along the Niobrara and its branches and that "back from the streams there is neither tree nor brush."

Bailey then moved north to "Clarks Canon, (10 mi S of Valentine)." We did not find this name on our maps but Bailey's notes state that this is the "canon" through which Gordon Creek flows. The general features of this spot were "very sandy, hilly, deep canons (or ravines), river valleys, and no trees or brush except in vallies." He evidently worked in this canyon as well as the valley of the Niobrara and along a "few plowed fields." Along the river and in the canyons he found a scattering of timber including "yellow pine, red cedar, bur oak, elm, ash, cottonwood, and of bushes, chokecherry, raspberry, willow, plum" and others. He noted that in the canyons and along the river, pine and bur oak are the "most important" trees. At the time he was there, corn was the principal crop in the area.

In April of 1890 Bailey visited the "village" of Valentine and described it as "situated on a level table land forming a wedge shaped point between the Niobrara River and . . . the Minnechaduza Creek . . . the streams flowing through narrow deep valleys with cut and broken sides. In each valley there is considerable brush and timber of . . . oak, elm, cottonwood, boxelder, green ash," red cedar, and yellow pine near the top of the valley banks. Describing the top of the tablelands he said they were "sandy, grassy, and treeless."

A. B. Baker apparently traveled from Trego County, Kansas, to Valentine and back from May to July 1889. He commented that south of the Middle Loup the hills are "composed entirely of yellowish-white sand and are covered very sparsely with grass. The valleys between are . . . covered more thickly with grass than are the hills. There is no timber except a very little on the banks of the Dismal River." He stated that north from the Middle Loup the character of the country changed rapidly and that for ten miles "there are Sandhills with fertile table-lands between: then the valleys become lower and more wet, till, at the North Loup they expand into broad marshes. For twenty miles northward from the North Loup River, the marshes and numerous small lakes occupy about one half of the territory, the remaining being isolated areas of Sandhills."

In summary, declines of large wildlife in the Sandhills likely followed a familiar pattern, with relatively dense populations in the early to mid-1800s, prior to the major push of westward expansion. There seems no doubt that in the late 1700s and early 1800s large mammals were common and abundant but as early as the 1860s populations of some species were declining in Nebraska while remaining common in less settled areas (e.g., Yellowstone). By 1870, buffalo, never abundant, were extirpated and major herds were south and west of northern Nebraska; perhaps only pronghorn were still truly abundant. Increasing settlement and breaking of the

prairie to cultivation and grazing continued the decline, often dramatically, up to the turn of the century, when game laws began to be enforced.

THE CONTEMPORARY LANDSCAPE AND FAUNAL CHANGE

Compared with many other areas the faunal-habitat assemblage of the northern Sandhills has changed relatively little since settlement by Europeans. Probably the most significant alteration to this area since 1850 has been in vegetative composition due to fire suppression and all-season grazing of domestic livestock. In the Niobrara valley, pines, bur oak and eastern red cedar have expanded up the south canyon walls and into the surrounding prairie. Steuter et al. (1990) suggest that the increasing canopy cover, reduced fuel load, higher fuel moisture and less frequent fire return will protect the expanding woody vegetation and ultimately result in further expansion of woodland patches. Secondary growths of hardwood, including ironwood, linden, and green ash, have sprouted from much of the old-growth cut by early settlers and are now dominants in the downslope community. Excepting advancement of the pine woodland up the southern canyon walls, much of the flora of the Niobrara valley likely resembles that of 1850.

Of all habitats within the Niobrara/Valentine refuge complex, the Sandhills are the most diverse and possibly least understood. The Sandhills have historically supported grasslands, although the sands may be more stabilized and vegetated at present. Hayden (in Warren 1875) and Wolcott (1906) describe the hills as bare, shifting sands subjected to much wind and only scantily covered by grasses with little to no woody vegetation except yucca. Smith (1892) stated that grass species composition on the Sandhills did not change appreciably from 1839 to 1892, but Frolik and Shepherd (1940) and Bragg (1978) believe that bluestems have decreased in coverage since 1900, possibly due to fire control (Burzlaff 1962). Anecdotal information gathered from long-term residents also suggests that vegetation was less dense during early settlement (M. Beel, pers. comm.), however, changes, if any, in species composition are not known. Some residents attribute these changes to dune stabilization efforts and fire suppression. Not all biologists conducting this study agreed with the generalization that grasses are denser now than in the past, and anecdotal evidence of grouse abundance in the past might suggest more dense cover.

Generalizations regarding landscape changes are problematic at best, since few recent comprehensive studies have been conducted. For example, Bragg (1978) points out that many investigators have described the vegetative composition of the Sandhills but because of variations in location, season, successional stage and aspect, each has reported different results. Given these limitations, a broad assessment of the Niobrara/Valentine landscape includes dunes that are currently stabilized by prairie sandreed, sand dropseed, and sand bluestem (Harrison 1980). Forbs, yucca and cacti, in order of decreasing coverage, constitute the remaining vegetation (Bragg 1978). Species that dominate the dry valleys include cool-season grasses such as wheatgrass and needlegrass, whereas rushes and spikerushes are most prevalent in the wet meadows (Kaul 1990).

The establishment of introduced woody vegetation in the Sandhills, and to a greater extent, along the shorelines of major lakes, suggests significant alterations in contemporary fire regimes. In the absence of fire, eastern red cedar has spread from planted windbreaks into the surrounding Sandhills, while plantings of cottonwood, Chinese elm, hackberry, and black locust are found along the shorelines of major lakes. Native willow still persists on the shoreline of many lakes. Pines also have encroached into the grasslands with fire suppression in recent times (Steinauer and Bragg 1987; Steuter et al. 1990).

Contemporary assemblages of large mammals in the Sandhills prairie are not representative of what the current landscape can support. Even though changes in composition and density may have occurred, the basic floral components of the 1850 landscape are present and viable. Bison, a seasonal wanderer in the Sandhills, is now restricted to pastures within FNNWR. Wapiti, once abundant along riparian habitats, is now also limited to the refuge. The historically abundant pronghorn is now scarce. It should be noted that these significant faunal changes all predate the establishment of both refuges. Only mule and white-tailed deer are likely as numerous and widespread within the Sandhills as they were circa 1850 (and that is because they have recovered from population lows near the turn of the century). Some floral changes, including continued encroachment of woody vegetation and possible changes in grass species composition, may be directly linked to existing management policies, e.g., fire suppression and grazing.

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FIGURE CAPTIONS

- Fig. 1. Travel routes of early western explorers (Goetzmann 1966).
- Fig. 2. Routes of three explorations into Cherry County (Miller 1990).
- Fig. 3. (Top) Minnechaduza Falls (1887) on the Minnechaduza River near Valentine, Nebraska; note rank nature of deciduous woody vegetation in this vicinity. The man with the heavy beard is Jules Sandoz. (Bottom) Fort Niobrara (1886) from a hill north of Niobrara River looking south; note extensive rank riparian vegetation on south side of river and lack of such on north side. Wildfires in Nebraska generally moved in a northwest-to-southeasterly direction. Photographs courtesy of Nebraska State Historical Society, Lincoln.
- Fig. 4. (Top) Along Rosebud Creek, South Dakota (about 1893), approximately 45 km NW of Valentine, Nebraska; again note rank nature of riparian vegetation. (Bottom) The Col. Snyder ranch (1888) at Milburn, Custer County, about 150 km SE of Valentine; note extensive cottonwood floodplain along Middle Loup River in background. Valentine, Nebraska, lies directly on a line between these two locales. Photographs courtesy of Nebraska State Historical Society, Lincoln.
- Fig. 5. Shoreline of Hackberry Lake (1911) showing lack of woody vegetation. Photographs courtesy of Frank Shoemaker Collection, The University Libraries, University of Nebraska-Lincoln.

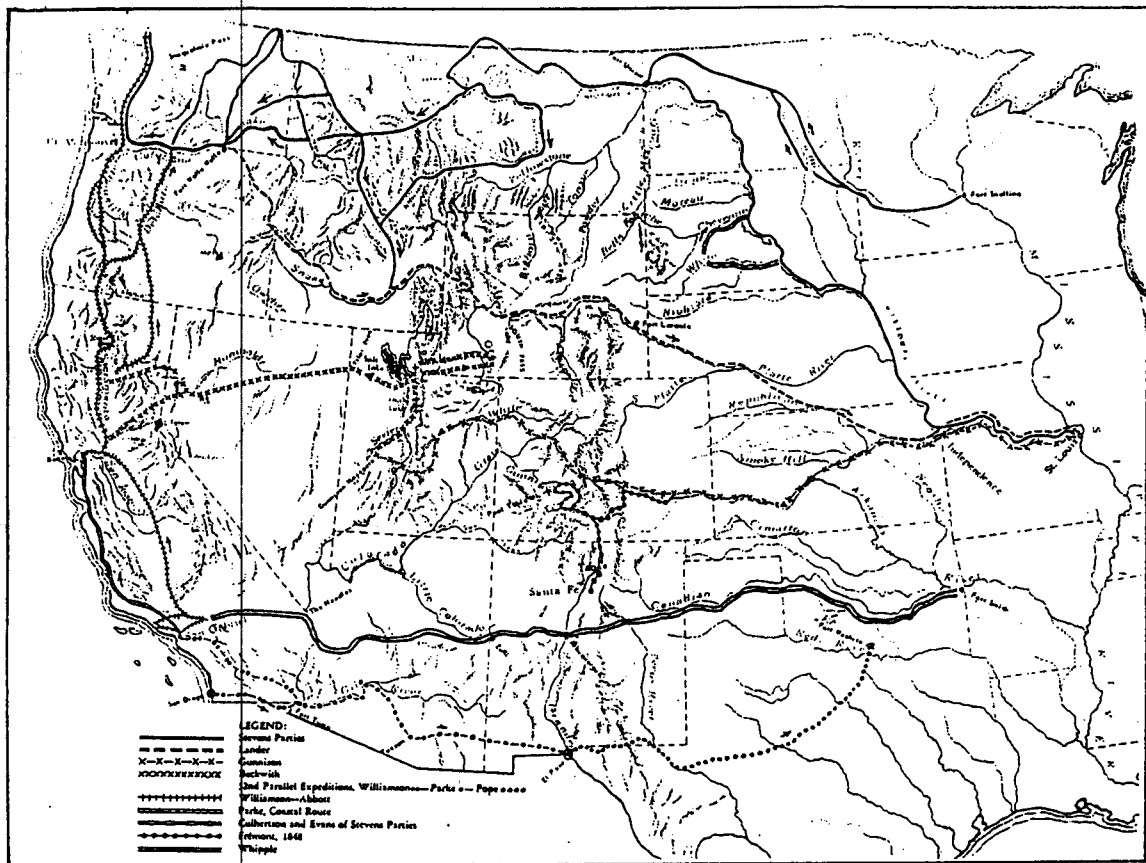


Fig. 1.

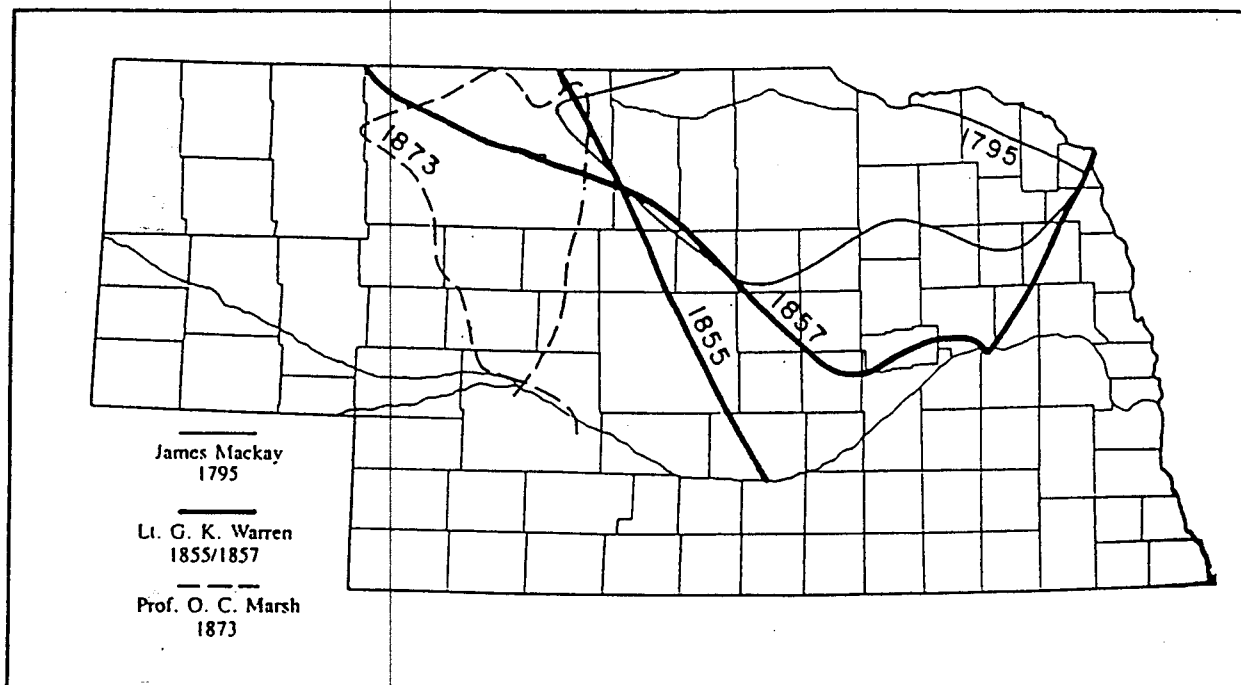


Fig. 2.



John A. Anderson Collection
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Fig. 3.



John A. Anderson Collection
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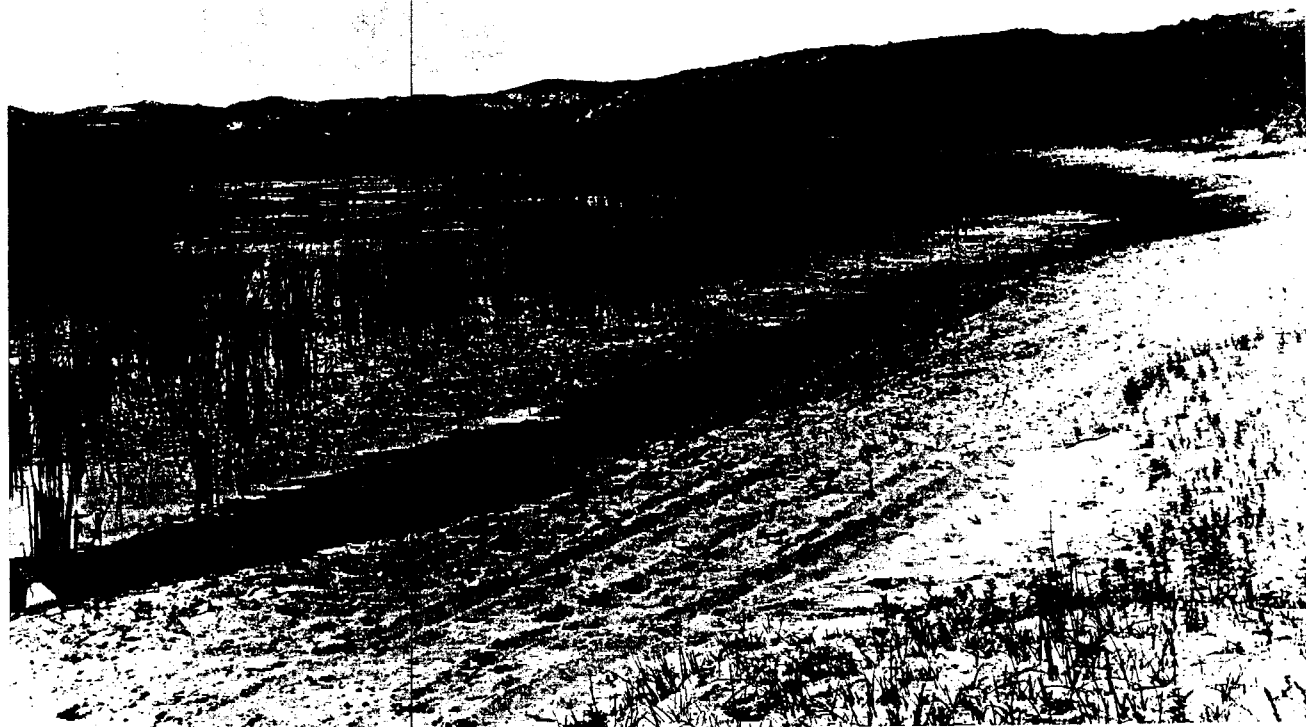


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Nebraska State Historical Society

Fig. 4.



Frank Shoemaker Collection
University of Nebraska



Frank Shoemaker Collection
University of Nebraska

Fig. 5.

**HISTORICAL DISTRIBUTION OF FISHES
IN NORTHCENTRAL NEBRASKA**

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INTRODUCTION

The Niobrara River and its tributaries contain fish communities unique to Nebraska. Repeated glaciation and tectonic activity resulted in the establishment of relict populations of more typical northern, southern, eastern, and western species, as well as fishes common to the northern Great Plains (Hrabik 1990). The historic presence and distribution of these communities has been influenced by the stability of the Niobrara River drainage: stable flows, consistent temperatures, reduced sedimentation, and low dissolved solids (Bentall 1990). While many rivers and streams in the surrounding northern Great Plains have been degraded through agricultural activities, most aquatic habitats within the Sandhills region remain relatively unchanged (Case 1986). This temporal stability suggests that most, if not all, of the historic habitat available to fish communities still exists within the pine-ridge escarpment now encompassed by Fort Niobrara National Wildlife Refuge (FNNWR).

Conversely, Sandhills lakes probably have never been stable enough to support fish assemblages, excepting those with permanent to semi-permanent drainages. Open drainages may have allowed adaptable species to move from lotic to lentic habitats during years of high water. However, most lakes are shallow (< 2 m) and susceptible to drying during drought conditions and oxygen depletion during winter (McCarraher 1972; Hrabik 1990). Additionally, many are slightly to strongly alkaline (McCarraher 1971, 1977). Most lakes, therefore, are physically or chemically incapable of natural establishment and persistence of fish communities.

HISTORICAL ICHTHYOFAUNA

Like other early reports on abundance and distribution of mammals, birds, and plants on the northern Great Plains, much of the historic ichthyological information comes from early explorers and settlers. However, occurrence and distributional information of fishes gleaned from these sources is often wanting because most early travelers were unfamiliar with western fishes or they failed to record and report catches. Information that was recorded was likely biased since early fishing devices were crude and techniques may have selected for larger, edible species. When reported, identification of species was nearly impossible because many common names were interchangeable and often colloquial. The oversight of fishery resources in early Nebraska was evidenced by the fact that early books and pamphlets printed to attract settlers often did not mention fishes (Jones 1963).

Information gleaned from early sources suggests that the clear, cool waters of the Niobrara and its tributaries, within the present-day boundaries of FNNWR, likely maintained fish assemblages dominated by cyprinids, catostomids and percids. More specifically, small stream order tributaries may have contained associations that included the central stoneroller (*Campostoma anomalum*), brassy minnow (*Hybognathus hankinsoni*), bigmouth shiner, blacknose shiner, sand shiner, fathead minnow, longnose dace, finescale dace (*Phoxinus neogaeus*), northern redbelly dace, plains topminnow, white sucker, Iowa darter, and brook stickleback. Near the mouth of tributaries and in the river, associations likely included the

flathead chub, sand shiner, red shiner, bigmouth shiner, river shiner, emerald shiner (*Notropis atherinoides*), suckermouth minnow (*Phenacobius mirabilis*), river carpsucker (*Carpionodes carpio*), white sucker, shorthead redhorse (*Moxostoma macrolepidotum*), green sunfish, and stonecat (*Noturus flavus*). Other less common species that likely occurred in the river were the plains minnow (*Hybognathus placitus*), silver chub (*Macrhybopsis storeriana*), creek chub, plains killifish (*Fundulus zebrinus*), black bullhead (*Ameiurus melas*), and flathead (*Pylodictis olivaris*) and channel catfish (*Ictalurus punctatus*). Scientific names not listed above may be found in Table 1.

Historical fish associations of the Sandhills lakes within VNWR are more difficult to establish, but grass pickerel and fathead minnow were likely well represented in open drainage lakes because of their high alkalinity tolerance. Brook stickleback and Iowa darter were previously reported from streams near VNWR (Table 1) and may historically have entered the headwaters of some low alkalinity Sandhills lakes during periods of high water. Although available information does not indicate distributions including Sandhills lakes, red shiner, river carpsucker, quillback (*Carpionodes cyprinus*), black bullhead, flathead catfish, and green sunfish have affinities for a wide variety of aquatic habitats and therefore may have occasionally found their way into Sandhills lakes.

ICHTHYOLOGICAL ACCOUNTS OF THE NIOBRARA RIVER AND SANDHILLS LAKES

Extensive ichthyological investigations in Nebraska did not begin until the 1890s (Meek 1892, 1894; Evermann and Cox 1896). Later, Bennett (1931), Johnson (1942), Jones (1963), Bliss and Schainost (1973) and Madsen (1985) provided additional information on the distribution of fishes in northcentral Nebraska. However, Jones (1963) suggested that because of the large number and inaccessibility of many streams in the Sandhills region, distribution of many endemic species was still not completely known. Numerous accidental (Jones 1963) and intentional (Johnson 1942) releases of nonendemic species in larger rivers and lakes of northcentral Nebraska further confound distributional data. The impacts these stockings had on abundance and distribution of native fish assemblages are not clear, but the predatory nature of most introduced fish likely affected endemic fish communities where they co-occurred.

Evermann and Cox (1896) recorded 13 species of fish from the Niobrara River and its tributaries near the present site of FNNWR (Table 1). Collections made in the 1930's by Schultz and Weander and Johnson and Wallace (now housed at the National Museum of Natural History and the Museum of Zoology, University of Michigan, respectively) each provided locations of two additional species, while Bennett (1931) located one species in this area (Table 1). Hrabik (1990) listed fishes of the Sandhills and identified 61 species from 14 families that were endemic to headwaters, streams and rivers of this region, but provided insufficient information to determine drainage-specific localities.

Most Sandhills lakes without open drainages probably were not suitable for natural establishment of fish communities (Jones 1963; McCarraher 1971, 1977; Hrabik 1990). Determining historical drainage patterns for specific lakes is difficult because long-term hydrological data are not available. Currently, however, of 28 lakes identified within VNWR, only 9 maintain permanent to semi-permanent drainage (McCarraher 1977). Of these 28, 8 are rated "poor," 7 "fair," and 13 "good" relative to fishery potential (McCarraher 1977). Unfortunately, ichthyological information for Sandhills lakes is scant and often anecdotal, making determinations of historical fish distributions difficult.

On his second journey through the Sandhills, Warren (1856) noted that while stopped at one lake he saw small fish, but provided no additional information. Considering his previous descriptions of highly alkaline lakes in this region, these small fish probably were fathead minnows. Early newspaper accounts indicate that fish were caught in Red Deer and Moon lakes during the mid- and late-1890s (Jones 1963) but the species were not identified. Whether or not these fish represent endemic species is not known because state and federal agencies, as well as private individuals, had extensively stocked northcentral Nebraska waters by this time. Bennett (1931) found grass pickerel in Dewey Lake (VNWR) and by 1954 the species had been collected from 15 Sandhills lakes; more recent surveys indicated that abundant populations remain in only four or five lakes (McCarraher 1977).

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Table 1. Locality records for fish found on or near the present sites of Fort Niobrara and Valentine National Wildlife Refuges.

Species	Locality record	Location
Shovelnose sturgeon <i>Scaphirhynchus platyrhynchus</i>	Johnson (1942)	Niobrara River near Valentine
Goldeye <i>Hiodon alosoides</i>	Evermann and Cox (1896)	Niobrara River
Grass pickerel <i>Esox americanus</i>	Bennett (1931)	Dewey Lake, VNWR
Western silvery minnow <i>Hybognathus argyritis</i>	USNM ¹	Minnechaduza Creek
Fathead minnow <i>Pimephales promelas</i>	Evermann and Cox (1896)	Minnechaduza Creek
Northern redbelly dace <i>Phoxinus eos</i>	Evermann and Cox (1896)	Minnechaduza Creek
Longnose dace <i>Rhinichthys cataractae</i>	Evermann and Cox (1896)	Minnechaduza Creek
Creek chub <i>Semotilus atromaculatus</i>	Evermann and Cox (1896)	Minnechaduza Creek
Blacknose shiner <i>Notropis heterolepis</i>	Evermann and Cox (1896)	Minnechaduza Creek
River shiner <i>Notropis bleinnius</i>	Evermann and Cox (1896)	Niobrara River near Valentine
Red shiner <i>Cyprinella lutrensis</i>	Evermann and Cox (1896)	Niobrara River near Valentine

Table 1. Concluded.

Species	Locality record	Location
Bigmouth shiner <i>Notropis dorsalis</i>	USNM ¹	Niobrara River near Valentine
Sand shiner <i>Notropis stramineus</i>	USNM ¹	Niobrara River near Valentine
Flathead chub <i>Platygobio gracilis</i>	Evermann and Cox (1896)	Niobrara River near Valentine
Lake chub <i>Couesius plumbeus</i>	Evermann and Cox (1896)	Minnechaduza Creek
White sucker <i>Catostomus commersoni</i>	Evermann and Cox (1896)	Niobrara River, widespread
Plains topminnow <i>Fundulus sciadicus</i>	UMMZ ²	Hatchery Creek near fish hatchery
Green sunfish <i>Lepomis cyanellus</i>	Evermann and Cox (1896)	Minnechaduza Creek
Brook stickleback <i>Culaea inconstans</i>	UMMZ ²	Schlager Creek near VNNWR
Iowa darter <i>Etheostoma exile</i>	Evermann and Cox (1896)	Minnechaduza Creek

¹U.S. National Museum of Natural History.²Museum of Zoology, University of Michigan.

AMPHIBIANS AND REPTILES

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INTRODUCTION

Historical records of amphibians and reptiles from the western United States are generally lacking or poorly documented prior to the early 1900s. Because most herpetofauna are diminutive, secretive, and cryptically colored, early explorers likely overlooked many of the amphibians and reptiles as they traveled westward. Additionally, many early accounts of animals included only those species that provided food or sport. Because amphibians and reptiles provided neither may explain why they were rarely mentioned during the early exploration of the west.

The first herpetological record for the Northern Great Plains was provided by Mackay in 1795 (*in* Diller 1955). While traversing the Sandhills of what is now Nebraska, MacKay (*in* Diller 1955:127) noted the area to be "great deserts of drifting sand without trees, soil, rocks, water, or animals of any kind, excepting some little varicolored turtles, of which there are vast numbers." Though we can never be sure exactly which species he saw, we suspect that since he did not mention water, he probably observed ornate box turtles. While traveling through the southwestern part of the Sandhills, Maghee (*in* Lindsey 1929:258) provided an anecdotal report of a "salamander or water lizard" in a lake (See Table 1 for scientific and common names).

By the 1850s, scientific exploration of the west was better established, but reptiles and amphibians still received little attention. For example, while accompanying Lt. Warren in the exploration of the Upper Missouri, F. V. Hayden made collections of the fauna and flora of the region (Hayden 1863). He provided locations for 593 plants, 291 birds, 65 molluscs, 47 mammals, and only 33 amphibian and reptile species. Of the 33 species, 9 were collected in or near the Sandhills of Nebraska (Hayden 1863:177-178): bullsnake, plains hognose snake, garter snake (2 species?), prairie racerunner, many-lined skink, lesser earless lizard, northern prairie lizard, and tiger salamander.

Allen (1872:113) described a collection made in the plains and mountains of the west as including "over fifteen hundred birds, representing about two hundred species, besides large suites of nearly all the mammals of the region visited, including all the large herbivorous species, large collections of fishes, many reptiles and insects." Though this expedition was primarily focused on ornithological collections, herbivorous mammals were well represented; other groups (e.g., reptiles and insects) were not well sampled. Likewise, Neligh (1902) recognized the presence of amphibians and reptiles in northwest Nebraska, but when assigning taxa to life zones he grouped only the plants, mammals and birds into their respective zones.

OCCURRENCE AND DISTRIBUTION OF HERPETOFAUNA IN NORTHCENTRAL NEBRASKA

The Sandhills and shallow lakes on VNWR and the wooded valley of the Niobrara River and its tributaries on the FNNWR provide habitat for at least 26 species of amphibians and reptiles (Table 1). This is a significant proportion of the herpetofauna of the Northern Great

Plains. Lynch (1985) lists 60 species of amphibians and reptiles in Nebraska, but many species are restricted to either the eastern border along the Missouri River (10 species) or the southern border along the Republican River (7 species). Habitat diversity is one factor in the high number of species in Cherry County, but zoogeography is also important. Species from several different regions of the United States come together or have overlapping ranges in northcentral Nebraska.

Three amphibians and four reptiles present on the refuges have continent-wide distributions: tiger salamander, Woodhouse's toad, western chorus frog, painted turtle, eastern yellow-bellied racer, red-sided garter snake, and bullsnake. Two amphibians and four reptiles are eastern species that are widely distributed in the Great Plains: bullfrog, northern leopard frog, common snapping turtle, prairie racerunner, northern prairie lizard, and pale milk snake. One amphibian and four reptiles are also eastern species but are at the margins of their ranges in central Nebraska: Blanchard's cricket frog, western spiny softshell, Blanding's turtle, eastern hognose snake, and northern water snake. Three reptiles are western or southwestern species: many-lined skink, lesser earless lizard, and prairie rattlesnake. Finally, one amphibian and four reptiles are endemic to, but widely distributed in, the Great Plains: plains spadefoot, yellow mud turtle, ornate box turtle, plains hognose snake, and plains garter snake.

Aside from the species with continental distributions, the herpetofauna of Cherry County is composed of about equal numbers of eastern and western species. The combination of habitat diversity and zoogeographic complexity makes the Valentine and Fort Niobrara refuges important for preserving the biological diversity of the Great Plains.

The distribution of the herpetofauna of Cherry County was relatively well known before our study. Hudson (1942) listed 24 species (Table 1), and many specimens have been collected from or near the two refuges. Many of these records resulted from the work of C. E. Burt and his students around 1930 (e.g., Burt and Hoyle 1934), so there is some information on the composition of the herpetofauna when the refuges were established. All of the known recent records have been compiled by Lynch (1985), but he added only one species (plains spadefoot) since Hudson's work.

In this chapter, we compare the occurrence and relative abundance of amphibians and reptiles in the major habitat types at Valentine and Ft. Niobrara NWR, evaluate the status of the herpetofauna, and discuss how habitat changes in the past 50 years may have affected these species.

METHODS

No single technique is adequate to sample amphibians and reptiles (Corn and Bury 1990; Heyer et al. 1994), so we employed a variety of techniques (Table 2). We established permanent transects for trapping terrestrial habitats and used aquatic traps to sample turtles. Several locations on both refuges were also opportunistically searched and specimens collected by hand or, in aquatic habitats, by dip net. In 1991, opportunistic collecting occurred 7-11 April, 13-

18 May, 3 June-3 July, 11-19 July, and 11-23 August. Opportunistic collecting often took place in conjunction with other activities, for example mammal trapping or turtle trapping, so the intensity of effort was sometimes limited. This was true for all opportunistic collecting in 1992 (27-30 April and 11 May-30 June). Some specimens were also obtained from funnel traps used to control bullsnakes at Marsh Lake, a project conducted by VNWR.

Drift Fence Transects.--We established six transects using drift fences with pitfall and funnel traps (Corn 1994) at VNWR and FNNWR during the spring of 1991. Four sites (2 sandhill and 2 wet meadow habitats) were sampled at VNWR (Fig. 1). We sampled two riparian sites at FNNWR (Fig. 1): a floodplain forest along the Niobrara River and along Big Beaver Creek, a tributary of the Niobrara on the north side of the refuge. Each transect consisted of three pitfall arrays, and each array (Fig. 2) consisted of 3, 5-m long, 0.6-m high aluminum drift fences radiating equally (120°) from the center, which contained a 19-liter plastic bucket. Each fence terminated at a funnel trap. One end of each transect was located near an access point (usually a road), but the first array was placed randomly from the access. The second and third arrays were placed on a straight line at 500-m intervals on a compass bearing that placed the entire transect within a given habitat type.

In 1991, transects were opened from early June through late June and from mid-August through mid-September. Total days each transect was open ranged from 51 to 55 days. Transects were left in place over the winter and reopened mid-May 1992 after necessary repairs to fences. All transects were operated continuously for 27 days in 1992, after which all traps were closed. Pitfall buckets, funnel traps and drift fences were removed in September 1992. Traps were usually checked every third day and any captures were usually taken to a field laboratory for identification and measurement. Specimens were deposited in the Service's Biological Surveys Collection in Fort Collins (BS/FC, now in Albuquerque).

We obtained weather data (monthly averages for maximum and minimum temperature and precipitation) from the National Weather Service stations at VNWR Headquarters (Valentine Lakes Game Refuge) and Valentine airport (Valentine Miller Field) for the years 1948-1993 (Earthinfo 1994). We compared the mean monthly values in 1991 and 1992 to the mean values for 1948-1993.

Turtle Trapping.--We used wire box type (modified from Iverson 1979) and mesh hoop (commercial 2-3" mesh) turtle traps in about equal proportions. We set traps at several lakes and marshes (Table 3) to assess aquatic turtle distributions. Traps were baited with cans of tuna fish or sardines, set for 1-5 days, and checked twice per day. We had a total of 323 trap-days in 1991-1992 (Table 3).

Most turtles captured were measured, weighed, and marked with a permanent individual number by filing notches in marginal scutes. Ages of turtles were determined by counting annuli on scutes. Annuli were most distinct (not worn) in Blanding's turtles because it favors soft-

bottom aquatic habitats. Turtles caught opportunistically were retained as specimens and deposited in the BS/FC.

Analyses.--We used total captures from drift fence transects, combined for both years, to compare riparian, wet meadow, and Sandhills habitats. We tested the hypothesis that captures of abundant species and taxonomic groups (amphibians, lizards, snakes) were equal among habitats using the log-likelihood ratio (Sokal and Rohlf 1981). We made no correction for varying trapping effort among transects, because the differences were slight and would have made only fractional differences in the totals for each species.

We compared similarity among transects and habitats by calculating Jaccard's coefficient of similarity between pairs of transects. This statistic is the number of species present on one transect in proportion to the total number of species present on both transects (Pielou 1984). We used multidimensional scaling (Wilkinson et al. 1992) to represent the pattern of similarity among transects in two dimensions.

We estimated the population size of Blanding's turtles at one site (Little Hay Valley marsh, Table 2) from mark-and-recapture data using program Capture (Rexstad and Burnham 1991).

RESULTS

Comparison of Techniques.--We captured 976 amphibians and reptiles representing 22 species on or near VNWR and FNNWR (Table 2). The drift fence transects at VNWR captured 257 specimens (26% of total): 93 amphibians, 19 lizards and 145 snakes. Transects at FNNWR yielded 3 amphibians, 13 lizards and 65 snakes ($\Sigma = 81$, 8%). Opportunistic collections from both refuges, including specimens from VNWR traps for bullsnakes, yielded 438 captures (45%): 197 amphibians, 14 lizards, 93 snakes and 134 turtles. Although numbers of individuals captured by drift fences and opportunistically differed considerably among species, both techniques produced essentially the same species richness for snakes. Drift fences captured more lizards than searches (Table 2). Drift fences provided no turtles whereas opportunistic searches yielded 113 (all but 7 at VNWR).

Drift fences yielded 93 amphibians compared to 173 by opportunistic searches. The plains spadefoot was captured only in a drift fence array, whereas cricket frogs and tiger salamanders were only taken by opportunistic searches. Locations of opportunistic collections are shown in Figs. 3 and 4.

Weather varied between 1991 and 1992 (Fig. 5). In 1991, temperature was similar to the long-term average and May and June were wetter than average. Very little rain fell during the second period of transect sampling in 1991 (August-September). Spring precipitation was below average and summer precipitation was above average in 1992. Temperature was below average in summer, 1992. Most of the transect sampling in 1992 was completed before the onset of cooler, wet weather. Rainfall enhances catchability of amphibians and reptiles (Vogt and Hine

1982; Bury and Corn 1987). Because about one-half of the transect sampling was conducted during dry weather, diversity and abundance of animals captured may have been lower than expected.

Drift Fence Transects.--There were differences in abundance of most species, higher taxonomic groups, and total captures among the major habitat types that were sampled by the drift fence transects (Table 4). In general, all amphibians, all snakes, and total captures were more abundant in wet meadow habitats. Chorus frogs, racers, and plains garter snakes were especially abundant in wet meadows. Prairie racerunners were more abundant in riparian habitats, and fence lizards were only captured in sandhill habitats. Common garter snakes were common in both wet meadow and riparian habitats but only one individual was captured in Sandhills. There were no differences among habitat types in abundance of bullsnares or species richness.

The two wet meadow transects at VNWR were the most similar pair. The similarity index was 0.75, meaning that 75% of all the species present on either of the two transects were present on both. Two pairs of transects had similarity indices of 0.25: the two sandhill transects at VNWR, and sandhill transect 2 and wet meadow transect 4. Multidimensional scaling of the similarities between pairs of transects shows this pattern graphically (Fig. 6). Low values of dimension 1 are correlated with higher species richness and total captures. The two wet meadow transects occur as a fairly tight unit, but the remaining four transects are not similar to this pair or to each other.

Turtles.--We found 6 species and 252 individual turtles on both refuges. This included one western spiny softshell trapped from a mill pond on Minnechaduza Creek in the town of Valentine (Stuart and Scott 1992). Although off of the refuge, this was a new county record and was the only amphibian or reptile we added to the species list for Cherry County (Table 1).

Painted and Blanding's turtles were the most abundant freshwater turtles, and ornate box turtles were abundant in sandhill habitats on VNWR. A few snapping turtles were encountered. This species was probably not well sampled by the types of turtle traps we employed (e.g., the mesh traps were too small to allow entry by mature snapping turtles). No yellow mud turtles were trapped, but a few were encountered on roads next to lakes. This species probably was the least abundant turtle at both refuges, but it was probably also undersampled by trapping efforts.

Turtle trapping resulted in 120 captures of 110 individuals of three species in 289 trap nights at VNWR in 1991 and 1992 (Table 2): 59 Blanding's, 46 painted, and 2 snapping turtles. Another 89 individuals of three species were captured in 28 trap nights at FNNWR in 1991: 82 painted, 6 snapping, and 1 softshell turtle.

At a small marsh in Little Hay Valley on VNWR, traps operated for five consecutive nights captured 34 individual Blanding's turtles. Six of these turtles were recaptured one time and one was recaptured four times. The population estimate from these data, using the null estimator

which assumes no recapture biases, was 66 turtles. The asymmetric 95% confidence interval was 46 to 112.

We also examined scute annuli and were able to detect ages on Blanding's turtles up to year 20 (Fig. 8). Most of the turtles (85%) in the ponds were immatures (<14 years old) and many (51% of total) were young turtles 1-8 years old. In lakes, there were fewer immatures (38%), but the total sample was small (N = 8). Immature Blanding's turtles are generally uncommon in wild populations (Kofron and Schreiber 1985).

DISCUSSION

Current species richness of amphibians and reptiles on Valentine and Ft. Niobrara NWR is similar to historic accounts. We failed to find eight species previously recorded from FNNWR (tiger salamander, Blanding's turtle, yellow mud turtle, lesser earless lizard, northern prairie lizard, eastern hognose snake, northern water snake, and prairie rattlesnake), and two species known from VNWR (many-lined skink and prairie rattlesnake).

There are several potential reasons for failing to find species. We sampled habitats at VNWR more intensively than at FNNWR, and this might account for the greater number of absences at FNNWR. Many species, particularly snakes, are uncommon, cryptic, and difficult to sample. The eastern hognose snake and the northern water snake should be found along the Niobrara River, but are probably rare because FNNWR is near the western extreme of the range of both species. The lists of species compiled from Hudson (1942) and Lynch (1985) were produced over a span of several decades, and it is not unexpected for a short-term survey such as ours to miss rare species.

Rare species can be documented when observations are made over several years. For example, at VNWR, several many-lined skinks were trapped in bullsnake traps at Middle and South Marsh Lake in 1983-1985 (L. McDaniel, VNWR, pers. comm.). Len McDaniel also reports that pale milk snakes, not documented at VNWR by specimens, have been observed dead on roads at the Hackberry Lake headquarters and in bullsnake traps at South Marsh and Pelican Lakes. None of these snakes were deposited in a museum collection. Four prairie rattlesnakes were observed at VNWR from 1976 to 1988: at Pelican Lake sub-headquarters, near Hackberry Lake headquarters, in a bullsnake trap at Middle Marsh Lake, and near Dewey Marsh (L. McDaniel, pers. comm.).

We added one species to those known from each refuge: the plains spadefoot at VNWR (although L. McDaniel told us that they are abundant in some years) and the western spiny softshell turtle from FNNWR (Stuart and Scott 1992). Softshell turtles should be present in the Niobrara River and its larger tributaries in FNNWR, as habitat appears suitable (soft, sand-bottom waters). These additions are not evidence for colonization of the refuges by these species, just as the absences of several species are not evidence of extirpation from either refuge. However, there have probably been quantitative changes in populations of amphibians and reptiles in the past 50

years (compared to Hudson 1942). Land-use and management activities in the Sandhills likely have caused decreases and increases of several species, as discussed below.

Construction of ponds at FNNWR has increased habitat for amphibians and turtles, although use of many of these ponds to rear game fish reduces their suitability for some species (e.g., pond-breeding amphibians). Fisheries management at VNWR has probably reduced populations of northern leopard frogs and tiger salamanders, because these species are most abundant in shallow ponds and lakes without fish. Elsewhere, populations of tiger salamanders and several species of western ranid frogs have been extirpated or declined after introductions of predatory fish (Hayes and Jennings 1986; Bradford 1989; Corn and Jennings, pers. observ.). Although there were native fish in some lakes (Jennings, this report), non-native game fish were introduced in sandhill lakes as early as the 1890s (Jones 1963). Most of the larger lakes at VNWR are now managed for species such as northern pike and largemouth bass, which are large predatory fish that eat amphibians.

Management of some terrestrial habitats likely have had negative effects on the herpetofauna. Vernon Bailey's early field notes (1888) describe the Sandhills with large blowout areas in many of the hills. Blowouts, which have little vegetative cover, are the primary habitats for the northern prairie lizard and the lesser earless lizard (Werth 1972; Jones and Droge 1980; Ballinger and Jones 1985). Fire suppression probably has resulted in greater vegetative cover of the Sandhills with consequently fewer blowouts.

Although grazing appears to be detrimental to terrestrial herpetofaunas in deserts (Busack and Bury 1974; Jones 1981), the absence of grazing may be detrimental to some prairie species. Ballinger and Jones (1985) observed that cessation of grazing at Arapaho Prairie, a Sandhills site southwest of VNWR, resulted in higher vegetative cover and lower lizard populations. Our results were similar. We had drift fence transects in two sandhill habitats. Transect 2 captured 19 individuals of three species of lizards, but transect 1 captured no lizards and was the transect with the lowest overall abundance and species richness. Transect 1 was in an area (George Wiseman Natural Area) that has been protected from grazing and fires for several decades, while transect 2, located near the old Stilwell Homestead, was in an area with a complex history that produced more open vegetation. This area was historically overgrazed but since 1968 has been grazed infrequently (L. McDaniel, pers. comm.).

Our results suggest that wet meadows are important habitats for many species of the regional herpetofauna. These habitats had the highest abundance of amphibians, turtles, and snakes. The pair of meadows that we sampled were more similar to each other than the pairs of sandhill and riparian habitats, which suggests higher continuity of species.

Many of the meadows at VNWR, however, are subject to relatively intensive agricultural use from haying and grazing. Lindvall (1990, unpubl. rept.) indicated that short-duration grazing regimes commonly used in the wet meadow habitats at VNWR may reduce bullsnake numbers. However, the highest rate of capture of bullsnakes by VNWR staff occurred following intensive

fall and spring grazing (L. McDaniel, pers. comm.). The effects of these agricultural activities on the herpetofauna in wet meadows are largely unknown and should be a subject of future research.

The turtle fauna of VNWR appears to be rich in species and with abundant populations; FNNWR has fewer suitable habitats and, in turn, reduced numbers of turtles. The numbers of snapping turtles we observed probably did not represent their true abundance. Furthermore, we trapped no yellow mud turtles (Table 3) but 11 were found opportunistically (Table 2). Mud turtles may have been inactive during our trapping periods or, since our traps were in larger waters not frequently used by the species, not subject to trapping. Also, females of yellow mud turtles spend considerable time on land in the summer (Christiansen et al. 1985) and some remain at the nest (Iverson 1990).

Of particular note is Blanding's turtle, whose range extends from the western edge of the Sandhills through central and northern Nebraska (Lynch 1985). This turtle is listed as a threatened or endangered species in Wisconsin (Ross 1989) and Missouri (Kofron and Schreiber 1985). Blanding's turtles are among the longest-lived freshwater turtles and have delayed sexual maturity at 14-20 years of age (Congdon and van Loben Sels 1992).

Rowe (1992) reported on population features of Blanding's turtles from five localities in western Nebraska. Over three years (1989-1991), he caught 76 turtles, suggesting that the turtle is not common. We caught a total of 87 Blanding's turtles (1 off refuge), all at VNWR. Most Blanding's turtles ($N = 53$) were taken during one trapping period (193 trap nights) in July-August 1991 (Table 3), which indicates a sizeable population on the refuge. We initiated a mark-recapture study of Blanding's turtles at VNWR (Table 3), and these populations merit further study.

Blanding's turtles may favor smaller, shallower waters. For example, four times as many turtles were in ponds than in lakes (Fig. 7). One way to denote habitat use is to examine size class structure. Although a small sample ($N = 8$), 80% of captured turtles in lakes were adults (≥ 190 mm long). Most turtles (68%) in ponds were juveniles (< 190 mm long), and 5 (11%) were small-sized young (< 130 mm long).

MANAGEMENT OPTIONS

Though we were limited to parts of two years of trapping and opportunistic efforts, in general we found the herpetofauna of VNWR and FNWR to be well represented and locally abundant for many species. However, it appears that some of the current management practices used on the two refuges may be detrimental to a few amphibians and reptiles. Below we indicate research needs and suggest future management that may help ensure the persistence of the herpetofauna of Valentine and Fort Niobrara National Wildlife Refuges.

- The upland reptile assemblage at VNWR and FNNWR may require open areas (e.g., possibly created from blowouts or prescribed burns). We suggest that the

responses of reptiles be tested in new open or blowout areas. These could be conducted as experiments in limited areas.

- Wet meadows contain a high diversity and number of amphibians and reptiles. The impacts of haying and grazing on these habitats and the herpetofauna are not well known, except limited information indicating reduced bullsnakes in grazed areas. Therefore, we recommend that investigations be initiated to determine the herpetofaunal response to habitat modification.
- The turtle fauna on the refuges appears to be exceptional in the number of species present and high abundance of populations. These are important traits for study of turtles under natural conditions and for their long-term survival. The abundance of turtles at VNWR has attracted the attention of several scientists (Packard et al. 1985; and on-going research on temperature of painted turtle nests by G. and M. Packard and students). Congdon and Gibbons (1989) pointed out the importance of management of turtles: *"Recognition of the importance of wetlands to species, such as most freshwater turtles, that do not have legal protection status is also worthy of note. This is especially true for species such as the snapping turtle (C. serpentina) that are subjected to commercial harvesting pressures as well as loss of wetland habitat. The low BP [Biomass Production] of soma coupled with high predation rates of eggs indicate that prolonged harvesting pressures of a single population of turtles for meat, even at relatively low levels, cannot be sustained by recruitment and individual body growth."* That turtles are long-lived animals and have a low replacement of individuals in populations, suggests that commercial or intensive fishing harvest of turtles could reduce their numbers in aquatic habitats. Apparently, turtles at VNWR and FNNWR have not been subjected to commercial harvest in recent years and remain as large, undisturbed populations. Because harvest is possible on most other lands, refuge operations should manage for undisturbed turtle populations.
- Blanding's turtles merit additional study as they appear common on VNWR. The status of the yellow mud turtle needs assessment on VNWR and FNNWR. Both of these species have been listed as threatened or endangered in nearby states and as Category 2 species by U.S. Fish and Wildlife Service, and their status needs better assessment on refuge lands.
- Finally, continued attention should be paid to monitoring nongame species on VNWR and FNWR. For example, Scott and Siegel (1992) stated that *"With some exceptions, populations of reptiles and amphibians are more difficult to estimate and monitor than most birds and mammals... Wildlife managers and herpetologists need to work together for the good of the resource; herpetologists must seriously consider the requirements of the wildlife managers, and managers*

must approach management and conservation of reptiles and amphibians in the same rigorous fashion as birds and mammals."

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Table 1. Amphibians and reptiles from Valentine (V) and Ft. Niobrara (N) National Wildlife Refuges, recorded by Hudson (1942), Lynch (1985), and this study.

Species	Hudson		Lynch		This study	
	V	N	V	N	V	N
Amphibians						
Tiger salamander, <i>Ambystoma tigrinum</i>	•	•		•	•	
Woodhouse's toad, <i>Bufo woodhousei</i> widespread	•	•	•	•	•	•
✓ Plains spadefoot, <i>Spea bombifrons</i> drier areas				•	•	•
Blanchard's cricket frog, <i>Acris crepitans</i> wet		•		•		•
✓ Western chorus frog, <i>Pseudacris triseriata</i> wet	•	•	•	•	•	•
✓ Bullfrog, <i>Rana catesbeiana</i> wet		•	•	•	•	•
✓ Northern leopard frog, <i>Rana pipiens</i> wet	•	•	•	•	•	•
Turtles						
✓ Western spiny softshell, <i>Apalone spinifer</i> drier areas						•
✓ Common snapping turtle, <i>Chelydra serpentina</i> wet	•				•	•
✓ Painted turtle, <i>Chrysemys picta</i> wet	•	•	•	•	•	•
Blanding's turtle, <i>Emydoidea blandingii</i>	•		•	•	•	
Yellow mud turtle, <i>Kinosternon flavescens</i>		•	•	•	•	
✓ Ornate box turtle, <i>Terrapene ornata</i> drier areas	•	•	•	•	•	•
Lizards						
✓ Prairie racerunner, <i>Cnemidophorus sexlineatus</i> drier areas	•	•	•	•	•	•
Many-lined skink, <i>Eumeces multivirgatus</i>	•		•			
Lesser earless lizard, <i>Holbrookia maculata</i>	•	•	•	•	•	
Northern prairie lizard, <i>Sceloporus undulatus</i>	•	•	•	•	•	
Snakes						
✓ Eastern yellow-bellied racer, <i>Coluber constrictor</i> widespread	•	•	•	•	•	•
Plains hognose snake, <i>Heterodon nasicus</i>	•		•		•	
Eastern hognose snake, <i>Heterodon platyrhinos</i>		•		•		
✓ Pale milk snake, <i>Lampropeltis triangulum</i> drier areas		•		•		•
Northern water snake, <i>Nerodia sipedon</i>		•		•		
✓ Bullsake, <i>Pituophis catenifer</i> drier areas	•	•	•	•	•	•
Plains garter snake, <i>Thamnophis radix</i>	•	•	•	•	•	•
✓ Red-sided garter snake, <i>Thamnophis sirtalis</i> wooded	•	•	•	•	•	•
Prairie rattlesnake, <i>Crotalus viridis</i>	•	•	•	•		

Table 2. Reptiles and amphibians captured on or near Valentine and Fort Niobrara NWR, 1991-1992.

Species	Valentine National Wildlife Refuge						Fort Niobrara National Wildlife Refuge			
	Transects			Hand	Funnel Trap	Turtle Trap	Off Refuge	Transects		Hand
	1	2	3	4						
	1	2	3	4				1	2	Off Refuge
Amphibians										
<i>Ambystoma tigrinum</i>					1					
<i>Acris crepitans</i>								9		
<i>Bufo woodhousii</i>	2	7			69		18			11
<i>Spea bombifrons</i>	1							1		
<i>Pseudacris triseriata</i>			77	5	48			1		
<i>Rana catesbeiana</i>					1					18
<i>R. pipiens</i>		1	7				6	1	9	
Turtles										
<i>Chelydra serpentina</i>					9	5	1		1	6
<i>Chrysemys picta</i>					36	46	5		4	73
<i>Emydoidea blandingii</i>					16	70	1			9
<i>Kinosternon flavescens</i>					11					
<i>Terrapene ornata</i>					34	1	4			1
<i>Apalone spinifera</i>										1

Table 2 (cont.)

Species	Valentine National Wildlife Refuge										Fort Niobrara National Wildlife Refuge									
	Transects				Hand	Funnel Trap		Turtle Trap	Off Refuge	Transects				Hand	Turtle Trap		Off Refuge			
	1	2	3	4						1	2	3	4		1	2	3	4		
Lizards																				
<i>Cnemidophorus sexlineatus</i>																				
	3														13		1			
<i>Holbrookia maculata</i>																				
	2									2		1								
<i>Sceloporus undulatus</i>																				
	14									10										
Snakes																				
<i>Coluber constrictor</i>																				
	12	6	35	19	3			15							2	20	4			
<i>Heterodon nasicus</i>																				
			2	1	1			1		1										
<i>Lampropeltis triangulum</i>																				
															1		1			
<i>Pituophis catenifer</i>																				
	6	3	6	2	19			29							3	6	1			
<i>Thamnophis radix</i>																				
			9	14	8			1												
<i>T. sirtalis</i>																				
	1	17	12	4	2										6	27	4			

Table 3. Turtle trapping at Valentine and Fort Niobrara NWR.

Location	Dates	Trap-nights	Species (number caught)
1991, VNWR Hackberry Lake	12-14 July 22 August	51	<i>C. serpentina</i> (2), <i>C. picta</i> (14), <i>E. blandingii</i> (5)
Dewey Lake	14-16 July 15-16 August	54	<i>C. serpentina</i> (2), <i>C. picta</i> (4), <i>E. blandingii</i> (5)
Ponds 1.6 km E of Dewey Lake	16-18 July	32	<i>C. picta</i> (1), <i>E. blandingii</i> (8)
Hay Valley marsh	16-20 July	48	<i>C. serpentina</i> (1), <i>C. picta</i> (4), <i>E. blandingii</i> (34)
Hay Valley Lake	18-19 July	4	<i>C. picta</i> (1)
Pond N of Hackberry Lake	18-19 July	4	<i>E. blandingii</i> (1)
1991, FNNWR Big Beaver Creek	18-19 August	6	<i>C. picta</i> (1)
Ponds 0.5 km SE of Refuge HQ	17-19 August	9	<i>C. serpentina</i> (1), <i>C. picta</i> (25)
Minnechaduza Creek, in Valentine	17-18 August	3	<i>A. spinifera</i> (1), <i>C. picta</i> (8)
Niobrara River	19-20 August	2	none
Minnechaduza Creek near hwy. 7	20-21 August	2	none
Pond at City Golf Course	20-22 August	3	<i>C. picta</i> (1)
Pond in 16B3 Pasture	20-21 August	3	<i>C. picta</i> (10)
Pond 6 km NE of Refuge HQ	20-21 August	1	<i>C. picta</i> (12)
Y Pond, .8 km E Refuge HQ	21-22 August	5	<i>C. picta</i> (25), <i>C. serpentina</i> (5)
1992, VNWR Pony Lake	28-29 April	24	none
Homestead Lake	29-30 April	24	<i>C. picta</i> (19), <i>E. blandingii</i> (2)
Pelican Lake	12-13 May	24	<i>C. picta</i> (3), <i>E. blandingii</i> (2)
West Long Lake	13-14 May	24	<i>E. blandingii</i> (2)

Table 4. Total captures of common species and taxonomic groups by drift fence transects in different habitats at VNWR and FNNWR, 1991-1992.

	Habitat			G	P
	Sandhills (VNWR 1-2)	Wet Meadow (VNWR 3-4)	Riparian (FNNWR)		
Species					
<i>Pseudacris triseriata</i>	0	82	1	170.5	<0.001
<i>Cnemidophorus sexlineatus</i>	3	0	13	19.11	<0.001
<i>Sceloporus undulatus</i>	14	0	0	29.70	<0.001
<i>Coluber constrictor</i>	18	54	22	23.15	<0.001
<i>Pituophis catenifer</i>	9	8	9	0.07	0.96
<i>Thamnophis radix</i>	0	23	0	49.46	<0.001
<i>Thamnophis sirtalis</i>	1	29	33	42.13	<0.001
Group					
Amphibians	3	90	3	156.9 1	<0.001
Lizards	19	0	13	26.66	<0.001
Snakes	28	117	65	59.11	<0.001
Total Captures	50	207	81	116.9 6	<0.001
Species Richness	8	8	8	0	1.00

FIGURE CAPTIONS

- Fig. 1. Location of reptile and amphibian transects on Valentine (top) and Fort Niobrara NWR.
- Fig. 2. Amphibian and reptile array design and transect layout.
- Fig. 3. Locations of anuran (A), turtle (B), lizard (C), snake (D), and opportunistic collections on Valentine NWR, 1991-1992.
- Fig. 4. Locations of anuran (A), turtle and lizard (B), snake (C), and opportunistic collections on Fort Niobrara NWR, 1991-1992.
- Fig. 5. Mean monthly temperature (top) and precipitation (bottom) for 1991, 1992, and 1948-1993. Values are averaged from weather stations at VNWR and Valentine Miller Field.
- Fig. 6. Multidimensional scaling of the similarities between pairs of transects. The encircled transects (WMV3 and WMV4) indicate that a greater percentage of species found on either transect were present on both. The remaining four transects were not similar to this pair or to each other.
- Fig. 7. Size of Blanding's turtles captured on ponds and lakes at Valentine NWR, 1991-1992.
- Fig. 8. Age of Blanding's turtles captured on ponds and lakes at Valentine NWR, 1991-1992.

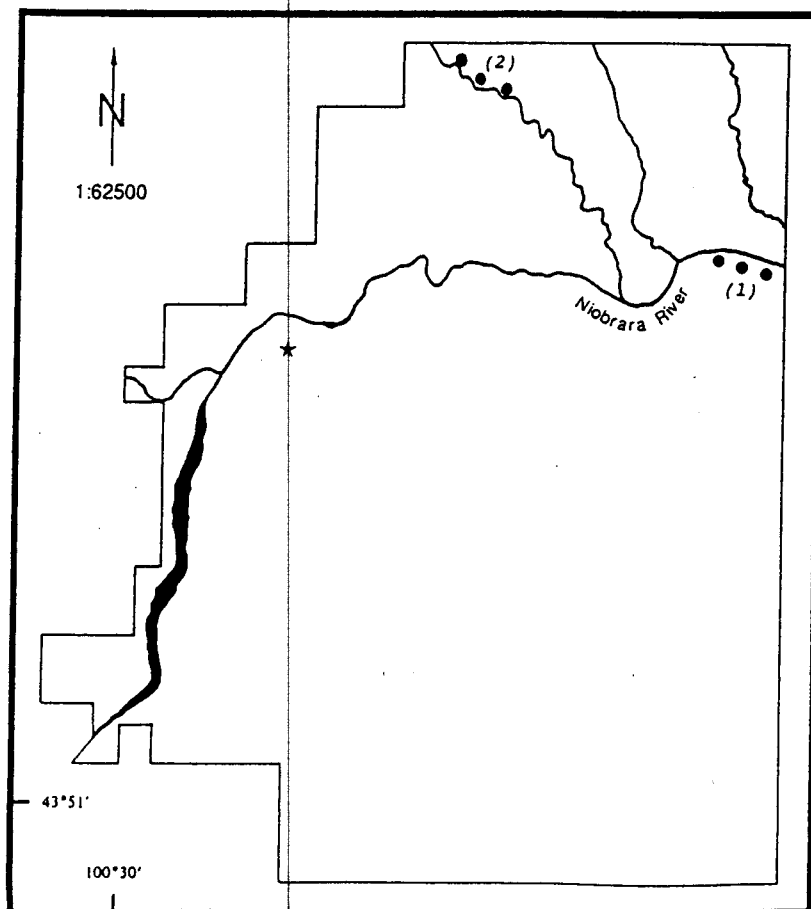
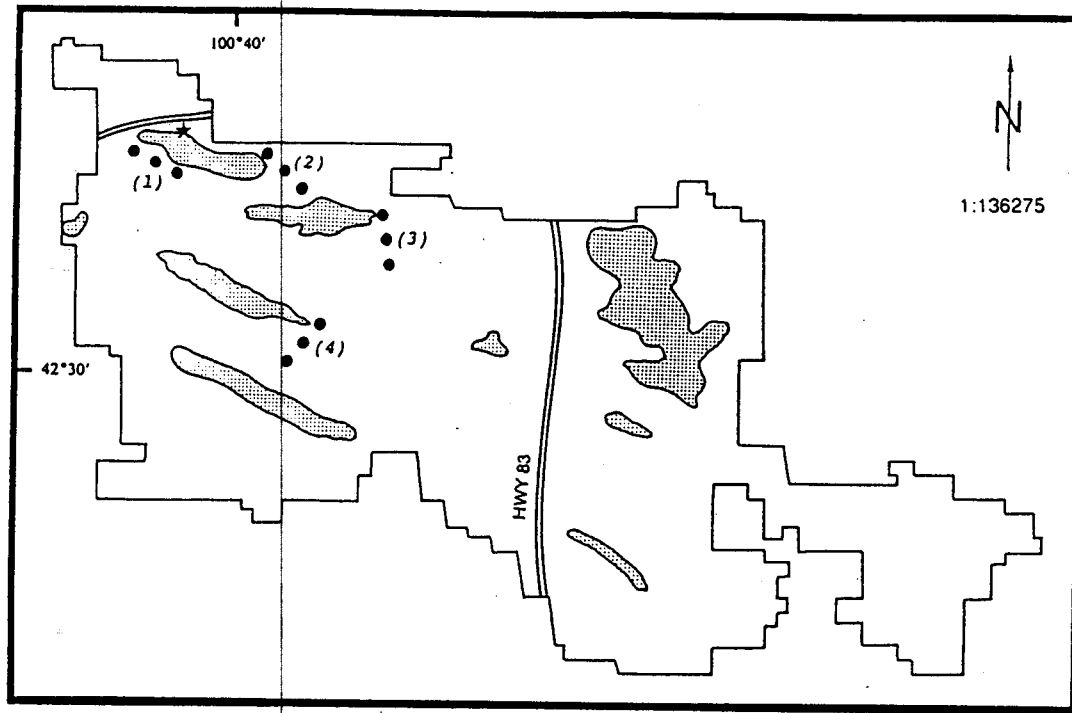


Fig. 1.

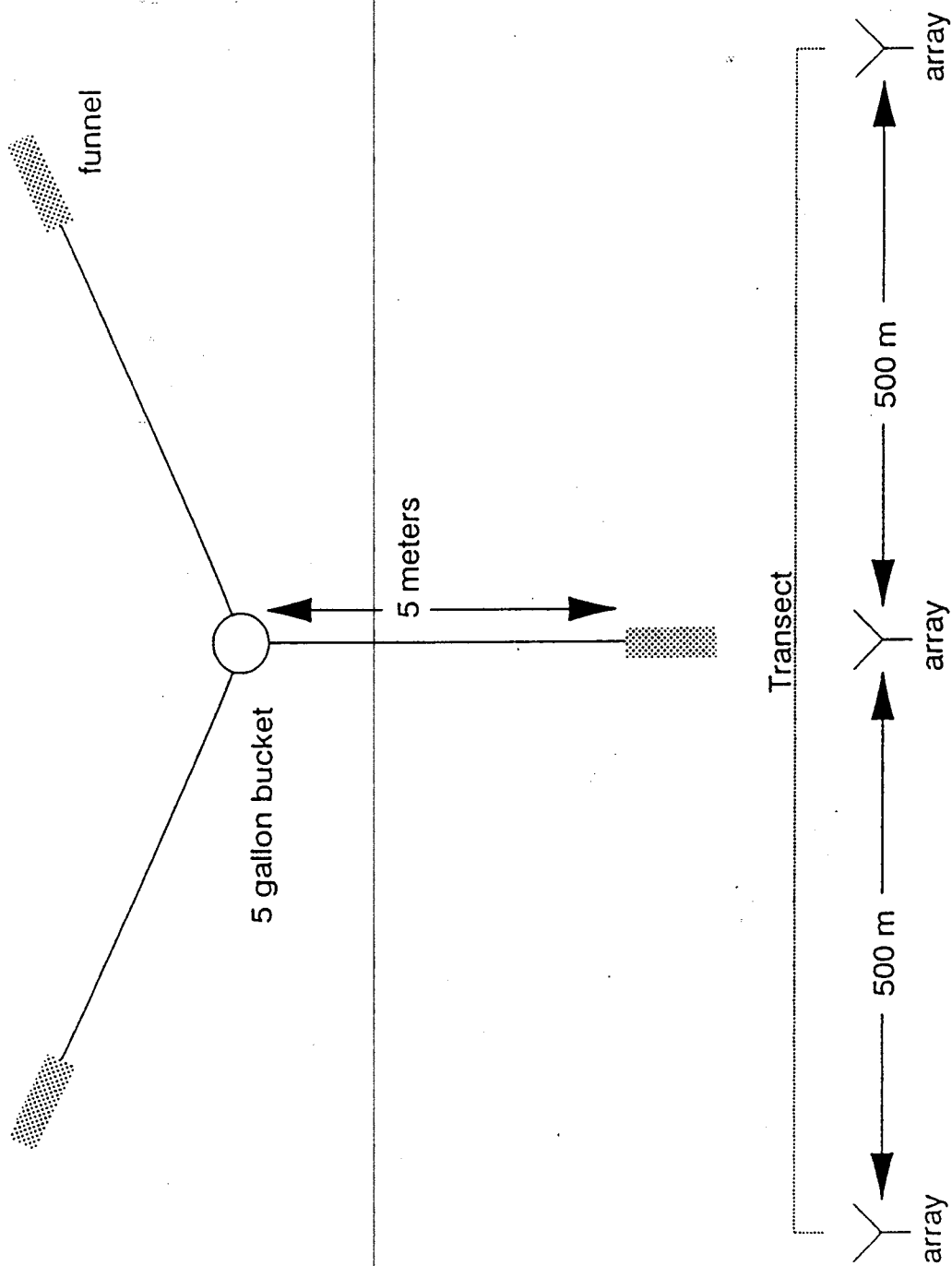


Fig. 2.

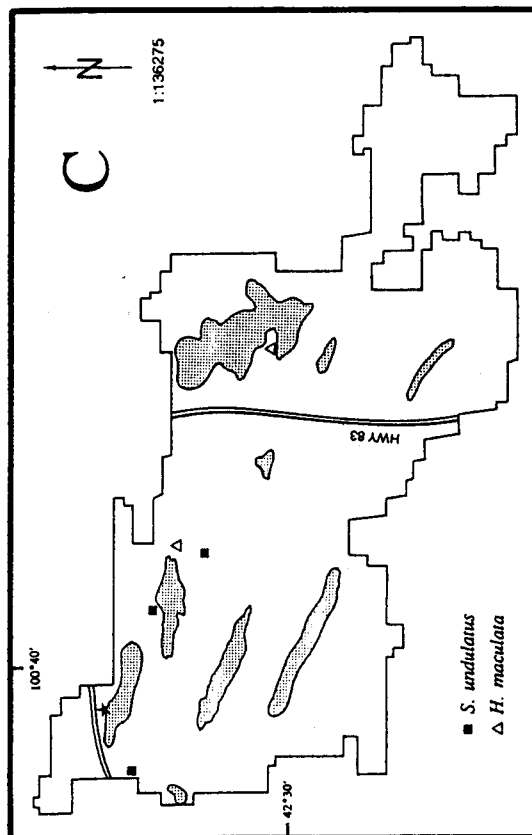
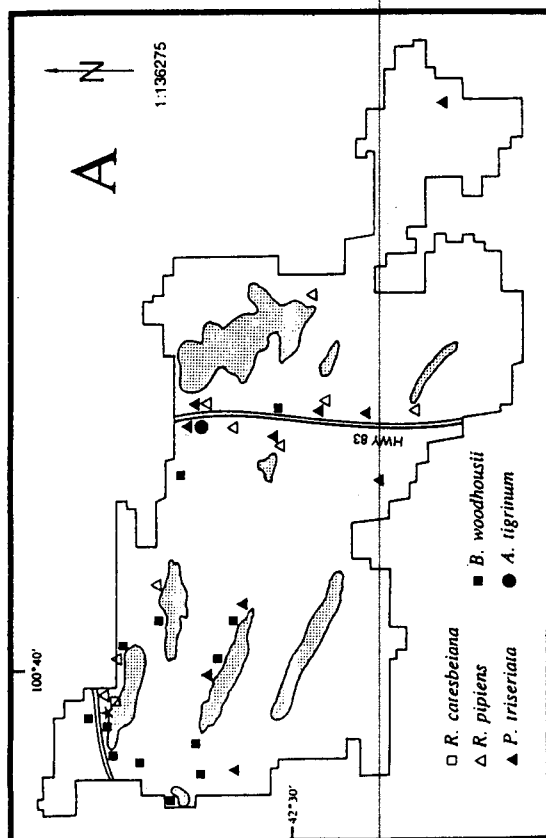
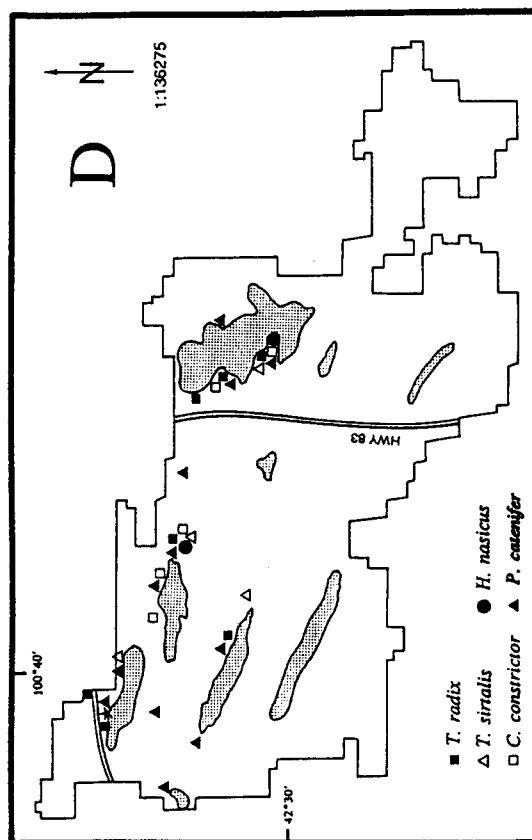
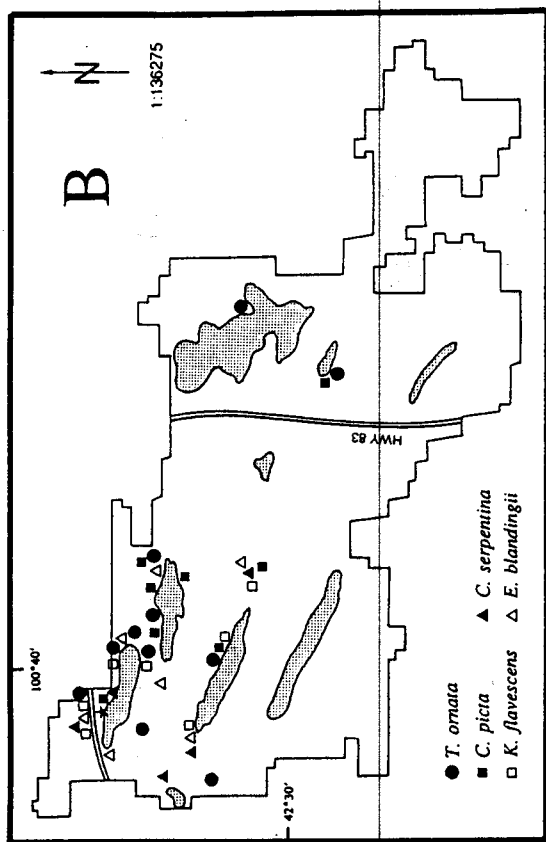


Fig. 3.

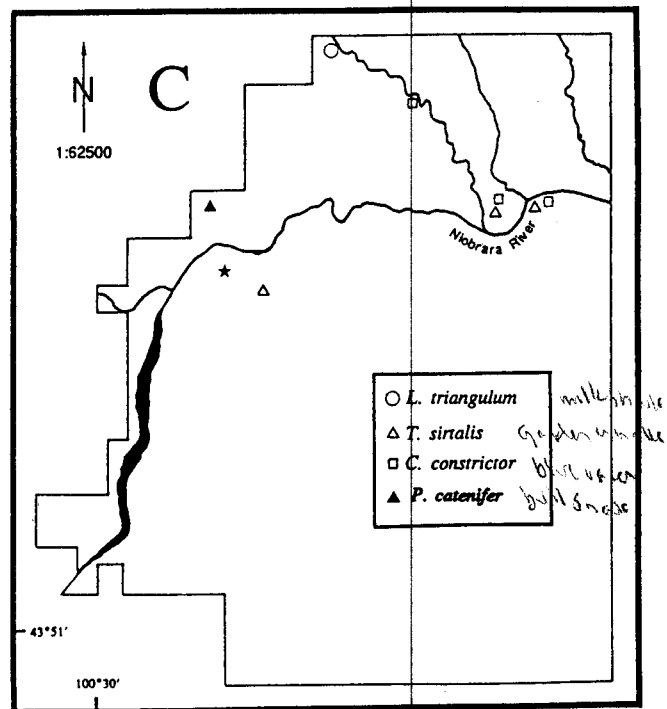
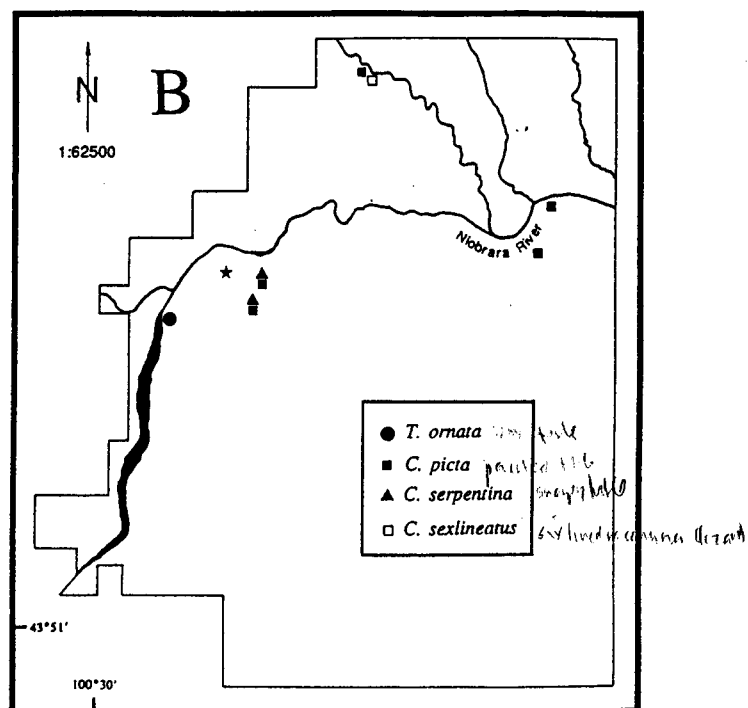
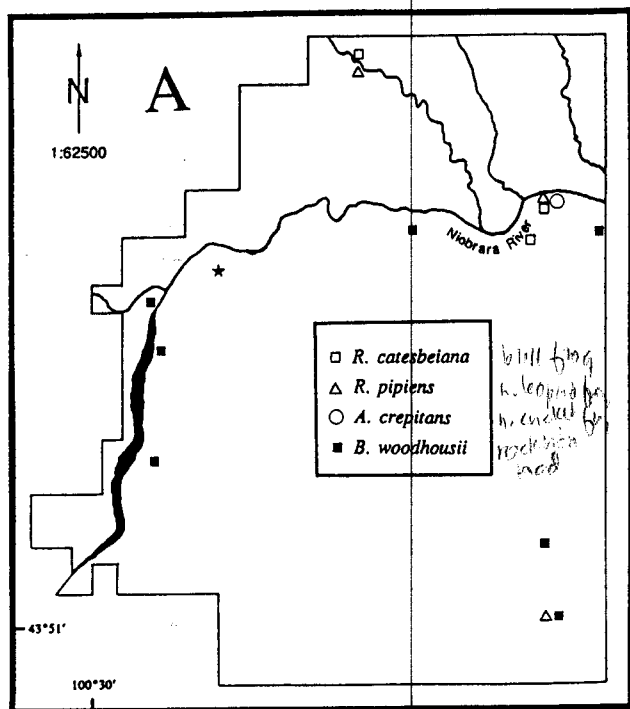


Fig. 4.

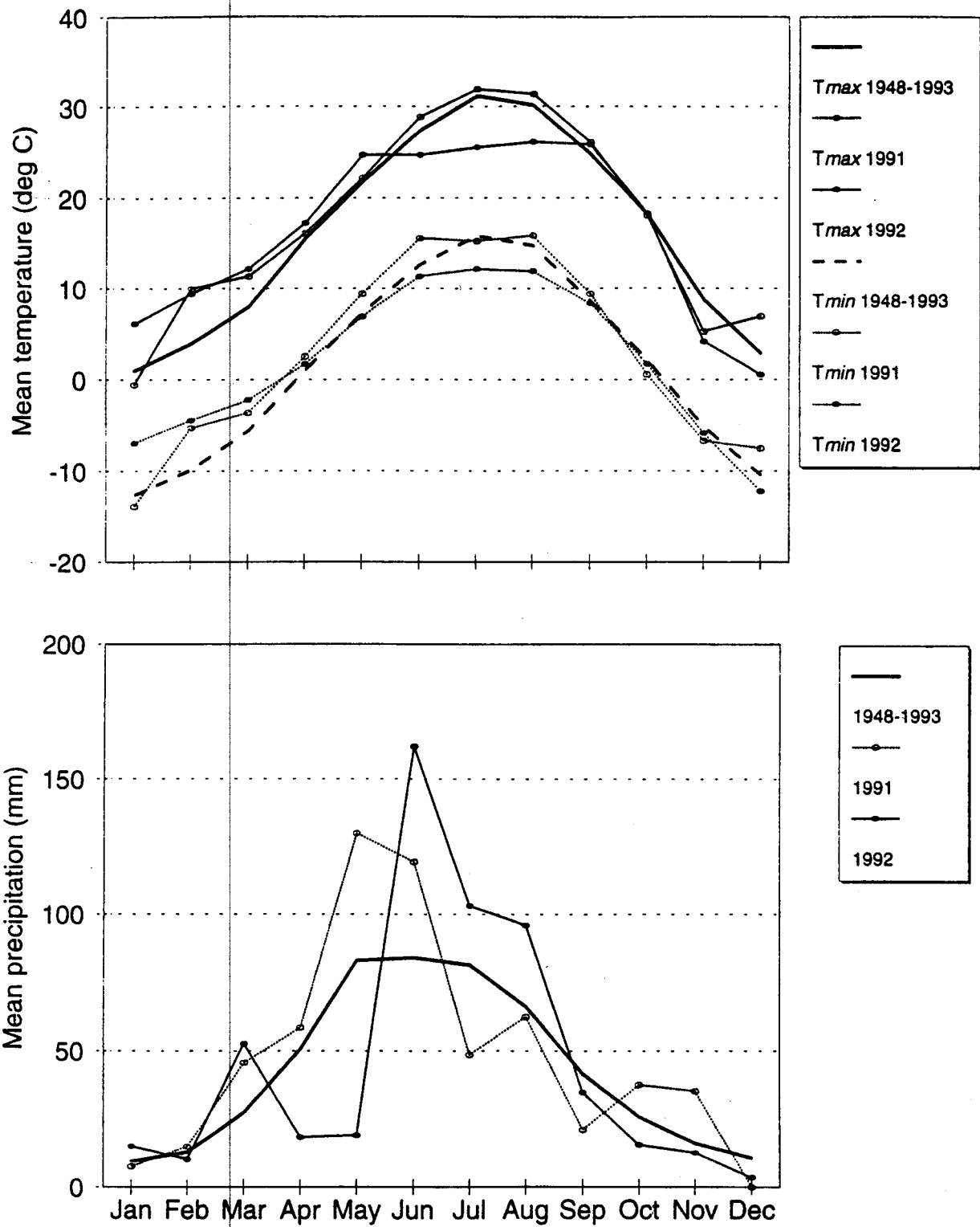


Fig. 5.

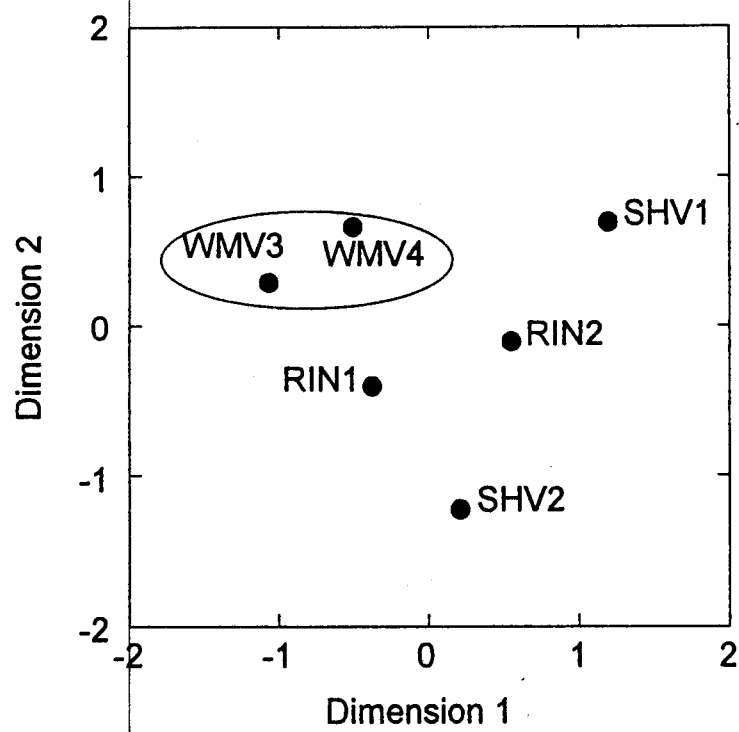


Fig. 6.

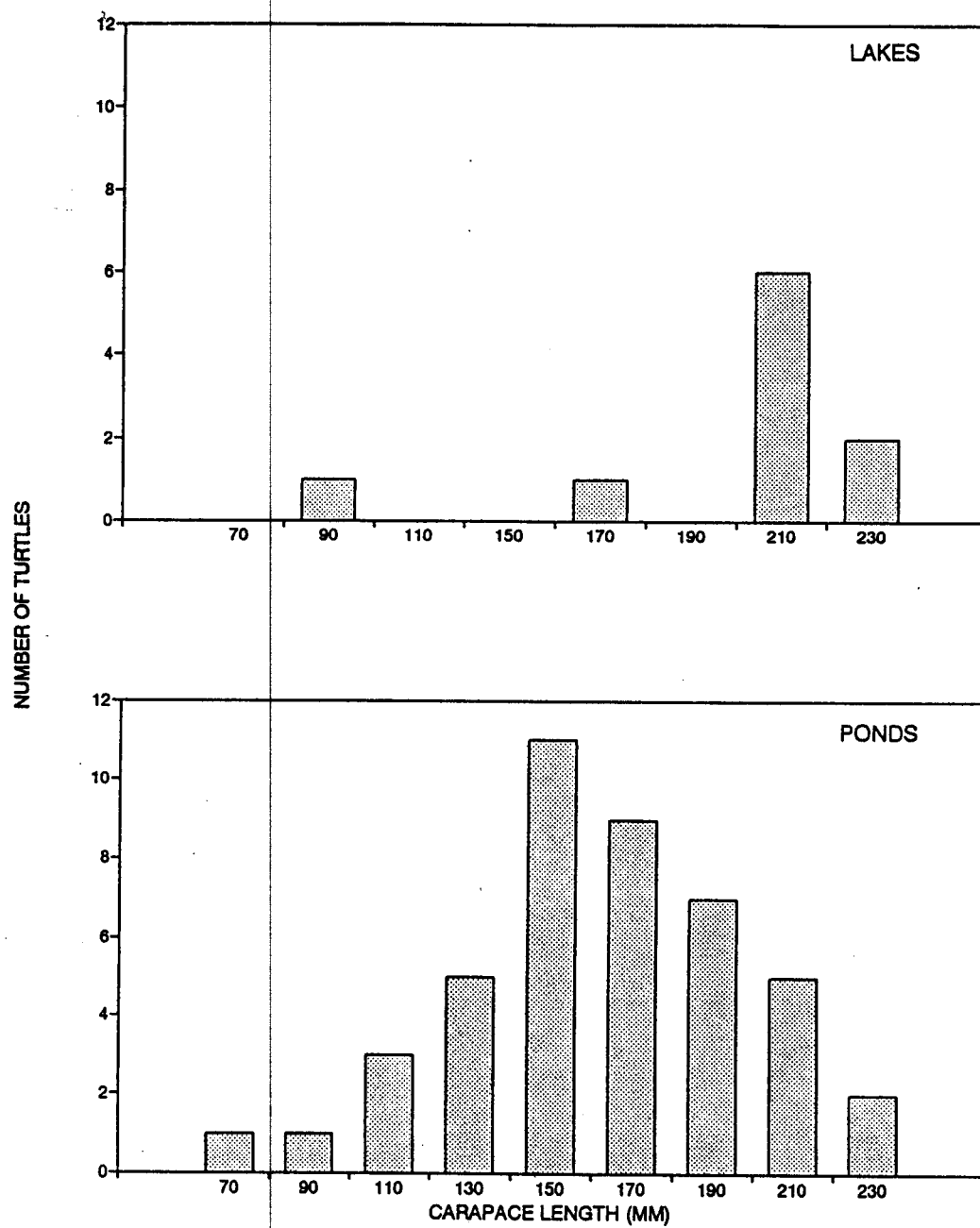


Fig. 7.

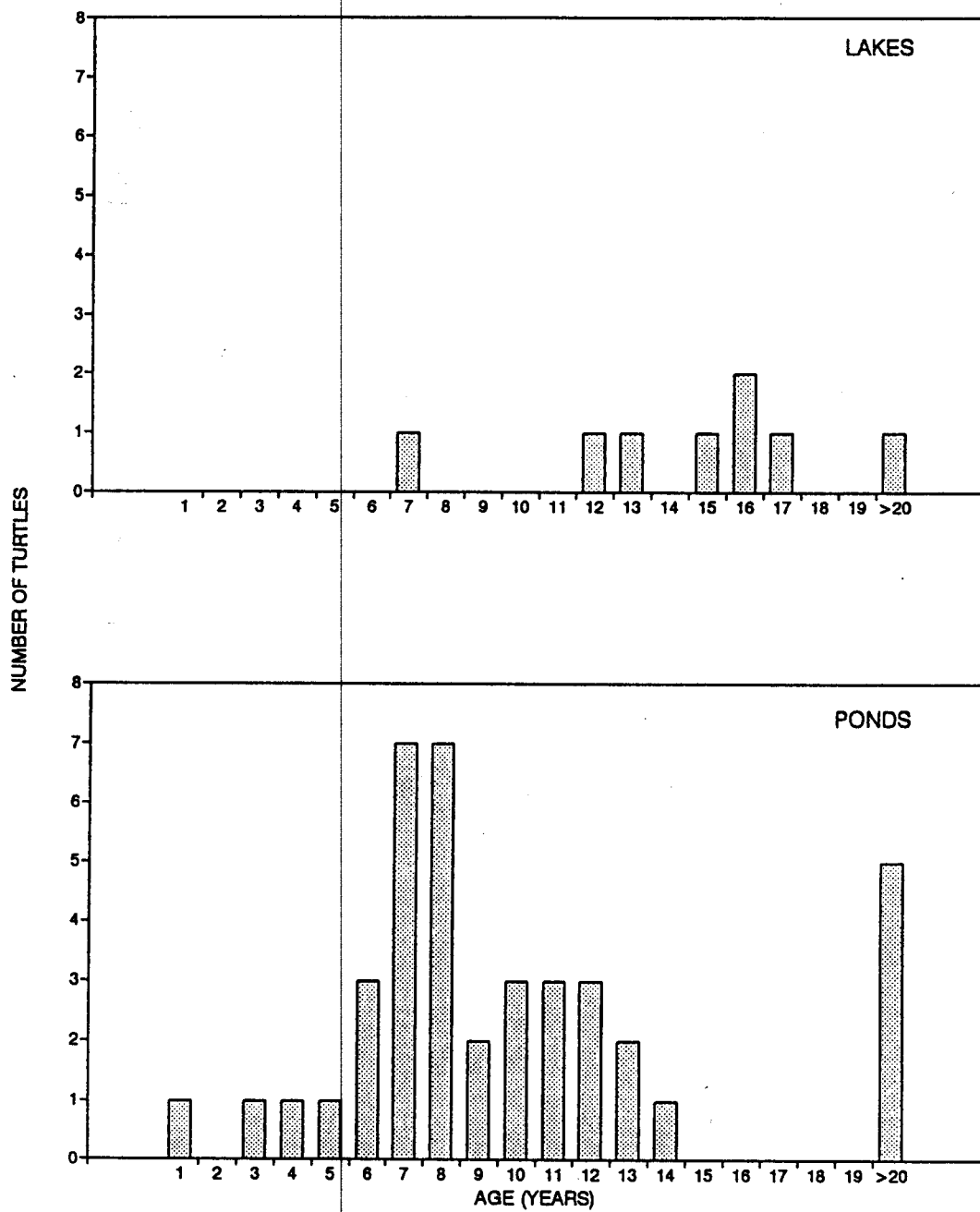


Fig. 8.

OCCURRENCE, DIVERSITY, AND HABITAT RELATIONSHIPS OF BIRDS

by

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INTRODUCTION

The grassland avifauna of the Great Plains and the associated avifaunas of Great Plains wooded stream bottoms and wetlands comprises a diverse and highly visible group of vertebrates. Because of their diurnal nature and conspicuousness, there is a considerable amount of information on the historical occurrence of Great Plains birds. Much of this information is anecdotal, however, and few of the early historical accounts provide perspectives on avian densities or vegetative associations. Furthermore, historical records are more plentiful for the larger, more conspicuous avian species and meager or nonexistent for species occurring only as uncommon migrants, those difficult to identify, or those that are inconspicuous. Currently, our knowledge of Great Plains avifauna, particularly on national wildlife refuges, is much greater for particular groups (e.g., waterfowl), habitats (e.g., marshes: waders, shorebirds, and marsh-nesting birds), and more prominent species (e.g., raptors). My approach to this study was influenced by these factors and by the recent interest in declining populations of neotropical migratory birds. Thus, this study included a strong habitat orientation, estimation of avian densities, and emphasis on neotropical migratory species, many of which are inconspicuous.

The objectives of the bird portion of the study were to assess and evaluate current avian occurrence and diversity at Valentine (VNWR) and Fort Niobrara (FNNWR) National Wildlife Refuges. Specific objectives were to: (1) provide relative abundance and distribution information for avian species; (2) provide this information by various habitat types during both the spring migration and breeding periods; (3) evaluate the relative importance of various habitat types to avian diversity; and, (4) compare the current vs. historical patterns of avian occurrence and diversity. *with this study see if could be expanded whole thing*

Limitations of the study were as follows: (1) no special effort was made to collect data on game birds (waterfowl and grouse) or raptors; (2) shorebirds, waders, and other waterbirds and marsh-nesting birds were de-emphasized; (3) surveys were not extensive, but sampled select, representative habitats intensively; (4) avian occurrence and diversity during winter were not assessed (the avifauna is depauperate during winter, contributing little to overall avian diversity); and, (5) no examination of various management impacts (e.g., grazing, fire suppression) was undertaken. *who decided they were representative did not work w/ refuge staff*

STUDY AREA AND METHODS

Study Plot Selection.--In treed habitats, study plot selection for avian surveys was based on tree stringer length, patch size, habitat type, and habitat homogeneity. To conduct point surveys, study plots needed to be long enough to establish 15 census stations ≥ 100 m apart. This assured necessary minimum sample sizes for the more common avian species and minimized the bias associated with double counting. In order to relate species to particular habitat types, we attempted to select study plots that were relatively homogenous in vegetation structure and plant species composition. To reduce the effects of small habitat patch size on species richness and density, we selected the largest habitat patches available. Seven plots were established at VNWR

in 1992--two Sandhills plots, three lakeshore shrub/tree plots, and two wet meadow plots. Six plots were established at FNNWR--two riparian/streamside plots, two woody draw plots, and two Sandhills plots. In 1991, six plots were censused at VNWR (two Sandhills, two lakeshore shrub/tree, and two wet meadow plots), and three at FNNWR (two riparian/streamside and one woody draw plot).

Study Plot Descriptions--VNWR.--(1) (1991 and 1992) Natural Area (Sandhills): south of Hackberry Lake in the VNWR Natural Area, beginning 100 m north of the fire tower and running east-west (Fig. 1 [D]); (2) (1991 and 1992) Dewey Sand (Sandhills): $\approx$ 500 m south of the southwest shore of Dewey Lake Marsh, running east-west (Fig. 1 [E]); (3) (1991 and 1992) Hackberry Tree (lakeshore shrub/tree; apparently mostly a natural succession to shrubs and trees but some trees established by plantings [L. McDaniel, pers. comm.]): along the southwest shore of Hackberry Lake (Fig. 1 [A]); (4) (1991 and 1992) Dewey Tree (lakeshore shrub/tree; established primarily by plantings): along the southwest shore of Dewey Lake (Fig. 1 [B]); (5) (1992 only) Duck Tree (lakeshore shrub/tree; a natural succession to shrubs and trees): around the northwest, northeast, and southeast sides of Duck Lake (Fig. 1 [C]); (6) (1991 and 1992) Pelican Lake (wet meadow): $\approx$ 200 m south of the southeast end of Pelican Lake and running east-west (Fig. 1 [F]); (7) (1991 and 1992) King Flat (wet meadow); beginning $\approx$ 200 m southeast of the southeast end of Cow Lake and running southeast (Fig. 1 [G]). These seven plots constitute three distinct habitat types defined as follows: (1) Sandhills type = VSAND (Natural Area and Dewey Sand); (2) shrub/tree type = VTREE (Hackberry Tree, Dewey Tree, and Duck Lake); and, (3) wet meadow type = VRWET (Pelican Lake and King Flat).

Study Plot Descriptions--FNNWR.--(1) (1991 and 1992) Niobrara East (riparian/streamside): along the south edge of the Niobrara River beginning at the extreme east end of the refuge and running west (Fig. 2 [C]); (2) (1991 and 1992) Niobrara South (riparian/streamside): along the east edge of the Niobrara River beginning about 1.2 km south-southwest of refuge headquarters and running south (Fig. 2 [D]); (3) (1991 and 1992) Beaver Creek (woody draw): beginning 100 m north of the Niobrara River and running north-northwest up Beaver Creek (Fig. 2 [A]); (4) (1992 only) Little Beaver Creek (woody draw): beginning 100 m north of the Niobrara river and running north up Little Beaver Creek (Fig. 2 [B]); (5) (1992 only) Sandhills West (Sandhills): beginning at the southeast corner of Unit 38 at the extreme south end of the refuge and running northwest (Fig. 2 [E]); (6) (1992 only) Sandhills East (Sandhills): beginning at the southeast corner of Unit 39 at the extreme south end of the refuge and running northwest (Fig. 2 [F]). These six plots constitute three distinct habitat types defined as follows: (1) Sandhills type = FSAND (Sandhills West and Sandhills East); (2) riparian/streamside type = FTREE (Niobrara East, and Niobrara South); and, (3) woody draw type = FDRAW (Beaver Creek and Little Beaver Creek).

Point Surveys.--The variable-radius circular plot (VCP) method was used to census birds (Reynolds et al. 1980). Fifteen points/study plot spaced 150 paces apart ($\approx$ 120 m) served as stations for bird counts. Points were marked with "T"-posts, plastic flagging, or wire flags depending on habitat. In 1992, each point was visited four times during each of two migration

periods and six times during the breeding period. Census periods in 1992 were defined as Early Migration (29 April - 9 May), Late Migration (11 May - 20 May), and Breeding (25 May - 3 June). In 1991, censuses were conducted only during the Breeding period (22 May - 4 June). Thus, we conducted a total of 2,730 point surveys on the two refuges in 1992 (13 study plots x 15 points/plot x [4 Early Migration censuses + 4 Late Migration censuses + 6 Breeding censuses]). We conducted 780 point surveys during each of the migration periods and 1,170 point surveys during the Breeding period. In 1991, we conducted a total of 540 point surveys (9 study plots x 15 points/plot x 4 Breeding censuses).

Four observers experienced at bird identification by both visual and aural cues conducted the surveys. Seven-minute censuses at each station began at, or shortly after, dawn and continued until the completion of 30 point surveys; most surveys were completed by about 1100-1200 h. Species, sex, and behavior of each bird were recorded as well as the distance from the observer. Rangefinders were used to determine distances. Counts were conducted between 29 April and 3 June in 1992 and required a total of 91 man-days. In 1991, counts were conducted between 22 May and 4 June and required 18 man-days.

Breeding Bird Survey Routes.--To assess avian diversity from a broader perspective and to establish a baseline for comparison with future long-term population trends, refugewide survey routes were initiated at VNWR and FNNWR. Methodology followed that of the U.S. Fish and Wildlife Service Breeding Bird Survey (Robbins and Van Velzen 1967). A 25-mile route was established at VNWR and a 20-mile route was established at FNNWR. Three-minute counts were made at one-half mile intervals for a total of 50 and 40, "stops," or 3-min counts, at VNWR and FNNWR, respectively. All birds heard and all birds seen $\leq$ one-quarter mile from the observer were counted. This survey was done twice in both 1991 and 1992 at VNWR and twice at FNNWR in 1992. Two different observers conducted the BBS surveys each year. Surveys at VNWR were conducted on 28 and 29 May in 1991 and on 4 and 5 June in 1992. At FNNWR, surveys were conducted on 4 and 5 June 1992.

The VNWR BBS route began just east of Watts Lake at the refuge boundary on state highway 16B, then south along the west end of the refuge, along the north shore of Pelican Lake, north toward Willow Lake, east to Highway 83, then south and east past VNWR sub-headquarters to the Greater Prairie Chicken observation blind (Fig. 1). The FNNWR BBS route began at the northwest corner of the refuge along Highway 12, south past headquarters to the two-track running east-west and one-third mile north of the south boundary of the refuge, east to the two-track one-half mile west of the eastern refuge boundary, north to the two-track along the Niobrara River, and then west along and one-eighth to three-quarter mile south of the Niobrara River to refuge headquarters (Fig. 2).

Habitat Surveys-Grassland and Wet Meadow Habitats.--In grassland and wet meadow habitats (FSAND, VSAND, and VRWET), we sampled the vegetation (1992 only) at and around each census point (15 points/study plot x 6 study plots). We conducted both visual obstruction sampling (Robel et al. 1970) and quadrat sampling. Visual obstruction readings

(VORs) were taken at eight locations around each census point in the eight cardinal directions (N, S, E, W, NW, NE, SW, SE) and 10 m from the census point. Four readings of obstruction were then made at each of the eight locations from four directions (N, S, E, W) for a total of 32 VORs/census point. Readings were taken kneeling, 4 m from a VOR pole marked off in 0.25-dm intervals. Beginning at ground level, the number of intervals completely obscured by standing residual vegetation, including the next higher partially obscured interval, was counted. The dominant grass species obscuring the VOR pole was recorded as well. Quadrat sampling was conducted using a 0.1 m² frame placed 5 m from each census point in the four cardinal directions. Cover estimates of bare ground and woody vegetation were estimated for each frame placement.

Habitat Surveys-Treed Habitats.--In the three treed habitats (VTREE, FTREE, and FDRAW), we sampled the vegetation (1992 only) at and around each census point (15 points/study plot x seven study plots). Vegetation variables were measured in each of the four quadrants in a 0.04 ha circle around each point (after James and Shugart 1970, Noon 1981), and included tree species (four closest trees), tree height (four closest trees, measured with a clinometer), diameter at breast height (four closest trees; dbh), basal area (using a 10 m²/ha/tree basal area factor forester prism), deciduous and coniferous canopy cover (mean of four densiometer readings taken at four points on the perimeter of the 0.04 ha circle in the four cardinal directions from the census point [Lemmon 1956]), number of snags (dead trees $\geq$ 10 cm dbh), and tree density in three dbh categories (<23 cm, 23-69 cm, and >69 cm).

To measure shrub cover, we extended transect lines 11.3 m (i.e., the radius of the 0.04 ha circle) along the four cardinal directions from the census point and recorded the distance along the lines intercepted by shrubby vegetation to the nearest decimeter. We used the density board technique to estimate vegetation density in two vertical layers: low (0-1.0 m) and high (1.0-2.0 m). With an observer at the census point and a second person holding a 1 x 2-m canvas density cloth at the perimeter of the 0.04 ha circle, the number of 0.1 m² squares on the cloth $\geq$ 50% obscured by foliage gave an index of vegetation density or obscurity. We estimated ground cover by placing a 0.5 m² plant frame 5 m from the census point in each of the four cardinal directions and determined cover for bare ground, grass, forb, woody, and litter cover categories.

Statistical Analyses.--In total, we measured or calculated 36 variables in grassland and treed plots to describe habitats used by various avian species at VNWR and FNNWR. Variables not normally distributed were transformed using either log (x + 1), square root (x + 1), or arcsin transformations which either corrected or improved heteroscedasticity and deviations from normality (Sokal and Rohlf 1981, Zar 1974). We performed one-way analysis of variance (ANOVA) to compare means of continuous variables. Discrete variables were compared using Chi-square analyses.

For treed habitats, we also used stepwise canonical descriptive discriminant analysis (Williams 1983, SAS Institute, Inc. 1988) to ordinate bird species in habitat space, and to describe differences in habitat associations among species and between species-occupied and unoccupied sites. Variables considered in the stepwise procedures were those significant ($P < 0.05$) in

univariate ANOVAs. Significance levels for entry and elimination of variables in the stepwise procedures were set at the default ($P = 0.15$), with variables contributing most or least to the discriminatory power of the model (as measured by Wilk's lambda) being entered or removed, respectively. Canonical discriminant analyses were then used to generate scores on canonical variables, plots of scores, and squared distances between class means (Mahalanobis distances) in discriminant habitat space. All statistical procedures were conducted on the Statistical Analysis System, Version 6.03 (SAS Institute, Inc. 1988). A statistical significance level of $P < 0.05$ was considered to infer biological difference in all tests.

Densities of selected species (Breeding period only) were calculated using Program Density (Laake et al. 1991). Key parameters used were: empirical calculation of variance from the replicate samples (VARN=EMPIRICAL); half-normal key function (KEY=HNORMAL), and cosine adjustment function (ADJUST=COSINE), specifying the model to be fit to $f(x)$ for estimation of $f(0)$.

Bird species diversities were calculated using the Shannon index ($H' = -\sum p_i \log_e p_i$) where H' is the diversity index and p_i is the proportion of all individuals in the i th species (Shannon and Weaver 1963). Components of this index are S , species richness, or the number of species occurring, and J , the equitability or evenness of species distribution ($J = H'/\log_e S$). Thus, the greater the number of species and the more evenly species are apportioned, the higher the species diversity.

RESULTS

We recorded a total of 148 species and 15,786 individuals during the 2,730 avian point surveys in 1992 (across all study plots and periods). Most detections were recorded during the Breeding period (6,439) with a similar numbers of detections during the two migration periods (Early = 4,722; Late = 4,625). Weighted by number of point surveys/period, the percentage of total detections was similar across periods (Early = 33.9%, Late = 34.6%, and Breeding = 31.5%). If each detection is considered as a unit of bird "use", then the value of VNWR/FNNWR habitats to birds is roughly similar during migration, when many species are using the refuges as "stopover" habitat, and during the breeding season. Mean number of birds detected per census point was 5.8, ranging from only 3.2 in the Dewey Sand plot to 10.0 at Duck Lake. Across all plots and periods, more detections were visual (59.0%) than aural (41.0%), ranging from a high of 88.9% visual detections in the open Natural Area plot to a low of 33.4% in the closed-canopy Niobrara East plot.

In 1991, we recorded a total of 108 species and 4,413 individuals (across all study plots, Breeding period only). Appendices 1-5 summarize 1991 point count results by habitat. Because rank order of abundance was similar between years by habitat and study plot, (compare Appendices 1-5 with 1992 results, below), and because the avian point survey effort was greatly expanded from 1991 to 1992 (9 vs. 13 study plots, 1 vs. 3 census periods, 540 vs. 2,730 point surveys), the remainder of this report will deal largely with 1992 results.

Avian Occurrence: Raw Counts

Breeding period by habitat.--An overview of species occurrence (1992) during the Breeding period by habitat is shown in Figs. 3-8.

Only 25 species of birds were detected in VSAND habitat (Fig. 3). Red-winged Blackbirds and Yellow-headed Blackbirds constituted 72% of all detections, although these two species do not breed in Sandhills habitat (Appendix 6 lists the scientific names of bird species). Detections of these two blackbird species in Sandhills habitat were of individuals moving back and forth between marsh and wet meadow breeding habitats. Grasshopper Sparrows were the most numerous breeder (39 detections), and all of the Grasshopper Sparrows occurred at Dewey Sand; none were recorded in the Natural Area. Lark Sparrows, Field Sparrows, and Western Meadowlarks were uncommon breeders in VSAND habitat.

Thirty-four species were detected during the Breeding period in VRWET habitat. Red-winged Blackbird was also the dominant species in this habitat comprising 53.4% of all observations (Fig. 4). Other common breeders, together comprising 35.9% of all detections included Brown-headed Cowbird, Black Tern, Eastern Meadowlark, Blue-winged Teal, Common Yellowthroat, Yellow-headed Blackbird, Grasshopper Sparrow, Marsh Wren, and Killdeer. In 1991 (Appendix 5) Brown-headed Cowbirds were far less common, and Soras, Wilson's Phalaropes, Black Terns, and Blue-winged Teal were much more common than in 1992. Accumulative net moisture, much greater in May 1991 than in May 1992 (L. McDaniel, pers. comm.), likely explains the difference in the numbers of wetland-nesting birds between years.

A very simple bird community (17 species detected) occurs in FSAND habitat, dominated by Grasshopper Sparrows (432 detections, 71.1% of all detections). Red-winged Blackbird was conspicuous by its virtual absence. Western Meadowlarks, Brown-headed Cowbirds, and Mourning Doves were other common to fairly common breeders in FSAND habitat (Fig. 5).

FTREE (riparian/streamside) habitat supported a much richer bird community (65 species detected) than either FSAND or VSAND (Fig. 6) and is not dominated by a single species to the extent of FSAND, VSAND, or VRWET. A number of neotropical migratory species were common in FTREE habitat, including Red-eyed Vireo, Ovenbird, House Wren, Eastern Kingbird, Great Crested Flycatcher, and Orchard Oriole.

FDRAW habitat supported a slightly different mix of bird species, a number of which are neotropical migrants, including Ovenbird, Great Crested Flycatcher, Black-and-white Warbler, Rufous-sided Towhee, House Wren, and Red-eyed Vireo (Fig. 7). Forty-six species were recorded in FDRAW habitat, with Black-capped Chickadee being the most numerous. In 1991 (Appendix 1), Black-capped Chickadee ranked only seventh and Red Crossbill, whose abundance in an area often corresponds to the coniferous cone crop, was the dominant species.

We detected more species (72) and more individuals (2,448) in VTREE habitat during the Breeding period than in any other habitat type. VTREE provided habitat for a diverse group of neotropical migrants, including Warbling Vireo, which occurred only in this habitat, and Bell's Vireo and Yellow Warbler, which occurred in significant numbers only in this habitat (Fig. 8).

Overall detections by habitat and census period.--An overview of detections by habitat and census period for the more common avian species is shown in Figs 9-22.

Red-winged Blackbird was the dominant species in VSAND habitat in all three census periods and was present in large numbers even during the Early Migration period (Fig. 9). The pattern of arrival on the breeding grounds is well illustrated by Yellow-headed Blackbird, Grasshopper Sparrow, and American Goldfinch, whose numbers gradually increased from the Early Migration period to the Breeding period.

A similar pattern of arrival can be seen for Grasshopper Sparrow in FSAND habitat (Fig. 10). This species was present in large numbers even in Early Migration and gradually increased and peaked during the Breeding period. Western Meadowlarks and Brown-headed Cowbirds were also fairly common FSAND species and occurred in roughly similar numbers during all three census periods, whereas Mourning Doves, Barn Swallows, and American Goldfinches were representative of later migrants, gradually increasing from the Early Migration period to the Breeding period.

VRWET habitat was important to a number of species during all three census periods (Figs. 11-12). Red-winged Blackbirds dominated the avian community, and Blue-winged Teal, Brown-headed Cowbirds, and Yellow-headed Blackbirds were common as well. Eastern Meadowlarks replaced Western Meadowlarks in this wetland habitat. Late-arriving migrants, gradually increasing in numbers from Early Migration to Breeding, were represented by Black Tern, Common Yellowthroat, Eastern Kingbird, Marsh Wren, American Bittern, Barn Swallow, and Grasshopper Sparrow.

FDRAW habitat supported a number of early migrant/resident species (Fig. 13), late migrants (Fig. 14) and early migrants (Fig. 15). Early migrant/resident species were dominated by Black-capped Chickadees, and all early migrant/residents were present in about equal numbers during all three census periods. Late migrants, dominated by Ovenbird and Great Crested Flycatcher, showed the typical pattern of late migrants, gradually increasing in numbers through the three census periods (Fig. 14). Most of the early migrants (e.g., Black-and-white Warbler) were present in high numbers during Early Migration and stayed to breed at VNWR/FNNWR, with the exception of Yellow-rumped Warbler, an early migrant which only passes through enroute to more northerly breeding grounds (Fig. 15).

Birds occupying FTREE habitat can be grouped in a fashion similar to those species in FDRAW habitat--early migrant/residents (Fig. 16), late migrants (Fig. 17), and early migrants (Fig. 18). Black-capped Chickadees again were the most common early migrant/resident and

Yellow-rumped Warbler was the most common early migrant, present only during the Early Migration period, and not remaining to breed (Fig. 16). Only a few late migrants, all neotropical migratory species, were present during the Early Migration period, with numbers rapidly increasing thereafter (Fig. 17). House Wrens and Mourning Doves were the most frequently detected early migrants (Fig. 18).

Red-winged Blackbirds were the most common early migrant/resident during any census period in VTREE habitat followed by Brown-headed Cowbird, Mourning Dove, and Yellow-headed Blackbird (Figs. 19, 20). Field Sparrows were much more common during Early Migration than during the Late Migration or Breeding periods, suggesting that while some Field Sparrows remain to breed, large numbers move farther north (Fig. 20). Bell's Vireo, Yellow Warbler, and Common Yellowthroat were the most common late migrants (Fig. 21). Most late migrants were not recorded until the Late Migration or Breeding census periods. Migrants which do not remain to breed at VNWR/FNNWR (Fig. 22) were dominated by Yellow-rumped Warbler, but a number of other migrants also passed through VTREE habitat during the Early and Late Migration periods, including Chipping Sparrow, Clay-colored Sparrow, Least Flycatcher, Orange-crowned Warbler, Swainson's Thrush, and White-crowned Sparrow.

Relative importance of habitats.--The relative "value" of VNWR/FNNWR habitats can be assessed by comparing the number of detections/habitat. FSAND habitat, for example, received much more bird "use" than VSAND habitat. The number of detections/census (i.e., per 15 point surveys) was significantly greater in FSAND habitat than in VSAND habitat for all three census periods (Early Migration, Late Migration, and Breeding) when Red-winged and Yellow-headed Blackbirds (which do not breed in Sandhills habitat) are excluded from the analysis (Early: FSAND = 44.0, VSAND = 10.8 birds/census, $F = 215.7$ [1, 2 df] $P = 0.0046$; Late: FSAND = 54.1, VSAND = 9.8 birds/census, $F = 106.7$ [1, 2 df], $P = 0.0092$; Breeding: FSAND = 43.1, VSAND = 7.9 birds/census, $F = 131.5$ [1, 2 df], $P = 0.0075$). Grasshopper Sparrows, which accounted for 71.1% of all detections in FSAND habitat, but which were infrequently encountered in VSAND habitat, accounted for most of this difference.

We recorded far more detections (over all three census periods and weighted by number of study plots) in VTREE habitat (5,652) than in FTREE (3,270) or FDRAW (3,023) habitat. All VTREE plots, however, were adjacent to lakeshore edges and included species associated with these bordering wetland/cattail-bulrush habitat types. We compared the three treed habitats, by census period, by excluding these species (Red-winged and Yellow-headed Blackbirds, Swamp Sparrow, Marsh Wren, and Common Yellowthroat) in statistical analyses. Significantly more detections/census were recorded in VTREE habitat (84.8) than in FTREE (67.6) or FDRAW (64.4) habitats only during the Breeding period ($F = 6.58$ [2, 35 df], $P = 0.0037$). During the Early Migration period, we recorded more detections/census in FDRAW (86.0) than in either FTREE (80.4) or VTREE (76.6) habitats, but differences were not significant ($F = 0.25$ [2, 21 df], $P = 0.78$). During the Late Migration period, there was also no significant difference in detections/census across habitats (VTREE = 83.9, FTREE = 78.3, FDRAW = 67.8; $F = 1.07$ [2, 21 df], $P = 0.36$).

To further evaluate the relative importance of the three treed habitats to neotropical migrants, we compared the number of detections/census for a subset of the 12 most common avian species which migrate through the region but do not remain to breed (Yellow-rumped Warbler, Chipping Sparrow, Least Flycatcher, Clay-colored Sparrow, Orange-crowned Warbler, Swainson's Thrush, White-crowned Sparrow, Blackpoll Warbler, Tennessee Warbler, Ruby-crowned Kinglet, Palm Warbler, and *Empidonax* flycatchers [may include some Least Flycatchers]). Weighted by number of study plots/habitat, more detections were recorded in VTREE habitat (528) than in either FTREE (258) or FDRAW (149) habitats. Significantly more neotropical migrants were detected/census in VTREE habitat (12.6) than in either FTREE (6.1) or FDRAW (3.5) across all three census periods combined ($F = 4.23$ [2, 91 df], $P = 0.018$). The difference was significant across study plots as well ($F = 2.66$ [4, 91 df], $P = 0.037$) ranging from highs of 21.6 and 9.1 migrants/census at Duck Lake and Hackberry Lake, respectively, to lows of 1.9 and 4.4 migrants/census at Little Beaver Creek and Niobrara East. The VTREE plots and Duck Lake in particular, provide important stopover habitat for neotropical migrants.

Avian Occurrence: Density Estimates

We calculated density estimates for the most common species (Breeding period only; ≥ 18 detections) in each of the six different habitat types (Tables 1-6). Whereas raw counts or number of detections provide an approximation of relative abundances, density estimates often refine this information and provide a better comparison across different studies or areas. Grasshopper Sparrow was the dominant species in FSAND habitat, occurring at a density nearly 14 times greater than that of the next most common species, Brown-headed Cowbird (Table 1). Western Meadowlarks probably occur in greater densities than is indicated in Table 1. Most individuals of this species appeared to be observer-shy; they were often present at census points, but were nearly always recorded at great distances from the observer.

Grasshopper Sparrow was also the principal species in VSAND habitat, but was recorded in only one of the two study plots (Dewey Sand) and occurred at densities only 13% as great as that at FSAND (Table 2). FSAND habitat is clearly preferred by Grasshopper Sparrows over that found in VSAND plots. Lark Sparrow and Field Sparrow occurred at very low densities, the latter only because of the presence of scattered, small eastern juniper (*Juniperus virginiana*) trees. Density estimates were not calculated for Red-winged and Yellow-headed Blackbirds, as these two species do not breed in VSAND habitat.

VRWET habitat was dominated by Red-winged Blackbirds and, as a consequence, by Brown-headed Cowbirds which often heavily parasitize Red-wings (Table 3). Eastern Meadowlarks replaced Western Meadowlarks in this habitat, and their low density with respect to sample size suggests that this species--similar to Western Meadowlark--is also observer-shy, being detected at relatively great distances from the observer. Blue-winged Teal, Black Terns, and Yellow-headed Blackbirds were other fairly common species in this habitat.

Rank order of species by density estimate in FTREE habitat differed somewhat from that of rank order by number of detections (Table 4). Cliff Swallows and American Goldfinches occurred in the highest densities; Red-eyed Vireo, with the greatest number of detections, ranked only fifth by density estimate. Ovenbirds and Black-capped Chickadees were the third and fourth most densely occurring species.

Black-capped Chickadees, Ovenbirds, Black-and-white Warblers, and Great Crested Flycatchers were the four most abundant species in FDRAW habitat (Table 5). Rank order by number of detections approximated rank order by density estimate. Seven species for which density estimates were calculated occurred in both FTREE and FDRAW habitats (Ovenbird, Black-capped Chickadee, Great Crested Flycatcher, House Wren, Mourning Dove, Brown-headed Cowbird, and Blue Jay). There was a significant difference in density between the two habitats only for Blue Jay ($t = 2.27$ [74 df], $P = 0.03$) which occurred at a greater density in FTREE (0.408 birds/ha) than in FDRAW (0.130 birds/ha) habitat.

VTREE habitat attracted more species, and often these species occurred at higher densities than in FTREE or FDRAW habitats (Table 6). Red-winged Blackbirds and Bell's Vireos were the two most abundant species. Eight species occurred at densities ≥ 1.0 /ha, whereas only two species occurred at such high densities in either FDRAW or FTREE habitats. Of seven species occurring in both VTREE habitat and either FDRAW or FTREE habitat, only densities of Orchard Orioles and Black-capped Chickadees differed significantly across habitats (Orchard Oriole: VTREE > FTREE, $t = 2.19$ [124 df], $P = 0.03$; Black-capped Chickadee: FTREE > VTREE, $t = 2.42$ [82 df], $P = 0.02$; Black-capped Chickadee: FDRAW > FTREE, $t = 2.51$ [130 df], $P = 0.01$). Densities of Eastern Kingbirds, American Goldfinches, and House Wrens were marginally different across habitats (Eastern Kingbird: VTREE > FTREE, $t = 1.90$ [113 df], $P = 0.06$; American Goldfinch: VTREE > FTREE, $t = 1.93$ [168 df], $P = 0.054$; House Wren: VTREE > FTREE, $t = 1.74$ [102 df], $P = 0.09$). Red-winged Blackbirds, which occurred at high densities in both VTREE and VRWET habitats, occurred at significantly higher densities in VTREE habitat ($t = 2.17$ [1073 df], $P = 0.03$).

Avian Occurrence: Diversity Indices

Diversity indices were calculated for all six habitats for each of the three census periods (Table 7). The three treed habitats supported a richer avifauna than VRWET or the two Sandhills habitat types in terms of diversity (H), evenness (J), and species richness (S). During the Late Migration and Breeding periods, the avifauna at FTREE was most diverse, and during the Early Migration period, diversity was highest at FDRAW. VTREE habitats attracted more species in all census periods, but because of the presence and dominance of Red-winged Blackbirds and Bell's Vireos, diversity and evenness ranked below that of FTREE and FDRAW. VRWET habitats had diversity indices somewhat higher than the Sandhills habitat types but all supported few species and had relatively low diversity indices. All three habitats (VRWET, VSAND, and FSAND) had low evenness indices due to the dominance of Red-winged Blackbirds or Grasshopper Sparrows.

Avian Occurrence: Breeding Bird Census Routes

Fort Niobrara NWR.--A total of 48 species was recorded on the two FNNWR BBS route surveys in 1992 (Table 8). Western Meadowlark and Grasshopper Sparrow were the top two species, accounting for 50.3% of all observations. The number of Western Meadowlarks/stop (3.98) was higher than the average number/stop recorded on 26 Nebraska BBS routes (2.84) during the period 1966-1991 and just slightly lower than the mean number (4.05) recorded on 42 BBS routes in physiographic region 36 (High Plains region) during the same time period (S. Droege, pers. comm.). Grasshopper Sparrows were far more abundant at FNNWR (2.39/stop) than in 39 Nebraska (0.27/stop) or in 36 Region 36 (0.49/stop) BBS routes. Comparisons for some of the other common species recorded on the FNNWR BBS route (given in number/stop for FNNWR, Nebraska, and Region 36, respectively) are as follows: Horned Lark--0.71, 0.48, 2.93; Mourning Dove--0.53, 1.53, 1.54; Upland Sandpiper--0.43, 0.14, 0.09; Brown-headed Cowbird--0.35, 0.56, 0.16; Greater Prairie Chicken--0.35, 0.03, 0.03; and, Eastern Kingbird--0.29, 0.26, 0.08. Avian diversity (H) for the FNNWR BBS route was 2.68.

Valentine NWR.--More species were recorded in both the 1991 (n = 72) and 1992 (n = 66) BBS surveys at VNWR than at FNNWR in 1992 (n = 48), reflecting the greater diversity of habitats at VNWR, especially the presence of wetland habitats (Tables 9, 10). Rank order of the top five species at VNWR was the same in 1991 and 1992 (Red-winged Blackbird, Western Meadowlark, Yellow-headed Blackbird, Double-crested Cormorant, and Eastern Kingbird). Numbers of individuals/stop were similar between 1991 and 1992, although slightly higher for most species in 1992. Of the more common species, Western Meadowlarks, Grasshopper Sparrows, and Horned Larks were much more common, or were recorded only on the FNNWR BBS route, whereas Red-winged Blackbird, Yellow-headed Blackbird, Double-crested Cormorant, Eastern Meadowlark, and Ring-necked Pheasant were more common, or were recorded only on the VNWR BBS route. Upland Sandpipers were equally common at VNWR (0.40/stop) and FNNWR (0.43/stop).

The number of Red-winged Blackbirds/stop in 1992 (4.58) was greater than the mean number recorded in the 1966-1991 Nebraska (1.52/stop) and Region 36 (1.34) BBS routes, as was the number of Yellow-headed Blackbirds (VNWR = 1.89/stop, Nebraska = 0.06/stop, Region 36 = 0.05/stop). Comparisons for some of the other common species recorded on the VNWR BBS route in 1992 (given in number/stop for VNWR, Nebraska, and Region 36, respectively, and not previously given [above]) are: Double-crested Cormorant--0.78, 0.02, 0.02; Common Yellowthroat--0.70, 0.08, 0.03; Eastern Meadowlark--0.58, 0.08, 0.02; Ring-necked Pheasant--0.68, 0.59, 0.64; and, American Crow--0.21, 0.14, 0.05. Avian diversity (H) for the VNWR BBS route in 1991 and 1992 was 3.21 and 3.16, respectively.

Habitats and Avian Habitat Selection

Sandhills and wet meadows.--Mean visual obstruction readings (0.25 dm intervals) were significantly higher in VSAND habitat ($\bar{x} = 2.40 + 0.06$) than in FSAND habitat ($\bar{x} = 2.00 + 0.08$;

$F = 15.39$ [1, 476 df], $P = 0.0001$), and were highest of all in VRWET habitat ($\bar{x} = 4.70 + 0.18$). Of the two VSAND plots, mean VORs were greater in the Natural Area ($\bar{x} = 2.64 + 0.14$) than in the Dewey Sand plot ($\bar{x} = 2.17 + 0.09$; $F = 7.68$ [1, 238 df], $P = 0.006$). Mean percent bare ground ranged from 13.13 ± 2.58 at FSAND Sandhills West to 40.53 ± 3.57 at VSAND Dewey Sand. Mean percent bare ground was significantly higher in VSAND habitat ($\bar{x} = 35.34 + 2.57$) than in FSAND habitat ($\bar{x} = 14.55 + 1.75$; $F = 45.48$ [1, 236 df], $P = 0.0001$) reflecting primarily the difference in range site classification between habitats; i.e., FSAND is primarily a sand range site whereas VSAND is primarily a choppy sand range site (L. McDaniel, pers. comm.). Additionally, grazing on Fort Niobrara NWR and the associated trampling by bison and longhorns resulting in litter being deposited and incorporated into the soils may also contribute to lower bare ground values at FSAND. Mean percent bare ground in VRWET habitat (sandy lowland and wetland to subirrigated range sites) was 5.63 ± 1.75 .

The frequency distribution of the 11 most common grasses and forbs providing visual obscurity in the VORs also differed between VSAND and FSAND habitats ($\chi^2 = 139.72$ [10 df], $P = 0.000$). Little bluestem (*Andropogon scoparius*), prairie sandreed (*Calamovilfa longifolia*), and soaptree yucca (*Yucca elata*) were more frequent in VSAND habitat, whereas sand bluestem (*Andropogon hallii*), sand dropseed (*Sporobolus cryptandrus*), sand lovegrass (*Eragrostis trichodes*), and switchgrass panicum (*Panicum virgatum*) were more frequent in FSAND habitat (plant names after Scott and Wasser 1980). Prairie cordgrass and switchgrass panicum dominated the VRWET plots.

Why were Grasshopper Sparrows, the only densely occurring species in either of the Sandhills habitats, much more common in FSAND plots? Grasshopper Sparrows were (a) absent in the Natural Area, which had the highest mean VOR of any of the four Sandhills plots, but which also had high percent bare ground; (b) occurred in low densities in the Dewey Sand study plot which had the highest percentage bare ground of any of the four plots; (c) were most abundant in FSAND plots, where percentage bare ground was low; and, (d) occurred in similar numbers in the two FSAND plots (499 vs. 514 total detections, all three census periods) which differed widely in mean VORs (Sandhills East VOR = 2.33 ± 0.09 ; Sandhills West VOR = 1.67 ± 0.09). Neither VORs nor bare ground appear to explain the occurrence and density of Grasshopper Sparrows at VNWR/FNNWR. Other factors, such as topography, soil type, range site, or floristics may explain the differences in Grasshopper Sparrow densities between habitats. For example, the widespread presence of switchgrass panicum and sand bluestem in FSAND vs. the dominance of little bluestem in VSAND may be a major determinant in the distribution and abundance of Grasshopper Sparrows.

Grazing regimes differed in the two VSAND and two FSAND study plots with the most intensely grazed plots (FSAND [1990 and 1991, respectively]: Sandhills East = 0.72 and 0.59 AUM/ha; Sandhills West = 1.24 and 1.43 AUM/ha) supporting more Grasshopper Sparrows (FSAND = 1.98/ha; VSAND = 0.26/ha) than the ungrazed or less intensely grazed plots (VSAND: Natural Area = ungrazed since refuge establishment [1935]; Dewey Sand [Unit 5B-1, 1990] = 1.26 AUM/ha; ungrazed in 1991 and last grazed in 1986). This is similar to results

reported by Anderson (1992), who studied the effects of grazing on VNWR and on nearby private land, where long-duration, higher-intensity grazing on private land (range of AUMs/ha, 1984-1991: 0.40 to 2.32) supported 0.18 males/ha, and short-duration, less-intensively grazed refuge plots (range of AUMs/ha, 1984-1991: 0.30 to 0.91) supported only 0.10 males/ha. Other studies (Skinner 1975) also have found Grasshopper Sparrows more abundant in grazed vs. ungrazed grasslands. Because grazed areas in some regions normally have higher populations of grasshoppers (Shotwell 1958, Skinner 1975), an important food item in the diets of grassland birds (Baldwin 1973, Maher 1979), as well as more annual grasses and forbs to provide a seed food resource, food, and not vegetation structure or bare ground, may be the key determinant of Grasshopper Sparrow densities in Sandhills grasslands.

Treed habitats: Comparisons.--Plot means of variables selected for inclusion in the canonical discriminant analysis (see below) are presented in Table 11. The two FDRAW plots were characterized by high snag densities, high deciduous canopy cover, low coniferous canopy cover, intermediate basal areas and tree heights, and were dominated by American elm (*Ulmus americana*), ironwood (*Ostrya virginiana*), bur oak (*Quercus macrocarpa*), and boxelder maple (*Acer negundo*).

The two FTREE plots exhibited more differences than similarities: Niobrara East had high values for basal area, small and medium tree density, deciduous canopy cover, and tree height, whereas Niobrara South had low values for these variables. Niobrara East was dominated by red ash (*Fraxinus pennsylvanica*), bur oak, and ironwood and Niobrara South was dominated by eastern juniper. Both plots had low values for shrub cover and shrub (high) obsc^{ur}ity. The presence of longhorns, elk, and bison in these bottomland habitats (Niobrara South: 1.70 and 2.15 AUMs/ha, 1990, 1991; Niobrara East: 0.32 and 0.27 AUMs/ha, 1990, 1991) has severely altered the shrubby understory, and overstory tree regeneration potential, as well. Although the evidence is correlative and not experimental, grazing impacts on the vertical vegetative structure have likely reduced the suitability of the nesting substrate for a number of neotropical migrants, especially those in the shrub-nesting guild. *wrong - he was provided info - bur oak played*

Two of the three VTREE plots (Dewey Tree and Hackberry Tree) were similar in having high values for the three measures of shrub dominance: (woody cover, high obsc^{ur}ity, and shrub [intercept] cover). But the Dewey Tree plot had high values for basal area and small tree density and was intermediate for deciduous canopy cover, whereas Hackberry Tree ranked low on these three measures of habitat. Both were dominated by eastern juniper and common hackberry (*Celtis occidentalis*), but at Dewey Tree, black locust (*Robinia pseudoacacia*) was a dominant overstory tree as well. The habitat at Duck Lake was unique, with the highest values of any of the seven treed study plots for dbh and medium and big tree density, and the lowest values for the three measures of shrub cover and obsc^{ur}ity. Overstory trees at Duck Lake were primarily (89.47%) peachleaf willow (*Salix amygdaloides*).

Treed habitats: Discriminant analysis of habitat selection.--Habitat selection of the 14 most common species of birds in the three treed habitats (FDRAW, FTREE, and VTREE) was

evaluated by ordinating these species along three dimensions of habitat. Presence or absence of a given species at census points during the Breeding period determined whether or not the habitat information collected at that point was included in the habitat sample for that species. A subset of 24 of 33 measured or calculated variables was selected by a stepwise discriminant analysis procedure to be used in a subsequent canonical discriminant analysis. The canonical discriminant analysis comparing the habitats of the 14 most common species of birds in the three treed habitat types produced three significant functions ($P < 0.0001$) that had a squared canonical correlation (R^2) of > 0.10 (i.e., the correlation between the canonical functions and the class [bird species] variables).

Discriminant function 1 (DF1) was largely a measure of bur oak, red ash, ironwood, snag density, and deciduous canopy cover (to the right along DF1) and common hackberry and shrub cover (to the left along DF1) (Fig. 23). Species associated with snags (Great Crested Flycatcher) or deciduous canopy cover (Red-eyed Vireo, Black-and-white Warbler, Ovenbird) are situated to the right along DF1 and species associated with shrub cover or common hackberry (Bell's Vireo) are situated to the left along DF1. DF2 was most highly correlated with common hackberry and all three measures of shrub cover and obscurity (top of DF2), and dbh and peachleaf willow (bottom of DF2). Bell's Vireo and Yellow-breasted Chat, associated with shrub cover and foliage obscurity, are situated along the top of DF2 and those species associated with large trees and willows (Eastern Kingbirds, Northern and Orchard Orioles) are positioned along the bottom of DF2. Shrub cover (line intercept) and ironwood were most strongly correlated with DF3 (top of axis) and basal area and deciduous canopy cover were most strongly negatively correlated with DF3 (bottom of axis). Showing a strong affinity for ironwood and shrub cover (Rufous-sided Towhee) and shrub cover (Bell's Vireo) were species with high values along DF3. Affinities for basal area and deciduous canopy cover are illustrated by Northern Oriole and Red-eyed Vireo, with low values along DF3.

The ordination of species along habitat axes most clearly separates the FDRAW/FTREE species (Ovenbird, Rufous-sided Towhee, Black-and-white Warbler, Great Crested Flycatcher, and Red-eyed Vireo, each of which occurred almost exclusively in FDRAW or FTREE habitats) from the VTREE species (Bell's Vireo, which occurred almost exclusively at Dewey Tree and Hackberry Tree, and Yellow Warbler, which occurred almost exclusively, and in similar numbers, at Dewey Tree, Hackberry Tree, and Duck Lake). Species which occurred in all three habitats and in all seven plots (Eastern Kingbird, Brown Thrasher, House Wren) are more centrally located, showing more flexibility in habitat selection.

A second canonical discriminant analysis was performed comparing the habitat at species-present census points with that at species-absent census points for the same group of 14 species ($n = 28$ classes [14 species-present classes, 14 species-absent classes]). Multivariate habitat distances (= Mahalanobis distances or the distance between classes in habitat space) for this analysis between species-present and species-absent classes (Table 12) and ranked by species, suggest that of the 14 species, Bell's Vireos ($\bar{M} = 6.13$) occupy the most unique habitats, Yellow Warblers ($\bar{M} = 6.11$) the second most unique, and Brown Thrashers, House Wrens, and Eastern

Kingbirds the least unique habitats. That is, because the habitats that Bell's Vireos select and occupy are farthest in habitat space (i. e., most different) from the habitats they do not select, then they are occupying relatively more unique habitats in comparison to all of the other species.

The habitats selected by Brown Thrashers ($\bar{M} = 1.62$) and House Wrens ($\bar{M} = 1.82$) on the other hand, were not that different from those habitats they did not occupy. In fact, all 14 sets of species-present vs. species-absent habitats were significantly segregated from one another in multivariate habitat space (multivariate F tests [$17, \infty$ df], $P < 0.05$) with the exception of those of House Wren and Brown Thrasher. Thus, for this group of species and for the three habitats considered, Bell's Vireos may be considered the most selective, and Brown Thrashers the least selective, in choice of habitat. Species having large distances between occupied and non-occupied habitat may be considered more "sensitive" and their habitats at more of a premium than those of other species. Species with small Mahalanobis distances between species-present and species-absent habitats may be considered more eurytopic, being more catholic in habitat selection.

Of the 14 species considered in the discriminant analysis, at least four can be considered area-sensitive or forest interior species--Great Crested Flycatcher, Red-eyed Vireo, Black-and-white Warbler, and Ovenbird (Robbins et al. 1989). These four species all had relatively large Mahalanobis distances, suggesting that not only are they habitat specialists, but that they are area-sensitive, as well.

OVERVIEW OF CURRENT AND HISTORICAL AVIAN DIVERSITY AT VNWR/FNNWR

Most of the species recorded on our surveys at VNWR/FNNWR also occurred historically (Appendix 7). All of the dominant Sandhills species occurring today (Tables 1, 2) were present prior to 1920, and of the 33 dominant species occurring today at FTREE, FDRAW, and VTREE (Tables 4-6), only two were not noted historically (Ovenbird and Great Crested Flycatcher). Many species for which there are no historical records (1) are either difficult to identify or are inconspicuous (e.g., Alder Flycatcher, Least Flycatcher, Willow Flycatcher, Ruby-crowned Kinglet); (2) are (and likely were historically) uncommon migrants in the Sandhills (e.g., Blackburnian Warbler, Mourning Warbler, Orange-crowned Warbler, White-throated Sparrow), or; (3) have only recently expanded their range and probably did not occur at VNWR/FNNWR historically (e.g., Northern Cardinal).

Notably absent historically were European Starling (not introduced to North America until 1890 and still uncommon today at VNWR/FNNWR), Ring-necked Pheasant (not introduced to Nebraska until 1909), and Wild Turkey (extirpated in Nebraska, then reintroduced in the 1920's and 1930's [unsuccessfully], then successfully reintroduced along the Niobrara in 1959-60). Notably present historically was the House Sparrow, introduced to North America about 1850 and recorded as early as ca. 1899 near Valentine.

Lack of evidence of historical occurrence is not positive proof that a species did not occur historically. In addition, without information on the relative historical abundance of a given species, and the precise location, few inferences can be made about what effects time, management impacts, or vegetation change may have had on today's avifauna vs. the historical avifauna. Species for which there are historical records, but which we did not record on VCP surveys or BBS routes are listed in Appendix 8.

Some of these species are winter residents or migrants occurring outside the timeframe of our surveys; many of these species occur on the refuge complex today (e.g., Townsend's Solitaire, Rough-legged Hawk, Bald Eagle, Sandhill Crane, Trumpeter Swan). Other species recorded historically and occurring commonly today were not recorded on our surveys due to survey technique, plot locations, or survey emphasis (i.e., neotropical migrants), including American Wigeon, American Avocet, Bufflehead, Burrowing Owl, Canvasback, Black-billed Magpie, Green-winged Teal, Ring-necked Duck, and Marbled Godwit.

Historical accounts and records suggest that much of the escarpment north of the Niobrara River supported a vegetational landscape similar to that occurring there today. This, in conjunction with museum and other historical records, suggests that most of the avifauna occurring today also was present historically. Similarly, the year-around flow of the Niobrara River suggests that a treed riparian corridor was present historically. Thus, the dominant species of today's FTREE and FDRAW habitats (Ovenbird, Great Crested Flycatcher, Black-and white Warbler, Black-capped Chickadee, Red-eyed Vireo, House Wren, Eastern Kingbird, Orchard Oriole, Common Yellowthroat) were likely present historically.

Sandhills habitats were apparently less vegetated historically than at present, and may have supported fewer species and in lower densities than today. Grasshopper Sparrows, the dominant species in Sandhills grasslands, were probably always present but perhaps in reduced densities historically.

Photographic evidence and historically frequent fires suggest far less tree and shrub development around lakeshores at VNWR than is present currently. Many of these shrub-tree stringers are the result of plantings; fire suppression and exclusion from grazing following refuge establishment no doubt helped these woody vegetation stringers become a permanent part of today's landscape. Thus, the VTREE avifauna of today was likely much reduced historically. Bell's Vireos, Yellow Warblers, American Goldfinches, Orchard Orioles, Eastern Kingbirds, House Wrens, Northern Orioles, Black-capped Chickadees, and Warbling Vireos all either did not occur as breeders at VNWR or occurred only at much lower densities. Due to the present and historical subterranean recharge of lakes and wetlands, the wetland (VRWET) avifauna, including the avifauna associated with marshes (Common Yellowthroat, Swamp Sparrow, Red-winged and Yellow-headed Blackbirds) was probably much the same historically as it is today.

SUMMARY AND MANAGEMENT RECOMMENDATIONS

Recently detected, widespread population declines of neotropical migratory birds--those species that breed in North America and winter in neotropical countries--have led to growing concerns relative to the long term conservation of these species. Forest fragmentation on the breeding grounds, leading to increased predation and parasitism by Brown-headed Cowbirds, and deforestation of wintering habitats have been advanced as the primary factors responsible for the population declines. The availability of suitable stopover habitat for migrating birds, and land management activities on the breeding grounds (e.g., livestock grazing, fire suppression) influence survival and population stability as well. Avian surveys and habitat analyses in 1991 and 1992 at Valentine NWR and Fort Niobrara NWR assessed the current status of, and evaluated the factors affecting, neotropical migratory birds on their breeding grounds. Surveys were conducted during the migration period as well, to assess the value of these refuges as migratory stopover habitats--in-transit habitats where energy reserves can be rapidly replenished. Major findings include:

- Lakeshore tree/shrub stringers at VNWR, and woody draws and riparian corridors at FNNWR contributed most to the overall avian diversity of the two refuges. VTREE habitats attracted more species in all census periods.
- Species richness was much lower in Sandhills grasslands, but this habitat nevertheless provided important breeding habitat for neotropical migrants.
- Frequently encountered (breeding) neotropical migrants at VNWR and FNNWR included: (1) lakeshore tree/shrub stringers--Bell's Vireo, Common Yellowthroat, Yellow-breasted Chat, Yellow Warbler, and Orchard Oriole; (2) woody draws--Ovenbird, Black-and-white Warbler, Great Crested Flycatcher; (3) riparian corridors--Ovenbird, Red-eyed Vireo, Eastern Kingbird, American Redstart, Great Crested Flycatcher, Common Yellowthroat; (4) wet meadows--Common Yellowthroat, Grasshopper Sparrow, and Marsh Wren; and, (5) Sandhills grasslands--Grasshopper Sparrow.
- The value of treed habitats at VNWR/FNNWR to migrants is significant--likely due to the paucity of riparian corridors in this region and the great distances between islands of habitat with appreciable vertical structure.
- Treed habitats at VTREE were especially frequently used by (nonbreeding) neotropical migrants, with significantly more migrants being detected/census in VTREE habitat than in either FTREE or FDRAW. The VTREE plots and Duck Lake in particular, provide important stopover habitat for neotropical migrants.
- In spite of the "artificial" nature of many of the tree/shrub stringers at VNWR (due to their initial establishment as plantings), and likely owing their continued presence to fire suppression and exclusion from grazing, they are clearly a valuable

nesting guild, in particular, then grazing in these riparian areas should be reduced, or eliminated altogether.

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Table 1. Avian density estimates (D = birds/ha) in FSAND plots (FNNWR: Sandhills East and Sandhills West), Fort Niobrara NWR, 1992.

N	Species	D	SE
432	GRSP ¹	1.97900	0.97280
67	WEME	0.11850	0.03019
30	BHCO	0.14140	0.06637
17	MODO	0.06387	0.03188

¹See Appendix 6 for species list and associated mnemonics.

Table 2. Avian density estimates (D = birds/ha) in VSAND plots (VNWR: Natural Area and Dewey Sand), Valentine NWR, 1992.

N	Species	D	SE
39	GRSP ¹	0.2577	0.09812
37	AMGO	0.1271	0.04717
19	LASP	0.1128	0.04300
18	FISP	0.1560	0.05614

¹See Appendix 6 for species list and associated mnemonics.

Table 3. Avian density estimates (D = birds/ha) in VRWET plots (VNWR: Pelican Lake and King Flat), Valentine NWR, 1992.

N	Species	D	SE
580	RWBL ¹	3.19000	0.50900
79	BHCO	0.56430	0.11640
64	BLTE	0.57580	0.24890
62	EAME	0.14980	0.13980
46	BWTE	0.34840	0.10080
34	COYE	0.10960	0.04456
34	YHBL	0.25150	0.08537
28	GRSP	0.06113	0.02716
23	MAWR	0.05021	0.02911
21	KILL	0.15500	0.07564

¹See Appendix 6 for species list and associated mnemonics.

Table 4. Avian density estimates (D = birds/ha) in FTREE plots (FNNWR: Niobrara South and Niobrara East), Fort Niobrara NWR, 1992.

N	Species	D	SE
52	OVEN ¹	0.8977	0.28370
66	REVI	0.4197	0.21210
54	BCCH	0.7426	0.15790
47	HOWR	0.2668	0.08338
44	AMGO	1.0360	0.27540
43	BLJA	0.4080	0.10270
42	EAKI	0.3674	0.10100
42	GCFL	0.3095	0.07524
39	CLSW	1.0980	0.42600
35	OROR	0.3171	0.08760
31	MODO	0.2319	0.07684
27	COYE	0.1257	0.04481
25	BHCO	0.1391	0.04451

¹See Appendix 6 for species list and associated mnemonics.

Table 5. Avian density estimates (D = birds/ha) in FDRAW plots (FNNWR: Beaver Creek and Little Beaver Creek), Fort Niobrara NWR, 1992.

N	Species	D	SE
102	BCCH ¹	0.9353	0.15420
87	OVEN	0.6153	0.11590
65	GCFL	0.3692	0.08310
59	BWWA	0.3921	0.08992
42	BHCO	0.2477	0.07127
33	BLJA	0.1298	0.03890
33	MOD0	0.1652	0.04705
31	RSTO	0.1554	0.04502
30	AMRO	0.3151	0.14650
26	HOWR	0.2492	0.11030
24	EAPH	0.1748	0.05412

¹See Appendix 6 for species list and associated mnemonics.

Table 6. Avian density estimates (D = birds/ha) in VTREE plots (VNWR: Hackberry Tree, Dewey Tree, and Duck Lake), Valentine NWR, 1992.

N	Species	D	SE
495	RWBL ¹	4.72400	0.47750
236	BEVI	2.97300	0.56450
198	YEWA	2.58200	0.27440
182	COYE	1.11200	0.14390
126	AMGO	2.81400	0.53490
121	BHCO	1.50100	0.29440
119	YHBL	0.81650	0.33150
91	OROR	1.31000	0.27940
73	EAKI	0.85790	0.18700
66	SWSP	0.14520	0.18120
60	MAWR	0.23640	0.06946
57	HOWR	0.68030	0.20470
55	MODO	0.22170	0.06204
44	COGR	0.49020	0.13610
38	NOOR	0.79710	0.21180
34	TRSW	0.84910	0.35690
30	BCCH	0.21580	0.06559
28	MALL	0.11190	0.04530
26	WAVI	0.16960	0.08537
25	CEWA	0.42870	0.29560
22	AMCR	0.21660	0.13810
22	BRTH	0.22610	0.07516
21	BASW	0.05978	0.04011
20	AMRO	0.41810	0.18260
20	DOWO	0.26290	0.09343
20	YBCH	1.39600	0.92930

¹See Appendix 6 for species list and associated mnemonics.

Table 7. Diversity (H), evenness (J), and species richness (S) values, VNWR/FNNWR, 1992.

Habitat	Period	H	J	S
FTREE ¹	EARLY ²	3.186	0.795	55
	LATE	3.600	0.867	64
	BREED	3.570	0.855	65
FDRAW	EARLY	3.285	0.835	51
	LATE	3.239	0.851	45
	BREED	3.147	0.822	46
VTREE	EARLY	3.018	0.712	69
	LATE	3.150	0.723	78
	BREED	3.146	0.736	72
VRWET	EARLY	2.165	0.595	38
	LATE	2.077	0.580	36
	BREED	1.991	0.565	34
VSAND	EARLY	1.724	0.535	25
	LATE	1.809	0.549	27
	BREED	1.575	0.489	25
FSAND	EARLY	1.246	0.472	14
	LATE	1.297	0.506	13
	BREED	1.188	0.419	17

¹FTREE = FNNWR: Niobrara South and Niobrara East; FDRAW = FNNWR: Beaver Creek and Little Beaver Creek; VTREE = VNWR: Duck Lake, Dewey Tree and Hackberry Tree; VSAND = VNWR: Natural Area and Dewey Sand; FSAND = FNNWR: Sandhills East and Sandhills West; VRWET = VNWR: Pelican Lake and King Flat.

²EARLY = early migration; LATE = late migration; BREED = breeding period.

Table 8. Mean number of individuals detected on the FNNWR BBS route, 1992 (40 stops; N=2 surveys).

Species	$\bar{x}$	No./Stop	Species	$\bar{x}$	No./Stop
WEME	159.0	3.98	NOFL	3.5	0.09
GRSP	95.5	2.39	NRWS	3.5	0.09
HOLA	28.5	0.71	RNPH	3.5	0.09
MODO	21.0	0.53	HOWR	2.5	0.06
UPSA	17.0	0.43	LASP	2.5	0.06
COGR	14.5	0.36	RWBL	2.5	0.06
BHCO	14.0	0.35	CONI	2.0	0.05
GRPC	14.0	0.35	COYE	2.0	0.05
EAKI	11.5	0.29	EABL	2.0	0.05
AMCR	11.0	0.28	WEKI	2.0	0.05
AMRO	10.0	0.25	BEVI	1.5	0.04
AMGO	8.5	0.21	BHGR	1.5	0.04
CLSW	8.5	0.21	CHSP	1.0	0.03
GCFL	8.0	0.20	EUST	1.0	0.03
FISP	7.0	0.18	TUVU	1.0	0.03
BASW	6.5	0.16	BLGR	0.5	0.01
REVI	5.5	0.14	EAPH	0.5	0.01
RSTO	5.5	0.14	EAWP	0.5	0.01
BCCH	4.5	0.11	HAWO	0.5	0.01
WITU	4.5	0.11	HOSP	0.5	0.01
BRTH	4.0	0.10	LBCU	0.5	0.01
INBU	4.0	0.10	RHWO	0.5	0.01
BLJA	3.5	0.09	WWPE	0.5	0.01
KILL	3.5	0.09	YEWA	0.5	0.01

Table 9. Mean number of individuals detected on the VNWR BBS route, 1991 (50 stops; N=2 surveys).

Species	$\bar{x}$	No./Stop	Species	$\bar{x}$	No./Stop
RWBL	213.0	4.26	REDH	7.5	0.15
WEME	77.5	1.55	AMGO	7.0	0.14
YHBL	75.5	1.51	WEKI	7.0	0.14
DCCO	34.0	0.68	EAGR	5.5	0.11
EAKI	27.5	0.55	YEWA	5.5	0.11
BHCO	25.5	0.51	PEEP	5.0	0.10
COYE	25.0	0.50	AMBI	4.5	0.09
EAME	24.0	0.48	AMRO	4.5	0.09
RNPH	22.0	0.44	FRGU	4.5	0.09
MALL	21.0	0.42	HOWR	4.5	0.09
AWPE	20.0	0.40	TRSW	4.5	0.09
BWTE	20.0	0.40	NOOR	4.0	0.08
UPSA	20.0	0.40	BRTH	3.5	0.07
CAGO	17.5	0.35	COSN	3.0	0.06
MOD0	16.0	0.32	LASP	3.0	0.06
BASW	15.0	0.30	SWSP	3.0	0.06
KILL	13.5	0.27	WILL	3.0	0.06
BLTE	12.5	0.25	BOBO	2.5	0.05
FOTE	11.5	0.23	CLSW	2.5	0.05
OROR	10.0	0.20	COGR	2.5	0.05
GRSP	9.0	0.18	CONI	2.5	0.05
MAWR	9.0	0.18	GADW	2.5	0.05
BEVI	8.5	0.17	NOSH	2.5	0.05
AMCR	7.5	0.15	RUDU	2.5	0.05

Table 9. Concluded.

Species	$\bar{x}$	No./Stop	Species	$\bar{x}$	No./Stop
BCNH	2.0	0.04	WITU	1.0	0.02
GBHE	2.0	0.04	YBCU	1.0	0.02
PBGR	2.0	0.04	ALFL	0.5	0.01
WAVI	2.0	0.04	BCCH	0.5	0.01
WIFL	2.0	0.04	BLPW	0.5	0.01
LOSH	1.5	0.03	CEWA	0.5	0.01
SWHA	1.5	0.03	GRCA	0.5	0.01
WIPH	1.5	0.03	NOHA	0.5	0.01
BLJA	1.0	0.02	NRWS	0.5	0.01
FISP	1.0	0.02	RTHA	0.5	0.01
GRPC	1.0	0.02	SPSA	0.5	0.01
LEYE	1.0	0.02			
NOFL	1.0	0.02			

Table 10. Mean number of individuals detected on the VNWR BBS route, 1992 (50 stops; N=2 surveys).

Species	$\bar{x}$	No./Stop	Species	$\bar{x}$	No./Stop
RWBL	229.0	4.58	GRPC	9.0	0.18
WEME	94.5	1.89	BEVI	8.5	0.17
YHBL	94.5	1.89	PBGR	8.5	0.17
DCCO	39.0	0.78	LASP	8.0	0.16
EAKI	35.5	0.71	NOOR	8.0	0.16
COYE	35.0	0.70	CAGO	7.0	0.14
RNPH	34.0	0.68	AMBI	6.5	0.13
MODO	29.5	0.59	HOWR	6.5	0.13
EAME	29.0	0.58	WEKI	4.5	0.09
BHCO	27.0	0.54	WITU	4.5	0.09
MALL	27.0	0.54	AMRO	4.0	0.08
MAWR	21.5	0.43	WAVI	4.0	0.08
UPSA	20.0	0.40	BRTH	3.5	0.07
AMGO	19.5	0.39	COGR	3.5	0.07
BLTE	17.0	0.34	COSN	3.5	0.07
FOTE	15.0	0.30	NOFL	3.5	0.07
AMWP	17.0	0.34	CONI	3.0	0.06
AMCR	10.5	0.21	GBHE	3.0	0.06
BWTE	10.5	0.21	REDH	3.0	0.06
OROR	10.5	0.21	TRSW	3.0	0.06
YEWA	10.5	0.21	WILL	3.0	0.06
GRSP	10.0	0.20	GADW	2.5	0.05
BASW	9.5	0.19	WIPH	2.0	0.04
KILL	9.5	0.19			

Table 10. Concluded.

Species	$\bar{x}$	No./Stops	Species	$\bar{x}$	No./Stops
AMCO	1.5	0.03	BLJA	0.5	0.01
WIFL	1.5	0.03	INBU	0.5	0.01
WODU	1.5	0.03	LBCU	0.5	0.01
BBCU	1.0	0.02	LEFL	0.5	0.01
DOWO	1.0	0.02	LESC	0.5	0.01
LOSH	1.0	0.02	NRWS	0.5	0.01
YBCU	1.0	0.02	RBGU	0.5	0.01
AMKE	0.5	0.01	RTHA	0.5	0.01
BCNH	0.5	0.01	SWSP	0.5	0.01

Table 11. Habitat characteristics (means) at 7 study plots in treed habitats (VTREE: Dewey Lake, Hackberry Lake, Duck Lake; FTREE: Niobrara East, Niobrara South; FDRAW: Beaver Creek, Little Beaver Creek), VNWR/FNNWR, 1992.

Habitat Variable	Study Plot						
	Beaver Creek	Little Beaver Creek	Niobrara East	Niobrara South	Dewey Lake	Hackberry Lake	Duck Lake
Basal Area (m ² /ha)	2.95	3.25	5.63	2.33	4.97	2.14	3.44
Small Trees (#/ha)	698.3	660.0	818.2	233.3	776.7	201.7	453.3
Medium Trees (#/ha)	120.0	90.0	179.5	83.3	126.7	80.0	218.3
Big Trees (#/ha)	0	5.0	4.5	0	1.7	0	11.7
Deciduous Canopy Cover (%)	60.2	60.2	77.0	28.5	52.4	22.3	41.3
Coniferous Canopy Cover (%)	1.5	2.3	13.7	10.5	22.7	24.8	0
Snags (#/ha)	48.3	46.7	36.4	5.0	15.0	0	26.7
Tree Height (m)	6.9	8.5	10.9	5.5	8.6	8.4	9.1
DBH (cm)	12.1	17.7	19.5	13.7	16.2	17.2	24.5
Forb Cover (%)	6.7	13.0	7.2	7.0	13.5	6.1	19.7
Bare Ground (%)	3.9	8.1	2.3	10.2	3.7	7.3	3.5
High Obscurity (%)	45.1	20.4	26.1	30.9	52.2	55.1	18.3
Shrub Cover (%)	22.2	11.7	7.6	8.9	27.8	30.8	5.2
Woody Cover (%)	11.4	7.8	6.7	10.0	18.9	25.0	3.3
% American Elm	6.67	11.67	2.27	0	0	0	0
% Black Locust	0	0	0	0	33.33	0	0
% Red Ash	11.67	15.0	22.73	8.77	1.75	0	0
% Common Hackberry	0	6.67	4.55	1.75	21.05	30.51	0
% Ironwood	28.33	18.33	13.64	0	0	0	0
% Bur Oak	30.00	38.33	34.09	10.53	0	0	0
% Boxelder Maple	21.67	3.33	9.09	3.51	0	1.69	0
% Ponderosa Pine	0	3.33	2.27	0	0	1.69	0

Table 11. Concluded.

Habitat Variable	Study Plot						
	Beaver Creek	Little Beaver Creek	Niobrara East	Niobrara South	Dewey Lake	Hackberry Lake	Duck Lake
% Peachleaf Willow	0	1.67	0	0	0	1.69	89.47
% Plains Cottonwood	0	1.67	0	0	0	0	7.02
% Eastern Juniper	1.67	0	11.36	73.68	43.86	62.71	3.51

Table 12. Mahalanobis distances (M) from species-present to species-absent plots, VNWR/FNNWR.

Species	Distance (m)	<i>P</i>	df (p, n - p + 1)
BEVI	6.13	<0.01	17, 288
YEWB	6.11	<0.01	17, 241
OVEN	5.65	<0.01	17, 183
RSTO	5.60	<0.01	17, 99
YBCH	4.73	<0.01	17, 106
COYE	4.65	<0.01	17, 234
REVI	4.46	<0.01	17, 143
GCFL	4.32	<0.01	17, 154
BWWA	4.32	<0.01	17, 123
OROR	4.12	<0.01	17, 172
NOOR	2.78	<0.05	17, 106
EAKI	2.42	<0.05	17, 160
HOWR	1.82	NS	17, 181
BRTH	1.62	NS	17, 98

FIGURE CAPTIONS

- Fig. 1. Valentine National Wildlife Refuge study plot locations for point surveys (---) and breeding bird survey route (-·-). Surveyed habitats include: lakeshore tree/shrub (A = Hackberry Lake, B = Dewey Lake, C = Duck Lake); Sandhills (D = Natural Area, E = Dewey Sand), and; wet meadow (F = Pelican Lake, G = King Flat).
- Fig. 2. Fort Niobrara National Wildlife Refuge study plot locations for point surveys (---) and breeding bird survey route (-·-). Surveyed habitats include: woody draw (A = Beaver Creek, B = Little Beaver Creek); riparian streamside (C = Niobrara East, D = Niobrara South), and; Sandhills (E = Sandhills West, F = Sandhills East).
- Fig. 3. Total avian detections ($\log_e$) in VSAND study plots (VNWR: Dewey Sand and Natural Area) during the breeding period, 1992.
- Fig. 4. Total avian detections ($\log_e$) in VRWET study plots (VNWR: Pelican Lake and King Flat) during the breeding period, 1992.
- Fig. 5. Total avian detections ($\log_e$) in FSAND study plots (FNNWR: Sandhills East and Sandhills West) during the breeding period, 1992.
- Fig. 6. Total avian detections ($\log_e$) in FTREE study plots (FNNWR: Niobrara East and Niobrara South) during the breeding period, 1992.
- Fig. 7. Total avian detections ($\log_e$) in FDRAW study plots (FNNWR: Beaver Creek and Little Beaver Creek) during the breeding period, 1992.
- Fig. 8. Total avian detections ($\log_e$) in VTREE study plots (VNWR: Hackberry Tree, Dewey Tree, and Duck Lake) during the breeding period, 1992.
- Fig. 9. Total detections of common avian species in VSAND study plots (VNWR: Natural Area, Dewey Sand) by census period, 1992.
- Fig. 10. Total detections of common avian species in FSAND study plots (FNNWR: Sandhills East, Sandhills West) by census period, 1992.
- Fig. 11. Total detections of common avian species in VRWET study plots (VNWR: Pelican Lake, King Flat) by census period, 1992.
- Fig. 12. Total detections of common avian species in VRWET study plots (VNWR: Pelican Lake, King Flat) by census period, 1992.

- Fig. 13. Total detections of common avian early migrant/resident species in FDRAW study plots (FNNWR: Beaver Creek, Little Beaver Creek) by census period, 1992.
- Fig. 14. Total detections of common avian late migrant species in FDRAW study plots (FNNWR: Beaver Creek, Little Beaver Creek) by census period, 1992.
- Fig. 15. Total detections of common avian early migrant species in FDRAW study plots (FNNWR: Beaver Creek, Little Beaver Creek) by census period, 1992.
- Fig. 16. Total detections of common avian early migrant/resident species in FTREE study plots (FNNWR: Niobrara East, Niobrara South) by census period, 1992.
- Fig. 17. Total detections of common avian late migrant species in FTREE study plots (FNNWR: Niobrara East, Niobrara South) by census period, 1992.
- Fig. 18. Total detections of common avian early migrant species in FTREE study plots (FNNWR: Niobrara East, Niobrara South) by census period, 1992.
- Fig. 19. Total detections of common avian early migrant/resident species in VTREE study plots (VNWR: Hackberry Tree, Dewey Tree, and Duck Lake) by census period, 1992.
- Fig. 20. Total detections of common avian early migrant species in VTREE study plots (VNWR: Hackberry Tree, Dewey Tree, and Duck Lake) by census period, 1992.
- Fig. 21. Total detections of common avian late migrant species in VTREE study plots (VNWR: Hackberry Tree, Dewey Tree, and Duck Lake) by census period, 1992.
- Fig. 22. Total detections of common avian early migrant/resident species in VTREE study plots (VNWR: Hackberry Tree, Dewey Tree, and Duck Lake) by census period, 1992.
- Fig. 23. Ordination of 14 bird species occurring in treed study plots (VTREE, FTREE, and FDRAW) along discriminant axes 1, 2, and 3, VNWR/FNNWR, 1992.

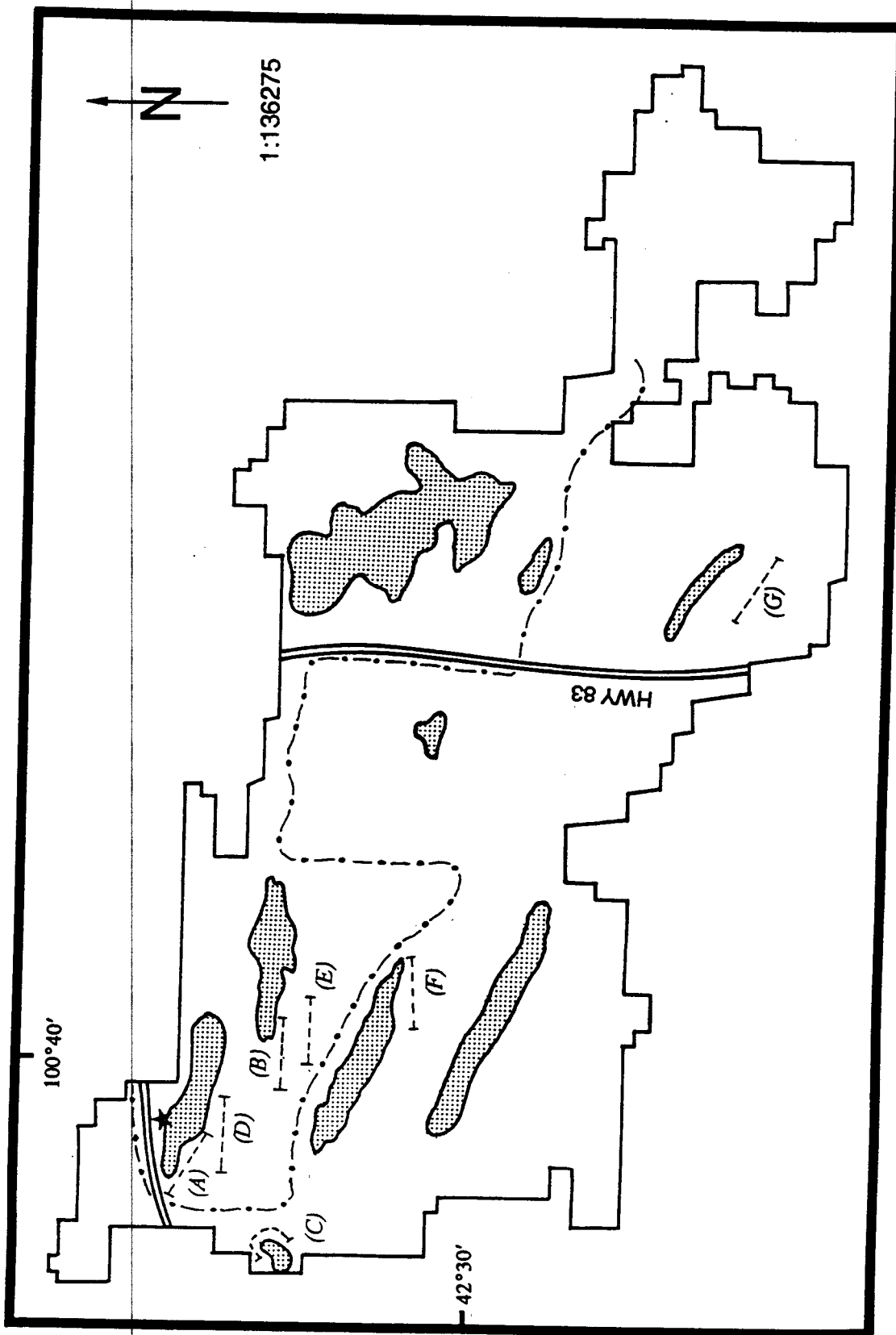


Fig. 1

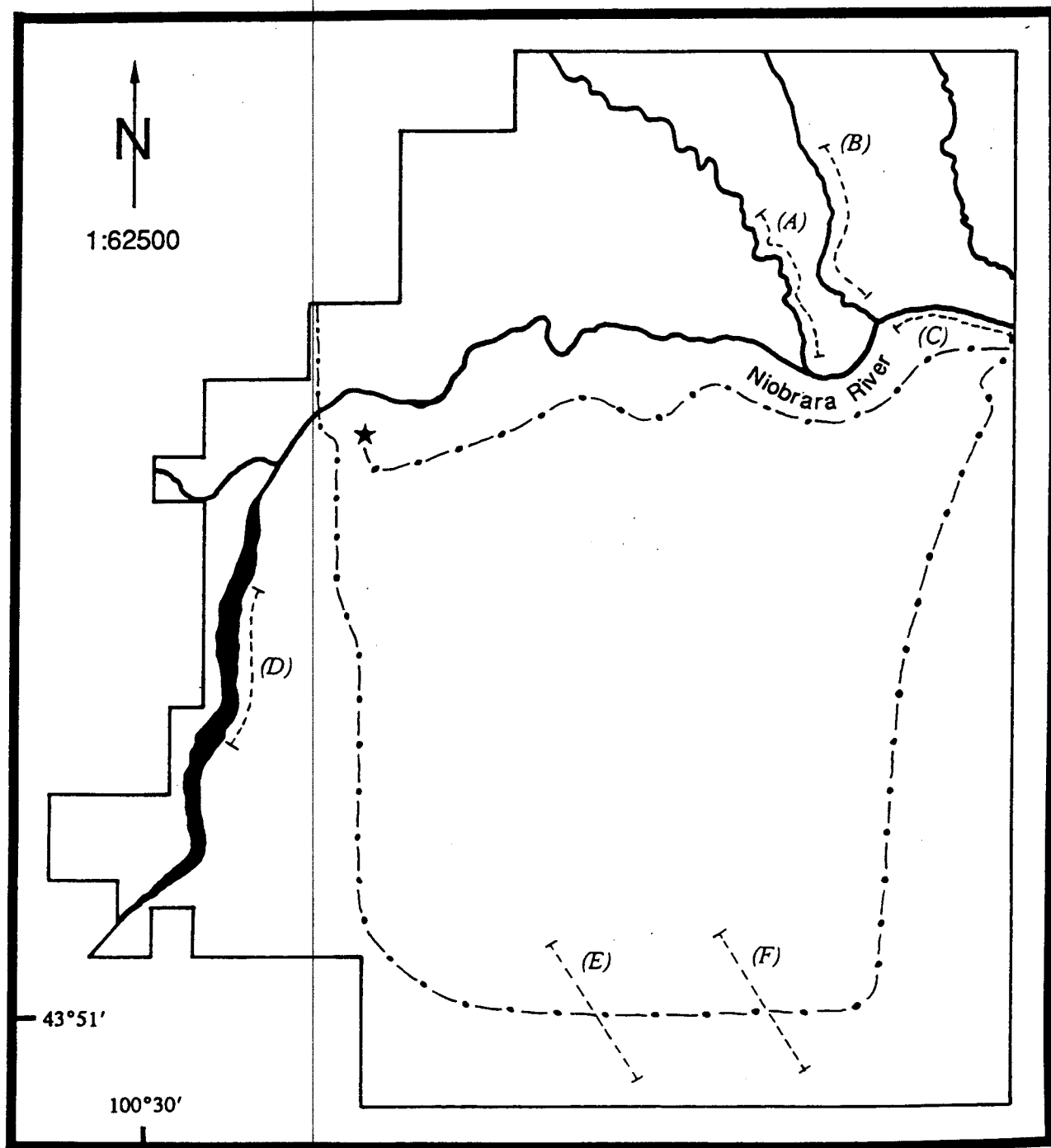


Fig. 2.

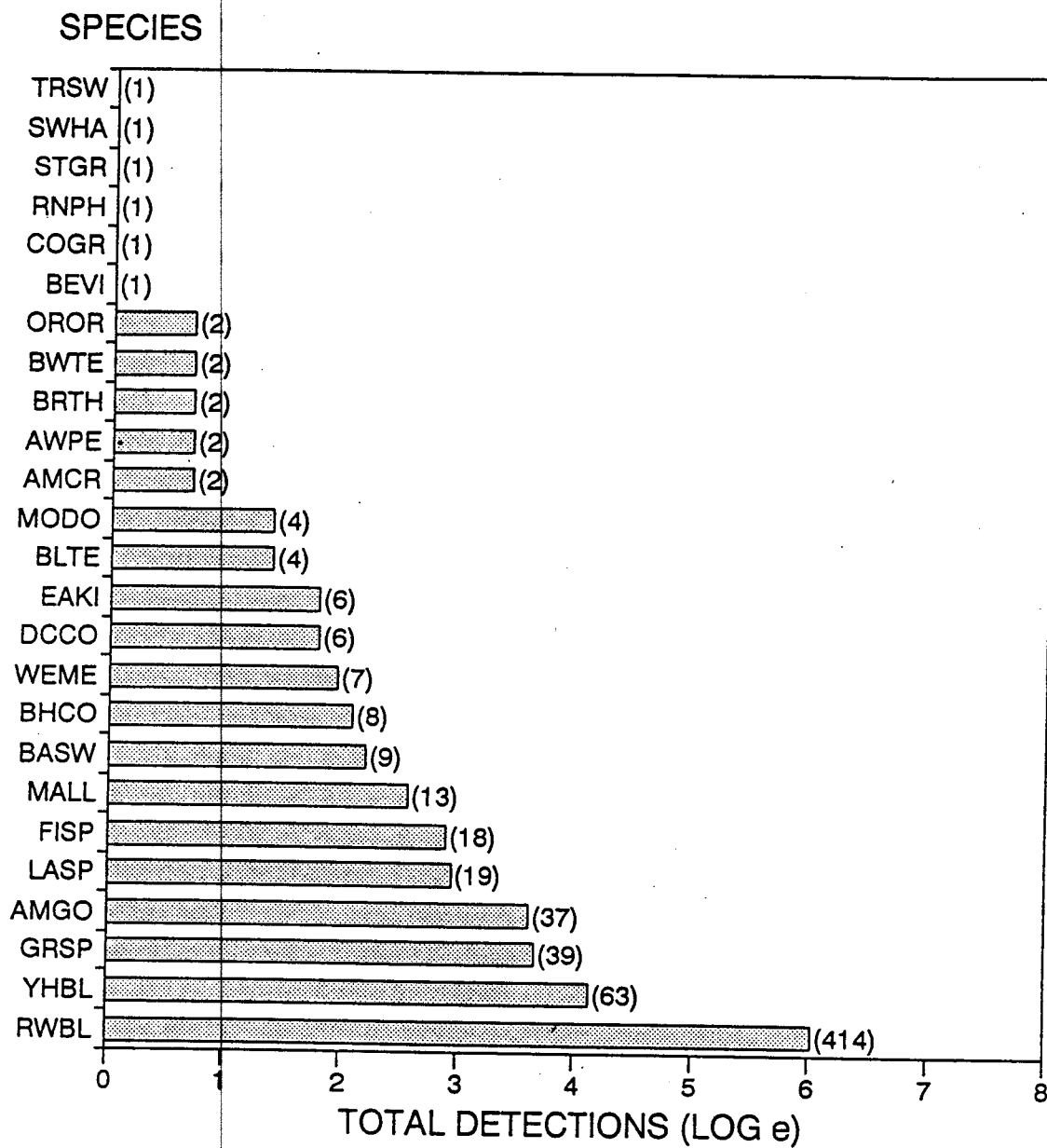


Fig. 3.

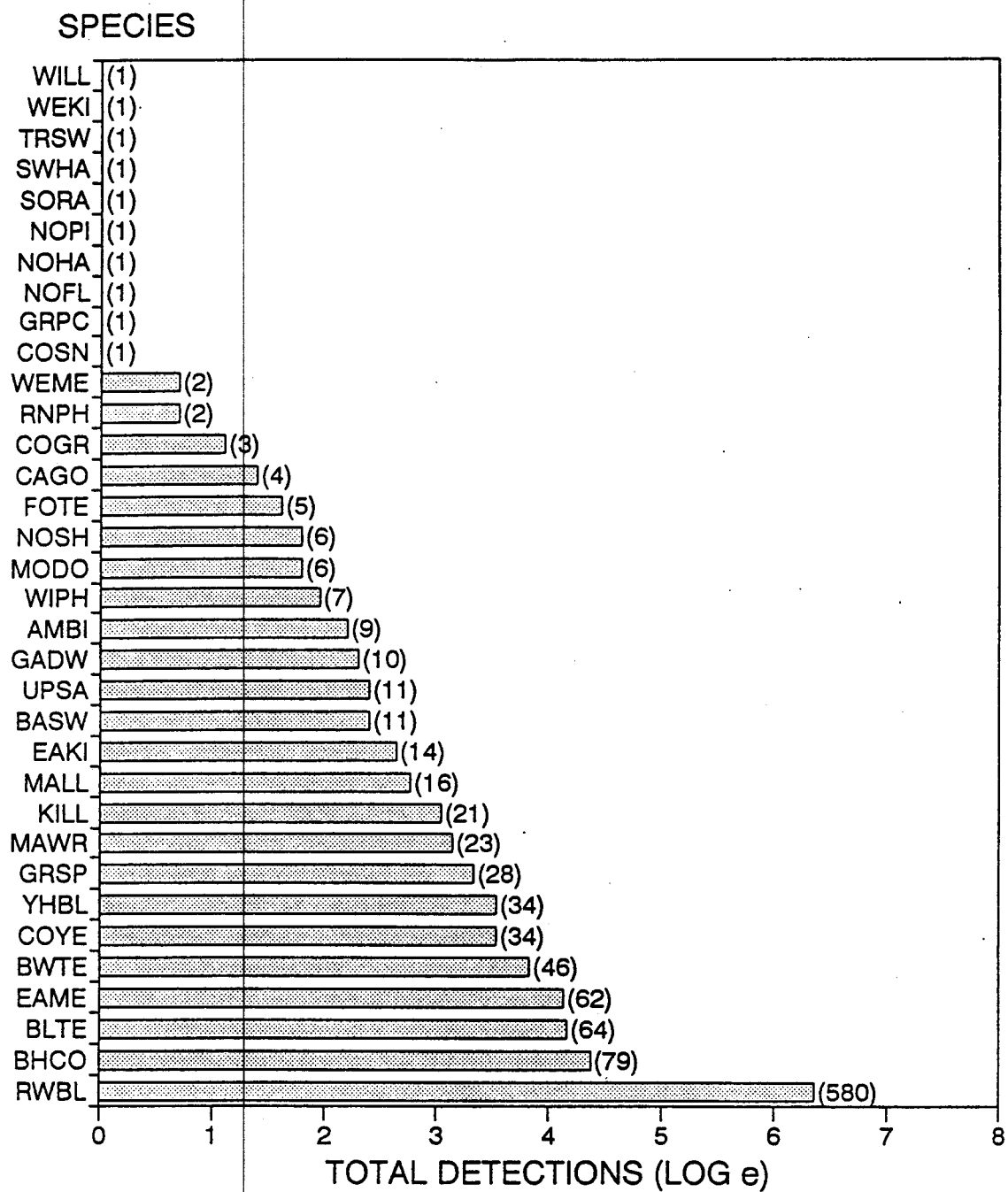


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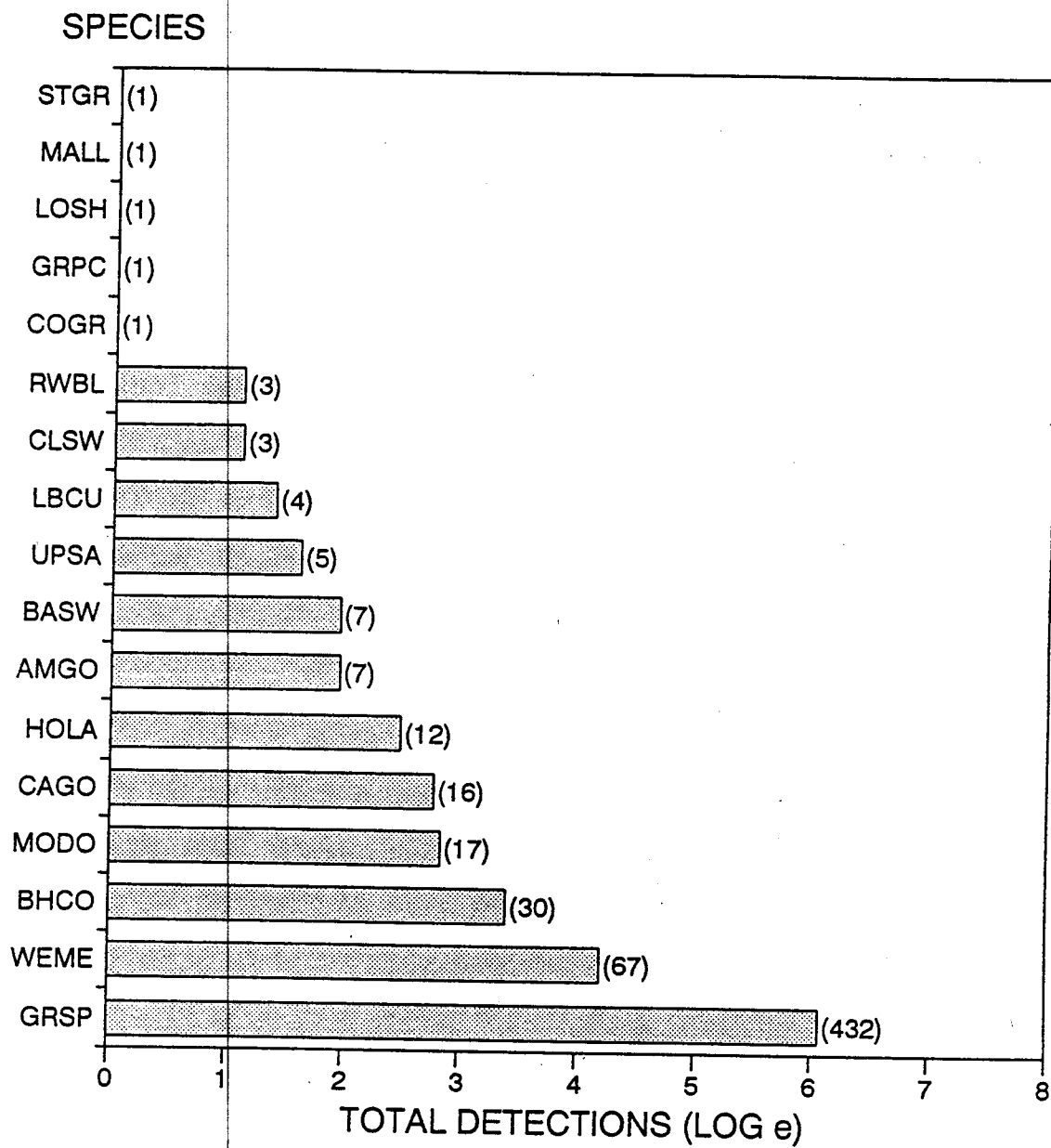


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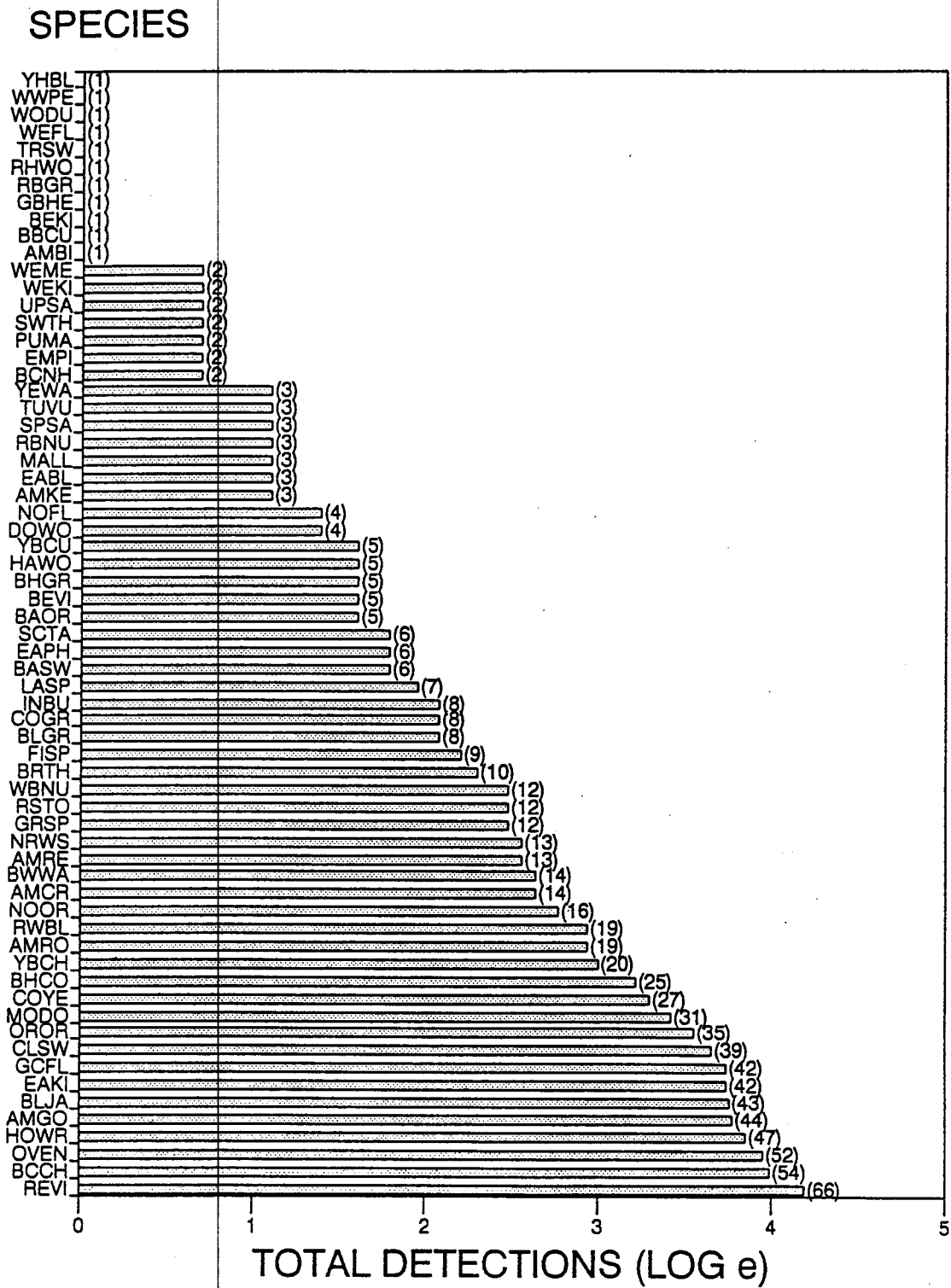


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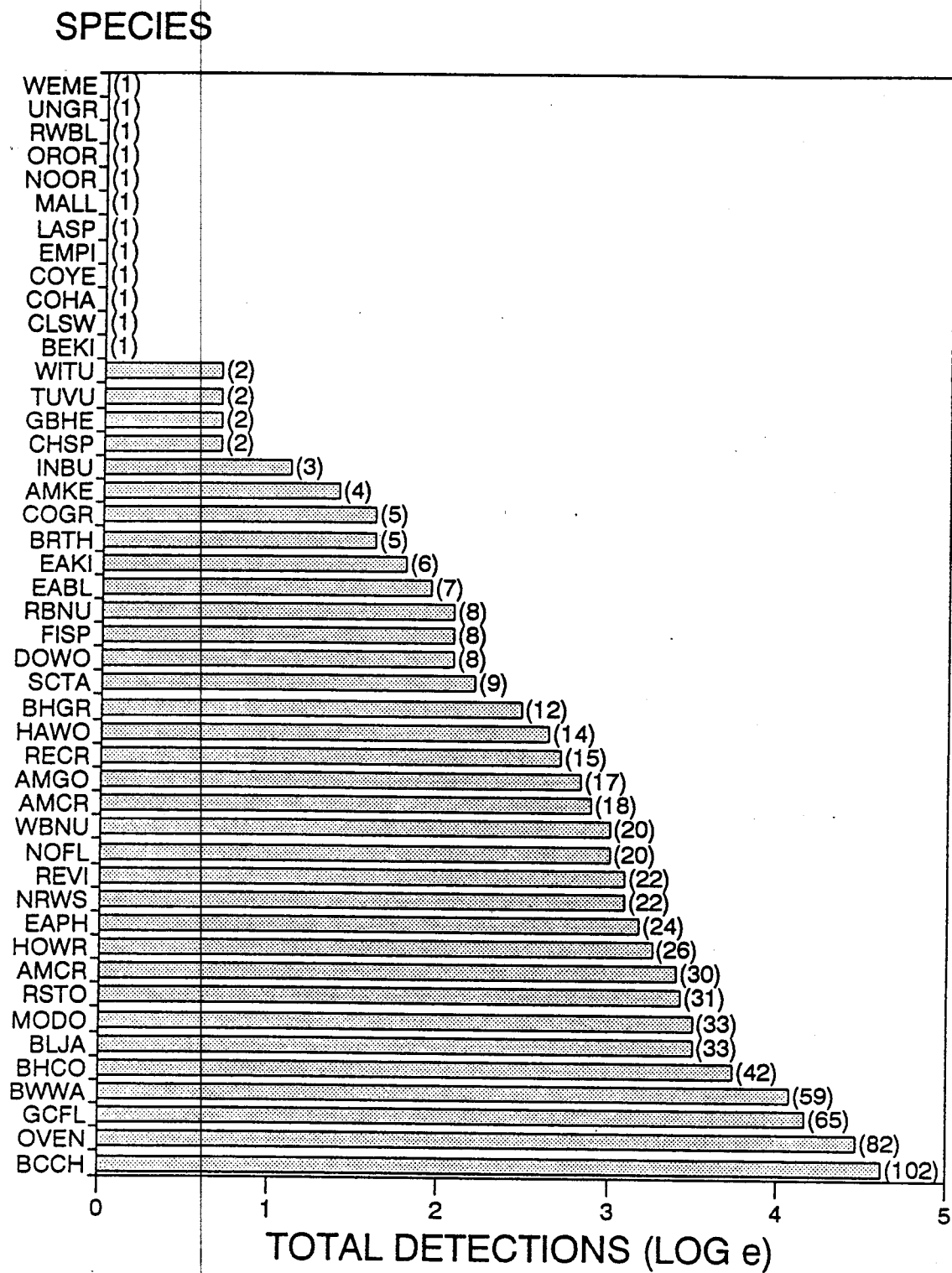


Fig. 7.

Horizontal bar chart showing the total number of detections (log e) for various bird species. The x-axis represents the total detections (log e), ranging from 0 to 8. The y-axis lists the species names. The bars are ordered by total detections, with RWBL having the highest total detections (495) and TEWA having the lowest (1).

Species	Total Detections (log e)
TEWA	1
NEWS	1
FEOW	1
GCCH	1
FOIT	1
CUSP	1
CONI	1
CAGG	1
BIGD	1
BBCK	1
AMKE	1
WODU	2
WVLY	2
WVLY	2
GHST	2
EUST	2
EABL	2
CHSP	2
AWPE	2
REWO	3
KIL	3
HAWO	3
GBHE	3
CLSW	3
BLPW	3
AMBI	3
VIFA	4
LEFA	4
GHOW	4
GCFL	4
BLJA	4
WITU	5
WEME	5
AMBT	5
BAOO	6
DCCO	7
NOFL	8
SWIL	9
BWTE	9
RNPL	10
RHWI	11
WIFP	13
EMPT	14
GRCA	16
FISP	16
BLTE	18
YBCH	20
DOWO	20
AMFO	20
BASW	21
BRIL	22
AMOR	22
CEWA	25
WAVI	26
MALL	28
BCCI	30
TRSW	34
NOOH	38
COGH	44
MODO	55
LOWO	57
MAWI	60
SWSP	66
EAKI	73
OROR	91
YHBL	119
BHCO	121
AMGO	126
COYE	182
YEWI	198
BEVI	236
RWBL	495

105

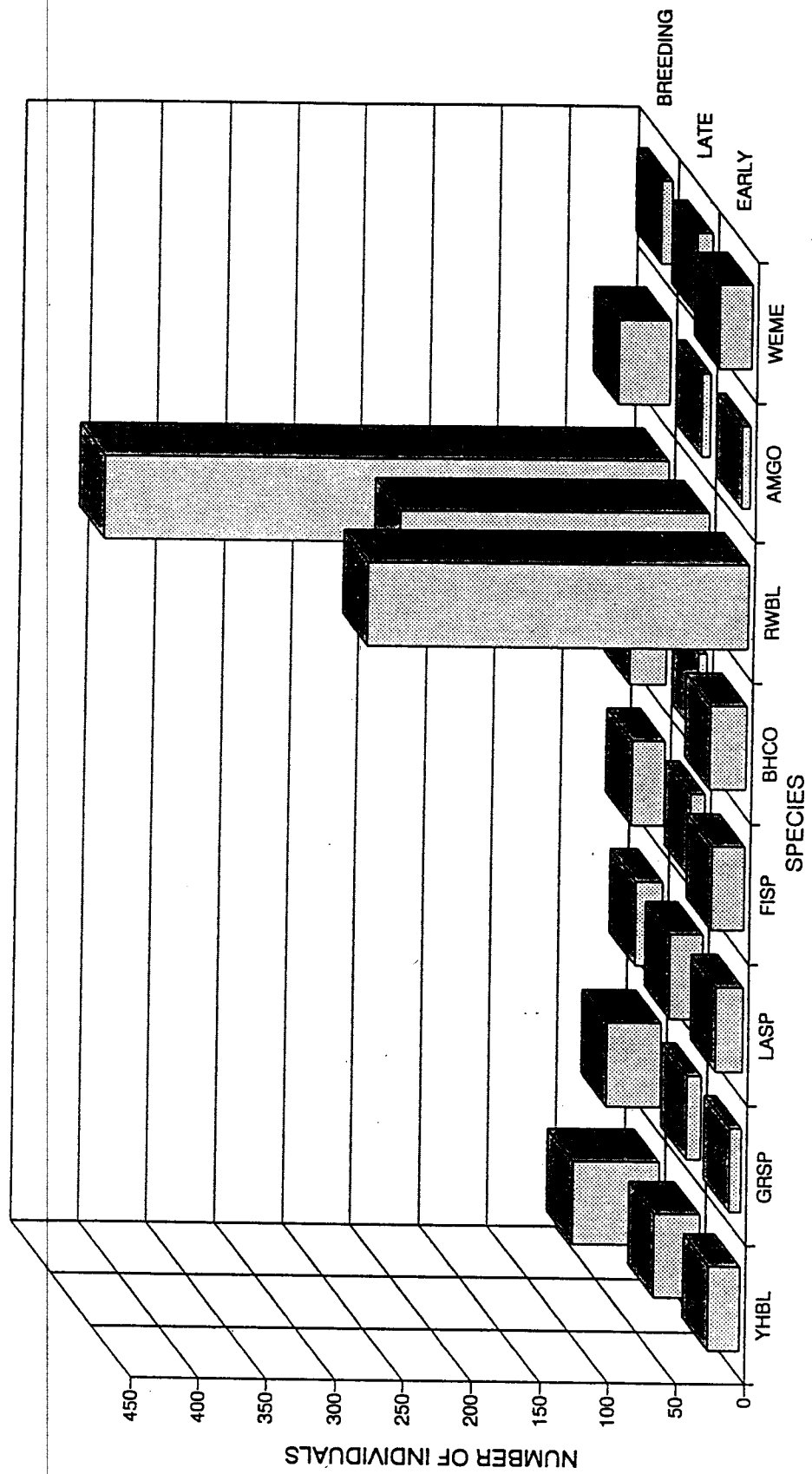


Fig. 9.

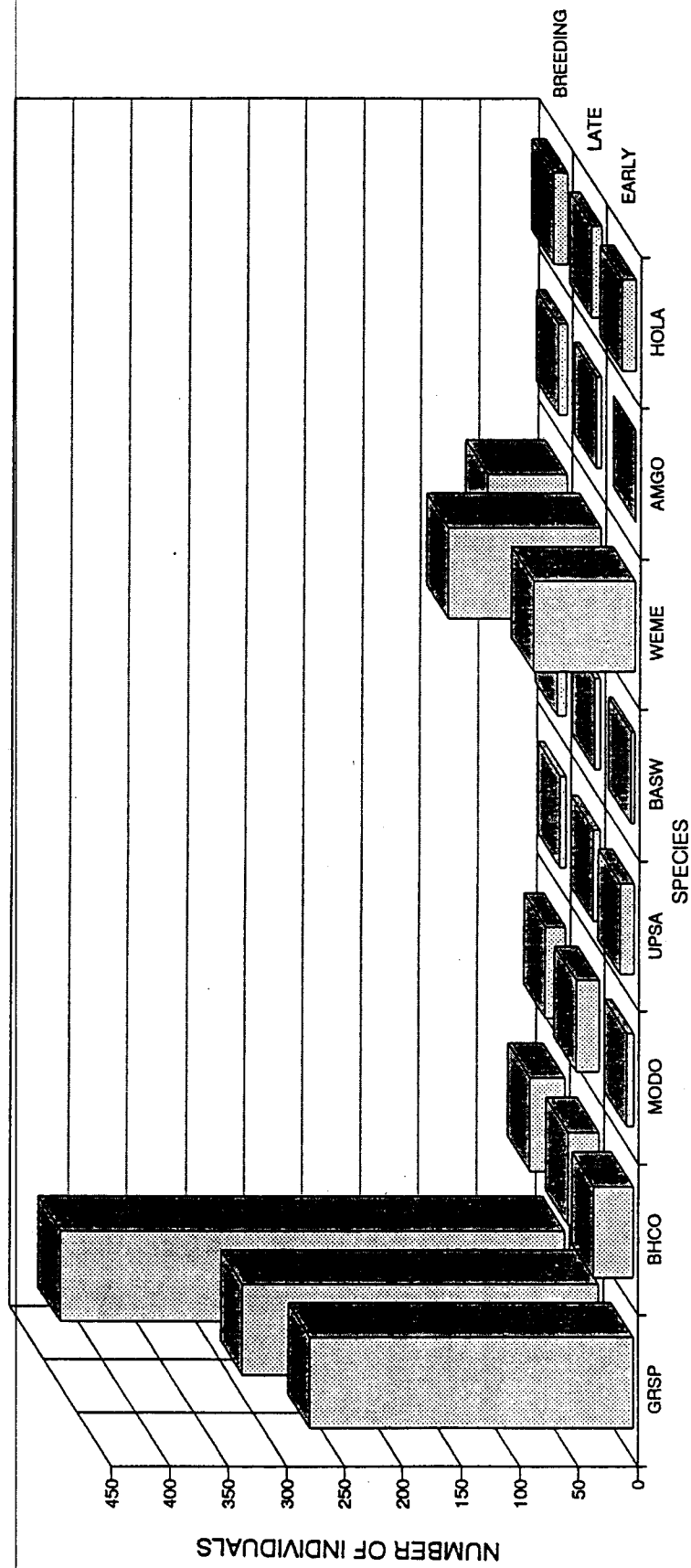


Fig. 10.

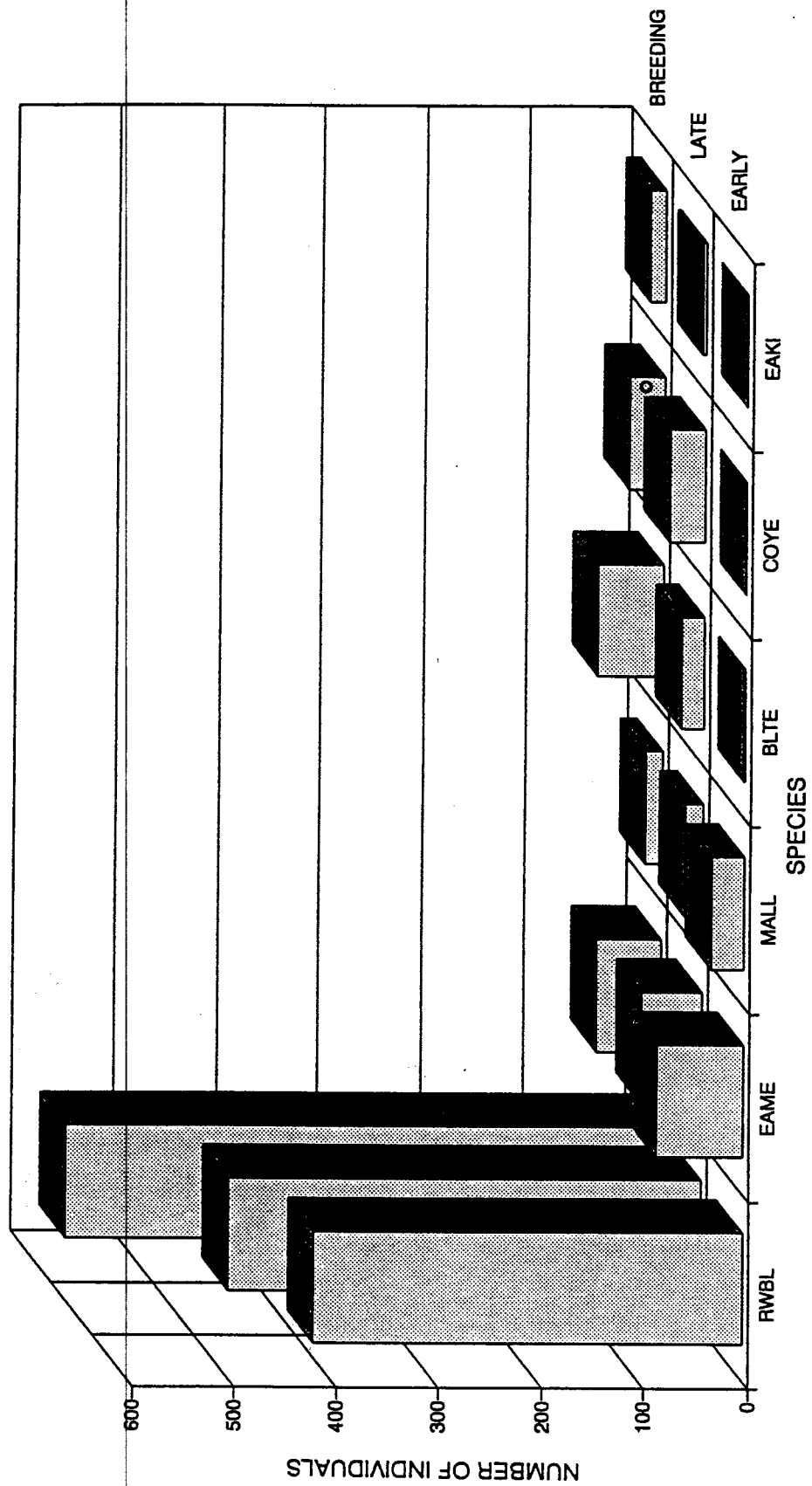


Fig. 11.

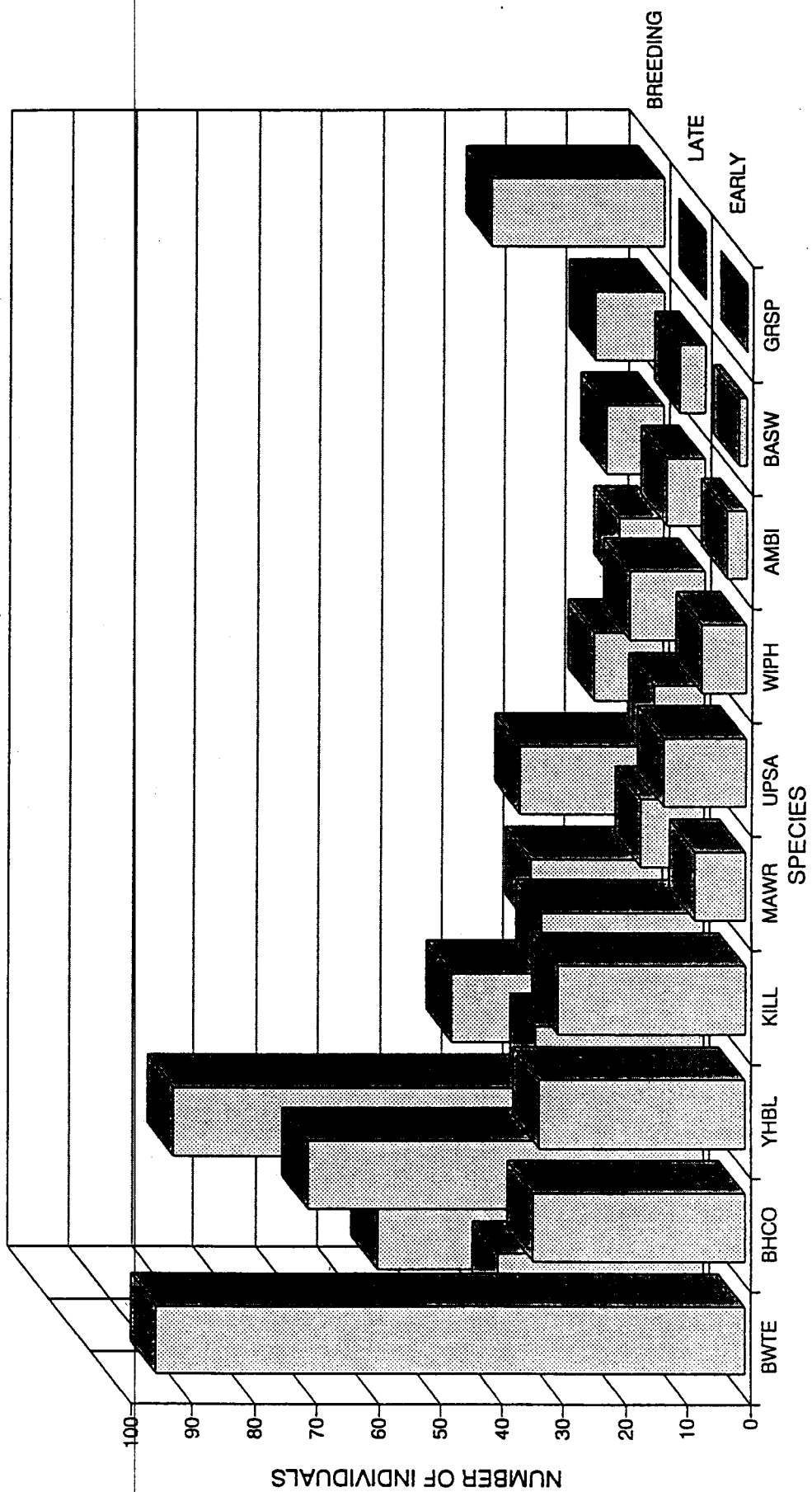


Fig. 12.

FLYING
early migrant / 10/10/10

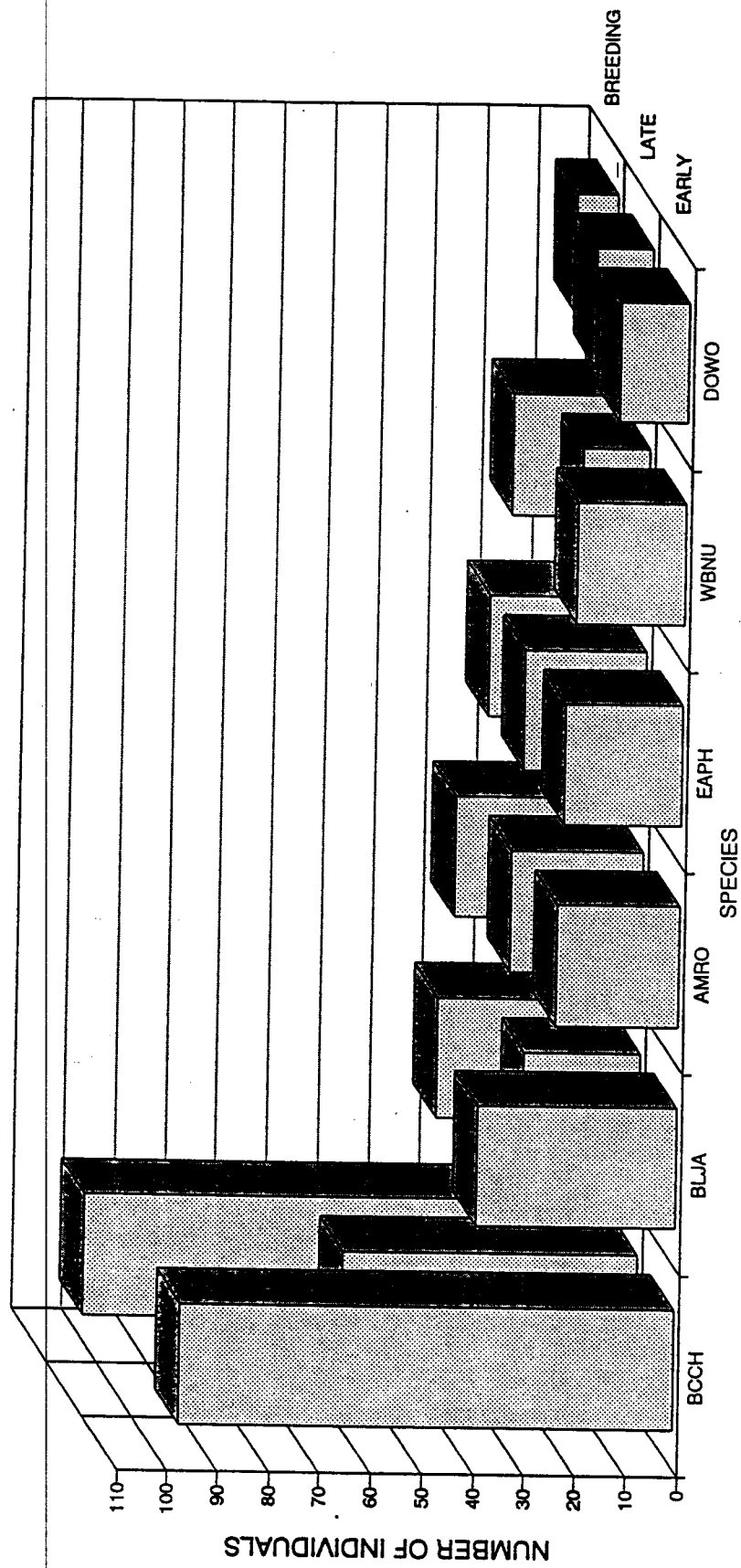


Fig. 13.

11/10/94
 10/10/94

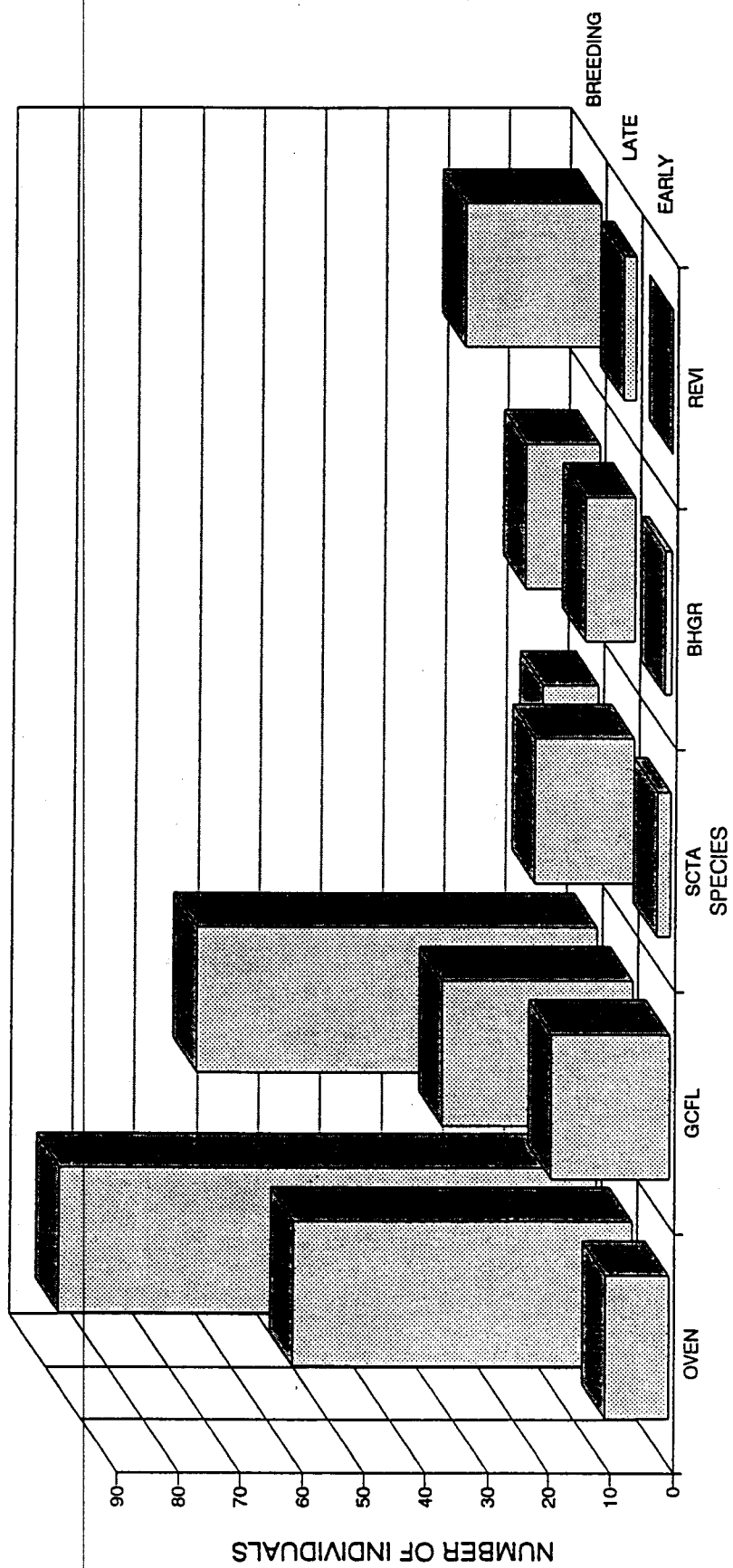


Fig. 14.

YRWA (1980-1981) early migrate

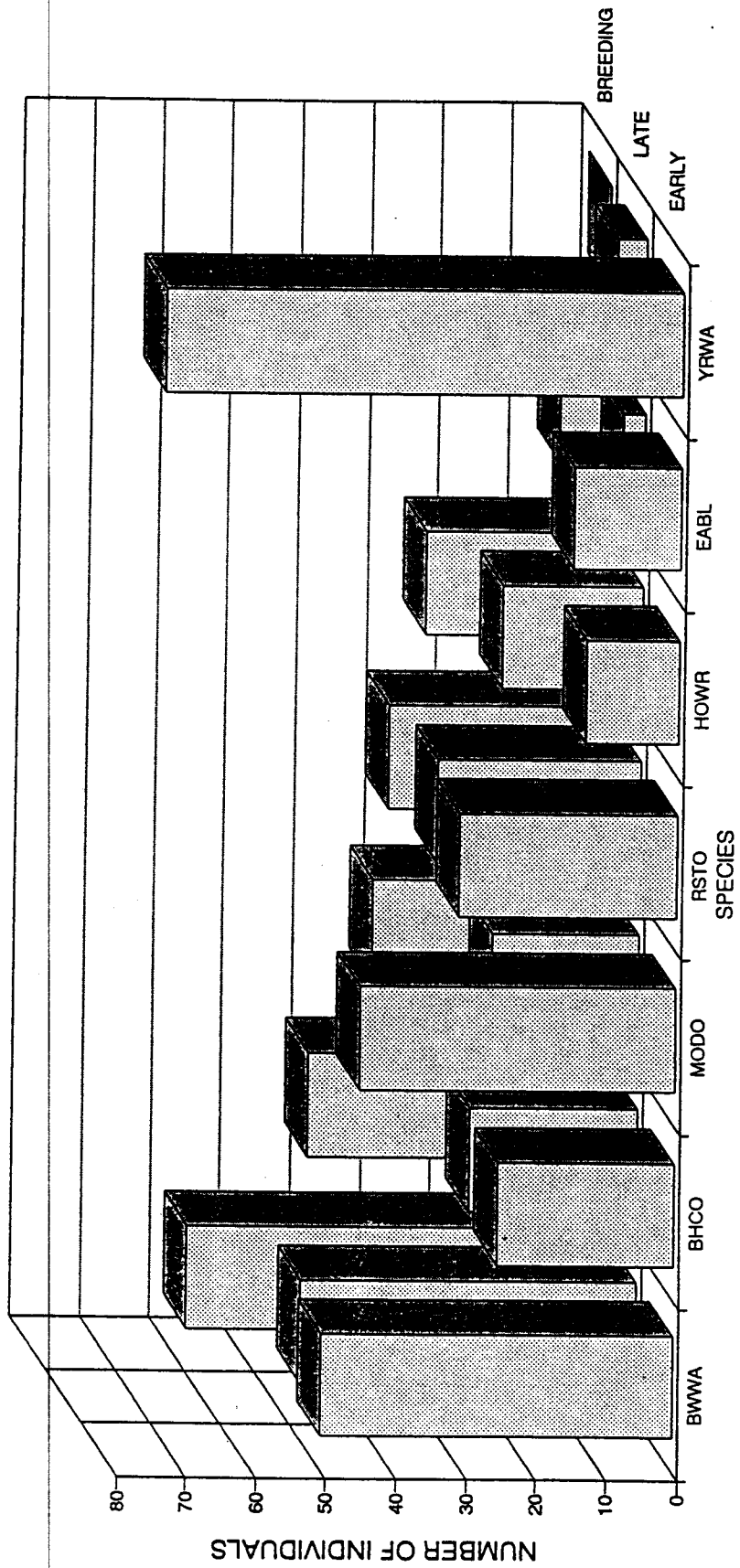


Fig. 15.

17100

early migratory - residents

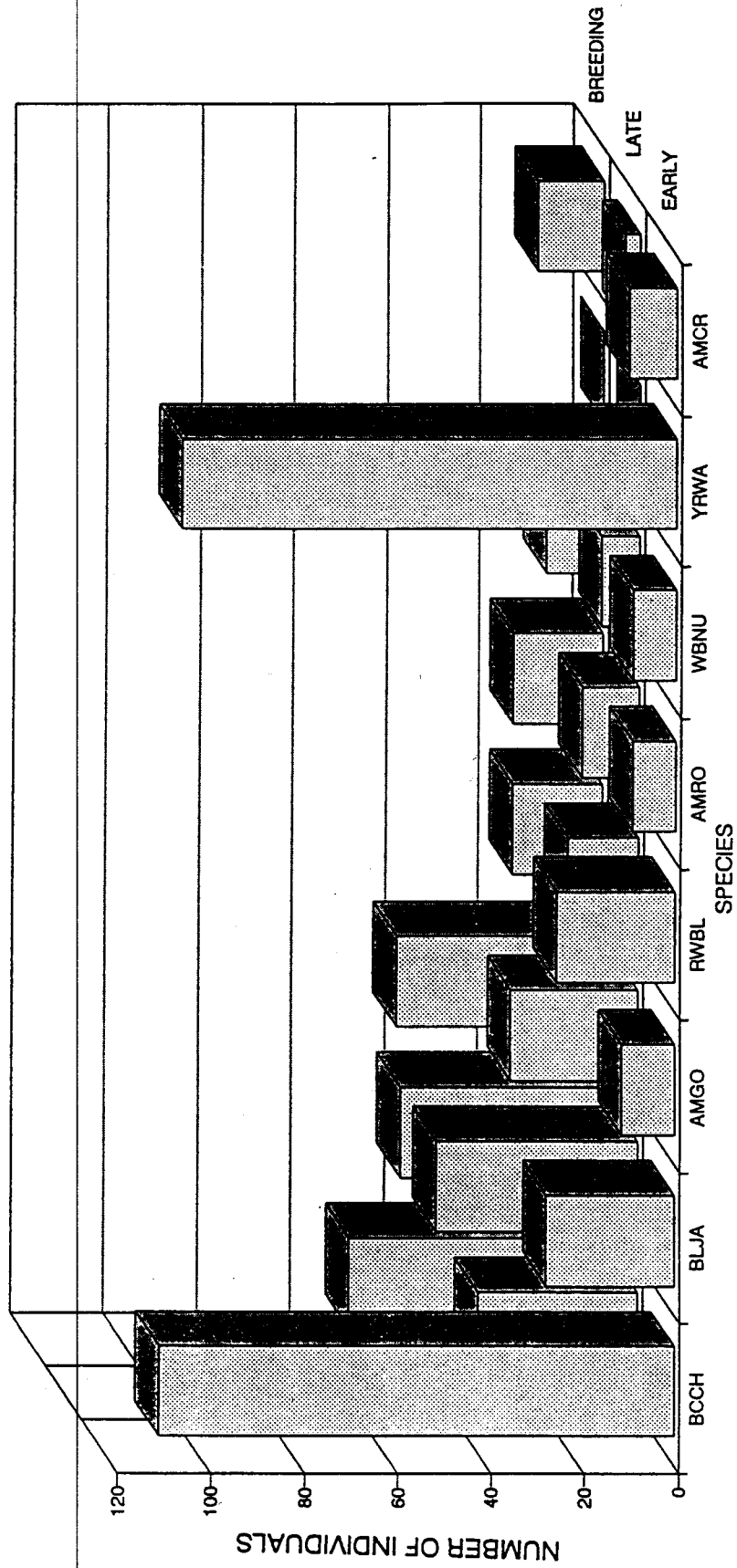


Fig. 16.

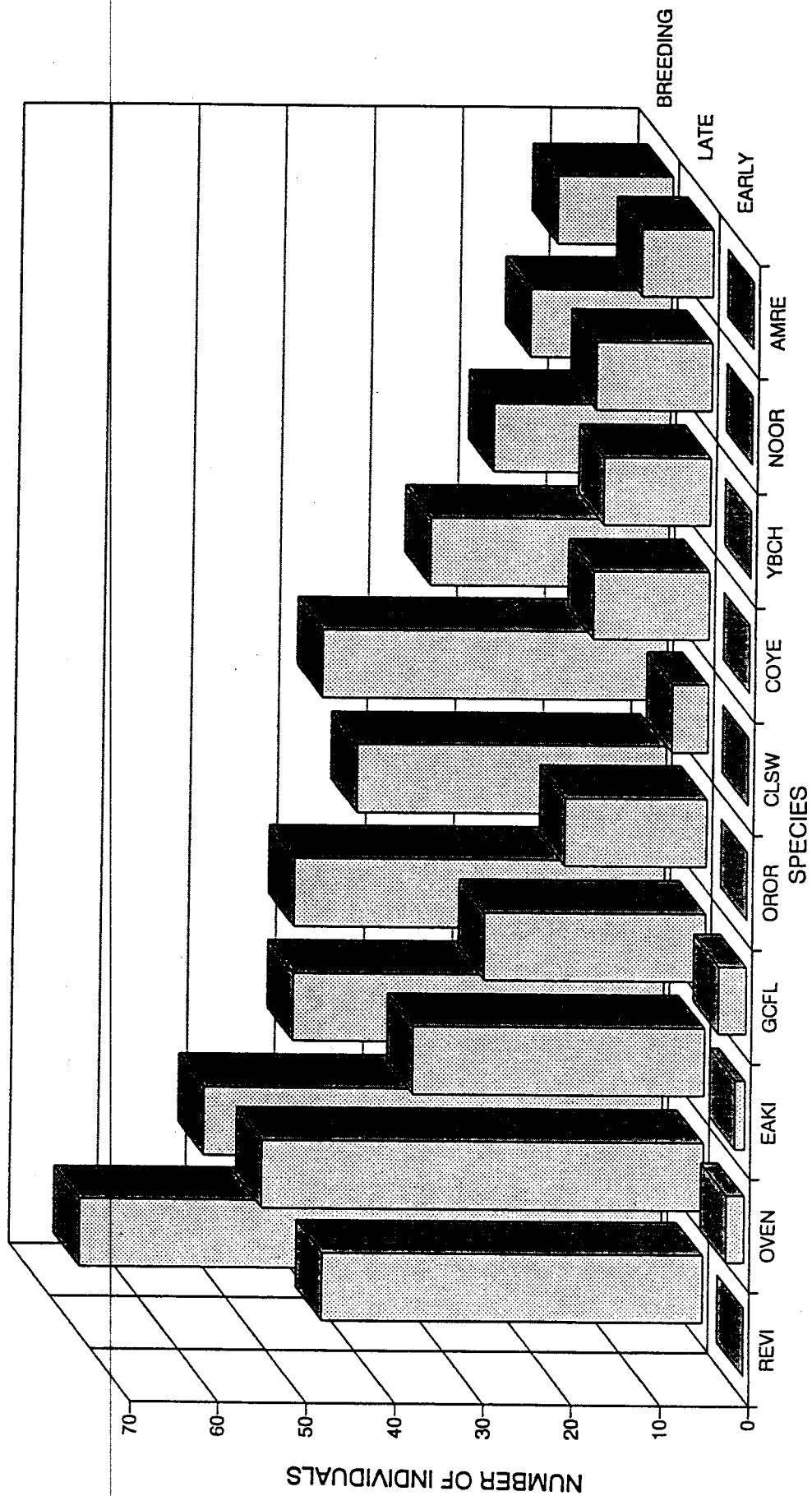


Fig. 17.

1-1963
corby ingalls

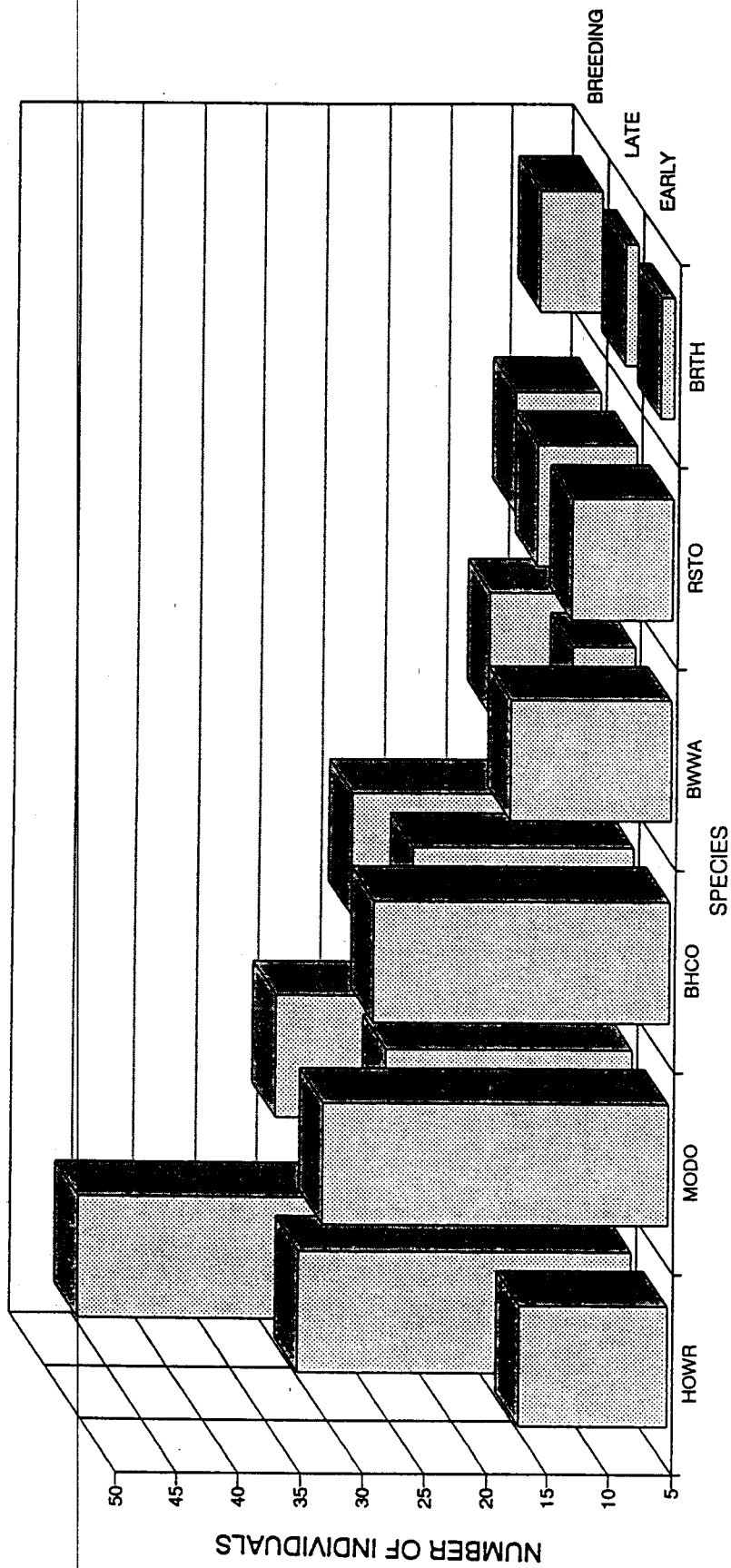


Fig. 18.

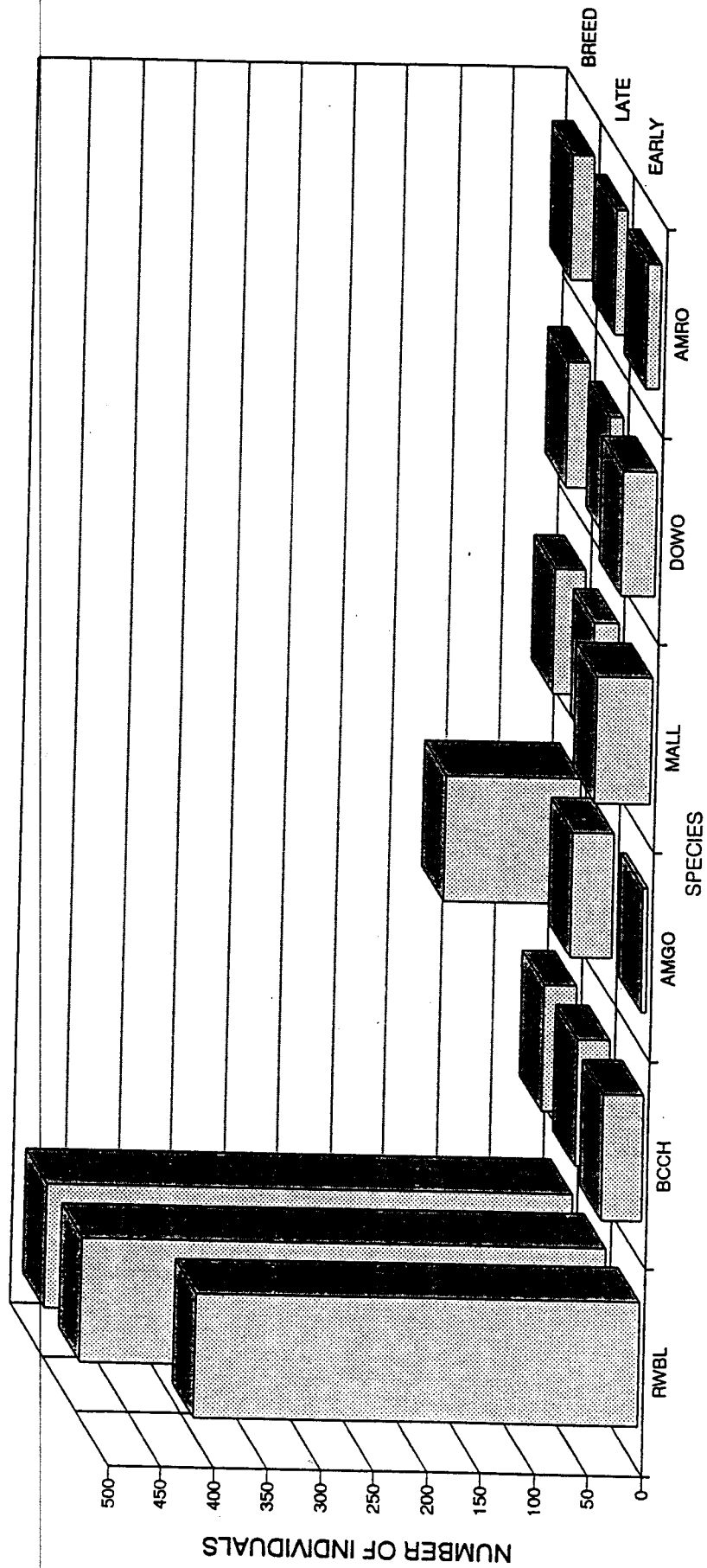


Fig. 19.

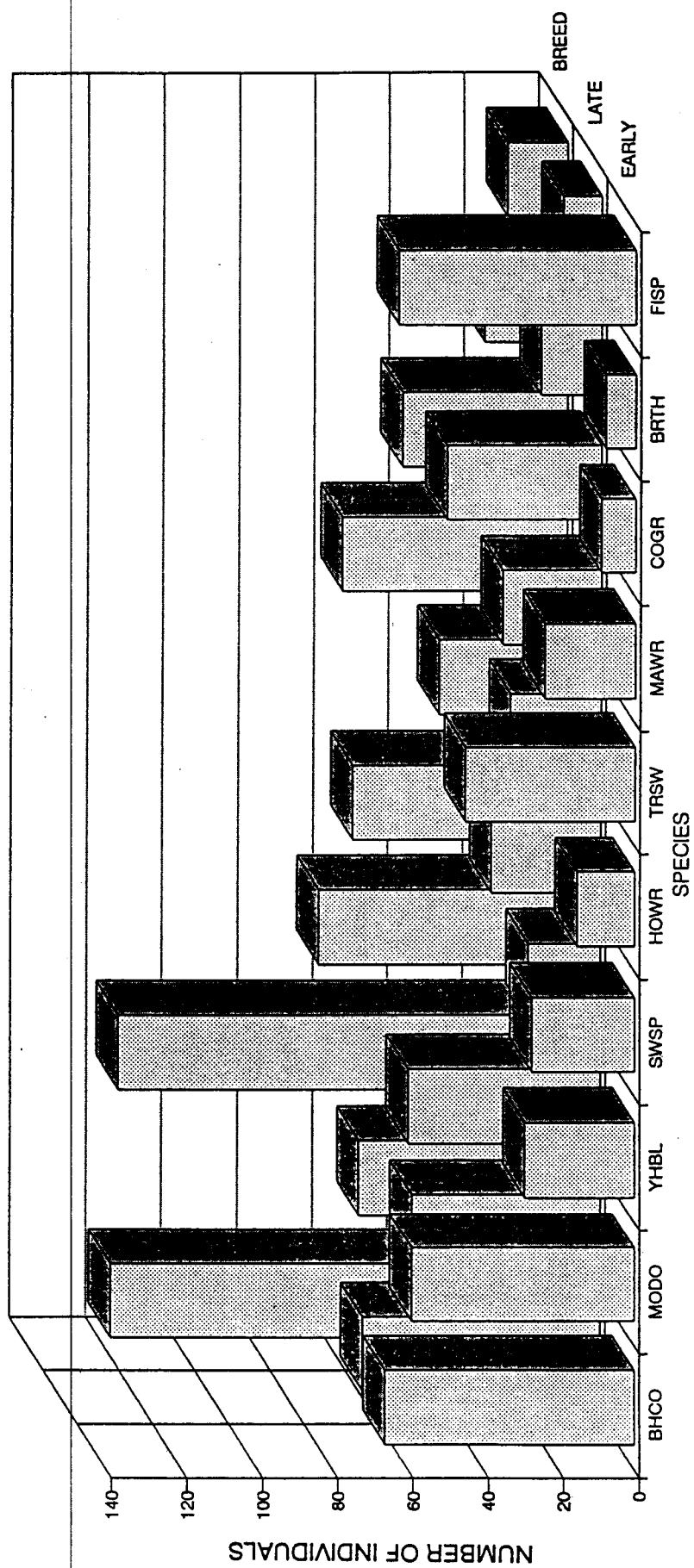


Fig. 20.

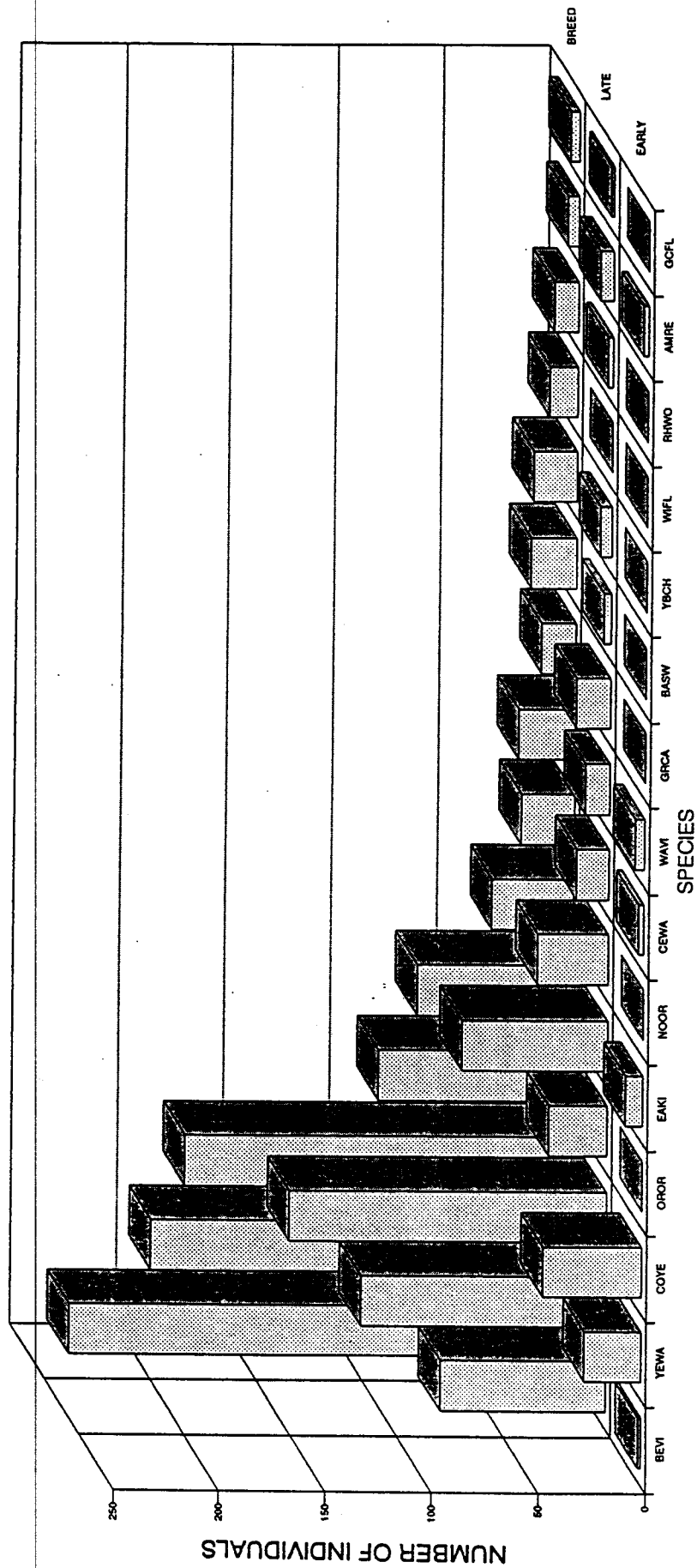


Fig. 21.

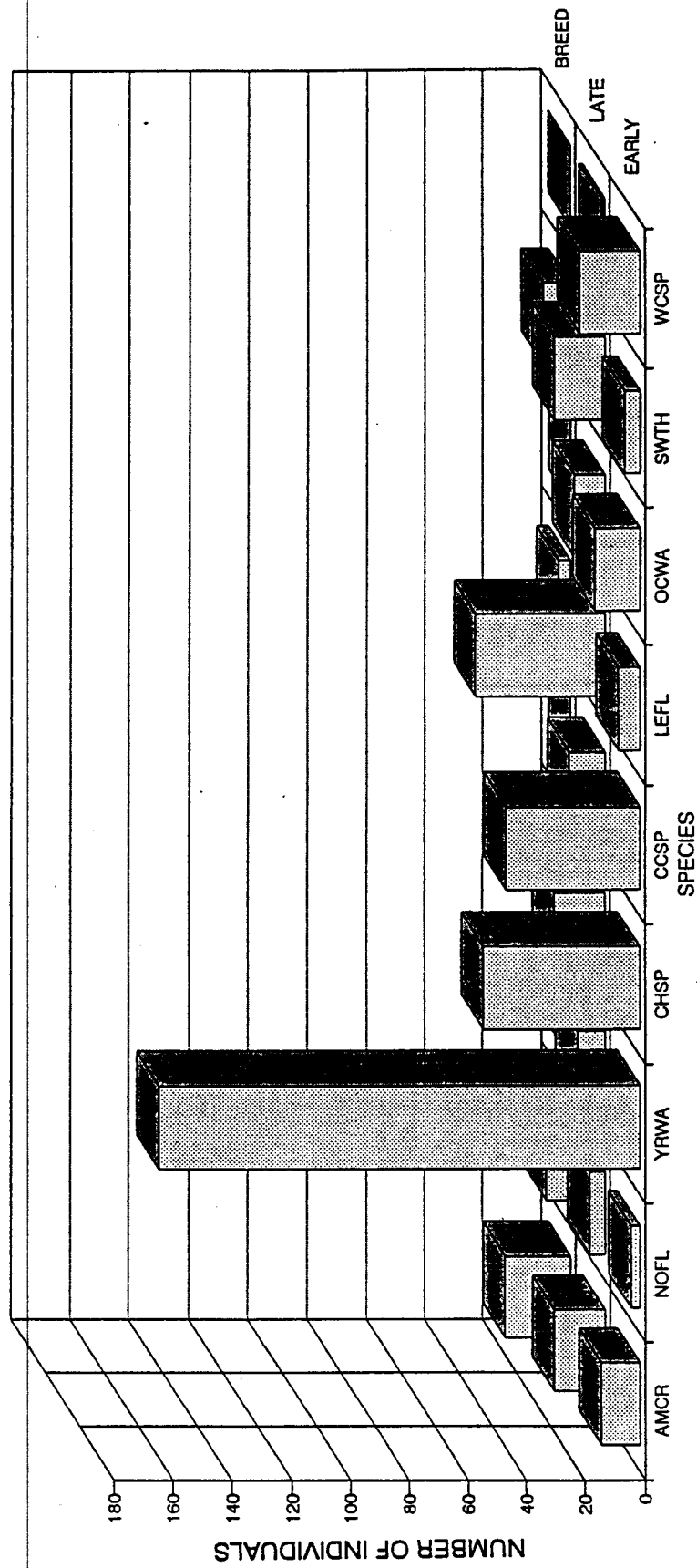


Fig. 22.

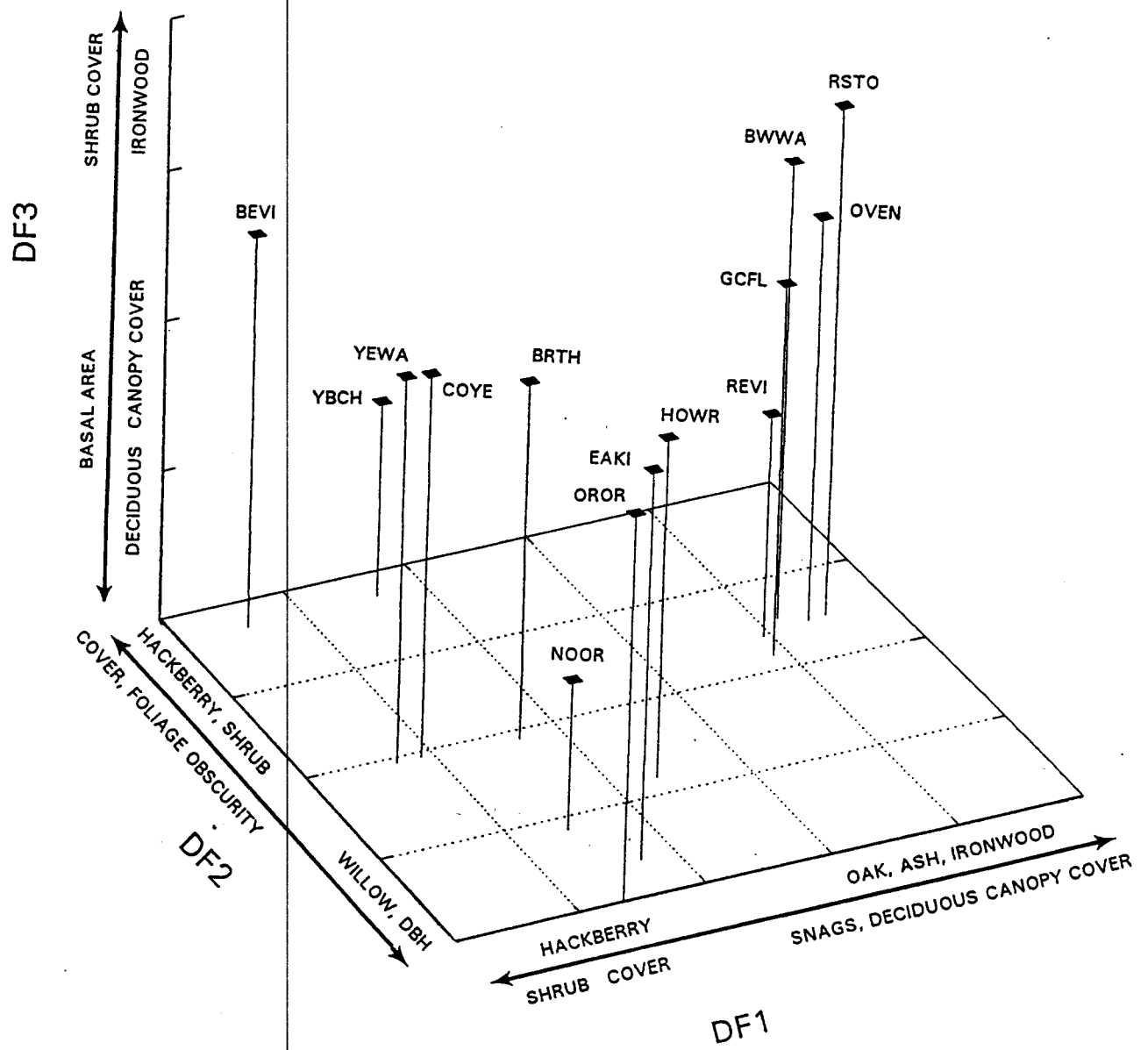


Fig. 23.

Appendix 1. Total avian detections in FDRAW study plots (FNNWR: Beaver Creek), 1991.

Species	No.	Species	No.
RECR	98	BRTH	4
GCFL	42	FISP	4
MODO	33	BEKI	3
AMGO	32	CEWA	3
BLJA	27	WBNU	3
BWWA	27	AMKE	2
BCCH	23	BHGR	2
OVEN	23	HAWO	2
AMRO	19	LEFL	2
HOWR	19	RBGR	2
AMCR	15	ALFL	1
NOFL	15	AMRE	1
BHCO	12	BASW	1
RSTO	12	CHSP	1
EABL	11	COGR	1
WEME	11	GBHE	1
EAPH	9	GHOW	1
EAKI	7	MOWA	1
NRWS	7	OROR	1
SCTA	7	RHWO	1
DOWO	5	TUVU	1
INBU	5	WITU	1
REVI	5		

Appendix 2. Total avian detections in FTREE study plots (FNNWR: Niobrara South and Niobrara East), 1991.

Species	No.	Species	No.
AMGO	79	RECR	8
REVI	63	BEKI	7
OVEN	57	NOFL	7
COYE	53	WAVI	7
GCFL	53	EWPE	6
EAKI	51	LASP	6
HOWR	41	WEME	6
BLJA	38	DOWO	5
BHCO	36	RTHA	5
BCCH	32	TUVU	5
MODO	31	ALFL	4
AMRE	30	BHGR	4
YBCH	27	YEWA	4
BWWA	22	CEWA	3
NRWS	22	COGR	3
RWBL	22	EAPH	3
FISP	21	GBHE	3
AMRO	20	MALL	3
AMCR	18	AMKE	2
RSTO	17	BASW	2
WBNU	14	BEVI	2
GRSP	13	BLGR	2
INBU	12	CAGO	2
NOOR	11	CONI	2
BRTH	10	DCCO	2
OROR	10	GRCA	2
HAWO	2	EAWP	1
RHWO	2	KILL	1
SCTA	2	RBNU	1
TEWA	2	RNPH	1
YBCU	2	SWTH	1
COHA	1	UPSA	1
EABL	1	WITU	1

Appendix 3. Total avian detections in VTREE study plots (VNWR: Dewey Tree and Hackberry Tree), 1991.

Species	No.	Species	No.
RWBL	311	DOWO	7
COYE	122	SORA	7
BEVI	111	BLJA	6
YEWA	101	NOOR	6
SWSP	65	BLTE	5
AMGO	58	AMRO	4
BHCO	52	CEWA	4
YHBL	51	DCCO	4
MAWR	38	SWTH	4
EAKI	34	BBCU	3
AMCR	31	BHGR	3
FISP	26	HAWO	3
YBCH	22	NOFL	3
RNPH	21	WODU	3
GRCA	19	AMBI	2
BCCH	17	FOTE	2
MALL	14	GCFL	2
HOWR	13	GHOW	2
COGR	12	NOHA	2
BWTE	11	ALFL	1
MODO	11	AMCO	1
TRSW	11	BASW	1
WIFL	11	BCNH	1
VIRA	9	BWWA	1
BRTH	8	CHSP	1
OROR	8	ESOW	1
GCTH	1	REVI	1
LABU	1	TEWA	1
LEFL	1	WAVI	1
LEOW	1	WITU	1
OVEN	1	YBCU	1
PBGR	1	YBFL	1

Appendix 4. Total avian detections in VSAND study plots (VNWR: Dewey Sand and Natural Area), 1991.

Species	No.	Species	No.
RWBL	177	AMCR	3
YHBL	41	WEKI	3
FISP	24	NOHA	2
WEME	22	SWHA	2
AMGO	20	AMRO	1
GRSP	16	BRTH	1
LASP	16	BWTE	1
MALL	15	COYE	1
EAKI	12	MODO	1
BHCO	9	NOPI	1
RNPH	9	NOSH	1
BLTE	8	TRSW	1
COGR	5	TUVU	1
BASW	4	UPSA	1

Appendix 5. Total avian detections in VRWET study plots (VNWR: Pelican Lake and King Flat), 1991.

Species	No.	Species	No.
RWBL	489	EAKI	10
BLTE	149	GADW	10
BWTE	111	WEME	7
EAME	74	RNPH	5
YHBL	56	AMGO	4
WIPH	55	AWPE	4
SORA	35	BASW	3
GRSP	30	NOPI	3
MALL	29	CLSW	2
COYE	28	COGR	2
BHCO	26	OROR	2
REDH	26	WEKI	2
MAWR	24	AMCO	1
UPSA	20	BOBO	1
COSN	17	CONI	1
AMBI	15	DCCO	1
GRPC	15	GBHE	1
NOSH	13	RBGU	1
FOTE	11	SEWR	1
KILL	11	WILL	1
VIRA	11		

Appendix 6. VNWR/FNNWR species list, from VCP surveys and BBS routes, 1991, 1992.

Mnemonic	Common name	Scientific name
ALFL	Alder Flycatcher	<u>Empidonax alnorum</u>
AMBI	American Bittern	<u>Botaurus lentiginosus</u>
AMCO	American Coot	<u>Fulica americana</u>
AMCR	American Crow	<u>Corvus brachyrhychos</u>
AMGO	American Goldfinch	<u>Carduelis tristis</u>
AMKE	American Kestrel	<u>Falco sparverius</u>
AMRE	American Redstart	<u>Setophaga ruticilla</u>
AMRO	American Robin	<u>Turdus migratorius</u>
AWPE	American White Pelican	<u>Pelecanus erythrorhynchos</u>
BAOR	Baltimore Oriole	<u>Icterus galbula</u>
BAOW	Barn Owl	<u>Tyto alba</u>
BASW	Barn Swallow	<u>Hirundo rustica</u>
BBCU	Black-billed Cuckoo	<u>Coccyzus erythrophthalmus</u>
BCCH	Black-capped Chickadee	<u>Parus atricapillus</u>
BCNH	Black-crowned Night-Heron	<u>Nycticorax nycticorax</u>
BEKI	Belted Kingfisher	<u>Ceryle alcyon</u>
BEVI	Bell's Vireo	<u>Vireo bellii</u>
BHCO	Brown-headed Cowbird	<u>Molothrus ater</u>
BHGR	Black-headed Grosbeak	<u>Pheucticus melanocephalus</u>
BLBW	Blackburnian Warbler	<u>Dendroica fusca</u>
BLGR	Blue Grosbeak	<u>Guiraca caerulea</u>
BLJA	Blue Jay	<u>Cyanocitta cristata</u>
BLPW	Blackpoll Warbler	<u>Dendroica striata</u>
BLTE	Black Tern	<u>Childonias niger</u>
BOBO	Bobolink	<u>Dolichonyx oryzivorus</u>
BRBL	Brewer's Blackbird	<u>Euphagus cyanocephalus</u>
BRTH	Brown Thrasher	<u>Toxostoma rufum</u>
BWTE	Blue-winged Teal	<u>Anas discors</u>
BWWA	Black-and-white Warbler	<u>Mniotilta varia</u>
CAGO	Canada Goose	<u>Branta canadensis</u>
CCSP	Clay-colored Sparrow	<u>Spizella pallida</u>
CEWA	Cedar Waxwing	<u>Bombycilla cedrorum</u>
CHSP	Chipping Sparrow	<u>Spizella passerina</u>
CLSW	Cliff Swallow	<u>Hirundo pyrrhonota</u>
COGR	Common Grackle	<u>Quiscalus quiscula</u>
COHA	Cooper's Hawk	<u>Accipiter cooperii</u>
COME	Common Merganser	<u>Mergus merganser</u>
CONI	Common Nighthawk	<u>Chordeiles minor</u>
COSN	Common Snipe	<u>Gallinago gallinago</u>
COYE	Common Yellowthroat	<u>Geothlypis trichas</u>

Appendix 6. Continued.

Mnemonic	Common name	Scientific name
CUSP	Cuckoo species	<u>Coccyzus spp.</u>
DCCO	Double-crested Cormorant	<u>Phalacrocorax auritus</u>
DEJU	Dark-eyed Junco	<u>Junco hyemalis</u>
DOWO	Downy Woodpecker	<u>Picoides pubescens</u>
EABL	Eastern Bluebird	<u>Sialia sialis</u>
EAGR	Eared Grebe	<u>Podiceps nigricollis</u>
EAKI	Eastern Kingbird	<u>Tyrannus tyrannus</u>
EAME	Eastern Meadowlark	<u>Sturnella magna</u>
EAWP	Eastern Wood-Pewee	<u>Contopus virens</u>
EAPH	Eastern Phoebe	<u>Sayornis phoebe</u>
EMPI	<u>Empidonax</u> flycatcher	<u>Empidonax spp.</u>
EUST	European Starling	<u>Sturnus vulgaris</u>
FEHA	Ferruginous Hawk	<u>Buteo regalis</u>
FISP	Field Sparrow	<u>Spizella pusilla</u>
FOTE	Forster's Tern	<u>Sterna forsteri</u>
FRGU	Franklin's Gull	<u>Larus pipixcan</u>
GADW	Gadwall	<u>Anas strepera</u>
GBHE	Great Blue Heron	<u>Ardea herodias</u>
GCFL	Great Crested Flycatcher	<u>Myiarchus crinitus</u>
GCTH	Gray-cheeked Thrush	<u>Catharus minimus</u>
GHOW	Great Horned Owl	<u>Bubo virginianus</u>
GRCA	Gray Catbird	<u>Dumetella carolinensis</u>
GRPC	Greater Prairie-Chicken	<u>Tympanuchus cupido</u>
GRSP	Grasshopper Sparrow	<u>Ammodramus savannarum</u>
GRYE	Greater Yellowlegs	<u>Tringa melanoleuca</u>
GWWA	Golden-winged Warbler	<u>Vermivora chrysoptera</u>
HASP	Harris' Sparrow	<u>Zonotrichia querula</u>
HAWO	Hairy Woodpecker	<u>Picoides villosus</u>
HOLA	Horned Lark	<u>Eremophila alpestris</u>
HOSP	House Sparrow	<u>Passer domesticus</u>
HOWR	House Wren	<u>Troglodytes troglodytes</u>
INBU	Indigo Bunting	<u>Passerina cyanea</u>
KILL	Killdeer	<u>Charadrius vociferus</u>
LABU	Lark Bunting	<u>Calamospiza melanocorys</u>
LASP	Lark Sparrow	<u>Chondestes grammacus</u>
LBCU	Long-billed Curlew	<u>Numenius americanus</u>
LBDO	Long-billed Dowitcher	<u>Limnodromus scolopaceus</u>
LEFL	Least Flycatcher	<u>Empidonax minimus</u>
LEOW	Long-eared Owl	<u>Asio otus</u>
LESC	Lesser Scaup	<u>Athya affinis</u>

Appendix 6. Continued.

Mnemonic	Common name	Scientific name
LEYE	Lesser Yellowlegs	<u>Tringa flavipes</u>
LISP	Lincoln's Sparrow	<u>Melospiza lincolni</u>
LOSH	Loggerhead Shrike	<u>Lanius ludovicianus</u>
MALL	Mallard	<u>Anas platyrhynchos</u>
MAWA	Magnolia Warbler	<u>Dendroica magnolia</u>
MAWR	Marsh Wren	<u>Cistothorus palustris</u>
MODO	Mourning Dove	<u>Zenaida macroura</u>
MOWA	Mourning Warbler	<u>Oporornis philadelphia</u>
NOCA	Northern Cardinal	<u>Cardinalis cardinalis</u>
NOFL	Northern Flicker	<u>Colaptes auratus</u>
NOHA	Northern Harrier	<u>Circus cyaneus</u>
NOOR	Northern Oriole	<u>Icterus galbula</u>
NOPI	Northern Pintail	<u>Anas acuta</u>
NOSH	Northern Shoveler	<u>Anas clypeata</u>
NOWA	Northern Waterthrush	<u>Seiurus noveboracensis</u>
NRWS	Northern Rough-winged Swallow	<u>Stelgidopteryx serripennis</u>
OCWA	Orange-crowned Warbler	<u>Vermivora celata</u>
OROR	Orchard Oriole	<u>Icterus spurius</u>
OVEN	Ovenbird	<u>Seiurus aurocapillus</u>
PAWA	Palm Warbler	<u>Dendroica palmarum</u>
PBGR	Pied-billed Grebe	<u>Podilymbus podiceps</u>
PEEP	(small shorebirds)	<u>Calidris spp.</u>
PISI	Pine Siskin	<u>Carduelis pinus</u>
PUMA	Purple Martin	<u>Progne subis</u>
RBGR	Rose-breasted Grosbeak	<u>Pheucticus ludovicianus</u>
RBGU	Ring-billed Gull	<u>Larus delawarensis</u>
RBNU	Red-breasted Nuthatch	<u>Sitta canadensis</u>
RBWO	Red-bellied Woodpecker	<u>Melanerpes carolinus</u>
RCKI	Ruby-crowned Kinglet	<u>Regulus calendula</u>
RECR	Red Crossbill	<u>Loxia curvirostra</u>
REDH	Redhead	<u>Athya americana</u>
REVI	Red-eyed Vireo	<u>Vireo olivaceus</u>
RHWO	Red-headed Woodpecker	<u>Melanerpes erythrocephalus</u>
RNPH	Ring-necked Pheasant	<u>Phasianus colchicus</u>
RSTO	Rufous-sided Towhee	<u>Pipilo erythrophthalmus</u>
RTHA	Red-tailed Hawk	<u>Buteo jamaicensis</u>
RUDU	Ruddy Duck	<u>Oxyura jamaicensis</u>
RWBL	Red-winged Blackbird	<u>Agelaius phoeniceus</u>
SCTA	Scarlet Tanager	<u>Piranga olivacea</u>
SORA	Sora	<u>Porzana carolina</u>

Appendix 6. Concluded.

Mnemonic	Common name	Scientific name
SOSP	Song Sparrow	<u>Melospiza melodia</u>
SPSA	Spotted Sandpiper	<u>Actitis macularia</u>
SSHA	Sharp-shinned Hawk	<u>Accipiter striatus</u>
STGR	Sharp-tailed Grouse	<u>Tympanuchus phasianellus</u>
SWHA	Swainson's Hawk	<u>Buteo swainsoni</u>
SWSP	Swamp Sparrow	<u>Melospiza georgiana</u>
SWTH	Swainson's Thrush	<u>Catharus ustulatus</u>
TEWA	Tennessee Warbler	<u>Vermivora peregrina</u>
TRSP	American Tree Sparrow	<u>Spizella arborea</u>
TRSW	Tree Swallow	<u>Tachycineta bicolor</u>
TUVU	Turkey Vulture	<u>Cathartes aura</u>
UNGR	(Unknown grosbeak)	<u>Pheucticus spp.</u>
UPSA	Upland Sandpiper	<u>Bartramia longicauda</u>
VESP	Vesper Sparrow	<u>Pooecetes gramineus</u>
VIRA	Virginia Rail	<u>Rallus limicola</u>
WAVI	Warbling Vireo	<u>Vireo gilvus</u>
WBNU	White-breasted Nuthatch	<u>Sitta carolinensis</u>
WCSP	White-crowned Sparrow	<u>Zonotrichia leucophrys</u>
WEFL	Cordilleran Flycatcher	<u>Empidonax occidentalis</u>
WEKI	Western Kingbird	<u>Tyrannus verticalis</u>
WEME	Western Meadowlark	<u>Sturnella neglecta</u>
WIFL	Willow Flycatcher	<u>Empidonax traillii</u>
WILL	Willet	<u>Catoptrophorus semipalmatus</u>
WIPH	Wilson's Phalarope	<u>Phalaropus tricolor</u>
WITU	Wild Turkey	<u>Meleagris gallopavo</u>
WIWA	Wilson's Warbler	<u>Wilsonia pusilla</u>
WODU	Wood Duck	<u>Aix sponsa</u>
WTSP	White-throated Sparrow	<u>Zonotrichia albicollis</u>
WWPE	Western Wood-Pewee	<u>Contopus sordidulus</u>
YBCH	Yellow-breasted Chat	<u>Icteria virens</u>
YBCU	Yellow-billed Cuckoo	<u>Coccyzus americanus</u>
YEWA	Yellow Warbler	<u>Dendroica petechia</u>
YHBL	Yellow-headed Blackbird	<u>Xanthocephalus xanthocephalus</u>
YRWA	Yellow-rumped Warbler	<u>Dendroica coronata</u>

Appendix 7. Historical (pre-1920) Cherry County records (specimens, egg sets, sightings) of VNWR/FNNWR bird species recorded on VCP surveys or BBS routes, 1991, 1992.

Species	Earliest records	Location	Source
ALFL			
AMBI	May 27-June 10 1903	Cherry Co.	G
AMCO	June 15, 1888	Kennedy	A
AMCR	April 21-27, 1887	Valentine	A
AMGO	June 24, 1889	Niobrara River	A
AMGO	May 27-June 10 1903	Cherry Co.	G
AMKE	June 21, 1888	Clark's Canyon ¹	A
AMRE	pre-1920	Cherry Co.	J
AMRO	June 15-21, 1888	Clark's Canyon ¹	A
AMRO	June 24, 1889	Niobrara River	A
AMRO	April 18-28, 1890	Kennedy	A
AWPE	June 5, 1897	Wood Lake	E
BAOR	pre-1896	Cherry Co.	H
BAOW	pre-1896	Cherry Co.	H
BASW	May 27-June 10 1903	Cherry Co.	G
BASW	≈ 1915	Nebr. Sandhills	D
BBCU	June 21, 1888	Clark's Canyon ¹	A
BCCH	April 21-27, 1887	Valentine	A
BCCH	April 18-28, 1890	Kennedy	A
BCNH	May 27-June 10 1903	Cherry Co.	G
BEKI	April 21-27, 1887	Valentine	A
BEKI	June 21, 1888	Clark's Canyon ¹	A
BEKI	June 24, 1889	Niobrara River	A
BEVI	May 27-June 10 1903	Cherry Co.	G
BEVI	≈ 1915	Nebr. Sandhills	D
BHCO	June 9-15, 1888	Kennedy	A
BHCO	June 21, 1888	Clark's Canyon ¹	A
BHCO	June 24, 1889	Niobrara River	A
BHGR	May 27-June 10 1903	Cherry Co.	G
BLBW			
BLGR	June 21, 1888	Clark's Canyon ¹	A
BLJA	April 21-27, 1887	Valentine	A
BLJA	June 24, 1889	Niobrara River	A
BLJA	April 18-28, 1890	Kennedy	A
BLPW	pre-1896	Cherry Co.	H
BLTE	June 15, 1888	Kennedy	A
BOBO	June 9-15, 1888	Kennedy	A
BOBO	June 24, 1889	Niobrara River	A
BRBL	April 21-27, 1887	Valentine	A

Appendix 7. Continued.

Species	Earliest records	Location	Source
BRTH	pre-1896	Cherry Co.	H
BRTH	May 27-June 10 1903	Cherry Co.	G
BWTE	June 15, 1888	Kennedy	A
BWTE	April 18-28, 1890	Kennedy	A
BWWA	pre-1896	Cherry Co.	H
BWWA	May, 1912	Cherry Co.	C
CAGO	April 18-28, 1890	Kennedy	A
CCSP	June 24, 1889	Niobrara River	A
CEWA	pre-1896	Cherry Co.	H
CHSP	May 4, 1913	Cherry Co.	F
CHSP	June 24, 1889	Niobrara River	A
CHSP	May 27-June 10 1903	Cherry Co.	G
CLSW	June 15-21, 1888	Clark's Canyon ¹	A
COGR	April 18-28, 1890	Kennedy	A
COHA	pre-1896	Cherry Co.	H
COME	pre-1896	Cherry Co.	H
CONI	June 21, 1888	Clark's Canyon ¹	A
CONI	June 24, 1889	Niobrara River	A
COSN	May 18, 1899	Merriman	E
COYE	June 9-15, 1888	Kennedy	A
COYE	June 15-21, 1888	Clark's Canyon ¹	A
DCCO	pre-1896	Cherry Co.	H
DEJU	April 18-28, 1890	Kennedy	A
DOWO	April 18-28, 1890	Kennedy	A, B
EABL	June 15-21, 1888	Clark's Canyon ¹	A
EABL	June 24, 1889	Niobrara River	A
EABL	May 27-June 10 1903	Cherry Co.	G
EAGR	June, 1902	Cherry Co.	C
EAKI	June 24, 1889	Niobrara River	A
EAKI	May 27-June 10 1903	Cherry Co.	G
EAME	June 16, 1902	Cherry Co.	F
EAWP	June 21, 1888	Clark's Canyon ¹	A
EAPH	pre-1896	Cherry Co.	H
EUST			
FEHA	May 27-June 10 1903	Cherry Co.	G
FISP	May 27-June 10 1903	Cherry Co.	G
FOTE	June, 1900	Cherry Co.	C
FRGU	May 27-June 10 1903	Cherry Co.	G
GADW	May 27-June 10 1903	Cherry Co.	G
GBHE			

Appendix 7. Continued.

Species	Earliest records	Location	Source
GCFL			
GCTH	May, 1912	Cherry Co.	C
GHOW	pre-1896	Cherry Co.	H
GRCA	June 15-21, 1888	Clark's Canyon ¹	A
GRPC	April 21-27, 1887	Valentine	A
GRPC	June 15, 1888	Kennedy	A
GRPC	June 24, 1889	Niobrara River	A
GRSP	May 27-June 10 1903	Cherry Co.	G
GRYE	pre-1896	Cherry Co.	H
GWWA			
HASP	May 27-June 10 1903	Cherry Co.	G
HASP	October, 1912	Cherry Co.	C
HAWO	pre-1896	Cherry Co.	H
HOLA	April 21-27, 1887	Valentine	A
HOLA	June 15-21, 1888	Clark's Canyon ¹	A
HOSP	≈ 1899	40 mi. from Valentine	E
HOSP	April 20, 1919	Cherry Co.	F
HOWR	June 15-21, 1888	Clark's Canyon ¹	A
INBU	September, 1900	Cherry Co.	C
KILL	April 21-27, 1887	Valentine	A
KILL	June 24, 1889	Niobrara River	A
LABU	June 9-15, 1888	Kennedy	A
LABU	June 21, 1888	Clark's Canyon ¹	A
LABU	June 24, 1889	Niobrara River	A
LASP	June 21, 1888	Clark's Canyon ¹	A
LBCU	June 15, 1888	Kennedy	A
LBCU	June 24, 1889	Niobrara River	A
LBDO	pre-1896	Cherry Co.	H
LEFL			
LEOW	June 24, 1889	Niobrara River	A
LESC	May 27-June 10 1903	Cherry Co.	G
LEYE	pre-1896	Cherry Co.	H
LEYE	May 27-June 10 1903	Cherry Co.	G
LISP	May 4, 1913	Cherry Co.	F
LOSH	pre-1896	Cherry Co.	H
MALL	July, 1902	Cherry Co.	F
MAWA			
MAWR	June 9-15, 1888	Kennedy	A
MODO	April 21-27, 1887	Valentine	A
MODO	June 24, 1889	Niobrara River	A

Appendix 7. Continued.

Species	Earliest records	Location	Source
MOWA			
NOCA			
NOFL	April 21-27, 1887	Valentine	A, B
NOFL	June 21, 1888	Clark's Canyon ¹	A
NOFL	June 24, 1889	Niobrara River	A
NOHA	June 15, 1888	Kennedy	A
NOHA	April 18-28, 1890	Kennedy	A
NOOR	June 21, 1888	Clark's Canyon ¹	A
NOPI	June 15, 1888	Kennedy	A
NOPI	April 18-28, 1890	Kennedy	A
NOSH	April 18-28, 1890	Kennedy	A
NOWA			
NRWS	May 27-June 10 1903	Cherry Co.	G
OCWA			
OROR	June 21, 1888	Clark's Canyon ¹	A
OVEN			
PAWA			
PBGR	June, 1902	Cherry Co.	C
PISI			
PUMA			
RBGR			
RBGU	April 18-28, 1890	Kennedy	A, B
RBNU			
RBWO			
RCKI			
RECR	November, 1915	Cherry Co.	C
REDH	May 27-June 10 1903	Cherry Co.	G
REVI	June 21, 1888	Clark's Canyon ¹	A
RHWO	June 21, 1888	Clark's Canyon ¹	A
RHWO	June 24, 1889	Niobrara River	A
RHWO	April 18-28, 1890	Kennedy	A
RNPH			
RSTO	April 21-27, 1887	Valentine	A
RTHA	May 27-June 10 1903	Cherry Co.	G
RUDU	May 27-June 10 1903	Cherry Co.	G
RWBL	April 21-27, 1887	Valentine	A
RWBL	June 24, 1889	Niobrara River	A
SCTA			

Appendix 7. Continued.

Species	Earliest records	Location	Source
SORA	pre-1896	Cherry Co.	H
SOSP	April 21-27, 1887	Valentine	A
SPSA	May 27-June 10 1903	Cherry Co.	G
SSHA	April 21-27, 1887	Valentine	A
STGR	June 24, 1889	Niobrara River	A
STGR	April 18-28, 1890	Kennedy	A
SWHA	June 15, 1888	Kennedy	A
SWSP	May 27-June 10 1903	Cherry Co.	G
SWTH	September 28, 1919	Cherry Co.	F
TEWA	May, 1919	Cherry Co.	C
TRSP	April 21-27, 1887	Valentine	A
TRSW	April 21-27, 1887	Valentine	A
TUVU	April 21-27, 1887	Valentine	A
TUVU	June 21, 1888	Clark's Canyon ¹	A
TUVU	June 24, 1889	Niobrara River	A
UPSA	June 15, 1888	Kennedy	A
UPSA	June 21, 1888	Clark's Canyon ¹	A
UPSA	June 24, 1889	Niobrara River	A
VESP	April 21-27, 1887	Valentine	A
VESP	June 9-15, 1888	Kennedy	A
VESP	June 24, 1889	Niobrara River	A
VIRA	June 14, 1902	Cherry Co.	F
WAVI	June, 1902	Cherry Co.	C
WBNU	May 27-June 10 1903	Cherry Co.	G
WCSP	April 21-27, 1887	Valentine	A
WEFL			
WEKI	May 27-June 10 1903	Cherry Co.	G
WEME	April 21-27, 1887	Valentine	A
WEME	June 24, 1889	Niobrara River	A
WIFL			
WILL	pre-1896	Cherry Co.	H
WIPH	June 15, 1888	Kennedy	A
WITU			

Appendix 7. Concluded.

Species	Earliest records	Location	Source
WIWA			
WODU	pre-1896	Cherry Co.	H
WTSP			
WWPE	July 25, 1901? ²	Cherry Co.	I
YBCH	June 15-21, 1888	Clark's Canyon ¹	A
YBCU	pre-1896	Cherry Co.	H
Yewa	June 15-21, 1888	Clark's Canyon ¹	A
YHBL	June 4, 1900	Cherry Co.	F
YRWA	April 21-27, 1887	Valentine	A

¹10 miles south of Valentine (= Clark's Canyon).

²At least as early as 1901.

Sources: A = Smithsonian Inst. Archives, Record Unit 7176, U.S. Fish and Wildl. Serv., 1860-1961; B = National Mus. Nat. Hist., Washington, D.C.; C = Museum Nat. Hist., Univ. Kansas, Lawrence; D = Oberholser, H. C. 1920. Waterfowl and their food plants in the Sandhills region of Nebraska. U.S. Dep. Agric. Bull. No. 794. Washington, D.C.; E = Bates, J. M. 1900. Additional notes and observations on the birds of northern Nebraska. Proc. Nebr. Ornith. Union 1:15-18; F = Univ. Nebr. State Mus. Div. Zool. Bird Coll. G = Ducey, J. 1983. A 1903 birding expedition in Cherry County, Nebraska. Nebr. Bird Rev. 51(2):35-37; H = Bruner, L. 1896. Some notes on Nebraska birds. Pages 48-178 in J. H. Hadkinson (Sec.). Annual report of the Nebraska state horticultural society for the year 1896. State Journal Co., Lincoln; I = Bates, J. M. 1901. Additional observations on the birds of northwestern Nebraska. Proc. Nebr. Ornith. Union 2:73-75.; J = Ducey, J. E. 1988. Nebraska birds--breeding status and distribution. Simmons-Boardman Books, Omaha. 148 pp.

Appendix 8. Historical (pre-1920) Cherry County records (specimens, egg sets, sightings) of VNWR/FNNWR bird species not recorded on VCP surveys or BBS routes, 1991, 1992.

Species	Earliest records	Location	Source
American Wigeon	May 27-June 10 1903	Cherry Co.	F
American Avocet	June 15, 1888	Kennedy	A
Baird's Sandpiper	May 27-June 10 1903	Cherry Co.	F
Bald Eagle	1901 ²	Cherry Co.	J
Bank Swallow	June 21, 1888	Clark's Canyon ¹	A
Bank Swallow	June 24, 1889	Niobrara River	A
Black-billed Magpie	1901 ²	Cherry Co.	J
Bohemian Waxwing	March 20, 1920	Cherry Co.	E
Brewer's Sparrow	1901 ²	Cherry Co.	J
Bufflehead	7 November 1891	Kennedy	H
Burrowing Owl	April 18-28, 1890	Kennedy	A
Canvasback	September 1, 1897	Hackberry Lake	D
Chestnut-collared Longspur	April 21-27, 1887	Valentine	A
Chimney Swift	June 21, 1888	Clark's Canyon ¹	A
Common Redpoll	November, 1915	Cherry Co.	C
Common Tern	1901 ²	Cherry Co.	J
Dickcissel	June 9-15, 1888	Kennedy	A
Dickcissel	June 21, 1888	Clark's Canyon ¹	A
Eastern Screech-Owl	January, 1919	Cherry Co.	C
Ferruginous Hawk	November, 1898	Kennedy	D
Golden Eagle	April 21-27, 1887	Valentine	A
Green-winged Teal	April 18-28, 1890	Kennedy	A
Hooded Merganser	June 15, 1888	Kennedy	A
Horned Grebe	June 15, 1888	Kennedy	A
King Rail	September, 1898	Ballard's Lake	D
Lapland Longspur	November 16, 1915	Cherry Co.	E
Least Bittern	May 27-June 10, 1903	Cherry Co.	F
Least Sandpiper	May 1900	Cherry Co.	G
Lewis' Woodpecker	≈ 1897	Valentine	D
Marbled Godwit	May 27-June 10, 1903	Cherry Co.	F
McCown's Longspur	April 21-27, 1887	Valentine	A
McCown's Longspur	April 18-28, 1890	Kennedy	A
Mountain Plover	1901 ²	Merriman	I
Northern Bobwhite	November, 1894	Valentine	B
Northern Bobwhite	April 21-27, 1887	Valentine	A
Northern Bobwhite	June 24, 1889	Niobrara River	A
Northern Goshawk	October 1896	Kennedy	D
Northern Mockingbird	June 24, 1889	Niobrara River	A

Appendix 8. Concluded.

Species	Earliest records	Location	Source
Osprey	April 21-27, 1887	Valentine	A
Pectoral Sandpiper	May 27-June 10 1903	Cherry Co.	F
Piping Plover	June, 1902	Cherry Co.	C
Pinyon Jay	1901 ²	Cherry Co.	I
Poorwill	June 21, 1888	Clark's Canyon ¹	A
Red-breasted Merganser	May 27-June 10 1903	Cherry Co.	F
Ring-necked Duck	1901 ²	Merriman	I
Rock Wren	June 15-21, 1888	Clark's Canyon ¹	A
Rough-legged Hawk	≈ 1897	Cherry Co.	D
Rusty Blackbird	May, 1919	Cherry Co.	C
Sanderling	May 1900	Cherry Co.	G
Sandhill Crane	June 15, 1888	Kennedy	A
Sandhill Crane	June 24, 1889	Niobrara River	A
Savannah Sparrow	April 18-28, 1890	Kennedy	A
Say's Phoebe	May 9, 1898	Valentine	D
Semipalmated Sandpiper	≈ 1897	Valentine	D
Short-eared Owl	1 February 1893	Kennedy	H
Solitary Sandpiper	May 27-June 10 1903	Cherry Co.	F
Stilt Sandpiper	≈ 1897	Cherry Co.	D
Townsend's Solitaire	March, 1898	Cherry Co.	C
Trumpeter Swan	pre-1896	Watts Lake	D
White-rumped Sandpiper	June, 1902	Cherry Co.	C

¹10 miles south of Valentine (= Clark's Canyon).

²At least as early as 1901.

Sources: A = Smithsonian Inst. Archives, Record Unit 7176, U.S. Fish and Wildl. Serv., 1860-1961; B = National Mus. Nat. Hist., Washington, D.C.; C = Museum Nat. Hist., Univ. Kansas, Lawrence; D = Bates, J. M. 1900. Additional notes and observations on the birds of northern Nebraska. Proc. Nebr. Ornith. Union 1:15-18; E = Univ. Nebr. State Mus. Div. Zool. Bird Coll.; F = Ducey, J. 1983. A 1903 birding expedition in Cherry County, Nebraska. Nebr. Bird Rev. 51(2):35-37; G = Hunter, J. S. 1901. A collecting trip in Cherry County. Proc. Nebr. Ornith. Union 2:79-84; H = Graves, A. R. 1901. Notes on birds from western Nebraska. Proc. Nebr. Ornith. Union 2:84-85; I = Bates, J. M. 1901. Additional observations on the birds of northwestern Nebraska. Proc. Nebr. Ornith. Union 2:73-75.; J = Bruner, L. 1901. Birds that nest in Nebraska. Proc. Nebr. Ornith. Union 2:48-61.

Appendix 9. Stop descriptions for the VNWR BBS route, 1991 and 1992.

Stop No.	Description	Stop No.	Description
1	Mile marker 12 on Rt. 16-B	26	Russian olive far left; 1.5 m willow right
2	Just before curve sign	27	0.12 mi E of turn; gate right
3	Just past mile marker 13	28	Windmill right
4	Just past pullout on left	29	Fenceline
5	0.1 mi past parking area on left	30	Small cattail pond left; windmill 250 m ahead
6	Middle of curve	31	0.1 mi past crest of hill
7	Middle of curve to left	32	20 m past culvert
8	Ca. 20 m before power line	33	Cottonwood/windmill 30 m ahead, left
9	Crest of hill	34	Between last cottonwood left & fenceline ahead
10	End of short tree row on left	35	At gate and Hwy. 83
11	Ca. 75 m past "No Hunting Zone" sign	36	0.05 mi past "No Passing" sign
12	Just past chokecherry on hill to left	37	At Calf Camp Valley entrance (0.7 mi between stops 36, 37)
13	0.1 mi past Pelican L. "Fish & Fishhook" sign	38	Between guard rails (0.6 mi between stops 37, 38)
14	One willow and 1 cottonwood on left	39	0.1 mi past mile marker 186 just as road widens
15	At small rise; a few willows, left	40	Near crest of hill; "Slippery When Wet" sign left
16	Curve to left; small willow patch left	41	0.1 mi past mile marker 185
17	At end of Cottonwood stringer, right	42	0.3 mi E of turn of Hwy. 83; cottonwood, E red cedar, right
18	Willow 200 m ahead, right	43	0.1 mi past reflectors, willows, right
19	Cattails left and right	44	0.2 mi past HQ; at "No Hunting Zone" sign
20	At fenceline	45	Just after curve right
21	Two small willows, right	46	Just past curve right; E red cedar 15 m ahead on right
22	At fenceline; just west of School L.	47	Fence curves right just ahead
23	0.15 mi past fence on east	48	0.12 mi past half-dead willow right
24	S. end of Dewey L. ; 0.2 mi N of turn	49	Willow stringer left; hill with poison ivy right
25	0.1 mi N of School L.	50	Go 1.3 mi through private land to "Photo Blind" sign

Appendix 10. Stop descriptions for the FNNWR BBS route, 1992.

Stop No.	Description	Stop No.	Description
1	0.3 mi S of Mile marker 5; at Hwy 83 detour sign	21	Gate 100 m ahead; on rise before dip to gate
2	At FNNWR sign and refuge entrance	22	Go through 2-panel metal gate at 0.1 mi (head N); in flat; plum clump left 0.2 mi
3	Just past curve; barn just ahead, left	23	At small dip ca. 0.15 mi past windmill
4	Just past curve left sign; 0.1 mi before "T" intersection	24	At 0.2 mi go through 2-panel metal gate; plum clump left 30 m
5	Gate/cattle guard 50 m ahead	25	Pass windmill at 0.3 mi; trees way off to E
6	Gate/cattle guard ca. 0.2 mi ahead	26	At 0.2 mi go through 2-panel red gate; flat area; windmill 0.25 mi ahead
7	0.3 mi past gate/cattle guard; P-pine clump ahead 0.25 mi, right	27	Pass windmill at 0.25 mi then head NE on indistinct trail to NE gate; open, flat, no markers
8	0.2 mi past gate and large pile of cut E. red cedar	28	0.1 mi from gate and stock ramp
9	0.1 mi past metal gate which opens at W end	29	Go through gate at 0.1 mi, W 0.2 mi, then NE on gravel 0.2 mi; between left and right arrow signs ahead & behind
10	Up small hill at 0.4 mi and to base of another at 0.5 mi; can just see fence 0.1 mi ahead	30	At locked gate to pasture bordering Niobrara R.
11	Go through 2-panel gate (opens at center) at 0.1 mi; at 0.45 mi bear left & go up and just past small rise	31	Go through gate & W to large chokecherry clump along fence
12	Pass windmill (w electric fence gates here) at 0.25 mi; in small dip;	32	Past pond; 50 m from fence and electric gate
13	At 0.2 mi go through metal gate (opens at S end, sits on concrete slab); now in Unit 38	33	Go 0.45 mi to 2-panel green gate; stop is 100 m beyond gate
14	150 m past windmill; small rise	34	Open area; gravel road 100 m left; woody draw 200 m right
15	75 m before gate	35	At 0.4 mi is gate at gravel road; go NW 0.1 mi to river and windmill
16	At 0.05 mi go through metal gate (opens at S end, sits on 2 square wood posts); now in Unit 39; just before small rise and just past dead tree 200 m to right	36	At 0.25 mi take fork to right; stop in low area
17	Windmill at 0.2 mi; in low flat area; gate 0.3 mi ahead	37	Just through gate; woody draw with Ponderosa pine to right
18	Go through metal gate at 0.3 mi (opens at N end); now in Unit 36-B; in flat area; E. red cedar ahead right	38	Follow fence SW 0.15 mi, then see sharp curve to Buffalo Bridge, right; take road toward corrals; stop just where can see red gate 150 m ahead
19	Past windmill; 2 E. red cedar ahead right 0.3 mi	39	Go through gate at 0.1 mi past corrals, ponds to intersection (at Fort Falls sign)
20	100 m from fence/boundary	40	Just across cattle guard (0.25 mi from HQ); at "Prairie Drive" sign

