USGS
science for a changing world

DRAFT FINAL REPORT: Relative Abundance and Diversity of Birds in Riparian Habitats at North Platte National Wildlife Refuge and in Grasslands at Crescent Lake National Wildlife Refuge, Nebraska

30 March 2004

Submitted to: Wayne King, Division of Wildlife Refuges, Region 6, U.S. Fish and Wildlife Service, Lakewood, CO

Prepared by: Cynthia Melcher[1], James D. Schmidt[2], Matthew R. Bain[2], Jamie E. Timson[2], Greg H. Farley[2], and Michael A. Bogan[3] ([1]U.S. Geological Survey, Fort Collins Science Center, Fort Collins, CO 80525, [2]Department of Biological Sciences, Fort Hays State University, Hays, Kansas 67601, [3]U.S. Geological Survey, Fort Collins Science Center, Museum of Southwestern Biology, University of New Mexico, Albuquerque, NM 87131)

INTRODUCTION

Since the onset of European settlement, ecosystems of central North America have undergone profound changes. As a result, many endemic bird species, as well as a large portion of the region's more wide-spread species, are believed to have undergone precipitous declines (Samson and Knopf 1996). However, in central North America, where the breeding, wintering, and/or migration ranges of many eastern, western, and Arctic-Neotropical bird species overlap (Labedz 1990), understanding avian community structure and trends adequately enough to maximize conservation is complicated at best. In the Nebraska Sandhills, where habitat diversity is relatively high, the potential for attracting a wide array of both regularly and irregularly occurring species is particularly high (Labedz 1990). As of the late 1980s, 314 of the 404 bird species that had been reported in Nebraska overall had also been reported in the Sandhills region (Bleed and Flowerday 1990).

Although riparian habitat represents only one percent of all vegetation cover in western United States, more avian species associate with riparian vegetation than with any other habitat type in the region (Knopf et al. 1988; Skagen et al. 1998). This is particularly true for migratory passerine species, many of which require suitable stopover sites and/or nesting habitats in these relatively rare habitats. However, western riparian systems have been severely altered and degraded due to changes in hydrologic and disturbance regimes (e.g., ground water depletion, reservoir development, fire suppression, diminished flooding, confined livestock, altered successional stages), influxes of exotic/invasive species (e.g., Brown-headed Cowbirds, *Tamarix* spp.), and other anthropogenic factors (Labedz 1990, Johnsgard 1995). Ironically, degradation of riparian systems on the plains includes increases in woody vegetation that, in some cases, may support a greater species richness than they did historically. Increases in species richness, however, are often due to occurrences of invasive or expanding species, in many cases at the expense of native, endemic species (Samson and Knopf 1996). In these cases, indices of diversity and equitability (evenness)---which account for the relative abundances and proportions of species---may actually decline.

Mid-western grasslands have also been severely altered and degraded. Most changes are due to the direct or indirect effects of habitat conversion and fragmentation (e. g., agriculture, shelterbelts), altered disturbance regimes and ecological processes (e.g., fire suppression, increased/decreased grazing intensities/rotations), invasions of woody vegetation and brown-headed Cowbirds, and the spread of exotic species (e.g., leafy spurge (Bleed and Flowerday 1990, Sampson and Knopf 1996, Scheiman et al. 2003). As a result, many species of North American grassland birds have been undergoing long-term population declines, including Long-billed Curlews, Lark Sparrows, Grasshopper Sparrows, and Western Meadowlarks (Knopf 1994). (See Appendix 1 for scientific names for all bird species mentioned herein.) Although the trend information provided by the North American Breeding Bird Survey (BBS) data are fraught with variability problems, the grassland bird group is one for which BBS data show indisputably that declines are real and, in many cases, precipitous (Sauer et all. 2003*a*). Of the 28 nesting species of grassland birds adequately monitored by the BBS, only seven have shown no signs of decline (Price et al. 1995). During the 1980s alone, BBS data indicated that grassland bird species declined 25-65%, more than any other avian group in North America (Price et al. 1995). By the late 20th Century, grassland-nesting birds had become one of the most-threatened animal groups in mid-western North America (Samson and Knopf 1994).

National Wildlife Refuges (NWRs) are among the few remaining tracts of land that have the potential for providing population-source habitats for many declining bird species. However, traditional origins and uses of NWRs focussed on waterfowl, thus basic information about other sectors of the avian communities at NWRs is often insufficient for setting conservation-management goals for passerines and other non-game birds. The overall purpose of this study was to establish and summarize baseline data on the relative abundances, distributions, and habitat associations of birds during migration/breeding seasons in riparian habitats of North Platte National Wildlife Refuge (NPNWR) and in grasslands of Crescent Lake National Wildlife Refuge (CLNWR). A secondary goal was to assess avian abundance, distribution, and foraging behaviors of birds as a function of apparent habitat condition/ management. The final goal was to discuss ways in which long-term monitoring for prairie species of concern might be conducted.

North Platte National Wildlife Refuge

NPNWR consists of four separate units---each centered on a reservoir or river impoundment---that provide sanctuary for up to 200,000 waterfowl throughout the year. Although they are not naturally occurring habitats, the riparian woodlands and associated vegetation that ring the each reservoir are believed to provide migration stopover and/or breeding habitat for many passerine species. However, a disproportionate amount of effort has been focused on monitoring the refuge's aquatic species, thus little is known about the community structure or dynamics of the birds that use riparian habitats. The survey project reported herein represents the first effort to quantify, and provide baseline data for long-term monitoring of, the riparian avian community at NPNWR. Specific objectives of this study for NPNWR included: (1) developing a standardized bird survey in NPNWR's riparian habitats and (2) quantifying the relative abundance of each species, particularly Nearctic-Neotropical migrants, in relation to migration/breeding season and vegetative structures/species used.

Crescent Lake National Wildlife Refuge

Most of CLNWR consists of extensive grasslands interspersed with various wetlands. Here again, however, a disproportionate amount of effort has been focused on monitoring the refuge's aquatic avifauna. In this report, we document the results of initial efforts to characterize the breeding bird communities in CLNWR's grassland habitats. Specific objectives of this study included: (1) developing a standardized upland bird survey; (2) collecting baseline survey data against which future surveys may be compared for monitoring purposes; (3) describing contemporary avian community structure in relation to three grassland habitat types on the refuge and adjacent lands; and 4) recommending long-term monitoring approaches for prairie species of concern at CLNWR.

DESCRIPTIONS OF STUDY SITES

North Platte National Wildlife Refuge

NPNWR is located in Scott's Bluff County, Nebraska, near the eastern edge of Nebraska's panhandle. Each of NPNWR's four units---Lake Alice, Lake Minatare, Winters Creek, and Stateline Island---centers on a reservoir (or, in the case of Stateline Island, an irrigation-dam impoundment) developed by the Bureau of Reclamation for irrigation. The Lake

Alice, Lake Minatare, and Winters Creek Lake units are clustered fairly close together north and northeast of the city of Scottsbluff. The Stateline Island unit lies along the North Platte River approximately 32 km west of the other three units near the Nebraska/Wyoming state line. The approximate latitudes and longitudes of each unit center are: Lake Alice 41° 59' 20" N, 103° 36' 50" W; Lake Minatare 41° 55' 55" N, 103° 29' 30" W; Winters Creek Lake 41° 57' 20" N, 103° 31' 35"; and Stateline Island 41° 59' 15" N, 104° 02' 20" W. Together the four units comprise approximately 2042 ha.

NPNWR's riparian habitats, most-prevalent at the two larger units (Lake Alice and Lake Minatare), are scattered along the reservoir and river edges. These habitats are dominated by mature stands of plains cottonwood (*Populus deltoides*) interspersed with young cottonwoods and willows (*Salix* spp., including peachleaf willow [*S. amygdaloides*]). Other tree species, including green ash (*Fraxinus pennsylvanica*), chokecherry (*Prunus virginiana*), and the exotic Russian-olive (*Elaeagnus angustifolia*), are common in some areas.

Crescent Lake National Wildlife Refuge

CLNWR is located in the north-central portion of Garden County, centered at approximately 41° 44' 00" N, 102° 20' 00" W. It consists of just under 8,620 ha of sandhills prairie near the southwestern edge of the 4.86-million ha "Nebraska Sandhills." Dominant terrestrial (grassland) habitat types at CLNWR are Choppy Sands and Sands, with lesser amounts of Sub-irrigated Meadow. The Choppy Sands type is characterized by irregular, steep-sloped hills with narrow ridges, sharp peaks, catsteps, and small blowouts (Nebraska Soil Conservation Service 1981). The potential natural vegetation of this type is described as 85% grasses (85%), the remainder consisting of roughly equal proportions of grasslike plants, forbs, and shrubs (Nebraska Soil Conservation Service 1981). Little bluestem (*Schizachyrium scoparium*), prairie sandreed (*Calamovilfa longifolia*), sand bluestem (*Andropogon hallii*), sand lovegrass (*Eragrostis trichodes*), and switchgrass (*Panicum virgatum*) represent at least 65% of the total annual production (Nebraska Soil Conservation Service 1981). Blowout grass (*Redfieldia flexuosa*), blue grama (*Bouteloua gracilis*), hairy grama (*Bouteloua hirsuta*), indian grass (*Sorghastrum nutans*), sandhill muhly (*Muhlenbergia pungens*), and forbs, such as sand lilly (*Mentzelia decapetala*) and small soapweed (*Yucca glauca*), also characterize this type. Relative to that in Sands and Sub-irrigated Meadow habitats, bare ground in Choppy Sands habitat is prevalent (Nebraska Soil Conservation Service 1981).

The Sands type occurs in gently undulating to rolling sandhills uplands (Nebraska Soil Conservation Service 1981). The potential natural vegetation in this type is described as 80% grasses, with the remainder consisting of 5% grasslike plants, 10% forbs, and 5% shrubs (Nebraska Soil Conservation Service 1981). Little bluestem, needle-and-thread (*Stipa comata*), prairie sandreed, and sand bluestem constitute at least 75% of the total annual production. Blue grama, indiangrass, sand dropseed (*Sporobolus cryptandrus*), sand lovegrass, and numerous forbs also characterize this type (Nebraska Soil Conservation Service 1981).

The Sub-irrigated Meadow type occurs mainly on nearly level to very gently sloping areas of bottomlands and sandhills valleys (Nebraska Soil Conservation Service 1981). The potential natural vegetation in this type is described as 75% grasses, 10% grasslike plants, 10% forbs, and 5% shrubs---most often willows (Nebraska Soil Conservation Service 1981, Bleed and Flowerday 1990). Big bluestem (*Andropogon gerardii*), indiangrass, little bluestem, prairie cordgrass (*Spartina pectinata*), switchgrass, and various members of the sedge family (*Carex*

spp.) comprise at least 75% of the total annual production. Slender wheatgrass (*Agropyron trachycaulum*) is also relatively common in this type (Nebraska Soil Conservation Service 1981).

METHODS

North Platte National Wildlife Refuge

Field surveys---We established seven transects for censusing birds in the strips of riparian habitat surrounding each unit at NPNWR: two transects around Lake Alice, three around Lake Minatare, and one each around Winters Creek Lake and Stateline Island. Using a Garmin 12 GPS unit, we recorded UTM coordinates for the beginning and ending points of each transect (Appendix 2). The number of transects per unit reflects the relative amount of riparian habitat at each unit and how much ground could be covered by one person during peak hours of avian activity.

Bird surveys were conducted along each transect during five survey periods: two in late May, one in early July, one in late July, and one in late August between May 2001 and May 2003 (Appendix 3). Surveys began at sunrise and ended approximately five hours later (0430 to 0930 MDT), when detectability among passerine species is greatest. To conduct the surveys, two to three observers, spaced approximately 50-100 m apart, walked parallel to one another along the transects (thus spanning the width of the riparian habitat), recording every bird detected. Efforts were made to avoid double-counting individual birds. For a given detection, surveyors recorded species; number of individuals; substrate (e.g., ground, water, air, tree), microhabitat (e.g., trunk, branch, leaf litter), and vegetation species (where applicable) the bird was using; and the bird's behavior (e.g., foraging).

Data management---Protocol for bird surveys in North America varies widely with respect to which taxonomic level is recorded. This is due, at least in part, to a need for retaining data comparability over time if taxonomies change, and/or for tracking subspecies whose ecologies and/or ranges may differ. In this study, we encountered two data-management problems associated with newer taxonomies: one concerning Northern Flickers, the other concerning Baltimore and Bullock's Orioles. Field personnel generally recorded flickers according to their current taxonomy (Northern Flicker [*Colaptes auratus*]), but on occasion they were recorded according to an older taxonomy that treated Red-shafted and Yellow-shafted flickers as separate species (American Ornithologists' Union 1983). Although many on-going, long-term bird surveys still require that the flickers be recorded separately to maintain data continuity, this study took place long after the taxonomic change, thus we were able to lump all flicker records as one species in our data analyses. Nonetheless, we developed a "PreLump" field in NPNWR's electronic database (accompaniment to this document) to indicate the original taxon recorded for future reference if desired. Based on the records that did indicate older taxonomy, we also calculated the relative proportions of each flicker subspecies detected at NPNWR.

A more complicated situation arose with respect to oriole taxonomy. Historically, the Northern Oriole was treated as two species---Baltimore and Bullock's orioles. Subsequently, they were lumped into one species (Northern Oriole); then they were split again into Baltimore and Bullock's orioles (American Ornithologists' Union 1957, 1983, 1998). During this study, observers generally recorded the orioles by their current taxonomy, but in some cases they were

recorded simply as Northern Orioles (this may have been due to auditory rather than visual detections---vocalizations of the two oriole species can be difficult to distinguish by ear alone). Because it was not possible to determine from the NPNWR data which 'Northern Oriole' records represented Baltimore or Bullock's orioles, we simply lumped all observations of Baltimore, Bullock's, and Northern orioles as 'Northern Orioles,' again retaining original species recorded in the "PreLump" field. This undoubtedly affected our calculations of species richness, diversity, and equitability, but the loss of information is minimal (discussed further in the results and discussion section). Based on records that did indicate current taxonomy, we also calculated the relative proportions of each species detected at NPNWR.

The final data-management issue pertained to unidentified species. During this study, observers recorded 28 '*Empidonax* species.' In general, *Empidonx* species are difficult to identify in the field, thus it is common for bird-survey results to include a number of unidentified *Empidonax*. In this study, all *Empidonx* were recorded only to the genus level, thus we had to treat all 28 records as one species in richness, diversity, and equitability calculations. Observers also recorded one unidentified *Vireo* species, but because it occurred at the same refuge unit during the same survey period as Warbling and Red-eyed vireos (the two *Vireo* species listed on the NPNWR bird checklist) we had to exclude it from richness, diversity, and equitability calculations. Again, the need to lump bird records that may have represented more than one species probably affected our richness, diversity, and equitability calculations, but the effects were probably minimal. After consulting NPNWR's bird checklist, museum collections, and other major references, we determined which species of both genera might have occurred---or could occur---at NPNWR.

Data analyses---To characterize NPNWR's riparian bird community, we calculated species richness, relative abundance, Shannon-Weiner Species Diversity (H) and Equitability (E_H) for each time period and for all periods combined, both for all refuge units combined and for each unit separately. H and E_H were defined as:

$$H = -\sum_{S=1}^{S} p_i \ln p_i \qquad E_H = H / H_{max} = H / \ln S$$

To reveal which species contributed most to the overall abundances, we also ranked them according to their frequencies of detection for the entire refuge within each survey period, and for each unit within each survey period. Finally, we calculated the numbers and percentages of birds recorded in each substrate and/or vegetation-species category. For individual birds recorded as foraging, we also calculated the numbers and percentages foraging in each substrate and/or vegetation-species category.

Briefly explain how and why 17 transects (number) was derived.
"point count" -? 5 minute

Crescent Lake National Wildlife Refuge

Field surveys---In early spring 2001, we established 17 transects, each measuring 1000 m long (Figures 1-5). We placed transects as close to central portions of the largest tracts of each habitat type as possible without severely compromising accessibility. Seven transects were located in Choppy Sands habitat (transects C1-C7), seven were located in Sands habitat (S1-S7), and three were located in Sub-irrigated Meadow habitat (M1-M3). The smaller number of transects in Sub-irrigated Meadow reflects the proportionately smaller amount of this habitat type at CLNWR. To provide possible comparisons of long-term bird responses to different land-

management practices, two transects (M3 and S7) and part of a third transect (C6) were established off the refuge.

At 250-m intervals along each transect, we established five survey points (points 0, 250, 500, 750, 1000). Each point had a radius of 100 m (3.14 ha/point), a common area used for conducting point counts of birds, especially in open habitats such as grasslands (Reynolds et al. 1980, Hutto et al. 1986). The 250-m distance between points thus provided a 50-m buffer between points. We marked each point with a fiberglass post and used a Garmin 12 GPS unit to record its UTM coordinates (Appendix 4a). We also recorded detailed descriptions of transect locations to facilitate finding them if they are used again in future survey work (Appendix 4b).

To conduct the surveys, one or two observers, walked from point to point along a given transect, spending five minutes at each point counting all birds seen and/or heard. (when two observers were present, only one counted while the other recorded.) Surveys were conducted from sunrise to approximately 5 hours after sunrise (0430 to 0930 MDT). At each point, observers recorded date, transect ID, point ID, number of individuals of each species detected, and method of detection (visual or auditory). Observers also noted birds (and nests) observed outside of the official survey times.

Because this project represented the first attempt to characterize and quantify CLNWR's grassland bird community, transects were surveyed repeatedly throughout the breeding season to determine which periods resulted in detecting the greatest number of breeding birds. The results of this approach provide information for determining peak times of bird detectabilities to help refuge staff maximize the efficiency of future survey efforts. In 2001, each transect was surveyed three times: once in late spring and twice in early summer (Appendix 5). In 2002 each transect was surveyed twice in late spring, five times in early summer, and once each in late summer and early fall, for a total of nice surveys/transect (except S3-S7, which were not surveyed in late summer and early fall)(Appendix 5). The number of transects surveyed each day depended upon the number of field personnel available.

To conduct a bird survey, one or two observers walked a given transect (when there were two observers, one consistently detected and counted birds while the other recorded data). Care was taken by each observer to count birds only within the 100-m point area. Observers also recorded bird species detected on the refuge outside official survey times (Appendix 1), and noted the locations/species of nests found (Appendix 6).

Data management and analyses---To calculate relative abundances of birds, we first summed all point count data for a given transect and survey date. Assuming that all birds detected were breeding birds (i.e., not migrants passing through), we selected the maximum number of birds detected, by species, for each transect within each survey period. We then used the maximums to calculate mean ($\pm$ se) relative abundances for each species by habitat type and survey period.

Because the sample size of 'off' refuge transects was small ($\leq$ transects/habitat type), it was not possible to make meaningful quantitative comparisons of avian abundances on vs. off refuge, thus we simply lumped the off-refuge data with the on-refuge data. However, for each habitat type, we summarized the species that were found both on and off the refuge, those found on the refuge but not off, and those found off the refuge but not on.

RESULTS and DISCUSSION

North Platte National Wildlife Refuge

A preliminary note on variation in survey results relative to long-term monitoring---Birds are highly mobile and often affected significantly by direct and indirect effects of long-term climate patterns and short-term weather fronts. Thus, their migration distributions---even their breeding and non-breeding ranges---can vary significantly from year to year. Within a given migration season, a weather front may result in hundreds, if not thousands of migrants occurring briefly at a site before they move on. Due to this variability, it takes 5-10 years of rigorous monitoring before trend data can begin to provide meaningful results for a given region, even among the most-common and regularly occurring species.

During this study, factors that may have amplified natural variation in bird species richness and abundance included increasing drought conditions and expansion of West Nile Virus (WNV) into the Great Plains region. For example, the number of bird detections in late May 2002 was about twice the number detected at the same time in 2003, both across all refuge units and at each unit (Tables 1a-1e). However, without 'pre-drought' and/or 'pre-WNV' data from NPNWR, we cannot determine the extent to which our results were affected by either phenomenon. Eventually, long-term regional survey data (e.g., the BBS) may provide some insights on the effects of the drought or WNV on bird populations in the western Great Plains.

Another major factor that affects bird-survey results is avian detectability. Early in the breeding season, many birds are easily detected by virtue of their breeding songs, behaviors, and, in some cases, conspicuous plumage. Thus, one might expect more detections overall in late spring and early summer than in mid or late summer. However, as the breeding season progresses, young-of-the-year can result in increased numbers of detections, particularly among those species whose young have conspicuous begging displays or vocalizations. The activities of adults feeding fledglings can also attract observer attention. Once post-breeding dispersal and migration begin, species that travel in large flocks and/or make constant contact calls among themselves also may increase detections considerably. NPNWR staff should keep all these factors in mind as they continue their monitoring efforts and compare future results to those reported herein.

Refuge-wide avian abundance---Not unexpectedly, avian abundance and species richness at NPNWR varied widely among refuge units and survey periods (Tables 1a-1e, Figures 6-7). For a given survey period across all four refuge units, the lowest abundance was recorded in late August 2002 (n=1293) and the highest in late July 2001 (n=3672) (Table 1a). For a single refuge unit, the greatest abundance was recorded at Lake Alice (n=1553) in late July 2001 and the lowest at Stateline Island (n=124) in late May 2003 (Tables 1b-1e). Generally, abundances at Winters Creek Lake and Stateline Island were lower than they were at Lake Alice or Lake Minatare (Figure 1), most likely because Winters Creek Lake and Stateline Island have less riparian habitat than the other two units. The only exception to this pattern occurred in late July 2001, when a single flock of 500 Common Grackles was observed at Stateline Island.

Refuge-wide avian species richness, diversity, and equitability---Similar to avian abundance, species richness and indices of diversity varied among units and survey periods. Overall, the number of species detected was 103, including five species not currently listed on NPNWR's website-based checklist of birds: Chimney Swift, Eastern Wood-Pewee, Eastern Phoebe, Bell's

Is this the same as equitability??

Be consistent

Table 1a. Avian species abundance, richness, diversity and evenness (Shannon-Wiener Diversity Index H and Evenness E_H), by survey period, for all NPNWR units combined. ('Abundance' for All Periods should be interpreted ***only*** as 'detections' and not abundances, as summing detections over all survey periods would result in counting many of the same individuals repeatedly).

Survey Period	Abundance	Richness	Diversity (H)	Equitability (E_H)
All Periods	(11655)	103	n/a	n/a
Late May '02	3104	81	3.0843	0.7019
Late May '03	1326	43	2.8557	0.7592
Early July '02	2260	50	2.7702	0.7081
Late July '01	3672	59	2.7983	0.6863
Late August '02	1293	47	2.7157	0.7053

Table 1b. Avian species abundance, richness, diversity and evenness (Shannon-Wiener Diversity Index H and Evenness E_H), by period, for the Lake Alice unit at NPNWR. ('Abundance' for All Periods should be interpreted ***only*** as 'detections' and not abundances, as summing detections over all survey periods would result in counting many of the same birds repeatedly).

Survey Period	Abundance	Richness	Diversity (H)	Equitability (E_H)
All Periods	(4831)	69	n/a	n/a
Late May '02	1295	47	2.8474	0.7396
Late May '03	514	27	2.5835	0.7839
Early July '02	1113	36	2.6254	0.7326
Late July '01	1553	39	2.6861	0.7332
Late August '02	356	25	2.5624	0.7960

Table 1c. Avian species abundance, richness, diversity and evenness (Shannon-Wiener Diversity Index H and Evenness E_H), by period, for the Lake Minatare unit at NPNWR. ('Abundance' for All Periods should be interpreted ***only*** as 'detections' and not abundances, as summing detections over all survey periods would result in counting many of the same birds repeatedly).

Survey Period	Abundance	Richness	Diversity (H)	Equitability (E_H)
All Periods	(3349)	63	n/a	n/a
Late May '02	1062	45	2.5789	0.6775
Late May '03	506	34	2.8167	0.7988
Early July '02	645	29	2.5141	0.7466
Late July '01	609	27	2.4911	0.7558
Late August '02	518	28	2.4525	0.7360

Table 1d. Avian species abundance, richness, diversity and evenness (Shannon-Wiener Diversity Index *H* and Evenness E_H), by period, for Winters Creek Lake unit at NPNWR. ('Abundance' for All Periods should be interpreted ***only*** as 'detections' and not abundances, as summing detections over all survey periods would result in counting many of the same birds repeatedly).

Survey Period	Abundance	Richness	Diversity (*H*)	Equitability (E_H)
All Periods	(1459)	71	n/a	n/a
Late May '02	419	44	3.0936	0.8175
Late May '03	182	28	2.6996	0.8102
Early July '02	197	25	2.7708	0.8608
Late July '01	427	31	2.7780	0.8090
Late August '02	234	26	2.2866	0.7018

Table 1e. Avian species abundance, richness, diversity and evenness (Shannon-Wiener Diversity Index *H* and Evenness E_H), by period, for the Stateline Island unit at NPNWR. ('Abundance' for All Periods should be interpreted ***only*** as 'detections' and not abundances, as summing detections over all survey periods would result in counting many of the same birds repeatedly).

Survey Period	Abundance	Richness	Diversity (*H*)	Equitability (E_H)
All Periods	(2025)	59	n/a	n/a
Late May '02	328	41	2.9872	0.8044
Late May '03	124	21	2.5622	0.8416
Early July '02	305	29	2.3238	0.6901
Late July '01	1083	31	1.6683	0.4858
Late August '02	185	28	2.6858	0.8060

Vireo, and Indigo Bunting. For each survey period, nine species accounted for 71-79% of all birds detected, and 53 of the 103 species were represented by 10 or fewer detections across all surveys periods (Appendix 7). Across all time periods, the highest number of species was recorded at Winters Lake Creek (n=71) and the lowest as Stateline Island (n=59) (Tables 1b-1e).

For any single survey period, species richness was highest (n=47) in late May 2002 at Lake Alice and lowest in late May 2003 at Stateline Island (n=21). Unlike abundance patterns, species richness was not typically low at Winters Creek Lake (Tables 1b-1e, Figure 7). In fact, for all survey periods combined, species richness, as well as indices of diversity and equitability, were greatest at Winters Creek Lake. This may be indicative of greater habitat diversity at Winters Creek Lake than at other refuge units. Typically, species richness and indices of diversity were lowest at Stateline Island (Tables 1b-1e). In part, this was due to the relatively high number of House Wrens in most survey periods, as well as the high numbers of one exotic (European Starling) and one invasive (Common Grackle) species.

what is this based on?

Late May 2002: avian abundance, species richness, diversity, and equitability---The overall abundance of birds detected was 3104 (Table 1a), 19% of which were European Starlings

(Figure 8). The next eight highest-ranking species were Common Grackle, House Wren, Mourning Dove, Western Kingbird, Yellow Warbler, Red-winged Blackbird, Northern Oriole, and Orchard Oriole, which represented 52% of the total birds detected in this period (Figure 8). Abundance and species richness were greatest at Lake Alice (n=1295 and 47, respectively) and lowest at Stateline Island (n=328 and 41, respectively) (Tables 1b-1e). However, diversity and equitability were highest at Winters Creek Lake (H=3.09, E_H=0.82) and lowest at Lake Minatare (H=2.58, E_H=0.68). Overall species richness for NPNWR in this period (n=81) was greater than at any other time during the project, most likely due to the presence of pass-through long-distance migrants, such as Western Wood-Pewee, Swainson's Thrush, Tennessee Warbler, Blackpoll Warbler, Wilson's Warbler, American Tree Sparrow, Clay-colored Sparrow, Lincoln's Sparrow, and Black-headed Grosbeak (Appendix 7).

Late May 2003: avian abundance, species richness, diversity, and equitability---The overall abundance of birds detected was 1326 (Table 1a), 18.5% of which were European Starlings (Figure 9). The next eight highest-ranking species were Common Grackle, Mourning Dove, House Wren, Western Kingbird, Northern Oriole, Yellow Warbler, Orchard Oriole, and Blue Jay, which represented 57.5% of the total birds detected in this period (Figure 9). The highest abundance (n=514) and species richness (n=34) were detected at Lake Alice and Lake Minatare, respectively, while lowest abundance (n=124) and species richness (n=21) both occurred at Stateline Island (Tables 1b-1e). Lake Minatare also had the highest diversity (H=2.82), but equitability was highest at Stateline Island (E_H=0.84). Diversity was lowest at Stateline Island (H=2.56), and equitability was lowest at Lake Alice (E_H=0.78). Overall species richness for NPNWR in this period (n=43) was nearly half what it was in 2002 during the same time period. Notably missing were many of the pass-through long-distance migrants detected in 2002 (Appendix 7). It remains unclear what contributed to this large difference, although drought and differences in year-to-year timing of migration may have been factors.

Early July 2002: avian abundance, species richness, diversity, and equitability---The overall abundance of birds detected was 2260 (Table 1a), 22.3% of which were House Wrens (Figure 10). The next eight highest-ranking species were Mourning Dove, Common Grackle, Western Kingbird, Northern Oriole, European Starling, American Robin, Blue Jay, and Black-capped Chickadee, which represented 56.8% of the total birds detected in this period (Figure 10). The highest abundance (n=1113) and species richness (n=36) were detected at Lake Alice, while the lowest abundance (n=197) and species richness (n=25) both occurred at Winters Creek Lake (Tables 1b-1e). However, diversity and equitability were highest at Winters Creek Lake (H=2.78, E_H=0.86) and they were lowest at Stateline Island (H=2.32, E_H=0.69). The low overall species richness in this time period undoubtedly reflects the fact that it falls between migration periods. Most species detected were locally breeding species (Appendix 7).

Late July 2001: avian abundance, species richness, diversity, and equitability---The overall abundance of birds detected was 3672 (Table 1a), 19.7% of which were House Wrens (Figure 11). The next eight highest-ranking species were Common Grackle, Western Kingbird, Mourning Dove, Orchard Oriole, Black-capped Chickadee, Red-winged Blackbird, Eastern Kingbird, and Blue Jay, which represented 58.1% of the total birds detected in this period (Figure 11). As in May 2002 and early July 2002, the highest abundance (n=1553) and species richness (n=39) were detected at Lake Alice, while lowest abundance (n=427) was at Winters

Creek Lake and lowest species richness (n=27) was at Lake Minatare (Tables 1b-1e). However, as in May and early July 2002, Winters Creek lake had the highest diversity (H=2.78) and equitability (E_H=0.81). Diversity (H=1.66) and equitability (E_H=0.49) were lowest at Stateline Island, undoubtedly due to a single flock of 500 Common Grackles detected during this period (Appendix 7).

The effects of local, ephemeral population increases due to fledging young and/or influxes of dispersal/migratory flocks could have contributed to the relatively high abundances of House Wrens, Common Grackles, Western Kingbirds, Mourning Doves, Orchard Orioles, and Black-capped Chickadees detected in late July 2001 this survey period (Figure 11). Of these species, all except Orchard Oriole are listed in the NPNWR bird checklist as 'common' to 'abundant' breeders; Orchard Oriole is listed as 'uncommon', although our data suggest that its status should be 'common.' Thus, one would expect local increases in abundances of these species as their young fledge. Also, by late July individuals of many species had likely begun their dispersal movements and/or migrations from other locations or regions, possibly contributing to the high abundances detected in this survey period. Because western riparian corridors represent significant migration and/or dispersal corridors for many species (Knopf et al. 1988; Skagen et al. 1998), and because all of NPNWR is located along or very near the North Platte River, one could expect large increases in bird abundances during migration seasons at NPNWR.

Late August 2002: avian abundance, species richness, diversity, and equitability---The overall abundance of birds detected was 1293 (Table 1a), 18.3% of which were House Wrens (Figure 12). The next eight highest-ranking species were European Starling, Chipping Sparrow, Black-capped Chickadee, Blue Jay, Mourning Dove, Northern Flicker, Black-billed Magpie, and Yellow Warbler, which represented 57.7% of the total birds detected in this period (Figure 12). Abundance was greatest at Lake Minatare (n=518), and species richness was greatest at both Lake Minatare and Stateline Island (n=28 at each unit) and lowest at Stateline Island (n=328 and 41, respectively). Diversity and equitability were highest at Stateline Island (H=2.69, E_H=0.81) and lowest at Winters Creek Lake (H=2.29, E_H=0.70). Overall species composition for this survey period was probably most unlike those in the other four periods, probably because many of the long-distance migrants had already left the region; thus, year-round residents accounted for a greater proportion of the overall avian community (Appendix 7). Undoubtedly, community composition at NPNWR continues to change throughout the later portions of fall migration as breeders from the north move through the area.

Profiles of most-abundant avian species and related management issues---Across all survey periods and refuge units, the species detected most often (at least 200 individuals; the highest-ranking species in Appendix 7) were House Wren, Common Grackle, European Starling, Mourning Dove, Western Kingbird, Black-capped Chickadee, Orchard Oriole, Blue Jay, Northern Oriole, American Robin, Yellow Warbler, Red-winged Blackbird, and Northern Flicker (Figures 5-9). Of these species, four are year-round residents (Northern Flicker, Blue Jay, Black-capped Chickadee, and European Starling), although, to an unknown extent, individuals of these species may turn over from one season to the next. Short- to medium-distance migrants included Common Grackle, Mourning Dove, House Wren, American Robin, and Red-winged Blackbird. The remaining four species---Western Kingbird, Yellow Warbler, Orchard Oriole, and Northern Orioles (predominantly Bullock's Orioles)---are long-distance migrants. The fact that there are

not more short- and long-distance migrants using the refuge riparian areas may indicate a lack of structural and species diversity in those habitats. One conspicuously missing guild of migratory species is that which depends heavily on understory shrubs and/or willow carr. However, because the riparian habitats at NPNWR are of artificial origin, it remains debatable as to whether management at the refuge should improve habitat diversity. That will depend on refuge goals.

House Wrens ranked among the top four most-abundant species in every survey period (Figures 8-12), possibly indicating that the riparian habitats at NPNWR are somewhat decadent. House Wrens typically defend very small territories, thus their densities in suitable nesting habitat can be quite high compared to neighboring species. In at least one study (near Denver, Colorado), House Wren densities ranged from 630-890 territorial males/100 ha over nine years of study (Bottorf et al. 1979). However, as cavity nesters, House Wrens are particularly attracted to areas with ample woody debris and decadent or damaged trees (although they will nest in a variety of natural and anthropogenic cavities [Barrett 1998}), and the majority of House Wrens detected at NPNWR were associated with logs, brush, and other woody debris. If not already accomplished, a vegetation survey should be initiated at NPNWR to ascertain the successional status of its riparian habitats. If it is found that cottonwood regeneration is absent or minimal, refuge management staff may wish to remedy the situation if it wishes to retain viable populations of obligate and facultative riparian birds.

At all refuge units, Common Grackles ranked among the top three species in all survey periods except late August 2002 (Figures 8-12), by which time the majority had likely migrated southward. The species is well known for its adaptability and use of rural habitats that are degraded or altered by human activities (e.g., farmyards, shelterbelts, and croplands [Chace 1995]). The species often forms loose breeding colonies of up to 100 pairs, benefiting especially from juxtapositions of vertical nesting structures (dense woody vegetation) and food resources, including waste grain, fruits (including those produced by non-native trees and shrubs), and other anthropogenically derived sources. These factors may be contributing to the species' range expansion (Chace 1998) north and west of its original range core in eastern North America (Sauer et al. 2003*b*). It should be noted that Common Grackles prey on the eggs and nestlings of other bird species (Chace 1995), but the extent to which this habit impacts local populations of other bird species where grackles have expanded remains unclear. Nesting-success studies would be required to determine whether or not this is a problem at NPNWR.

European Starlings ranked among the top five most-common species in all but one survey period. This species was introduced to North America in the late 1800s, but in just 100 years it had expanded across most of North American, including much of Canada and parts of northern Mexico (National Geographic Society 1999). The extent to which this species out-competes native cavity nesters remains uncertain. Cabe (1993) summarized many observations of starlings evicting flickers and bluebirds from their nesting cavities. Vierling (1998), on the other hand, found that starlings were unsuccessful in evicting 58 of 59 pairs of Lewis' Woodpeckers from their nest cavities. Thus, the potential effects of starlings on other cavity nesters may depend on which, if any, competitive advantages other cavity nesters have over starlings (e.g., earlier nest initiation, larger size, more-aggressive nature).

Cavity-nesting species detected at NPNWR, and which potentially nest at NPNWR, included Wood Duck, American Kestrel, Barn Owl, Red-headed Woodpecker, Downy Woodpecker, Hairy Woodpecker, Northern Flicker, Great Crested Flycatcher, Tree Swallow, Black-capped Chickadee, White-breasted Nuthatch, Red-breasted Nuthatch, House Wren,

Eastern Bluebird, House Finch, and House Sparrow (also exotic). (Belted Kingfishers, Northern Rough-winged Swallows, and Bank Swallows also nest in cavities---burrows in embankments---but starlings typically use cavities well above ground level.) On size difference alone, starlings could potentially out-compete all of the species listed above except the duck, kestrel, and owl. However, the smaller species (e.g., chickadee, nuthatches, wrens) probably use cavities small enough to preclude starlings from accessing them. Therefore, the NPNWR cavity-nesting species most likely to have competition from starlings are the mid-sized migrant passerines that arrive after starlings have begun to nest (Red-headed Woodpecker, Great Crested Flycatcher, Tree Swallow, Eastern Bluebird).

To determine whether or not starlings may be suppressing populations of other cavity nesters, refuge management could experiment with depressing local starling populations. If pursued, this should be done with a non-toxic method during winter, at which time large starling roosts can be targeted with aerial applications of Turgitol---a non-toxic liquid soap that drenches the target birds and eliminates feather-insulation qualities, causing death via hypothermia. However, at this point it is highly unlikely that starlings will ever be extirpated from North America, thus the benefits of any starling-control efforts would be negated quickly. Another approach would be to erect nest boxes that have species-specific dimensions/entry sizes and which are placed at species-preferred heights/orientations on preferred substrates, just prior to the species' predicted arrival date (see the websites listed below for nest-box information).

<http://midwest.fws.gov/marktwain/kids/crafts/Nestbox/nest_box2.htm>
<http://birds.cornell.edu/birdhouse/speciesaccounts/GRCRFLYC.HTM)>
<http://www.50birds.com/BPGreat-crestedFlycatcher.htm>

Boxes can be removed/cleaned/maintained after breeding season ends. Successful flicker, swallow, and bluebird use of nest boxes has been well-documented. At least one study suggests that Great-crested Flycatchers will use nest boxes (Miller 2002), although they appear to prefer natural cavities (Hebert and Elkins *in* Foss 1994).

Avian use of substrates/tree species---Of the 11655 total bird detections during this study, 41% were observed in cottonwoods or willows, including both live trees (young and mature) and snags (Table 2). In contrast, only 4.9% of the birds detected were observed in Russian olives (live trees and snags included). However, tree species were not recorded for approximately 32% of all birds detected in trees (during most woodland-bird surveys, a large proportion of detections are made by ear); thus, we do not know what percent of those trees may have been cottonwoods, willows, Russian olives, etc. Moreover, data indicating which substrates and vegetation species birds used most could be simple reflections of the overall availability of these habitat components as opposed to indications of bird preferences. If refuge staff wish to learn something more about avian choices, it will be essential to conduct a vegetation survey to characterize and quantify the riparian vegetation community. Then avian use of specific substrates and vegetation species can be compared to their overall availability.

Only 1295 of all birds detected were recorded as engaged in feeding behavior. Collecting behavior data in addition to vegetation/substrate and bird-census data can become overwhelming for field workers when many birds are present; in these cases, tasks must be prioritized (usually not behavior data). And, as mentioned above, many auditory detections do not lead to visual contact with the bird detected. Finally, a bird could appear to be engaged in one behavior (e.g., recorded as resting) when in actuality it is feeding (e.g., perching, stalking, waiting), thus many behaviors not recorded as foraging actually may have been foraging. Despite the preliminary

Table 2. Number (and percent) of bird detections in various tree species and other substrates during surveys over five survey periods at North Platte National Wildlife Refuge, 2001-2003. Live trees included both young and mature trees.

Species/Substrate	Live Tree	Snag	Other
Cottonwood	3285 (28.19%)	297 (2.55%)	n/a
Willow	1128 (9.68%)	34 (0.29%)	n/a
Russian olive	448 (3.84%)	121 (1.04%)	n/a
Other tree species (blue spruce, mulberry, chokecherry, eastern red cedar, green ash, boxelder)	31 (0.27%)		n/a
Unidentified tree species	3844 (29.93%)	202 (1.73%)	n/a
Logs, woody debris	n/a	n/a	666 (5.71%)
Ground/herb layer	n/a	n/a	364 (3.12%)
Water/aquatic emergents	n/a	n/a	304 (2.61%)
Air	n/a	n/a	312 (2.68%)
Miscellaneous (shrubs, wires, fences, posts, poles; many—large flock)	n/a	n/a	619 (5.31%)

and limited nature of the behavior data, however, they do indicate that, of the tree species identified, cottonwood was used more than other species, and mature trees were used more than young trees (Table 3). To gain a deeper understanding of which vegetation species and substrates birds use preferentially at NPNWR, refuge staff may wish to consider a behavior-specific study in conjunction with a vegetation survey.

Table 3. Number (percent) of birds foraging at the time of detection, by substrate and/or vegetation species, during surveys at North Platte National Wildlife Refuge, 2001-2003. Only species/substrates on which birds were recorded as foraging are included.

	Cottonwood	Willow	Russian olive	Unid'd. tree	Water/ Aquatic	Ground/ herb layer	Air
Mature tree	51 (3.9)	17 (1.3)	70 (5.4)	263 (20.3)	n/a	n/a	n/a
Young Tree	22 (1.7)	26 (2.0)	5 (0.4)	64 (4.9)	n/a	n/a	n/a
Tree	308 (23.8)	103 (8.8)	0	21 (1.6)	n/a	n/a	n/a
Snag	4 (0.3)	6 (0.5)	0	25 (1.9)	n/a	n/a	n/a
Log	78 (6.0)	11 (0.9)	13 (1.0)	31 (2.3)	n/a	n/a	n/a
Totals	463 (35.8)	163 (12.6)	88 (6.8)	404 (31.2)	38 (2.9)	136 (10.5)	3 (0.2)

Avian abundances affected by changes in taxonomy and unidentified species---According to BBS distribution and abundance maps (Price et al. 1995), Nebraska's panhandle is located at the eastern edge of the Bullock's Oriole's range and at the western edge of the Baltimore Oriole's range. Thus, one might expect roughly equal proportions of both species to occur at NPNWR. However, of the 360 Northern Orioles, Baltimore Orioles, and Bullock's Orioles detected during this study, only two (0.6%) were recorded as Baltimore Oriole, 27 (7.5%) were undifferentiated to species (Northern Oriole), and 331 (92%) were recorded as Bullock's Oriole. Moreover, the NPNWR bird checklist rates the Bullock's Oriole as 'uncommon' (although our data would suggest that they are 'common' or 'abundant'), which means it is more likely to be found at NPNWR than the Baltimore Oriole, which the checklist rates as 'rare.' Thus, at least during the breeding season, the majority of 'Northern Orioles' occurring at NPNWR are actually Bullock's Orioles. It is possible, however, that the proportions of each species vary from year to year according to weather patterns and other factors that affect migration and breeding-bird distributions through western Nebraska. Long-term monitoring may demonstrate whether or not this occurs.

Of the 32 flickers recorded to subspecies level, 26 (81%) were Red-shafted and six (19%) were Yellow-shafted. If these proportions represented actual proportions of each subspecies, then 181 of the 224 total flicker records would have been Red-shafted and 43 would have been Yellow-shafted. According to BBS distribution and abundance maps (Price et al. 1995), NPNWR is somewhat closer to the eastern edge of the Red-shafted's range than to the western edge of the Yellow-shafted's range; thus one would expect the Red-shafted to be the predominant flicker race at NPNWR.

The only *Empidonax* flycatchers included on the NPNWR bird species checklist are Willow (rated as an 'occasional' migrant), Least ('rare' migrant), and Cordilleran ('accidental' migrant). Thus, it would be reasonable to presume that most of the unidentified *Empidonax* during this study were Least Flycatchers ('rare' being a more common status than 'occasional' or 'accidental'). However, the avian collection at University of Nebraska's State Museum includes two Acadian Flycatchers from relatively nearby locations---one from northern Sioux County (the county north of Scotts Bluff County) collected on 28 May 1900, and another collected in Cherry County (somewhat farther north and east than NPNWR) on 29 May 1932. Labedz (1990) lists six *Empidonax* species as occurring in the nearby Nebraska Sandhills region, including Alder, Willow, Yellow-bellied, Least, and Western (now Cordilleran) flycatchers; all but one of which he considers pass-through migrants (he treats Willow Flycatcher as a 'possible breeder' in the region). Thus, it is possible that additional *Empidonax* species occur at NPNWR but remain undocumented due their inconspicuous nature and/or misidentification. Long-term monitoring, and recruitment of *Empidonax* experts to conduct surveys, at NPNWR may help refine what is known about *Empidonax* use of NPNWR. It is also worth noting that if large stands of willow carr were to develop at NPNWR, they might attract nesting Willow Flycatchers.

The two *Vireo* species listed on NPNWR's bird checklist are Warbling (rated as 'uncommon') and Red-eyed ('occasional' in spring and fall, 'rare' in summer) vireos. The Warbling Vireos status as 'uncommon' would lead one to expect that species at NPNWR more often than Red-eyed Vireo. However, the avian collection at University of Nebraska's State Museum includes four *Vireo* species collected in the western panhandle counties of Nebraska, including Bell's (1 specimen), Warbling (3 specimens), Plumbeous (8 specimens), and Red-eyed

(6 specimens) vireos. Labedz (1990) lists six *Vireo* species as occurring in the nearby Nebraska Sandhills, including Bell's ('breeder'), Solitary ('migrant'); now split into three species--- Plumbeous, Blue-headed, and Cassin's vireos, with Plumbeous and Blue-headed being the two most-likely to occur in western Nebraska (National Geographic Society 1999), Yellow-throated ('possible breeder'), Warbling ('breeder'), Philadelphia ('migrant'), and Red-eyed ('breeder') vireos. Thus, we cannot assume that the unidentified *Vireo* species was a Warbling or Red-eyed vireo. NPNWR lies well within the breeding range of Bell's Vireo, although its behavior and vocalizations generally give it away fairly easily during breeding season (not necessarily during migration). During our surveys, two Bell's Vireos were identified at Winter's Creek Lake in late July 2001, and, if a shrubby understory were a stronger component of NPNWR's overall riparian vegetation, it is possible that Bell's Vireo would be more common there.

Crescent Lake National Wildlife Refuge

Overall species composition, abundance, and habitat affinities---A total of 40 species were detected along the 17 CLNWR transects during 2001 and 2002 (Appendix 1, Table 4). However, the number of species detected in 2002 (n = 40) was about a third greater than the number detected in 2001 (n = 26), most likely due to more-intensive survey efforts (more surveys/transect and additional survey periods) in 2002 (Table 5, Appendix 8). Not surprisingly, the numbers of species detected in Choppy Sands (n = 19) and Sands (n = 16) habitats were similar, whereas the number of species (n = 31) detected in Sub-irrigated Meadow was higher than in the other two habitat types (Table 4). Species assemblages were also similar in Choppy Sands and Sands, whereas the assemblage in Sub-irrigated Meadow was quite different (Tables 4-5, Appendix 8).

Across all survey periods, only 17 species were detected more than 20 times (16 were detected $\leq$ five times) (Tables 4-5, Appendix 8). However, the number of species detected >20 times was similar across habitat types: 12 species in Choppy Sands, 14 in Sub-irrigated Meadow, and 11 in Sands (Tables 4-5, Appendix 8). Of the species detected in CLNWR's grasslands, 11 are considered primary (endemic) or secondary (more widespread) to North American grasslands (Mengel 1970, Samson and Knopf 1996)(Table 4). Some consider the Bobolink a species of tallgrass prairies as well, although Bobolinks also inhabit grassland/shrubland ecotones (Price et al. 1995). Brown-headed Cowbirds use a variety of habitat types, but because they are obligate brood parasites, they are of special concern in grassland bird conservation. Thus, we have included the Bobolink and Brown-headed Cowbird with the 11 endemic and secondary grassland species in our more-detailed results and discussions of grassland birds in the habitat sections below.

Choppy Sands---The most frequently detected species in this type during spring and early summer survey periods were Lark Sparrow (mean maximum of 7.29 / transect in early summer 2002), Western Meadowlark (mean maximum of 6.86 / transect in late spring 2001), and Brown-headed Cowbird (mean maximum of 5.0 / transect in early summer 2002)(Table 5, Figures 13-15). Species detected less frequently (mean maximum of $\leq 1 < 5$ / transect) were Sharp-tailed Grouse, Mourning Dove, Horned Lark, Grasshopper Sparrow, Vesper Sparrow, and Yellow-headed Blackbird (Table 5, Appendix 8). The remaining 10 species were detected only at very low numbers (mean maximum of <1 / transect for all survey periods) and/or detected in only 1-2 survey periods. Of the species in the last category, one was a focal grassland species (Upland

Table 4. Species detected in each of three habitat types during bird surveys conducted in spring (2001, 2002), early summer (2002, 2002), late summer (2002), and fall (2002) at CLNWR. Species in italics were detected >20 times throughout the study; species in boldface are considered primary (endemic) or secondary (more widespread) grassland species in North America (Mengel 1970, Samson and Knopf 1996).

Common Name	Habitat Type[a]	Common Name	Habitat Type
American Kestrel	C	Red-tailed Hawk	C, S
Western Kingbird	C	Eastern Kingbird	C, S
American Goldfinch	C	***Horned Lark***	C, S
Lark Bunting	S	***Lark Sparrow***	C, S
American Bittern	M	***Vesper Sparrow***	C, S
White-faced Ibis	M	Common Nighthawk	C, M
Wood Duck	M	*Yellow-headed Blackbird*	C, M
Mallard	M	Common Grackle	C, M
Blue-winged Teal	M	Ring-necked Pheasant	S, M
Northern Pintail	M	**Long-billed Curlew**	S, M
Bald Eagle	M	***Sharp-tailed Grouse***	C, S, M
American Coot	M	*Killdeer*	C, S, M
Willet	M	***Upland Sandpiper***	C, S, M
Wilson's Phalarope	M	*Mourning Dove*	C, S, M
Black Tern	M	***Grasshopper Sparrow***	C, S, M
Tree Swallow	M	*Red-winged Blackbird*	C, S, M
Barn Swallow	M	***Western Meadowlark***	C, S, M
Marsh Wren	M	*Brown-headed Cowbird*	C, S, M
Common Yellowthroat	M		
Dickcissel	M		
Bobolink	M		
Eastern Meadowlark	M		

[a]C = Choppy Sands, S = Sands, M = Sub-irrigated Meadow

Sandpiper) detected somewhat regularly in this type but at very low numbers (mean maximum of 0.14/transect)(Table 5, Figure 16).

Species found exclusively in Choppy Sands (Table 4) were habitat generalists that use a variety of relatively open habitats and which nest above ground level; most likely they were only passing through or temporarily foraging in the area as opposed to nesting in Choppy Sands. There were, however, three species (Horned Lark, Lark Sparrow, Vesper Sparrow) detected only in Choppy Sands and Sands habitats (Table 4; Figures 13, 17-18); all three are secondary grassland species that generally nest on the ground (occasionally Lark Sparrows, rarely Vesper Sparrows, will nest in low shrubs)(Ehrlich et al. 1988). Vesper Sparrows prefer short- to mixed-height grasses, and Lark Sparrows prefer econtonal areas with short- to mixed height grasses and scattered shrubs or trees (Ehrlich et al. 1988, Samson and Knopf 1994). The small shrub component in Choppy Sands (Nebraska Soil Conservation Service 1981) may attract the Lark Sparrows. According to Sharpe et al. (2001), Lark Sparrows are most common in the Sandhills where yucca occurs (Sharpe et al. 2001). Rosche (1982) indicates that Vesper Sparrows prefer disturbed Sandhills prairie with occasional small shrubs, such as yucca. In fact, Lark and Vesper

Table 5. Mean (se) of maximum detections of grassland birds / transect (3.14 ha / point, five points / transect, 15.7 ha / transect) during breeding season in three grassland-habitat types at CLNWR, 2001-2002. (Means for non-focal species are listed in Appendix 8). Gray shading indicates periods when frequencies of detection were greater, thus providing a guideline for timing future surveys.

Habitat	Species	Spring 2001	Spring 2002	Early Summer 2001	Early Summer 2002	Late Summer 2002	Early Fall 2002
Choppy	Brown-headed Cowbird	2.86 (1.14)	3.0 (0.82)	4.0 (1.36)	5.0 (0.69)	0	0.57
Sands	Brown-headed Cowbird	0.86 (0.55)	3.0 (1.11)	0.86 (0.40)	2.14 (1.34)	0.5 (0.50)	0.5 (0.50)
Meadow	Brown-headed Cowbird	0	2.67 (2.18)	0.5 (0.5)	0.2 (0.2)	0	0.33 (0.33)
Choppy	Grasshopper Sparrow	2.0 (0.53)	0.71 (.42)	1.14 (0.40)	1.29 (0.29)	0	1.14 (0.55)
Sands	Grasshopper Sparrow	15.29 (1.52)	18.29 (2.45)	16.14 (2.09)	20.0 (2.73)	6.0 (3.00)	2.5 (0.50)
Meadow	Grasshopper Sparrow	4.67 (2.60)	3.0 (0.58)	3.17 (0.60)	11.0 (2.44)	2.0 (0.58)	1.0 (0.00)
Choppy	Western Meadowlark	6.86 (0.67)	5.14 (0.46)	5.29 (0.68)	5.0 (0.87)	0.71 (0.42)	3.29 (0.68)
Sands	Western Meadowlark	8.57 (0.65)	7.0 (0.66)	5.86 (0.74)	5.71 (0.52)	3.5 (1.50)	0.5 (0.50)
Meadow	Western Meadowlark	6.0 (1.00)	5.67 (1.76)	2.67 (0.33)	3.27 (1.54)	2.0 (1.0)	1.67 (0.33)
Choppy	Sharp-tailed Grouse	1.14 (0.99)	0	0	0.14 (0.14)	0	0.29 (0.29)
Sands	Sharp-tailed Grouse	0	2.7 (1.69)	0.43 (0.30)	1.0 (0.53)	0	0.5 (0.50)
Meadow	Sharp-tailed Grouse	0	0.33 (0.33)	0	0	0.33 (0.33)	0
Choppy	Upland Sandpiper	0.14 (0.14)	0.14 (0.14)	0.14 (0.14)	0.14 (0.14)	0	0
Sands	Upland Sandpiper	0.14 (0.14)	0.43 (0.30)	0.71 (0.57)	0	0	0
Meadow	Upland Sandpiper	0	1.0 (1.0)	1.17 (0.44)	2.33 (2.23)	1 (1)	0
Choppy	Horned Lark	0.43 (0.30)	2.0 (1.40)	1.0 (0.53)	1.57 (0.92)	0	0.43 (0.43)
Sands	Horned Lark	0.29 (0.29)	1.57 (0.72)	1.0 (0.58)	2.86 (0.86)	0	1.0 (0.00)
Choppy	Lark Sparrow	2.86 (0.70)	5.0 (065)	5.71 (1.06)	7.29 (0.64)	2.0 (0.53)	0
Sands	Lark Sparrow	0.29 (0.18)	0.71 (0.29)	1.29 (0.84)	4.57 (2.81)	6.5 (5.50)	2.0 (0.00)
Choppy	Vesper Sparrow	0.71 (0.29)	0.43 (0.20)	0.71 (0.47)	1.57 (0.69)	0.14 (0.14)	0
Sands	Vesper Sparrow	0	0.14 (0.14)	0	0.57 (0.30)	0	0
Sands	Long-billed Curlew	0.29 (0.18)	0.43 (0.30)	0.29 (0.29)	0	0	0
Meadow	Long-billed Curlew	0.33 (0.33)	1.67 (1.20)	0	0	0	0
Meadow	Lark Bunting	0	0.29 (0.18)	0	0.14 (0.14)	0	0
Meadow	Bobolink	0	1.33 (1.33)	0	0.6 (0.6)	0	0
Meadow	Dickcissel	0	1.0 (0.58)	1.5 (1.50)	2.2 (1.22)	0	0
Meadow	Eastern Meadowlark	1.67 (0.33)	5.0 (2.08)	2.17 (1.69)	3.0 (1.42)	0.33 (0.33)	0

sparrows were detected more frequently in Choppy Sands than in any other type (Figures 13 and 18, respectively). The same is true for Brown-headed Cowbird (Figure 15), which may find more perches in this type than in the other two types (cowbirds typically use elevated perches from which they scan for nests to parasitize). Horned Larks, on the other hand, typically inhabit areas nearly devoid of vegetation or vegetated with very short grass (Ehrlich et al. 1988, Samson and Knopf 1996), important components of Choppy Sands habitat.

Sands---The most frequently detected species in this type during spring and early summer survey periods were Grasshopper Sparrow (mean maximum of 20.0 / transect in early summer 2002) and Western Meadowlark (mean maximum of 8.57 / transect in late spring 2001)(Table 5, Figures 14 and 20). In fact, Grasshopper Sparrow and Western Meadowlark were detected more often in this type than any other species in any type except Red-winged Blackbird in Sub-irrigated Meadow (Table 5; Appendix 8; Figures 14, 20). Species detected less frequently (mean maximum of $\leq 1 < 5$ / transect) were Sharp-tailed Grouse (detected more often in this type than in any other type; Figure 21), Mourning Dove, Horned Lark, Lark Sparrow, Red-winged Blackbird, and Brown-headed Cowbird (Table 5, Appendix 8). The remaining 8 species were detected only at very low numbers (mean maximum of <1 / transect for all survey periods) and/or detected in only 1-2 survey periods. Of the species in the last category, four were focal grassland species (Long-billed Curlew, Upland Sandpiper, Lark Bunting, Vesper Sparrow) that were detected somewhat regularly in this type but at very low numbers (mean maximum of 0.29-0.71 / transect)(Table 5; Figures 16, 18-19, 22).

The one species (Lark Bunting) found exclusively in Sands (Table 4, Figure 22) was detected only a total of three times. Although CLNWR falls within the eastern edges of the Lark Bunting's range (National Geographic Society 1999), the vertical structure and/or density of grass cover at CLNWR may not be suitable for this species. Lark Buntings typically inhabit very short-grass habitats (Samson and Knopf 1006) more typical of the western-most regions of the Great Plains. In both grasslands and agricultural fields, they tend to be more common where cover values are lowest (Shane 2002). Also, Lark Buntings were recorded only in 2002, a possible reflection of their nomadic nature (Shane 2002); the species is known to shift its breeding range from year to year, possibly tracking patterns in residual cover driven by weather patterns. Grasshopper Sparrows prefer mixed/tall and tall grass habitats (Samson and Knopf 1996), indicating that cover in CLNWR's Sands habitat is relatively tall when the birds settle in early breeding season. Of the three species (Horned Lark, Lark Sparrow, Vesper Sparrow) detected only in Sands and Choppy Sands habitats (Table 4), neither seemed to prefer Sands over Choppy Sands (see discussion above in section on Choppy Sands), and only the Horned Lark appeared to use both habitats relatively equally (Figures 13, 17-18). A detailed vegetation survey at CLNWR would be required to further refine the habitat relationships of grassland birds using these two types.

Sub-irrigated Meadow---The focal grassland species detected in this type most often during spring and early summer survey periods were Grasshopper Sparrow (mean maximum of 11.0 / transect), Eastern Meadowlark (mean maximum of 5.0 / transect), and Western Meadowlark (mean maximum of 6.0 / transect)(Table 5; Figures 14, 20, 23). Wetland species detected most frequently during spring and early summer were Marsh Wren, Red-winged Blackbird, and Yellow-headed Blackbird (mean maximums of 15.0, 32.67, 12.33 / transect, respectively; Appendix 8). Focal species detected less frequently (mean maximum of $\leq 1 < 5$ / transect) were

Upland Sandpiper, Dickcissel, and Brown-headed Cowbird (Table 5, Figures 15-16, 24). Wetland or aquatic species detected less frequently (mean maximum of $\leq 1 < 5$ / transect) were Killdeer, Wilson's Phalarope, Black Tern, Mourning Dove, and Common Yellowthroat (Appendix 8). The remaining 17 species were detected only at very low numbers (mean maximum of <1 / transect for any survey period) and/or in only 1-2 survey periods. Of the species in the last category, three were focal species (Sharp-tailed Grouse, Long-billed Curlew, and Bobolink) that were detected somewhat irregularly in this type at low numbers (mean maximums of 0.33-1.67 / transect)(Table 5; Figures 19, 21, 25). The relatively high number of species for which there were <20 detections is probably attributable to late-migrating waterfowl, wetland birds that occasionally venture into more-terrestrial habitats, species with very large territories, and/or those simply wandering through the area without really using the habitat.

All but three species found exclusively in Sub-irrigated Meadow (Table 4) were wetland obligates or those that typically forage at wetland areas. The other three (Dickcissel, Bobolink, and Eastern Meadowlark) are species that prefer the taller cover of relatively mesic grasslands and/or ecotonal habitats [Lanyon 1956, Martin and Gavin 1995, Price et al. 1995, Samson and Knopf 1996, Temple 2003]). Rosche (1982) indicates that Eastern Meadowlarks inhabiting the Nebraska Sandhills select wet meadows, often in association with Bobolinks. All three species are declining precipitously at highly significant levels (Samson and Knopf 1996, Sauer at al. 2003*b*); thus, even though Sub-irrigated Meadow is a small portion of CLNWR's overall habitat, it is very important for species of mesic grasslands.

On-refuge vs. off-refuge comparisons---Overall, significantly more species were found on refuge sites than off the refuge, although this may be due, in large part, to the small number of transects off the refuge. With that caveat, we summarize the number of species detected in each habitat type, both on and off refuge. Of the 19 species that were detected in Choppy Sands, six occurred on and off refuge, 13 were detected only on the refuge, and no species were detected only off the refuge. Of the 16 species that were detected in Sands, eight occurred on and off the refuge, seven were detected only on the refuge, and one species (Eastern Kingbird) was detected only off the refuge. Finally, of the 31 species that were detected in Sub-irrigated Meadow, 21 occurred both on and off refuge, seven were detected only on the refuge, and three species were detected only off the refuge (Mallard, Sharp-tailed Grouse, and Barn Swallow). Of the four species detected off the refuge but not on the refuge, each was detected at very low numbers and/or only sporadically in those habitats.

Off-refuge transects could make it possible to compare bird densities in various habitat types under different management regimes. However, the sample size of transects per type and per management regime (e.g., grazing, burning, cutting) would need to be enlarged significantly. Ideally, these comparisons would be made under controlled conditions (i.e., experiments) to diminish the variability that could otherwise swamp future bird-density data.

Incidental observations of additional bird species and nests---In addition to the species recorded during official transect surveys, species detected incidentally while working on the refuge were recorded as well (Appendix 1). For the most part, incidental species sighted occurred in or near stands of trees and/or bodies of water. All species observed incidentally are listed on Crescent Lake National Wildlife Refuge's bird checklist.

While working at CLNWR, observers also found 15 bird nests, four of which were located along transects (Appendix 9). In each case, nests were found when observers

inadvertently flushed birds from their nests. Of the 15 nests, the only one for a focal grassland species was that of a Lark Sparrow. It was found on 1 July 2002 under a *Yucca* sp. in Choppy Sands habitat along transect C5 near point 0. The observer noted three eggs in the nest on the date it was found, but the final outcome of that nesting attempt is not known.

Grassland species expected but not detected at CLNWR---Based on CLNWR's bird checklist, museum specimens collected from nearby Sandhills counties (Arthur, Cherry, Garden, Grant, Hooker, Keith, McPherson, Morrill, and Sheridan)(collections from University of Nebraska State Museum, The Field Museum of Chicago, Yale Peabody Museum, and the University of California Museum of Vertebrate Zoology), and range maps (National Geographic Society 1999), there were some avian species that do occur in the region, but which we did not find during surveys at CLNWR. Undetected species included Northern Harrier, Swainson's Hawk, Ferruginous Hawk, Prairie Falcon, Greater Prairie Chicken, Mountain Plover, Short-eared Owl, Burrowing Owl, Loggerhead Shrike, Clay-colored Sparrow, Field Sparrow, Savannah Sparrow, McCown's Longspur, Lapland Longspur, and Chestnut-collared Longspur. The relative rarity of raptors, prairie chickens, and shrikes makes them poor candidates for detecting and monitoring through point counts; rather, surveys that account for their large territories, wide-ranging spatial distributions, and/or seasonal congregations (i.e., lek counts for the grouse, evening surveys for Short-eared Owls) are more appropriate.

CLNWR is located only at the fringe of the Ferruginous Hawk's range, and only in the winter range of Prairie Falcon (National Geographic Society 1999). CLNWR may provide habitat for Swainson's Hawk (shortgrass), Northern Harrier and Short-eared Owl (taller, mesic grasslands), although each of these species is somewhat area sensitive. The Burrowing Owl is an obligate burrow nester (generally prairie dog burrows), thus they do not occur in the absence of burrows. Mountain Plovers typically occur in association with prairie dogs, in heavily grazed shortgrass, in recently burned grasslands, and in plowed agricultural fields; furthermore, the current distribution of this species no longer includes western Nebraska. The majority of undetected sparrows and sparrow allies occur in the region only briefly as migrants (i.e., earlier than early June, later than late August), only in winter, and/or as occasional vagrants beyond the normal limits of their ranges (National Geographic Society 1999).

FUTURE MONITORING AND MANAGEMENT RECOMMENDATIONS

Survey protocol---For preliminary assessments of bird-habitat relationships and species richness, relative abundance measures are adequate indices. For long-term monitoring, however, sampling protocol must account for the variations in avian detectabilities (Rosenstock et al. 2002, Thompson 2002). Not only do detectabilities vary widely among species, they vary within species in accordance with habitat differences, densities, time of year, and other factors. To account for detectability differences, common bird-survey protocols include variable circular plot point counts and variable line transects (Reynolds et al. 1980, Hutto et al. 1986, Bibby et al. 1992, Buckland et al. 1993, Rosenstock et al. 2002), for which the distance from the observer to each bird detected must be measured as accurately as possible and recorded.

Estimating distances can be difficult for field personnel, often resulting is large biases and poor density estimates. Two methods for assisting observers with distance estimations are the use of laser rangefinders (Ransom and Pinchak 2003) and/or distance-specific markers placed

systematically throughout survey plots. The use of rangefinders, however, is very distracting and can result in fewer bird detections as observers use the rangefinder. Thus, rangefinders should be used only when surveying a focal or limited number of species or in habitats where bird densities are low. To calculate bird densities using distance data, biologists use Program DISTANCE, which is downloadable from the internet at: <http://www.ruwpa.st-and.ac.uk/distance/>. Ultimately, protocol for monitoring birds in riparian areas at NPNWR should entail variable line transects conducted by a single observer at a time, and for monitoring breeding grassland birds (predominantly passerines) at CLNWR protocol should entail variable circular plot point counts along transects. At CLNWR, we recommend adding as many replicates (transects) as possible to provide better density estimations over the long run. If transects are run only once in the breeding season, it would potentially allow time to run more transects.

Another protocol consideration is the duration of point counts (at CLNWR) and the timing of surveys (both refuges). In at least one study, the time needed to reach 80% of the predicted asymptote of detection frequency during the breeding season was one minute in grassland habitat; during the non-breeding season, the required time was three minutes (Shiu and Lee 2003). Thus, the five-minute counts at CLNWR may have been too long, increasing the risk that birds would be double-counted.

As far as timing of surveys is concerned, we recommend additional surveys in migration periods to capture a more-complete picture of the species and abundance of pass-through migrants. Unfortunately, this will require a significant amount of work from early April through the end of May, and from late July through early November; we recommend that each unit be surveyed at least once every two weeks, if not more often. We approached our CLNWR field survey as a pilot study to determine when the most detections for grassland species would occur. This would then allow us to make recommendations as to the ideal time for conducting annual surveys of breeding birds in CLNWR's grasslands, thus increasing significantly the efficiency of CLNWR's staff time. No one time is most-ideal for detecting all species. For example, Horned Larks typically begin nesting long before some species arrive on the breeding grounds. However, the North American BBS in central U.S. is conducted any time from late May to late June, which coincides approximately with our spring and early summer surveys at CLNWR; one can see from our results (shaded areas of Table 5) that the peak number of bird detections for most focal species at CLNWR occurred in this same period. Thus, for monitoring breeding grassland birds at CLNWR, we recommend conducting surveys in early to late June. (Lek counts for grouse, however, should be run in April).

For species that typically occur at very low densities even in the most-suitable habitats, we recommend species-specific surveys (e.g., lek counts for grouse and prairie chickens, refuge-wide area searches for raptors and shorebirds of concern). Not only will this yield more satisfactory results, DISTANCE requires a minimum number of detections unlikely at CLNWR.

Focal species---If CLNWR staff wish to select focal species for long-term monitoring, the more-common ones will yield enough detections within 5-10 years to yield valid trend estimates. Because the Grasshopper Sparrow occurs at relatively high numbers in all three habitat types, and because it has been one of two grassland species declining at the highest rates (-4.11, $P < 0.01$ from 1966-1993 [Samson and Knopf 1996]), CLNWR may wish to consider this a focal species for long-term monitoring and habitat management. Western Meadowlarks were also detected at relatively high frequencies in all three habitat types, thus they too would be suitable

for long-term monitoring. However, Western meadowlarks are more general in their choices of grassland habitats (Sharpe et al. 2001), thus the species would not be a particularly strong indicator for condition of any one habitat type. Rather, Lark and Grasshopper sparrows may be suitable for monitoring in Choppy Sands, Sands, (and, possibly, drier portions of Sub-irrigated Meadows habitats), while Eastern Meadowlarks and Bobolinks, Dickcissels, and Bobolinks may be good candidates for monitoring conditions in Sub-irrigated Meadows.

Management implications---The results of our bird surveys suggest that disturbances capable of initiating woodland regeneration (e.g., stand-replacing floods and drawdowns at NPNWR) or set back succession and/or keep grasses very short (e.g., grazing, burning, cutting at CLNWR) are infrequent, not particularly intense, and/or take place only in certain areas at any one time. However, the effects of disturbances, such as grazing, on the density and height of grass cover varies according to when grazing takes place and at which levels of intensity (Reece et al. 2003). The same would be true for burning and cutting. In other words, different species are affected differently by any one management regime, and any one management regime may have very different effects on a species if initiated at different times of year. Ultimately, if refuge staff wish to learn how differing management regimes affect bird use of the either CLNWR or NPNWR, they should consider experimental approaches. It is also essential to take advantage of quasi-experimental opportunities (e.g., if there is a plan to burn meadow X in early spring 2006, then bird surveys should be conducted in Meadow X (the 'treatment') and similar meadow Y ('the control') during springs 2004 and 2005 to provide a minimum amount of 'pre-treatment' data.

Two other areas of work should be conducted before management recommendations can be made for maximizing avian potentials at either refuge. As indicated several times throughout this document, a thorough vegetation survey is needed to further understand bird-habitat relationships at NPNWR and CLNWR. The second are of work would be a stud of avian nesting success in each habitat type, because density is not always a good indication of habitat quality (Van Horne 1983) or whether a given population/habitat is a source or a sink.

ACKNOWLEDGMENTS

We thank Trevor VanEaton for assisting with data collection and entry. We also express our sincere gratitude to the U.S. Fish and Wildlife Service, particularly to Wayne King of the regional office in Denver, Refuge Manager Steve Knode in Scottsbluff, Refuge Biologist Marlin French, for sharing his knowledge of Crescent Lake National Wildlife Refuge and providing accommodations during field work, and Assistant Refuge Manager Brad McKinney for assistance at North Platte NWR. Thomas Labedz, Collections Manager at the University of Nebraska State Museum, generously provided collections data for historical comparisons. Additional historical data were downloaded from the collection websites of: The Field Museum, Chicago, IL; Yale Peabody Museum, New Haven, CT; and the University of California Museum of Vertebrate Zoology, Berkeley, CA. Region 6 and the refuges, U.S. Fish and Wildlife Service, provided funding for this study.

REFERENCES and LITERATURE CITED

AMERICAN ORNITHOLOGISTS' UNION. 1957. *The A.O.U. Check-list of North American Birds*, 5th edition. The Lord Baltimore Press, Baltimore, MD. 691 pp.

AMERICAN ORNITHOLOGISTS' UNION. 1983. *The A.O.U. Check-list of North American Birds*, 6th edition. Allen Press, Lawrence, Kansas. 877 pp.

AMERICAN ORNITHOLOGISTS' UNION. 1998. *The A.O.U. Check-list of North American Birds*, 7th edition. American Ornithologists' Union, Washington, D.C. 829 pp.

ANDERSON, J. 1992. *Upland Territorial Birds and Cattle Grazing Regimes in Nebraska Sandhills Prairie*. Master's thesis, University of Nebraska, Omaha.

BARRETT, N. M. 1998. House Wren. Pages 370-371 *in* Kingery, H. E. (ed.). *Colorado Breeding Bird Atlas*. Colorado Bird Atlas Partnership, Denver, CO. 636 pp.

BIBBY, C. J., N. D. BURGESS, AND D. A. HILL. 1992. *Bird Census Techniques*. Academic Press, London. 257 pp.

BOGAN, M. A., (ed.). 1995. *A Biological Survey of Fort Niobrara and Valentine National Wildlife Refuges*. Final Report. Midcontinent Ecological Science Center, U.S. Dept. Interior National Biological Service, Fort Collins, CO. 193 pp.

BOTORFF, R., N HURLEY, F. JUSTICE, J. JUSTICE, R. KELLEY, H. E. KINGERY, U. KINGERY, D. STOTZ, AND J. TRAINOR. 1971-1984. *In* Van Velzen, W. T. Breeding bird censuses. American Birds 25:966, 26:980, 27:996, 28:1036, 29:1125, 31:71, 32:83, 33:81, 34:73, 35:87, 37:84, 38:98.

BUCKLAND, S. T., D. R. ANDERSON, K. P. BURNHAM, AND J. J. LAAKE. 1993. *Distance Sampling: Estimating Abundance of Biological Populations*. Chapman and Hall, London. 446 pp.

CABE, P. R. 1993. European Starling. *In* The Birds of North America, no. 48 (A. Poole and F. Gills, eds.). Academy of Natural Science, Philadelphia, PA, and American Ornithologists' Union, Washington, DC.

CHACE, J. F. 1998. Common Grackle. Pages 510-511 *in* Kingery, H. E. (ed.). *Colorado Breeding Bird Atlas*. Colorado Bird Atlas Partnership, Denver, CO. 636 pp.

COLE, T. 1976. A Comparative Study of Two Grassland Bird Communities. Master's thesis, University of Nebraska, Omaha.

EHRLICH, P.R., D. S. DOBKIN, AND D. WHEYE. 1988. *The Birder's Handbook: A field Guide to the natural History of North American Birds*. Simon and Schuster Inc., New York, NY. 785 pp.

FOSS, C. R. (ED.). 1994. *Atlas of Breeding Birds in New Hampshire*. Audubon Society of New Hampshire, Dover, NH.

HUTTO, R. L., S. M. PLETSCHET, AND P. HENDRICKS. 1986. A fixed-radius point count method for nonbreeding and breeding season use. *Auk* 103:593-602.

JOHNSGARD, P. A. 1995. *This Fragile Land: A Natural History of Nebraska Sandhills*. University of Nebraska Press, Lincoln. 256 pp.

JOHNSGARD, P. A. 2001. *Prairie Birds: Fragile Splendor in the Great Plains*. University Press of Kansas, Lawrence. 331 pp.

KNOPF, F. L. 1994. Avian assemblages on altered grasslands. *Studies in Avian Biology* 15:247-257.

KNOPF, F. L., J. R. ROY, AND R. TERRELL. 1988. Conservation of riparian ecosystem in the United States. *Wilson Bulletin* 100:272-284.

LABEDZ, T. E. 1990. Birds. Pages 161-180 *in* A. BLEED AND C. F. FLOWERDAY, (eds.). *An Atlas of the Sand Hills*. Conservation and Survey Division Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln. 265 pp.

LANYON, W.E. 1956. Ecological aspects of sympatric distribution of meadowlarks in the north-central states. *Ecology* 37:98- 108.

MARTIN, S. G. AND T. A. GAVIN. 1995. Bobolink. *In* The Birds of North America, no. 176 (A. Poole and F. Gill, eds.). Academy of Natural Science, Philadelphia, PA, and American Ornithologists' Union, Washington, DC.

MAGURRAN, A. E. 1988. *Ecological Diversity and Its Measurement*. Princeton University Press, Princeton, NJ.

MENGEL, R. M. 1970. The North American Central Plains as an isolating agent in bird speciation. Pp. 280-340 *in* W. Dort and J.K. Jones, (eds.). *Pleistocene and Recent Environments of the Central Great Plains*. University of Kansas Press, Lawrence.

MILLER, K. E. 2002. Nesting success of the Great-crested Flycatcher in nest boxes and in tree cavities: are next boxes safer from nest predation? *Wilson Bulletin* 114:179-185.

NATIONAL GEOGRAPHIC SOCIETY. 1999. *Field Guides to the Birds of North America*. National Geographic Society, Washing ton, DC. 480 pp.

NEBRASKA SOIL CONSERVATION SERVICE. 1981. Interpretative information for rangeland and grazable woodland. Section II-E, NE-T.G. Notice 124. 22 pp.

PRICE, J., S. DROEGE, AND A. PRICE. 1995. *The Summer Atlas of North American Birds.* Academic Press Limited, London. 364 pp.

PROSE, B. L, B. S. CADE, AND D. HEIN. 2002. Selection of nesting habitat by Sharp-tailed Grouse in the Nebraska Sandhills. *The Prairie Naturalist* 34:85-105.

RANSOM, D., JR, AND W. W. PINCHAK. 2003. Assessing accuracy of a laser rangefinder in estimating grassland bird density. *Wildlife Society Bulletin* 31:460-463.

RAPPOLE, J. H. 1995. *The Ecology of Migrant Birds: A Neotropical Perspective*. Smithsonian Institution Press, Washington D.C.

REECE, P. E., J. D. VOLESKY, AND W. H. SCHACHT. 2001. Cover for wildlife after summer grazing on Sandhills rangeland. *Journal of Range Management* 54:126-131.

REYNOLDS, R. T., J. M. SCOTT, AND R. A. NUSSBAUM. 1980. A variable circular-plot method for estimating bird numbers. *Condor* 82:309-313.

RODDA, G. H., AND E. W. CAMPBELL. Distance sampling of forest snakes and lizards. 2002. *Herpetological Review* 33:271-272.

ROOT, T. 1988. *Atlas of Wintering North American Birds: An Analysis of Christmas Bird Count Data*. The University of Chicago Press, Chicago. 312 pp.

ROSCHE, R. C. 1982. *Birds of Northwestern Nebraska and Southwestern South Dakota, An Annotated Checklist*. Cottonwood Press, Crawford, NE.

ROSENSTOCK, S. S., D. R. ANDERSON, K. M. GIESEN, T. LEUKERING, AND M. F. CARTER. 2002. Landbird counting techniques: current practices and an alternative. *Auk* 119:46-53.

ROSENWEIG, M. L. 1995. *Species Diversity in Space and Time*. Cambridge University Press, New York, NY.

SAMSON, F. B., AND F. L. KNOPF. 1994. Prairie conservation in North America. *Bioscience* 44:418-421.

SAMSON, F. B., AND F. L. KNOPF. 1996. *Prairie Conservation: Preserving North America's Most Endangered Ecosystem*. Island Press, Washington, DC. 339 pp.

SAUER, J. R., J. E. FALLON, AND R. JOHNSON. 2003*a*. Use of North American breeding bird survey data to estimate population change for bird conservation regions. *Journal of Wildlife Management* 67:372-389.

SAUER, J. R., J. E. HINES, AND J. FALLON. 2003*b*. The North American Breeding Bird Survey, Results and Analysis 1966-2002. Version 2003.1 (available online at: http://www.mbr-pwrc.usgs.gov/bbs/bbs.html). USGS Patuxent Wildilfe Research Center, Laurel, MD.

SCHEUMAN, D. M., E. K. BOLLINGER, AND D. H. JOHNSON. 2003. Effects of leafy spurge infestation on grassland birds. *Journal of Wildlife Management* 67:115-121.

SHANE, T. G. 2002. Lark Bunting. *In* The Birds of North America, no. 542 (A. Poole and F. Gills, eds.). Academy of Natural Science, Philadelphia, PA, and American Ornithologists' Union, Washington, DC.

SHARPE, R. S., W. R. SILCOCK, AND J. G. JORGENSEN. 2001. *Birds of Nebraska: Their Distribution and Temporal Occurrence*. University of Nebraska Press, Lincoln.

SHIU, H.-J., AND P.-F. LEE. 2003. Assessing avian point-count duration and sample size using species accumulation functions. *Zoological Studies* 42:357-367.

SKAGEN, S. K., C. P. MELCHER, W. H. HOWE. 1998. Comparative use of riparian corridors and oases by migrating birds in southeast Arizona. *Conservation Biology* 12:896-909.

TEMPLE, S. A. 2003. Dickcissel. *In* The Birds of North America, no. 703 (A. Poole and F. Gills, eds.). Academy of Natural Science, Philadelphia, PA, and American Ornithologists' Union, Washington, DC.

THOMPSON, W. L. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. *Auk* 119:18-25.

THOMPSON, W. L., G. C. WHITE, AND C. GOWAN. 1998. *Monitoring Vertebrate Populations*. Academic Press, Inc., London. 365 pp.

U.S. FISH AND WILDLIFE SERVICE. 2002. Birds of Conservation Concern. U.S. Fish and Wildlife Service, division of Migratory Bird Management, Arlington, VA. Available at:

VAN HORNE, B. 1983. Density as a misleading indicator of habitat quality. *Journal of Wildlife Management* 47:893-901.

VIERLING, K. T. 1998. Interactions between European Starlings and Lewis' Woodpecker at nest cavities. *Journal of Field Ornithology* 69:376-379.

Appendix 1. Common and scientific names and AOU alpha codes of bird species detected during bird surveys conducted at North Platte (NP) and Crescent Lake (CL) National Wildlife Refuges, 2001-2003.

Key[a]	Common Name	Scientific Name	Code	NP[b]	CL[c]
1	Common Loon	*Gavia immer*	COLO	X	
2	Pied-billed Grebe	*Podilymbus podiceps*	PBGR	X	√
3	Eared Grebe	*Podiceps nigricollis*	EAGR	X	
4	Western Grebe	*Aechmophorus occidentalis*	WEGR	X	√
5	American White Pelican	*Pelecanus erythrorhynchos*	AWPE	X	√
6	Double-crested Cormorant	*Phalacrocorax auritus*	DCCO	X	√
7	American Bittern	*Botaurus lentiginosus*	AMBI		X
8	Great Blue Heron	*Ardea herodias*	GTBH	X	√
9	Green Heron	*Butorides virescens*	GRHE	X	
10	Black-crowned Night-Heron	*Nycticorax nycticorax*	BCNH	X	√
11	White-faced Ibis	*Plegadis chihi*	WFIB	X	X
12	Turkey Vulture	*Cathartes aura*	TUVU	X	
13	Trumpeter Swan	*Cygnus buccinator*	TRUS		√
14	Canada Goose	*Branta canadensis*	CAGO	X	√
15	Wood Duck	*Aix sponsa*	WODU	X	X
16	Gadwall	*Anas strepera*	GADW	X	√
17	Mallard	*Anas platyrhynchos*	MALL	X	X
18	Northern Pintail	*Anas acuta*	NOPI		X
19	Blue-winged Teal	*Anas discors*	BWTE	X	X
20	Cinnamon Teal	*Anas cyanoptera*	CITE		√
21	Northern Shoveler	*Anas clypeata*	NSHO	X	√
22	Canvasback	*Aythya valisineria*	CANV		√
23	Redhead	*Aythya americana*	REDH		√
24	Common Merganser	*Mergus merganser*	COME	X	
25	Ruddy Duck	*Oxyura jamaicensis*	RUDU		√
26	Osprey	*Pandion haliaetus*	OSPR	X	
27	Bald Eagle	*Haliaeetus leucocephalus*	BAEA	X	X
28	Northern Harrier	*Circus cyaneus*	NOHA		√
29	Swainson's Hawk	*Buteo swainsoni*	SWHA	X	
30	Red-tailed Hawk	*Buteo jamaicensis*	RTHA	X	X
31	American Kestrel	*Falco sparverius*	AMKE	X	X
32	Prairie Falcon	*Falco mexicanus*	PRFA	X	
33	Ring-necked Pheasant	*Phasianus colchicus*	RINP	X	X
34	Sharp-tailed Grouse	*Tympanuchus phasianellus*	STGR		X
35	Northern Bobwhite	*Colinus virginianus*	NOBO	X	X
36	Wild Turkey	*Meleagris gallopavo*	WITU	X	
37	Virginia Rail	*Rallus limicola*	VIRA		√
38	American Coot	*Fulica americana*	AMCO	X	X

Key[a]	Common Name	Scientific Name	Code	NP[b]	CL[c]
39	Killdeer	*Charadrius vociferus*	KILL	X	X
40	American Avocet	*Recurvirostra americana*	AMAV	X	√
41	Willet	*Catoptrophorus semipalmatus*	WILL	X	X
42	Spotted Sandpiper	*Actitis macularia*	SPSA	X	
43	Long-billed Curlew	*Numenius americanus*	LBCU	X	X
44	Upland Sandpiper	*Bartramia longicauda*	UPSA		X
45	Dowitcher sp.	*Limnodromus sp.*	UNDO		√
46	Wilson's Phalarope	*Phalaropus tricolor*	WIPH	X	X
47	Ring-billed Gull	*Larus delawarensis*	RBGU	X	
48	Forster's Tern	*Sterna forsteri*	FOTE		√
49	Black Tern	*Chlidonias niger*	BLTE		X
50	Mourning Dove	*Zenaida macroura*	MODO	X	X
51	Yellow-billed Cuckoo*	*Coccyzus americanus*	YBCU	X	
52	Barn Owl	*Tyto alba*	BANO		√
53	Eastern Screech-Owl	*Otus asio*	EASO	X	
54	Great Horned Owl	*Bubo virginianus*	GHOW	X	√
55	Common Nighthawk	*Chordeiles minor*	CONI	X	X
56[d]	**Chimney Swift***	***Chaetura pelagica***	**CHSW**	**X**	
57	Belted Kingfisher	*Ceryle alcyon*	BEKI	X	
58	Red-headed Woodpecker	*Melanerpes erythrocephalus*	RHWO	X	√
59	Downy Woodpecker	*Picoides pubescens*	DOWO	X	
60	Hairy Woodpecker	*Picoides villosus*	HAWO	X	
61	Northern Flicker	*Colaptes auratus*	NOFL	X	√
62	Red-shafted Flicker	*Colaptes auratus*	RSFL	X	
63	Yellow-shafted Flicker	*Colaptes auratus*	YSFL	X	
65	Western Wood-Peewe*	*Contopus sordidulus*	WEWP	X	
64	**Eastern Wood-Peewe***	***Contopus virens***	**EWPE**	**X**	
65	Yellow-bellied Flycatcher*	*Empidonax flaviventris*	YBFL		
66	Acadian Flycatcher*	*Empidonax virescens*	ACFL		
67	Alder Flycatcher*	*Empidonax alnorum*	ALFL		
68	Willow Flycatcher*	*Empidonax traillii*	WIFL		
69	Least Flycatcher*	*Empidonax minimus*	LEFL		
70	Cordilleran Flycatcher* (previously Western Flycatcher)	*Empidonax occidentalis*	COFL		
71	Unidentified Empidonax	*Empidona sp.*	UNEM	X	
72	**Eastern Phoebe***	***Sayornis phoebe***	**EAPH**	**X**	
73	Great Crested Flycatcher*	*Myiarchus tyrannulus*	GCFL	X	
74	Western Kingbird*	*Tyrannus verticalis*	WEKI	X	X
75	Eastern Kingbird*	*Tyrannus tyrannus*	EAKI	X	X
76	Loggerhead Shrike	*Lanius ludovicianus*	LOSH	X	
77	**Bell's Vireo***	***Vireo belli***	**BEVI**	**X**	

Key[a]	Common Name	Scientific Name	Code	NP[b]	CL[c]
78	Cassin's Vireo*	*Vireo cassinii*	CAVI		
79	Plumbeous Vireo*	*Vireo plumbeus*	PLVI		
80	Blue-headed Vireo*	*Vireo solitarius*	BHVI		
81	Yellow-throated Vireo*	*Vireo flavifrons*	YTVI		
82	Philadelphia Vireo*	*Vireo philadelphicus*	PHVI		
83	Red-eyed Vireo*	*Vireo olivaceus*	REVI	X	
84	Warbling Vireo*	*Vireo gilvus*	WAVI	X	
85	Vireo sp.	*Vireo sp.*	UNVI	X	
86	Blue Jay	*Cyanocitta cristata*	BLJA	X	
87	Black-billed Magpie	*Pica pica*	BBMA	X	
88	American Crow	*Corvus brachyrhynchus*	AMCR	X	
89	Horned Lark	*Eremophila alpestris*	HOLA		X
90	Tree Swallow*	*Tachycineta bicolor*	TRES	X	X
91	Northern Rough-winged Swallow*	*Stelgidopteryx serripennis*	NRWS	X	
92	Bank Swallow*	*Riapria riparia*	BANS	X	
93	Cliff Swallow*	*Petrochelidon pyrrhonata*	CLSW	X	
94	Barn Swallow *	*Hirundo rustica*	BARS	X	X
95	Black-capped Chickadee	*Poecile atricapillus*	BCCH	X	
96	Red-breasted Nuthatch	*Sitta canadensis*	RBNU	X	
97	White-breasted Nuthatch	*Sitta carolinensis*	WBNU	X	
98	House Wren*	*Troglodytes aedon*	HOWR	X	
99	Marsh Wren *	*Cistothorus palustris*	MAWR	X	X
100	Eastern Bluebird*	*Sialia sialis*	EABL	X	
101	Swainson's Thrush*	*Catharus ustulatus*	SWTH	X	
102	American Robin*	*Turdus migratorius*	AMRO	X	
103	Gray Catbird*	*Dumetella crolinensis*	GRCA	X	
104	Brown Thrasher*	*Toxostoma rufum*	BRTH	X	
105	European Starling	*Sturnus vulgaris*	EUST	X	
106	Tennessee Warbler*	*Vermivora peregrina*	TEWA	X	
107	Yellow Warbler*	*Dendroica petechia*	YWAR	X	
108	Blackpoll Warbler*	*Dendroica striata*	BLPW	X	
109	American Redstart*	*Setophaga ruticilla*	AMRE	X	
110	Common Yellowthroat*	*Geothlypis trichas*	COYE	X	X
111	Yellow-breasted Chat*	*Icteria virens*	YBCH	X	
112	Wilson's Warbler*	*Wilsonia pusilla*	WIWA	X	
113	Spotted Towhee*	*Pipilo maculatus*	SPTO	X	
114	American Tree Sparrow*	*Spizella arborea*	ATSP	X	
115	Chipping Sparrow*	*Spizella passerina*	CHSP	X	
116	Clay-colored Sparrow*	*Spizella pallida*	CCSP	X	
117	Vesper Sparrow*	*Pooecetes gramineus*	VESP		X
118	Lark Sparrow*	*Chondestes grammacus*	LASP	X	X

Key[a]	Common Name	Scientific Name	Code	NP[b]	CL[c]
119	Lark Bunting*	*Calamospiza melanocorys*	LARB		X
120	Grasshopper Sparrow*	*Ammodramus savannarum*	GRSP	X	X
121	Song Sparrow*	*Melospiza melodia*	SOSP	X	
122	Lincoln's Sparrow*	*Melospiza lincolnii*	LISP	X	
123	Black-headed Grosbeak*	*Pheucticus melanocephalus*	BHGR	X	
124	**Indigo Bunting***	***Passerina cyanea***	**INBU**	**X**	
125	Dickcissel*	*Spiza americana*	DICK		X
126	Bobolink*	*Dolichonyx oryzivorus*	BOBO		X
127	Red-winged Blackbird*	*Agelaius phoeniceus*	RWBL	X	X
128	Eastern Meadowlark*	*Sturnella magna*	EAME		X
129	Western Meadowlark*	*Sturnella neglecta*	WEME	X	X
130	Yellow-headed Blackbird*	*Xanthocephalus xanthocephalus*	YHBL	X	X
131	Common Grackle	*Quiscalus quiscula*	COGR	X	X
132	Brown-headed Cowbird	*Molothrus ater*	BHCO	X	X
133	Northern Oriole	*Icterus galbula*	NOOR	X	
134	Baltimore Oriole*	*Icterus galbula*	BAOR	X	
135	Bullock's Oriole*	*Icterus bullockii*	BUOR	X	
136	Orchard Oriole*	*Icterus spurius*	OROR	X	
137	House Finch	*Carpodacus mexicanus*	HOFI	X	
138	American Goldfinch	*Carduelis tristis*	AMGO	X	X
139	House Sparrow	*Passer domesticus*	HOSP	X	

* Long- and medium-distance migratory passerines (or similar) are noted with an asterisk.

[a] The Key column sorts the bird list (in the electronic version of this document) on taxonomic order, but records may be sorted on their 4-letter alpha codes or refuge-specific occurrence.

[b, c] Species detected during official surveys are indicated with an 'X.'

[c] Species found incidentally (not during surveys) are indicated with a '√.'

[d] Species listed in boldface type are not listed on the refuge species list.

[e] Species referenced in the text but not found at either refuge have no 'X' or check marks.

Appendix 2. UTM coordinates (zone 13) for beginning and ending points of bird-survey transects established in 2001 at NPNWR.

Transect	Start Point		End Point	
	Easting	Northing	Easting	Northing
Lake Alice North	616363	4648849		
Lake Alice South	616008	4648152	613960	4648939
Lake Minatare North	646919	4644837	624061	4644877
Lake Minatare West	624033	4643549	623834	4644728
Lake Minatare South	622794	4643789	623357	4642457
Winters Creek Lake	622844	4645383	621647	4645868
Stateline Island	578994	4648864	579973	4648118

Appendix 3. Bird-survey periods during 2001-2003 at NPNWR.

2001	**2002**			**2003**
Late July	Late May	Early July	Early Fall	Late May
7/25-7/31	5/21-5/28	7/2-7/6	8/25-8/28	5/23-5/30

Appendix 4a. UTM coordinates (zone 13) for each survey point along 17 transects established for grassland bird surveys at CLNWR. All transects except C7, M3, and the last two points (750, 1000) on S6 were established on the refuge.

		Choppy Sands (C)		Sands (S)		Sub-irrigated Meadow (M)	
Transect	Point	Northing	Easting	Northing	Easting	Northing	Easting
1	0	4626983	711987	4625268	709598	4625879	707072
	250	4627135	711792	4625018	709594	4625691	707246
	500	4627335	711508	4624767	709582	4625503	707416
	750	4627497	711313	4624516	709574	4625315	707587
	1000	4627659	711121	4624283	709417	4625066	707557
2	0	4628027	710792	4624303	709133	4623603	719582
	250	4627783	710840	4624549	709097	4623650	719335
	500	4627538	710881	4624820	709057	4623633	719028
	750	4627288	710860	4625044	709018	4623884	718891
	1000	4627045	710833	4625299	708974	4624141	718744
3	0	4624238	712940	4617954	727980	4624935	707133
	250	4624424	712776	4617904	728226	4624436	707282
	500	4624614	712605	4617855	728474	4624206	707393
	750	4624806	712437	4617808	728719	4623981	707504
	1000	4625000	712263	4617760	728964	4623744	707598
4	0	4625093	712124	4617574	729143		
	250	4624838	712115	4617384	728983		
	500	4624582	712100	4617193	728817		
	750	4624316	712101	4617008	728659		
	1000	4624071	712165	4616805	728488		
5	0	4624154	720044	4616910	728216		
	250	4624175	720297	4617119	728104		
	500	4624189	720565	4617335	727988		
	750	4624216	720814	4617557	727868		
	1000	4624254	721070	4617774	727748		
6	0	4623883	721310	4616849	727081		
	250	4624136	721299	4616835	726829		
	500	4624342	721247	4616834	726596		
	750	4624589	721167	4616828	726348		
	1000	4624827	721079	4616814	726097		
7	0	4625041	720996	4616379	726203		
	250	4625009	720745	4616346	726453		
	500	4624974	720494	4616324	726696		
	750	4624933	720248	4616300	726947		
	1000	4624894	720006	4616447	727148		

Appendix 4b. Transect locations on and off CLNWR.

CHOPPY SANDS:

C1: N of house, SW of Goose Lake at top of hill; bearing 308° to hill in gap (distant); note bearing to tree: 232°

C2: Bearing 54° from C1-1000 to 500 m.; bearing 0° for 2 pts. N (0 m. and 250 m.) **and** bearing 170° for 2 pts. S (750 m. and 1000 m.) towards blowout on horizon; bearing 272° from chokecherry patch ("Porcupine Woods") to flagging on fence near end of C2 (1000 m.)

C3: N of Hackberry Lake, S of HQ as road begins to climb; start on bearing 322°; 1000 m. is at cross between trail from back of HQ and fence

C4: Start at hilltop W of C3-1000 (references: bearing 122° to C3-1000, bearing 28° to HQ); bearing 170° to 250 m. to left of blowout at 100 m.; at 750 m., see Hackberry Lake and shift to bearing 160° (aim for high fence post on hilltop); transect ends at road

C5: Start 800 to 1000 m. NE from windmill #35; bearing 200° to windmill (fence bearing is 168°); starting at 0 m., bearing 78° towards old blowout

C6 (points 0, 250, 500 on refuge): Bearing from flag beyond 1000 m. to 250 m. is 118°; bearing to 0 m. is 168°; bearing to 500 m. is 342°; flag on fence at 100 m. N of 500 m. (continues onto private land)

C6 (points 750, 1000 on adjacent private land): Used **GPS**, no fiberglass stakes; from fence post, 750 m. is 150 m. at bearing of 330° towards blowout with yucca (reference: fence (E/W) runs at bearing of 260° from flagged post)

C7: Used **GPS**, no fiberglass stakes; at bearing of 340°, 250 paces from C6-1000; from flagged fence at end of transect to 1000 m. is 70°

SANDS:

S1: Transect at windmill #16 (100 m. S.), NW of Nature Conservancy building; 170° to windmill #15 (right- hand windmill in distance); stop at 850 m., turn SW (bearing 222°), align on fence at top of hill

S2: Begins approx. 400 m. W of windmill #15 (bearing 349°); across flat towards barren top; at 1000 m., about 90° for return to windmill #16; (254° from windmill to 1000 m.)

S3: 5° to windmill #70; 185° from 0 m. to windmill #57; ran transect to tallest hill 92°; from 1000 m. to windmill #62 is 270°

S4: From 0 m. to S3-1000 is 311°; from 0 m. to windmill #57 is 267°; heads towards east edge of mesa in distance at about 212°

S5: From 0 m. to S4-1000 is 104°; S4-1000 between blowout and 0 m.; from 0 m. to windmill #70 is 346°; transect S5 headed to lake left of windmill #57**;** from 0 m. to east edge of lake is 325°; from 1000 m. to windmill #62 is 280° and from 1000 m. to windmill #70 is 18°

S6: Transect runs 260° from 0 m. to 1000 m. (this bearing is the same as the fence's bearing between S6 and S7); from 0 m. to windmill #71 is 129°; running parallel to fence toward rough hill 100 m. away; at 1000 m., walk straight S. and run into flagged fence

S7 (off refuge): Used **GPS**, no fiberglass stakes; starting point 100 m. from fence; yucca to fence about 270°; transect runs 90° parallel to fence; from 750 m. to 1000 m. changes to 45° (toward blowout—big one to left); from 1000 m. to "T" in fence is 20°; from 1000 m. to S6-0 is 344°

SUB-IRRIGATED MEADOWS:

M1: 130° bearing from flagged snowberry to railroad car; at 750 m., turn to 180° bearing on yuccas on horizon (flag on fence)

M2: No bearings, landmarks, etc.—between Christ Lake and fence around perimeter of subirrigated meadow

M3 (off refuge): Used **GPS**, no fiberglass stakes; thistle off refuge marks 0 m.; transect runs approx. 148° (left edge of tall grass)—reversed is 324° (tallest peak in chain of hills in distance)

Appendix 5. Number of times each transect was surveyed during each of six survey periods in 2001 and 2002 at CLNWR.

	Transect[a]																
Survey Period	**C1**	**C2**	**C3**	**C4**	**C5**	**C6***	**C7**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7***	**M1**	**M2**	**M3***
Spring 2001 (6/4 - 6/6)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Early Summer 2001 (6/19 – 7/3)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Spring 2002 (6/1 – 6/6)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Early Summer 2002 (6/21 – 7/10)	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Late Summer 2002 (7/29 – 7/30)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1
Early Fall 2002 (8/22 – 823)	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1

[a] Transects identified with a 'C' prefix were in Choppy Sands habitat; those with 'S' were in Sands habitat; those with 'M' were in Sub-irrigated Meadow.

* Transects established off the refuge (except C6, where only points 750 and 1000 were off the refuge).

Appendix 6. Species, dates, substrates/vegetation species, approximate locations, status, and fates of avian nests located at CLNWR during field studies in breeding seasons 2001-2002.

Species	Date	Substrate/vegetation, approximate location	Status	Fate
Blue-winged Teal	05/23/01	grass, near Perrin Lake	2 eggs	Unknown
Mallard (?)	05/23/01	grass, near Perrin Lake	3 eggs	Unknown
Mourning Dove	05/24/01	Russian-olive, near refuge HQ	2 eggs	Unknown
Mallard	05/24/01	under yucca, north of refuge HQ	2 eggs	Unknown
Mourning Dove	05/24/01	under yucca, north of refuge HQ	1 egg	Unknown
Mourning Dove	05/24/01	Russian-olive, near refuge HQ	2 eggs	Unknown
Loggerhead Shrike	05/24/01	honeylocust (*Gleditsia triacanthos*), near Island Lake	Unknown	Unknown
Marsh Wren	05/25/01	cattails, by Gimlet Lake	Unknown	Unknown
Western Meadowlark	06/04/01	grass, near point 500 on transect M1	5 eggs	Unknown
Sharp-tailed Grouse	06/06/01	grass, near point 500 on transect C3	4 chicks	Unknown
Sharp-tailed Grouse	06/07/01	under yucca, near point 1000 on transect C5	11 eggs	10 chicks
Western Meadowlark	06/18/01	grass, north of Christ Lake	4 chicks	Unknown
Marsh Wren	06/18/01	cattails, by Christ Lake	Unknown	Unknown
Eared Grebe	06/26/02	on Goose Lake	4 chicks	Unknown
Lark Sparrow	07/01/02	under yucca, near point 0 on transect C5	3 eggs	Unknown

Appendix 7. Species' detection frequency (and frequency rank) at each unit of NPNWR. Species with the same frequency for a given survey period were assigned the same rank value. The Key column sorts on taxonomic order, but in the electronic version of this document the user may sort species according to detection frequency for a given survey period. (For scientific names, see Appendix 4.)

		Lake Alice				
Key	**Common Name**	**Late May '02**	**Late May '03**	**Early July '02**	**Late July '01**	**Late Aug. '02**
1	Common Loon				5 (23)	
2	Western Grebe			1 (22)		
3	Double-crested Cormorant			14 (12)	36 (11)	
4	Turkey Vulture	3 (22)		1 (22)		
5	Canada Goose	2 (23)				
6	Wood Duck	2 (23)	4 (14)		6 (22)	
7	Mallard	2 (23)		2 (21)	2 (25)	
8	Blue-winged Teal				1 (26)	
9	Common Merganser			2 (21)		
10	Osprey				2 (25)	
11	Bald Eagle	2 (23)				2 (14)
12	Swainson's Hawk				2 (25)	
13	Red-tailed Hawk	4 (21)	1 (17)	2 (21)		
14	American Kestrel	10 (16)	7 (12)	7 (16)	3 (24)	3 (13)
15	Prairie Falcon				2 (25)	
16	Ring-necked Pheasant	3 (22)		2 (21)		
17	American Coot				1 (26)	
18	Killdeer	3 (22)	2 (16)	8 (15)		
19	Spotted Sandpiper	2 (23)			7 (21)	
20	Ring-billed Gull	10 (16)				
21	Mourning Dove	107 (5)	58 (4)	159 (3)	153 (4)	7 (10)
22	Great Horned Owl	6 (19)	10 (11)	3 (20)	6 (22)	6 (11)
23	Common Nighthawk				2 (25)	
24	Belted Kingfisher				5 (23)	
25	Red-headed Woodpecker	2 (23)	2 (16)			8 (9)
26	Downy Woodpecker	6 (19)	3 (15)	13 (13)	15 (18)	10 (8)
27	Hairy Woodpecker	2 (23)				1 (15)
28	Northern Flicker	5 (20)	1 (17)	15 (11)	30 (12)	13 (7)
29	Western Wood-Peewe	5 (20)		6 (17)	11 (19)	6 (11)
30	Unidentified Empidonax	4 (21)			6 (22)	4 (12)
31	Eastern Phoebe			1 (22)		
32	Great Crested Flycatcher			1 (22)		
33	Western Kingbird	126 (4)	64 (2)	176 (2)	322 (1)	7 (10)
34	Eastern Kingbird	2 (23)	4 (14)	8 (15)	71 (5)	

Key	Common Name	Lake Alice				
		Late May '02	Late May '03	Early July '02	Late July '01	Late Aug. '02
35	Warbling Vireo	5 (20)	16 (8)	10 (14)	8 (20)	1 (15)
36	Blue Jay	26 (11)	14 (9)	51 (8)	55 (8)	26 (5)
37	Black-billed Magpie	9 (17)	7 (12)	7 (16)	18 (16)	24 (6)
38	American Crow	4 (21)				
39	Tree Swallow			5 (18)		
40	Northern Rough-winged Swallow	3 (22)				
41	Barn Swallow			1 (22)		1 (15)
42	Black-capped Chickadee	13 (15)	5 (13)	16 (10)	67 (7)	33 (4)
43	White-breasted Nuthatch		1 (17)	2 (21)		2 (14)
44	House Wren	151 (3)	52 (5)	179 (1)	270 (2)	90 (1)
45	Swainson's Thrush	14 (14)	2 (16)			
46	American Robin	61 (7)	22 (7)	64 (6)	28 (13)	
47	Gray Catbird	3 (22)				
48	Brown Thrasher	16 (13)	3 (15)	5 (18)	16 (17)	13 (7)
49	European Starling	213 (1)	100 (1)	63 (7)	44 (10)	44 (2)
50	Tennessee Warbler	8 (18)				
51	Yellow Warbler	55 (8)	11 (10)	7 (16)	20 (15)	13 (7)
52	Blackpoll Warbler	1 (24)				
53	American Redstart					2 (14)
54	Common Yellowthroat				1 (26)	
55	Wilson's Warbler					4 (12)
56	American Tree Sparrow	1 (24)				
57	Chipping Sparrow	10 (16)				35 (3)
58	Clay-colored Sparrow	1 (24)				
59	Lark Sparrow	28 (10)		4 (19)	20 (15)	
60	Grasshopper Sparrow				1 (26)	
61	Black-headed Grosbeak					1 (15)
62	Red-winged Blackbird	3 (22)		16 (10)	69 (6)	
63	Western Meadowlark	1 (24)	2 (16)			
64	Common Grackle	158 (2)	63 (3)	118 (4)	48 (9)	
65	Brown-headed Cowbird	8 (18)	3 (15)	7 (16)		
66	Northern Oriole	104 (6)	43 (6)	103 (5)	21 (14)	
67	Orchard Oriole	52 (9)	11 (10)	34 (9)	170 (3)	
68	American Goldfinch	23 (12)	3 (15)		8 (20)	
69	House Sparrow	16 (13)			1 (26)	

Key	Common Name	Lake Minatare				
		Late May '02	Late May '03	Early July '02	Late July '01	Late Aug. '02
1	Western Grebe	2 (23)		1 (19)		
2	Great Blue Heron			2 (18)	3 (15)	
3	Turkey Vulture	1 (24)	1 (20)	4 (16)	8 (13)	
4	Canada Goose	25 (7)		30 (7)		
5	Wood Duck	24 (8)	3 (18)	6 (14)	1 (16)	
6	Mallard	6 (19)				
7	Blue-winged Teal	3 (22)				
8	Bald Eagle					1 (15)
9	Swainson's Hawk				1 (16)	
10	Red-tailed Hawk	2 (23)				2 (14)
11	American Kestrel	1 (24)	2 (19)	5 (15)	3 (15)	1 (15)
12	Killdeer	5 (20)			1 (16)	
13	Spotted Sandpiper	1 (24)				
14	Long-billed Curlew	1 (24)				
15	Mourning Dove	76 (4)	46 (3)	82 (3)	92 (3)	33 (6)
16	Yellow-billed Cuckoo		1 (20)			
17	Great Horned Owl	8 (17)	5 (17)	2 (18)	5 (14)	7 (11)
18	Chimney Swift	2 (23)				
19	Common Nighthawk	1 (24)				1 (15)
20	Belted Kingfisher			1 (19)	1 (16)	
21	Red-headed Woodpecker		10 (14)			
22	Downy Woodpecker	11 (14)	13 (11)	13 (11)	14 (8)	13 (8)
23	Hairy Woodpecker		1 (20)	1 (19)		
24	Northern Flicker	10 (15)	2 (19)	18 (9)	34 (6)	14 (7)
25	Eastern Wood-Pewee		1 (20)			
26	Western Wood-Peewe	6 (19)		3 (17)	11 (10)	1 (15)
27	Unidentified Empidonax		6 (16)			4 (13)
28	Western Kingbird	31 (6)	22 (7)	21 (8)	39 (5)	6 (12)
29	Eastern Kingbird	9 (16)	12 (12)		9 (12)	
30	Red-eyed Vireo	1 (24)				
31	Warbling Vireo	22 (9)	20 (8)	3 (17)		2 (14)
32	Blue Jay	13 (13)	30 (5)	15 (10)	14 (8)	34 (5)
33	Black-billed Magpie	14 (12)	3 (18)	9 (12)		7 (11)
34	American Crow					6 (12)
35	Tree Swallow	3 (22)	2 (19)	1 (19)		
36	Northern Rough-winged Swallow		2 (19)			
37	Black-capped Chickadee	22 (9)	10 (14)	44 (6)	108 (2)	53 (3)

		Lake Minatare				
Key	**Common Name**	**Late May '02**	**Late May '03**	**Early July '02**	**Late July '01**	**Late Aug. '02**
38	White-breasted Nuthatch	7 (18)	3 (18)	8 (13)	10 (11)	13 (8)
39	House Wren	82 (3)	48 (2)	160 (1)	135 (1)	85 (2)
40	Swainson's Thrush	2 (23)	9 (15)			
41	American Robin	15 (11)	11 (13)	50 (5)	46 (4)	
42	Gray Catbird	2 (23)				
43	Brown Thrasher		2 (19)			1 (15)
44	European Starling	342 (1)	123 (1)	51 (4)	28 (7)	147 (1)
45	Tennessee Warbler	4 (21)				
46	Yellow Warbler	44 (5)	24 (6)	9 (12)	12 (9)	11 (9)
47	Blackpoll Warbler	2 (23)				
48	American Redstart					1 (15)
49	Common Yellowthroat					1 (15)
50	Wilson's Warbler					13 (8)
51	Spotted Towhee		14 (10)			
52	Chipping Sparrow	10 (15)				40 (4)
53	Clay-colored Sparrow					10 (10)
54	Red-winged Blackbird	24 (8)	2 (19)	2 (18)	10 (11)	
55	Western Meadowlark	1 (24)				
56	Common Grackle	179 (2)	37 (4)	91 (2)	3 (15)	
57	Brown-headed Cowbird	1 (24)	2 (19)		1 (16)	
58	Northern Oriole	20 (10)	15 (9)	8 (13)	3 (15)	
59	Orchard Oriole	10 (15)	15 (9)	2 (18)	12 (9)	
60	House Finch	2 (23)				
61	American Goldfinch	14 (12)	9 (15)	3 (17)	5 (14)	4 (13)
62	House Sparrow					7 (11)

Key	Common Name	Winters Creek				
		Late May '02	Late May '03	Early July '02	Late July '01	Late Aug. '02
1	Pied-billed Grebe	1 (19)				
2	Eared Grebe	5 (15)				
3	Western Grebe	2 (18)				
4	American White Pelican	1 (19)				
5	Great Blue Heron	1 (19)				
6	Black-crowned Night-heron	1 (19)				
7	White-faced Ibis	4 (16)				
8	Canada Goose	20 (7)			25 (6)	
10	Wood Duck		2 (9)			
11	Gadwall	1 (19)				
12	Mallard	2 (18)	2 (9)			
13	Blue-winged Teal	15 (8)				
14	Northern Shoveler	4 (16)				
15	Ring-necked Pheasant			2 (11)		
16	American Coot	20 (7)				
17	Killdeer	23 (6)	5 (8)	7 (7)		20 (3)
18	American Avocet	1 (19)				
19	Willet	1 (19)				
20	Spotted Sandpiper					1 (11)
21	Wilson's Phalarope	8 (12)				
22	Mourning Dove	13 (10)	16 (4)	34 (1)	31 (3)	12 (5)
23	Eastern Screech-Owl					1 (11)
24	Great Horned Owl				1 (16)	1 (11)
25	Common Nighthawk		1 (10)			
26	Belted Kingfisher	2 (18)		2 (11)	3 (14)	1 (11)
27	Red-headed Woodpecker					1 (11)
28	Downy Woodpecker				5 (12)	2 (10)
29	Northern Flicker	1 (19)	2 (9)	5 (9)	2 (15)	11 (6)
30	Unidentified Empidonax					1 (11)
31	Western Kingbird	14 (9)	13 (5)	7 (7)	30 (4)	
32	Eastern Kingbird	8 (12)	2 (9)	5 (9)	6 (11)	4 (8)
33	Loggerhead Shrike				1 (16)	
34	Bell's Vireo				2 (15)	
35	Red-eyed Vireo	1 (19)				
36	Warbling Vireo		6 (7)	2 (11)		
37	Blue Jay	1 (19)		2 (11)	1 (16)	7 (7)
38	Black-billed Magpie	6 (14)	1 (10)			

		Winters Creek				
Key	**Common Name**	**Late May '02**	**Late May '03**	**Early July '02**	**Late July '01**	**Late Aug. '02**
39	Tree Swallow				17 (8)	
40	Northern Rough-winged Swallow		2 (9)	1 (12)	20 (7)	
41	Bank Swallow				20 (7)	
42	Cliff Swallow			1 (12)	20 (7)	
43	Barn Swallow				6 (11)	
44	Black-capped Chickadee	4 (16)	1 (10)		25 (6)	3 (9)
45	House Wren	28 (4)	10 (6)	28 (2)	52 (2)	19 (4)
46	Marsh Wren			7 (7)	4 (13)	7 (7)
47	Eastern Bluebird				1 (16)	
48	Swainson's Thrush	1 (19)	1 (10)			
49	American Robin	7 (13)	1 (10)	2 (11)	1 (16)	
50	Gray Catbird	1 (19)	1 (10)			1 (11)
51	Brown Thrasher	5 (15)	5 (8)	3 (10)	9 (9)	4 (8)
52	European Starling	6 (14)	2 (9)	6 (8)		
53	Yellow Warbler	25 (5)	22 (3)	2 (11)	8 (10)	11 (6)
54	Common Yellowthroat	12 (11)	1 (10)	5 (9)	9 (9)	1 (11)
55	Wilson's Warbler					3 (9)
56	Spotted Towhee	2 (18)			1 (16)	
57	Chipping Sparrow					90 (1)
58	Clay-colored Sparrow					1 (11)
59	Lark Sparrow	1 (19)				
60	Song Sparrow					1 (11)
61	Indigo Bunting	4 (16)		2 (11)	1 (16)	
62	Red-winged Blackbird	66 (1)	5 (8)	10 (6)	26 (5)	
63	Yellow-headed Blackbird	4 (16)				
64	Common Grackle	40 (3)	31 (1)	23 (3)		
65	Brown-headed Cowbird		1 (10)	5 (9)		
66	Northern Oriole	3 (17)	13 (5)	14 (4)	2 (15)	
67	Orchard Oriole	41 (2)	28 (2)	12 (5)	88 (1)	
68	House Finch					2 (10)
69	American Goldfinch	12 (11)	6 (7)	10 (6)	9 (9)	2 (10)
70	House Sparrow		1 (10)			27 (2)

Key	Common Name	Stateline Island				
		Late May '02	Late May '03	Early July '02	Late July '01	Late Aug. '02
1	Great Blue Heron				4 (11)	
2	Green Heron			1 (13)		
3	Canada Goose	8 (11)				
4	Wood Duck	7 (12)		1 (13)	1 (14)	
5	Mallard	2 (17)				
6	Blue-winged Teal	10 (9)				
7	Red-tailed Hawk				1 (14)	1 (12)
8	American Kestrel	1 (18)				
9	Northern Bobwhite	1 (18)		2 (12)	1 (14)	1 (12)
10	Wild Turkey	2 (17)				
11	Killdeer				1 (14)	
12	Spotted Sandpiper				1 (14)	
13	Wilson's Phalarope	1 (18)				
14	Mourning Dove	16 (5)	15 (3)	20 (2)	46 (3)	2 (11)
15	Great Horned Owl	2 (17)	1 (9)	3 (11)		1 (12)
16	Belted Kingfisher			1 (13)	6 (10)	
17	Downy Woodpecker	1 (18)	1 (9)	2 (12)	4 (11)	4 (9)
18	Hairy Woodpecker	1 (18)				
19	Northern Flicker	11 (8)	3 (7)	13 (5)	21 (6)	13 (4)
20	Western Wood-Peewe	1 (18)		3 (11)	7 (9)	2 (11)
21	Unidentified Empidonax					3 (10)
22	Great Crested Flycatcher	1 (18)				
23	Western Kingbird		6 (5)	5 (10)	4 (11)	
24	Eastern Kingbird	5 (14)		8 (7)	20 (7)	1 (12)
25	Loggerhead Shrike					1 (12)
26	Warbling Vireo	1 (18)	1 (9)	1 (13)	2 (13)	2 (11)
27	Blue Jay	12 (7)	5 (6)	14 (4)	40 (5)	19 (3)
28	Black-billed Magpie	4 (15)	2 (8)	6 (9)	1 (14)	7 (7)
29	Tree Swallow			6 (9)		
30	Northern Rough-winged Swallow		2 (8)			
31	Bank Swallow	1 (18)				
32	Barn Swallow				1 (14)	
33	Black-capped Chickadee	9 (10)	7 (4)	13 (5)	45 (4)	29 (2)
34	White-breasted Nuthatch			1 (13)	3 (12)	3 (10)
35	House Wren	54 (1)	15 (3)	137 (1)	268 (2)	43 (1)
36	Marsh Wren					4 (9)
37	Eastern Bluebird	8 (11)				

Key	Common Name	Stateline Island				
		Late May '02	Late May '03	Early July '02	Late July '01	Late Aug. '02
38	Swainson's Thrush	1 (18)				
39	American Robin	6 (13)	2 (8)		3 (12)	
40	Brown Thrasher	1 (18)	5 (6)	1 (13)	4 (11)	8 (6)
41	European Starling	37 (2)	20 (2)	7 (8)		7 (7)
42	Tennessee Warbler	4 (15)				
43	Yellow Warbler	13 (6)	5 (6)	2 (12)	7 (9)	1 (12)
44	Common Yellowthroat	7 (12)	1 (9)	3 (11)	3 (12)	4 (9)
45	Yellow-breasted Chat	38 (1)				2 (11)
46	Wilson's Warbler					12 (5)
47	Spotted Towhee	4 (15)		5 (10)	4 (11)	4 (9)
48	Chipping Sparrow	1 (18)				
49	Lincoln's Sparrow	1 (18)				
50	Red-winged Blackbird	31 (3)	2 (8)	11 (6)	1 (14)	
51	Western Meadowlark	3 (16)				
52	Common Grackle	17 (4)	24 (1)	19 (3)	554 (1)	5 (8)
53	Brown-headed Cowbird	5 (14)		2 (12)		
54	Northern Oriole			5 (10)	1 (14)	
55	Orchard Oriole	1 (18)	3 (7)	5 (10)	7 (9)	
56	American Goldfinch	4 (15)	2 (8)	8 (7)	9 (8)	

Appendix 8. Mean (se) of maximum abundances of grassland birds detected per transect (3.14 ha / point, five points / transect, 15.7 ha / transect) during breeding season in Choppy Sands, Sands, and Sub-irrigated Meadow habitats at CLNWR, 2001-2002. (Means for endemic and secondary grassland species are listed in Table 5).

Choppy Sands[a]	Spring 2001	Spring 2002	Early Summer 2001	Early Summer 2002	Late Summer 2002	Early Fall 2002
American Goldfinch	0	0	0	0.43 (0.43)	0	0.71 (0.47)
American Kestrel	0	0	0	0	0	0.57 (0.57)
Common Grackle	0	0.14 (0.14)	0	0.29 (0.29)	0	0.29 (0.29)
Common Nighthawk	0.29 (0.18)	0.14 (0.14)	0.14 (0.14)	0.14 (0.14)	0	0
Eastern Kingbird	0.29 (0.29)	0	0	0	0	0
Killdeer	0	0	0	0	0	0.29 (0.29)
Mourning Dove	0.71 (0.71)	1.0 (0.72)	0.29 (0.29)	0.71 (0.29)	0.14 (0.14)	0
Red-tailed Hawk	0.29 (0.29)	0	0	0	0	0
Red-winged Blackbird	0	0	0	0.71 (0.71)	0	0
Western Kingbird	0	0	0	0.14 (0.14)	0.14 (0.14)	0
Yellow-headed Blackbird	2.14 (2.14)	0	0	0	0	0

[a]Based on maximum numbers detected along seven transects.

Sands[a]	Spring 2001	Spring 2002	Early Summer 2001	Early Summer 2002	Late Summer 2002*	Early Fall 2002*
Eastern Kingbird	0	0	0	0.14 (0.14)	0	0
Killdeer	0	0	0	0.29 (0.29)	0.5 (0.50)	
Mourning Dove	0	0.43 (0.43)	0.43 (0.30)	1.14 (0.55)	0	0
Ring-necked Pheasant	0	0.29 (0.29)	0	0	0	0
Red-tailed Hawk	0	0.29 (0.29)	0	0	0	0
Red-winged Blackbird	1.57 (1.57)	0	0.49 (0.49)	0.29 (0.29)	0	0

[a]Based on maximum numbers detected along seven transects.
*Only two transects surveyed during this time period.

Sub-irrigated Meadow[b]	Spring 2001	Spring 2002	Early Summer 2001	Early Summer 2002	Late Summer 2002	Early Fall 2002
American Bittern	0.67 (0.33)	0.67 (0.67)	0	0	0	0
American Coot	0.33 (0.33)	1.0 (1.00)	0.5 (0.50)	0	0	0
Bald Eagle	0	0.33 (0.33)	0	0	0	0
Barn Swallow	0	0	0	0	0	0.67 (0.67)
Back Tern	1.33 (1.33)	2.0 (2.00)	0	2.33 (2.33)	2.67 (2.67)	5.0 (5.00)
Blue-winged Teal	0.33 (0.33)	0.67 (0.67)	0	0	0	0
Common Grackle	0	0	0	0.07 (0.07)	0	1.67 (1.67)
Common Nighthawk	0	0	0	0	0.33 (0.33)	0
Common Yellowthroat	3.33 (0.88)	2.67 (1.20)	3.17 (0.17)	0.87 (0.47)	0.67 (0.33)	0
Killdeer	0.67 (0.33)	0.67 (0.67)	0.67 (0.44)	1.13 (1.13)	1.67 (1.20)	0
Mallard	0	0.67 (0.67)	0	0	0	0
Marsh Wren	4.67 (2.91)	15.0 (10.41)	4.17 (2.09)	6.67 (3.61)	5.0 (1.00)	2.67 (1.20)
Mourning Dove	0	1.0 (1.00)	0	0.67 (0.67)	0.33 (0.33)	0
Northern Pintail	0	0.33 (0.33)	0	0	0	0
Ring-necked Pheasant	0.33 (0.33)	0.33 (0.33)	0	0	0	0
Red-winged Blackbird	29.33 (9.60)	32.67 (10.27)	21.5 (2.89)	18.93 (7.29)	5.33 (4.82)	3.0 (3.00)
Tree Swallow	0	0	0	0.2 (0.20)	3.0 (2.52)	0
White-faced Ibis	0	0	0	0.13 (0.13)	0	0.33 (0.33)
Willet	0	1.33 (0.33)	0	0	0	1.67 (1.67)
Wilson's Phalarope	0.33 (0.33)	1.67 (0.88)	0	0.13 (0.13)	0	3.33 (3.33)
Wood Duck	0	0	0	0.2 (0.20)	0	0
Yellow-headed Blackbird	4.67 (2.60)	12.33 (6.23)	4.83 (4.59)	5.4 (3.06)	14.67 (14.67)	0

[b]Based on three transects.

Appendix 9. Species, dates, substrates/locations, status, and fates of nests found during bird survey work at CLNWR, 2001-2002.

Species	Date	Substrate/vegetation, approximate location	Status	Fate
Blue-winged Teal	05/23/01	grass, near Perrin Lake	2 eggs	Unknown
Mallard (?)	05/23/01	grass, near Perrin Lake	3 eggs	Unknown
Mourning Dove	05/24/01	Russian-olive, near refuge HQ	2 eggs	Unknown
Mallard	05/24/01	under yucca, north of refuge HQ	2 eggs	Unknown
Mourning Dove	05/24/01	under yucca, north of refuge HQ	1 egg	Unknown
Mourning Dove	05/24/01	Russian-olive, near refuge HQ	2 eggs	Unknown
Loggerhead Shrike	05/24/01	honeylocust (*Gleditsia triacanthos*), near Island Lake	Unknown	Unknown
Marsh Wren	05/25/01	cattails, by Gimlet Lake	Unknown	Unknown
Western Meadowlark	06/04/01	grass, near point 500 on transect M1	5 eggs	Unknown
Sharp-tailed Grouse	06/06/01	grass, near point 500 on transect C3	4 chicks	Unknown
Sharp-tailed Grouse	06/07/01	under yucca, near point 1000 on transect C5	11 eggs	10 chicks
Western Meadowlark	06/18/01	grass, north of Christ Lake	4 chicks	Unknown
Marsh Wren	06/18/01	cattails, by Christ Lake	Unknown	Unknown
Eared Grebe	06/26/02	on Goose Lake	4 chicks	Unknown
Lark Sparrow	07/01/02	under yucca, near point 0 on transect C5	3 eggs	Unknown

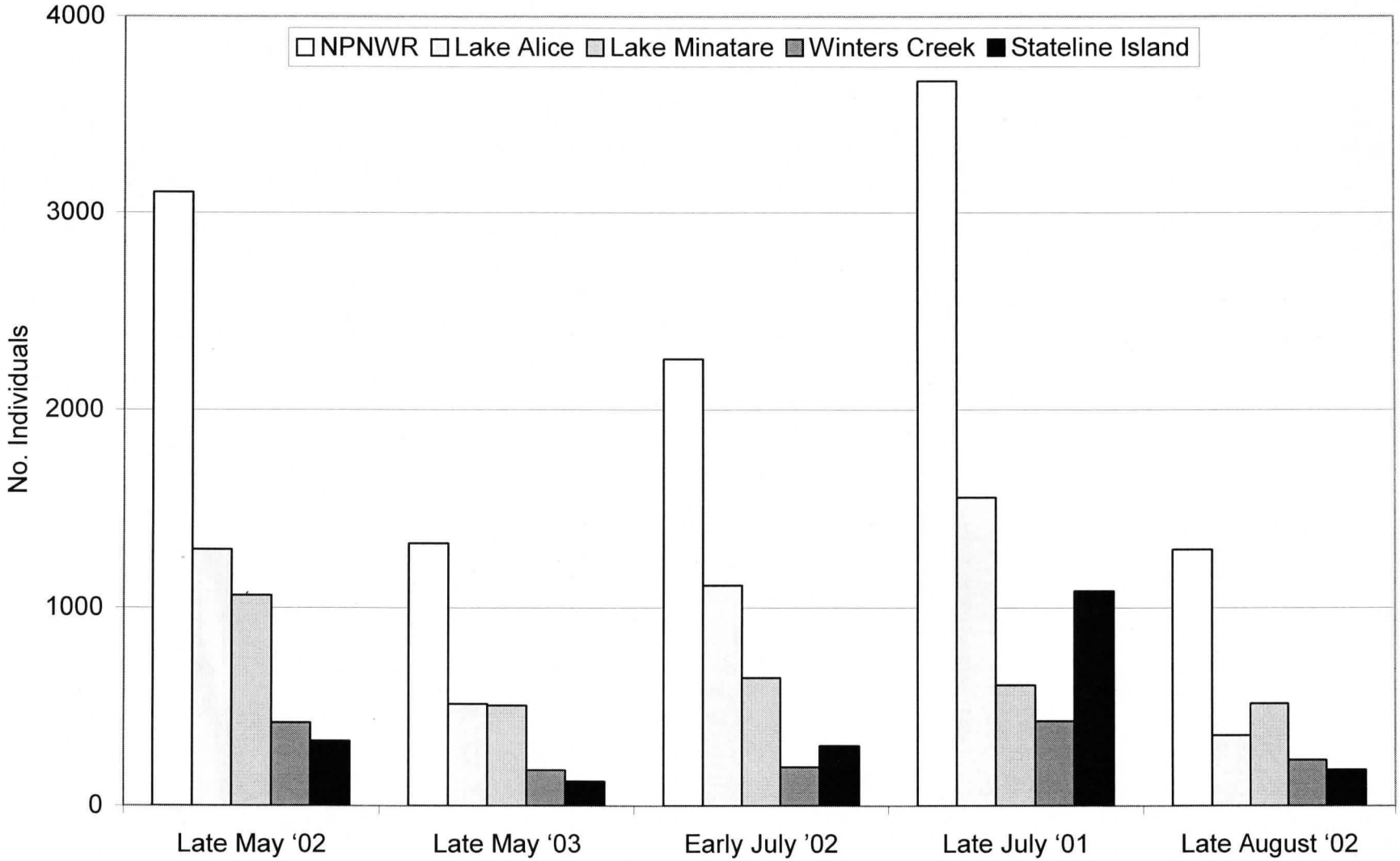

Figure 6. Number of individual birds detected on surveys conducted during five periods of 2001-2003 in riparian habitats at NPNWR.

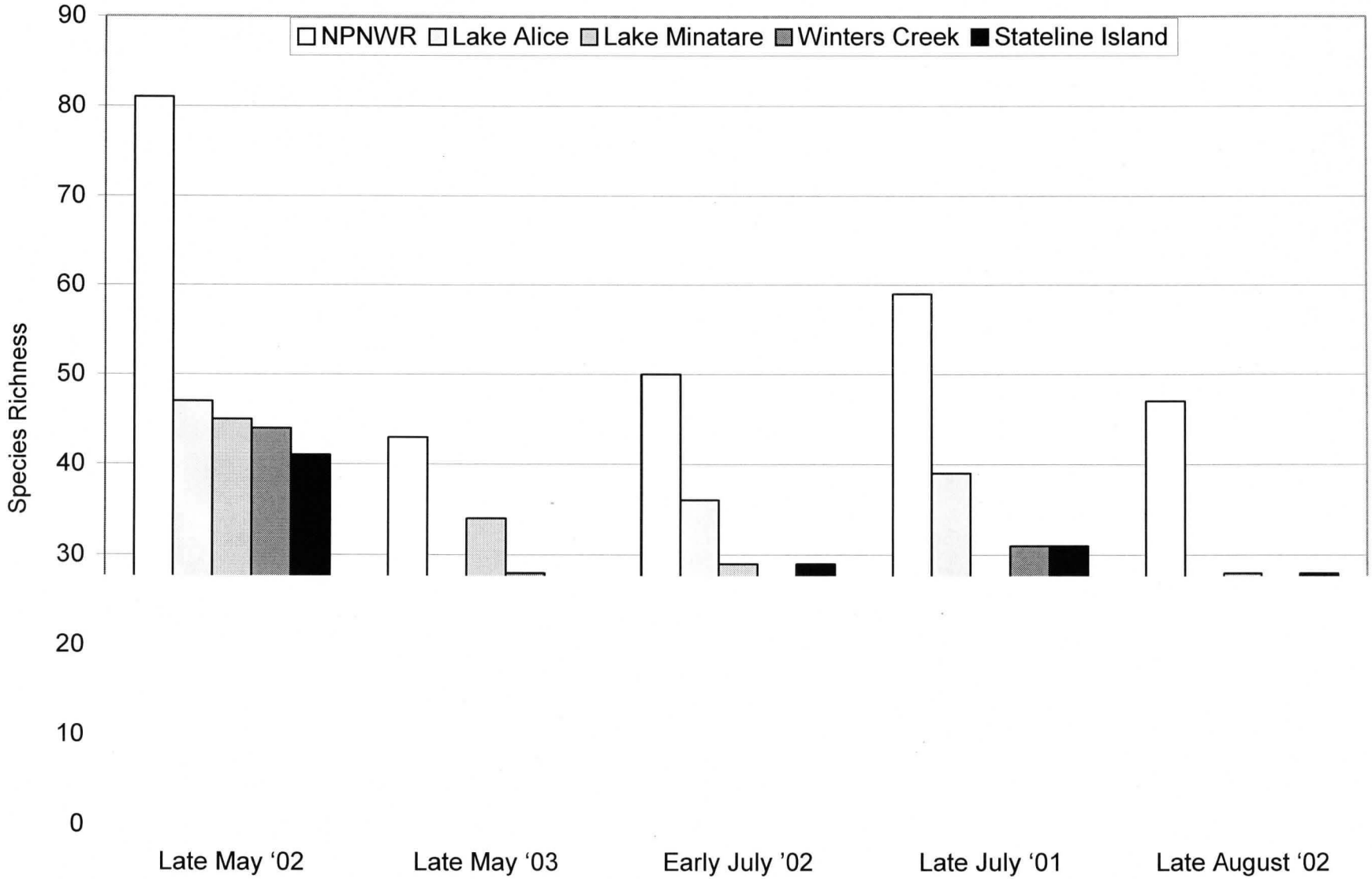

Figure 7. Species richness detected during five survey periods of 2001-2003 in riparian habitats at NPNWR.

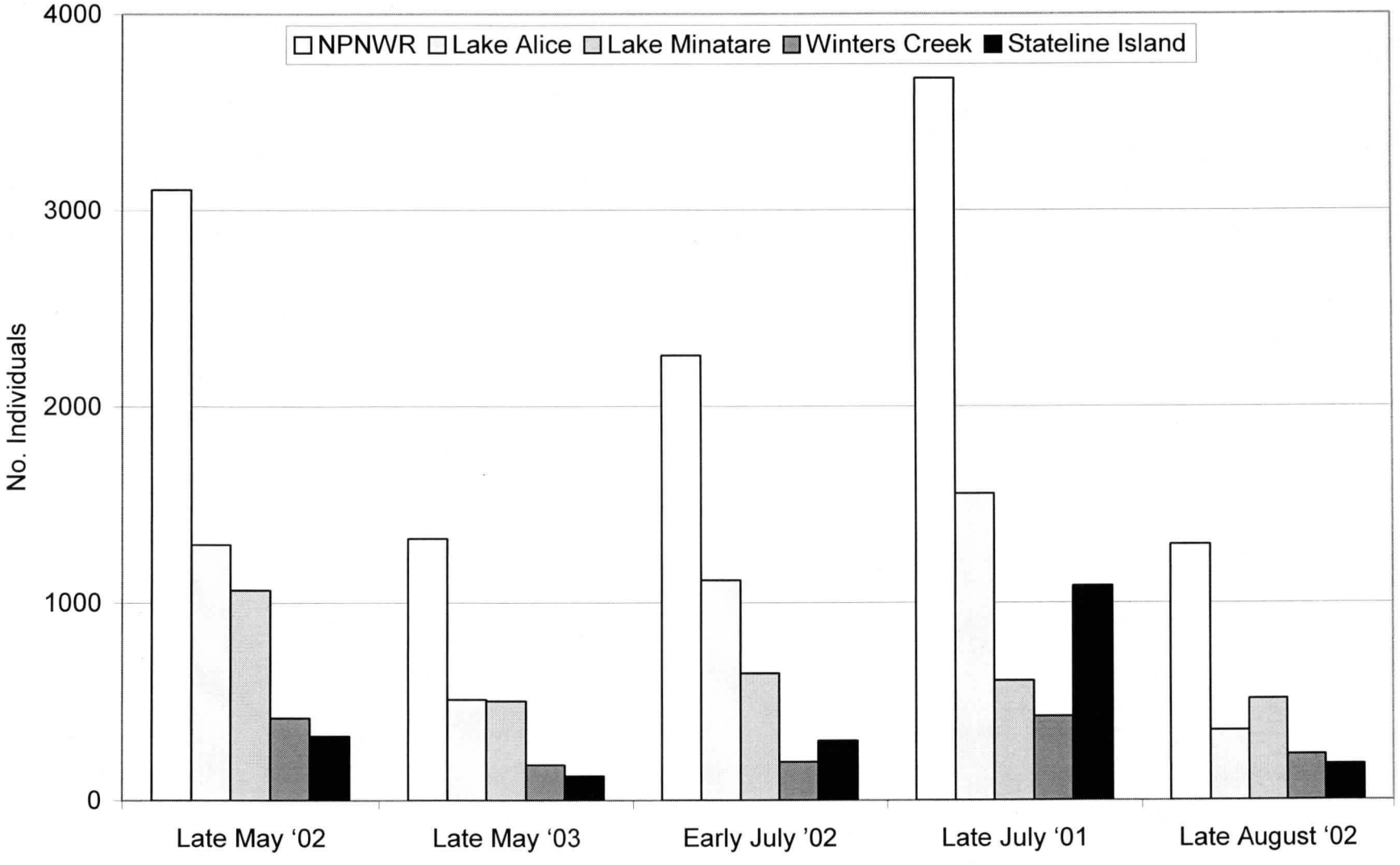

Figure 6. Number of individual birds detected on surveys conducted during five periods of 2001-2003 in riparian habitats at NPNWR.

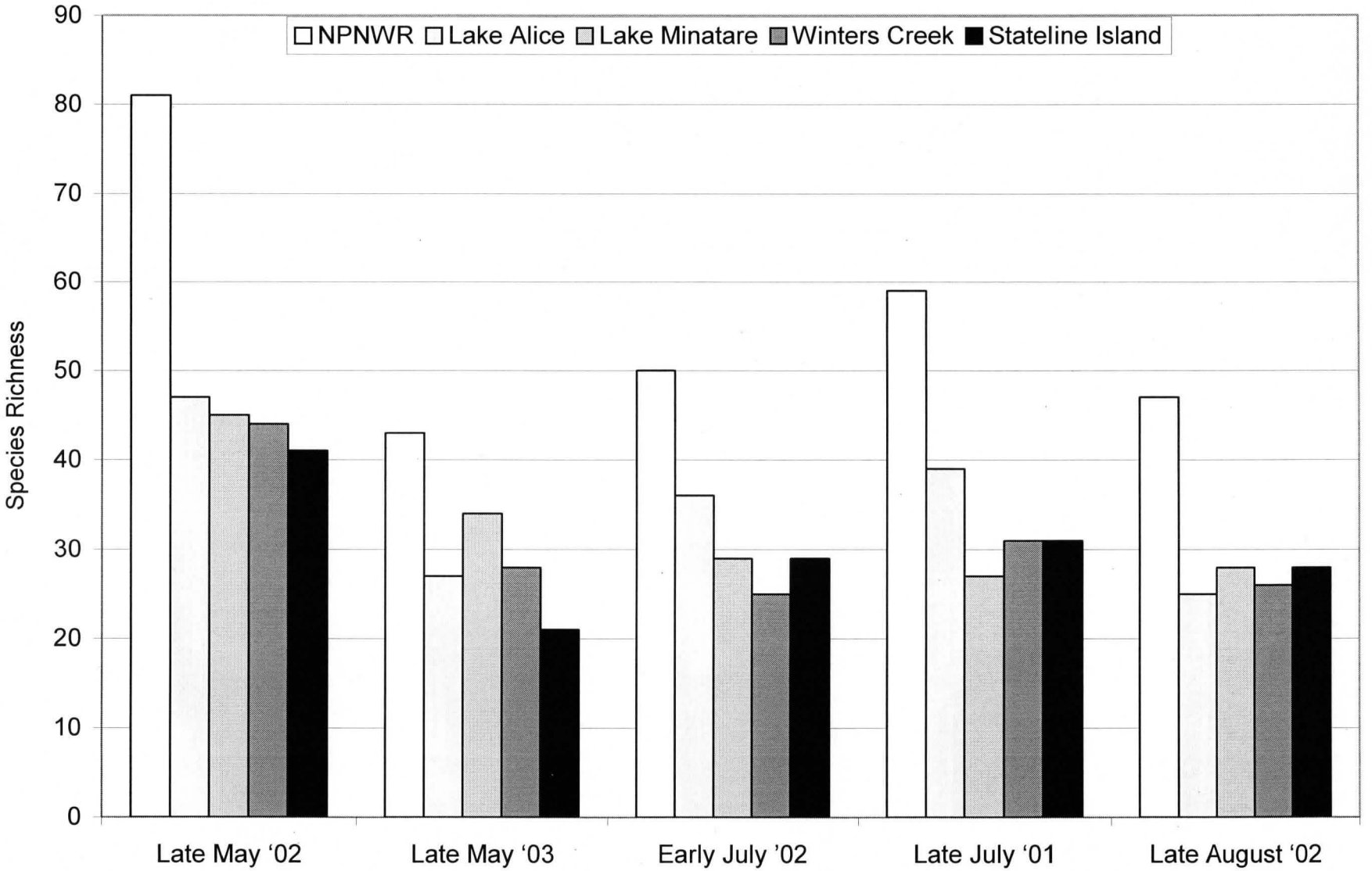

Figure 7. Species richness detected during five survey periods of 2001-2003 in riparian habitats at NPNWR.

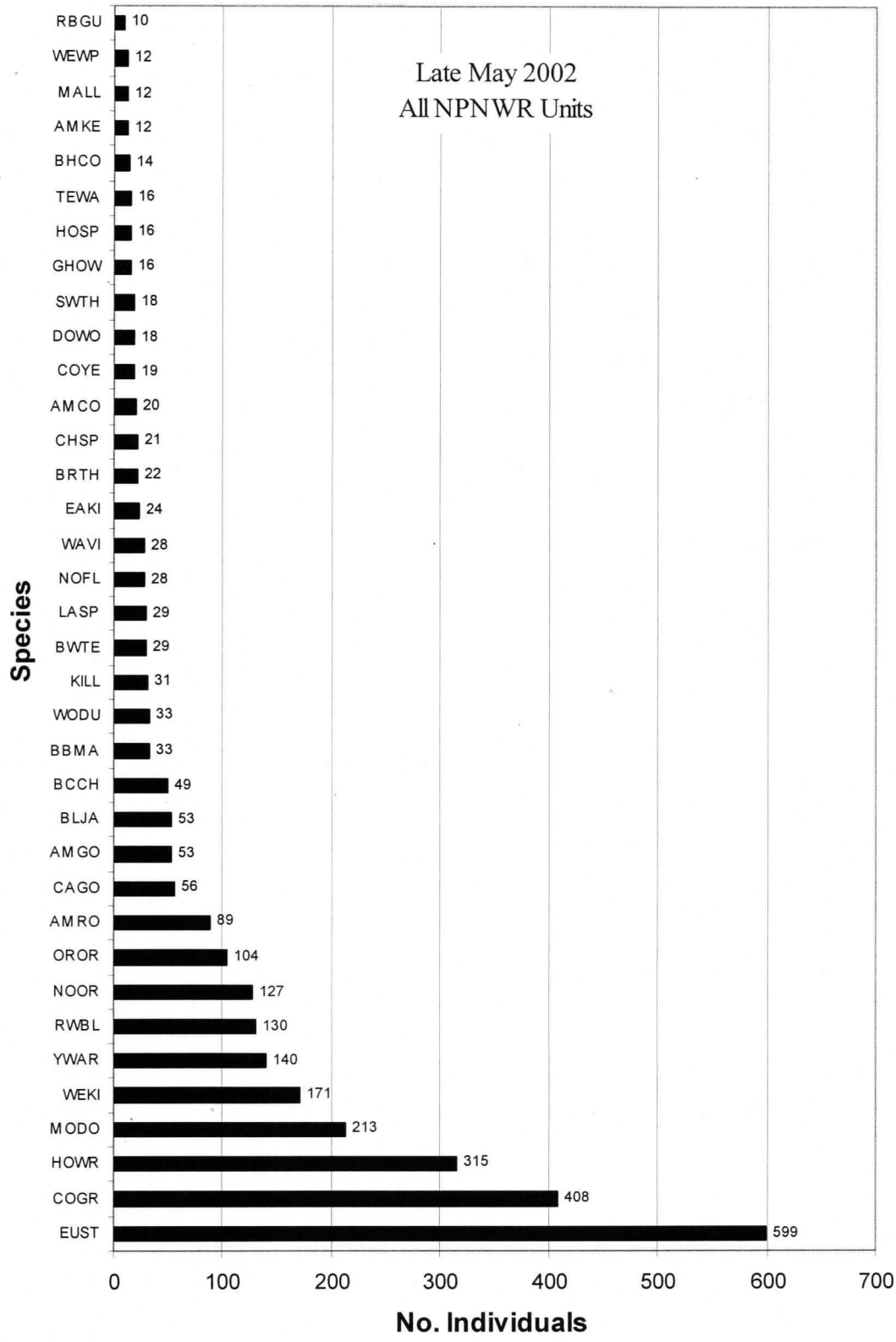

Figure 8. Number of birds detected during the late May 2002 survey period for all four units of North Platte National Wildlife Refuge. Species ranked from 1 to 26 in abundance are shown.

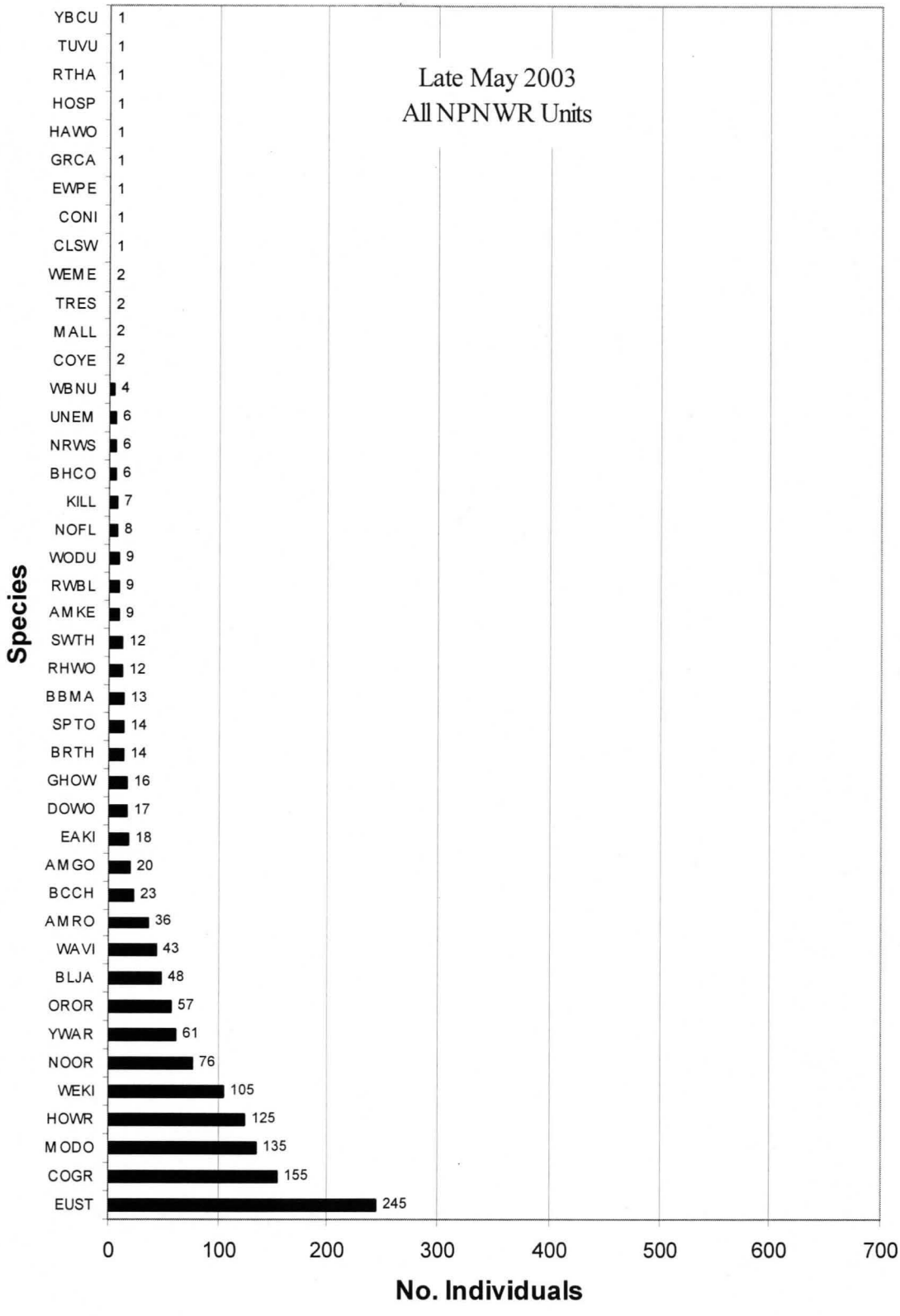

Figure 9. Number of birds detected during the late May 2003 survey period for all four units of North Platte National Wildlife Refuge. Species ranked from 1 to 26 in abundance are shown.

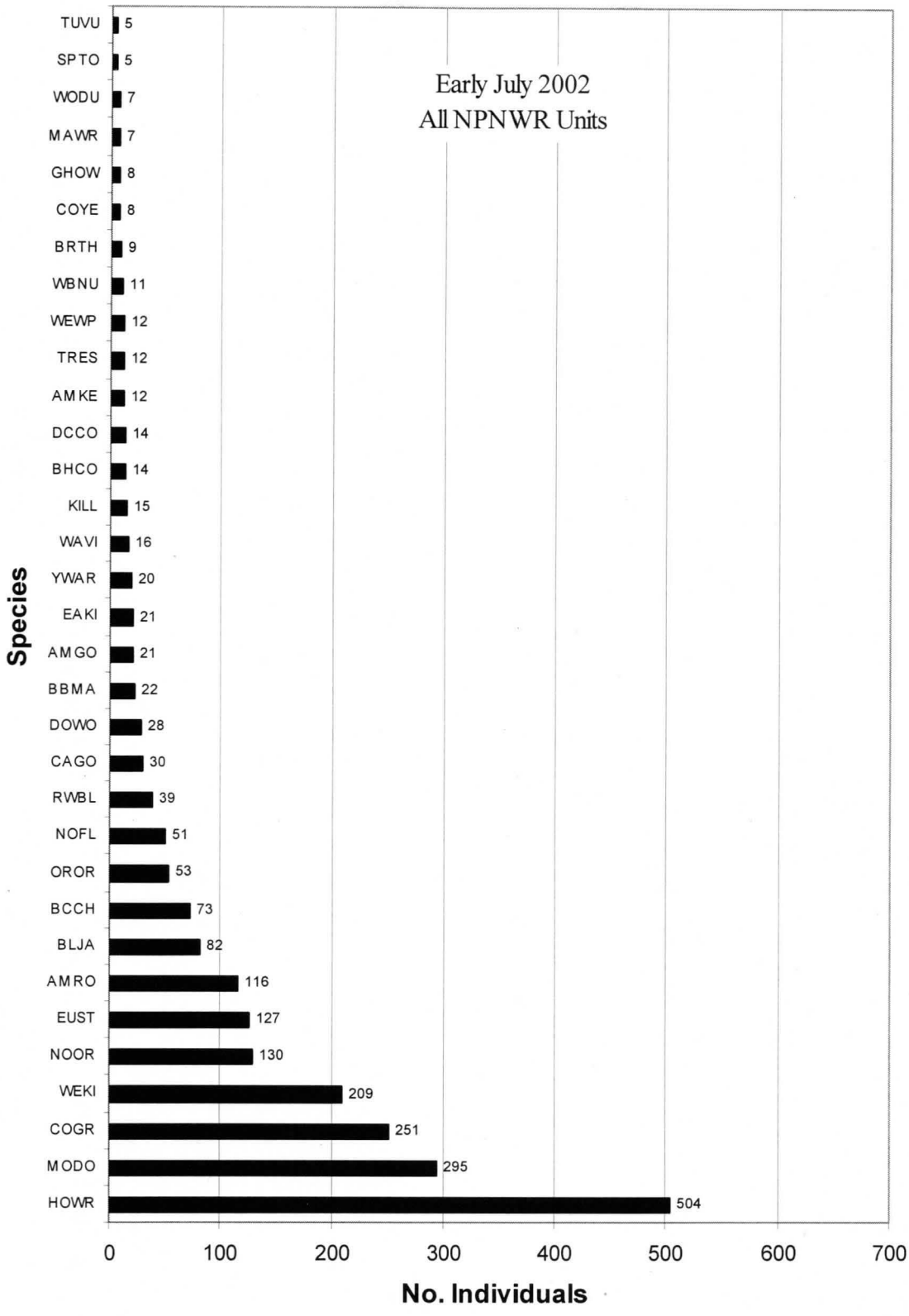

Figure 10. Number of birds detected during the early July 2002 survey period for all four units of North Platte National Wildlife Refuge. Species ranked from 1 to 26 in abundance are shown.

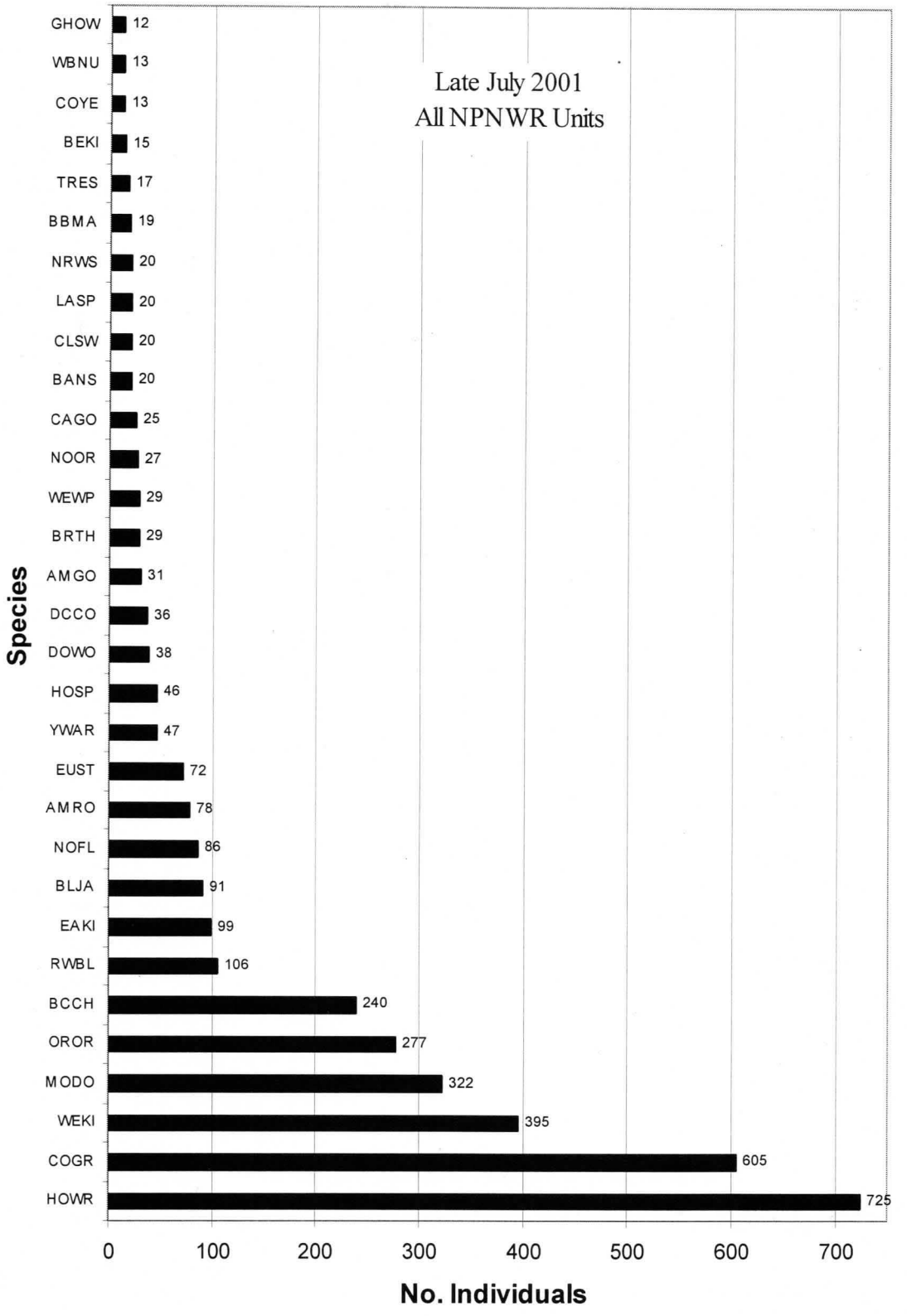

Figure 11. Number of birds detected during the late July 2001 survey period for all four units of North Platte National Wildlife Refuge. Species ranked from 1 to 26 in abundance are shown.

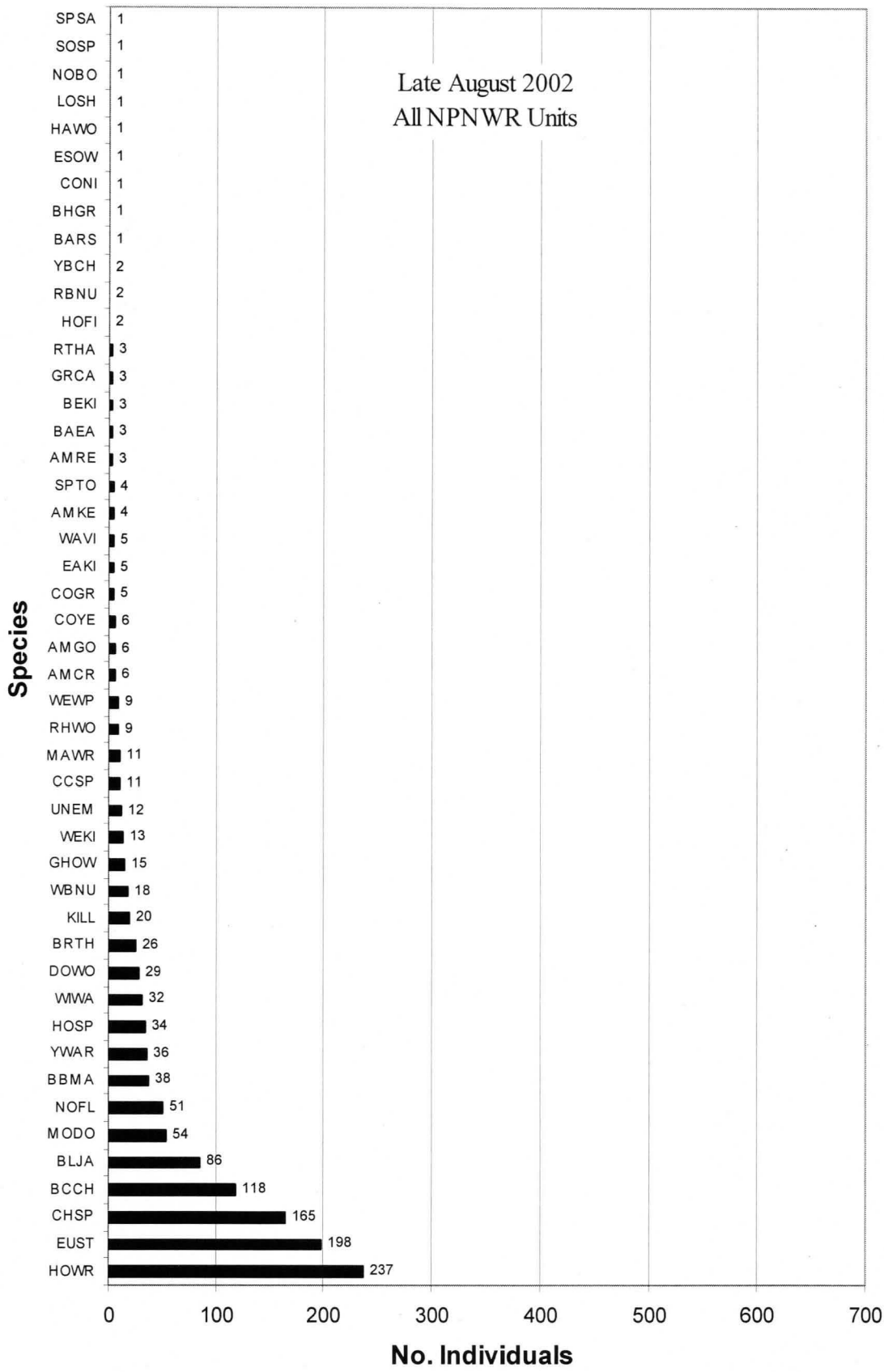

Figure 12. Number of birds detected during the late August 2002 survey period for all four units of North Platte National Wildlife Refuge. Species ranked from 1 to 26 in abundance are shown.

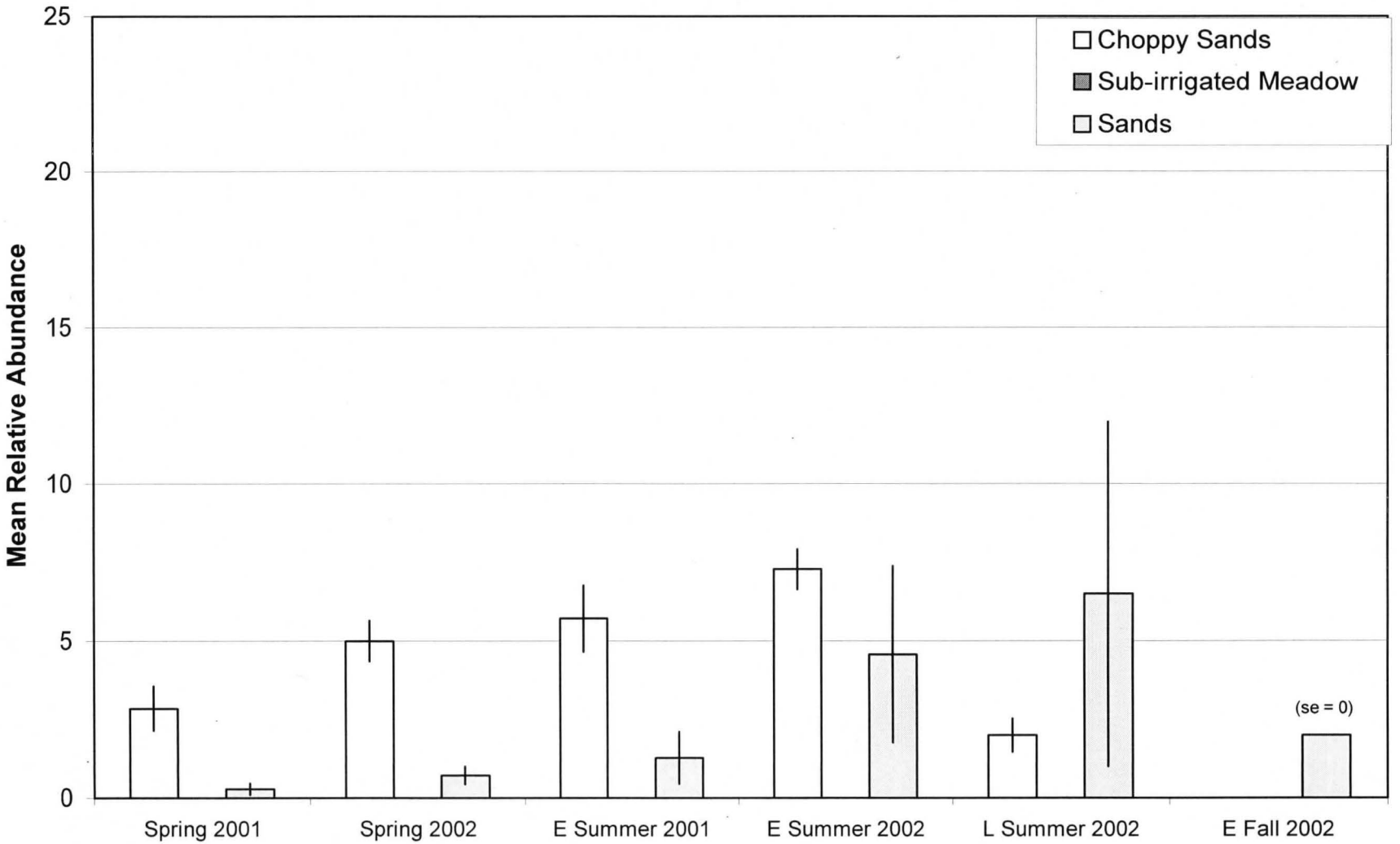

Figure 13. Mean relative abundance (± se) of Lark Sparrow detected within each habitat type during the breeding season at CLNWR, 2001-2002.

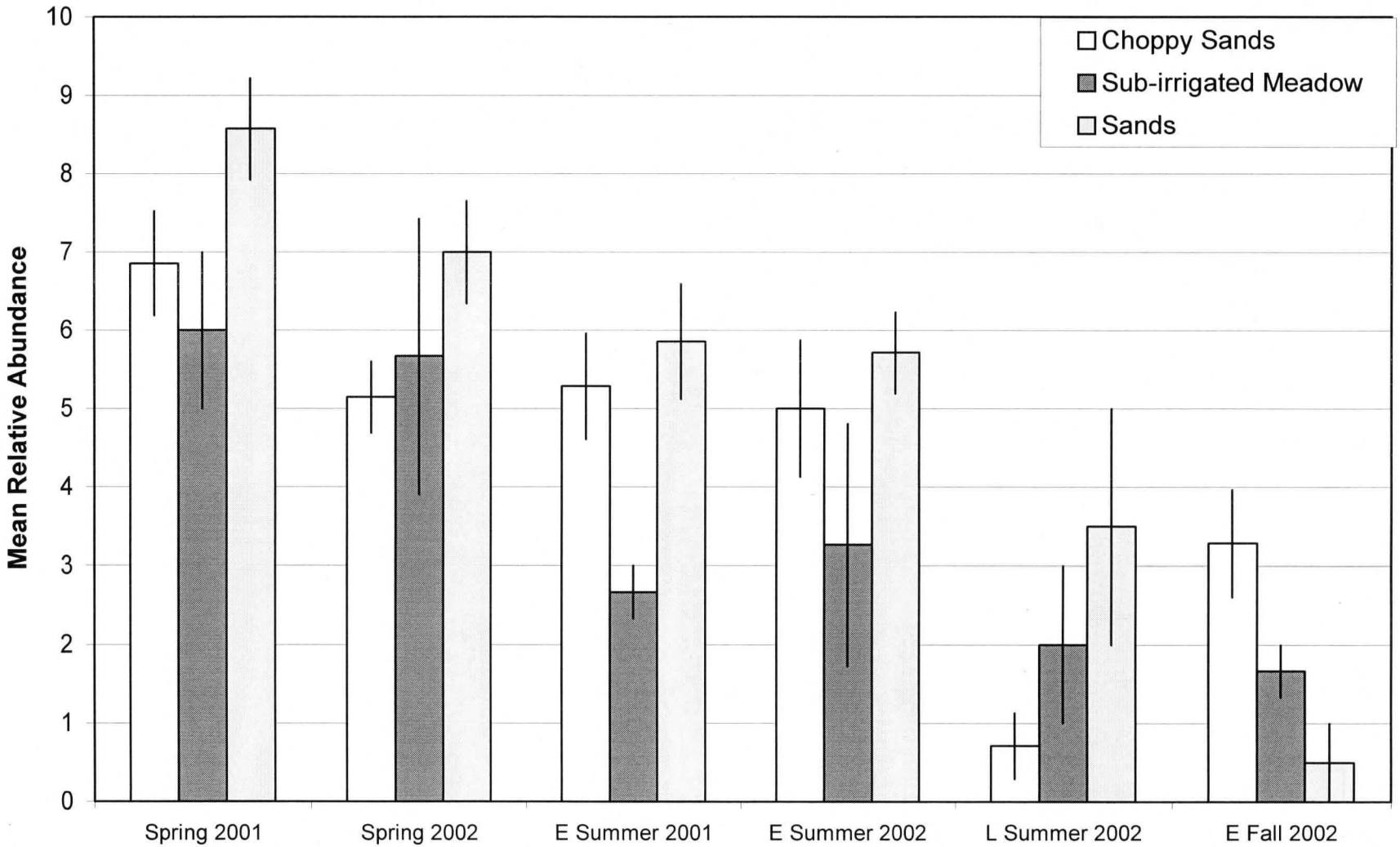

Figure 14. Mean relative abundance (± se) of Western Meadowlark detected within each habitat type during the breeding season at CLNWR, 2001-2002.

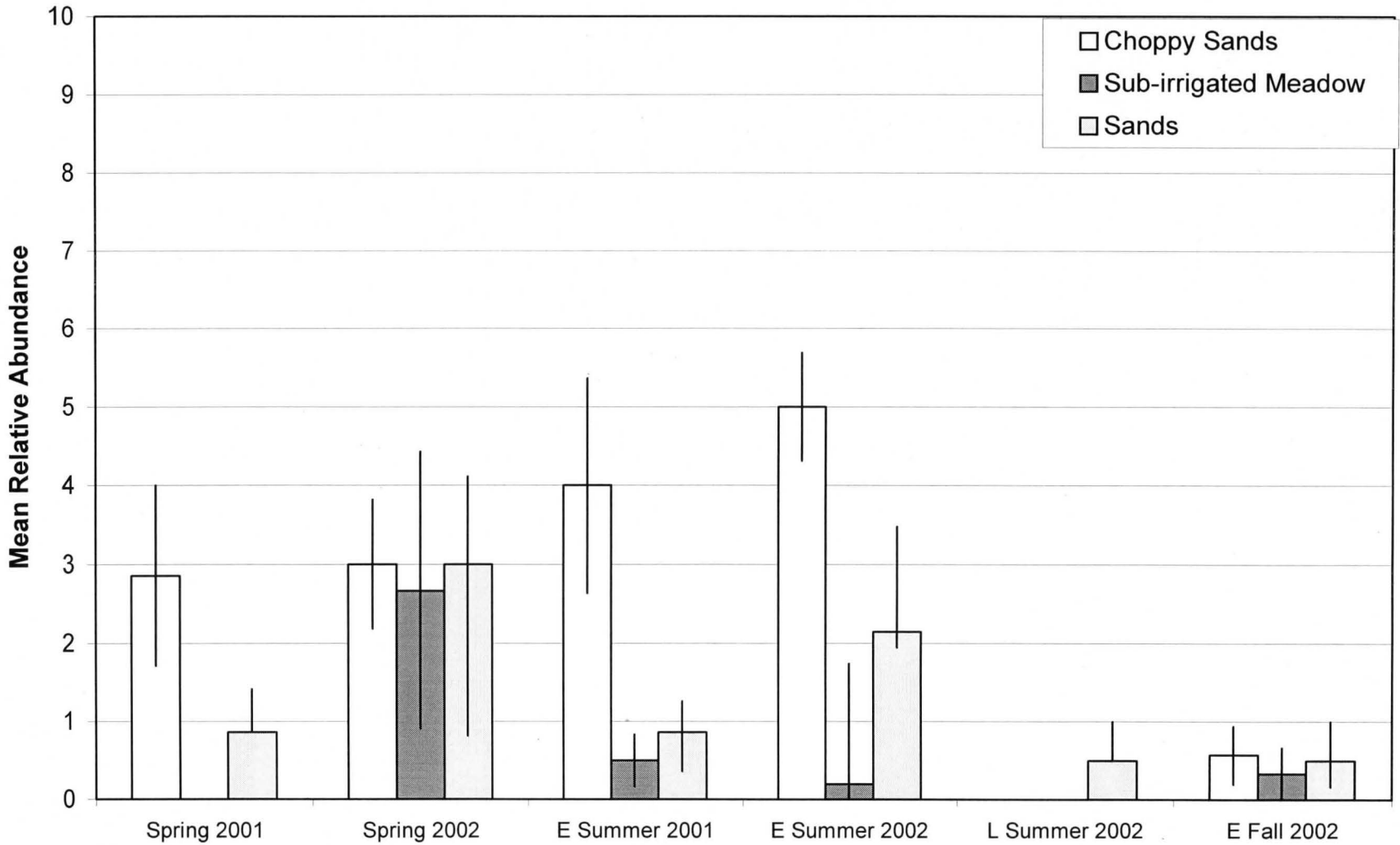

Figure 15. Mean relative abundance (± se) of Brown-headed Cowbird detected within each habitat type during the breeding season at CLNWR, 2001-2002.

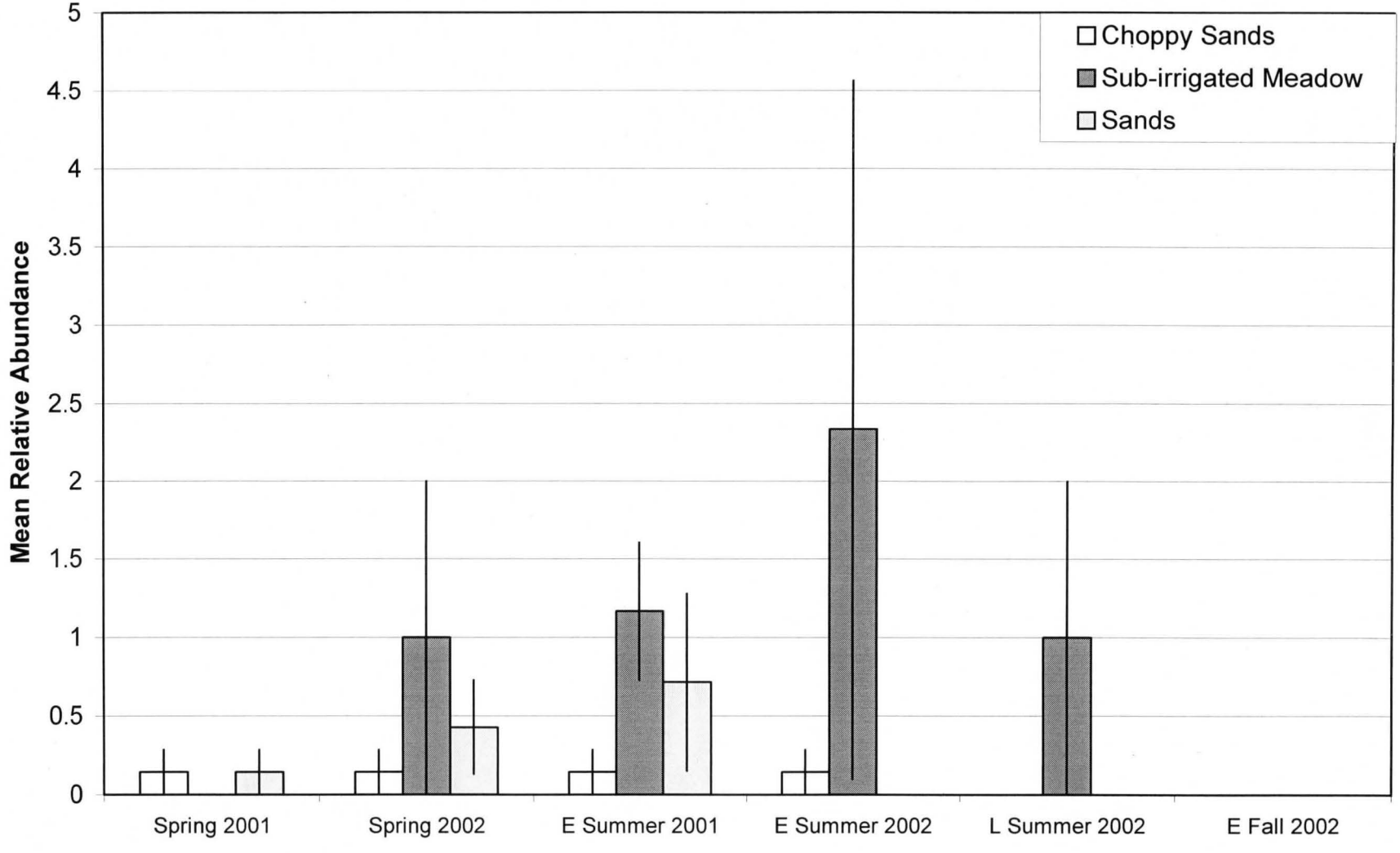

Figure 16. Mean relative abundance (± se) of Upland Sandpiper detected within each habitat type during the breeding season at CLNWR, 2001-2002.

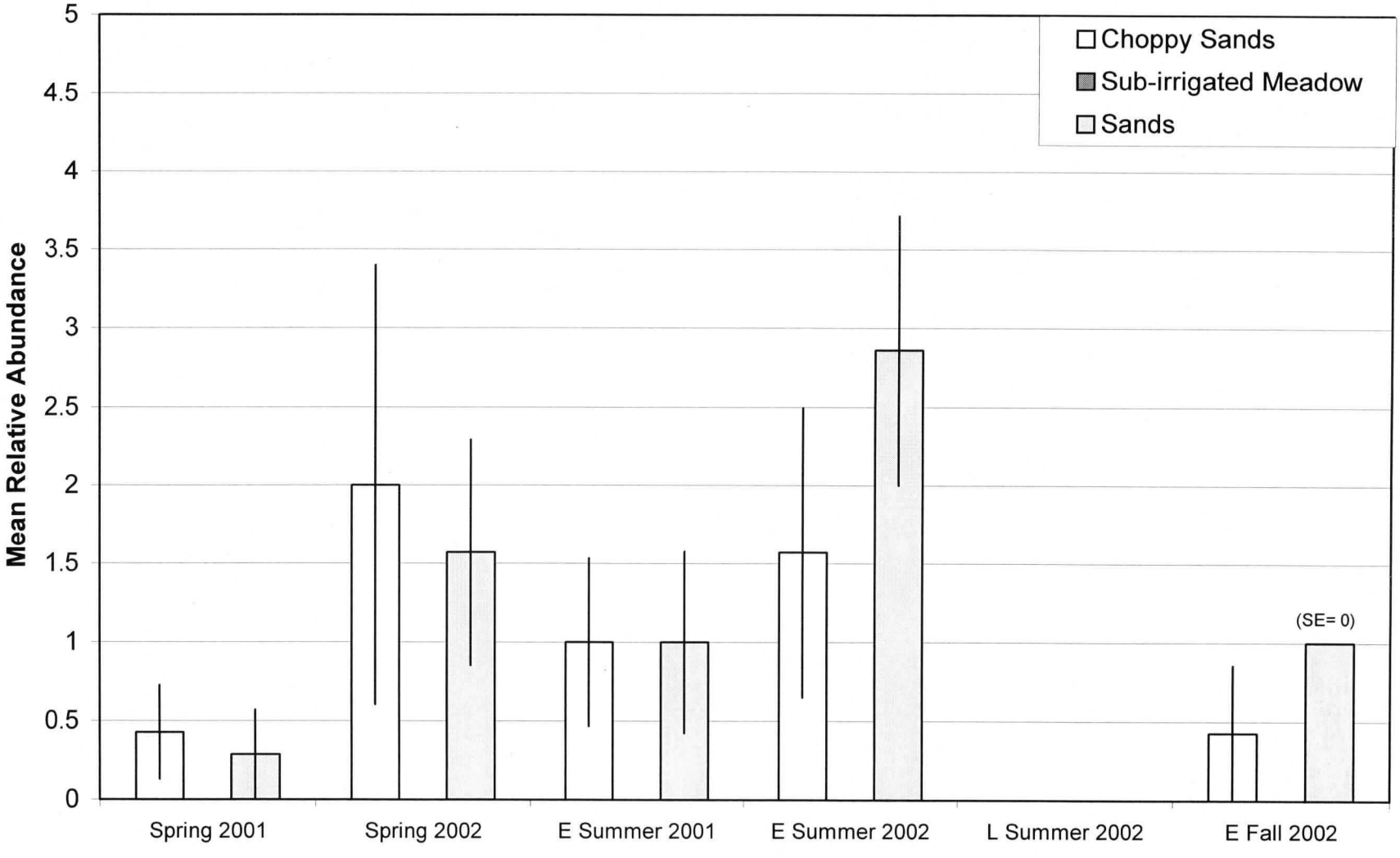

Figure 17. Mean relative abundance (± se) of Horned Lark detected within each habitat type during the breeding season at CLNWR, 2001-2002.

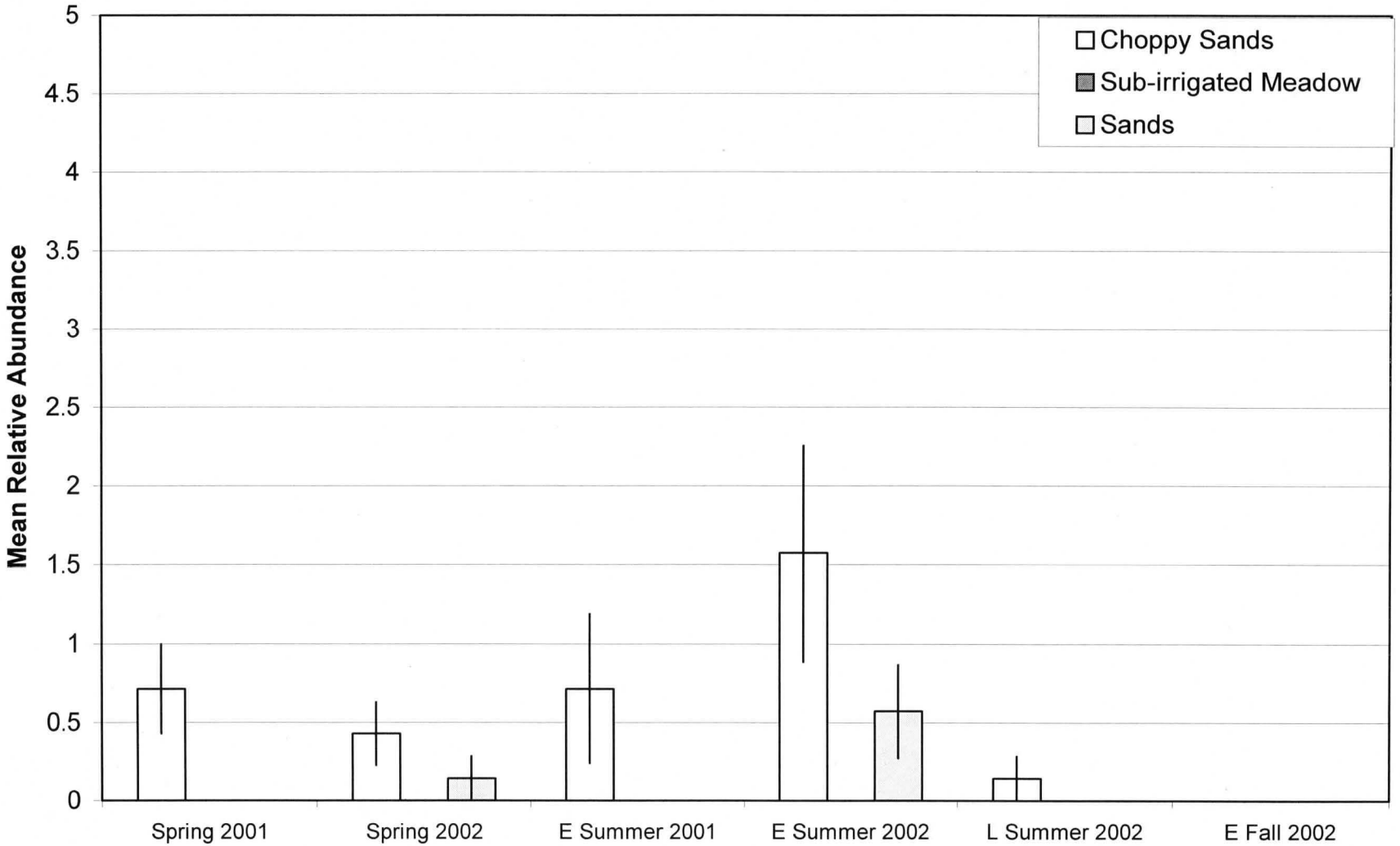

Figure 18. Mean relative abundance (± se) of Vesper Sparrow detected within each habitat type during the breeding season at CLNWR, 2001-2002.

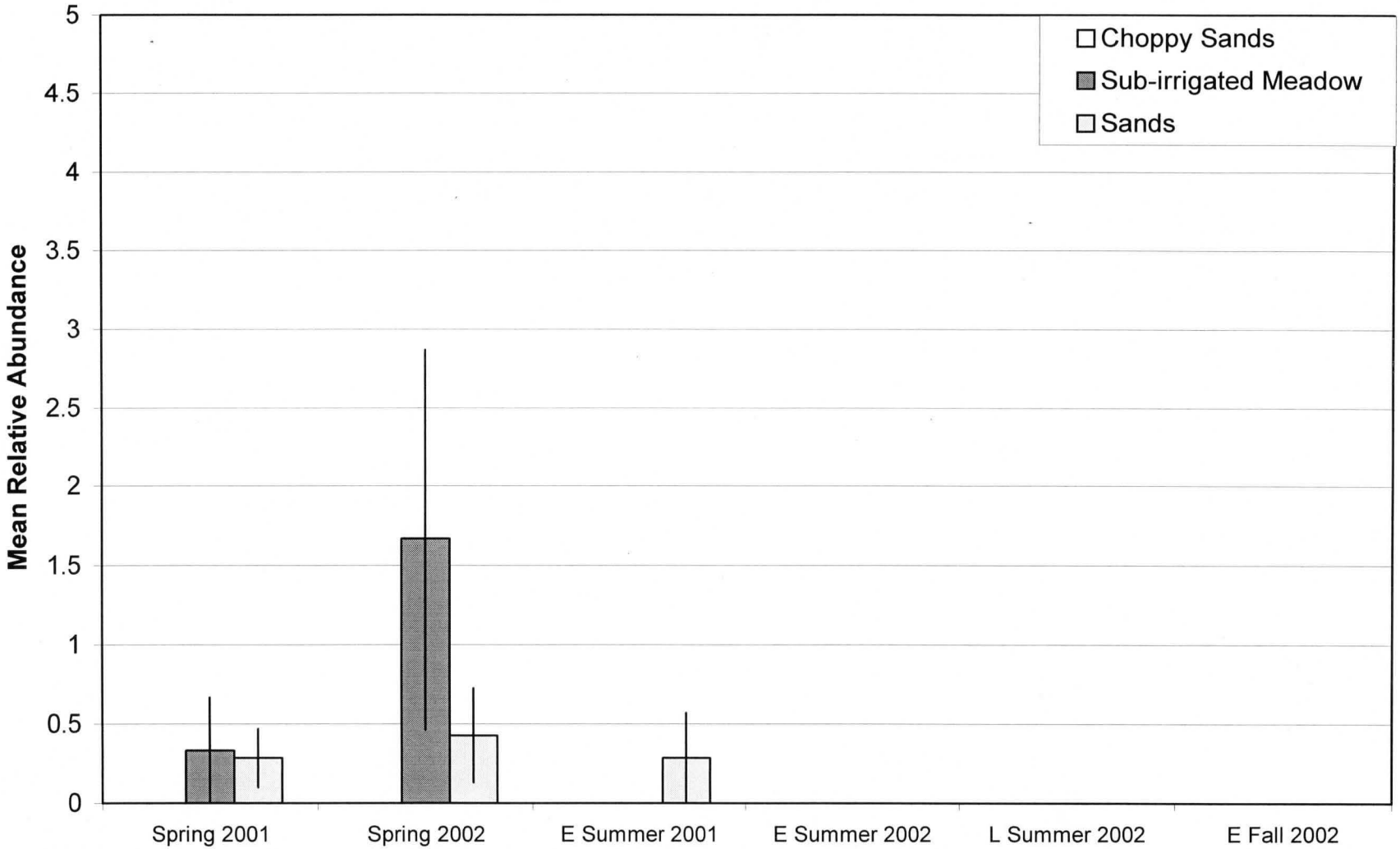

Figure 19. Mean relative abundance (± se) of Long-billed Curlew detected within each habitat type during the breeding season at CLNWR, 2001-2002.

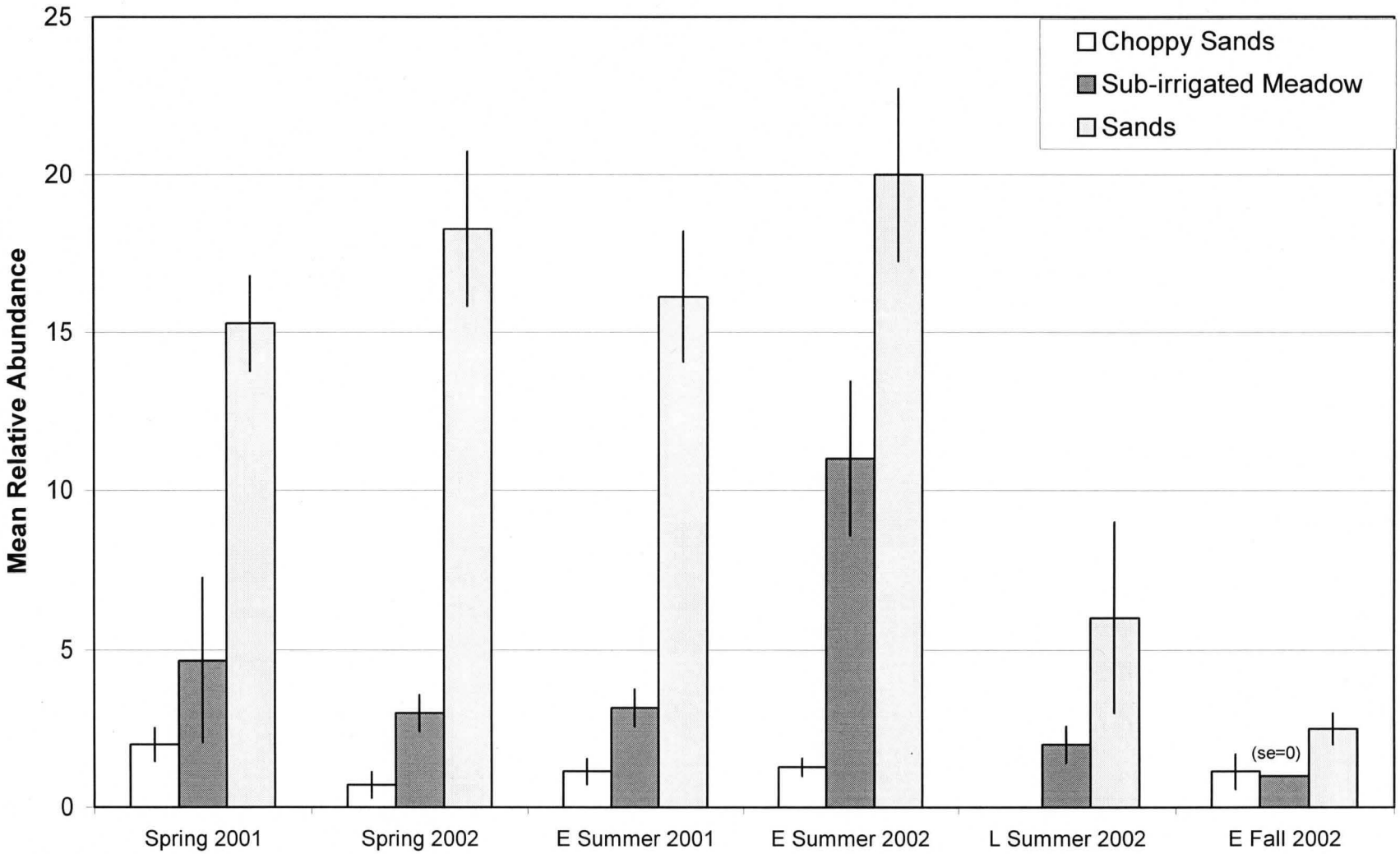

Figure 20. Mean relative abundance (± se) of Grasshopper Sparrow detected within each habitat type during the breeding season at CLNWR, 2001-2002.

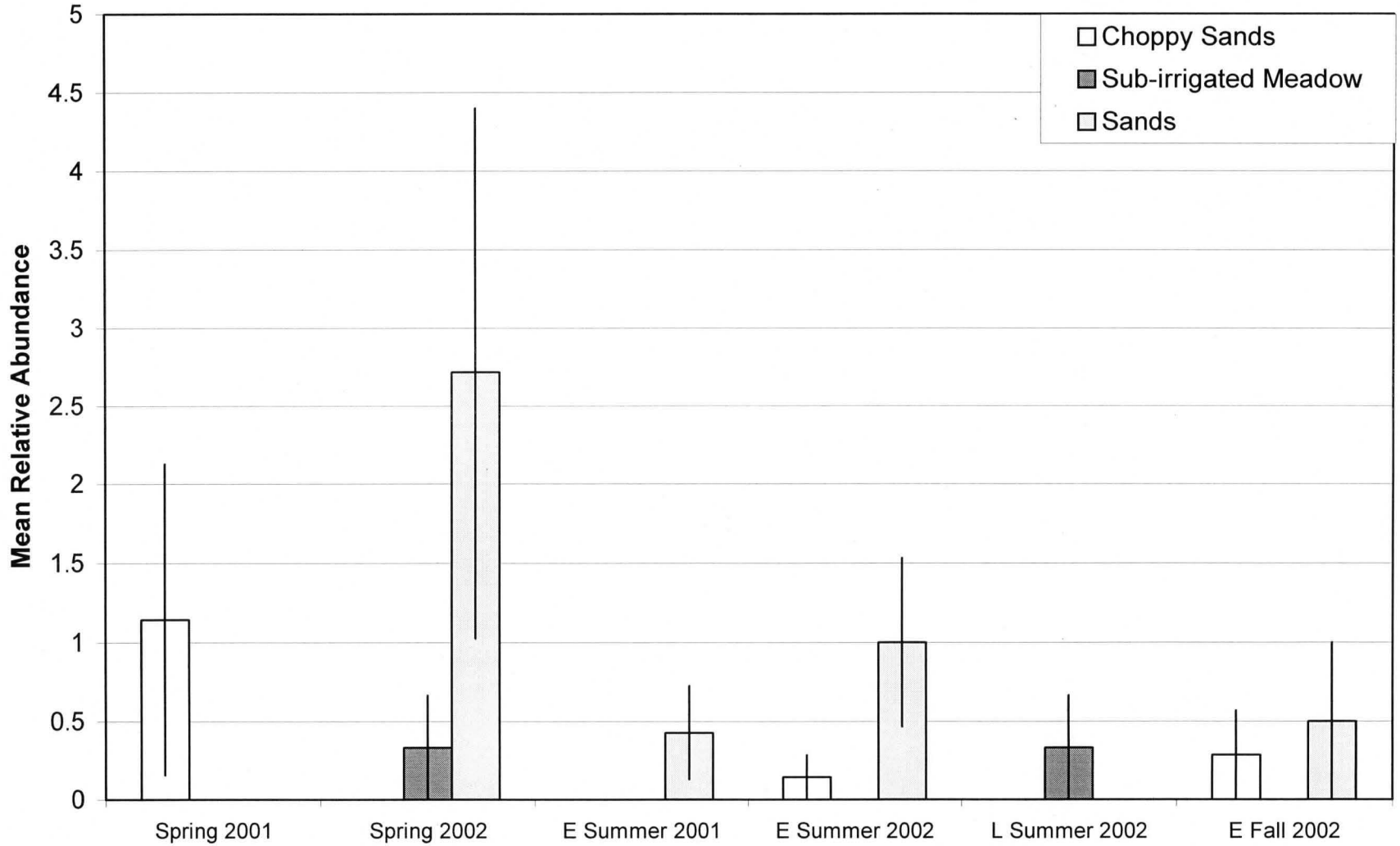

Figure 21. Average relative abundance (± se) of Sharp-tailed Grouse detected within each habitat type during the breeding season at CLNWR, 2001-2002.

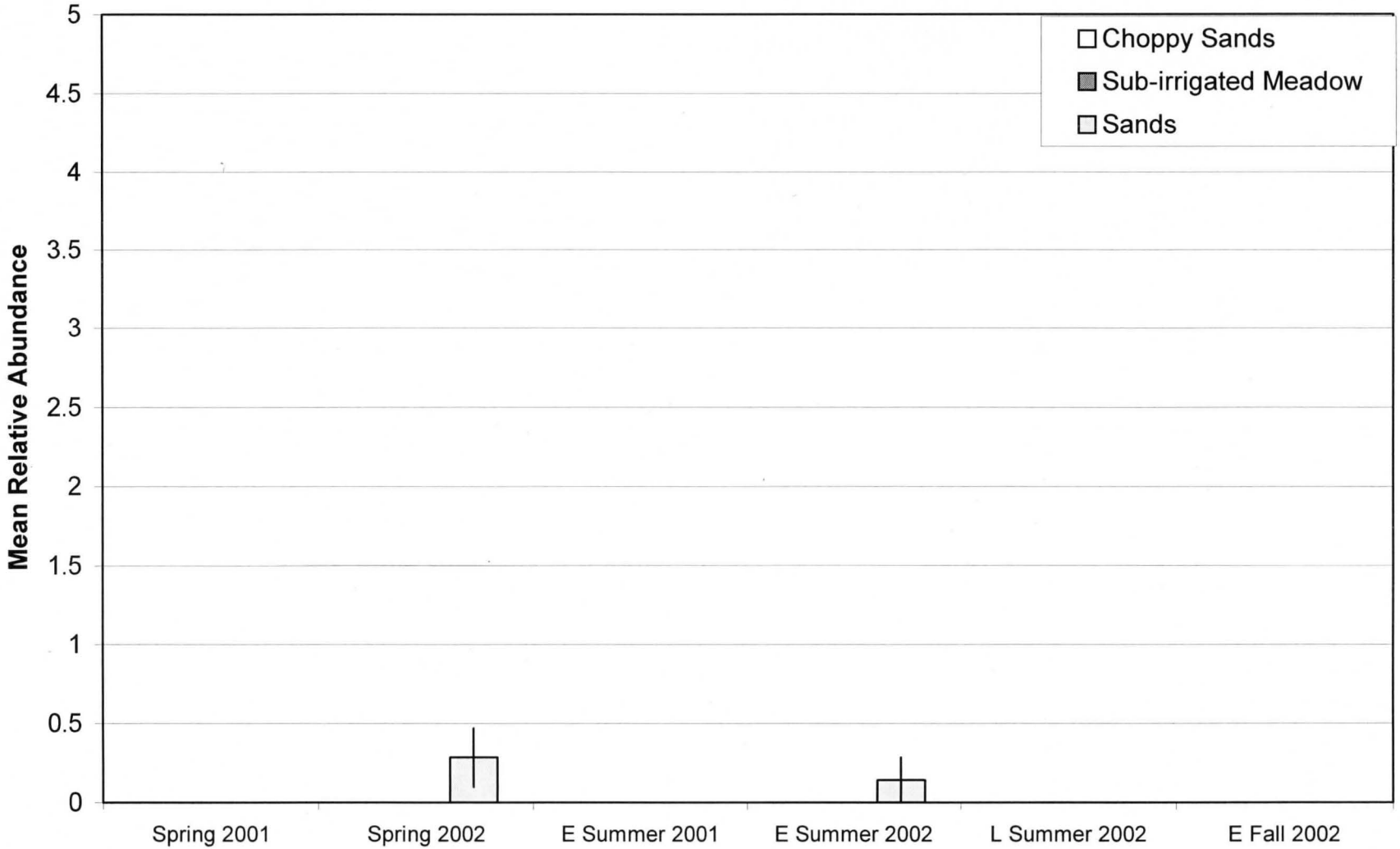

Figure 22. Average relative abundance (± se) of Lark Bunting detected within each habitat type during the breeding season at CLNWR, 2001-2002.

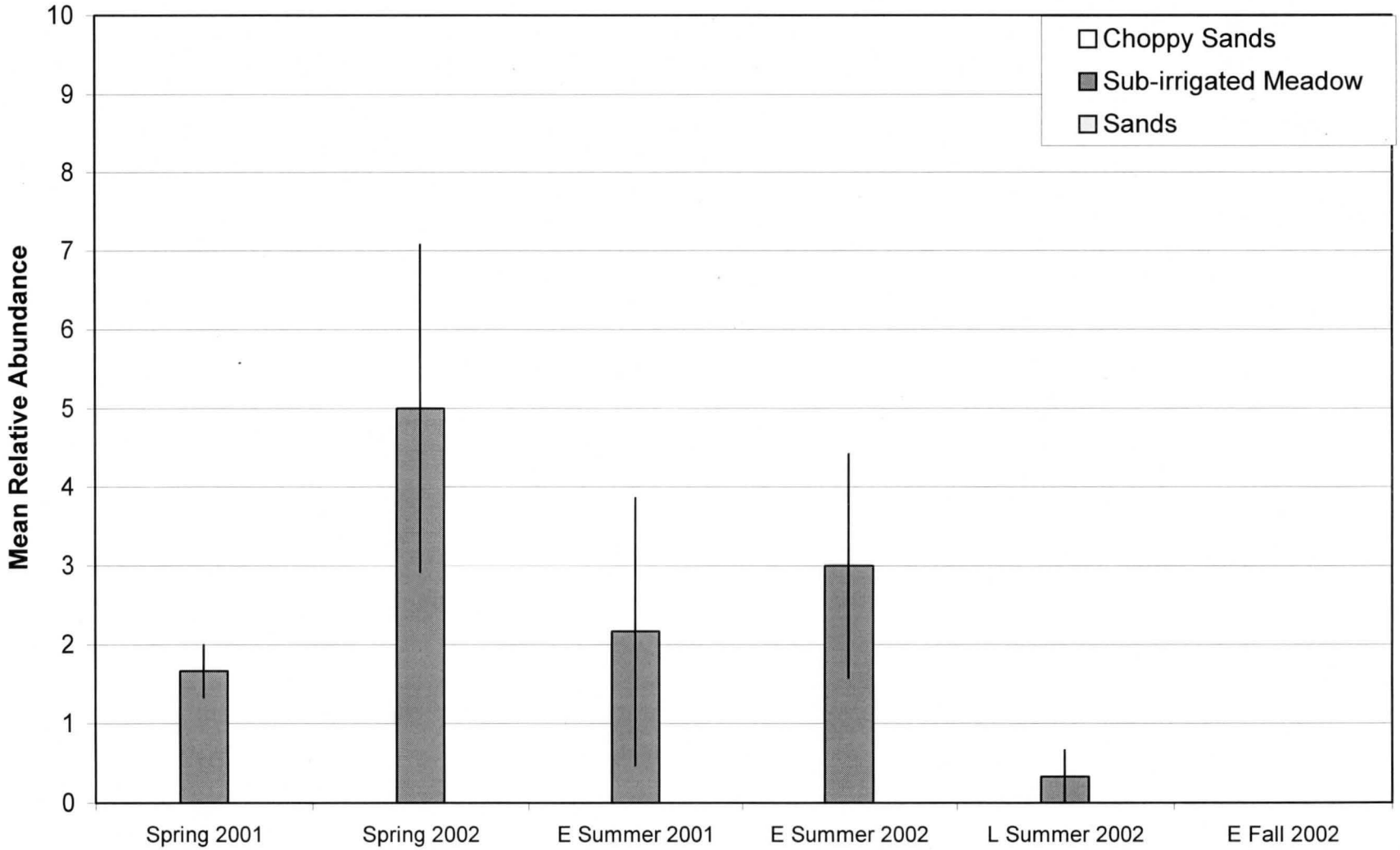

Figure 23. Average relative abundance (± se) of Eastern Meadowlark detected within each habitat type during the breeding season at CLNWR, 2001-2002.

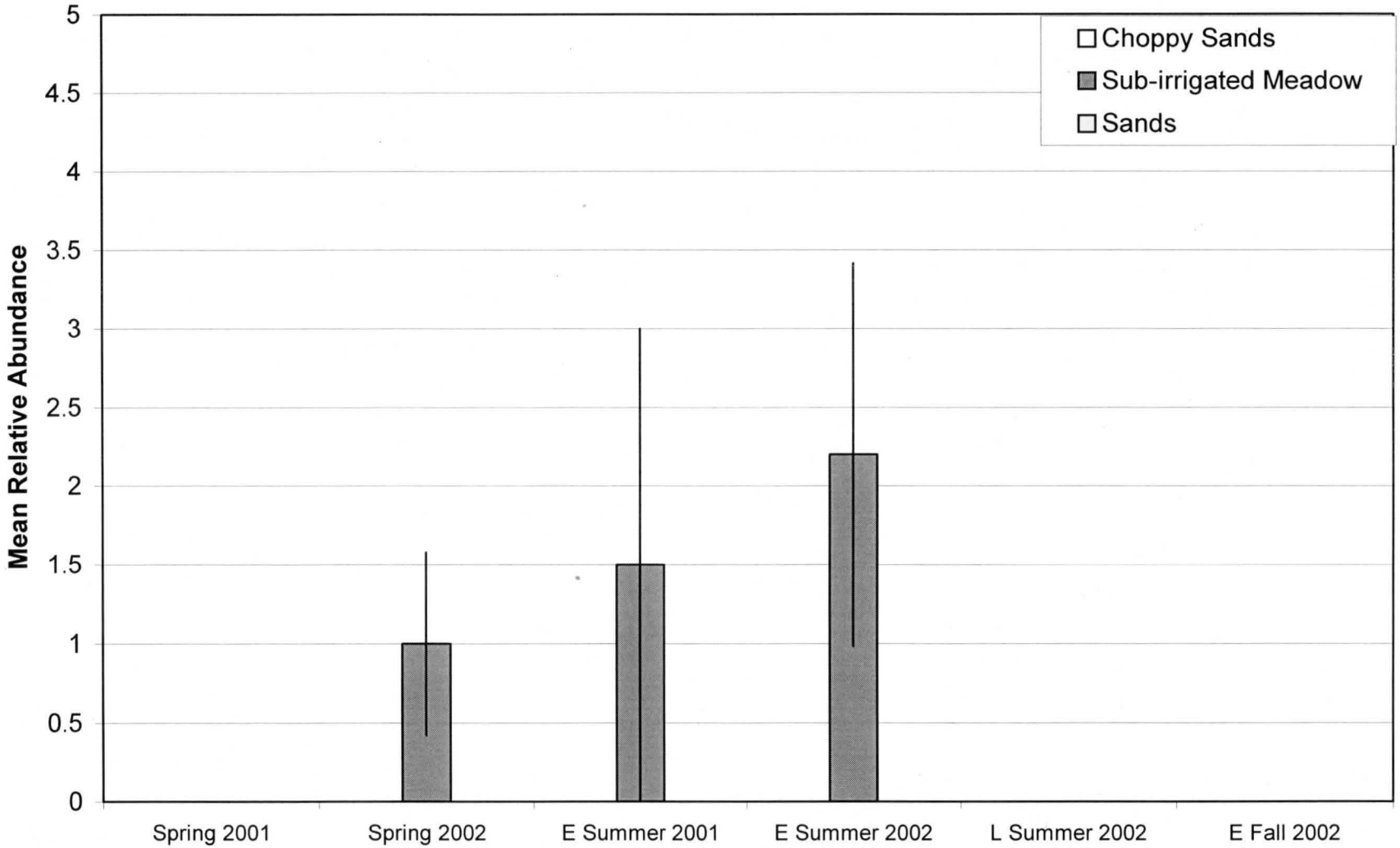

Figure 24. Average relative abundance (± se) of Dickcissel detected within each habitat type during the breeding season at CLNWR, 2001-2002.

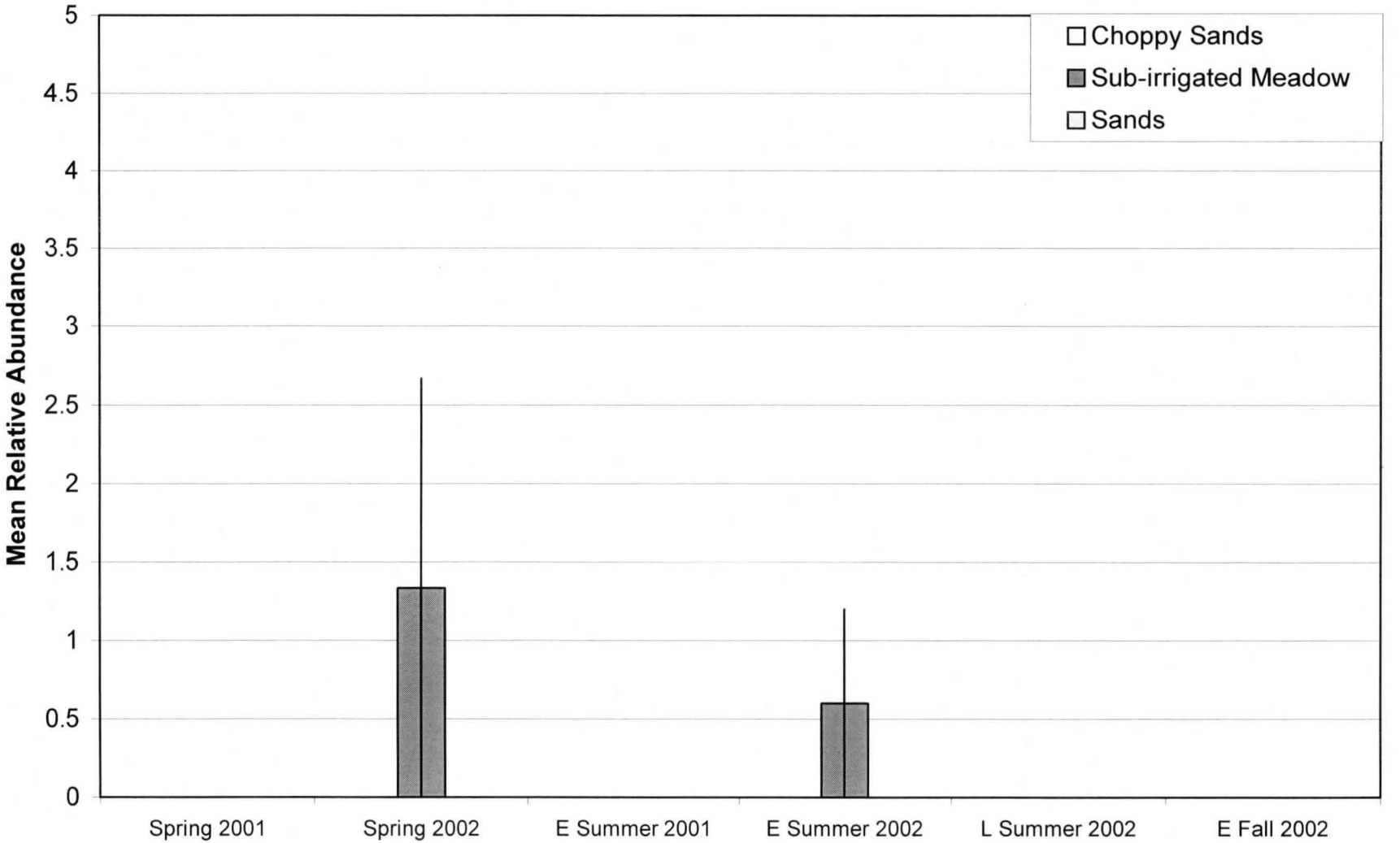

Figure 25. Average relative abundance (± se) of Bobolink detected within each habitat type during the breeding season at CLNWR, 2001-2002.

Meadow	Spring 2001	Spring 2002	Early Summer 2001	Early Summer 2002	Late Summer 2002	Early Fall 2002
American Bittern	0.67 (0.33)	0.67 (0.67)	0	0	0	0
American Coot	0.33 (0.33)	1.0 (1.00)	0.5 (0.50)	0	0	0
Bald Eagle	0	0.33 (0.33)	0	0	0	0
Barn Swallow	0	0	0	0	0	0.67 (0.67)
Brown-headed Cowbird	0	2.67 (2.18)	0.5 (0.5)	0.2 (0.2)	0	0.33 (0.33)
Back Tern	1.33 (1.33)	2.0 (2.00)	0	2.33 (2.33)	2.67 (2.67)	5.0 (5.00)
Blue-winged Teal	0.33 (0.33)	0.67 (0.67)	0	0	0	0
Bobolink	0	1.33 (1.33)	0	0.6 (0.6)	0	0
Common Grackle	0	0	0	0.07 (0.07)	0	1.67 (1.67)
Common Nighthawk	0	0	0	0	0.33 (0.33)	0
Common Yellowthroat	3.33 (0.88)	2.67 (1.20)	3.17 (0.17)	0.87 (0.47)	0.67 (0.33)	0
Dickcissel	0	1.0 (0.58)	1.5 (1.5)	2.2 (1.22)	0	0
Eastern Meadowlark	1.67 (0.33)	5.0 (2.08)	2.17 (1.69)	3.0 (1.42)	0.33 (0.33)	0
Grasshopper Sparrow	4.67 (2.60)	3.0 (0.58)	3.17 (0.60)	11.0 (2.44)	2.0 (0.58)	1.0 (0.00)
Killdeer	0.67 (0.33)	0.67 (0.67)	0.67 (0.44)	1.13 (1.13)	1.67 (1.20)	0
Long-billed Curlew	0.33 (0.33)	1.67 (1.20)	0	0	0	0
Mallard	0	0.67 (0.67)	0	0	0	0
Marsh Wren	4.67 (2.91)	15.0 (10.41)	4.17 (2.09)	6.67 (3.61)	5.0 (1.00)	2.67 (1.20)
Mourning Dove	0	1.0 (1.00)	0	0.67 (0.67)	0.33 (0.33)	0
Northern Pintail	0	0.33 (0.33)	0	0	0	0
Ring-necked Pheasant	0.33 (0.33)	0.33 (0.33)	0	0	0	0
Red-winged Blackbird	29.33 (9.60)	32.67 (10.27)	21.5 (2.89)	18.93 (7.29)	5.33 (4.82)	3.0 (3.00)
Sharp-tailed Grouse	0	0.33 (0.33)	0	0	0.33 (0.33)	0
Tree Swallow	0	0	0	0.2 (0.20)	3.0 (2.52)	0
Upland Sandpiper	0	1.0 (1.0)	1.17 (0.44)	2.33 (2.23)	1.0 (1.0)	0
Western Meadowlark	6.0 (1.00)	5.67 (1.76)	2.67 (0.33)	3.27 (1.54)	2.0 (1.0)	1.67 (0.33)
White-faced Ibis	0	0	0	0.13 (0.13)	0	0.33 (0.33)
Willet	0	1.33 (0.33)	0	0	0	1.67 (1.67)
Wilson's Phalarope	0.33 (0.33)	1.67 (0.88)	0	0.13 (0.13)	0	3.33 (3.33)
Wood Duck	0	0	0	0.2 (0.20)	0	0
Yellow-headed Blackbird	4.67 (2.60)	12.33 (6.23)	4.83 (4.59)	5.4 (3.06)	14.67 (14.67)	0

Sort Key	Period	Date	Site	Transect	Transect area	Species	PreLump
1	Late July '01	######	L Alice	North	shore	RWBL	
2	Late July '01	######	L Alice	North	shore	RWBL	
3	Late July '01	######	L Alice	North	shore	RWBL	
4	Late July '01	######	L Alice	North	shore	WEKI	
5	Late July '01	######	L Alice	North	shore	ORORO	
6	Late July '01	######	L Alice	North	shore	HOWR	
7	Late July '01	######	L Alice	North	shore	HOWR	
8	Late July '01	######	L Alice	North	shore	MODO	
9	Late July '01	######	L Alice	North	shore	COGR	
10	Late July '01	######	L Alice	North	shore	HOWR	
11	Late July '01	######	L Alice	North	shore	MODO	
12	Late July '01	######	L Alice	North	shore	ORORO	
13	Late July '01	######	L Alice	North	shore	AMGO	
14	Late July '01	######	L Alice	North	shore	RWBL	
15	Late July '01	######	L Alice	North	shore	HOWR	
16	Late July '01	######	L Alice	North	shore	ORORO	
17	Late July '01	######	L Alice	North	shore	MODO	
18	Late July '01	######	L Alice	North	shore	AMKE	
19	Late July '01	######	L Alice	North	shore	COGR	
20	Late July '01	######	L Alice	North	shore	MODO	
21	Late July '01	######	L Alice	North	shore	BLJA	
22	Late July '01	######	L Alice	North	shore	WEKI	
23	Late July '01	######	L Alice	North	shore	MODO	
24	Late July '01	######	L Alice	North	shore	HOWR	
25	Late July '01	######	L Alice	North	shore	EUST	
26	Late July '01	######	L Alice	North	shore	BCCH	
27	Late July '01	######	L Alice	North	shore	RWBL	
28	Late July '01	######	L Alice	North	shore	HOWR	
29	Late July '01	######	L Alice	North	shore	ORORO	
30	Late July '01	######	L Alice	North	shore	COGR	
31	Late July '01	######	L Alice	North	shore	EAKI	
32	Late July '01	######	L Alice	North	shore	HOWR	
33	Late July '01	######	L Alice	North	shore	HOWR	
34	Late July '01	######	L Alice	North	shore	MODO	
35	Late July '01	######	L Alice	North	shore	HOWR	
36	Late July '01	######	L Alice	North	shore	MODO	
37	Late July '01	######	L Alice	North	shore	BRTH	
38	Late July '01	######	L Alice	North	shore	DCCO	
39	Late July '01	######	L Alice	North	shore	MODO	
40	Late July '01	######	L Alice	North	shore	BCCH	
41	Late July '01	######	L Alice	North	shore	WODU	
42	Late July '01	######	L Alice	North	shore	MALL	
43	Late July '01	######	L Alice	North	shore	BWTE	
44	Late July '01	######	L Alice	North	shore	RWBL	
45	Late July '01	######	L Alice	North	shore	BEKI	
46	Late July '01	######	L Alice	North	shore	WODU	
47	Late July '01	######	L Alice	North	shore	COYE	
48	Late July '01	######	L Alice	North	shore	ORORO	
49	Late July '01	######	L Alice	North	shore	WEKI	
50	Late July '01	######	L Alice	North	shore	MODO	