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Habitat Use and Migration Patterns of Sandhill Cranes Along the Platte River, 1998 – 2001

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HABITAT USE AND MIGRATION PATTERNS OF SANDHILL CRANES ALONG THE PLATTE RIVER, 1998-2001

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ABSTRACT—During spring migration, sandhill cranes (*Grus canadensis*) rely on the central Platte River valley in Nebraska as a staging area to replenish depleted energy and nutrient reserves. From mid-February to mid-April 1998-2001, we conducted ground and aerial surveys of sandhill cranes in the central Platte River valley. Peak numbers of sandhill cranes (121,000-285,000 cranes) detected during ground surveys occurred in mid-March (1998, 2001) or early March (1999, 2000). From 42% to 55% of the cranes occurred in cornfields, 26%-38% in lowland grassland, 7%-13% in alfalfa, and 2%-12% in other habitats (soybean, winter wheat, shrub-grassland, upland grassland). In general, sandhill cranes preferred channel widths >150 m and avoided channel widths <100 m. Channel widths at roost sites were significantly wider ($P < 0.001$) than channel widths at unused sites (229 m $\pm$ 2.9 S.E. vs. 83 m $\pm$ 2.1 S.E.). Our research suggests future management of sandhill cranes in central Nebraska should include protecting and restoring critical habitats, maintaining appropriate stream flows, and providing adequate river channel widths and food resources.

KEY WORDS: *Grus canadensis*, habitat use, Nebraska, Platte River valley, roost sites, sandhill crane, spring migration

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Introduction

Each spring, hundreds of thousands sandhill cranes (*Grus canadensis*) migrate through the central Great Plains from wintering grounds in Texas, New Mexico, and Mexico en route to breeding grounds in Siberia, Alaska, and northern Canada. During migration, sandhill cranes briefly concentrate

at stopover sites throughout the Great Plains (Johnson and Stewart 1974; Tacha et al. 1984). In central Nebraska, the Platte River valley is considered an important spring staging site, with approximately 80%-90% of the midcontinental population of sandhill cranes (500,000–550,000 cranes; Solberg 2000) staying there for up to six weeks (Tacha et al. 1992). The importance of this region is related to high-quality foraging habitat, that is, croplands and wet meadows, and roosting habitat, that is, wide, shallow, unobstructed river channels associated with the Platte River (Tacha et al. 1994). Waste grain (primarily corn) in croplands provides sandhill cranes with readily available, highly metabolizable foods to build up fat stores (Krapu et al. 1985; Tacha et al. 1987). Invertebrates that inhabit wet meadows provide cranes with essential amino acids and calcium not available in corn and other grains (Reinecke and Krapu 1986). Sandhill cranes accumulate fat and protein reserves during their stay along the Platte River (Krapu et al. 1985), and these reserves likely contribute to successful completion of migration and successful reproduction on the breeding grounds. Wide, unvegetated channels of the Platte River are important to sandhill cranes because they provide secure, undisturbed sites for nocturnal roosting (Krapu et al. 1984; Davis 2001).

During the last 100 to 150 years, wet meadow and open-channel habitats critical to staging sandhill cranes on the Platte River have declined (McDonald and Sidle 1992; Johnson 1994; Currier 1997). During this period approximately 70% of the Platte's flow was stored in reservoirs to be diverted for irrigation and electric generation (Williams 1978). This long-term reduction in the Platte's flow has had a profound impact on wet meadow and open-channel habitats. For example, the reduction in flows has facilitated the conversion of wet meadows, which are hydrologically linked to river flows (Hurr 1983; Wesche et al. 1994), to croplands, homesites, and commercial properties; only 20%-25% of the original wet meadows along the central Platte River remain (Currier and Ziewitz 1987). Additionally, encroachment of woody vegetation on sandbars and narrowing of river channels have resulted from reduced river flows (Williams 1978; Eschner et al. 1981; Johnson 1994; Currier 1997). Sidle et al. (1989) reported that the active river channel in some river segments had been reduced by as much as 90%. Although there is some debate over whether the Platte River historically was a wooded or prairie river (Currier and Davis 2000; Johnson and Boettcher 2000), it is clear that habitat changes during the last 40 to 50 years have influenced sandhill crane distributions in the Platte River. For example, Faanes and LeValley (1993) reported that 60% of the sandhill crane

population in 1957 was located within the Lexington to Kearney reach, but by 1989 only 5% of the population was located in that reach (see Fig. 1). In addition, they found that while only 9% of the population was located in the Kearney to Chapman reach in 1957, by 1989 over 80% of the population was located there.

For most of the last 30 years, the midcontinental population of sandhill cranes has been increasing, but the population may have recently stabilized (Tacha et al. 1994; Sharp et al. 2001). However, the future of this population could be in jeopardy if habitat quality along the Platte River declines further. Moreover, the population also is potentially threatened by other factors, such as food shortages, incompatible farming practices, a burgeoning lesser snow goose (*Chen caerulescens*) population, and inadequate river flows (US Fish and Wildlife Service 1981; Currier et al. 1985; Reinecke and Krapu 1986; Davis 2001). Because of concern over the well-being of this population, the Platte River Whooping Crane Maintenance Trust (hereafter, the Trust) initiated an ongoing, long-term monitoring program to assess the status of sandhill cranes during their stay in the Platte River valley. The objective of this program is to assess sandhill crane distributions, numbers, and habitat-use patterns in relation to weather and habitat conditions. I present the results for the first four years (1998-2001) of this monitoring program.

Methods

Study Area

The study was conducted within a 120 km long by 5 km wide stretch of the Platte River between Chapman and Overton, Nebraska (Fig. 1). The study area encompassed approximately 774 km^2. The dominant habitat types within the study area are cropland, lowland grassland (including wet meadows), upland grassland, riparian forest, and shrubland. Croplands are composed of corn, soybean, wheat, sorghum, and alfalfa. Corn is the principal crop grown in the area. The dominant plants associated with the lowland grasslands in the area are big bluestem (*Andropogon gerardii*), indiangrass (*Sorghastrum nutans*), switchgrass (*Panicum virgatum*), and sedges (*Carex* spp.), and the dominant plants in the upland grasslands are big bluestem, blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), and little bluestem (*Schizachyrium scoparium*) (US Fish and Wildlife Service 1981). The dominant trees of riparian forests include

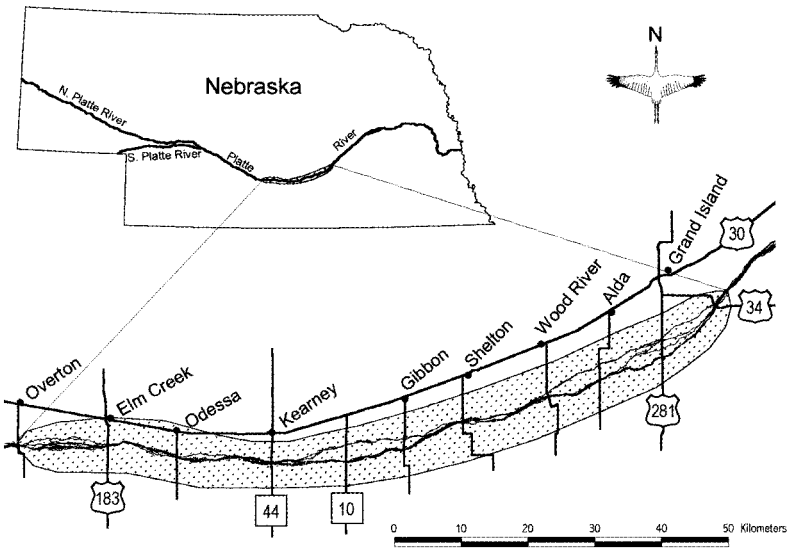

Figure 1. Location of study area in central Nebraska between Grand Island and Overton.

eastern cottonwood (*Populus deltoides*), green ash (*Fraxinus pennsylvanica*), eastern redcedar (*Juniperus virginiana*), red mulberry (*Morus rubra*), rough-leaved dogwood (*Cornus drummondii*), sandbar willow (*Salix exigua*), and American elm (*Ulmus americana*). The shrubland plant community is characterized by a mixture of lowland grassland plants and woody plants such as buffaloberry (*Shepherida argentea*), false indigo (*Amorpha fruticosa*), rough-leaved dogwood, and eastern redcedar (US Fish and Wildlife Service 1981).

Ground and Aerial Surveys

We conducted weekly ground surveys of sandhill cranes along five designated routes throughout the study area from late winter to early spring (15 February–25 April 1998 [spring 1998], 25 February–15 April 1999 [spring 1999], 20 February–15 April 2000 [spring 2000], and 4 March–14 April 2001 [spring 2001]. We selected routes based on sandhill crane

distribution patterns from past studies in the Platte River valley. Routes were located along county roads north and south of the river and were generally within 4 km of the river. We drove approximately 1,452 km on these routes during morning (sunrise to 1200 P.M. CST) and afternoon (1201 P.M. CST to sunset) once each week. Sandhill crane flocks were located along the designated survey routes. We defined individual flocks as groups of sandhill cranes that were separated by ≥100 m from other groups (Iverson et al. 1987). For each observation, we recorded the estimated number of cranes in the flock and associated habitat type (e.g., lowland grassland, upland grassland, corn, alfalfa, and soybean) and land-use practice (e.g., grazed, ungrazed, idled, hayed, tilled, and shredded).

To determine distribution patterns of sandhill crane roosts and numbers, aerial surveys of the river from Chapman to Overton were conducted via a Cessna 172 fixed-wing airplane. These surveys were initiated at sunrise and continued for approximately 2 hr. A total of 27 aerial surveys were conducted during the study (20 February–10 April 1998, $n = 5$; 1–29 March 1999, $n = 8$; 8 March–3 April 2000, $n = 6$; 4 March–6 April 2001, $n = 8$). Sandhill cranes often departed roost sites in the western portion of the survey area early. Thus, surveys were initiated from alternate directions each week from the eastern portion (Grand Island) of the survey area on one day and from the western portion (Kearney) on another day. During flights, one person videotaped crane roosts using an 8 mm video camera, and a second person recorded roost site locations and sizes onto recent (1996) aerial photographs. Individual roosts were defined by groups of cranes that were separated from other groups by ≥100 m (Iverson et al. 1987). Crane roost numbers and roost locations were later confirmed from the videotapes.

Habitat Availability

Habitat availabilities were classified during ground surveys in mid-February 1999 and late November to early December 1999 and 2000. Habitat type was mapped on digital orthophoto quadrangles. ArcView GIS version 2.0a (Environmental Systems Research Institute 1996) was used to determine the area of each habitat type. Availability of each habitat type was expressed as a percentage of the total area classified. Land-use availabilities were not determined because land-use practices changed during each season.

Roost Habitat Characteristics

Roost site selection was evaluated by comparing channel widths of sites used and unused by cranes. Unobstructed channel width is considered an important variable for roosting requirements of sandhill cranes because cranes rely heavily on eyesight to detect approaching predators (Armbruster and Farmer 1982). For this study we determined unobstructed channel widths, that is, where view was not impeded by high islands, stream banks, or trees, for used versus unused sites from aerial photos. Visual obstructions were at least 1 m high (Armbruster and Farmer 1982; Folk and Tacha 1990). Flight videos were used to delineate unobstructed views for measurements on aerial photographs. For sites actually used by cranes, one to four measurements were taken, depending on the length of the roost site (Sidle et al. 1993). For those roosts with multiple channel width measurements, channel widths were averaged. To determine the widths for unused channels, I recorded channel widths at 0.8 km increments on aerial photographs, and only those increments not delineating a roost site were used for comparison with unused sites.

Statistical Analysis

Preference or avoidance of habitat types and channel widths for each year was determined using the log likelihood ratio test for goodness of fit (G-test; Sokal and Rohlf 1981) and Bonferroni Z-statistic (Neu et al. 1974). Habitat availability was based on the percentage of each habitat type within the study area, while channel width availability was based on the percentage of 0.8 km segments that occurred in each channel width class ($\leq$50 m, 51-100 m, 101-150 m, 151-200 m, 201-250 m, 251-300 m, and $\leq$301 m). Habitat-use was based on the percentage of sandhill cranes observed in each habitat type (based on total number of cranes observed each year during ground surveys), and roost use was based on the percentage of sandhill cranes observed in each channel width class (based on total number of cranes observed each year during aerial surveys). Habitat and channel width availability greater than the upper end of the confidence interval on proportional use indicated avoidance, while values less than the lower end indicated preference (Neu et al. 1974). I used one-way analysis of variance to evaluate differences between unobstructed channel widths of used and unused sites (SYSTAT 1992). I used a normality plot to test assumptions of normality and Levene's test to test for homoscedasticity (SYSTAT 1992).

For the one-way analysis of variance, unobstructed channel width was the dependent factor, and site type was the independent factor. All statistical tests were considered significant at $P \leq 0.10$. I selected the higher significance level to control for Type II error.

Results

During 1998-2000, approximately 2,500–10,000 sandhill cranes arrived in central Nebraska in mid- to late January, prior to initiation of our surveys. In 2001 sandhill cranes arrived in central Nebraska in early February, with the first large groups of cranes (2,000–4,000 cranes) arriving in mid-February. In 1998 and 2001 sandhill crane numbers within the study area peaked by mid-March, while in 1999 and 2000 crane numbers peaked by the first week of March (Fig. 2). Crane numbers declined after early April during all four years.

During each year, most of the sandhill cranes were observed in three habitat types: corn, lowland grassland, and alfalfa (Table 1). Crane use of these three habitat types varied among the four years. Sandhill crane use of corn ranged from 42% in 1999 to 55% in 2001, while their use of lowland grassland ranged from 26% in 2001 to 38% in 1999 (Table 1). Sandhill crane use of alfalfa ranged from 7% in 2001 to 13% in 1999. In general, sandhill cranes used the other habitats minimally, except for upland grassland (5%) in 1999 and soybean (6%) in 2001. Sandhill cranes did not use habitat types in proportion to their availability during the study ($G_{7\ d.f.} \geq 15.15$, $P \leq 0.034$). During all four years, cranes exhibited preference for alfalfa and used corn less than its availability (Table 1). Cranes exhibited preference for lowland grassland in 1998-2000 but used this habitat in proportion to its availability in 2001.

Sandhill crane use of corn and lowland grassland was greatly influenced by land-use practice. During the study, most of the crane observations in corn were in grazed and ungrazed stubble. Sandhill crane use of corn stubble was highest (88%) in 2001 (56% for grazed, 32% for ungrazed) and lowest (64%) in 2000 (41% for grazed, 23% for ungrazed). Sandhill crane use of tilled and shredded corn ranged from 12% in 2001 (5% for tilled, 7% for shredded) to 36% in 2000 (16% for tilled, 20% for shredded). In 1999 and 2000, 80% of the cranes observed in lowland grassland were in grazed pastures and 12%-14% were in hayed meadows. In 1998 and 2001 sandhill crane use of grazed pastures was lower (47% for 1998, 70% for 2001) and use of hayed meadows was higher (30% for both years). Sandhill crane use

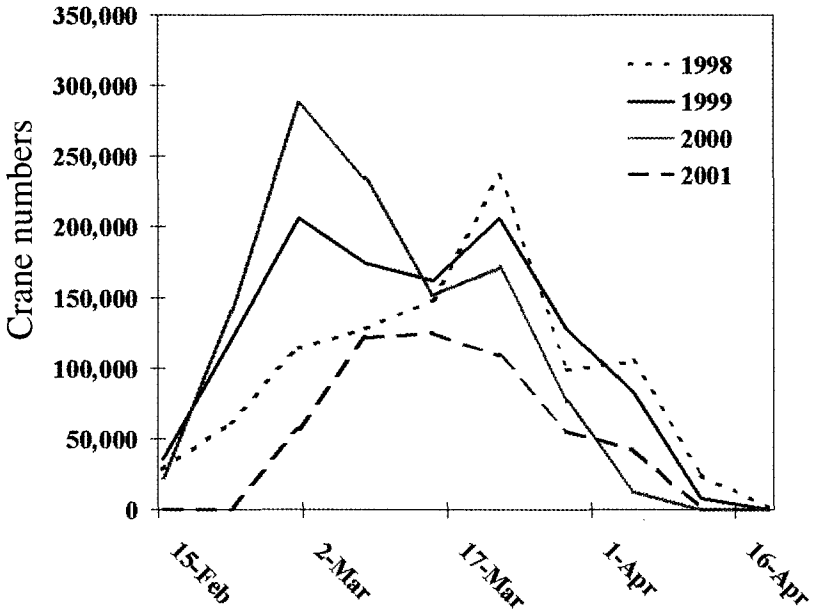

Figure 2. Staging sandhill crane numbers from ground surveys conducted along the Platte River in central Nebraska during spring, 1998-2001.

of idled grassland was minimal (0.6%-2.2%), except in 1998 when use was 21%.

During the study, the maximum number of roosting cranes observed on the river was highly variable. In 1998-2000 the maximum number of roosting cranes observed on the river ranged from 207,700 (28 March 1998) to 284,500 (15 March 1999). In 2001, however, the maximum number of roosting cranes observed on the river was 412,700 (20 March). Crane numbers at each roost site averaged 6,842 ± 205.3 S.E. (n = 1,111 roost sites, range = 4–75,000 cranes). During each year, most of the roosting cranes (89%-98%) were observed in the Highway 34 to Shelton reach (43 km river stretch) and the Gibbon to Highway 10 reach (9 km river stretch) (see Fig. 1).

Most of the roosting cranes (77%-97%) were observed in river channels with widths >200 m (Table 2). Sandhill cranes did not use channel widths in proportion to availability during any year of the study ($G_{6\ d.f.} \geq 179.98$, $P < 0.001$). Sandhill cranes avoided river channels with widths

TABLE 1

AVAILABILITY AND USE OF HABITAT BY STAGING SANDHILL CRANES IN CENTRAL NEBRASKA DURING SPRING MIGRATION, 1998-2001

Habitat	Habitat available (%)[a]	Habitat use (%)				Habitat selection[b]			
		1998	1999	2000	2001	1998	1999	2000	2001
Corn	60.4	54.2	41.5	48.0	55.0	<	<	<	<
Soybean	5.0	1.9	2.4	4.0	6.0	0	0	0	0
Alfalfa	4.7	12.3	13.0	10.0	7.0	>	>	>	>
Winter wheat	0.4	0.5	0.1	0.2	0.6	0	<	0	0
Lowland grassland	26.5	29.7	37.5	35.0	26.0	>	>	>	0
Upland grassland	1.5	0.5	4.5	2.0	4.0	<	>	>	>
Shrubland	1.3	0.2	0.9	0.1	0.6	<	0	<	<
Other[c]	0.2	0.7	0.1	0.2	0.6	>	0	0	>

[a] Habitat availability is based on inventories conducted mid-February 1999 and late November and early December 1999 and 2000.

[b] > indicates use of habitat greater than expected and < indicates use of habitat less than expected. 0 indicates habitat used in proportion to expectation. Habitat preferences calculated following Neu et al. (1974) with $P \leq 0.10$.

[c] Includes farmsteads and feedlots.

≤150 m in 1998, 1999, and 2000 and river channels with widths ≤100 m in 2001 (Table 2). River channel width preferred by sandhill cranes varied during the study from >150 to >250 m. In 2001 sandhill cranes preferred channel widths >150. In 1998 and 1999 they preferred channel widths >250 m and >200 m, respectively. In 2001 sandhill cranes preferred channel widths 201-250 m and >300 m. Overall, channel widths at occupied roost sites were wider (229.33 m ± 2.9 S.E.) than channel widths at unused sections of the river (82.7 m ± 2.11; $F_{1, 2452} = 1{,}709.61$, $P < 0.001$).

Discussion

Historically, sandhill cranes tend to arrive in central Nebraska in mid-February and increase through February (US Fish and Wildlife Service

TABLE 2

AVAILABILITY AND RIVERINE USE BY ROOSTING SANDHILL CRANES IN CENTRAL NEBRASKA DURING SPRING MIGATION, 1998-2001

Channel width classes (m)	Habitat available (%)[a]	Percentage of roosting sandhill cranes (%)				Channel width selection[b]			
		1998	1999	2000	2001	1998	1999	2000	2001
≤ 50	37.4	0.0	0.5	1.7	0.6	<	<	<	<
51-100	25.9	0.5	2.4	7.0	3.1	<	<	<	<
101-150	11.6	0.3	6.7	5.1	7.0	<	<	<	0
151-200	5.2	2.0	9.9	13.2	12.7	0	0	>	0
201-250	7.1	13.7	15.7	21.3	38.2	0	>	>	>
251-300	4.9	14.2	24.4	23.3	10.7	>	>	>	0
≥ 301	7.9	69.2	40.4	28.5	27.8	>	>	>	>

[a] Habitat availability based on the proportion of 406 0.8-km river segments within each channel width class. Measurements were recorded from 1996 aerial photos of the Platte River from Chapman to Overton.

[b] > indicates use of channel width greater than expected and < indicates use of channel width less than expected. 0 indicates use of channel width in proportion to expectation. Habitat preferences calculated following Neu et al. (1974) with $P \leq 0.10$. Samples sizes were 135, 264, 562, and 132 for 1998, 1999, 2000, and 2001, respectively.

1981; Currier et al. 1985). This study supports this pattern, but indicates major variability in the exact date of arrival. In 1998-2000, 5,000–10,000 sandhill cranes arrived in central Nebraska by late January. In contrast, in 2001 the arrival of sandhill cranes was later; large groups of cranes did not begin arriving until mid-February. Such differences in the migration phenology are likely a function of the different weather conditions that occurred during the study. In 1998-2000 mild weather conditions in January and February occurred throughout the central Great Plains. Average temperatures during January and February 1998-2000 ranged from 3°C to 6°C above normal for central Nebraska (National Oceanic and Atmospheric Administration 1998; 1999; 2000). In 2001 weather conditions were colder and snowier in the central Great Plains, especially in February, when aver-

age temperatures were 3°C below normal (National Oceanic and Atmospheric Administration 2001). Over 61 cm of snow fell in central Nebraska during January and February 2001. Melvin and Temple (1982) noted that sandhill crane departures during the spring are usually heaviest with clear skies and southeastern winds. In 1998-2000 these conditions were common in January and February throughout the central Great Plains; in 2001, however, cloudy skies and northerly winds were common (National Oceanic and Atmospheric Administration 1998, 1999, 2000, 2001).

Peak sandhill crane numbers, based on both ground and aerial surveys, fluctuated considerably during the study. For ground surveys, the fluctuating peak numbers may have been due to differences in availability of waste corn as increased fall tillage within the study area during some years may have reduced its availability. As a result, sandhill cranes may have flown farther than the 3 km width of the study area in search of available corn. In fact, large numbers of cranes were observed foraging up to 20 km from the river in 1999 and 2000 (G.L. Krapu and D.A. Brandt, US Geological Survey, Jamestown, ND, unpublished data). For the aerial surveys, the fluctuating peak numbers also may be related to differences in morning departure times of cranes from roost sites and temporal differences in migration phenologies for each year. Norling et al. (1992) noted that departure times of sandhill cranes from roosts were earliest during the beginning of the staging period (9-21 March) in central Nebraska. Moreover, they found that the greatest proportion of sandhill cranes departing before sunrise occurred during that period. In 2001 I recorded a considerably higher maximum number of roosting sandhill cranes (412,700 cranes) than recorded during the previous years. One possible explanation for this higher number may be that the cranes remained on the roost sites longer during that survey, which may have allowed for a more complete survey of the staging population. An examination of the video from the survey tended to confirm the high numbers recorded during the survey, however, poor lighting conditions during videotaping made it difficult to quantify a correction factor. As a result, for some roost sites an overestimation of crane numbers may have played a role in the high number. Additionally, in 2001 larger concentrations of sandhill cranes arrived later in the Platte River valley compared to previous years. Hence, the higher number of cranes may have also been related to more cranes departing from the Platte River valley later, resulting in more cranes occurring on the Platte River during the survey.

Similar to the results of Krapu et al. (1984) for the Platte River valley in 1979 and Iverson et al. (1987) and Folk and Tacha (1991) for the North

Platte River valley in 1980 and 1989, respectively, we observed staging sandhill cranes predominantly using corn stubble, lowland grasslands, and alfalfa. These habitats serve important functions for staging sandhill cranes. Corn stubble provides an abundant, easily accessible, high-energy food (Krapu et al. 1985; Tacha et al. 1987), while alfalfa and lowland grasslands provide important sources of invertebrate foods (Reinecke and Krapu 1986). Additionally, lowland grasslands are important to cranes for pair-formation activities, drinking, and loafing (Iverson et al. 1987; Tacha 1988).

In this study, sandhill crane habitat-use patterns were influenced by land-use practices. In cornfields, cranes exhibited high use of ungrazed and grazed stubble (64%-88%) compared to tilled and shredded stubble (12%-36%). Although availability of these habitat types may have influenced habitat-use patterns, the high use of ungrazed and grazed stubble is likely related to waste corn being more available in those fields compared to fields of tilled and shredded stubble. In West Texas, tilling of corn stubble reduced availability of waste corn by 77% (Baldassarre et al. 1983). Although the effect of shredding on waste corn availability is unknown, shredding likely reduces waste corn availability because corn kernels may become buried in the shredded litter.

During the last 20 years, a precipitous decline in waste corn available to staging sandhill cranes has occurred in central Nebraska. From 1978 to 1998 waste corn available to sandhill cranes declined by nearly 50% (G. L. Krapu and D. A. Brandt, US Geological Survey, Jamestown, ND, unpublished data). This decline has been attributed primarily to improved corn harvesting efficiency; however, increased foraging pressure by expanding populations of wintering Canada geese (*Branta canadensis*) and of staging lesser snow geese prior to sandhill crane arrival in central Nebraska has also contributed to the decline (G.L. Krapu and D.A. Brandt, US Geological Survey, Jamestown, North Dakota, unpublished data). Currently, waste corn availability does not appear to be limiting to the midcontinental population of sandhill cranes. However, if the midcontinental population of lesser snow geese continues to grow rapidly, availability of waste corn could become limiting to sandhill cranes. Moreover, if fall tillage of cornfields continues to increase in central Nebraska, supplies of waste corn would be further depleted. Future management for sandhill cranes in central Nebraska may need to consider discouraging both snow goose use and fall tillage in the areas heavily relied upon by the cranes.

Sandhill cranes tend to prefer grasslands with lower vegetation height (<25 cm) and sparse cover (Lovvorn and Kirkpatrick 1982; VerCauteren

1998). Lower vegetation height and sparse cover provide cranes with an unobstructed view of the surrounding landscape and allow freedom of movement through the grassland (Lovvorn and Kirkpatrick 1982). In this study, sandhill cranes extensively used grazed pastures and hayed meadows. Sandhill crane selection of these grasslands is probably related to the lower vegetation height created by the management practices. Additionally, sandhill cranes may be attracted to the grazed pastures because of enhanced foraging opportunities for soil invertebrates. Grazing can increase soil invertebrate numbers, particularly scarab beetles (Scarabaeidae) and earthworms (*Aporrectodea* spp.), by adding organic matter to the system (Ritcher 1958; Edwards and Lofty 1977; Davis and Vohs 1993a). In grasslands of the Platte River valley, sandhill cranes primarily feed on scarab beetles and earthworms (Reinecke and Krapu 1986; Davis and Vohs 1993b).

In general, sandhill cranes preferred wide river channels (>150 m) and avoided narrow river channels (<100 m) during this study. Similarly, Krapu et al. (1984) found that sandhill cranes staging in the central Nebraska preferred river channels >150 m wide and avoided river channels ≤50 m wide. Several researchers have suggested that sandhill cranes select roosting sites based on the association of wide, unobstructed river channels to lowland grasslands (Folk and Tacha 1990; Faanes and LeValley 1993; Sidle et al. 1993). In this study, roosting cranes were primarily concentrated within two reaches of the Platte River (Highway 34 to Shelton and Gibbon to Highway 10) that contained some of the widest river channels (>250 m) and largest tracts of lowland grasslands.

Maintaining adequate river flows is critical for providing roosting habitat for sandhill cranes during the spring. Currier et al. (1985) reported that river flows need to be maintained at a minimum of 57 m^3/sec to provide ideal roosting habitat for sandhill cranes. Specifically, these flows will provide the optimum range of roosting depths (10.2-20.3 cm; Armbruster and Farmer 1982) within a 150 m wide channel required by sandhill cranes. During this study, average river flows ranged from 49 m^3/sec in 1999 to 116 m^3/sec in 1998 (D. Hitch, US Geological Survey, North Platte, NE, unpublished data). For the most part, river flows during this study appeared to provide adequate roosting habitat for sandhill cranes. However, during a two-week period in 1998, river flows averaged 165 m^3/sec (D. Hitch, US Geological Survey, North Platte, NE, unpublished data). These extremely high flows (170% above long-term flows), which were caused by above-normal precipitation in Colorado and releases from reservoirs on the North Platte River, appeared to have a significant impact on roosting cranes. The

higher flows resulted in many traditional sandhill crane roost sites being inundated with deep water. As a result, large numbers of cranes were forced to search for alternative roost sites after sunset, making them more vulnerable to power-line collisions.

Conservation and management of habitat complexes composed of riverine roost sites in close proximity to cornfields, lowland grasslands, and alfalfa should be a high priority for sandhill crane management in central Nebraska (Tacha et al. 1994). Protection of existing habitat complexes and development of future habitat complexes are important components of a sandhill crane management plan for central Nebraska. Additionally, maintenance of adequate stream flows in the Platte River for roosting cranes is important. Lowland grasslands are the most limited habitat along the Platte River (Currier and Ziewitz 1987), and yet they play a critical role in sandhill crane pair formation and foraging activities; restoration of marginal croplands to lowland grasslands, especially those croplands adjacent to wide river channels, should also be examined in management plans. During the last 20 years the Trust and other conservation organizations have been maintaining wide, unvegetated river channels for crane roosting by using heavy equipment to remove vegetation from islands and riverbanks (Currier 1991). Faanes and LeValley (1993) suggested the increase of sandhill cranes in the reaches downstream of Kearney may be attributed to mechanical removal of vegetation. Because woody vegetation is no longer controlled by peak scouring flows of the Platte River during the spring, future management of roosting habitat should continue to include mechanical removal of vegetation. The future of the midcontinental sandhill crane population may depend on comprehensive and proactive management to protect existing habitats, restore lowland grassland and riverine roosting habitats, manage appropriate stream flows, and ensure adequate and available food resources.

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