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AVAILABILITY OF STOPOVER HABITAT FOR MIGRANT WHOOPING CRANES IN NEBRASKA

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Abstract: Four stratified random samples of 512 National Wetland Inventory (NWI) maps within the central Nebraska portion of the Wood Buffalo-Aransas whooping crane (*Grus americana*) migration corridor were used to evaluate the availability of wetland roost sites. Wetlands were eliminated as potential roosts if visibility was obscured by vegetation or slope, if certain human activities occurred within 100–800 m, or if water <30 cm deep was not available. Seasonal emergent wetlands, available as roosts primarily in spring, dominated all samples, particularly in the north. Sixty-five percent of all wetlands >0.04 ha passed map review and 52% passed when ground-truthed. NWI map review was a good predictor of both suitability (63% correct) and unsuitability (73% correct). More than one-half of all open and emergent wetlands >1 ha passed both map and field review. Four of 6 major east-flowing rivers provide additional roosting habitat of varying quality. Stopover habitat is available throughout the migration corridor in Nebraska, though quality is best in the northern sandhill region and along major rivers. NWI map review, with adequate ground-truthing and observer experience, can provide good estimates of roost availability in open prairie where woody vegetation is limited.

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Key words: *Grus americana*, habitat maps, migration, Nebraska, whooping crane.

The whooping crane was one of the most perilously endangered of species; all individuals alive today are descended from 16 cranes that wintered at Aransas National Wildlife Refuge, Texas, in 1941 (U.S. Fish and Wildlife Service 1986). Research and management from the 1930's through the mid-1970's were concentrated on wintering and breeding (Wood Buffalo National Park, Canada) areas. Documentation of the migration route (Howe 1989, Kuyt 1992) and stopover roosting habitat requirements (Lingle et al. 1984, Howe 1987, Ward and Anderson 1987) came in the 1980's and is ongoing. As information has accrued on roost sites of migratory cranes, suitability criteria and indices for non-traditional stopover roosts (sites generally used only 1 night [Melvin and Temple 1982]) were developed (Armbruster 1990). Concern about the availability of suitable wetland roosts within the migration corridor (Lingle 1987) prompted efforts to inventory potential roost sites.

Nebraska has long been known as an important stopover for migrating whooping cranes (Swenk 1933, Johnsgard and Redfield 1977). Research and management efforts there have concentrated on the Platte River, where conflicts have been high (Krapu et al. 1982, Lingle 1982, Faanes 1992). Suitable riverine roosting habitat for whooping cranes in the Big Bend region of the Platte has declined an average of 55% since 1938 (Currier et al. 1985) to less than 5,000 ha. Such detailed information on habitat availability elsewhere in Nebraska is not currently available.

NWI, the U.S. Fish and Wildlife Service's (USFWS) catalog of the nation's wetlands, provides baseline data on the physical characteristics and extent of all United States wetlands (Montanari and Townsend 1977, Cowardin et al. 1979). Though NWI has not yet been completed throughout the Wood Buffalo-Aransas whooping crane migration corridor, it does provide a potentially large data base for analysis of the availability of stopover habitat to this crane population. Stahlecker (1992) found that NWI maps, when used in conjunction with aerial photo maps and suitability criteria (Armbruster 1990), were poor predictors (33% correct) of suitable whooping crane roosts in Oklahoma, but good predictors (97% correct) of unsuitability of potential crane roosts. Experience gained in Oklahoma was used in the second phase of this project to estimate roost availability in Nebraska.

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STUDY AREA AND METHODS

Central Nebraska is largely privately owned and highly agricultural. Cattle ranching dominates the northcentral third (sandhills) of the state, where sandy soils on rolling hills are largely unsuitable for tillage but very productive of grass and hay. The high water table in the sandhills produces many natural lakes and streams, and few man-made wetlands have been constructed. Though pastures and cattle are also present in the heavier-soiled southcentral two-thirds of Nebraska, farming of grains, particularly corn, is the dominant land use and man-made stock ponds are common.

Table 1. Wetland classifications and modifiers (Cowardin et al. 1979) commonly encountered on Nebraska National Wetlands Inventory maps and their stopover roost categories.

Roost type	Map code	Wetland classification: System (subsystem), class	Modifiers: Water regime[a]	Modifiers: Special[b]
Open	L2AB	Lacustrine(2 = Littoral), Aquatic Bed	A = temporary	d = partially drained
	PAB	Palustrine, Aquatic Bed	C = seasonal	
	PAB/EM	Palustrine, Aquatic Bed/EMergent	F = semipermanent	f = farmed
	PUS	Palustrine, Unconsolidated Shore,	G = intermittently exposed	h = impounded
	PUB	Palustrine, Unconsolidated Bottom		x = excavated
Emergent	PEM	Palustrine, EMergent	H = permanent	
Riverine	R2UB	Riverine (2 = Lower Perennial), Unconsolidated Bottom		
	R2US	Riverine (2 = Lower Perennial), Unconsolidated Shore		
No good[c]	R4SB	Riverine (4 = Intermittent), Stream Bed		
	PFO	Palustrine, FOrested		
	PSS	Palustrine, Shrub/Scrub		

[a] Modifiers indicate length of time wetland has surface water.
[b] Modifiers indicate mostly human activities.
[c] Intermittent streams are seldom suitable roosts; wooded wetlands most likely have horizontal visibility problems.

I used NWI maps, U.S. Geological Survey (USGS) topographic maps, whooping crane roost suitability criteria (Armbruster 1990), and ground truthing to estimate the density of potential whooping crane roosts in central Nebraska. There are 11 common NWI wetland classes (Cowardin et al. 1979) in the study area. Eight have potential as whooping crane roost sites and can be grouped into 3 general wetland types: open water, emergent, and riverine (Table 1).

Two USGS map scales are pertinent to this study: 1:24,000 and 1:100,000. NWI maps are 1:24,000 topographic maps (157.5 km^2) of categorized wetlands. There are 32 (4 by 8) NWI maps within each smaller scale 1:100,000 map and 16 (15 full maps plus 2 half maps) 1:100,000 maps within the whooping crane migration corridor in central Nebraska (Fig. 1). Sandhills dominate 7 of the northern and westernmost 1:100,000 maps.

I conducted 4 stratified random samples of the 512 (16 × 32) NWI maps available as detailed below. In Sample I all wetlands were evaluated and in Sample II only wetlands ≥1 ha were examined. Both samples were first evaluated from data on NWI maps (subscript ME = Map Exam); later a subsample of each was ground-truthed (subscript GT = Ground Truth). In addition, the USFWS has totaled all wetlands by type on 8 of the 17 1:100,000 maps used in this study. I summarized those totals by potential roost type (open, emergent, or riverine) to make comparisons and extrapolations with the data from samples within those 8 mapping units.

Sample I_{ME}

This 32-map (6%) sample was obtained by randomly selecting 2 NWI maps from each of the 16 1:100,000 map units (Fig. 1). Previous migration studies documented that >50% of whooping crane stopover roosts were in wetlands <1 ha and that wetlands as small as 0.01 ha were used (Howe 1987, 1989). Therefore, any wetland large enough (≥0.04 ha) to appear on a NWI map was evaluated. Wetlands were subtotaled on each 256-ha (640-acre) section and totaled for the entire NWI map.

All wetlands were categorized by roost type (open, emergent, or riverine) and by size (<1 or ≥1 ha). I used a Wainer Land Area and Slope Indicator to estimate wetland size. Streams were difficult to categorize by size. Therefore the entire reach of a stream in a 1.6-km^2 (1-mi^2) section was considered 1 wetland; a stream that crossed more than 1 section was recorded as a separate wetland in each section. This portion of my evaluation was equivalent to Armbruster's (1990) Suitability Index of Wetland Size (SIWS) (Fig. 2A).

A Suitability Index of Horizontal Visibility (SIHV) was then determined for each wetland. A wetland <25 m from obstructions ≥1 m height, such as shrubs, trees, or steep slopes along ≥5° of shoreline, is considered unsuitable for crane roosting (Armbruster 1990) and was assigned SIHV of 0 (Fig. 2B). The aerial photographs used to delineate wetlands by the USFWS were not readily available, so they could not be used to check for visual obstructions. Soil

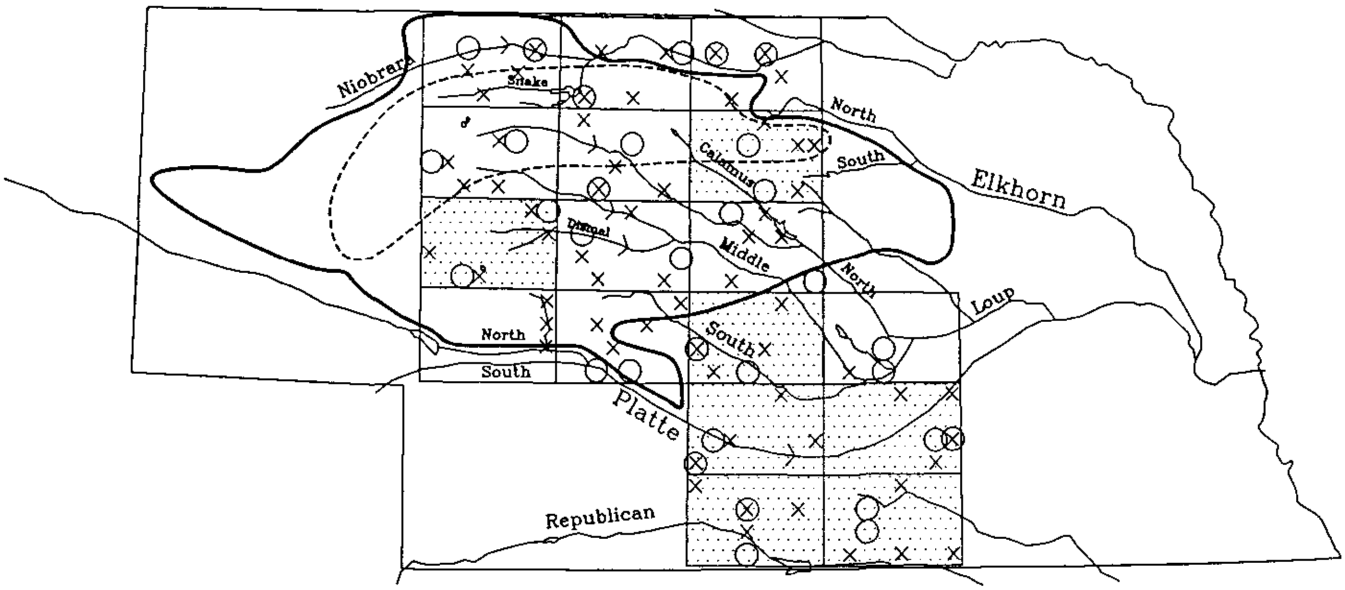

Fig. 1. Rivers and sample National Wetlands Inventory maps in central Nebraska. Sample I maps are X's and Sample II maps are O's. All 17 1:100,000 map units are shown; shaded 1:100,000 map units are those where the total numbers of wetlands by type were known. The dark line encircles the Sandhills; the light line encircles the area containing many natural lakes. Arrows (>) on major rivers indicate point below which there are consistently high SIHV's.

Conservation Service county aerial photographs (Stahlecker 1992) were also not available for all Nebraska counties in the sample, so I used standard USGS topographic maps to look for potential visual obstructions. I used contour lines on NWI maps to estimate slope; 2 or more 3-m contour lines within 30 m of the shoreline for $\geq 180°$ portion of the wetland also resulted in an SIHV of 0 and deletion from further consideration.

Those wetlands meeting the SIHV criteria were then evaluated for disturbance factors (Table 2) (Armbruster 1990). If at least 0.04 ha of a wetland was beyond the range of all disturbance factors shown, and measured on the NWI map, it had Passed Map Examination (PME).

Sample I_{GT}

I randomly selected 3 sections (2.56 km^2) from each NWI map in Sample I_{ME} (n = 96) to ground truth. During October 1992, I visited 86 sample sections (I was denied, or could not find, access to 10 sections). For each wetland an SIHV was estimated and disturbance factors evaluated. If SIHV and disturbance criteria were met, I determined a Suitability Index of Water Depth (SIWD) by either measuring or estimating water depth. An SIWD of 1 was assigned if water was <30 cm deep at 20 m from shore; otherwise SIWD was 0 (Armbruster 1990). If at least 1 wetland in a section passed all 3 tests, the section had Passed Ground Truthing (PGT). PGT results were compared directly with PME results quantified in the same sections during Sample I_{ME}.

Sample II_{ME}

The study in Oklahoma had shown that so few small wetlands (<1 ha) were suitable roosts that a second sample only of larger (≥ 1 ha) wetlands was taken (Stahlecker 1992). In Nebraska I again randomly selected 4 NWI maps from each 1:100,000 unit (Fig. 1), a total of 64 maps (12%), to sample wetlands ≥ 1 ha. I followed the same procedures outlined in Sample I_{ME} to eliminate unsuitable wetlands.

Sample II_{GT}

During October 1992 I visited 55 open, 82 emergent, and 233 riverine wetlands ≥ 1 ha in a stratified random sample of the total counted in Sample II_{ME}. No more than 3 wetlands of the open and emergent roost types were visited in each NWI map in Sample II_{ME}; all riverine sections were visited because riverine habitat was much less common. Each wetland was evaluated following the same procedure as outlined for Sample I_{GT}. Since many large wetlands were seasonally dry during ground testing, I also recorded whether a wetland was likely to be suitable during the drier autumn period rather than the wetter spring period when aerial photographs for

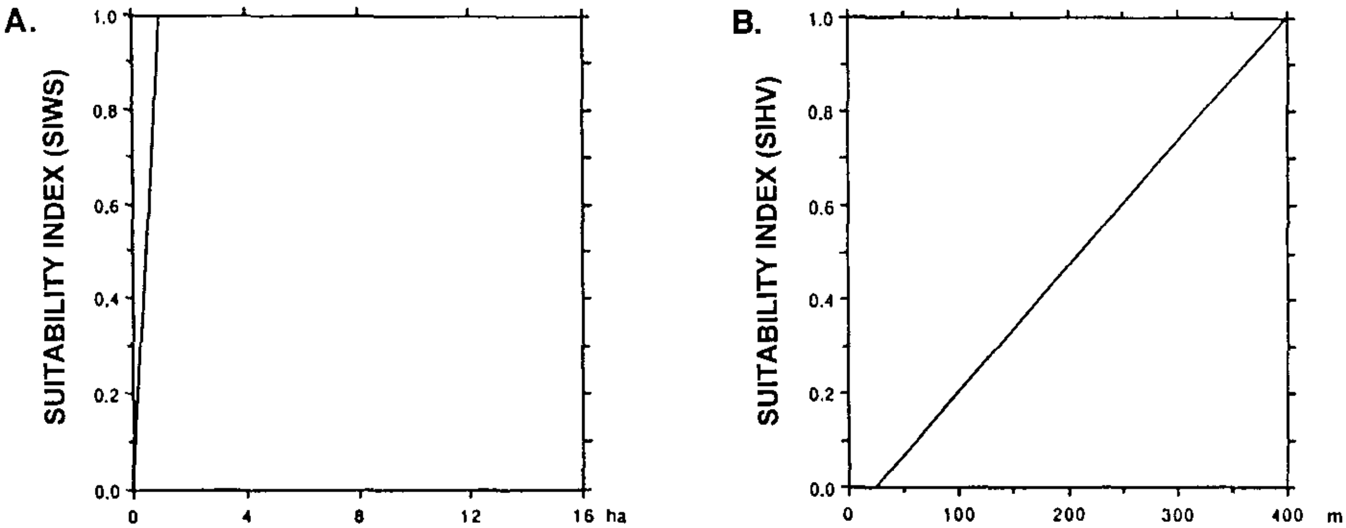

Fig. 2. Predicted relationships between (A) wetland size and (B) horizontal visibility and roosting suitability for non-traditional (migration) stopover sites (from Armbruster 1990).

NWI evaluation are generally taken.

Analysis

I categorized wetlands by roost type, size, and suitability criteria for each NWI map in Samples I_{ME} and II_{ME} and for each section for Sample I_{GT}, then converted to wetlands/100 km^2 and wetlands/km^2, respectively. I used regression analysis and paired *t*-tests to evaluate the relationships between variables within Samples I_{ME} and II_{ME} and a binary response model to test the ability of PME wetlands to predict PGT wetlands in Sample I_{GT}.

RESULTS

Sample I_{ME}

More than 10,500 wetlands were evaluated on NWI maps. Many (62%) met SIHV or disturbance suitability criteria. Emergent wetlands accounted for 79% of all wetlands in the sample and 81% passed map examination. Five percent of 2,172 open wetlands and 54% of 87 riverine wetlands passed map exam (Table 3).

The average number of potential roosts/100 km^2 was 209 (range = 12-1,582), and the mean number of PME roosts was 135/100 km^2 (range = 4-1,482). Potential roosts did not decline from north to south (F = 0.51, P = 0.481), PME roosts <1 ha did, though not significantly (F = 3.16, P = 0.086), but the north-south decline in numbers of PME roosts ≥1 ha was significant (F = 7.45, P < 0.001).

Potential open wetland roosts increased significantly from north to south (F = 41.53, P < 0.001), but PME open wetlands did not (F = 0.07, P = 0.800). Though both potential and PME emergent (F = 2.57, P = 0.120; F = 3.24, P = 0.082; respectively) and riverine roosts (F = 2.13, P = 0.155; F = 2.20, P = 0.149; respectively) declined southward, none of the declines was significant.

If emergent wetlands are excluded, mean potential crane roosts/100 km^2 were 45 (range = 0-192) and increased significantly to the southeast (F = 40.94, P < 0.001).

Table 2. Disturbance types and their estimated zones of influence (m) on whooping crane selection of stopover roosts. From Armbruster and Farmer (1981) as adapted by Armbruster (1990).

Disturbance type	Width of affected area (m)[a]
Windmill[b]	100
Private road	100
Power line	100
Gravel road	200
Rural dwelling	200
Recreation area	200
Paved road	400
Railroad	400
Bridge	400
Urban dwellings	800
Commercial development	800

[a] Width of a band on each side of a linear feature, or radius of a circle around a point.

[b] Added as a result of this study.

Table 3. Percentages of central Nebraska wetlands that passed or failed map and/or field examination.

Sample	Wetland type	*n*	Passed examination		Failed examination			
			<1 ha	≥1 ha	Visibility	Disturbance	Slope/depth	Misidentified
I_{ME}	Open	2,172	3	2	+	2	93	
	Emergent	8,263	78	3	+	13	6	
	Riverine	87		54	32	14	0	
	Totals	10,522	62	3	+	11	24	
I_T	Open	120	5	3	0	4	88	
	Emergent	426	64	3	2	20	11	
	Riverine	6		66	17	0	17	
	Totals	552	51	3	1	17	28	
I_{GT}	Open	110	12	6	19	22	41	
	Emergent	382	59	2	8	27	4	
	Riverine	6		66	17	0	17	
	Totals	498	48	4	10	26	12	
II_{ME}	Open	190		58	0	5	37	
	Emergent	895		94	1	4	1	
	Riverine	233		41	54		5	
	Totals	1,294		80	9	4	7	
II_{GT}	Open	55		58	13	16	9	4
	Emergent	82		69	7	15	2	8
	Riverine	233		34	48	10	8	
	Totals	370		45	34	12	6	3

Because a high percentage of open wetlands failed map exam, an average of only 2.8 PME open roosts/100 km^2 (range = 0-9.5) was in the study area and no directional trend occurred (F = 2.51, P = 0.123).

Sample I_{GT}

The percentages of PME wetlands/km^2 in the 86 randomly selected 2.56-km^2 sections in Sample I tested (I_T) appeared to be representative of Sample I_{ME}. Fifty-four percent of the combined roost types of Sample I_T passed map exam, and 52% of Sample I_{GT} passed ground truthing (Table 3). The percentage of PGT open wetlands was 18%, up from 8% PME open wetlands; PGT emergent wetlands declined to 61% from 67% PME emergent wetlands, and PGT and PME riverine wetlands were constant at 66%.

The purpose of ground truthing was to test the predictive value of map examination by asking the question "Does a 2.56-km^2 section have at least 1 suitable crane roost?" A binary response model produced a 2 × 2 contingency table (Table 4) which showed a high association between map and ground examinations (χ^2 = 11.26, df = 1, P = 0.001). NWI map review was best as a predictor of unsuitability because it was correct 35 of 48 times (73%) but also correctly predicted suitability 24 of 38 times (63%).

Sample II_{ME}

Potential roosts ≥1 ha examined in this 64-map sample totaled 1,294 ($\bar{x}$ = 12.8/100 km^2; range = 0-92). The majority were emergent wetlands (65%); riverine wetlands comprised 21% of the sample, and open wetlands were least common (14%). Open wetlands increased significantly toward the south (F = 5.20, df = 63, P = 0.026); emergent wetlands decreased in the same direction (F = 5.71, P = 0.020) and riverine wetlands showed no pattern (F = 0.53, P = 0.468). In total, potential roosts ≥1 ha decreased toward the southeast, but the trend was just short of significant (F = 3.06, P = 0.086).

Table 4. A 2 × 2 contingency table of Sample I_T and I_{GT} sections containing (Yes) or not containing (No) suitable whooping crane roosts.

		Map Examination (I_T)		
		No	Yes	Total
Ground truthing	No	35	13	48
	Yes	14	24	38
	Total	49	37	86

Table 5. Roost suitability and average SIHV of major rivers and their tributaries, Sample II_{GT}.

River	No. of NWI maps	No. of sections[a]	Suitable sections[a] No.	%	$\bar{x}$ SIHV
Niobrara	5	42	16	38	0.92
Snake[b]	1	8	0	0	0.00
North Loup	4	28	27	96	0.57
Calamus	1	9	6	67	0.50
Middle Loup	3	22	13	59	0.67
South Loup	2	13	0	0	0.00
North Platte	1	19	1	05	0.10
Birdwood	3	18	10	56	0.80
Platte	3	28	6	21	0.17
Republican	4	46	0	0	0.00

[a] A section is 2.56 km^2 (1 mi^2).

[b] When the name of a stream is indented, the stream is a tributary of river listed above it.

PME wetlands averaged 10.3/100 km^2 (range = 0–92). Most PME roosts were emergent (81%) wetlands because they predominated within the sample and most (94%) passed map exam. Total PME wetlands ≥1 ha decreased significantly (F = 6.21, P = 0.015) from northwest to southeast, primarily because PME emergent wetlands ≥1 ha decreased significantly (F = 5.82, P = 0.019).

Sample II_{GT}

Comparable percentages of open (58% PME, 58% PGT) and riverine (41% PME, 34% PGT) wetlands ≥1 ha passed both map examination and ground truthing. The percentage of emergent wetlands (69%) passing ground truthing, however, was considerably less than that (94%) passing map examination (Table 3). Most of 32 open (91%) and all 79 riverine (100%) PGT roosts were likely to have shallow standing water during autumn migration, but only 23% of 56 PGT emergent roosts met the same criteria.

Open roosts ≥1 ha were of significantly higher quality in the Sandhills than in Farmlands. Ninety-six percent of 24 open roosts checked in the Sandhills passed ground truthing with a mean SIHV of 0.95, but only 23% of 31 Farmland open roosts passed ground truthing and their mean SIHV was only 0.21 (t = 12.94, P < 0.001).

More emergent roosts in the Sandhills, 84% of 43, passed ground truthing with a higher mean SIHV (0.84) than outside the Sandhills (67% of 37; SIHV $\bar{x}$ = 0.67), but the difference was not significant (t = 0.097, P = 0.340). However, if SIHV was averaged over all roosts visited, whether suitable or not, the SIHV means were lower (Sandhills = 0.70, Farmlands = 0.38) and the difference was significant (t = 3.47, P < 0.000).

Central Nebraska is drained by 6 major rivers and their tributaries (Table 5, Fig. 1). These rivers flow generally west to east, perpendicular to the whooping crane migration corridor. Sample II included 25 maps with potential riverine roosting habitat. Within Sample II, 5 rivers had no or few sections with suitable roosting habitat and low mean SIHV's, and 5 had moderate to high suitability rates and mean SIHV's (Table 5).

Comparisons of Samples

The USFWS has totaled wetlands within 8 of the 17 1:100,000 maps in the study area (Fig. 1); consequently, it was possible to compare my randomly selected samples with actual wetland totals. I grouped wetlands into the 3 roost types (open, emergent, riverine), calculated the percentage for each roost category, and compared these percentages for Sample I_{ME}, Sample I_{GT}, and the actual wetlands available within each 1:100,000 map unit with a series of 3 × 3 contingency tables (Table 6). In 4 of the 1:100,000 map units, the samples were representative of the actual wetlands present. In the 4 units for which samples were not representative, the smallest sample, I_{GT}, was the aberrant sample.

Samples I_{ME} and II_{ME} tabulated PME wetlands ≥1 ha, so results could be tested with 2-sample t-tests. In comparisons of open (t = 1.34, P = 0.18), emergent (t = 1.52, P = 0.13), riverine (t = 0.2, P = 0.84), and total PME (t = 1.47, P = 0.15) roosts, none was significantly different. This similarity indicates that both samples were from the same population of wetlands capable of passing map examination.

Table 6. Results of χ^2 analysis of percentages of 3 potential roost types in Samples I_{ME} and I_{GT} with the actual wetland totals within 8 1:100,000 map units in the central Nebraska study area.

Map unit	Geographic region	χ^2	P	Samples represent actual?	Aberrant sample
Valentine NW	Sandhills	3.39	0.495	Yes	none
O'Neill SW	Sandhills	6.89	0.142	Yes	none
N. Platte NW	Sandhills	19.50	0.000	No	I_{GT}
Broken Bow SW	Farmlands	4.67	0.323	Yes	none
Grand Island NW	Farmlands	60.26	0.000	No	I_{GT}
Grand Island NE	Farmlands	12.18	0.016	No	I_{GT}
Grand Island SW	Farmlands	6.93	0.140	Yes	none
Grand Island SE	Farmlands	17.79	0.001	No	I_{GT}

DISCUSSION

Evaluation of Technique

In Oklahoma, NWI map examination overestimated suitable roost sites, primarily because it was difficult to ascertain the presence and height of woody vegetation blocking horizontal visibility and because most mapped wetlands were small, steep-sided, dammed stock ponds that did not have adequate shallows to meet minimum criteria (Stahlecker 1992). In Nebraska, vision blocking vegetation adjacent to potential roost sites was much less common, though impossible to locate from NWI and difficult to locate from topographic maps. However, I was more familiar with Nebraska landscapes than I had been with Oklahoma landscapes when I initiated respective map reviews. That experience made analysis of SIHV much easier than it had been in Oklahoma. The reduced visibility problems in Nebraska were ultimately confirmed by ground truthing; 84% of wetlands ≥0.04 ha checked in Oklahoma (Stahlecker 1992) were rejected for SIHV, but only 10% were rejected in Nebraska (Table 3).

Narrow stock ponds sampled in Oklahoma never had suitable shallows for crane roosting, so I rejected similar impoundments during review of Nebraska NWI maps. However, during ground truthing I found that some impoundments had suitable shallows, apparently because Nebraska's sandier soils are more erodible and filled inlets more quickly. In the 4 southernmost 1:100,000 map units there were 9 sample sections that had no PME wetlands that in fact had PGT wetlands. However, there were also 10 sample sections that map review correctly predicted did not have any suitable roosts. Though the proportion of impoundments that have suitable roosting shallows might be predicted, the suitability of a particular wetland cannot be predicted from NWI maps.

Sampling 2 of 32 NWI maps/1:100,000 mapping unit appears to have been representative of the proportion of available wetland types, but the ground truthing sample of 3 sections/NWI map was not representative in one-half of the tests conducted (Table 6). The important aspect of ground truthing, however, was to test the predictive value of map examination, no matter what wetland types were present, and it appeared to do so successfully.

Stopover Roost Availability in Nebraska

The large number and wide distribution of wetlands within the whooping crane migration corridor in Nebraska suggest that this population should have multiple options of roost sites during migration through the state. Much higher proportions of wetlands of all sizes passed map and ground testing in Nebraska (Table 3) than in Oklahoma (Stahlecker 1992). The average number of PME wetlands ≥1 ha/100 km^2 was 3–6 times higher in Nebraska (12.8/100 km^2) than was estimated for Oklahoma (2–4/100 km^2, Stahlecker 1992).

Emergent wetlands were 78% of all wetlands tested during map examination. Tall emergents, such as cattails (*Typha* sp.) and bulrushes (*Scirpus* sp.) are not attractive to roosting cranes because they interfere with horizontal visibility. However, 80–97% of the emergent wetlands in the 8 1:100,000 map units totaled by USFWS were classified as temporary (PEMA) or seasonal (PEMC); similar rates were likely for the other 9 map units in the study. Throughout Nebraska, but particularly in the Sandhills, these ephemeral wetlands are cut for hay late in the summer. They are most likely to have standing water in spring after snowmelt and therefore are most available to northbound whooping cranes. However, 77% of all PGT emergent wetlands ≥1 ha (n = 56) examined in October 1992 did not have standing water and therefore would not attract southbound cranes. Therefore, whooping cranes in autumn have an average of 4.8 PME roosts ≥1 ha/100 km^2, a rate more comparable to that predicted for Oklahoma, regardless of season. An even higher rate of unsuitable emergent wetlands <1 ha is likely in autumn.

Suitable roost sites also varied in quality. The Sandhill region had palustrine wetlands ≥1 ha with significantly higher SIHV ratings than the remainder of the state. Though it could not be tested in the same manner, palustrine wetlands <1 ha likely showed a similar difference. Man-made palustrine wetlands, especially those <5 ha, do not have the same high qualities as crane roosts as their natural counterparts.

Though not statistically confirmed in this sample, natural open wetlands, especially those ≥1 ha, in the Sandhill region are not randomly or uniformly distributed. The majority of these highly attractive roost sites are concentrated in an arc that includes the higher elevations of the Sandhills and the headwaters of its major streams (Fig. 1). Fortunately, adjacent lower elevation areas were crossed by major eastward flowing rivers and/or areas where man-made stock ponds were common.

Nebraska's eastward flowing rivers are well spaced north-to-south and could provide an abundance of roost site possibilities for migrant whooping cranes. The relatively unbridled Niobrara, North Loup, and Middle Loup rivers in the northern two-thirds of Nebraska had high SIHV values (Table 5) once they had attained flows that provided active wide and sandy channels. The South Loup River is much smaller and never attains flows needed to create suitable roosting channels. The southernmost of Nebraska's rivers, the Platte and Republican rivers, have major mainstem dams and diversions. The impact of control and diversion on channel activity in the Platte (Currier et al. 1985) and its primary tributaries (McDonald and Sidle 1992) are well documented. The Platte provides wide sandy channels, likely to have high SIHV's, only after some of the diverted water is returned below Lexington. Only 1 of 3 sample maps encompassing the Platte fell within this region. The Republican River, a considerably smaller river than the Platte, has been so controlled that its narrow channel, usually less than 30 m wide, is tree-lined and unsuitable for roosting cranes.

The minimum SIHV for this study was 0.1; this required a minimum channel width of 100 m for a river segment to pass map and/or ground examination. Whooping cranes have been seen roosting within Platte River channels as narrow as 52 m (SIHV = 0.0), though most roost sites were >150 m (SIHV >0.32) (Faanes et al. 1992). Faanes et al. (1992) found that whooping cranes selected channels that were >150 m wide and were wet for >80% of that width. Though whooping cranes will use channels meeting minimum criteria, they prefer higher quality roost sites. The approximate location where each Nebraska river becomes consistently attractive to migrant whooping cranes is indicated in Figure 1.

CONCLUSIONS AND RECOMMENDATIONS

NWI map and ground review of wetlands in Nebraska indicates that there are sufficient numbers of potential roosts that meet minimum criteria for migrating whooping cranes (Armbruster 1990), though quality varies extensively. Potential roosts are widely distributed. Riverine roosts meeting minimum standards (this study, Stahlecker 1992) and roosts that whooping cranes have chosen to use (Faanes et al. 1992) are quite different. Numerous sightings of migrant whooping cranes have been documented by state and federal agencies in Nebraska. Consequently, the next logical step appears to be a comparative study of these 2 data sets.

NWI map review was a better predictor of roost site unsuitability (0.73) than of roost site suitability (0.63). Both prediction rates fall within an acceptable range, though higher rates would be more useful. Predictive values from this study may be applicable to South Dakota, North Dakota, and Montana portions of the whooping crane migration corridor, where terrain, rainfall, and the general lack of woody vegetation are similar.

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