ECOLOGY AND STATUS OF GREATER SANDHILL CRANES IN SOUTHEASTERN WISCONSIN

by

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ABSTRACT

The population and ecology of greater sandhill cranes was studied in 17 southeastern Wisconsin counties during 1976 and 1977. A population of 1,106 adult cranes was censused, of which 52 percent consisted of breeding pairs and the remainder non-breeding flocks numbering 5 to 90 birds. Ninety-two percent of the population was located in 4 counties. The population has increased substantially since 1930. Over 78 percent of the crane population occurs on privately owned wetlands which are currently subject to an annual rate of wetland drainage exceeding 3 percent. The average size wetland used by cranes was 126 ha and a significant preference was exhibited for wetland Types 2, 3, and 8. Significant correlations (r=0.72) between wetland size and years of crane occupancy indicated that intensive pioneering into formerly unoccupied habitat has occurred. Fifty-three crane nests were found, most in cattail communities along sedge-cattail ecotones. The highest nest densities occurred on wetlands with floating bog mats. Mean clutch size was 1.91 eggs and the mean hatching date was 10 May. Hatching success was 84 percent and the fledging rate of chicks averaged 69 percent. Cranes preferred cattle pastures for brood rearing habitat. The mean size of 7 territories was 38 ha. The average brood size at fledging was 1.36 chicks/nesting pair and the annual recruitment rate was 11.1 percent. Crane roosts consisted of ponds 1.4 ha in size, 5-27 cm deep, surrounded by tall

emergent vegetation. Peak arrival of cranes at roosts occurred during the first 15 minutes after sunset and peak departure was 5 minutes before to 30 minutes after sunrise. Thirty-seven cranes were banded and 136 observations were made on color-marked cranes within the study area. Non-breeding cranes fed primarily on the tubers of aquatic plants in spring and almost exclusively in grain fields after July. Only 5 percent of the farmers adjacent to wetlands occupied by cranes reported significant crop depredations. A peak migratory population of 2,400 cranes was censused on 7 major staging areas on 20 September 1977. Current management recommendations involve the preservation of scattered wetland units in each county identified as optimal crane nesting habitat.

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INTRODUCTION

The eastern population of greater sandhill cranes (*Grus canadensis tabida*) nests in Minnesota, Michigan, Wisconsin, central Manitoba, and western Ontario (Drewin et al. 1975: 229). They migrate south through Illinois, Indiana, Ohio, Tennessee, Kentucky, and Georgia (Walkinshaw 1960), to winter in central and northern Florida and southern Georgia (Williams and Phillips 1972, Melvin 1977). The Jasper-Pulaski Fish and Game Area in northern Indiana is the only major spring and fall staging area for the eastern population.

The size of the eastern population has increased from less than 1,000 birds in 1944 (Walkinshaw 1949:134), to about 12,000 birds (Gould 1977). In Wisconsin, the resident greater sandhill crane population has recovered from an estimated 5 breeding pairs in 1929 (Leopold 1929 unpubl.), to over 1,000 birds (Hunt and Gluesing 1976). Early population surveys by Henika (1936), Walkinshaw (1949), and Grange (1955) revealed that this recovery was initially very slow as they began extending their range from nucleus populations in the central and southeastern regions of the state.

Hamerstrom (1938) was the first to describe sandhill crane habitat in Wisconsin. He described 3 basic elements which were common to wetlands used by cranes in central Wisconsin; large size (600 ha or larger), isolation from humans, and "openness" provided by vast areas of sedge

meadow or low prairie vegetation.

Gluesing (1974) estimated the summer population of cranes to number 850 birds in 1973, distributed primarily in 7 south-central Wisconsin counties. A significant finding of his study was the presence of a large number of cranes on small wetlands (50 ha or less) in private ownership. Howard and Nauman (1975) described crane nesting habitat requirements in 4 central Wisconsin counties.

Additional research needs at the time of this study included: 1) a field census of cranes in a given region to check previous mail card survey estimates; 2) an investigation into the characteristics of wetland habitat presently being used, and its present status with regard to human and natural influence; 3) the tolerance of nesting cranes to human activity; 4) preferred feeding, nesting, and roosting habitat; 5) population characteristics, including nest success, survival of young and recruitment rates; 6) behavioral studies; 7) prevalence of crop depredations; and 8) location of staging areas, local movements, and migratory chronology.

This study had the following objectives:

1. To determine the adult sandhill crane population in southeastern Wisconsin.
2. To locate and classify all wetland habitat used by breeding, non-breeding, and migrating cranes.
3. To determine present and future landowner use and trends in plant succession on wetlands with sandhill cranes.

4. To describe the ecology and behavior of cranes with reference to nesting, feeding, roosting, and staging.
5. To describe sandhill crane use of agricultural lands and to identify the extent and distribution of crop depredations.

This study was conducted from 1 May-15 October 1976 and 15 March-15 November 1977.

STUDY AREA

The area defined as southeastern Wisconsin includes 17 counties located east and south of Marquette County (Fig. 1). Crane population surveys and habitat status evaluations were conducted in each of the 17 counties. Intensive ecological and habitat studies were conducted in Marquette, Green Lake and Jefferson counties.

The study area lies within the glaciated portion of Wisconsin where the topography is characterized by recessional moraines formed by the Cary Ice Sheet. The average elevation is about 300 m above sea level with relief of about 30 m between ridges and lowlands. Underlying most of the area is Ordovican sandstone (St. Peter Formation) and dolomite (Prairie du Chien Group) (Hole and Lee 1955). With the exception of the northwestern portion of the study area, which lies within the central sand plain, most soils are greyish-brown silt loams (Hole and Beaty 1957). Interspersed in glacial pockets are extensive areas of muck and peat deposits.

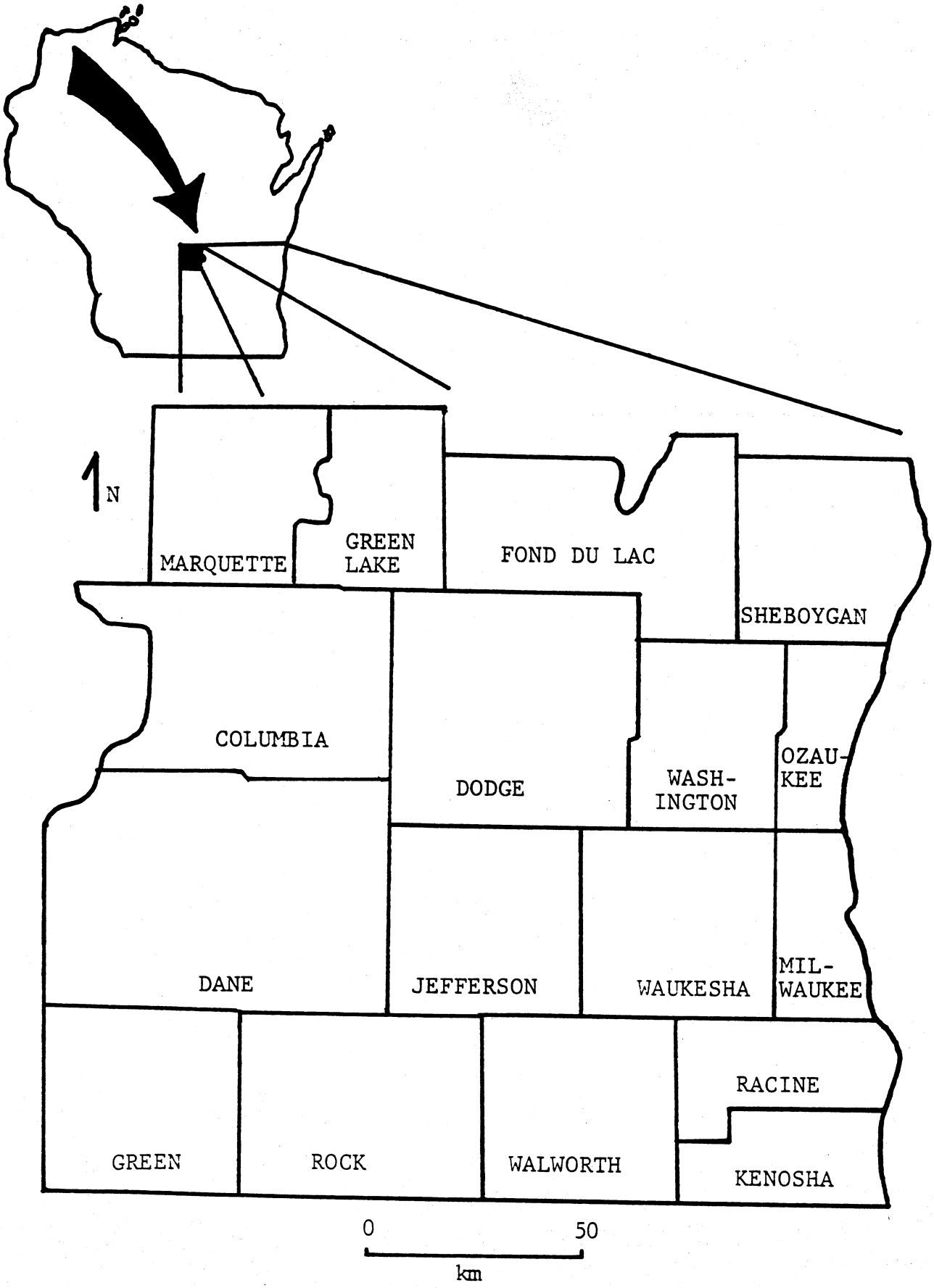


Fig. 1. Sandhill crane study area, southeastern Wisconsin, 1976-1977

Climate of the region is continental. Annual precipitation averages 76 cm with 55 percent falling between May and September. The average annual temperature variation ranges from a maximum of 59°F to a minimum of 35°F. The growing season averages 150 days (Burley 1967).

In his original map of the vegetation of Wisconsin, Curtis (1959) indicated that the study area is located along an ecotone between prairie and oak savanna. Today, most of the prairie has been plowed for cropland and the woodlands cleared for pasture and cultivation. Approximately 63 percent of the total land area is currently in cultivation, ranging from 42 percent in Marquette County to over 80 percent in Green County. The primary agricultural enterprises are dairy farming and production of cash crops. Vegetables and livestock production are of secondary importance. Major crops grown on inorganic soils are corn, oats, and alfalfa, whereas mint, carrots, onions, and turf sod are grown on the organic soils (Schmude 1975).

An average of 14 percent of the study area consists of wetlands, ranging from 30 percent in Marquette County to 5 percent in Washington County (Wisconsin Conservation Department 1963). Most wetlands consist of extensive areas of sedge meadow and shallow marshes. Wetlands have been intensively exploited for agriculture and those that remain exhibit varying degrees of disturbance due to grazing, mowing, peat fires, and partial drainage.

While comprising only 20 percent of the land area, 60

percent of the human population of Wisconsin is centered within the study area. Included are the 6 most densely populated counties in the state (King et al. 1972).

METHODS

Population Survey

The following techniques were used to locate wetlands used by sandhill cranes and census the population level in each county: 1) auditory censusing, 2) ground searches and observations, 3) personal interviews with landowners residing near wetlands, and 4) reports from local naturalists and state game managers. On most wetlands several of the above techniques were used.

A Craig Model 2626 tape player-recorder was used for auditory censusing. Tape recordings of crane vocalizations were obtained by recording the calls of captive birds at the International Crane Foundation, Baraboo, Wisconsin, and from calls transcribed from collections of the Cornell Laboratory of Ornithology, Ithaca, New York. Three different crane vocalizations were used - the unison and flight calls from a pair of cranes, and the guard call from a single crane. Calls were amplified and broadcast with a Realistic Model MPA-10 mobil 12-volt public address system through dual Vanco PH-5 speaker-horns mounted on the roof of a vehicle. Wetlands unapproachable by vehicle were censused on foot with a hand held speaker and cassette tape player. Calls were played at the edge of wetlands during the first

2 hrs after sunrise and 1 hr before sunset. A minimum of 5 min was spent awaiting the response from cranes at each census point.

Ground observations of wetlands having a prominent vantage point were made with the use of 8X binoculars and a 20-60X spotting scope. Small wetlands were searched on foot or by boat. On wetlands containing large numbers of non-breeding cranes, roosts were located and the birds counted as they departed for morning feeding areas. Resident landowners near wetlands, or those having an unobstructed view of the wetland, were interviewed to determine the presence of cranes. Censusing of resident cranes was initiated upon the arrival of the birds in spring and terminated 31 July each year. Staging areas were censused by morning roost counts (Lewis 1974), from 1 August to 30 October at 7-10 day intervals.

Wetland Classification

All wetlands receiving use by cranes were classified into one of 8 wetland Types as described by Shaw and Fredine (1956). A comparison of wetland Types to the interim wetland classification system proposed by Cowardin et al. (1976) is given in Appendix A. Wetland Type classifications were obtained from previous wetland inventories (Wisconsin Conservation Department 1963). Re-classifications were made by field investigation where changes had occurred, discrepancies noted, or more detail required.

The wetland covertype, defined by Stewart and Kantrude (1971) as the relative proportions of cover and open water, was determined for each wetland from aerial photographs. Aerial photographs (scale 1:10,000) were borrowed from County Agricultural offices. These photographs were taken for cropland inventory during the last 3-5 years.

The size of each wetland was estimated by using a dot grid over an aerial photograph (Golet and Larson 1974). All wetlands were delineated for measurement on the basis of upland boundaries or other physical features (highways, bridges) and include all wetland Types therein regardless of their actual use by cranes. Wetland boundaries were determined from aerial photographs and organic soil survey maps (Bartelli 1975).

Upland covertypes adjacent to wetlands were determined by field investigation and air photo interpretation. The history of wetland usage and rates of plant succession on wetlands in Marquette County were determined from aerial photographs and interviews with landowners.

Breeding Biology

During 1977 sandhill crane nests were located by ground searches of wetlands and with the limited use of a helicopter. Nests were located on the ground by walking through wetlands with known resident pairs and flushing the incubating bird, and by observing the behavior of pairs on nesting territories. Several wetlands too large for ground searches were flown by

helicopter at an altitude of about 30 m. Air searches were concentrated on those areas of the wetland where the water depth and plant composition appeared favorable for nesting cranes. Most nest searching was conducted during the morning and late afternoon hours. Nest searches were initiated on 10 April, when the first cranes began incubating, and terminated on 30 June, when most nests had hatched.

On the initial visit to each nest, measurements were taken of the nest diameter and height, and the water depth at 4 equally spaced sites encircling the nest. The dominant vegetation at each nest site (defined as an area within a 0.5 ha radius of the nest) was also analyzed on the initial visit. Nests were checked on foot at 5-7 day intervals to monitor hatching dates and success. The plant composition of each nest and the species composition of vegetation at each nest site were evaluated. Nests were considered monotypic if over 95 percent of the material consisted of one plant species. Nests composed of two or more plant species were analyzed volumetrically by collecting a 10 percent sample of the nest vegetation and expressing the percent composition of each species by water displacement.

The distance of nests to open water, roads, human dwellings, and other crane nests was measured in the field or from aerial photographs.

Landowner Survey

All private landowners owning 10 percent or more of a

wetland occupied by cranes were interviewed. Resident landowners, or those available during the field study, were interviewed personally. Non-residents and those not contacted during the summer were sent a written questionnaire (Appendix B).

Feeding and Roosting Behavior

The feeding behavior of pairs of cranes with chicks was studied from observation blinds concealed within their feeding territories. Seasonal feeding habits and habitat selection of non-breeding cranes were determined by direct observations of the birds and by investigations of the feeding site. Observations also were made on the number of cranes using each field type and distances moved to uplands for feeding. An index of field preference was determined by dividing the percentage of cranes seen in a specific field type by the percentage of occurrence of that type adjacent to wetlands used by cranes (Hoffman 1976). Index values greater than 1.0 suggest greater use of a field type than expected if the cranes had no preference, and values less than 1.0 reflect avoidance of a field type.

The size, water depth, and surrounding vegetation was determined for all major crane roosts in southeastern Wisconsin. Arrival and departure times and activities of cranes at roosts were observed from blinds placed near the roosts. Flight observations were made on an equal number of clear and overcast days at 2 major roosts within the study areas.

Crop Depredations

During spring 1977 an attempt was made to "lure" cranes from sprouting corn fields by artificial feeding. Sites baited with corn were established on wetlands and upland fields near major crane roosts and on sprouting corn fields being depredated by cranes. Use of bait sites and feeding movements was monitored daily during the peak depredation period.

Observations were also made on the amount of damage caused by cranes relative to the amount of time they spent feeding in the fields. Small groups of cranes (4 to 6 birds) were allowed to feed on corn seedlings for 30 minutes and then flushed. A total count was then made of the number of plants destroyed during this period. In addition, probe holes in corn fields were excavated and examined to determine the planting depth of the seed, the maximum depth at which cranes can effectively extract the seed, and the efficiency of cranes at extracting seeds.

Capture and Banding

Adult sandhill cranes were captured with recoiless rocket nets (Wheller and Lewis 1972). Nets were camouflaged and baited with corn. Trapping sites included sprouting corn fields, hay fields, and harvested fields of wheat and corn. Trapping was conducted between 15 June and 30 August 1977. Sandhill crane chicks 30 days and older were captured during June by observing their movements for several days

and then running them down from a concealed location within their feeding territory.

All cranes captured were banded with size 9 locking aluminum U.S Fish and Wildlife Service leg bands. Adult cranes were also color-marked with lime-green patagial tags measuring 6 X 23 cm attached to each wing. Tags were constructed of double thickness Saflag material (Safety Flag Co. of America, Pawtucket R.I.) which was double stiched around the borders for durability. A black lettered four-digit code was sewed onto the upper surface of each tag for identification. Standard weights and measurements (Stephen et al. 1966) were recorded on all captured cranes for verification of subspecies.

RESULTS AND DISCUSSION

Population Survey

A resident population of 1,106 adult sandhill cranes was censused on the study area in 1977. Four counties contained 92 percent of the population (Figure 2). Small groups of cranes were found in each of the remaining counties except Sheboygan, Ozaukee, and Milwaukee. Gluesing (1974) reported a similar pattern of distribution and relative density of 400 cranes located in 1973. The location (county, township, and section) of cranes in southeastern Wisconsin is given in Appendix C.

Breeding pairs of cranes (defined as a pair occupying and defending a specific wetland from 1 April to 31 July)

comprised 52.5 percent of the population (Table 1). Non-breeding groups of cranes (5 or more birds) comprised the remaining 47.5 percent of the population. The average size group of non-breeding cranes was 28 (SD=16, range 5-90).

During 1976 Marquette and Green Lake counties had a resident population of 418 birds (Table 1). The 1977 survey revealed a population of 615, or 197 (32 percent) more cranes. This population occupied the same type and amount of habitat, and few cranes were found on wetlands not supporting cranes in 1976. A major portion of this increase involved larger groups of non-breeding cranes. The proportion of non-breeding to breeding pairs in 1976 was 44.9 percent, and this increased in 1977 to 51.2 percent. The number of breeding pairs also increased during 1977 by 11 percent. Many large wetlands supporting 1 pair of cranes in 1976 contained 2 or more pairs during 1977.

The average proportion of resident non-breeding cranes (48.5 percent) found in this study is higher than that reported in other populations of greater sandhill cranes. Walkinshaw (1973:326) found that non-breeding groups of cranes comprised an average of 41 percent of the adult population over a 10 year period in Michigan. Thirty-one to 39 percent of the crane population at Grays Lake, Idaho were non-breeders (Drewin 1973), and 25 percent of the cranes were non-breeders at Malheur (Littlefield and Ryder 1968).

Yearly movements of non-breeding groups of cranes in Wisconsin are highly irregular. Non-breeding adult cranes

Table 1. Relationship of breeding to non-breeding cranes in southeastern Wis., 1976-1977.

County	Pairs with young	Pairs with no young	Total pairs	Non-breeders	Total cranes
Marquette (1977)	55	51	106	153	367
" (1976)	37	49	86	68	270
Green Lake (1977)	21	18	39	174	252
" (1976)	15	14	29	90	148
Columbia (1977)	-	-	81	150	312
Jefferson (1977)	12	18	30	27	87
	143 (25.1%)	153 (26.4%)	377	682 (48.5%)	1,436

banded in central Wisconsin have returned from their wintering grounds to areas of the state farther than 150 km from their banding site (Scott Melvin pers. comm.). Offspring of breeding pairs originating in counties with minimal wetland habitat and cranes displaced by wetland destruction also contribute to the large number of non-breeders. The vast area of wetlands available in Marquette, Columbia, and Green Lake counties may serve as a concentration area for non-breeding cranes originating throughout Wisconsin.

Census Techniques

Auditory censusing located the largest number of cranes (168 breeding pairs) in the least amount of time. Cranes generally responded to the recorded calls within 2 minutes by answering with their unison call or flying to the playback location. Of the total cranes responding, 117 (70 percent) responded by giving their unison call from the ground, and 51 pairs (30 percent) responded by both calling and flying to the location of the recorded calls. The cranes flew directly to where the calls originated and frequently circled several times before landing nearby. Subsequent visits produced similar responses from each pair. One pair responded 23 times over a 5 week period by both calling from the ground and flying to the location of the recorded calls. Cranes exhibited a remarkable ability at directional orientation to the source of the recorded calls.

On many occasions cranes farther than 2 km away would respond by landing within 40 m of the playback location. Frequently this occurred 5-10 min after I had left the census site. On 5 occasions a single crane responded by flying to the calls. Later observations revealed that these birds had mates incubating at the time of the census. Flight calls were the most successful for consistently illiciting a response from a breeding pair of cranes. When more than 1 pair was within hearing distance, flight calls generated a response from all pairs, while unison or guard calls produced variable results. If cranes were present on a wetland, they generally responded within 3 census attempts.

I could not determine the proportion of all breeding cranes that responded to the recorded calls. However, calls were played on 68 occasions to pairs within view and known hearing range. Of these, 59 pairs (88 percent) responded to the calls. Several factors affect this census technique and the individual responsiveness of breeding cranes. Dow (1970) found that the time of day, noise level, and wind velocity were important considerations when using auditory censusing of cardinals (*Cardinalis cardinalis*). These factors were very important in censusing sandhill cranes where calls frequently must be broadcasted 1 km or more away from a pair. Auditory censusing was most effective during the first hour after sunrise while cranes were still at the roost. They rarely responded during midday while feeding or loafing on upland fields. Glahn (1974) found

the stage of incubation and relative breeding densities very important for illiciting individual response in rails. Sandhill cranes were most responsive to recorded calls before nesting. Cranes in the later stages of incubation and immediately after hatching rarely responded to recorded calls. Responsiveness was regained later in the summer after the chicks were several weeks old. Territory size and the proximity of other breeding pairs also affected crane responsiveness. Breeding pairs with the smallest territories and those visually or audibly remote from other pairs responded most frequently, usually by both calling and flying to the recorded calls. Auditory censusing was most valuable on inaccessible wetlands or those not having a prominent vantage point for visual observations.

Cranes were also successfully located by visiting wetlands at sunrise and listening for crane vocalizations, or by visually searching for cranes with binoculars. However, this technique required the greatest amount of time per crane located. To be confident that cranes may or may not be present, a minimum of 30-60 min must be spent at each wetland, therefore only a small number of wetlands can be censused in one morning by this method. Visual observations are best suited to very large wetlands where several pairs may be present or when a large number of observers is available.

Interviews with landowners adjacent to wetlands were valuable in identifying areas used by cranes. However, rarely did landowners know the exact number of cranes using

their land or whether any young were present. In addition, confusion arose over the distinction of cranes from great blue herons (Ardea herodias) and American egrets (Casmerodius albus) and identification was further complicated by "local names" given these birds. Landowner interviews frequently had to be followed up by a field survey to ascertain the exact number of cranes present.

Local nature centers and birdwatching groups were an invaluable source of information regarding both the current and former numbers of cranes in a county. A survey of these individuals was found to be the most valuable preliminary step in the crane census of a county. The guidance provided by people familiar with the area and the presence of cranes can save countless hours of field investigation. Very often these people volunteered to participate in the field census and provided information on crane sightings throughout the summer.

Wetland Classification

Very few wetlands exist in those counties which are not occupied by cranes (Fig. 2). Over 50 percent of the wetlands in Marquette County contain 2 or more pairs of cranes and several contained more than 4 pairs.

Sandhill cranes occupy and nest in a wide variety of wetland habitats in southeastern Wisconsin, including river basin wetlands, lake shore wetlands, sedge openings, margins of tamarack swamps, bogs and fens, glacial kettles, seepage

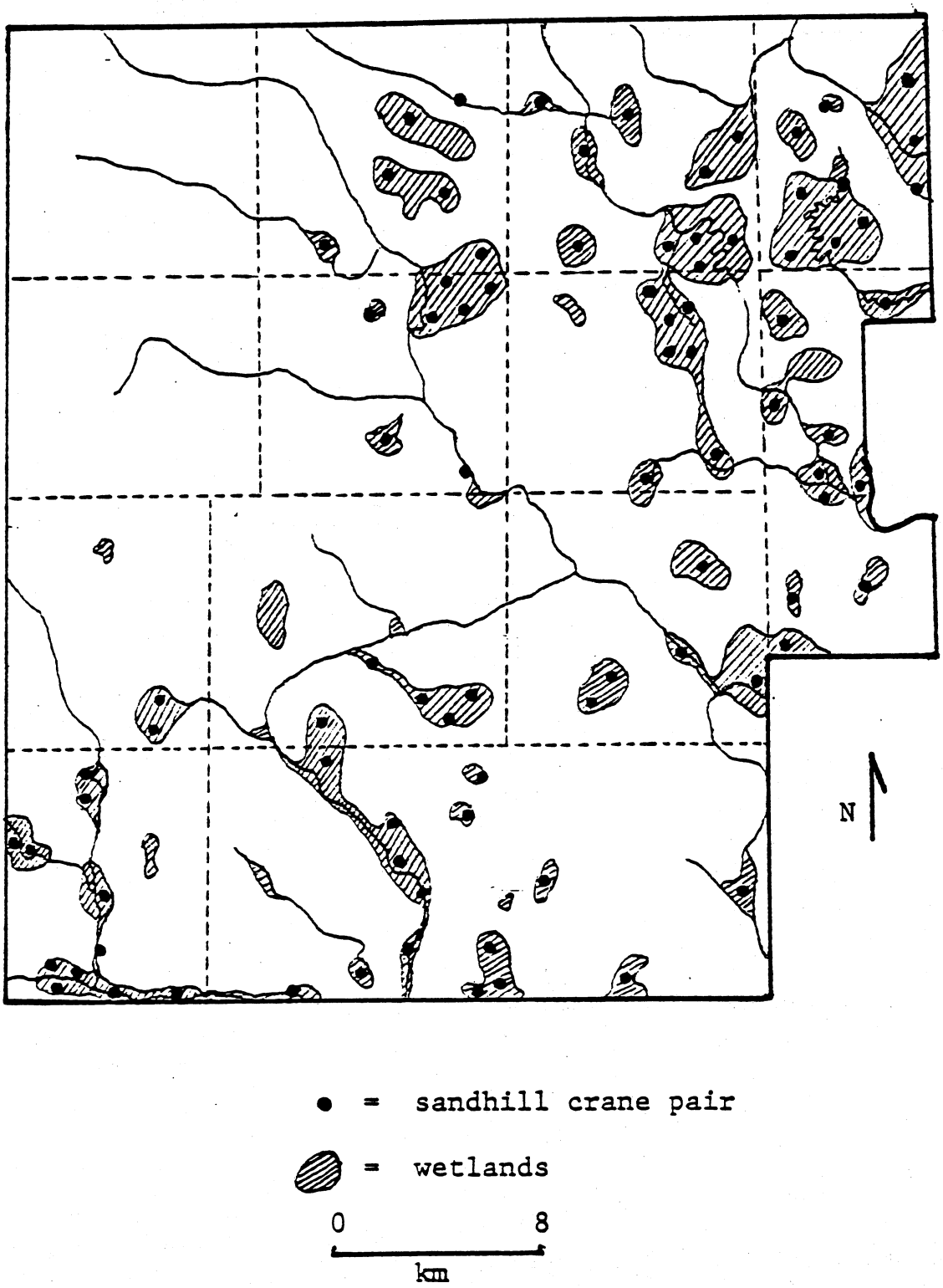


Fig. 2. Distribution of sandhill crane pairs in relation to the wetlands of Marquette County, Wis., 1977.

basins in agricultural fields, and seasonally flooded pastures.

Wetland Type

Type 2 wetlands comprised over half of the total area and occurred in 92 percent of the wetlands (Table 2). This wetland Type predominates in Marquette County where it comprises 68 percent of the total wetland area. While Type 3 wetlands were of low relative abundance, 60 percent of these wetlands were used. The composition of wetland Types 4, 6, and 7 on wetlands occupied by cranes was in direct proportion to their occurrence. A difference in the classification of Type 8 wetlands between former surveys (Wisconsin Conservation Department 1963) occurred in both counties. Only a small number of bogs was present, but each received intensive use by cranes.

Wetland Size

The average size wetland utilized by sandhill cranes in Jefferson, Green Lake, and Marquette counties was 130 ha (SD=127, range 95-170) (Table 3). Cranes in Jefferson County were associated primarily with a small number of very large wetlands. The smallest wetland occupied by cranes in this county was 19 ha and only 29 percent of the wetlands were smaller than 80 ha. In contrast, 68 percent of the wetlands in Marquette County were 80 ha or less and many cranes were found on wetlands smaller than 1 ha. Several wetlands in Green Lake County were larger than those in

Table 2. Wetland Type composition of 107 wetlands used by sandhill cranes in Marquette and Green Lake counties, Wis., 1976-1977.

Wetland Type	Frequency of occurrence[1] %	Hectares	% composition	Total hectares[2]	% area used
2	92.1	4,609	51.7	30,826	14.9
3	64.6	1,553	17.3	2,610	60.0
4	18.1	284	3.2	1,436	20.2
5	63.9	768	8.4	3,748	20.1
6	44.3	1,214	13.5	6,629	18.3
7	2.8	530	5.9	214	100.0
		8,964	100.0	45,464	19.7

[1] Occurrence of Wetland Type in 107 samples.

[2] Wisconsin Conservation Department (1963)

Table 3. The size of 126 wetlands used by sandhill cranes in 3 southeastern Wisc. counties, 1976-1977.

	Jefferson	Green Lake	Marquette	Total
Wetland area occupied by cranes (ha)	3,240	3,616	5,384	12,204
Number of wetlands delineated	19	36	71	126
Average wetland size	170	128	95	130
Median size	232	82	45	97
Standard deviation	165.6	118.4	52.0	127.3
Range	19 - 800	0.8 - 880	0.4 - 360	0.4 - 880
Percent of wetlands 80 ha or less	29	41	68	40
Wetland area/crane (ha)	37	14	14	17

Jefferson, but the wetland area per crane was similar to that of Marquette County.

The size of wetlands used by cranes in each county was a combined function of the availability of different size wetlands, wetland quality, and the number of cranes present. Quantitative data on the size distribution of wetlands in Jefferson County is not available. However, very few wetlands of 80 ha or less exist, primarily due to intensive exploitation for agriculture. In addition, many wetlands are of poor quality because of siltation, runoff, partial drainage, and irrigation. Such wetlands suffer severe water level fluctuations and the invasion of monotypic stands of woody vegetation. As a result, only a small segment of many large wetlands provide suitable habitat for cranes, and many wetlands receive use only during exceptionally wet years.

In Marquette and Green Lake counties, about 51 percent of the wetlands are less than 80 ha in size (Wisconsin Conservation Department 1963) and 54.5 percent of the wetlands used by cranes are of this size (Table 3). This reflects an equal degree of preference for large and small wetlands when all sizes are present.

Wetland Covertype

The term wetland covertype has been defined by Stewart and Kantrude (1971:10) as the spatial relation of emergent cover to open water. Over 75 percent of the wetlands in the

study area had very little open water (Table 4). This is due primarily to the low composition of Type 4 and 5 wetlands in these counties (less than 5 percent). On most wetlands no permanent open water exists other than that provided by rivers and streams. Cranes generally avoided wetlands containing extensive areas of open water. No cranes were observed roosting, nesting, or feeding in open water greater than 40 cm deep.

Wetland Juxtaposition

The value of a wetland to wildlife is generally enhanced if it is located near other wetlands, especially if they contain types or subtypes different from the wetland being evaluated (Golet and Larson 1974). Fifty-one percent of the wetlands used by cranes in Jefferson, Marquette, and Green Lake counties were interconnected by permanently flowing rivers and streams and an additional 8 percent were associated with large lakes. The remaining 41 percent consisted of small glacial kettles and seepage basins and had no direct connection to other wetlands. However, cranes frequently occupied a group of small wetlands in close proximity and defended them as one unit. Habitat requirements lacking in one wetland were met in another and cranes could make alternate use of each for feeding, nesting, and roosting. This may be a significant factor allowing for the extensive use of small sized wetlands by cranes in this area.

Table 4. Wetland covertype of 107 wetlands used by sandhill cranes in Marquette and Green Lake counties, Wis., 1976.

	Number of wetlands	%
More than 95 percent cover	81	75.7
76 to 95 percent cover	14	13.0
25 to 75 percent cover	10	9.3
5 to 25 percent cover	2	1.9
less than 5 percent cover	0	0.0

Water Levels

Wetlands with a seasonally permanent and static water level which remained at or near the soil surface consistently received the most use by cranes. Wetlands in which the water table dropped 25 cm or more below the soil surface were often abandoned. Seasonal movements of cranes in response to fluctuating water levels also has been observed in northern California (Naylor et al. 1954). The water level of the Puckyan Marsh in northeastern Green Lake County averages 60 cm below the soil surface during a normal year (Thompson 1959). Relative to its size (400 ha), this wetland represents the poorest crane habitat in the county.

The largest crane populations and highest nesting densities occurred on wetlands which had floating sedge mats. Flood or drought conditions on floating-bog wetlands rarely threaten crane nests and the sedge mat assures a constant water supply throughout the summer. Adequate water levels are also important considerations in the abundance and availability of food. The high water tables in Marquette, northern Columbia, and western Green Lake counties are important factors contributing to the high populations of cranes in this region.

Upland Cover Type

Wetlands used by cranes in most of southeastern Wisconsin are adjacent to cropland (Table 5). Only 20 percent of the wetlands were completely surrounded by

Table 5. Composition of upland cover types adjacent to wetlands used by sandhill cranes in Marquette and Green Lake counties, Wis., 1976.

Upland covertype	Average % composition	Frequency of occurrence	Existing Upland cover type[1] (%)
Woods	41.6	92.1	35
Pasture	20.2	58.5	18
Alfalfa (*Medicago* sp.)	14.8	38.1	15
Corn (*Zea mays*)	13.1	31.6	23
Oats (*Avena fatua*)	5.1	8.9	-
Mint (*Mentha* sp.)	2.0	6.3	-
Fallow	1.2	5.0	4
Grass	0.4	3.3	-
Wheat (*Triticum estivum*)	0.1	0.8	1
Other	1.5	6.7	4

[1] Agricultural Stabilization and Conservation Service figures for Marquette and Green Lake counties (1976).

woodland or were relatively remote from cropland. Smaller wetlands (70 ha or less) generally had a higher percentage of their perimeter adjacent to cropland than larger areas. Forty-one percent of the wetlands were partially bordered by woods and this cover type occurred along 92 percent of the wetlands.

Wetland Vegetation

The relationship of cranes to wetland vegetation appears to be regulated more by plant physiognomy than by species composition. Sandhill cranes use an extensive diversity of vegetation types for feeding, nesting, loafing, and roosting. The plant physiognomy used in each activity is not only partially determined by species composition, but also by phenology. Monotypic stands of tall robust species such as reed canary grass (*Phalaris arundinaceae*) are used as feeding areas in the early stages of growth, but are abandoned when they approach maturity. If such areas are mechanically cut, they are again used by cranes. Vegetation is usually avoided if it has a density or height which impedes the free movements of cranes or hinders feeding activity. Cover types in this category include dense stands of cattail (*Typha latifolia*), burreed (*Sparganium eurycarpum*), and reed grass (*Phragmites communis*).

The preference exhibited by cranes for wetlands with floating bog mats has already been referred to. The vegetation associated with them is an important element in

this preference. The suspended root systems and low uptake of minerals rarely result in tall or dense stands of cattail and burreed. Instead, they exist as scattered, low density clones and provide maximum edge effect.

Plant Succession

Much confusion exists in the literature regarding the sequence of plant succession on Type 2 and 3 wetlands in southeastern Wisconsin. A major part of this confusion arises from the extensive alteration of wetlands by man which has occurred over the last 150 years (White 1965). Very few undisturbed areas remain which demonstrate natural patterns of wetland plant succession.

Curtis (1959) considered shallow marshes and sedge meadows to be intermediate stages in the natural development of shrub swamps and eventually timber communities. However, many historical records do not verify the invasion of shrubs on sedge meadows (Chamberlin 1882). White (1965) and Vogl (1969) found the development of shrub-carrs occurring only on wetlands with a history of disturbance, primarily lowered water tables. Bedford et al. (1974) contend that under natural conditions a sedge meadow is a climax community.

The effects of wetland drainage which occurred in the early 1900's upon plant succession in southeastern Wisconsin was largely masked by the farming practices of marsh haying, burning, and grazing. The advent of high yield alfalfa introduced in 1940 resulted in a discontinuation of the

practices of cutting marsh hay. This has resulted in a rapid invasion of shrubs in most wetlands of southeastern Wisconsin (White 1965). In the poor agricultural counties of Marquette and Green Lake, the harvest of marsh hay persisted into the early 1950's and the invasion of shrubs on sedge meadows is presently reaching its peak in these counties.

Changes in the composition of shrubs on wetlands in Marquette County from 1960 to 1975 is shown in Table 6. The most dramatic change in shrub composition occurred on wetlands which were already dominated by shrubs in 1960. No successional change occurred on 35 percent of the wetlands examined. These two extremes probably represent the difference between disturbed and undisturbed wetlands. Although the history of each wetland was not investigated, all wetlands exhibiting an 8 percent or greater change in shrub composition had been ditched previously for drainage. Close examination of many wetlands which appeared to be unaltered revealed the presence of hand dug drainage ditches remaining from the early 1900's.

Wetlands not previously ditched frequently may reflect successional change resulting from intensive burning. While fire generally is considered a retrogressive agent in plant succession, re-establishing pioneer conditions (Curtis 1959, Davis 1959), studies by Vogl (1969) demonstrated successional acceleration after a fire on many wetlands in southeastern Wisconsin.

The present loss of crane habitat to shrub invasion is

Table 6. Changes in shrub composition on 70 Type 2 wetlands in Marquette County, Wis., 1960-1975.

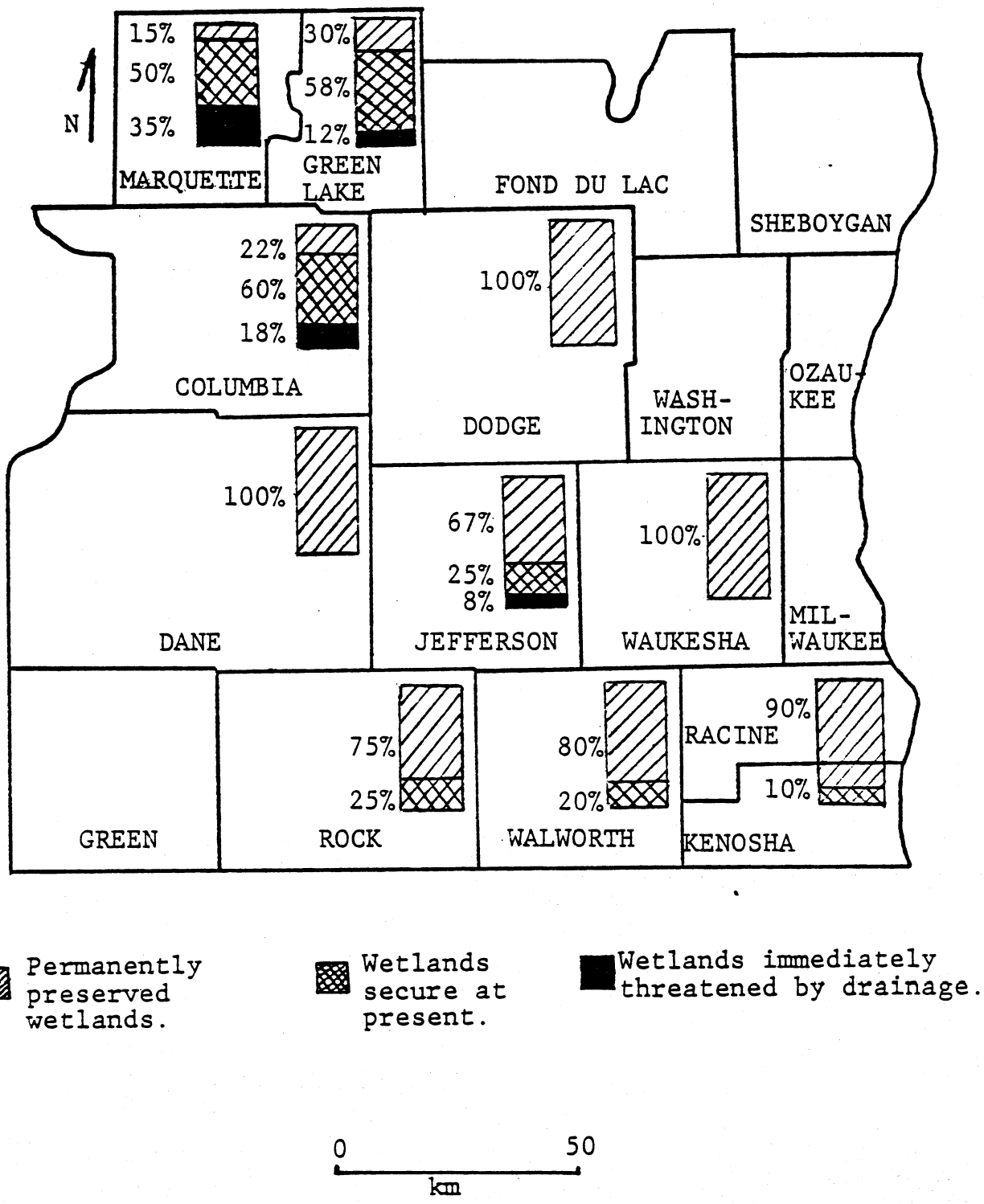
Wetland area dominated by shrubs (%)	Number of wetlands (1960)	Number of wetlands (1975)	% change
Greater than 75	6	10	+25.0
50 to 74	8	11	+15.7
26 to 49	12	17	+17.2
11 to 25	18	20	+ 5.2
0 to 10	25	24	- 2.0
	70	70	+ 8.9

gradual and difficult to assess, and the tolerance of cranes to increased brushy conditions on wetlands is not clearly understood. Hunt and Gluesing (1976) believed that the establishment of woody vegetation on small previously mowed meadows provides concealment, and thereby enhances their value to cranes. In southeastern Wisconsin cranes were found on several wetlands dominated by shrubs. Several crane nests were constructed of shrubs and placed under a shrub canopy. However, several thousand ha of shrub swamp exist in Marquette and Green Lake counties which receive no use by cranes, and those townships with the highest ratio of shrub swamp have the smallest crane populations. The effects of shrub encroachment is currently most serious on small wetlands (16 ha or less) which can become totally dominated by dense monotypic stands of shrubs in 10 years or less. On larger wetlands shrub enclosure is more graudal and scattered openings of sedge meadow often persist.

Wetland Drainage and Development

Seventy-eight percent of the cranes in southeastern Wisconsin are found on wetlands in private ownership, 21 percent on state-owned wetlands, and 1 percent on county or federally owned wetlands. At present, the greatest threat to private wetlands is drainage and conversion into cropland.

Three categories of wetland status were established on the basis of land ownership and the future intended use of wetlands by landowners (Fig. 3). The first category includes



Permanently preserved wetlands.

Wetlands secure at present.

Wetlands immediately threatened by drainage.

Fig. 3. Status of wetlands used by sandhill cranes in southeastern Wisconsin, 1977.

permanently preserved wetlands. These include wetlands owned by federal, state, or county conservation agencies, or by private nature centers. The second category includes privately owned wetlands presently being conserved for their recreational or agricultural value. Category three is comprised of wetlands which are immediately threatened by destruction through drainage or filling for agriculture. Wetlands in this category include those currently owned by muck farmers, wetlands drained but not presently cultivated, and wetlands scheduled for drainage during the next 1-3 years.

The greatest loss of wetland crane habitat in southeastern Wisconsin is presently occurring in Marquette, Columbia, Jefferson, and Green Lake counties. Thirty-five percent of the wetlands in Marquette County are immediately threatened by drainage and only five were classified as permanently preserved.

The long range future of wetlands being preserved by private landowners is difficult to predict. The status of many large and extremely valuable wetlands can change quickly, contingent upon financial motivation. Several large muck farming agencies currently solicit the purchase of wetland acreage from small independent farmers. Fifteen percent of the wetland landowners in Marquette and Green Lake counties have stated that they intend to drain their wetlands before 1980. An additional 12 percent have expressed a desire to sell all or part of their wetland acreage.

In addition to the current loss of wetland crane habitat,

an index to previous drainage was determined from former crane surveys (Table 7). I found that 12.5 percent of the wetlands reported to have resident cranes in 1973 by Gluesing (1974) had been converted to cropland and were no longer used by cranes in 1977. This represents an annual wetland loss of 3.1 percent. The destruction of these wetlands resulted in the displacement of at least 14 breeding pairs of cranes from their nesting habitat.

The effects of accelerated rural housing developments and road construction along the perimeter of wetlands used by cranes is difficult to assess. At present, such development appears to be of minor significance to cranes in most of southeastern Wisconsin. Lakeshore residences and resort areas have not curtailed crane use of wetlands along the Fox River and Lake Puckaway wetlands in Green Lake County, an area which supports the densest population of cranes in Wisconsin.

History of Wetland Use

Approximately 35 percent of the landowners interviewed were able to provide accurate information on the number of years that cranes have occupied their wetlands. Accuracy was judged on the basis of cross checks from several landowners on the same wetland, the ability of landowners to produce the approximate year cranes were first sighted, and the knowledge of cranes shown by the landowner throughout the interview.

Table 7. Re-survey of 64 wetlands occupied by cranes during 1973 (Gluesing 1974) in Marquette, Green Lake and Jefferson counties, Wis.

	Number of wetlands	%
Cranes present during 1977	44	68.7
Cranes absent during 1977		
Wetland drained and cultivated.....	8	12.5
Wetland filled and developed for housing.	1	1.5
Wetland filled for road construction.....	1	1.5
Wetland appeared to be unaltered.....	10	15.6

Sandhill cranes have occupied 73 percent of the wetlands for 20 years or less (Table 8) while 17 percent of the wetlands were occupied for 30 years or longer. Two wetlands along the White River in northern Green Lake County were occupied for 53 and 47 years, respectively. Nesting in 1935 was reported in both of these wetlands by W. Scott and D. Trainer Sr. (pers. comm.) and by Scott (1941). In Marquette County, the Endeavor and Colmstock Marshes had at least a 48 and 44 year history, respectively, of sandhill crane nesting, and three other wetlands had cranes for 35 to 39 years. Records produced by Walkinshaw (1949) indicated three nests found on wetlands in northern Marquette County during 1933 and 1934. These nest locations may have included the Colmstock area. Pairs of cranes have been reported nesting on the wetlands of Lake Koshkonong for 48 years and on the Jefferson Marsh in Jefferson County for at least 39 years. Early records of cranes on both of these wetlands were reported by Kumlien and Hollister (1903).

The large number of cranes moving into formerly unoccupied wetlands directly reflects the population increase over the past 25 years. In 1973, Gluesing (1974) found that 71 of 82 pairs of cranes (88 percent) were present on Wisconsin wetlands for 20 years or less.

The population increase is also reflected in the recent appearance of cranes on smaller sized wetlands. A significant correlation ($r=0.716$) was found between the size of wetlands and the number of years that cranes were known to be resident.

Table 8. Years of crane occupancy on 51 wetlands in Marquette, Green Lake, and Jefferson counties, Wis.

Years of crane occupancy	Number of wetlands	%
3 years or less	6	11.7
4 to 8 years	11	21.5
9 to 14 years	14	27.4
15 to 20 years	6	11.7
21 to 29 years	5	9.8
30 to 39 years	4	7.8
40 to 49 years	4	7.8
50 years or longer	1	1.9

(Fig. 4). Early distribution records indicate that cranes were usually found on the largest wetlands in each county. As the crane population grew and the amount of wetland habitat remained stable or declined, cranes began using smaller sized wetlands. Within the last 10 years cranes have occupied and successfully nested on wetlands less than 2 ha in size. The adaptation to the use of smaller sized wetlands is one of the major reasons why the sandhill crane population has continued to increase.

Breeding Biology

Between 15 April and 10 June 1977, 53 crane nests were located. Ground searches produced 49 nests in 141 man-hours of search time or 2.9 hrs/nest. This includes time periods of 18 hrs when only 1 nest was located and a period of one-half hr when 3 nests were located. When approached on foot incubating cranes would flush directly from the nest or after they had walked a short distance from the nest. The average flushing distance was about 25 m (SD=21, range 3-250).

Four nests were located in 3.0 hrs of helicopter search time or 0.8 hrs/nest. An additional 3.1 man-hrs/nest were spent to relocate these nests on the ground. Eleven wetlands known to have resident pairs were searched by helicopter, but cranes were only located on the 3 largest wetlands searched (240 to 400 ha) whereas no nests were found on 8 smaller wetlands (16 to 120 ha). Later observations revealed that cranes on 5 of these wetlands raised young and were nesting

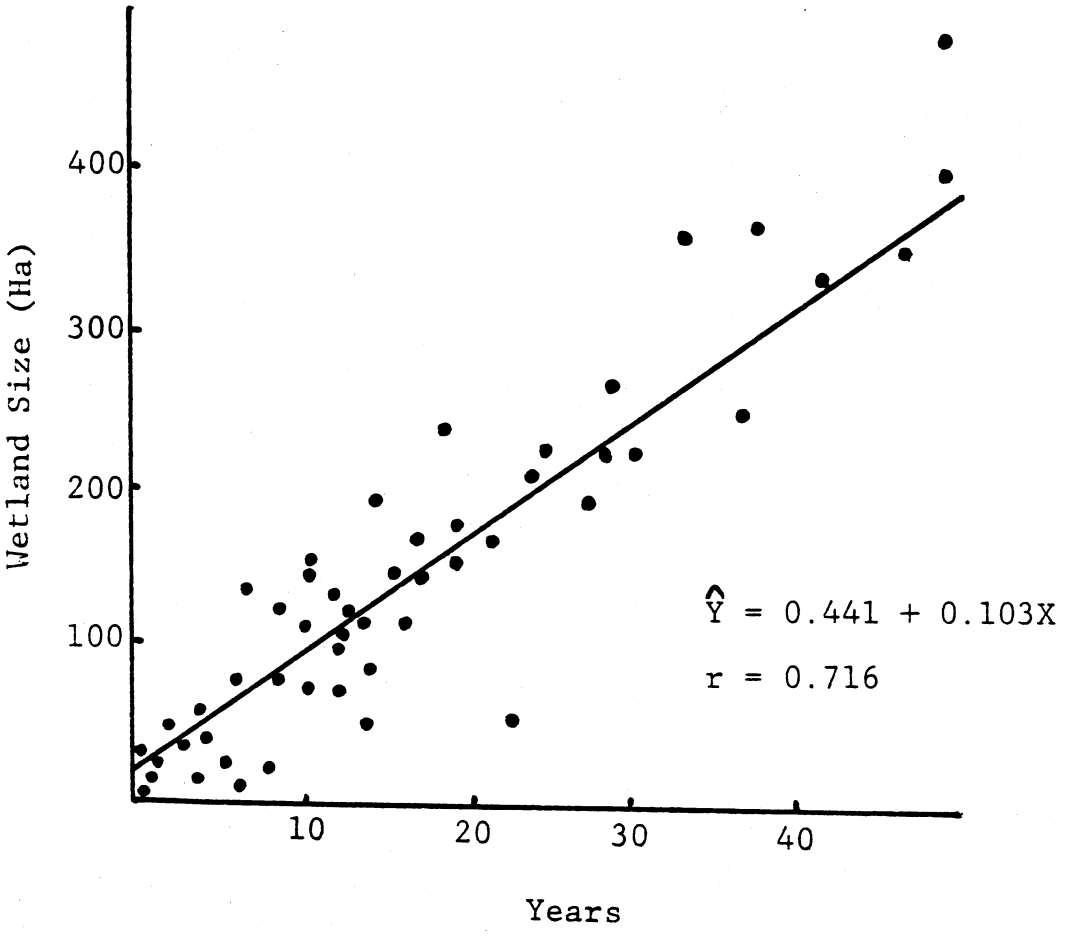


Fig. 4. Correlation between wetland size and years of crane occupancy in southeastern Wis., 1977.

at the time of the survey. The tendency for cranes to remain motionless on the nest when approached by aircraft, and the placement of nests in dense cover on small wetlands, is largely responsible for the poor success of the aerial search.

On wetlands of 50 ha and smaller, ground searches are the most efficient means of locating crane nests in southeastern Wisconsin. On such wetlands an observer familiar with crane nesting habitat requirements can often walk directly to the nest site.

Nest Dimensions

The average nest diameter was 116.7 cm (SD=41.2, range 15.2-231.6) and average nest height was 11.7 cm (SD=3.9, range 2.5-33.0). Average nest dimensions reported by other researchers are given below:

Authority	Location	Dia. (cm)	Ht. (cm)	Sample Size
Howard & Nauman (1975)	Cent. Wisc.	91	17.0	50
Walkinshaw (1973)	S. Michigan	100-122	13.6	110
Drewin (1973)	Idaho	80-86	-	337

The average water depth at nests was 11 cm (SD=5, range 0-25). The average water depth at 110 nests in southern Michigan was 21.2 cm (Walkinshaw 1965a), and it was 20 cm for 187 nests in Idaho (Drewin 1973).

Many crane nesting studies have concluded that nest size is largely a function of water depth and the type and abundance of vegetation at the nest site. The largest nests in this study were associated with robust emergents, such as cattail and bulrush (*Scirpus validus*), and were in water depths exceeding 15 cm. The smallest nests were on sedge meadows

and drier sites. Two single egg clutches were found on dry land with no evidence of nest construction.

Clutch Size and Hatching Dates

Of 43 clutches, 39 were double egg clutches and 4 were single egg clutches for an average of 1.91 eggs/clutch. All nests were visited at six day intervals and several nests initially containing one egg contained two on subsequent visits. Drewin (1973) reported a clutch size of 1.94, Walkinshaw (1973) 1.97, and Littlefield and Ryder (1968) 1.91.

The mean hatching date was 10 May and 71 percent of the nests hatched during a 10-day period from 5 to 15 May 1977 (Fig. 5). The hatching dates in this study parallel those reported by Walkinshaw (1965a) for southern Michigan, where the average hatching date was 14 May. However, a larger difference exists in the hatching dates reported by Howard and Nauman (1975) on wetlands in central Wisconsin (an aerial distance of about 80 km), where the peak hatching date was 19 to 30 May, or 2 weeks later than the peak indicated for this study. Much of this difference probably can be attributed to an exceptionally mild spring in the Lake States during 1977. Peak hatching dates for cranes in southern Michigan were also 10 days earlier than normal in 1977 (L. Walkinshaw pers. comm.).

Hatching Success

Two double egg clutches and one single egg clutch were

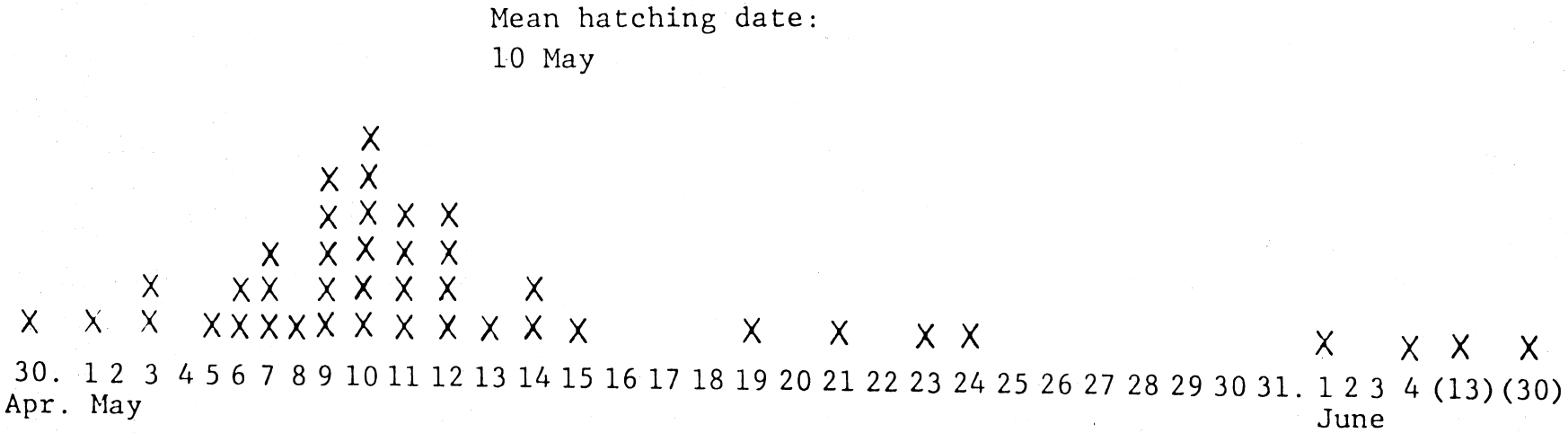


Fig. 5. Hatching dates of 42 sandhill crane nests in southeastern Wis., 1977.

infertile (Table 9). Both two-egg clutches were abandoned within 1 week beyond the normal 30-31 day incubation period. The single egg was incubated for 44 days until the egg became decomposed and cracked.

Two nests were destroyed by raccoons (Procyon lotor). Both of these nests were located in small stands of aquatic emergents in cattle pastures. Such areas are natural travelways for raccoons and very likely enhanced the opportunity for nest destruction by this predator. The importance of raccoons as nest predators of sandhill cranes has been documented by Littlefield (1976) and Walkinshaw (1965a).

Both abandoned nests were initially located by helicopter and were found deserted after 5 days when revisited on foot. These nests contained only a single egg and it is possible that these pairs were in the early stages of incubation, at which time they are most sensitive to disturbance (Walkinshaw 1949). No re-nesting by any of the pairs with abandoned or destroyed nests was observed.

The hatching success of 84 percent is similar to the rate of 80 percent reported by Howard and Nauman (1975) for central Wisconsin, and 77 percent reported by Walkinshaw (1973) in southern Michigan, and Drewin (1973) in Idaho.

Vegetation Analysis of Nests and Nest Sites

Twenty-two nests (42 percent) were composed entirely of 1 plant species. Seventeen of these nests were constructed

Table 9. Hatching success of 43 sandhill crane nests in southeastern Wis., 1977.

Status	Nests	%
Successfully hatched	36	83.7
One or both eggs infertile	3	6.9
Destroyed by predator	2	4.6
Nest abandoned	2	4.6

of cattails, 3 of bulrush, and 2 of sedge. The remaining 30 nests were constructed of 2 or more plant species. Many nests constructed of several plant species still had 1 dominant plant comprising most of the material and usually were located in a pure stand of this species (Table 10).

The vegetative composition of nests suggests that cranes used whatever material was available at the nest site for construction. However, one pair constructed a nest entirely of water plantain (Alisma plantago-aquatica) panicles in a pure stand of cattails. Cattails were dominant at this site and bordered the nest on all sides but none were used in its construction.

Cranes constructed all nests except one built on a muskrat (Ondatra zibethica) house. Walkinshaw (1973) has reported similar nests in Michigan.

The appearance of crane nesting wetlands differed but the conditions at the nest site (defined as an area of 10 m^2 encircling the nest) remained relatively constant. Most nests were located in pure stands of robust emergents, primarily cattail, burreed, and bulrush. On most wetlands in this region these are the only aquatic emergents which provide residual cover over winter and are available to cranes in late March. Cattail was the most common and provided the most cover of these species, and therefore received the greatest use by cranes. Beecher (1942) and others have demonstrated that innate requirements for nest sites are satisfied by plants of many species as long as

Table 10. Plant composition of 52 sandhill crane nests in southeastern Wis., 1977.

Plant species	% of occurrence	Average % composition
Typha latifolia, *T. angustifolia*	76.9	53.6
Carex stricta, *C. stipata*, *C. lasiocarpa*	48.0	13.1
Sparganium eurycarpum	40.4	8.9
Carex rostrata	21.1	7.3
Scirpus validus	30.7	6.5
Carex comosa	5.7	3.3
Scirpus cyperinus	17.3	2.6
Alisma plantago-aquatica	1.9	1.8
Spiraea latifolia, *Betula pumila*, *Salix* sp.	7.6	1.3
Phalaris arundinacea	1.9	0.2
Misc. (includes roots, bark, mud, etc.)	13.5	0.8

they are similar in life form.

Most crane nests were placed at the edges of plant communities of different physiognomy and at water-cover edges. Nests built in cattails or other tall emergents were placed generally in small patches or along the edge of larger patches (Fig. 6). No nests were found in large or continuous monotypic stands of these emergents. The average distance that 28 nests were placed from a sedge-cattail edge into denser cover was 12 m (SD=6, range 2-40). The average size of 27 stands of emergents (primarily cattail) used as nest sites was 0.4 ha.

The denisty of cattails used as nest sites was not evaluated in this study but it seems to be an important factor in the selection of a nest site. No nests were found in very dense stands of cattail or in those which contained a large amount of residual dead plant material. Moderate density stands of emergents which allow cranes to walk freely to and from the nest appear to be an important requirement.

At 83 percent of the nests one species of vegetation clearly dominated the site (Table 11).

Nests usually were placed along a sedge-shrub edge in Type 2 wetlands consisting only of Carex species and without any of the coarser emergents (Fig. 7). Of 53 nests, 6 (11 percent) were of this type. Small stands of low density shrubs may provide nesting concealment in the absence of other aquatic emergents on some wetlands. Less than 2.0 percent of the

Fig. 6. Sandhill crane nest in a low density clone of cattails, Marquette County, Wis., 1977.

Table 11. Dominant plant species at 42 sandhill crane nest sites in southeastern Wis., 1977.

Species	No. of Nests	%
Typha latifolia	29	69
Scirpus validus	4	9
Sparganium eurycarpum	4	9
Carex stricta	3	7
Carex rostrata	2	5

Fig. 7. Sandhill crane nest along a shrub swamp-sedge meadow ecotone, Marquette County, Wis., 1977.

nests reported by Littlefield and Ryder (1968) and Walkinshaw (1965a) were located among willow or other shrubs.

Distance from Nests to Open Water

Fourteen of 53 nests were on wetlands adjacent to lakes or wetlands containing a large amount of open water. The average distance from the nests to open water was 357 m (SD=211, range 10-980). On Lake Puckaway 2 nests were found on small peninsulas of vegetation where each nest was placed only 10 m from the water's edge. The remaining nests were on wetlands containing no open water other than that provided by small streams.

Nesting Density

The mean distance between active crane nests on the same marsh was 327 m (SD=108, range 160-1,800). The highest nesting density was observed on Colmstock Marsh, an area which represents near optimum crane habitat. Five nests were found in a 34 ha area in the center of this wetland and there may have been additional nests which I did not find. The vegetation in this area was a mixture of bulrush, cattail, and sedge, and there was no screening effect provided by dense vegetation as noted on other wetlands with multiple nesting pairs. Similar nesting densities have been reported by Drewin (1973) and Littlefield and Ryder (1968) who contend that crane nesting density is a function of the number of birds present in an area and the quality of the habitat.

Proximity of Crane Nests to Sources of Human Activity

The average distance that each nest was located from a source of human disturbance (farms, houses, recreational facilities, or major state highways) was 655 m (SD=387, range 90-1,130). In contrast, Howard and Nauman (1975) found the average distance was 1,714 m (range 305-5,630) for central Wisconsin. This difference is largely a reflection of the smaller sized wetlands used by cranes in southeastern Wisconsin and the higher human population density. However, it does indicate that the high degree of seclusion provided by large and remote wetlands, considered an essential requirement by Hamerstrom (1938), is presently not a serious limiting factor to crane nesting in southeastern Wisconsin.

Territory Size and Defense

The size of 7 nesting territories studied averaged 38 ha (SD=17, range 4-92). Sandhill crane nesting territories in upper Michigan averaged 41 ha for 13 nests, and 53 ha for 76 nests in lower Michigan (Walkinshaw 1973). Littlefield and Ryder (1968) found the average size of 8 territories to be 25 ha in Oregon, and Drewin (1973) reported the size of 5 territories in Idaho to be 17 ha.

All territories contained 3 divisions as described by Walkinshaw (1965b:77); a feeding area, nesting cover, and a water supply. Territories often contained upland fields or pastures as feeding areas on small wetlands.

Established territories were defended by both members of the pair against intruding cranes. One territory was occupied by 3 cranes throughout incubation and for the first 2 weeks after hatching. The extra bird was probably a yearling from the preceding year. On wetlands containing multiple nesting pairs physical features such as islands, woods, railroad tracks, and highways served as territorial boundaries. Where territories met or overlapped, these physical boundaries frequently were neutral ground and were used by neighboring pairs of cranes.

On one wetland a railroad track served as a territorial boundary dividing the wetland into 2 units. Both pairs used the railroad as a preening and loafing area, often at the same time. In flight, each pair flew perpendicular to their side of the tracks. Encroachment of one pair onto the others territory was observed only once, and resulted in the intruding pair being immediately driven away.

Most encounters involved transient non-breeding cranes landing within the territory of a breeding pair. Conflicts between neighboring pairs was seldom observed after nesting was initiated. Where higher densities of breeding cranes occurred, territories were smaller and conflicts between pairs were observed less frequently. Territorial conflicts were most common on small wetlands where few cranes were present. I observed the most intensive territorial defense by a pair occupying a 4 ha wetland. This pair actively defended a 350 ha area around the nest site primarily

consisting of uplands. On 11 occasions this pair was observed leaving their nest or prefledged chick unguarded to pursue cranes which were feeding on uplands as far as 2 km away. One encounter lasted over 3 hrs before a group of 8 cranes was eventually driven off the territory. This pair was never observed using many of the fields they defended.

Abandonment of territories following nest destruction or loss of broods was variable. Of 7 pairs which suffered nest destruction, 3 abandoned their territories. Two pairs which deserted their nests due to human disturbance also left their territories and 3 out of 4 pairs abandoned their territories after losing their chicks.

Survival of Chicks

Sibling strife and aggresion between young sandhill crane chicks had been reported by many researchers (Prill 1922, Hyde 1957, Walkinshaw 1965a, Littlefield and Ryder 1968, Drewin 1973). Miller and Hatfield (1974) contend that this aggression and rivalry often results in the death of the younger or weaker chick. I observed aggressive interactions between siblings on several occasions. All interactions occurred during feeding and involved one sibling driving the other away from a parent who had located food. Most encounters resulted in no apparent injury. However, on one occasion I observed a chick (chick A) continually drive off his sibling (chick B) during a 40

minute interval. During this time chick B appeared intimidated and remained a distance of 30 m or more from chick A, who was attended by both parents. Neither parent was observed approaching or feeding chick B. Suddenly the adults became startled and began leading chick A into heavy cover. Chick B soon lost visual contact with the adults and began wandering off in another direction. He was not observed rejoining his parents and when this pair was sighted 2 days later they had only 1 chick with them. I did not see the other chick again despite continual observations throughout the summer.

Very little information exists on the loss of prefledged sandhill crane chicks to predators. Littlefield (1976) reported coyotes (Canis latrans) as predators on crane chicks in Oregon. He recorded heavy losses of sandhill crane chicks to coyotes in 1973 and 1974 during a low in the black-tailed jackrabbit (Lepus californicus) population. Walkinshaw (1949) reported having searched many red fox (Vulpes fulva) dens located near crane nests in Michigan without finding any crane remains.

Of 76 crane chicks monitored in Marquette and Green Lake counties, 25 (32.8 percent) were lost between hatching and fledging. The greatest loss (71 percent) occurred during the first 2 weeks after hatching. Sibling strife may have resulted in the loss of some chicks, but 13 pairs of cranes lost their entire brood of 1 or 2 chicks.

Red foxes preyed upon at least 3 crane chicks within

the study area. Two chicks were found at a fox den within the Horicon National Wildlife Refuge in Dodge County (Drieslein and Bennett 1978). The chicks were lying at an entrance to a den where 3 fox pups had been observed on several occasions earlier in the week. Both chicks had been bitten in the back and neck, and judging from their fresh appearance, they probably were killed that day. Based on growth curves developed for captive cranes, the chicks were between 3 and 5 days old (Baldwin 1977).

On 22 May 1977 I was observing a pair of sandhill cranes with their 6-day old chick with a 60X spotting scope at a distance of 200 m. The birds were feeding in a 2 ha field of short grass surrounded on 3 sides by shrubs. At 0710 a red fox approached from an adjacent field and disappeared into a row of shrubs at the edge of the field where the cranes were feeding. The cranes were screened visually from the fox and did not appear to be aware of his presence. At 0720 the fox reappeared on a wooded ditch bank directly in line with the cranes at a distance of about 30 m. For the next 15 to 20 minutes, the fox remained partially concealed and motionless while the cranes continued feeding along the edge of the ditch. At 0740 the fox ran toward the cranes, picked up the chick which was within 2 m of one adult, and continued running with the chick into the nearest shrubs. Both adult cranes had their heads down when the fox charged and did not react until it was within 6 to 8 m of the chick. Their initial

response was a distraction display with each adult running in opposite directions with head and wings lowered. They continued this display for 10 minutes after their chick had been captured. The pair of cranes remained in the area for 1 week after the incident.

In addition to foxes, I suspect that chicks were preyed upon by great horned owls (Bubo virginianus). Horned owls are capable of killing adult sandhill cranes (Craighead and Craighead 1956) and are suspected predators of adult cranes at roosts (Walkinshaw 1949, Lewis 1974). The intensive use of semi-wooded pastures by cranes with young chicks greatly enhances the opportunity for horned owl predation. I often observed horned owls roosting during midday in large trees above feeding families of cranes.

Several landowners reported seeing crane chicks captured by dogs or trampled to death by cattle. Crane chicks also were subject to a variety of accidents. One farmer found a dead chick which had become entangled in a woven-wire fence and 2 other farmers reported that they had removed entangled crane chicks from wire fences. One crane chick was killed on a road by an automobile and another was killed by a hay mower.

Seventy-two percent of the total brood mortality occurred on wetlands near active farms, residences, or along major highways. Cranes nesting in small depressions in active cropland fields, cattle pastures, or near residences, were 3 times as susceptible to losing their

prefledged young as were cranes nesting in wetlands remote from these areas. The mortality rate of broods was constant relative to wetland size and nesting density of cranes.

The average brood size at fledging was 1.36 chicks/nesting pair (Table 12). This compares closely with brood sizes in Michigan of 1.31 (Walkinshaw 1973) and 1.35 in Idaho (Drewin 1973).

The annual recruitment rate averaged 11.1 percent and was 13.8, 9.6, and 8.4 in Marquette, Green Lake and Jefferson county, respectively. Of 9,894 greater sandhill cranes examined at the Jasper-Pulaski Wildlife Area, Indiana in 1977 (pers. observ.), 11.3 percent were juveniles. Littlefield and Ryder (1968) reported an annual recruitment rate of 8 to 10 percent on Malheur Marsh in Oregon, while Drewin (1973) observed a frequency of 15 to 16 juveniles per 100 adults (13 to 14 percent juveniles in the total population) in fall flocks at Grays Lake, Idaho. Buller (1976) determined the age ratio of 36,000 Canadian (*G. c. rowani*) and lesser (*G. c. canadensis*) sandhill cranes in the central flyway, and found annual recruitment to average 11 percent.

Feeding Behavior of Pairs With Chicks

The feeding habits of 2 pairs of cranes each having 1 chick were studied during the first 8 weeks after hatching. Pair A occupied a small wetland exposed to agricultural land on three sides while pair B had no access to upland

Table 12. Survival of sandhill crane chicks and annual recruitment rates in Marquette, Green Lake, and Jefferson counties, Wis., 1976-1977.

	1976	1977	Average
Number of breeding pairs with young	44.0	49.0	46.5
Chick survival to fledging (%)	71.8	66.8	69.3
Brood size at fledging	1.40	1.32	1.36
Annual recruitment rate (%)	10.6	11.5	11.1

agricultural fields. During the first 2 days after hatching the movements of both pairs were restricted to within a 35 m radius of the nest. Food identified at this time consisted entirely of animal matter, primarily insects and insect larvae.

When their chick was 3-4 days old, pair A began feeding in a heavily grazed lowland cattle pasture. This pair used the pasture almost exclusively each day for the next 5 weeks. Almost 75 percent of the feeding observations made during this period consisted of the adults probing for earthworms. Areas of the pasture containing moist deposits of peat soil with high densities of earthworms were visited 3 or more times each day. Following a rainfall, cranes would cover large areas of the pasture picking up worms on the surface. Cranes often were observed turning over or splitting up old piles of cattle manure which harbored large concentrations of worms and soil invertebrates. During midday this pair commonly retired to a small grove of trees within the pasture where the chick was fed small insects from the bark of trees. When their chick was 5 weeks old the cranes resumed feeding in the wetlands and made only irregular use of the pasture.

When their chick was 4 days old pair B began using a sparsely vegetated sedge meadow. This pair relied very heavily on animal matter caught on the ground or from the water surface and did little probing for invertebrates. Their daily feeding movements were over 5 times greater

than those of pair A. This pair was observed capturing insects, frogs (Rana sp.), mice (Microtus sp.), garter snakes (Thamnophis sirtalis), and mud minnows (Unbra limi). Large food items were broken apart before being fed to the chick. This pair also was observed preying upon a nest of mallards (Anas platyrhynchos) and feeding the clutch of eggs to their chick. Harvey et al. (1969) reported that lesser sandhills often are predators on the nests of blue geese (Chen caerulescens).

While sandhill cranes are considered omnivorous (Walkinshaw 1973), several generalizations can be made about the feeding movements of pairs with chicks observed in this study. Cranes consistently exhibited a preference for cattle pastures. Almost 72 percent of all observations made of pairs feeding on uplands involved cattle pastures (Fig. 8). When this covertype was available, cranes made minimal use of wetlands for feeding during the first 5 weeks after hatching. The low height of the vegetation and an abundant food supply are important factors in this preference. Small moist depressions in pastures receive extensive runoff and are very fertile, supporting high concentrations of small animal and invertebrate insect life. The importance of this cover type is evidenced by the increasing number of cranes which are nesting in or near cattle pastures.

Feeding Behavior of Non-breeding Cranes

Relatively little information exists on the feeding

Fig. 8. Partially wooded cattle pasture used by sandhill cranes with broods, Green Lake County, Wis., 1977.

habits of non-breeding cranes upon arrival in early spring. Walkinshaw (1949) reported that cranes feed largely on the roots of Carex species and several other aquatic plants during spring in Michigan. In southeastern Wisconsin, cranes arriving in April fed almost entirely in the wetlands. Major food items in spring and early summer were the tubers and rhizomes of arrowhead (Sagittaria latifolia). Cranes were observed feeding for 3 to 5 hrs each day on small (1.0 ha) beds of this species. Cranes also made limited use of the rhizomes of burreed and beaked sedge (Carex rostrata). From 10-21 April, a group of 40 cranes on Lake Puckaway was observed feeding on the carcasses of winterkilled carp (Cyprinus carpio) and northern pike (Esox lucius).

Intensive upland use for feeding did not occur until June. During both years the movement of cranes from wetlands to uplands for feeding appeared to be correlated with receding marsh water levels. In 1976, cranes were observed feeding on the uplands by 20 May in response to drought conditions; during the moist spring of 1977 cranes did not begin feeding on the uplands until 15 June. The water level may be an important element in the ability of cranes to successfully extract the tubers and roots of aquatic plants.

Throughout the first half of the summer 68 percent of the cranes were seen in either pasture or alfalfa fields (Tables 13 and 14). With the advent of fall crop harvesting in mid-August, 83 percent of the crane observations occurred in harvested or partially harvested fields of corn (Zea mays),

Table 13. Percent monthly distribution of sandhill cranes by field type, Marquette and Green Lake counties, Wis., 1976-1977.

Field type	Distribution of cranes (%)					Weighted means
	May	June	July	August	September	
Alfalfa	34	26	29	11	3	20
Corn	9	18	3	9	77	24
Pasture	37	36	40	14	0	26
Grass	6	2	4	0	0	3
Mint	5	7	6	0	5	4
Wheat	0	2	7	48	12	14
Fallow	4	7	2	1	0	3
Oats	0	2	9	17	0	5
Woods	2	0	0	0	3	1
Other	1	0	0	0	0	0

Table 14. Monthly field preference indices[1] of sandhill cranes, Marquette and Green Lake counties, Wis., 1976-1977.

Field type	Monthly indices					Weighted means
	May	June	July	August	September	
Alfalfa	1.4	1.0	1.1	0.6	0.1	0.8
Corn	0.6	1.4	0.1	0.8	5.1	1.6
Pasture	1.6	1.7	2.1	0.7	0.1	1.2
Grass	0.6	0.3	0.4	0.2	0.0	0.2
Mint	0.1	0.7	0.5	0.0	0.3	0.3
Wheat	0.0	0.9	1.4	9.7	3.4	3.0
Fallow	0.3	0.5	0.1	0.3	0.0	0.2
Oats	0.0	0.1	0.5	1.9	0.0	0.5
Woods	0.1	0.0	0.0	0.0	0.2	0.0
Other	0.2	0.0	0.0	0.0	0.0	0.0

[1] Index values greater than 1.0 suggest greater usage of a field type than expected if the cranes had no preference, whereas values less than 1.0 reflect avoidance of a field type.

oats (Avena fatua), and wheat (Triticum estivum).

Sandhill cranes exhibited the strongest preference for wheat fields. Wheat is a very uncommon crop in the two counties studied and preference indices of 9.7 and 3.4 in August and September, respectively, demonstrate the high selectivity and utilization of this field type. Studies by Munro (1950), Stephen (1967), and Hoffman (1976) have shown similar preferences for wheat.

Corn fields ranked second in the average preference rating. The first peak in corn use occurred in June with cranes feeding on corn seedlings. However, only 18 percent of the cranes were observed feeding in corn during this month, and feeding persisted until the corn attained a 10 cm height. The highest use occurred in September when 77 percent of the cranes were observed feeding in corn fields.

Alfalfa fields and cattle pastures were 2 of the most available upland agricultural cover types. Alfalfa received extensive and consistent use by cranes throughout the summer, but preference ratings indicated this use was only proportional to its availability. Peak use of alfalfa usually occurred after harvesting. The removal of vegetation enhances the availability of grasshoppers and soil invertebrates to cranes.

Pastures had the third highest preference rating. Those lying adjacent to wetlands often were used as both feeding and midday loafing sites, particularly if the pastures had a water supply. Moderately to heavily grazed

pastures were preferred over wild or lightly grazed pastures. Cranes were often observed foraging through cattle manure for waste grain as reported by Hoffman (1976).

Cranes extensively used fields of oats, particularly where wheat fields were unavailable. Cranes were first observed feeding on the ripened seedheads of unharvested oats during July. The birds were efficient at stripping the seeds from erect oat plants and often fed in a field for 5 to 10 days after harvesting. Use of oats ended abruptly when the harvest of corn began. The preference for oats by cranes in southeastern Wisconsin differs from the findings of Munro (1950), Stephen (1967), and Hoffman (1976) who reported minimal use of oats by cranes and for only a short period after harvesting. The field types of grass, fallow, and mint received insignificant use or were avoided. However, during 1976 a group of 25 cranes fed daily for over 6 weeks on a large mint field during June and July. Feeding activity consisted of probing for soil invertebrates between the rows of mint. This behavior was not observed in 1977 despite the presence of a large number of cranes near mint fields. Small groups of cranes often were observed feeding on acorns in oak (*Quercus* sp.) woodlots during September. Oak woods used by cranes were usually grazed and contained little underbrush. Similar feeding behavior has been reported by Walkinshaw (1953) and Guthery (1976).

Crop Depredations

Crop depredations by sandhill cranes in Wisconsin consisted almost entirely of damage to sprouting corn plants in the spring. On the basis of personal interviews and card survey data, about 20 percent of the landowners adjacent to wetlands occupied by cranes have experienced some crop damage. Of this total, only 25 percent considered the damage to be significant. Most landowners reported that damage is non-recurrent over the years. The history of crop losses to cranes in most counties revealed year to year depredations on a small number of fields in close proximity to wetlands containing large populations of non-breeding cranes. Damage by single pairs, which may occur more often, is less noticeable and often overlooked by farmers. No damage due to nesting pairs was observed. Ninety-three percent of the crane depredations to sprouting corn observed in this study occurred on muck farms adjacent to wetlands occupied by cranes.

Attempts to bait cranes from sprouting corn fields during 1977 was of limited success. Four of 5 bait stations established at crane roosts were used over a 3 week period by groups of 10-70 cranes. However, use of the sites was very irregular, with flocks feeding intensively for several days and then abandoning the site. Observations of nearby corn fields revealed that groups of cranes often fed on corn seedlings before or after visiting the bait site.

Baiting was more successful when sites were established

directly on a field being depredated by cranes. On each of these fields the cranes immediately began feeding on the shelled corn which reduced both the amount of time that cranes spent in the fields and the damage to sprouting corn. On 3 fields heavily depredated by groups of 5-15 cranes, no further damage occurred after bait sites were established. The fact that cranes could be captured successfully with rocket nets in sprouting corn fields attests to their preference for these bait sites. Dambach and Leedy (1948) and Dambach (1949) reported that scattering shelled corn around the margins of sprouting corn fields successfully reduced crop damage by pheasants (Phasianus colchicus). Burgess (1973) demonstrated that waterfowl damage could be reduced significantly with feeding stations, and that such projects are economically justified.

Random observations made of cranes feeding on corn seedlings revealed that 1 bird can destroy an average of 102 plants per hr (Table 15). Feeding intervals reflect the amount of corn eaten while the birds are in the field and includes periods of preening, resting, or watching for danger. The figures in Table 15 probably reflect maximum feeding rates since these observations were all made immediately after the birds landed in a field, when feeding is most intense. If unmolested, cranes generally spent an average of 1.5 hrs (SD=0.8, range 0.1-3.2, n=18) each morning feeding in sprouting corn fields. Afternoon depredations were seldom observed, and usually only involved

Table 15. Rate of corn seedling depredation by sandhill cranes, Green Lake County, Wis., 1977.

Feeding interval (min)	No. of plants destroyed	No. of cranes	Plants destroyed/ crane/hour
30	182	4	91
30	448	7	128
15	364	7	104
15	39	2	78
30	228	4	114
30	145	3	97
2.5 hrs.	1,406	27	102

half the number of cranes seen in the morning.

For reimbursement of crops lost to cranes, the Wisconsin Department of Natural Resources asks farmers to estimate the number of cranes using the fields, the number of days on which damage has occurred, and seeding rates. Because damage by cranes if very irregular and dispersed over a large area, an accurate assessment of the loss is difficult to make. Information on feeding rates of sandhill cranes in corn fields may be useful in estimating crop losses and verifying crop damage claims made by farmers.

The shallow planting depth of seeds on peat land soil enhances the conditions for crop depredations (Table 16). Thirty-eight percent of the seeds examined which were planted at a depth of 13 cm or greater were missed by cranes. The depth of seeds is usually responsible for the random or scattered nature of crane depredations. When seeds are planted shallow, cranes walk directly down the rows destroying each plant encountered. If a crane fails to reach a seed in several attempts, it moves throughout the field to locate seeds of a shallow depth. The high moisture content of muck soil in spring, and the short-day corn varieties used, require very shallow planting depths to achieve normal germination. Due to the seed varieties currently used, deeper planting to reduce damage by cranes does not appear feasible.

Table 16. Efficiency of corn seed extraction by sandhill cranes in relation to soil depth in Green Lake County, Wis., 1977.

Average soil depth (cm)	Probe holes examined	Kernels found	Efficiency of removal (%)
2.5	100	6	94
8.0	100	17	83
13.0	100	38	62

Roosting Behavior

Habitat Selection

Ten major crane roosts were identified in southeastern Wisconsin (Table 17). Crane roosts typically consisted of small shallow ponds or flooded mudflats and oxbows along the shores of slow-moving rivers. While the actual size of crane roosts was small (1.4 ha), roosts were all centered in very large wetlands of 300 ha or more.

A large degree of variation existed in the vegetation types surrounding the roosts. Half of the roosts consisted of the open water zones of Type 3 and 4 wetlands, and were surrounded by dense stands of cattail and burreed. Three roosts were located in Type 2 wetlands and surrounded by sedges. One roost was located in a flooded stand of dead timber, and another was surrounded by a mature stand of oak trees. Three roosts contained large amounts of submerged aquatic plants. On Lake Puckaway, cranes roosted in shallow sloughs of American lotus (*Nelumbo lutea*).

Crane roosts surrounded by woody vegetation were very similar to those I observed used by migrating cranes at the Jasper-Pulaski Fish and Wildlife Area, Indiana. However, the densely vegetated nature of roosts in southeastern Wisconsin differs from those described by Lewis (1974) in the central flyway, where crane roosts were usually sparsely vegetated or not vegetated. Relatively flat and open roost conditions which afford the birds a wide field of view do not appear to be a critical element in Wisconsin.

Table 17. Major roosts used by resident and migrant sandhill cranes in southeastern Wis., 1976-1977.

Location and marsh name	Number of cranes	Roost type	Roost size (ha)	Water depth (cm)	Surrounding covertype
Marquette County					
Colmstock Marsh	30-450	Pond	1.0	10-35	Sedge-oak woods
Widow Creek Marsh	25-400	Pond	1.2	5-25	Cattails
Germania Marsh	35	River	0.5	4-18	Burreed
Fox River Marsh	40-200	River	2.8	9-40	Cattails
Green Lake County					
White River 1	35-275	Pond	2.1	8-16	Oak woods
White River 2	40-600	River	3.0	1-30	Sedge
Puckaway Lake	100	Pond	2.0	4-28	Cattails
Grand River Marsh	80	Pond	0.8	11-43	Cattails
Columbia County					
Dates Millpond	35-200	Pond	1.0	3-15	Burreed
Jefferson County					
Rome Pond	30	Pond	0.4	1-20	Sedge-burreed
			1.4	5-27	

Daily Arrival and Departure of Cranes at Roosts

Seventy-one percent of the cranes left the roost during the first 40 min after sunrise (Fig. 9). Only 15 percent left the roost before sunrise. Cranes which remained at the roost over an hour usually fed along the shores or slowly walked to other areas of the marsh. Cloudy days delayed the initial flights from the roost an average of 30 min and distributed the peak flight over a 1-2 hr period. On cloudy days a larger number of cranes remained at the roost all morning.

The largest flight of cranes (64 percent) occurred from 15 min before to 30 min after sunrise (Fig. 10). However, evening roost flights were very irregular. Frequent disturbance of the birds in nearby fields usually resulted in late afternoon arrival of cranes at the roost. In addition, cranes often used other portions of the wetland as a secondary roost. Secondary roosts were defined by Wheller and Lewis (1972) as areas within a half mile of the primary roosts which were used for feeding, preening, dancing, or feeding. Cranes which arrived during the late afternoon and loafed on other portions of the wetland usually were the last to arrive at the roost. On clear evenings these cranes were observed flying or walking to the roost 1 hr or more after sunset. On overcast days, most cranes were at the roost site before sunset. The timing and movements of cranes to and from roosts was similar to that reported by Lewis (1974) in Nebraska, and Walkinshaw (1949) in Florida and Texas.

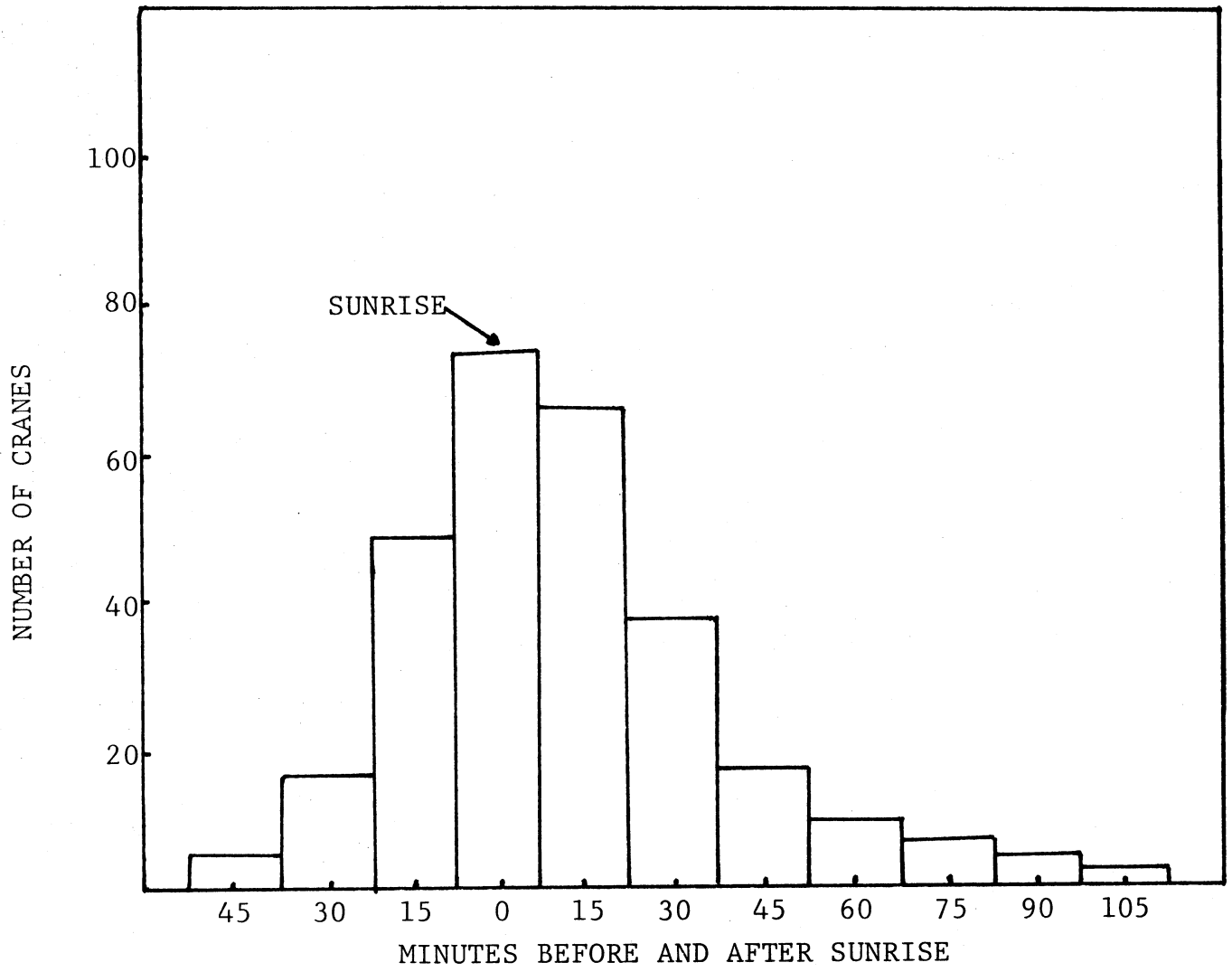


Fig. 9. Time of departure of sandhill cranes from their roost in relation to sunrise, 18 mornings, southeastern Wis., Sept. 1977.

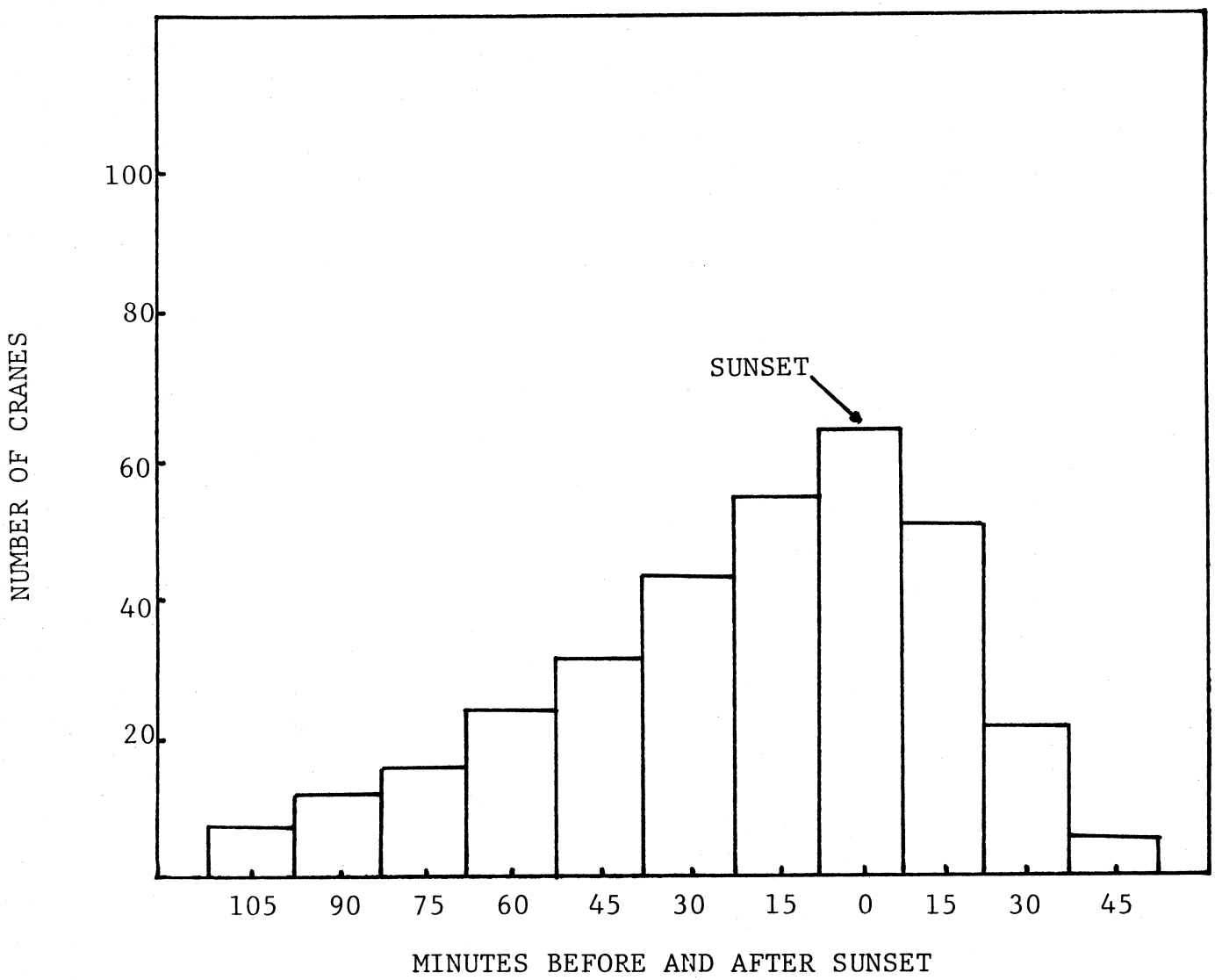


Fig. 10. Time of arrival of sandhill cranes at their roost in relation to sunset, 23 evenings, southeastern Wis., Sept. 1977.

Activity of Cranes at Roosts

Cranes roosted in the open water zone of ponds beyond the edge of emergent vegetation in water 5-15 cm deep. Most cranes arriving 1 hr or more before sunset would land around the perimeter of the pond to feed, preen, or bathe. As sunset approached, cranes would begin to walk or fly into the open water areas of the pond. When peak numbers of cranes arrived at sunset or later the birds landed directly in the water.

Cranes arriving at the roost during the afternoon spent several hrs probing in the shallow water for snails. A high density of the orb snail (*Helisoma trivolvis*) was identified in the Colmstock Marsh roost pond. While probing, cranes submersed their entire head and often several inches of their neck to reach the bottom. They located snails with short lateral and forward movements of the bill. Cranes usually continued feeding on snails long after sunset. Walkinshaw (pers. comm.) has found cranes feeding on orb snails (*H. trivolvis* and *H. anceps*) on roosts in southern Michigan. Guthery (1976) also reported snails in the diet of sandhill cranes in Texas.

During late May, feather staining (Taverner 1929) was commonly observed at the roosts. When staining their feathers, small groups of cranes (3 to 6 birds) would lie down in vegetated areas of water about 10-25 cm deep. They would then uproot small clumps of vegetation (primarily *Carex* and *Sparganium* sp.) and roll them across their back.

Quite often the same piece of vegetation was repeatedly dipped into the water and applied to the feathers. Soil particles which adhered were preened into the feathers. Head and neck feathers were stained as materials were rubbed onto the back. Staining activity usually lasted 10-30 min and was usually followed by bathing. Nesbitt (1975) described similar staining behavior by Florida sandhill cranes (*G. c. pratensis*).

Adult Mortality

Information regarding the illegal shooting of sandhill cranes provided by local wetland residents suggests a substantial annual rate of mortality in several counties. Based on 5 accounts, over 7 percent of the crane population in Jefferson County was illegally shot during 1976. Seventy percent of the shooting incidents occurred on public hunting grounds during the first week of the waterfowl hunting season and involved hunters "misidentifying" cranes for geese, purposely shooting cranes out of curiosity, or simply shooting them for target practice.

Two reports also were received of cranes being shot in spring by muck farmers to protect their crops. One incident involved the shooting of 13 cranes on a wetland in northern Marquette County during 1975. Most landowners reported that cranes were absent from their wetlands for several years after one or both members of the resident pair were shot.

Capture and Banding

A total of 11 prefledged sandhill crane chicks were captured between 15-22 June 1977. Hatching dates were available for all chicks, which ranged in age from 28 to 50 days (Appendix D). All chicks had legs large enough to accomodate size 9 U.S. Fish and Wildlife Service leg bands. Crane chicks 4-5 weeks old usually crouched or attempted to hide when pursued and were the most easily caught. Chicks 6 weeks and older usually ran for heavy cover when pursued and were difficult to catch. Capture attempts were most successful in small fields and wooded pastures where cranes could be surprised and had little chance to react. Eight of the 11 banded chicks were known to have fledged and their mortality rate (28%) was equal to that of unbanded chicks in the study area.

Twenty-eight adult sandhill cranes were captured by rocket netting in August and September 1977. Numbered patagial tags (A100, A106, A115-A138) were placed on 26 of the captured cranes. Two birds died during handling, 1 from a head injury and the other from unknown causes. Measurements taken on cranes verified that all were *G. c. tabida* (Appendix D).

There were 136 observations on the above tagged cranes within the study area after banding. Only 2 cranes were not observed after capture. Cranes were very sedentary for 3-4 days after banding and remained at or near the roost. Similar behavior has been observed by Wheller and Lewis

(1972). Within a week all tagged cranes rejoined flocks feeding in the uplands and no further unusual behavior was noted.

All tagged cranes remained on the wetlands where they were banded until migration. Cranes often fed at distances of up to 10 km from their roost but no exchange of resident birds was noted between any of the staging areas.

Nineteen (76 percent) of the color-marked cranes banded in southeastern Wisconsin were later observed at the Jasper-Pulaski Wildlife Area in northeastern Indiana during October 1977.

Staging and Migration

Seven major staging areas were identified in southeastern Wisconsin (Table 18). Several other wetlands within the study area supported smaller concentrations of birds (50 or less).

Each staging area had a long history of use and area landowners can recall a gradual yearly increase in the number of birds. Three wetlands which had the longest history of use are the White River, Colmstock, and Endeavor marshes. The White River Marsh collectively refers to a vast and remote series of wetlands comprising over 16 km^2 of fresh meadow and shallow marsh and containing at least 3 major crane roosts. Flocks of over 100 cranes began stopping at White River each fall during the early 1930's (A. Reetz and D. Trainer Sr., pers. comm.). By 1949, 600

Table 18. Staging areas and population counts of sandhill cranes in southeastern Wis., 1977.

Roost Location	August			September			October		
	10	20	30	10	20	30	10	20	30
Marquette County									
Colmstock Marsh T16N-R10E, Sec. 10,11,15	97	158	291	344	400	296	0	0	0
Widow-Green Creek T14N-R8E, Sec. 17,18	59	116	248	366	450	390	0	0	0
Endeavor Marsh T14N-R9E, Sec. 15	0	0	41	50	180	200	0	0	0
Green Lake County									
White River Marsh T17N-R11,12,13E, Sec. 8, 13,21	200	361	400	700	1,030	981	200	46	0
Lake Puckaway T15N-R12E, Sec. 17,19,20	0	100	91	140	156	126	0	0	0
Grand River T14N-R11,12E, Sec.8	0	0	0	76	96	90	0	0	0
Columbia County									
French Creek T13N-R9E, Sec. 11	0	59	71	70	88	0	0	0	0
Totals	356	794	1,142	1,746	2,400	2,079	200	46	0

cranes were sighted on 16 October (Walkinshaw 1960:377) and on 15 September 1972 J. Weber (pers. comm.), reported seeing over 750. Small groups of cranes also began stopping at Colmstock Marsh during the late 1930's (W. Kelm, pers. comm.) and over 200 cranes were sighted in the fall of 1943 (D. Owens, pers. comm.). Walkinshaw (1960:136) reported a record of 1,000 cranes on the Endeavor Marsh in 1892. Barger (1940) sighted 150 in late October in 1940, and since 1947 flocks of 250 or more cranes have stopped annually at Endeavor Marsh (H. Jones, pers. comm.).

Use of the other staging areas by sandhill cranes appears to have been more recent. The number of cranes stopping at Widow Creek has grown from 50 to over 400 birds during the past 20 years (D. Smith and O. Gromme, pers. comm.).

All staging areas were also major concentration areas for resident non-breeding cranes, and several contained 80 or more birds throughout the summer. If all resident pairs of cranes and their young move to 1 of the staging areas in the fall, they would account for only 28 percent of the birds present. Seventy-two percent of the cranes present in fall originate outside the study area. Five cranes which were color-marked by R. Windingstad and S. Melvin (pers. comm.) during the summer 1977 in Shawano County were all sighted at the Colmstock and White River staging areas in early September. This represents a southwestward movement of about 130 km. Cranes from the upper peninsula of Michigan are believed to migrate south through eastern

Wisconsin. In 1977 the build-up of cranes at the White River Marsh was synchronous with the departure of a large number of cranes from northern Michigan (B. Taylor, pers. comm.).

Sandhill cranes began congregating at staging areas during the first week in August (Table 18). The peak concentration of cranes occurred during the last half of September. No cranes were observed at any of the staging areas after 1 November 1976 and 1977.

The departure of cranes in the fall was closely correlated with the 1 October opening of the waterfowl hunting season. Roosts at 9 of the staging areas are subject to intensive hunting pressure. The intolerance of sandhill cranes to disturbances near their roosts has been reported by Stephen (1967) and Walkinshaw and Hoffman (1974). Over 100 cranes deserted a roost on the Puchyan Marsh after a duck blind was erected along the shore. Only 1 staging area (a portion of the White River Marsh) was closed to hunting providing refuge for several hundred cranes into October. The pattern of crane departure after the hunting season was the same on each staging area. Immediately after hunting started the cranes flushed and began circling the wetland at a high altitude. After 3-4 hrs the birds were no longer within sight. On larger wetlands some cranes could take refuge on areas less intensively hunted, but invariably they left within several days. On the refuge segment of the White River Marsh the

birds continued their normal flight patterns with no unusual movements or loss of birds noted. The effects of waterfowl hunting on crane migration are similar in southern Michigan (Walkinshaw and Hoffman 1974).

MANAGEMENT CONSIDERATIONS

Wetland Preservation

The most critical management need for sandhill cranes in southeastern Wisconsin at present is the preservation of existing wetland habitat. Crane populations in most counties cannot continue to grow or remain stable in the future if the current rates of wetland exploitation continue. The preservation of all remaining wetlands is certainly not realistic. However, the carefully planned preservation of wetlands identified as optimal crane habitat in each county is both possible and essential. I recommend that the following priorities be considered in future wetland preservation for sandhill cranes:

1. The preservation of natural, unaltered wetlands composed primarily of wetlands Types 2, 3, and 8. Undisturbed wetlands are usually successionally stable and require little or no management to maintain a balanced diversity of wetland Types and vegetative communities.
2. The preservation of small (20-40 ha) wetlands is preferable to large or continuous wetlands of 200 ha or larger. Such areas will accommodate a higher number of cranes in the same amount of area. The

preservation of only a segment of a wetlands may provide habitat for a pair of cranes despite drainage of the adjoining area.

3. The preservation of upland buffer area adjoining at least one side of the wetland for protection against development.

Habitat Management

There is currently no wetland habitat management being directed toward the greater sandhill crane across its breeding range. In northern Michigan, the U.S. Forest Service presently develops and maintains scattered forest openings within the breeding territories of sandhill cranes (Taylor 1976).

Sandhill cranes have benefited indirectly from wetland management directed at increasing waterfowl populations (Hunt and Gluesing 1976). The reclamation and flooding of drained wetlands has provided a large amount of habitat for sandhill cranes in southeastern Wisconsin. It is reasonable to assume that the elimination and control of woody vegetation, combined with restoration of water levels on drained wetlands, could substantially increase crane populations in formerly unoccupied areas. However, the high costs of such a program would be prohibitive unless benefits were achieved for a wide variety of wildlife species.

The agricultural practices of grazing and mowing lowland pastures prevents shrub invasion and maintains open areas of

sedge meadow. Such practices should be encouraged on state-owned wetlands where unfavorable shrub succession is occurring.

Crop Depredations

Damage to corn seedlings by cranes will no doubt continue to be a yearly occurrence. Depredations may increase if the size of non-breeding flocks continues to grow while their wetland habitat continues to be destroyed. A cost-benefit analysis is needed to weigh the present state expenditures for crop reimbursement against the cost of existing means of depredation control. Considering the localized nature of depredations and the small number of cranes involved, damage reimbursement may be more efficient than control measures. There is also an urgent need for the development of a systematic and uniform method of handling damage complaints.

Anticipation and prompt reaction by game personnel in areas with a long history of crane damage has proven to be an important step in reducing much of the problem. In many areas of southeastern Wisconsin experienced game personnel can predict where and when damage will occur. Carbide exploding devices and flagging material have not proven to be effective means of control in all situations. Altering land use and the planting of lure crops deserve experimentation.

Population Surveys

The status of breeding and non-breeding crane populations

should be surveyed in each county at 3-4 years intervals. Periodic crane surveys are needed to determine the location and magnitude of population increases or declines. This information will assist in assessing rates of habitat loss identifying areas with crop depredation potentials, and following population trends.

Non-consumptive Use

The sandhill crane is becoming locally abundant in much of Wisconsin, but is seldom viewed or enjoyed by the general public. This majestic and esthetic bird has an unlimited market potential as a non-consumptive wildlife resource. The sandhill crane is an excellent species to use in educating the public on the value of wetlands and to promote an interest in wetland preservation. There is an immediate need for the development of crane viewing facilities (observation towers, food patches along highways) at wetlands which have large spring and fall migrating concentrations. Programs involving the public in crane studies and surveys (Blomquist 1977) have proven to be a valuable educational tool and should be promoted.

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Appendix A. Correlation between wetland types (Shaw and Fredine 1956) and the interim wetland classification system proposed by Cowardin et al. (1976).

Shaw and Fredine (1956)	Cowardin et al. (1976)				
	System	Class/subclass	Water regime	Water chemistry	Order
1. Seasonally flooded basins or flats	Palustrine	Emergent wetland	Temporarily flooded Seasonally flooded	Fresh Subsaline	Mineral
		Deciduous forested wetland	Seasonally flooded	Fresh	
	Lacustrine	Emergent wetland	Temporarily flooded Seasonally flooded Intermittently flooded	Fresh Subsaline	
	Riverine	Emergent wetland	Seasonally flooded		
2. Inland fresh meadows	Palustrine	Emergent wetland	Saturated Temporarily flooded Seasonally flooded	Fresh Subsaline	Mineral Organic
3. Inland shallow fresh marshes	Palustrine Lacustrine Riverine	Emergent wetland	Seasonally flooded Semipermanently flooded Permanently flooded	Fresh Subsaline	Mineral Organic
4. Inland deep fresh marshes	Palustrine Lacustrine Riverine	Emergent wetland	Permanently flooded Semipermanently flooded Seasonally flooded	Fresh Subsaline	Mineral Organic

Appendix A. (continued)

	System	Class/subclass	Water regime	Water chemistry	Order
5. Inland open fresh water	Palustrine Lacustrine Riverine	Submergent bed Floating leaf bed Bottom	Permanently flooded Semipermanently flooded	Fresh Subsaline	Mineral Organic
6. Shrub swamps	Palustrine Riverine-tidal	Shrub wetland	Seasonally flooded Semipermanently flooded Irregularly flooded Regularly flooded	Fresh	Mineral Organic
7. Wooded swamps	Palustrine Riverine-tidal	Forested wetland	Seasonally flooded Semipermanently flooded Irregularly flooded Regularly flooded	Fresh Fresh	Mineral Organic
8. Bogs	Palustrine	Shrub wetland Evergreen forested wetland Emergent wetland	Saturated Seasonally flooded	Fresh/acid	Organic Mineral

Appendix B. Sample landowner coverletter and questionnaire on wetlands and sandhill cranes in southeastern Wis., 1976-1977.

Dear Landowner:

I am a graduate student at the University of Wisconsin-Stevens Point conducting a survey to locate marshes used by sandhill cranes in southeastern Wisconsin. I believe you may own a portion of a marsh which is used by cranes.

Enclosed please find a self-addressed, stamped postcard with four questions relating to cranes and wetlands. The answers will help me determine the best areas in the county for sandhill cranes, the future of these areas, and where cranes may be creating a problem.

Your cooperation and answers to these questions will be of great help and certainly appreciated. The future of sandhill cranes as well as ducks, pheasants, grouse, and many other forms of wildlife directly depends on how landowners intend to use their marshes. If you have any additional information or questions on sandhill cranes, please contact me.

Sincerely,

Alan J. Bennett
College of Natural Resources
University of Wisconsin
Stevens Point, Wisconsin 54481

Appendix B. (continued)

HAVE YOU SEEN ANY SANDHILL CRANES ON YOUR LAND? Yes___No___

IF SO, ABOUT HOW MANY YEARS HAVE YOU SEEN THEM? ___yrs.

HAVE YOU EXPERIENCED ANY CROP LOSS FROM SANDHILL CRANES?
Yes___No___. Number of acres damaged____.

WOULD YOU BE WILLING TO SELL ALL OR PART OF YOUR MARSH?
Yes___No___.

DO YOU INTEND TO DRAIN ANY OF YOUR MARSH? Yes___No___

ADDITIONAL COMMENTS:

Appendix C. Location of sandhill cranes in southeastern Wis., 1976-1977.

Wetland location	Breeding pairs	Young	Non-breeders	Years occupancy
COLUMBIA COUNTY				
Lodi Township				
T10N - R8E				
Sec. 2,3	1			
Hampden Township				
T10N - R11E				
Sec. 2	1			
Sec. 27,28,33	1			
Sec. 23	1			
Columbus Township				
T10N - R12E				
Sec. 2	1			
Sec. 18	1			
Caledonia Township				
T11-12N - R8E				
Sec. 5	1			
Sec, 8,9,10	2		12	
Sec. 19,30	1			
Dekorra Township				
T11N - R8-9E				
Sec. 1,2	2			
Sec. 13,18	1			
Sec. 25,26,30	3		8	
Sec. 29,32	2			
Lowville Township				
T11N - R10E				
Sec. 16	1			5+
Ostego Township				
T11N - R11E				
Sec. 1	1			
Sec. 14,15	2			
Sec. 27,28	1	1		
Sec. 33	1			
Fountain Prairie Township				
T11N - R12E				
Sec. 3,10	1			
Sec. 5	1			
Sec. 18	1			

Appendix C. (continued)

Wetland location	Breeding pairs	Young	Non-breeders	Years occupancy
Pacific Township				
T12N - R9E				
Sec. 33	1			
Sec. 2,3,10,11	2		8	18
Sec. 13,14,23,24	2		20	11
Wyocena Township				
T12N - R10E				
Sec. 5,6	1		10	10+
Sec. 7,8	2			
Sec. 10,11,12	3		10	21
Sec. 19,20	1			
Sec. 24	1			
Sec. 35	1			
Springvale Township				
T12N - R11E				
Sec. 2	1			5+
Sec. 27,28	1			
Courtland Township				
T12N - R12E				
Sec. 26,27	1			
Newport Township				
T13N - R6-7E				
Sec. 4,9	2			
Lewiston Township				
T13N - R7-8E				
Sec. 3	1			10+
Sec. 2,3,4			11	10+
Sec. 5,8	2			10+
Sec. 13	1			
Sec. 21	1			
Sec. 26,34,35	1			7+
Ft. Winnegabo Township				
T13N - R9E				
Sec. 3	1			
Sec. 5	1			
Sec. 9	1			14
Sec. 2,10-14	5		80	20
Sec. 22-24	2			5+
Sec. 27,28	2			11

Appendix C. (continued)

Wetland location	Breeding pairs	Young	Non-breeders	Years occupancy
Marcellon Township				
T13N - R10E				
Sec. 19-21	2			
Sec. 32	1			
Scott Township				
T13N - R11E				
Sec. 3	1			
Sec. 7	1			8+
Sec. 20-22	4			
DANE COUNTY				
Albron Township				
T5N - R12E				
Sec. 33	1			
Dunn Township				
T6N - R10E				
Sec. 10,15	1			
Deerfield Township				
T7N - R12E				
Sec. 2,11,12	2		1	
Medina Township				
T8N - R12E				
Sec. 6	1			
Montrose Township				
T5N - R8E				
Sec. 36	1			
DODGE COUNTY				
Portland Township				
T9N - R13E				
Sec. 29,33	2			4+
Williamstown Township				
T12N - R16E				
Sec. 8	1			
Burnett Township				
T12N - R15E				
Sec. 2	1			

Appendix C. (continued)

Wetland location	Breeding pairs	Young	Non-breeders	Years occupancy
FOND DU LAC COUNTY				
Rosendale Township				
T16N - R15E				
Sec. 15,22	1			
GREEN COUNTY				
Spring Grove Township				
T1N - R9E				
Sec. 18	1			
GREEN LAKE COUNTY				
Kingston Township				
T14N - R11-12E				
Sec. 8-10	3	2		15+
Sec. 15,22	1	1		6
Marquette Township				
T14-15N - R11-12E				
Sec. 2,3	1	1		9
Sec. 18	2			21
Sec. 17,19,20	2		6	30+
Sec. 13,14	1	1		16
Sec. 19,30	2	3	40	35
Sec. 23,24,26	2	2	50	30
Princeton Township				
T15-16N - R11E				
Sec. 15	1			8
Sec. 33,34	1			6+
Seneca Township				
T17N - R11-12-13E				
Sec. 7,8	1	1		6
Sec. 10,11	1			3
Sec. 17	1			
Sec. 11-14,18	6	5	35	53
Sec. 19-21	2	2	33	47
Sec. 23	1			11
St. Marie Township				
T16-17N - R11-12E				
Sec. 3	1			1
Sec. 1,2,35,36	3	3	10	30+
Sec. 5,6	1	2		12
Sec. 13,14	2	1		16
Sec. 35	1			4
Sec. 19,28-32	2		4	4+

Appendix C. (continued)

Wetland location	Breeding pairs	Young	Non-breeders	Years occupancy
JEFFERSON COUNTY				
Cold Springs Township				
T5N - R15E				
Sec. 4,11,12	1			5+
Concord Township				
T7N - R16E				
Sec. 2	1			
Sec. 19	1			4+
Sec. 25	1			14
Sec. 34	1			
Sec. 14,22,23,27	2	1	3	28
Farmington Township				
T7N - R15E				
Sec. 32	1			6
Sec. 35,36	1			7
Hebron Township				
T6N - R15E				
Sec. 25	1			12
Sec. 27,28	1			
Sec. 20,21,29	2			
Jefferson Township				
T6N - R15E				
Sec. 13	1	2		5+
Sec. 7-9,16-18	3	1	9	39
Lake Mills Township				
T7N - R13E				
Sec. 26,27,35	2			14+
Sullivan Township				
T6N - R16E				
Sec. 4,9	1			4+
Sec. 15,16,21,22	4	4	15	20+
Sumner Township				
T5N - R13E				
Sec. 10	2			40+
Sec. 7,12,13	2	2		
Sec. 18,19,24	1			
Waterloo Township				
T8N - R13E				
Sec. 34,35	1			5+

Appendix C. (continued)

Wetland location	Breeding pairs	Young	Non-breeders	Years occupancy
KENOSHA COUNTY				
Brighton Township				
T2N - R20E				
Sec. 9,10	1			
MARQUETTE COUNTY				
Douglas Township				
T14N - R8E				
Sec. 4,5	2	2		23
Sec. 17,18	2	2	10	20
Sec. 16,21	1	1		10
Sec. 28	1			3
Sec. 29,32	3	2		30
Sec. 33,34	2	1		21
Moundville Township				
T14N - R8-9E				
Sec. 22,23	1	1		40+
Sec. 26,27	1	1	20	
Sec. 33	1			4
Sec. 34	1			15
Sec. 36	1	1		8
Buffalo Township				
T14N - R9-10E				
Sec. 1	1	2		6
Sec. 19,21	1			5
Sec. 14,15	2	1		40+
Sec. 11	1	2		3
Sec. 24	1	1		5+
Sec. 33,34	1			10
Sec. 25,31,36	3	3	90	22
Oxford Township				
T15N - R8E				
Sec. 26,35	2	1	7	20+
Montello Township				
T15N - R10E				
Sec. 10,11	1			10+
Sec. 22	1			
Sec. 24,25	2	3		28
Sec. 28,29	1			5

Appendix C. (continued)

Wetland location	Breeding Pairs	Young	Non-breeders	Years occupancy
Packwaukee Township				
T14-15N - R9E				
Sec. 1	1	1		7
Sec. 21,22	1	2		6
Sec. 25,26,35,36	3	2		10+
Sec. 4,5,32,33	1	1	21	27
Mecan Township				
T15-16N - R11E				
Sec. 10	1			10
Sec. 5,32	2	2		25+
Sec. 18	1	1		4
Sec. 19	1	1		1
Sec. 29	1	1		5+
Sec. 30	1			8
Sec. 30	1			12
Harris Township				
T16N - R9E				
Sec. 10	1			4
Sec. 1,2,11,12	4	2		15
Shields Township				
T16N - R10E				
Sec. 8	1			5
Sec. 10,11,14,15	7	8	20	50+
Sec. 25,26	1	1		17
Sec. 34	1			7
Newton Township				
T17N - R9E				
Sec. 10,11	1			10
Sec. 14,15	2	1		10+
Sec. 21	1	2		8
Sec. 22,23,26	2		9	15+
Sec. 28	1			4
Sec. 36	1			
Crystal Lake Township				
T17N - R10E				
Sec. 16	1			1
Sec. 17	1			3
Sec. 20,21	1	1		10
Sec. 13,14,23,24	2			16
Sec. 25,26	1	1		8
Sec. 31,32	1			8+
Sec. 34-36	3	3	16	10+

Appendix C. (continued)

Wetland location	Breeding pairs	Young	Non-breeders	Years occupancy
Neshkoro Township				
T17N - R11E				
Sec. 15	1	1		20+
Sec. 16	1	2		9
Sec. 17	1	2		5
Sec. 19	1			
Sec. 21	1	1		4
Sec. 28-33	2			15+
WASHINGTON COUNTY				
Jackson Township				
T10N - R20E				
Sec. 9,16	1			5+
RACINE COUNTY				
Burlington Township				
T3N - R19E				
Sec. 18,19	1			
Waterford Township				
T4N - R19E				
Sec. 4	1			
Sec. 9	1			
Sec. 16	1			
ROCK COUNTY				
Milton Township				
T4N - R13E				
Sec. 24,25	2		7	15+
Lima Township				
T4N - R14E				
Sec. 15,21,22	2		3	10
WALWORTH COUNTY				
East Troy Township				
T4N - R18E				
Sec. 12,13	2		1	
Geneva Township				
T2N - R17E				
Sec. 24	1			
Lagrange Township				
T4N - R16E				
Sec. 31	1			

Appendix C. (continued)

Wetland location	Breeding pairs	Young	Non-breeders	Years occupancy
Lyons Township				
T2N - R18E				
Sec. 16,17	1			
Troy Township				
T4N - R17E				
Sec. 2	1			
Whitewater Township				
T4N - R15E				
Sec. 30	1		1	
WAUKESHA COUNTY				
Eagle Township				
T5N - R17E				
Sec. 17	2			
Mukwonogo Township				
T5N - R18E				
Sec. 12,13	1		1	
Oconomowoc Township				
T8N - R17E				
Sec. 9,10	1			
Ottawa Township				
T6N - R17E				
Sec. 31	1			
Summit Township				
T7N - R17E				
Sec. 21	1			

Appendix D. Marking data, measurements, and weights of adult and prefledged sandhill crane chicks captured in southeastern Wis., 1977.

USFW band number	Patagial tag number	Location	Date	Mid toe length (mm)	Tarsus length (mm)	Bill tip to post. nares (mm)	Total bill (mm)	Weight (gm)
599-26235	A100	Marquette Co.	6-17-77	88	275	104	130	4700
255	-	Green Lake Co.	8-10-77	97	250	98	126	5000
256	A106	Green Lake Co.	8-10-77	86	261	100	132	4100
265	A115	Marquette Co.	8-18-77	85	283	101	132	5000
266	A116	Marquette Co.	8-18-77	80	260	90	121	4450
267	A117	Marquette Co.	8-18-77	90	285	106	140	5250
268	A118	Marquette Co.	8-18-77	84	242	114	139	4200
269	A119	Marquette Co.	8-18-77	81	251	91	117	3950
270	A120	Marquette Co.	8-18-77	87	268	109	142	4800
271	A121	Marquette Co.	8-18-77	76	231	95	121	4200
272	A122	Marquette Co.	8-18-77	87	284	106	142	5150
273	A123	Marquette Co.	8-18-77	92	273	106	145	5750
274	A124	Marquette Co.	8-21-77	86	260	94	123	4700

Appendix D. (continued)

USFW band number	Patagial tag number	Location	Date	Mid toe length (mm)	Tarsus length (mm)	Bill tip to post. nares (mm)	Total bill (mm)	Weight (gm)
599-26275	A125	Marquette Co.	8-21-77	83	282	112	149	5250
276	A126	Marquette Co.	8-21-77	81	244	94	126	4450
277	A127	Marquette Co.	8-21-77	88	261	95	130	4700
278	A128	Marquette Co.	8-25-77	79	257	102	123	4750
279	A129	Marquette Co.	8-25-77	83	272	95	129	4800
280	A130	Marquette Co.	8-25-77	79	269	94	131	4850
281	A131	Marquette Co.	8-25-77	84	274	103	138	5600
282	A132	Marquette Co.	8-25-77	80	271	103	136	4550
283	A133	Marquette Co.	8-26-77	81	259	96	132	4950
284	A134	Marquette Co.	8-26-77	78	255	95	129	4400
285	A135	Marquette Co.	8-26-77	92	276	101	141	5400
286	A136	Marquette Co.	8-26-77	80	251	101	137	5100
287	A137	Marquette Co.	8-26-77	90	251	102	136	4850
288	A138	Marquette Co.	8-26-77	90	277	106	142	5550

Appendix D. (continued)

USFW band number	Patagial tag number	Location	Date	Mid toe length (mm)	Tarsus length (mm)	Bill tip to post. nares (mm)	Total bill (mm)	Weight (gm)
-	-	Marquette Co.	8-26-77	86	271	106	141	5200
599-26230	-	Marquette Co.	6-15-77	84	200	34	63	2170
231	-	Marquette Co.	6-15-77	81	196	33	65	2000
232	-	Marquette Co.	6-16-77	84	190	35	65	2100
233	-	Marquette Co.	6-16-77	81	176	30	58	1600
234	-	Marquette Co.	6-16-77	78	162	30	52	1400
236	-	Marquette Co.	6-17-77	76	156	31	53	1250
237	-	Marquette Co.	6-18-77	72	134	26	47	1200
238	-	Green Lake Co.	6-18-77	82	220	39	70	2500
239	-	Green Lake Co.	6-18-77	71	135	29	47	1200
240	-	Marquette Co.	6-20-77	89	257	42	79	3100
241	-	Marquette Co.	6-22-77	87	233	39	76	3000