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Abstract: During 1987, 59 nests of 57 pairs of greater sandhill cranes (*Grus canadensis tabida*) were located, mainly from the air, on or near the Seney National Wildlife Refuge, Michigan, and 52 nests were ground-checked. Nests were in available palustrine classes without tree canopies. Only 19% were in Sphagnum bogs, in which most nests from other areas of the Upper Peninsula have been found. Cattail (*Typha latifolia*) marshes, most prevalent in the managed area of the refuge, contained 44% of the nests, and sedge (*Carex* spp.) marshes accounted for 37%. Important co-dominant plant species were leatherleaf (*Chamaedaphne calyculata*), especially in bogs and sedge marshes, and willows (*Salix* ssp. *Carex*) in cattail and sedge marshes, sometimes forming shrub swamps. An estimated 33 of 52 clutches (63%) successfully hatched at least one chick. Thirteen clutches (25%) were believed destroyed by predators. Predation rate was least in sedge marshes, but differences in water depth, concealment, shrub cover, and distance from nearest upland were not statistically significant between sites of depredated and non-depredated nests. Nests of 30 pairs were found in an 11,600-ha intensively studied area in the eastern part of the refuge. An estimated 50 breeding pairs occur in this area, a density of 0.43 pairs/km^2. The population has increased in recent history, and available nesting habitat is not a limiting factor to a larger nesting population.

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Walkinshaw (1978) pioneered study of greater sandhill cranes in the Upper Peninsula of Michigan with work beginning in 1934. He noted (Walkinshaw 1949) 2 general types of crane habitat, both with high crane populations. The first consisted of the marshes at Seney National Wildlife Refuge. The second type, bogs dominated by sphagnum mosses (*Sphagnum* spp.) and leatherleaf, generally occurred more eastward, and it was to this type that he directed most of his attention. Size of the Upper Peninsula crane population has increased substantially since Walkinshaw's early work (Taylor 1977; Walkinshaw 1978). During 1984-87 the first intensive study of sandhill cranes on Seney NWR was conducted to determine the suitability of the area for possible reestablishment of whooping cranes (*G. americanus*) in the region. This paper deals with the nesting biology of cranes on Seney and concentrates on the 1987 breeding season.

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STUDY AREA

Seney NWR comprises 38,631 ha in Schoolcraft County in the east-central Upper Peninsula of Michigan (latitude 460 15'N, longitude 860 04' W). The refuge is part of the Great Manistique Swamp. Elevation ranges from 195 to 242 m above sea level and grades S 15^0 E at 3-6 m/km. The area was inundated by a high water phase of the glacial Great Lakes, and the Seney plain was reworked by shore processes 9,500-10,000 years ago. The sand plain was deposited from outwashes when the last ice sheet (Valders) receded, and a peat blanket of organic soil has accumulated in the outwash valley since glacial retreat (Anderson 1982).

The region is characterized by a cool. continental climate with temperature extremes of -44^0 to 40^{0}C. The mean annual temperature is 4.4^0 C. The average annual precipitation is 70 cm, more than half of which occurs between April and September. A snowpack of 75 cm or more forms annually from a mean annual snowfall of more than 255 cm (Anderson 1982). Precipitation and runoff were relatively low during the spring 1987 nesting season. The winter snowpack melted during March, and precipitation for April and May was only 6.6 cm, 7.5 cm below normal.

Vegetation is 54% marsh, grassland, and shrub, 21% upland conifer, 9% upland hardwood, 7% lowland conifer, 7% open water, and 2% lowland hardwood (U.S. Department of the Interior 1978). The open water occurs in 26 major pools, 21 of which have water control structures. Wetlands contain linear upland landforms (relict sand dunes) dominated by red pines (*Pinus resinosa*) and jack pines (*P. banksiana*). Seney NWR is primarily a palustrine system (Cowardin et al. 1979) (Fig. 1). Palustrine habitats without tree canopies comprised most of the area and consisted of 3 general habitat types—cattail marsh, sedge marsh and sphagnum bog. Cattail was a dominant species in cattail marsh with sedges co-dominant in some marshes. Leatherleaf formed dense patches along some marsh edges. A continuum of successional stages was represented, from little or no shrubs to extensive stands of willows. Speckled alder (*Alnus*) was common, especially on marsh edges. Coarse sedges (primarily *Carex rostrata*) and/or fine sedges (primarily *C. lasiocarpa*) were dominant species in sedge marshes. Bluejoint grass (*Calamarostis canadensis*) was also common. As in cattail marsh, a continuum of successional stages was represented, from no shrubs to well-developed stands of willows. Dwarf birch (*Betula pumila*) and leatherleaf were also common in patchy distributions. Bogs were graminoid, low shrub or graminoid-rich treed muskeg types dominated by sphagnum, fine sedges, leatherleaf, and black spruce (*Picea mariana*). Dead conifers were common in several Wetlands west of the Driggs River (Fig. 1} were burned in an extensive 1976 wildfire that killed a substantial amount of the woody vegetation.

METHODS AND MATERIALS

During 1987, 2 aerial nest surveys were conducted. The first, 28 April to 3 May, was made by a pilot and 2 observers in a Hiller 12-E helicopter. Search altitude and speed were approximately 30 m and 50 km/h, respectively. The primary study area (PSA, A in Fig. 2) was searched completely. Fifty randomly selected quarter-section plots (a 20% sample) of Area B were searched. Area C was not surveyed. A total of 23 cranes equipped with solar/Ni-Cad radiotransmitters (164 MHz) were also tracked, including 7 off the refuge whose approximate territories had been previously delineated by tracking from fixed-wing aircraft. A single forward-facing, horizontally-oriented H-antenna was mounted to the right skid of the helicopter; a Telonics TS-1/TR-2 scanner/receiver was monitored for signals. Areas of patchy nesting habitat in the PSA were examined without searching nearby uplands or open pools. Large expanses of suitable habitat were examined by flying east-west transects about 200 m apart. The plots in Area B were searched first by flying east-west transects 200 m apart, and those plots with suitable nesting habitat were searched again with north-south transects 250 m apart. The second survey was made 14-17 May, iust before the earliest anticipated hatching dates, by a pilot and 2 observers in an Engstrom F 28 C-2. Previously discovered nests were checked for continued occupancy, and a search for additional nests was made. Methods were siilar except that search speed averaged 80-100 km/h, and only those plots in Area B with suitable nesting habitat were searched only once with east-west transects 200 m apart. Searches for nests of radiotagged birds not on the nests when checked from the air and nests at some traditionally used sites were also made from the ground.

Monitoring of nests for hatching success began on the ground on 19 May. Hatching dates that were not determined directly were estimated by noting phase in the hatching process and extrapolating to date of emergence. Fertile eggs not yet in the scratching/peeping phase were presumed to hatch 1 day after their nest counterpart if no other information was available. Hatching dates were also estimated from chick size, based on tarsal measurements we collected from chicks of known age in 1986 (unpubl. data). If hatched chicks were not seen, clutches were considered destroyed if (1) egg shell fragments with membranes firmly attached or (2) no egg remains were found at the nest. Confirmed successful hatches, i.e. with at least 1 fully emerged chick seen (N = 18 nests), were always characterized by small shell fragments without attached membranes in the upper layers of the center of the nest. These fragments result because parents may break the shells into small pieces after hatching to feed to the chicks (Johnsgard 1983). Larger shell pieces also might be present and large pieces of membranes without shell often could be found in the water near these successful nests. Presence of small fragments without membranes attached was therefore used to indicate successful hatching. Beginning on 23 May, eggs were checked for fertility. By this stage of incubation contents of infertile or addled eggs were usually liquified, a condition detectable when eggs were gently shaken.

Measurements of nests and habitat variables were made as soon as possible after nest outcome was known. Water depth was measured 1 m from the perimeter of the nest in each of the 4 cardinal directions. The degree of nest concealment by adjacent vegetation was measured with a 30.5-cm high x 61.0-cm long red/white plastic checkerboard held upright on the center of each nest with a metal stake. The center of each of the 25 white squares was marked with a point consisting of a small drilled hole. The number of points visible by an observer (eye level 1.61 m above ground surface) at a measured distance of 5 m from the center of the nest was made in each of the 4 cardinal directions. These 4 values were summed and the total subtracted from 100 to yield the concealment score. The species and number of woody shrub stems 4 mm or more in diameter that were 30.5 cm above and within 1.5 m of the center of the nest were recorded. The species and number of tree species 2.5 cm DBH or more and within 5 m of the center of each nest were also recorded. Distance from nest to nearest upland was measured from 1:15,460 color infrared aerial photographs. Nest length (longest maximum dimension) and width (perpendicular to length) were measured across the compressed top of each nest; nest composition and height above water were recorded.

The habitat was classified as sphagnum bog if a nearly continuous mat of sphagnum covered the area within 50 m of the nest. The site was designated as cattail marsh if subjective visual estimation showed that the amount of area occupied by cattail was greater or equal to that of any other herbaceous species within 50 m of the nest or the nest was on the edge of such a marsh. Sedge marsh was designated if sedges accounted for greater estimated areal coverage than any other herbaceous species within 50 m of the nest or the nest was on the edge of such a marsh. Wetland classes and subclasses of the Cowardin classification were taken from an existing cover map, prepared from aerial photographs, of most of the nesting areas. Errors, the most common being identification of some scrub-shrub vegetation dominated by leatherleaf as emergent class, were corrected based on ground-truth data. Nesting areas not on cover maps were classified based on their similarity on aerial photographs to those mapped and on ground-truthing.

RESULTS

Eighteen radio-tagged birds whose arrivals were detected returned to Seney or vicinity 30 March to 13 April in 1987; peak return was 8-9 April.

Nest Survey

In approximately 37 hours of nest-searching, radiotracking and travel between searched areas, 48 nests were found during the first nest survey, including 27 in the PSA, 6 in sample plots or on plot boundaries, 5 in Area B but outside plots and 10 others. In the second aerial survey 6 additional nests were found, 4 in the PSA and 2 in Area B but outside plots. Ground searches yielded 5 more nests. Forty-nine nests of 47 different pairs were found on the refuge; 32 nests of 30 pairs were in the PSA. Of the radiotracked birds, the farthest nest from the refuge was 26 km north-northeast. Average clutch size was 1.9 eggs (including renests). Fifty-two nests, including all those found on Seney and the 3 nearest the northeast corner but off the refuge but within 13 km of the refuge boundary) were monitored on the ground. Eleven of the clutches were apparently destroyed between the first and second aerial surveys. An additional 4 clutches were destroyed after the second nest survey. The fate of 1 clutch was not determined. Data from 44 chicks of which hatching dates were known or could be reliably estimated showed that hatching was highly synchronous, peaking 23-24 May (Fig. 3). The size of 1 chick (M-2 West territory), whose nest was not found, indicated it had hatched about 18 May, which would have been the earliest known hatching date on Seney in 1987. In 1985 and 1986 the pair on this territory produced the earliest chicks. Hatching occurred on 11-12 May in 1986, l week before any other known hatching of cranes that year.

Some renesting was observed, with 1 pair apparently renesting in the same nest. That renest consisted of 1 addled egg that was still being incubated on 27 June when the senior author removed it. Renesting by another pair in a same nest in the same year was also noted on Seney in 1984. Another pair (Lower Goose Pen territory) apparently produced 3 clutches of 2 eggs each. On 28 April 2 nests were found—1 unattended in high water and the other, 360 m away, with a bird incubating 2 eggs. By 3 May the second nest was also flooded and the eggs were gone. Another fully-built nest (not compressed and apparently never having contained eggs) was also found flooded in the same 18.5-ha marsh. Lower Goose Pen Pool had been partially drawn down for the previous 3 years, and the resident pair had fledged young in each of those years. The pool was to be completely filled in spring 1987 as part of a water management plan. Because of water supply problems, the pool was filled slower and later than planned, resulting in flooding of the nests shortly after they were occupied. The pair renested again, this time building the nest 220 m from the first and 140 m from the second egg-containing nests and away from the flooded cattail marsh, in sedges near a woods at the marsh edge. Both eggs in the last clutch were, however, infertile or addled; they were still being incubated on 27 June when the senior author removed them. Of 71 eggs checked for viability, 8 (11%) in 6 clutches were infertile or addled, including 1 in each of 2,2-egg clutches, both eggs in 1,2-egg clutch, 1 egg in a 1-egg clutch (this was a late clutch, possibly a renest), and the single egg in the above-noted renest by 1 pair and both eggs in the second renest of another.

Nest and Nest Site Characteristics

Nests averaged 77.3 ± 3.1 (1 SE) cm in length by 62.0 ± 2.3 cm wide and were constructed of nearby materials, especially cattail, leatherleaf, and coarse sedges. In 11 of 15 instances of estimated preference, cattail was preferred over other vegetation, particularly leatherleaf. Twigs were commonly found in nests, as was bark in nests in bogs with dead trees. Nests in boggy areas usually had less nesting materials, usually were on sphagnum mats, and were significantly smaller ($P<0\ 01$, *t*-test) than others. Nests on sphagnum hummocks averaged 59.4 ± 3.1 by 44.1 ± 1.6 cm (N = 11), and nests built on marsh substrate averaged 82.1 ± 3.5 by 66.8 ± 2.4 (N = 41).

Nest height above water averaged 10.9 ± 0.7 cm (N = 45). Three nests were on small islands, 2 of which appeared to be on abandoned ant hills and contained little nesting material. One of the latter nests was used in 1985, 1986, and 1987. Water depth 1 m from the nests averaged 7.0 ± 0.8 cm (N = 49) in 1987.

Nesting habitat was classified into 3 general categories based on dominance by key species (Table l). Seney contains a high degree of intergradation and transition among habitats, but these 3 categories were reasonably discrete. According to the classification of Cowardin et al. (1979), all nesting occurred in palustrine systems, mostly in seasonal or seasonal grading to semipermanent water regimes except in some bogs in which the substrate was merely saturated. Wetland class was either emergent or scrub-shrub (hereafter called shrub) or, in a few instances, forested (dead trees). The latter was combined with shrub wetland in this paper because it differed little from other sites classified as shrub on the existing cover maps. Shrub was designated rather than emergent if greater than 30% of the area was covered by shrubs. Because of variability within small areas and a continuum in degree of shrub cover, some sites were classified as transitional (Table l).

Number of shrub stems within 1.5 m of the nest center ranged from 0 to 60; mean numbers were 11.5, 23.2, and 14.7 for cattail marsh, sedge marsh and sphagnum bog, respectively. Three deciduous shrub taxa were found in all nesting habitats and accounted for 96% of deciduous stems recorded. Willows (primarily *Salix pellita*) accounted for 63% and 52% of stems in sedge and cattail marshes respectively. In the sedge habitat 27% of the willow stems were dead. Dwarf birch accounted for 38% of stems in sphagnum bog. Alder comprised 40% of stems in cattail marshes. The number of tree stems within 5 m of the nest varied from none in most cattail marshes to 26 in 1 dead tree bog. Predominant species were jack pine, black spruce and tamarack (*Larix laxicina*). Dead trees accounted for 82% of tree stems near nests.

Nest Depredation

An estimated 33 of 52 clutches (63%) of 49 breeding pairs hatched at least 1 chick in 1987. Loss of 13 clutches (25%) was believed caused by predators. Of 15 destroyed clutches for which predator data were available (including 2 clutches initially abandoned due to flooding and l of 2 eggs in a successful nest), 8 nests contained shell fragments with membranes attached and broken along the same fissures as the shell, 5 nests contained no egg remains, l nest had 1 egg completely gone and the other cracked, and l nest that successfully hatched 1 chick had a hole in the end of the other egg and the brain of the fully-formed chick inside was eaten.

Differences in water depth, concealment score, shrub cover or distance to nearest upland between clutches lost due to predators and other clutches were not statistically significant ($P>0.05$, *t*-tests), but differences ($X^2=6..58$. 2 df, $P<0.05$) among habitat types were significant (Table 2). Nests in cattail marshes experienced 32% loss, in sedge marshes only 17%. The distribution of depredated and non-depredated nests may also have been different; most depredated nests were in a band extending across the southeastern portion of the refuge (Fig. 2).

Estimation of Number of Breeding Pairs

The random sample of Area B (Fig. 2) did not reveal enough nests within plot boundaries to facilitate an adequate estimate or confidence interval for breeding pairs in that area. No sampling of Area C was attemptedJ thus no estimate is available for that area. Area A (11,660 ha) was examined completely in 1987, and nests of 30 pairs were found. A minimum density for Area A was thus 0.26 breeding pair/km^2. Eight birds that nested in Area A were equipped with radiotransmitters, and results of tracking indicated that nests of 2 would not have been found if they had not been tracked to the nest. A crude estimate of nests present but missed would thus be 33% of those found, or 10. The chick found on M-2 West territory and 2 chicks found on T-2 territory were, for example, from these undetected nests. In addition, neither the nests nor the young chicks in traditional territories were found for 8 pairs thought to be alive and with a nesting history during 1984-86. Because mortality of adult cranes is low, it is reasonable to assume that most of these pairs were extant and either did not nest in 1987 or the nests were destroyed before they were found. Finally, 2 chicks were found in traditionally used territories for which the nests were never found during 1984-87. Thus an additional 20 breeding pairs might have occupied Area A for an estimated total of 50 breeding pairs, or 0.43 pair/km2.

DISCUSSION

The nesting habitat at Seney seems to be a mixture of other Great Lakes area and northern types, resembling sedge and sphagnum habitat in Wisconsin (Howard 1977; Crete & Grewe 1981), sedge marsh/muskeg in Alberta (Carlisle 1981), cattail sedge marshes in lower Michigan (Walkinshaw 1965; Hoffman 1983), and sphagnum bogs in other parts of the Upper Peninsula (Walkinshaw 1965). Unlike most previously reported nests from the Upper Peninsula (Walkinshaw 1965), only 19% of nests at Seney were in sphagnum bogs, and sedge marshes were commonly used for nesting. Although cover-mapping to determine the relative amounts of sphagnum bog, cattail marsh and sedge marsh has not been done for Seney NWR, there were no obvious differences in the availability of these 3 types and their use by nesting cranes on Seney. Cranes spread over available palustrine habitat and used whatever types comprised their territories. Halbeisen (1980, in lower Michigan and Tebbel (1981) in the Algoma District of Ontario (adjacent to and east of the Upper Peninsula of Michigan) found no differences in vegetation structure between sites used and not used for nesting, although Tebbel thought that sphagnum and leatherleaf were preferred species.

Although precipitation during spring 1987 was unusually low, most wetlands on Seney still contained or received an ample supply of water, and little potential nesting habitat was lost. Cranes on Seney tended to select shallower water for nesting than crane populations in Oregon (Littlefield & Ryder 1968) or lower Michigan (Halbeisen 1980; Hoffman 1983). However, results were similar to other Upper Peninsula sites (Walkinshaw 1965) and Algoma (Tebbel 1981). Hoffman (1983) noted that cranes have used shallower water for nesting as their densities have increased in lower Michigan. Halbeisen (1980) noted the preference of cranes to nest immediately proximate to open water, but Tebbel found no correlation between nesting and open water. Although nests were common near pools on Seney with 1 exception they were always located below the dikes. In 1987 only 1 pair nested in the marsh on a pool edge, building 4 nests and producing 3 clutches, only to have the first 3 nests and 2 clutches flooded. The pools on Seney have usually been maintained at high spring levels for production of Canada geese (*Branta canadensis*) throughout the history of the refuge, and in response the cranes have apparently chosen lower but more stable water levels away from the pool edges for nesting.

Spring arrival dates, hatching dates, and nest sizes were similar among Seney and other Upper Peninsula areas (Walkinshaw 1978). The preference for cattail over leatherleaf as nest material was also noted by Tebbel (1981). Dead leaves of cattail from the previous year provide a bulky, brittle material that is easily removed and manipulated for construction. Leatherleaf, on the other hand, is tough and less substantial in mass. The small size and minimal construction of nests on sphagnum was also expected, for this vegetation already provided a measure of support that was lacking on other substrates.

Nest failure was not a major detriment to recruitment on Seney NWR. The success rate of 63% was similar to 67% reported by Walkinshaw (1978) for other areas of the Upper Peninsula and slightly lower than other reported values, exclusive of Oregon (Stern et al. 1987). Success values should be regarded with caution because of unaccountability of nests destroyed early in incubation (Mayfield 1961). The Seney data may be more complete because of intensive nest searching just after peak of egg-laying. The major cause of nest failure on Seney was apparently predation. Nests with small shell fragments and a good deal of shell unaccounted for, and 1 egg with a hole in 1 end, were believed destroyed by ravens (*Corvus corax*) or crows (*C. brachyrhynchos*), according to Rearden's (1951) criteria. Nests with no egg remains and a cracked egg might have been due to coyotes (Stern et al. 1987). These species, as well as raccoons (*Procyon lotor*) were common on Seney and were the most probable predators. Ring-billed gulls (*Larus delawarensis*), mink (*Mustela vision*), striped skunks (*Mephitis mephitis*), and black bears (*Ursus americanus*) were also possible but less likely in the nesting areas. Ravens (Littlefield 1976) and coyotes (Stern et al. 1987) were responsible for extensive nest failures in Oregon. Ravens take the eggs when both parents are off the nest, often when high crane density interferes with normal nest attentiveness (Littlefield & Ryder 1968). The extent of this problem is definitely less at Seney. Three nests with abandoned eggs (2 infertile, 1 flooded) still had the eggs unmolested after at least 3 days in 2 of the instances.

Water depth and concealment did not appear to affect susceptibility to predation. Behavior patterns of the predators in individual crane territories might have been more important. Distances to upland did not appear to affect risk of predation on a local scale, but an apparent band of higher predation in the southeastern part of the refuge (Fig. 2) might have resulted from juxtaposition of wetland and upland habitats (Fig.1) favorable to predators such as ravens, crows and coyotes, which roost in or regularly frequent uplands.

Predation was higher in cattail marshes and bogs than in sedge marshes. Cattails generally occurred in patchy distributions, in more fertile areas and often near dikes. Bogs were often on edges of wooded areas or contained wooded areas themselves. On the other hand, sedge marshes, especially those dominated by *Carex lasiocarpa*, were more expansive and homogeneous. Two of 3 nests destroyed in sedge marshes were in edge situations containing coarse rather than fine sedges. Predator populations might have been higher in the more complex mosaics encompassing areas such as cattail marshes, and foraging routes were probably closer to nests. In these habitats, water depths might have been more important as a deterrent to predators, and the lower water levels in 1987 also might have resulted in increased predation.

In the aerial nest surveys it was generally necessary to flush incubating birds to find nests, unless a particular crane was radiotagged or was using a traditional site. The 2 pairs nesting in the PSA that would not have been found if not radiotagged were in open areas and not concealed from above by vegetation. Therefore habitat characteristics, such as concealing vegetation, were not as important as bird behavior as causes for non-detection of some potential nests. We therefore believe that the sample of nests obtained was representative of general nesting in the areas searched. In addition, the nest characteristics of radiotagged birds were unbiased in terms of both habitat and bird behavior. The 3 nests off the refuge that were included in the data summaries were of radiotagged birds and were chosen in relation to proximity to the northeastern corner of the refuge; the habitat conditions at these nests were also unbiased in terms of nest site selection.

Hoffman (1983) summarized breeding pair densities for various greater sandhill crane populations. The estimated density of 0.43 pair/km^2 (minimum known 0.26 pair/k^2 on the Seney PSA is well below the 2.0 pairs/km^2 for the marsh proper and adjacent shore areas at Grays Lake, Idaho (Drewien 1973) and 1.35 pairs/km^2 for Sycan Marsh, Oregon (Stern et al. 1987), 2 areas like Seney, with large expanses of wetland habitat. Nests on Seney were, however, rather widely spaced (Fig.2), and a great deal of suitable nesting habitat exists in which no nests were found. The wildfire of 1976 improved some additional habitat in the western part of the refuge. Availability of nesting habitat is not a limiting factor to size of the crane population on Seney NWR.

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Table 1. Number of nests in habitats classified by general wetland type (key plant species) and by wetland class and subclass (Cowardin et al. 1979), Seney NWR, 1987.

Wetland Class and Subclass	Cattail Marsh	Sedge Marsh	Sphagnum Bog	Total Nests
Emergent	12	2	0	14
Emergent/BLE[a] Shrub	3	4	2	9
Emergent/BLD[b] Shrub	3	4	0	7
Emergent/Dead Shrub	0	0	1	1
Emergent/BLE/BLD Shrubs	2	4	2	8
Emergent/BLE/Dead Shrubs	0	0	4	4
BLD Shrub	3	3	0	6
BLD/BLE Shrubs	0	2	1	3
Total Nests	23	19	10	52

[a]Broad-leaved evergreen (leatherleaf).
[b]Broad-leaved deciduous (willow, alder, or dwarf birch).

Table 2. Relationships between nest depredation and habitat variables and type, Seney NWR, 1987, (means are ± 1 SE).

	Destroyed by Predators	Not Depredated[a]
Water depth (cm)[b]	5.4 ± 1.5 (N=12)	7.5 ± 0.9 (N=37)
Concealment score[b]	51.0 ± 6.6 (N=12)	50.0 ± 3.4 (N=37
Shrub stems within 1.5 m of nest center[b]	21.8 ± 5.4 (N=12)	15.8 ± 2.8 (N=37
Distance (m) to nearest upland island[c]	35.g ± 6.2 (N=11)	45.8 ± 5.2 (N=35)
Clutches in each habitat type[d]		
Cattail marsh	7 (31.8%)	15 (68.2%)
Sedge marsh	3 (16.7%)	15 (83.3%)
Sphagnum bog	3 (30.0%)	7 (70.0%)

[a]Includes infertile clutches that were incubated full-term (N = 4).

[b]Data from 2 flooded nests and 1 nest of undetermined fate not included.

[c]Same exclusions as b (above) plus no data available for 3 nests off the refuge.

[d]Same exclusions as b (above) but data from the first clutch of nest in which 2 clutches were laid were included (data for this clutch were not included in preceding calculations).

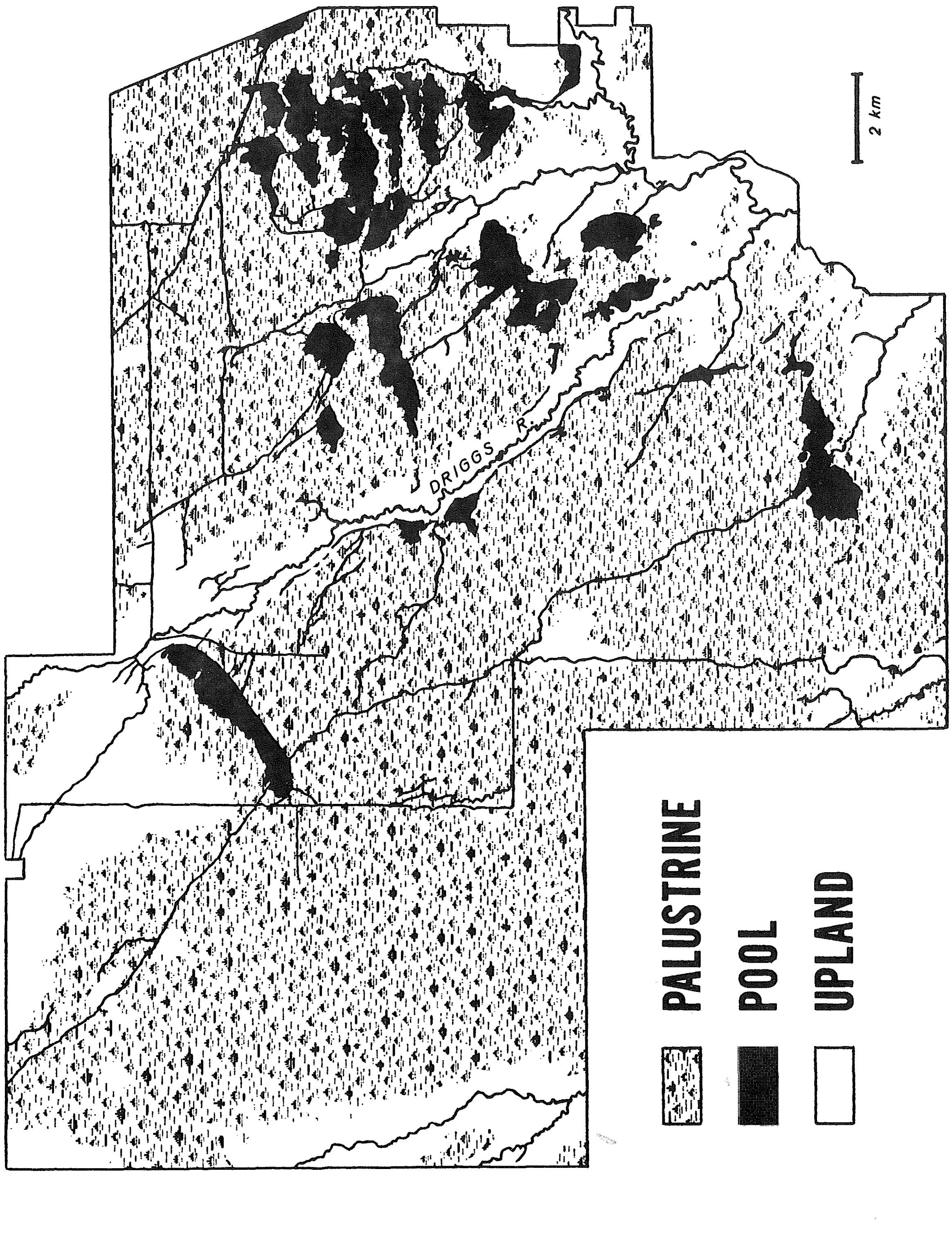

Figure 1. Generalized cover map of Seney National Wildlife Refuge, Upper Peninusula of Michigan. Wetlands indicated also contain upland ridges, or islands. Uplands indicated may contain some small wetlands.

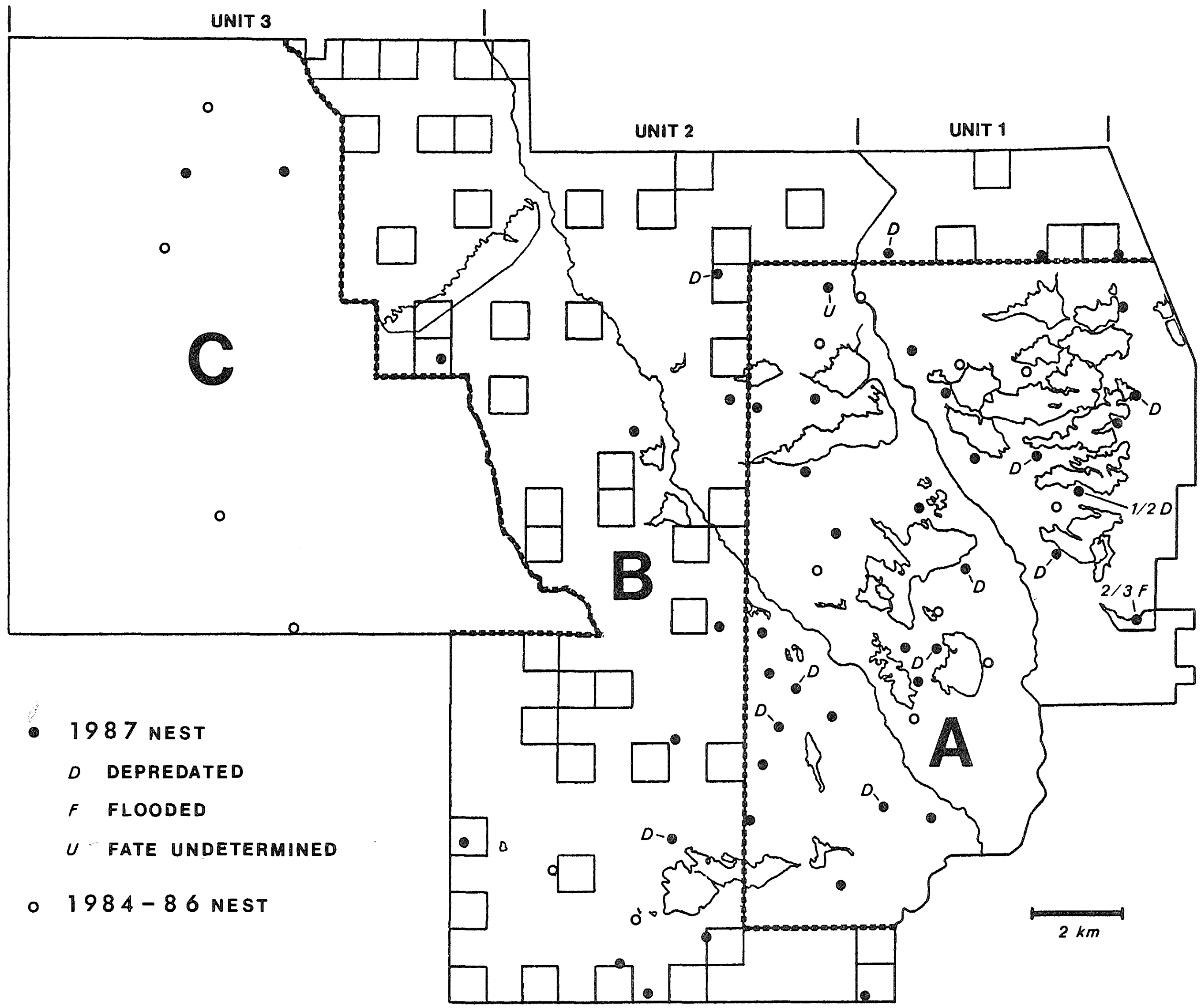

Figure 2. *Locations of greater sandhill crane nests found on Seney NWR, 1984-87. Only location of the most recent nest in each territory is shown. Fractions are numbers of clutches affected by designated fate. Survey areas: A = Complete search, B = 20% sample composed of random quarter-section plots, C = no survey.*

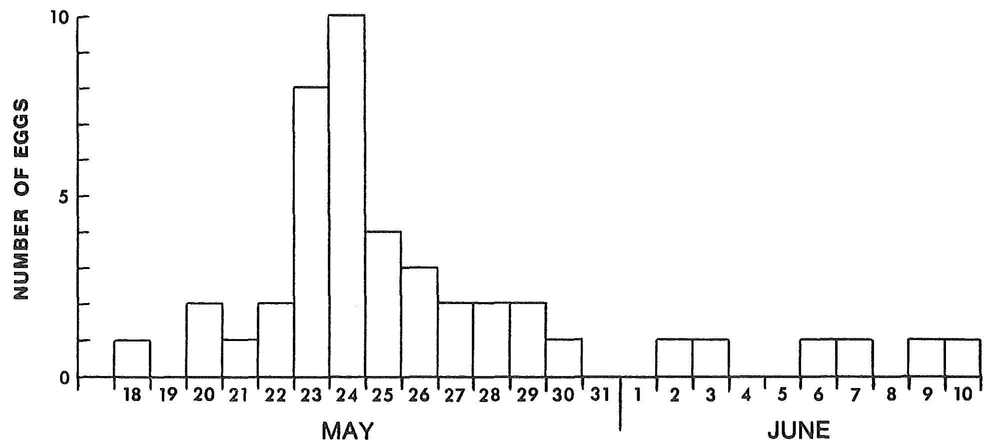

Figure 3. *Hatching dates for chicks of known age on Seney NWR, 1987*

RENESTING OF MISSISSIPPI SANDHILL CRANES IN JACKSON COUNTY, MISSISSIPPI 1965-1989

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Abstract: Among 118 active nests of Mississippi sandhill cranes (*Grus canadensis pulla*) in Jackson County, Mississippi, 1965-1989, 13 were renests. Three chicks from 19 wild and 3 from 3 Patuxent Wildlife Research Center (PWRC) switched eggs hatched in 13 first nests, but 5 died early and 1 after 2 weeks. Ten eggs were dead (infertile or the embryos died) in or at the nest. Two clutches (3 eggs) were destroyed by mammalian predators, 2 eggs were taken for captive propagation, and 1 was pecked and destroyed by the crane pair. Three chicks hatched from 22 wild eggs and 1 from a PWRC switch in 13 renests. Three died early and 1 wild chick fledged. Seventeen eggs from 11 clutches failed to hatch. One nest was deserted after 1 of 2 eggs was destroyed by predation; another was deserted (1 egg gone and 1 cracked). One second clutch was laid 17 days after a 1-egg clutch was removed for captive propagation. The time between first and second sets of other matings has been much longer. Mean clutch size for 13 completed first clutches was 1.46 eggs; for 13 renests was 1.69 eggs.

Proc. 1988 N.Am. Crane Workshop

Littlefield & Ryder (1968) found 4 second clutches and 3 other "possible attempts" among 108 greater sandhill crane (*G. c. tabida*) nests. Boise (1978), studying lesser sandhill cranes (*G.c. canadensis*) in Alaska, did not report any renesting. Bennett (1978) found no renesting among 53 nests in Wisconsin in 1976-1978. Walkinshaw (1973, 1978), however, noted 3 instances of renesting in southern Michigan, and found 2 second clutches among 46 nests in Michigan's Upper Peninsula. McMillan (1987) reported renesting was rarely observed at Seney National Wildlife Refuge, Michigan, but in 1987 1 pair renested. Another pair was believed to have laid a third clutch after the first 2 were flooded. Although renesting of Florida sandhill cranes (*G. c . pratensis*) was not reported by Thompson (1970) or Walkinshaw (1976), Nesbitt (1988) reported renesting to be frequent in Florida. Renesting is probably more common than the literature indicates.

METHODS

In this study, renesting data were collected 1966-1989 from Mississippi sandhill crane nests in southern Jackson County, Mississippi. Most of the breeding range of the cranes is within the Mississippi Sandhill Crane National Wildlife Refuge (MSCNWR), but a few pairs nest outside the refuge. In Mississippi, early evidence for renesting was circumstantial, but in the course of investigating nesting habitats in summer, I had found egg shells and membranes indicating that eggs had been laid and hatched in territories where I knew first clutches had failed. From 1 year to the next, a pair usually built their nest within a few hundred meters of their previous nest. If I found a second nest near an unsuccessful first nest during the same season, I assumed it was a second clutch.

ACKNOWLEDGMENTS

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RESULTS

Among 78 active nests found in Mississippi 1965-1980 only 2 (2%) were considered renests, but during 1981-1989 , when nest searches continued later in the season, 11 (18%) among 61 were renests. No third clutches were confirmed.

On 3 May 1966, I took the only egg in Nest 4-1966 (Composite Nesting Area [CNA] So Sav 2) for captive propagation. The egg hatched at John Lynch' s aviary, Lafayette, Louisiana, on 17 May.