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HOME RANGE AND HABITAT USE BY ISOLATION-REARED SANDHILL CRANES

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Abstract: We isolation-reared, placed radio transmitters on, and released 38 greater sandhill cranes (*Grus canadensis tabida*) on Seney National Wildlife Refuge (Seney) in 1988-90 to develop procedures for initiating new populations of cranes. Here we report on habitat selection by breeding birds with functional radio transmitters. Home ranges established by 6 cranes in 1992, when they were 2 to 4 years old, averaged 199±50.8 (SE) ha (harmonic mean method, 75% utilization) and were of 2 types: feeding grounds separated from nesting habitat and feeding grounds adjacent to nesting habitat. Home ranges consisted of 36% emergent palustrine wetlands, 28% forested upland, 11% open upland, and 11% forested palustrine; the remainder was scrub-shrub, upland shrub, bog, or open water. Four of 5 cranes monitored in 1993 nested-all in emergent palustrine wetlands, also the nesting habitat of wild sandhill cranes at Seney. Open field and mudflat were the major feeding habitats, as they were for wild cranes. Five of the 6 cranes did not use habitats in proportion to availability in the home range (χ^2, $P < 0.05$). Three cranes significantly selected emergent palustrine wetlands and no crane avoided this habitat type; 2 cranes selected open upland, and no crane avoided this type; and 4 cranes avoided forested palustrine, and no crane preferentially selected this habitat type. The nesting areas of the 4 cranes in 1993 were the same areas they used in 1992, when they were paired but were not known to have nested. Feeding grounds changed according to their availability in the 2 years.

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Key words: *Grus canadensis*, isolation-rearing, release, home range, habitat use, sandhill crane, reintroduction technique.

As part of an effort to effect recovery of the endangered whooping crane (*Grus americana*), and other endangered cranes, the Ohio Cooperative Fish and Wildlife Research Unit isolation-(costume-)reared 38 sandhill cranes and released them into a migratory population of sandhill cranes at Seney in 1988-90. Hereafter, unless otherwise indicated, all reference to sandhill cranes means the isolation-reared cranes. Among the cranes, 16 (9 males, 7 females) were released in 1988, 13 (4 males, 9 females) in 1989, and 9 (5 males, 4 females) in 1990. These birds exhibited high survival (84% 1 year after release) and return (74%) to the natal area after migration to winter sites (Urbanek and Bookhout 1992*a*, 1994). Before isolation-rearing can be declared successful as a reintroduction technique, the cranes must exhibit normal sexual behavior, establish a breeding territory, mate successfully with wild cranes, and produce and fledge chicks. In this paper we describe home ranges and habitat use for 6 male cranes, 4 of which we monitored in both 1992 and 1993.

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METHODS AND STUDY AREA

Seney consists of about 38,000 ha in Schoolcraft County in the east-central Upper Peninsula of Michigan. Vegetation cover is about 54% marsh, grassland, and shrub; 30% forested upland; 9% forested wetland; and 7% open water (U.S. Department of the Interior 1978). About 65% is wetland. There are 26 major pools, 21 of which have controllable water levels.

Dominant marsh plants are cattail (*Typha latifolia*) and sedges (*Carex* spp.). Dominant shrubs are willow (*Salix* spp.), leatherleaf (*Chamaedaphne calyculata*), and alder (*Alnus rugosa*). Dominant tree species are jack pine (*Pinus banksiana*) and red pine (*P. resinosa*) on forested sand ridges in wetland and sugar maple (*Acer saccharum*) and red pine in forested upland.

All cranes were radio-tagged and color-marked (for details see Urbanek and Bookhout 1992*a*). Cranes on the refuge with functional radios (n = 5 in 1992, 5 in 1993, 4

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birds common to both years) were monitored daily or weekly from a vehicle (truck with Yagi antenna and a Telonics TS-1/TR-2 scanner/receiver) in summer. When a radio signal was detected, the triangulation method (Kenward 1987:151-156) was used to ascertain the location of the cranes. If the crane could not be observed, the triangulation data were calculated by program Locate II (Nams 1990) to obtain the Universal Transverse Mercator (UTM) coordinates of the crane's location and 95% error ellipses. Each crane location was triangulated from 2 or 3 different detection sites in open areas and from 3 to 6 sites in forested areas. All locations with a calculated error of >1 ha were discarded. All cranes visually detected were observed with a 15-60× spotting scope to ascertain identification according to color bands.

Crane locations were marked on 1:24,000 U.S.G.S. topographic maps with UTM coordinates, or recorded on 1:10,000-1:12,000 aerial photos taken in August 1992. The locations of any crane for which more than 50 samples were located, the minimum sample size recommended by Ackerman et al. (1990), were calculated with the program Home Range (Ackerman et al. 1990). The activity center of the roosting or nesting territory and the activity center of the feeding grounds also were calculated with the Home Range program. For the home range study, an important goal was to obtain unbiased location samples. Directly observing the crane and recording habitat type and UTM coordinates provided the best accuracy.

Home range shape and size were determined by 2 different methods: convex polygon and harmonic mean. The harmonic mean method (Dixon and Chapman 1980) was judged by McMillen (1988) to be the better one to represent crane home range, because the method does not assume any a priori distribution and it also can define a home range of any shape; therefore, we selected this method for analysis. The convex polygon (Mohr 1947) is one of the most common methods used to represent animal home ranges, so for comparison purposes this method also was used (for details of harmonic mean and minimum convex polygon methods see White and Garrott 1990:145-180; Samuel and Garton 1985, 1987). The 75% utilization harmonic mean home range was used to identify home range outline, because this pattern best represented what we thought was actually occurring in the field.

Habitat of cranes was classed as open water, upland, and palustrine. All 6 crane pairs selected their roosting or nesting habitats in palustrine wetland. The 3 palustrine classes used in the analysis were emergent palustrine (E-P), scrub-shrub (S-S), and forested palustrine (F-P) (after Cowardin et al. 1979). Upland areas were classified as open upland (O-U), forested upland (F-U), and upland shrub (U-S).

Information on habitats used by cranes was collected based on even distribution sampling and aerial photos. The sample points were selected every 100 m and based on the UTM coordinates base line on 1:10,000-1:12,000 aerial photos. We took vegetation samples after cranes had left the use area. The number of samples was approximately equal to the number of hectares of the use area except in deep marshes, open water, and private property, where sampling effort was less intensive. The plot size was 20 × 20 m (400 m^2) in upland, 5 × 5 m (25 m^2) in scrub-shrub wetland and forested palustrine, and 2 × 2 m (4 m^2) in other wetland areas. The dominant tree species and shrubs, tree diameter, and coverage of tree canopy were recorded in upland and forested palustrine habitat. In scrub-shrub habitat, dominant shrub species, height of shrubs, and depth of water were recorded. In emergent palustrine wetland, dominant plant species were documented.

A use area cover map was made for each crane according to the habitat samples and 1:10,000-1:12,000 aerial photos. The preference of habitat used by the cranes was calculated independently by χ^2 analysis (Neu et al. 1974). A χ^2 test was used to test for the goodness-of-fit of utilized habitat to availability within a crane home range. Two specific hypotheses were (1) cranes used habitat in proportion to availability, all habitat types considered simultaneously, and (2) cranes used habitat in proportion to availability of habitat type, each habitat type considered separately. To test hypothesis 1, we compared the total χ^2 value with χ^2 critical values ($P < 0.05$). To test hypothesis 2, we compared the confidence interval on the observed sample locations for each habitat type with availability of this habitat within a crane home range.

RESULTS

During the 2 study years (1992 and 1993), 17 cranes were observed. We computed home ranges for 6 cranes for which more than 50 summer locations were identified. Average home range sizes computed by the harmonic mean method were 384 ± 109 (SE) ha for 95% utilization, 199 ± 51 ha for 75% utilization, and 131 ± 36 ha for the core area (the maximum area where the observed utilization distribution exceeds a uniform utilization distribution [Ackerman 1990]). Average home range sizes depicted by the convex polygon method were 254 ± 65 ha for the 100% convex polygon and 198 ± 47 ha for the 95% convex polygon (Table 1).

Home range patterns were of 2 types: roosting and nesting habitat separated from the feeding ground, and feeding ground adjacent to the roosting or nesting area. The largest percentage area (about 36%) of the 6 home ranges was emergent palustrine wetland (Fig. 1). The home range of

Table 1. Home range sizes (ha) of isolation-reared cranes, Seney National Wildlife Refuge, Michigan, 1992-93.

Crane	Harmonic mean		Convex polygon	
	95%[a]	75%	100%	95%
88-05	652	329	467	391
88-13	432	232	266	186
89-02[b]	728	349	409	249
89-06	270	146	191	185
89-14	90	54	62	50
90-09	132	84	128	125
$\bar{x}$	384	199	254	198
SE	109	51	65	48

[a] Percentage in harmonic mean is the percentage of utilization volume; percentage in convex polygon is actual percentage of sample points included in the polygon.

[b] 1992 data only; this bird died on Kanapaha Prairie, Florida, in the winter of 1992-93.

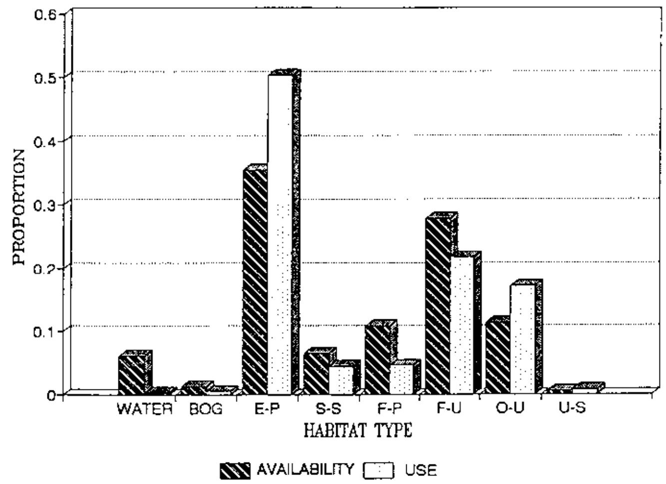

Fig. 1. Average habitat availability and use for 6 isolation-reared sandhill cranes, Seney National Wildlife Refuge, Michigan, 1992-93. E-P = emergent palustrine, S-S = scrub-shrub, F-P = forested palustrine, F-U = forested upland, O-U = open upland, U-S - upland shrub.

crane 89-06 contained 63% emergent palustrine wetland, but the home range of crane 90-09 contained only 10%. The emergent palustrine wetland was dominated by cattail or sedge, and most area of the emergent palustrine wetland was dotted by willow or alder. Four of the 5 cranes monitored in 1993 nested, all in emergent palustrine wetland. Forested upland was the second largest percentage area of crane home ranges. The home ranges contained 28% forested upland on average.

Feeding centers of 3 of the 6 cranes (88-05, 89-14, 90-09) were in open hayfield or at the border area between open field and forested upland. Two crane feeding grounds (88-05, 90-09) were separated from nesting habitat; those feeding grounds contained only open upland (hayfield) and forested upland. Cranes 88-13 and 89-06 selected feeding grounds at mudflats created by drawn-down pools. The home range of crane 89-02 contained no open fields; he spent about 90% of his time in emergent palustrine (40%) and forested upland (48%).

A sample of 777 locations for which sample intervals were ≥1 hour was obtained in the summers of 1992 and 1993. Habitat use was variable (Table 2), but 50% of the total samples of the 6 cranes were located in emergent palustrine wetland dominated by cattail or sedge and often dotted by willow or alder. Upland contained 40% of the total samples, which included forested upland (22%), open upland (17%), and upland shrub (1%). Open water and bog were rarely used (1%). Cranes 88-05, 88-13, and 89-06 spent more than one-half (58-77%) of their time in emergent palustrine wetland, and cranes 89-02 and 89-14 spent about 40% of their time in that habitat type. Crane 90-09, however, spent most (72%) of his time in upland rather than in emergent wetland (14%).

The 4 cranes that nested in 1993 used emergent palustrine wetland as their nesting territories, and all 6 monitored cranes roosted in emergent palustrine wetland or shallow water. About 22% of samples were in forested upland, all near the border between forested upland and open upland. On average about 17% of the total samples were in open uplands (hayfield).

A χ^2 test of use (observed) to availability (expected), considering all habitats simultaneously, showed (Table 2) that 5 of the 6 cranes did not use habitats in proportion to availability (Hypothesis 1 was rejected), but crane 89-02 did use habitat in proportion to its availability (Hypothesis 1 was not rejected). Results of habitat preference and avoidance analysis (Table 3) showed that 3 cranes (88-05, 88-13, 89-06) significantly preferred emergent palustrine wetland. The other 3 cranes (89-02, 89-14, 90-09) did not select emergent palustrine, but they used this type commonly. Cranes with open water (88-05, 89-06, 89-14) or bogs in their home ranges (88-02 and 90-09) avoided those types.

No crane preferred forested palustrine within its home range, and 4 cranes avoided forested palustrine wetland. These sites were dominated by red pine and black spruce (*Picea mariana*). Basal areas ranged from 1.4 to 4.1 m^2/ha. Three cranes avoided scrub-shrub habitat, and no crane preferred this habitat. The scrub-shrub habitat in the 6 crane home ranges was dominated by alder (mean height = 260 ± 15.7 [SE] cm) and willow (mean height = 165 ± 5.5 [SE] cm). Two cranes (89-06, 89-14) showed preference for

Table 2. Calculation of the χ^2 statistic on habitat[a] availability and habitat use (%) for isolation-reared sandhill cranes, Seney National Wildlife Refuge, Michigan, 1992–93.

Crane		Water	Bog	E-P	S-S	F-P	F-U	O-U	U-S	Total
88-05	O	0.5	1.1	69.3	1.1	0.5	11.1	11.6	4.8	1.0
	E	**16.5**	**2.8**	**41.3**	**5.9**	**18.7**	**10.0**	**1.4**	**3.5**	**1.0**
	χ^2	15.5	1.0	19.0	3.9	17.7	0.1	74.3	0.5	132.1
88-13	O	0.5	2.2	58.6	0.0	10.2	27.4	1.1		1.0
	E	**0.5**	**4.2**	**31.2**		**18.4**	**45.4**	**0.2**		**1.0**
	χ^2		1.0	24.1		3.7	6.0	4.1		38.7
89-02	O			40.4	9.0		48.3	2.2		1.0
	E			**29.4**	**10.7**		**57.8**	**2.4**		**1.0**
	χ^2			4.1	0.3		1.6			6.0
89-06	O			77.2	4.3	2.2	16.3			1.0
	E	**10.4**	**0.8**	**62.9**	**14.0**	**7.2**	**4.7**			**1.0**
	χ^2	10.4	0.8	3.3	6.7	3.5	28.6			53.3
89-14	O	0.8		43.0	12.4	0.8	8.3	34.7		1.0
	E	**9.7**		**37.9**	**8.0**	**6.1**	**11.7**	**26.7**		**1.0**
	χ^2	8.2		0.7	2.4	4.6	1.0	2.4		19.3
90-09	O			14.0		14.0	19.0	53.0		1.0
	E			**10.1**	**0.5**	**14.8**	**37.6**	**37.1**		**1.0**
	χ^2			1.5	0.5		9.2	6.8		18.1

[a] E-P = emergent palustrine, S-S = scrub-shrub, F-P = forested palustrine, F-U = forested upland, O-U = open upland, U-S = upland shrub, O = observed (use), E = expected (availability).

forested upland, but 2 cranes (88-13, 90-09) showed an avoidance for forested upland. Two cranes (88-05, 90-09) preferred open upland, and no crane avoided open upland. Results of this analysis indicated that Hypothesis II also was to be rejected.

A comparison of home ranges between 1992 and 1993 was made for 3 of the nesting cranes (the fourth nesting crane had a non-functional transmitter in 1992 that was replaced in autumn 1992). There was little difference in location of the home range of crane 88-05 (Fig. 2A) in the 2 years, although size was larger in 1993. In the summer of 1992, M Pool was filled with water so that the home range of 88-13 (Fig. 2B) included only the edge of M Pool. This pool was drawn down in spring 1993, creating a large mudflat. Crane 88-13 fed on a portion of that mudflat. Thus the size of home range of 88-13 was larger and shifted more southwesterly in 1993 than in 1992. Crane 89-06 selected the G Pool mudflat, created by drawdown of that pool, as his feeding ground in the summer of 1992 (Fig. 2C). But in 1993 G Pool was filled with water, so the home range of 89-06 was smaller in 1993 than in 1992.

DISCUSSION

Home range is defined as the area occupied by the individual in its normal activities of food gathering, mating, and caring for young (Burt 1943). The term "home range" is used to describe a normal movement of an animal so that exploratory movements outside that area should not be included. In this study the "summer home range" was

Table 3. Selection[a] of habitat types within home ranges of 6 isolation-reared sandhill cranes, Seney National Wildlife Refuge, Michigan, 1992–93.

	Crane					
Type	88-05	88-13	89-02	89-06	89-14	90-09
Open water	−	0	n	−	−	n
Bog	−	−	n	−	n	n
Emergent palustrine	+	+	0	+	0	0
Scrub-shrub	−	n	0	−	0	−
Forested palustrine	−	−	n	−	−	0
Forested upland	0	−	0	+	+	−
Open upland	+	0	0	n	0	+
Upland shrub	0	n	n	n	n	0

[a] + = selected, − = avoided, 0 = no evidence for selection or avoidance, n = not present in home range.

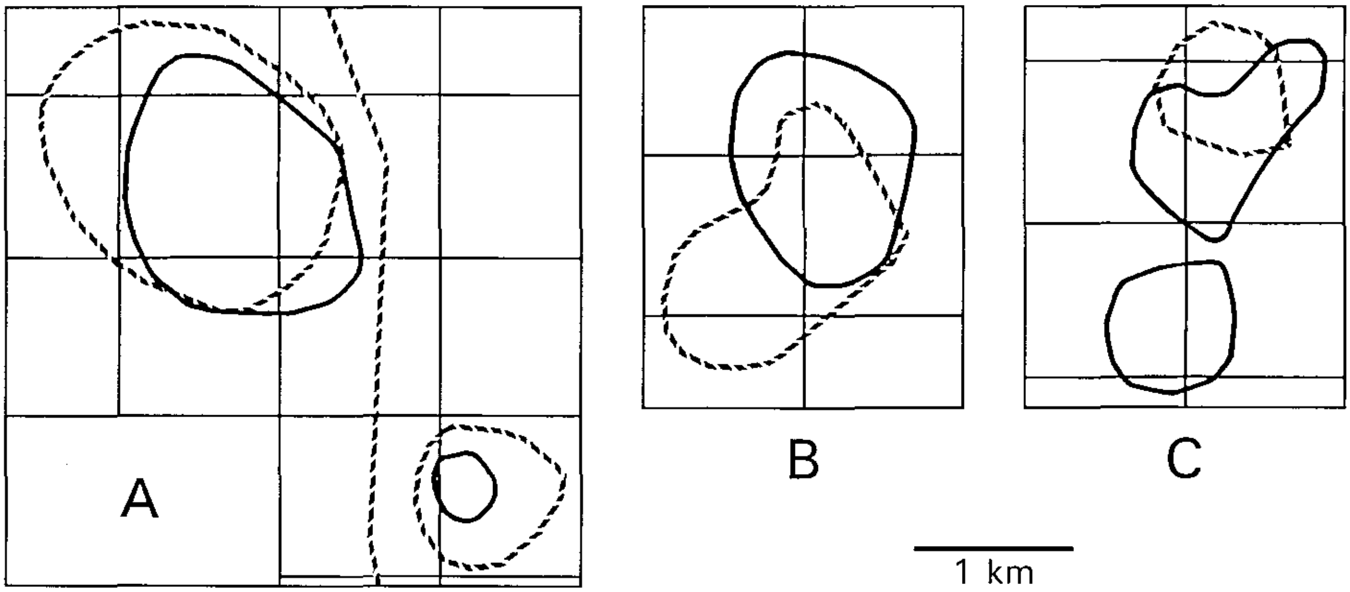

Fig. 2. Comparison of the 75% harmonic mean home ranges of cranes (A) 88-05, (B) 88-13, and (C) 89-06 at Seney National Wildlife Refuge, Michigan, in 1992 (solid lines) and 1993 (dashed lines).

defined as the area occupied by a crane (or a pair of cranes) in its normal activities from its arrival at the home range area to the time that it started congregating with other cranes prior to migration. Most Great Lakes sandhill cranes spend the winter in Florida and southern Georgia, so congregation and migration must be excluded from home range calculations. For the isolation-reared cranes, it is important to know the size of home range, the habitat they use for nesting and foraging, and how their time was spent in each habitat, i.e., the habitat time budget. This information can be used to formulate a habitat management plan and also may be useful to selection of whooping crane release sites.

McMillen (1988) chose the 95% harmonic mean utilization distribution to estimate home ranges of crane chicks. We observed that the area used by adult cranes was much larger than the area used by crane chicks, and the use area pattern of adult cranes was different from that of chicks because some feeding grounds of adult cranes were isolated from the nesting area by highways or towns. Three crane home ranges (cranes 88-05, 89-02, 90-09) calculated by the 95% harmonic mean utilization included highway M-77 or the town of Germfask, which cranes never used. For this reason we chose 75% harmonic mean home range instead of 95% harmonic mean home range for habitat analysis. The former better represented what we thought was actually occurring in the field.

Although average size of the 6 home ranges was about 200 ha (Table 1), extremes were 50 ha to about 300 ha (75% harmonic mean). Home ranges of wild cranes also vary greatly in size. Littlefield and Ryder (1968) reported that the territory size of western greater sandhill cranes varied with density of birds in a particular area. The smallest crane territory they recorded was 1.2 ha, and average size was 25.1 ha. In Okefenokee Swamp in Georgia the average annual home range (convex polygon) of non-migratory, adult Florida sandhill cranes was 93 $\pm$ 26 (SE) ha (Bennett 1989). However, the average home range (convex polygon) of Florida sandhill cranes in Florida was about 1,370 ha for territorial adults and 550 ha for resident adult crane pairs (Nesbitt 1990). Many factors affect size of home range, such as food availability, habitat type, and crane density in the area. At Seney the smallest home range (crane 89-14) included the nesting marsh adjacent to the feeding ground, so the crane pair could walk to its feeding ground. On the other hand, 2 pairs of wild cranes also used this same marsh as their territory, which limited the activity area of crane 89-14. Crane 89-02 established a territory on the east side of highway M-77, off Seney but abutting the refuge. In this home range predominant habitats were forested upland and emergent palustrine dotted by willow or alder. Lack of open hayfield for feeding in the home range and lower crane density near the crane territory may have been the main reasons for the larger size of this home range. The home range of 88-05 had an isolated feeding ground. The separate feeding ground was about 2.4 km from the nesting marsh, so this home range was the second largest among home ranges of the 6 cranes.

On average the 6 crane home ranges contained 36%

emergent palustrine wetland (range 10–63% of total area of home ranges). In different places sandhill cranes use different habitats. For example, in southern Michigan breeding territories of sandhill cranes are mostly located in sedge marsh, but in the Upper Peninsula of Michigan they are located mostly in sphagnum moss (*Sphagnum* spp.)-leatherleaf habitat except at Seney (Walkinshaw 1933, 1978). Although sandhill cranes use habitat variably, almost all of them select breeding territories in wetlands (Walkinshaw 1981, Johnsgard 1983). At Seney the most extensive study of wild cranes was in 1985–87 (McMillen 1988, Urbanek and Bookhout 1992*b*), and most of them nested in emergent palustrine wetland that contained cattail or sedge. They selected nest sites in or near emergent (non-woody) wetlands and avoided forested uplands (Baker et al. 1995). Comparison of the confidence interval on the proportion of habitat used to that available (home range components) indicates that the cranes we studied, like other cranes at Seney, selected their breeding territory in emergent palustrine wetland.

Home ranges of the 6 cranes contained 40% upland. Taylor (1976) reported upland openings within several kilometers of the nest site were important feeding grounds for wild sandhill cranes in the Upper Peninsula of Michigan and that openings were used increasingly as summer progressed. Our observations support his. Feeding grounds of cranes 89-14 and 90-09 were open hayfield (2.5–30 ha) surrounded by forested upland, and the feeding ground of crane 89-02 contained an open field (about 8 ha) dominated by bracken fern (*Pteridium aquilinum*) and surrounded by forested upland. Although feeding grounds of cranes 88-13 and 89-06 did not contain a hayfield, they did contain open mudflats created by drawn-down pools. By comparing the confidence interval on the proportion of observed habitat use to the proportion of habitat available (home range components), we conclude the cranes preferred to use open upland.

According to vegetation sampling data and vegetation cover maps, dominant tree species of the forested upland in home ranges of cranes were red pine and sugar maple. Cranes 89-06 and 89-14 significantly preferred forested upland, but cranes 88-13 and 90-09 significantly avoided forested upland. One possible reason for the difference is that the home range of crane 89-06 was located in a tourist area, and the home range of crane 89-14 was located on Seney near a main entrance to the refuge. Human activities and vehicles disturbed the 2 cranes more often, so they stayed at the edge of forested upland instead of in the open area. The home range of crane 88-13 was located near M Pool where human activities were rare, and the feeding ground of crane 90-09 was located at a private hayfield and forested upland with no human activities. Thus cranes 88-13 and 90-09 spent more time in open upland rather than in forested upland. The distribution of locations indicated that the cranes preferred to use the border between forested upland and open upland, especially where hayfield was adjacent to hardwood forested upland. Cranes rarely visited deep forested upland without open ground.

We conclude that the cranes we studied were selective in their choice of habitat types and that their primary preference for emergent palustrine matched that of wild sandhill cranes at Seney. Further, location of breeding territory was fixed as long as the selected site continued to be available; feeding grounds changed according to availability and were particularly influenced by pool drawdowns.

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