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NESTING HABITAT OF COOPER'S HAWKS IN NORTHERN GREAT PLAINS WOODLANDS

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Cooper's Hawk (*Accipiter cooperii*) nesting habitat has been described quantitatively in the eastern (Titus and Mosher 1981, Bosakowski et al. 1992), midwestern (Wiggers and Kritz 1991, Garner 1999, Trexel et al. 1999), southwestern (Fischer 1986, Kennedy 1988, Boal and Mannan 1998), and western (Reynolds et al. 1982, Moore and Henny 1983, Asay 1987) regions of North America, but not for the northern Great Plains, where the hawk has been considered a species of special concern due mainly to its perceived scarcity (Nenneman et al. 2002). Woodland habitat within the northern Great Plains was scarce prior to European settlement in the early 1900s, limited primarily to gallery forests along major rivers (Coues 1897, Stewart 1975). Since then, tree coverage has increased. For example, woodland area in northwestern and north-central North Dakota more than doubled during 1938–91 (T. Grant and R. Murphy unpubl. data). Cooper's Hawk nesting habitat in the region may differ from that in other regions due to isolation of available woodland habitats, lower tree species diversity, and differences in structural complexity of woodlands. Recent studies have shown Cooper's Hawks to be markedly plastic in their nesting habits (Boal and Mannan 1998, Bielefeldt et al. 1998, Trexel et al. 1999). However, species-habitat relationships inferred from data collected in one region may not adequately predict Cooper's Hawk use of woodland habitat in another region (Kennedy 1988, Trexel et al. 1999).

Our objectives were to: (1) describe quantitatively habitat characteristics of Cooper's Hawk nest-sites across the Souris River basin of North Dakota, (2) compare nest site habitat used to woodland habitat available, and (3) compare Cooper's Hawk nesting habitat in North Dakota to that in other regions.

STUDY AREA AND METHODS

Our study area was the Souris River basin in north-central North Dakota (48°40′N, 101°25′W; Ward, Renville, and McHenry counties; Fig. 1). The area is characterized by level to rolling plains found within the Drift Plain physiographic region (Bluemle 1991). Climate is subhumid continental, with mean monthly temperatures ranging from −15°C in January to 20°C in July. Mean annual precipitation is about 42 cm, most of which falls as rain between April and September (U.S. Fish Wildl. Serv. unpubl. data).

The Souris River flows along a 110-km "loop" from Canada south into north-central North Dakota, then back north again (Bluemle 1991; Fig. 1). In 1994–95, we

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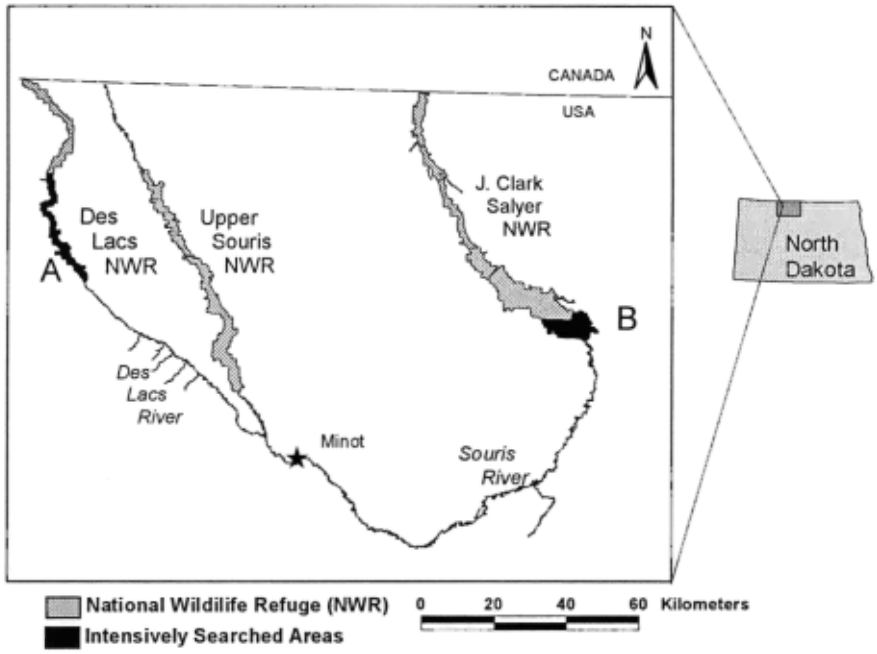

Figure 1. Cooper's Hawk study area in the Souris River basin of North Dakota, including two intensive search areas where nesting habitat use and availability were compared: (A) the southern one-half of Des Lacs National Wildlife Refuge (3951 ha) and (B) the far southern one-fifth of J. Clark Salyer National Wildlife Refuge (5263 ha).

located Cooper's Hawk nests in woodlands along the western one-half of this loop, the adjoining Des Lacs River, and intermittent tributaries ("coulees") of these rivers. Des Lacs and Upper Souris National Wildlife Refuges (NWR) were included, as well as privately-owned woodlands in Ward and southwestern McHenry counties. Des Lacs NWR has about 740 ha of woodland (10% of the refuge), mostly on north- and east-facing slopes of coulees. The Souris River has a narrow (<0.2 km wide) band of woodlands along its meandering bottoms, and wooded coulees in adjacent uplands.

In 1996, we located Cooper's Hawk nests along the eastern one-half of the Souris River loop, focusing our search for nests on the far southern part of J. Clark Salyer NWR (about 4000 ha of woodland, 17% of the refuge; Fig. 1). Here, the Souris River bisects an upland sandhills complex derived from the shores of glacial Lake Souris (Bluemle 1991). We also located nests in the Souris River floodplain woodlands adjacent to this sandhills complex.

Woodlands in our study area represented the naturally-occurring deciduous woodlands available in the northern Great Plains region: quaking aspen (*Populus tremuloides*)-bur oak (*Quercus macrocarpa*) woodland in the sandhills, green ash (*Fraxinus pennsylvanica*)-American elm (*Ulmus americana*) on north and east slopes of coulees, and green ash-American elm woodland in the river floodplain. The only other woodland habitat available within our study area was planted tree shelterbelts around farmsteads.

Woodlands were searched regardless of their perceived suitability for nesting (Trexel et al. 1999). We searched woodland habitat on foot during late April–June and found nests mainly by scanning individual trees (Nenneman et al. 2002). We completely searched all woodland habitat within two intensive search areas arbitrarily selected to determine Cooper's Hawk nesting density (Des Lacs NWR, 3951 ha and J. Clark Salyer NWR, 5263 ha; Nenneman et al. 2002). We restricted comparisons of nest-site habitat use and availability to these two areas. Additional nests were located by searching parts of other woodlands scattered throughout the study area. In Ward County, this included areas around nest sites originally identified during a 1986–87 breeding bird atlas (G. Berkey and R. Martin unpubl. data).

We quantified woodland habitat with techniques described by James and Shugart (1970) and Noon (1981). A 0.04-ha circular plot, centered on the nest tree, was the basis for nest habitat measurements (James and Shugart 1970, Trexel et al. 1999; Table 1). We measured habitat only once at each nest area (i.e., the area within 0.4 km of the first nest found [Rosenfield et al. 1995]), to avoid interdependency among sampling points (Bosakowski et al. 1992).

To assess nest habitat use by Cooper's Hawks, we compared habitat characteristics at nest sites with those at random woodland plots. We confined this analysis to nest sites located within our two intensive search areas. Woodlands at Des Lacs NWR were roughly linear (mostly <0.1 km wide), so we chose three to six plots centered at 200-m intervals from a random starting point (from 0–40 m from

Table 1. Mean habitat characteristics of 48 Cooper's Hawk nest sites across north-central North Dakota, 1994–96.

CHARACTERISTIC	DESCRIPTION	$\bar{x}$ (SE)
Nest tree		
Nest height	Height (m) from ground to top of nest (meter tape)	9.2 (0.3)
Nest tree height	Height (m) of nest tree canopy (Abney level or rangefinder)	13.2 (0.4)
% nest height	(Nest height/tree height) × 100	69.7 (1.6)
DBH	Diameter of nest tree (cm) at breast height	24.7 (1.0)
Nest canopy cover	% canopy cover within a 1-m horizontal radius of the nest[a]	77.4 (2.9)
Nest site		
Canopy height	Mean height (m) of canopy of three trees in study plot	13.3 (0.4)
Stand DBH	Mean DBH (cm) of canopy trees in the study plot	16.0 (0.3)
Tree density	Number of canopy trees ≥7.5 cm DBH per ha.	1156.3 (64.0)
Basal area	Cross-sectional area (m^2/ha) of canopy trees	25.9 (1.5)
Shrub density	Number of shrub stems (<7.5 cm DBH and >1.5 m tall)/ha	1364.1 (152.8)
% canopy cover	% of area over plot occluded by canopy tree foliage[b]	63.9 (2.2)
% ground cover	% of ground in plot covered by ground layer foliage[b]	72.1 (2.7)
Slope	Slope (degrees) of plot (Abney level)	3.0 (0.8)
Distance to water	Distance (m) to nearest permanent water source (pacing or measured from aerial photographs)	494.5 (72.0)
Distance to edge	Distance (m) to nearest opening in woodland canopy (pacing or measured from aerial photographs)	23.9 (2.8)
Stand age	Determined from core samples on the two largest trees[c]	63.5 (5.1)
Habitat (%) within 1 km of nest site		
Woodland	Percent of landscape covered by trees	24.6 (2.2)
Cropland	Percent of landscape covered by annually-tilled cropland	13.5 (2.5)
Grassland	Percent of landscape covered by native mixed-grass prairie (grazed or idle), planted grassland, or perennial forage crop	49.9 (2.4)
Wetland	Percent of landscape covered by riparian wet meadow or potholes	4.5 (1.3)
Open Water	Percent of landscape covered by rivers, lakes, or impoundments	5.7 (1.5)
Urban/other	Percent of landscape covered by cities, roads, etc.	2.0 (0.9)

[a] Ocular estimate.
[b] Forty ocular tube readings (James and Shugart 1970).
[c] Measured at 14 nest sites.

the woodland edge), on transects that bisected (linearly) the woodlands. We chose the nearest tree on a random compass bearing from the plot center to compare to nest trees. In sandhill woodlands at J. Clark Salyer NWR, we paced a random distance (up to 40 m) and direction in the field from random x-y coordinates identified on aerial photographs (1992, 1:7920), then selected the nearest tree along a random compass bearing as the center of the random plot (modified from Titus and Mosher [1981]). We determined percentage area of woodland, grassland, cropland, wetland, open water on rivers, and urban/other land use within 1 km (314 ha) of each nest and random plot using aerial photographs (1:21120, 1:7920) and an electronic planimeter or a dot grid.

We used standard statistical software (Hintze 1995) to conduct our data analyses. We grouped variables into subsets that characterized similar features, and conducted a multivariate analysis of variance (MANOVA) on each of these subsets. Variables characterizing the nest or center tree (tree height and DBH) comprised one subset, and variables characterizing the nest or plot stand (canopy height, stand DBH, tree density, and percent canopy cover) comprised the second subset (Tables 2 and 3) Using these subsets and the remaining variables, we made seven (six at J. Clark Salyer NWR) simultaneous comparisons between nest sites and random plots for each intensive search area. To maintain an experimentwise alpha of 0.10, we applied a Bonferroni correction (Sokal and Rohlf 1995); thus an alpha of 0.0143 was used for these simultaneous comparisons. When differences were detected, we compared individual variables with 2-tailed *t*-tests, or if data were non-normal, we used nonparametric rank tests (Mann-Whitney *U*-test) or unequal variance tests (Aspin-Welch [Hintze 1995]). Variables that did not logically fit into subsets (e.g., slope) were compared using 2-tailed *t*-tests. We used Chi-square goodness-of-fit tests to compare species composition of nest

Table 2. Mean (SE) values of habitat characteristics at Cooper's Hawk nest sites ($N = 11$) and random plots ($N = 32$) at Des Lacs National Wildlife Refuge, North Dakota, 1994–95.

HABITAT CHARACTERISTIC	NEST SITES	RANDOM PLOTS	P[a]	P[b]
Nest tree or center tree				
Height (m)	12.4 (0.8)	8.6 (0.6)	0.002	<0.001*
DBH (cm)	22.1 (1.6)	17.3 (1.7)		0.004
Nest site or random plot				
Canopy height	12.4 (0.6)	11.4 (0.6)	0.090	0.247
Stand DBH	15.0 (0.4)	15.4 (0.6)		0.821
Tree density (no./ha)	1054.5 (99.9)	755.5 (49.8)		0.017
% canopy cover	64.5 (4.1)	58.3 (3.1)		0.233
Shrub density (stems/ha)	1120.5 (224.9)	2010.2 (226.1)	0.009	
Slope (degrees)	7.0 (2.3)	12.6 (0.9)	0.043	
Distance to water (m)	422.9 (167.9)	302.4 (73.8)	0.358	
Distance to edge (m)	22.2 (4.7)	22.0 (3.1)	0.979	
Stand age (years)	59.9 (4.7)	72.6 (3.2)	0.041	

[a] P-value is for group MANOVA or t-test (rows that share a common P-value comprise a MANOVA group); experiment-wise alpha = 0 10.

[b] P-value is for Aspin-Welch Unequal-Variance t-test, except * denotes Mann-Whitney U-test.

trees used to that available based on center trees of 0.04-ha random plots.

RESULTS

We measured 48 Cooper's Hawk nests found during 1994–96. Cooper's Hawks tended to nest in woodland sites with dense canopies and high tree densities (Table 1). Canopy cover directly over individual nests was also high, with the exception of a nest in an aspen snag. Although shrubs were common at most nest sites (Table 1), shrub stem densities were highly variable, ranging from almost none in grazed woodlands to 4125 shrub stems/ha at one sandhill woodland site. Most nests (78%) were on slopes <5°, even though steeper wooded slopes (5–25°) were typical of coulee and some sandhill woodlands. Cooper's Hawks nested consistently close to woodland edge (Table 1). Distance to water, however, was more variable, ranging from 34–2000 m. Mean stand age (determined at three floodplain and 11 coulee nest sites) was 64 yr (Table 1), but nests occurred in stands as young as 35 yr.

Cooper's Hawks typically placed their nests within the lower part of the tree canopy, at slightly more than two-

Table 3. Mean (SE) values of habitat characteristics at Cooper's Hawk nest sites ($N = 18$) and random plots ($N = 40$) in sandhill woodlands at J. Clark Salyer National Wildlife Refuge, North Dakota, 1996.

HABITAT CHARACTERISTIC	NEST SITES	RANDOM PLOTS	P[a]	P[b]
Nest tree or center tree				
Height (m)	12.7 (0.4)	9.8 (0.4)	<0.001	<0.001
DBH (cm)	23.8 (1.4)	17.5 (1.1)		<0.001
Nest site or random plot				
Canopy height	12.7 (0.4)	10.7 (0.4)	0.012	<0.001
Stand DBH	15.9 (0.6)	15.5 (0.7)		0.387*
Tree density (no./ha)	1277.8 (112.0)	1042.5 (60.2)		0.076
% canopy cover	54.2 (3.0)	50.6 (2.2)		0.351
Shrub density (stems/ha)	2265.3 (230.0)	2510.3 (183.9)	0.410	
Slope (degrees)	1.0 (0.7)	5.1 (0.9)	<0.001*	
Distance to water (m)	677.7 (89.0)	665.3 (61.3)	0.909	
Distance to edge (m)	25.2 (6.3)	16.3 (2.2)	0.073	

P-value is for group MANOVA or t-test (rows that share a common P-value comprise a MANOVA group); experiment-wise alpha = 0 10.

[b] P-value is for Aspin-Welch Unequal-Variance t-test, except * denotes Mann-Whitney U-test.

thirds of tree height (Table 1). Heights of nest trees and surrounding trees were similar ($t_{94} = 0.23$, $P = 0.822$), but nest tree DBH was larger than stand DBH ($t_{94} = 9.78$, $P < 0.001$). Nests were primarily in green ash (46%) or quaking aspen (31%); one (2%) was in an aspen snag, and remaining nests (21%) were in five other tree species.

Grassland, woodland, and cropland comprised most land cover within 1 km of Cooper's Hawk nests (Table 1). Wetlands, open water, and urban lands generally comprised a small portion of land cover around nests (means <6%), but were major components of land cover (31–44%) surrounding a few nests.

At Des Lacs NWR, nest trees were taller and larger than those available (Table 2). Nest sites had lower shrub density than random plots. Cooper's Hawks also appeared to select sites with less slope than that available. Two-thirds of the nests at Des Lacs NWR were on slopes ≤10°, compared to only one-third of the random plots. Nest tree species were used in proportion to their availability ($\chi^2_3 = 1.66$, $P > 0.50$). Other variables were similar between nest sites and random plots at Des Lacs NWR.

At J. Clark Salyer NWR, nest trees again were taller and larger than expected based on random sampling (Table 3). Canopy height was greater, and slope was less at nest sites than at random plots. Tree species were used for nesting in proportion to their availability ($\chi^2_3 = 1.94$, $P > 0.50$).

DISCUSSION

Cooper's Hawks breeding in North Dakota selected nest sites with less canopy cover and with shorter nest trees of lesser DBH compared to most other regions (Table 4). These differences may be due, in part, to structurally-inherent contrasts between woodlands in North Dakota when compared to other regions. Most woodlands in the northern Great Plains are relatively young (<100 yr), and the cool, subhumid continental climate (Stewart 1975:3) may slow tree growth. Although nest trees in this study were smaller than in other regions, Cooper's Hawks still placed their nests at about two-thirds of the nest tree height.

Cooper's Hawks nested in areas with a surprisingly small amount of woodland cover (as little as 1.0% within 1 km of nest), although most nested in areas with ≥10% woodland cover. Cooper's Hawks have also nested in an area in northwestern North Dakota where woodland may comprise only 2% of the landscape (Peterson and Murphy 1992).

We observed two parallel patterns of Cooper's Hawk nest-site use on our two intensive search areas; typically, sites with the greatest tree density and with little or no slope were used. Other authors (Reynolds et al. 1982, Bosakowski et al. 1992) have noted that most Cooper's Hawks nest in relatively flat terrain. Steeper slopes in our study area tend to have shorter trees due to drier and more poorly-developed soils. Trees on slopes also have relatively more exposed canopies than those on level ground.

Table 4. Reported Cooper's Hawk nest site characteristics (means) for North America.

	Nest Tree Characteristics					Nest Site Characteristics				
Study Area	Nest Height (m)	Tree Height (m)	Percent Nest Height[a]	DBH (cm)	N	Basal Area (m^2/ha)	Percent Canopy Cover	Dist. to Edge (m)	N	Source
North Dakota	9.2	13.2	69.7	24.7	48	25.9	63.9	23.9	48	This study
North Dakota	6.2	9.5	65.4	20.0	13	—[b]	—	15	13	Murphy 1993
New York-New Jersey	16.7	25.0	67.3	44.0	21	30.9	88.9	120	21	Bosakowski et al. 1992
Maryland	15.4	—	67.5	44.5	6	24.3	76.0	129	6	Titus and Mosher 1981
Wisconsin	13.1	19.1	69.8	32.6	52	31.6	84.9	58	52	Trexel et al. 1999
NE Oregon	12.1	—	—	43.7	31	39.9	—	—	31	Moore and Henny 1983
NW Oregon	15.2	22.3	—	33.2	18	30.7	75.0	—	4	Reynolds et al. 1982
E Oregon	14.0	22.6	—	39.6	15	41.3	64.0	—	5	Reynolds et al. 1982
New Mexico	16.1	24.1	—	52.1	12	17.0	—	—	12	Kennedy 1988
Arizona	15.2	22.1	69.0	79.0	52	15.0	64.8	—	49	Boal and Mannan 1998
Utah	7.1	12.2	—	17.6	17	—	83.1	—	17	Fischer 1986
Arkansas	16.9	21.4	—	31.2	12	—	71.3	51.1	12	Garner 1999

[a] Percent nest height = (nest height/nest tree height) × 100

[b] Data unavailable

Distance to woodland edge was similar among nests and between nest sites and random plots on both intensive search areas, but was far less than reported elsewhere in North America (Table 4). Cooper's Hawk habitat in our study was relatively edge-dominated, with floodplain and coulee woodlands consisting of narrow, linear belts of timber and sandhill woodlands composed of timber interspersed within a grassland matrix. Despite these constraints of woodland configurations, North Dakota Cooper's Hawks placed nests near the center of woodlands, relatively "far" from edges. Distances from nests to water were extremely variable. Reynolds et al. (1982) and Boal and Mannan (1998) suggested that a nearby water source is important to nesting Cooper's Hawks in arid western and southwestern North America. However, our data and results from other studies (Titus and Mosher 1981, Bosakowski et al. 1992, Trexel et al. 1999) indicate that nesting near a permanent water source is not required in more temperate areas.

Our data, combined with those from other studies, indicate that nesting Cooper's Hawks exploit a wide array of woodland habitats across their range, including suburban and urban areas (Rosenfield et al. 1995, Boal and Mannan 1998), pine plantations (Wiggers and Kritz 1991, Rosenfield et al. 2000), and deciduous and coniferous forest (Titus and Mosher 1981, Reynolds et al. 1982, Bosakowski et al. 1992, Trexel et al. 1999). In our study area, Cooper's Hawks used natural woodlands, planted shelterbelts (R. Murphy unpubl. data), and even tall shrubs (Sondreal and Murphy 1998). In the northern Great Plains, such flexibility apparently has allowed Cooper's Hawks to exploit nesting habitat only recently available, and to become perhaps the most abundant breeding raptor in the region's sparsely distributed woodlands (Nenneman et al. 2002).

RESUMEN.—El gavilán de Cooper (*Accipiter cooperii*) ha sido poco estudiado como una especie que se reproduce en las Grandes Planicies, debido a esto, los responsables del manejo de los recursos en la región deben referirse a descripciones cuantitativas de otras partes de Norteamérica para identificar los hábitats probables de anidación. Durante 1994–96 se midieron las características del hábitat en 48 sitios de anidación del gavilán de Cooper, en una variedad de tipos de bosque en el centro-norte de Dakota del Norte. Los nidos se construyeron principalmente en arboles de *Fraxinus pennsylvanica,* 46% y de *Populus tremuloides,* 31%, en sitios de alta densidad de los mismos (0 = 1156 árboles/ah) y con una pendiente pequeña (0 = 3.0°). El gavilán de Cooper utilizó los sitios con menos cobertura de dosel (0 = 64%) y que estuvieran más cerca a los bordes de bosque (0 = 24 m) que lo previamente reportado. Comparado con los hábitats disponibles del bosque, el gavilán de Cooper anidó en bosques con menos pendiente y ubicó los nidos entre los árboles más grandes y altos. Los gavilanes de Cooper en periodo de anidación utilizaron los bosques con los atributos estructurales que fueran relativos a otras regiones. Al igual que con los hallazgos recientes en otros hábitats, los datos apoyan la idea que el gavilán de Cooper explota una amplia serie de hábitats de bosque para su anidación.

[Traducción de César Márquez]

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DYNAMICS AND TEMPORAL VARIATION IN AGE STRUCTURE AT A COMMUNAL ROOST OF EGYPTIAN VULTURES (*NEOPHRON PERCNOPTERUS*) IN NORTHEASTERN SPAIN

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The Egyptian Vulture (*Neophron percnopterus*) is a small vulture that occasionally gathers in communal roosts (Ceballos and Donázar 1990, Donázar et al. 1996). The existence of such roosts seems to be linked to abundant and regular food sources and also to the species' gregarious behavior under such conditions (Donázar 1993, Donázar et al. 1996). In small cathartid vultures, Rabenold (1983) has suggested that this behavior would be an adaptation in order to increase an individual's foraging efficiency on dispersed and unpredictable food supplies.

The Spanish population of Egyptian Vultures represents 80% of the total in the European Union, and has undergone a significant decline in recent years (Del Moral and Marti 2002). Communal roosts are thus important in terms of conservation, particularly bearing in mind that a large fraction of the preadult population concentrates in them (Donázar et al. 1996). The underlying causes leading to the formation and disappearance

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