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## BREEDING DISTRIBUTION AND NEST-SITE HABITAT OF NORTHERN GOSHAWKS IN WISCONSIN

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**ABSTRACT.**—We found Northern Goshawks (*Accipiter gentilis*) nesting widely throughout the northern two-thirds of Wisconsin during 1996–97, with no evidence of range contraction as might be expected as one index of changing status if the state's breeding population were declining. During 1977–97, habitat was sampled on 0.04 ha circular plots at 37 goshawk nests, of which 78% were in deciduous trees, especially trembling aspen (*Populus tremuloides*). Mean nest-tree height, mean nest-tree diameter-at-breast-height (dbh), and mean tree density were 25 m, 41 cm, and 423 stems/ha, respectively. A comparison of these and 20 other habitat features at nest sites found by unbiased vs. potentially-biased methods failed to detect statistically significant differences between these two data sets. Goshawks nested in a broad array of forest types, including pine plantations and forest fragments in agriculturally-dominated landscapes.

**KEY WORDS:** *Northern Goshawk; Accipiter gentilis; nesting distribution; breeding range; nest-site habitat.*

### Distribucion del habitat de anidación de *Accipiter gentilis* en Wisconsin

**RESUMEN.**—Encontramos a *Accipiter gentilis* anidando a través de los dos tercios del norte de Wisconsin durante 1996–97, sin evidencias de que su rango de distribución disminuya como se podría esperar de su declinación en su población reproductiva. Durante 1977–97, se hicieron muestras de habitat en parcelas circulares de 0.04 ha en 37 nidos de azor de los cuales 78% se encontraban en árboles caducifolios (*Populus tremuloides*). La media de altura, la media de diámetro a la altura del pecho y la media de la densidad de los árboles fue de 25m, 41 cm y 423 troncos/ha respectivamente. Una comparación de estas y otras 20 características de habitat en los sitios de los nidos encontrados entre métodos sin sesgos y potencialmente sesgados no reportó diferencias estadísticamente significativas entre estos dos grupos de datos. Los azores anidaron en una amplia variedad de tipos de bosques incluyendo plantaciones de pinos y fragmentos de bosques en paisajes agrícolas.

[Traducción de César Márquez]

There is concern that populations of the Northern Goshawk (*Accipiter gentilis*, hereafter goshawk) may be declining in North America because of human-induced habitat alterations (Braun et al. 1996, Kennedy 1997, Squires and Reynolds 1997). There is a consequent need for baseline information on key population attributes that may, or may not, yield evidence of population declines (Block et al. 1994). Kennedy (1997) investigated the possibility of goshawk population declines in North America, in part through a literature review of its breeding distribution for evidence of range contractions. Because the bulk of studies she examined were geographically limited, she was unable to provide information from mid-continental regions. Moreover, the majority of studies on nest-site habitat in North America have focused on goshawks in the western U.S., where most investigations have used biased searching techniques to locate nests (Squires and Reynolds 1997). Apfelbaum and Seelbach (1983) have reported nest tree species at 22 goshawk nests in the midwestern U.S., but their tally included Pennsylvania as a supposedly mid-western state and did not associate nest-tree data with specific locales at state or sub-state levels. As with distributional data mentioned above, published information on nest-site habitat for the goshawk in mid-continental North America thus remains very limited.

Here, we show that the goshawk currently (1996–97) has a wide breeding distribution in Wisconsin with no sign of range contraction and describe nest-site habitat for 37 nests sampled from 1977–97, including a comparison of habitat features at goshawk nests found by unbiased vs. potentially biased methods.

#### STUDY AREA AND METHODS

We found goshawk nests in Wisconsin from 1996–97 by using three methods. First, we searched four quadrats, each about 3885 ha in size, that were objectively established (i.e., without past or present knowledge of forest seral stages or use of these sites by goshawks) within predominately wooded habitats in the northern third of Wisconsin. Second, we searched historic goshawk nesting areas and, third, we obtained nest-site information from nonproject personnel including staff of the Wisconsin Department of Natural Resources (WDNR) and other agencies, falconers, and others.

Nest-site habitat data were collected in 0.04 ha circular plots (11.3 m radius) centered on the nest tree, using procedures described by James and Shugart (1970) as modified by Titus and Mosher (1981). We sampled habitat at four occupied nests (i.e., eggs laid), one in each of the four quadrats during 1996–97, and at 33 occupied

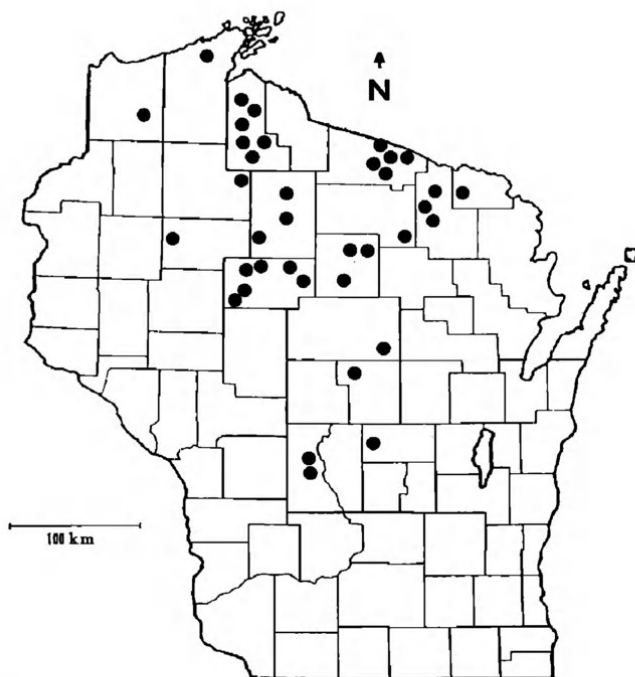


Figure 1. The distribution of Northern Goshawk nests (1977–97) in Wisconsin at which nest-site habitat data were collected.

nests elsewhere in Wisconsin during 1977–97 (Fig. 1). Of these 37 geographically separate goshawk nest sites, 23 (62%) were sampled in the year of breeding, while four and seven other nest sites were sampled one or two years, respectively, following nesting. Habitat at three nest sites unaltered by logging or other human activities was sampled five to seven years after discovery of nests. Table 1 describes vegetation and physical measurements obtained at each nest site.

In addition, we arbitrarily divided the nest-site habitat sample into those nests that we regarded as found by unbiased means ( $N = 21$ ) and those found by potentially biased means ( $N = 16$ ). We compared values of habitat features in these two categories on the premise that nests found by potentially biased searching techniques may not be representative of nest-site habitats used by goshawks (Siders and Kennedy 1996, Squires and Reynolds 1997). Nests found by unbiased means were characterized as those found on the quadrats ( $N = 4$ ) or detected during activities other than searching for goshawks, such as songbird inventories, botanical surveys, recreational hiking, and other incidental discoveries, excluding cruising forests for timber ( $N = 17$ ). Nests were classified as being found by potentially biased methods when searches for goshawk nests were conducted in habitat presumed suitable for nesting, such as mature, late seral northern hardwood-conifer forests in Wisconsin ( $N = 9$ ) or when nests were found during timber cruising ( $N = 7$ ), an activity that may not equally represent all potential nesting habitats (Hayward and Escano 1989). The majority of habitat variables did not exhibit normal distributions in Lilliefors Tests so nonparametric Mann-Whitney  $U$  tests were used to assess the potential significance of differences between

Table 1. Vegetational and physical features measured at Northern Goshawk nest sites in Wisconsin.

FEATURE	DESCRIPTION
Dist. to Water	Distance to nearest permanent water source (pacing or USGS 7.5' quadrangle)
Dist. to Opening	Distance to nearest forest opening ≥5 ha in size (pacing or USGS 7.5' quadrangle)
Nest Tree Height	Height of nest tree (Haga altimeter)
Nest Tree dbh	Diameter at breast height of nest tree
Nest Height	Height of nest (meter tape or Haga altimeter)
Nest Percent Degree Slope	(Nest height/Tree height) (100)
Tall Shrub Index	Index of tall shrubs <3 cm dbh and ≥shoulder height <sup>a</sup>
Low Shrub Index	Index of low shrubs <3 cm dbh between knee and shoulder height <sup>a</sup>
Under. Density	Number of understory trees ≥9 cm dbh per ha
Canopy Height	Mean height of five canopy trees in study plot (Haga altimeter)
Total Canopy	Percent of area over study plot occluded by overstory foliage <sup>b</sup>
Decid. Canopy	Percent of area over plot (not of total canopy) occluded by deciduous overstory foliage <sup>b</sup>
Conif. Canopy	Percent of area over plot occluded by evergreen overstory foliage <sup>b</sup>
Total Understory	Percent of area over plot occluded by understory foliage <sup>b</sup>
Decid. Understory	Percent of area over plot occluded by deciduous understory foliage <sup>b</sup>
Conif. Understory	Percent of area over plot occluded by coniferous understory foliage <sup>b</sup>
Total Ground	Percent of ground in plot covered by ground-layer foliage <sup>b</sup>
Decid. Ground	Percent of ground in plot covered by ground-layer deciduous foliage <sup>b</sup>
Conif. Ground	Percent of ground in plot covered by ground-layer coniferous foliage <sup>b</sup>
Tree Density	Number of canopy trees ≥9 cm dbh per ha
Basal Area	Basal area in m <sup>2</sup> /ha of canopy trees
Mean dbh	Mean dbh of canopy trees in study plot

<sup>a</sup> Sum of stems on 4 plot radii.  
<sup>b</sup> 40 ocular tube readings.

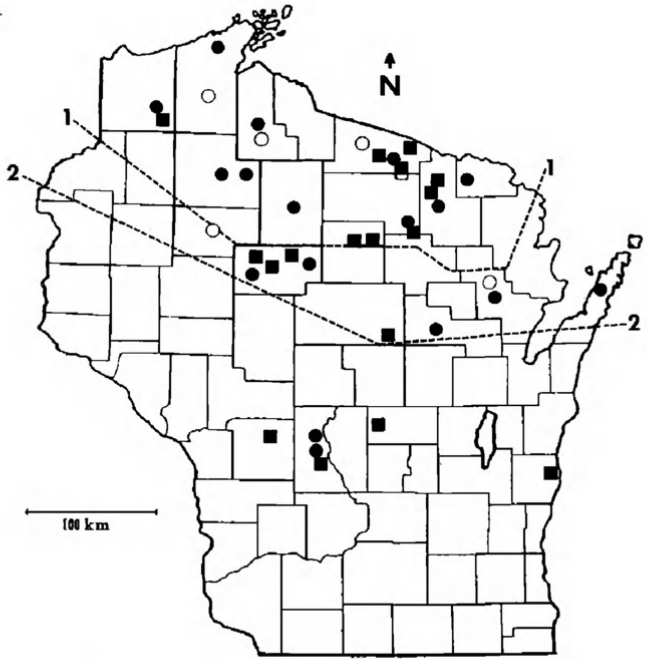


Figure 2. Known past and present distributions and 1996–97 nest-site locations of the Northern Goshawk in Wisconsin. 1 = resident range (Gromme 1963); 2 = resident range (Robbins 1991). Unshaded circles = counties with nests before 1958; shaded circles = 1996 nest locations; squares = 1997 nest locations.

these two nest-site categories. Because of the number of multiple univariate comparisons, we calculated that an alpha of 0.002 was the appropriate level of significance for statistical inference (Sokal and Rohlf 1981). Statistical analyses were performed on SYSTAT (Wilkinson 1992)

RESULTS AND DISCUSSION

In 1996–97, goshawk nests ( $N = 34$ ) were widely distributed in the northern two-thirds of Wisconsin (Fig. 2). The historic breeding distribution of the goshawk in Wisconsin in the mid-1800s, before timber harvests became pervasive in the northern part of the state, is unknown. The first known nests in the state were found in the 1890s (Robbins 1991). Through 1958, only about 12 nests had been documented, all in five northern counties. As late as 1964 (Scott 1964), the northern half of the state held only 15% of the in-state members of the Wisconsin Society for Ornithology. During the same time period, no goshawk nests were reported in the southern half of the state in counties that held the large majority of society members engaged in ornithological activity (Scott 1964). Gromme (1963) probably based his map of the resident range of the goshawk (Fig. 2) on the above nests plus summer sight records. Robbins (1991) pic-

tured a somewhat larger resident range for the goshawk. We interpret their maps of resident range as a presumed but perhaps imperfectly documented breeding range. Squires and Reynolds (1997) explicitly interpreted Robbins' map as breeding range in the state. Several additional sources portray a similar resident or breeding distribution in northern Wisconsin (Palmer 1988, Johnsgard 1990, Rosenfield et al. 1991).

The current nesting range of the goshawk in Wisconsin is much larger than previously indicated by maps of resident and breeding ranges. Therefore, there is no current evidence for a contraction of the goshawk's nesting range in the state, as might be expected as one index of changing status if the state's breeding population were declining (Kennedy 1997). S. Postupalsky (pers. comm.) has suggested that the 1996–97 nesting range may actually indicate that there has been an expansion in the breeding distribution, as has occurred in Michigan (Postupalsky 1991) and possibly other eastern states (Kennedy 1997).

The southern distributional limit mapped by Robbins (1991) corresponds approximately with the present limit of extensively forested lands in northern Wisconsin (Wisconsin Department of Natural Resources 1995). Many of the nests found in 1996–97 south of Robbins' line were located in woodlands in the predominately agricultural landscape that characterizes much of the southern half of the state.

We tallied the nest tree species used by goshawks at 37 nests in 1977–97, a sample including 25 nests from 1996–97 and 12 nests from prior years (Table 2). Of these nests, 29 (78%) were built in deciduous trees. Of these, 12 (41%) were in trembling aspens (*Populus tremuloides*). Goshawks nested in a broad array of other deciduous trees at  $\leq 17\%$  of the nest sites. Nest trees occurred in woodlands at both early (e.g., trembling aspen and white birch [*Betula papyrifera*]) and late seral stages (e.g., sugar maple [*A. saccharum*] and eastern hemlock [*Tsuga canadensis*]). Forest stands used for nesting included such varied habitats as pine plantations, upland maple (*Acer* spp.) and maple-oak (*Quercus* spp.) woodlands, black ash (*Fraxinus nigra*) swamps, and aspen monotypes, as well as forest fragments in southern Wisconsin. It is not surprising that the goshawk appears to use diverse woodland habitats for nesting in Wisconsin, given its wide breeding distribution over two-thirds of the state and the breadth of its nesting habitats throughout North

Table 2. Tree species used for nesting (%) by Northern Goshawks in Wisconsin, 1977–97.

TREE SPECIES	NO. NEST TREES (N = 37)
Trembling aspen ( <i>Populus tremuloides</i> )	12 (32)
Sugar maple ( <i>Acer saccharum</i> )	5 (14)
Yellow birch ( <i>Betula alleghaniensis</i> )	5 (14)
White pine ( <i>Pinus strobus</i> )	5 (14)
Eastern hemlock ( <i>Tsuga canadensis</i> )	3 (8)
Northern red oak ( <i>Quercus rubra</i> )	2 (5)
Black ash ( <i>Fraxinus nigra</i> )	2 (5)
Red maple ( <i>Acer rubrum</i> )	1 (3)
White birch ( <i>Betula papyrifera</i> )	1 (3)
Basswood ( <i>Tilia americana</i> )	1 (3)

America (Braun et al. 1996, Squires and Reynolds 1997). Elsewhere in the western Great Lakes region, trembling aspen was also used for nesting in a majority (10 of 14) of recent (1994–96) goshawk nest sites in Minnesota (Martell and Dick 1996). In Michigan, aspens (*P. grandidentata* and *P. tremuloides*) were again used more frequently than other tree species by breeding goshawks (S. Postupalsky pers. comm.).

Of the 37 goshawk sites sampled, four were in pine plantations. Nests were built in white pine (*Pinus strobus*,  $N = 3$ ) and a trembling aspen ( $N = 1$ ) within the plantation. These four plantation nests, all found by unbiased means, were located in northeasternmost ( $N = 1$ ) and southcentral ( $N = 3$ ) parts of the state. At least three of these four plantation nests fledged young. S. Postupalsky (pers. comm.) also reports that pine plantations have recently been used as nest sites by successfully breeding goshawks in Michigan. Squires and Reynolds' (1997) review of nest-site habitats used by goshawks in North America did not report pine plantations as occupied nesting habitat.

Our comparison of habitat features at goshawk nest sites found by unbiased vs. potentially biased means failed to detect statistically significant differences ( $P > 0.002$ ) between these two data sets for any of the 23 analyzed features with the sample sizes available (Table 3). The overall statistical similarity between habitat features at goshawk nests found by unbiased vs. potentially biased methods thus appeared to uphold the utility of a pooled sample as a descriptor of goshawk nest-site habitat in Wisconsin, a sample derived from a wide geo-



Table 3. Northern Goshawk habitat features at nests found by unbiased methods, potentially biased methods, and pooled methods. Data are reported as mean values  $\pm$  SE (95% confidence interval).  $P$  = exact probability value of test between unbiased vs. biased categories.

FEATURE	UNBIASED $N = 21$	BIASED $N = 16$	POOLED $N = 37$	$P$
Dist. to Water (m)	193.8 $\pm$ 43.3	241.1 $\pm$ 75.9 <sup>a</sup>	213.5 $\pm$ 40.0 <sup>b</sup> (132.3–294.7)	0.75
Dist. to Opening (m)	184.0 $\pm$ 43.0	133.5 $\pm$ 21.0 <sup>a</sup>	163.3 $\pm$ 26.6 <sup>b</sup> (109.3–217.1)	0.89
Nest Tree Height (m)	23.7 $\pm$ 0.6	25.7 $\pm$ 0.8	24.6 $\pm$ 0.5 (23.6–25.6)	0.05
Nest Tree dbh (cm)	35.7 $\pm$ 2.4	47.4 $\pm$ 3.3	40.8 $\pm$ 2.2 (36.4–45.2)	0.01
Nest Height (m)	14.1 $\pm$ 0.4	15.5 $\pm$ 0.6	14.7 $\pm$ 0.4 (14.0–15.4)	0.12
Nest Percent (%)	59.9 $\pm$ 1.8	60.3 $\pm$ 2.1	60.1 $\pm$ 1.3 (57.4–62.8)	0.85
Degree Slope (°)	6.2 $\pm$ 1.6	6.2 $\pm$ 1.6	6.2 $\pm$ 1.2 (3.9–8.6)	0.79
Tall Shrub Index	14.4 $\pm$ 4.1	33.4 $\pm$ 10.2	22.6 $\pm$ 5.1 (12.2–33.0)	0.21
Low Shrub Index	46.9 $\pm$ 8.1	49.6 $\pm$ 10.7	48.0 $\pm$ 6.4 (35.1–61.0)	0.84
Under. Density (trees/ha)	283.3 $\pm$ 42.7	268.8 $\pm$ 42.5	277.0 $\pm$ 30.0 (216.1–338.0)	0.78
Canopy Height (m)	23.9 $\pm$ 0.7	25.5 $\pm$ 0.7	24.6 $\pm$ 0.5 (23.6–25.6)	0.10
Total Canopy (%)	78.7 $\pm$ 4.4	85.5 $\pm$ 3.1	81.6 $\pm$ 2.9 (75.8–87.4)	0.20
Decid. Canopy (%)	61.5 $\pm$ 7.5	72.3 $\pm$ 7.7	66.2 $\pm$ 5.4 (55.3–77.1)	0.12
Conif. Canopy (%)	17.2 $\pm$ 6.5	13.1 $\pm$ 6.8	15.4 $\pm$ 4.7 (6.0–24.9)	1.00
Total Understory (%)	45.4 $\pm$ 6.0	48.1 $\pm$ 4.8	46.6 $\pm$ 3.9 (38.6–54.6)	0.74
Decid. Understory (%)	40.3 $\pm$ 6.2	43.1 $\pm$ 5.0	41.5 $\pm$ 4.1 (33.2–49.8)	0.65
Conif. Understory (%)	5.1 $\pm$ 3.3	5.0 $\pm$ 2.6	5.1 $\pm$ 2.1 (0.7–9.4)	0.94
Total Ground (%)	58.4 $\pm$ 4.3	43.9 $\pm$ 5.0	52.1 $\pm$ 3.4 (45.2–59.1)	0.03
Decid. Ground (%)	56.4 $\pm$ 4.3	42.0 $\pm$ 5.3	50.2 $\pm$ 3.5 (43.1–57.3)	0.04
Conif. Ground (%)	2.0 $\pm$ 1.1	1.9 $\pm$ 1.1	2.0 $\pm$ 0.8 (0.4–3.5)	0.75
Tree Density (trees/ha)	458.3 $\pm$ 63.4	376.6 $\pm$ 42.3	423.0 $\pm$ 40.4 (341.0–505.0)	0.69
Basal Area (m <sup>2</sup> /ha)	28.2 $\pm$ 3.7	33.0 $\pm$ 3.2	30.3 $\pm$ 2.5 (25.2–35.4)	0.16
Mean dbh (cm)	27.0 $\pm$ 1.4	32.9 $\pm$ 1.8	29.4 $\pm$ 1.2 (27.0–31.9)	0.03

<sup>a</sup>  $N = 15$  due to missing data.

<sup>b</sup>  $N = 36$  due to missing data.

graphic area of the state. For this pooled sample, mean nest-tree height was 25 m and mean nest-tree dbh was 41 cm (Table 3). Mean canopy height (25 m) was identical to mean nest-tree height, but mean tree dbh within 0.04-ha sample plots surrounding nest trees was substantially less than mean nest-tree dbh (29 vs. 41 cm). Mean canopy closure was 82%. Squires and Reynolds (1997) have suggested that such a high degree of canopy closure is one of the most uniform aspects of habitat at goshawk nest sites in North America.

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