

## NESTING HABITAT OF *ACCIPITER* HAWKS: IS BODY SIZE A CONSISTENT PREDICTOR OF NEST HABITAT CHARACTERISTICS?

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**Abstract.** In western coniferous forests a general correlation of accipiter size and structural size of nesting stands and nest trees used by sympatric *Accipiter* species has been reported. In this paper we review the literature to evaluate the following predictions: accipiter hawks consistently use nesting habitat in which their body size is (1) positively correlated with nest tree height, and average stand tree diameter, and (2) inversely correlated with average stand tree density and stand % canopy closure. We include in this review summary habitat data collected at 42 Northern Goshawk (*Accipiter gentilis*), 52 Cooper's Hawk (*A. cooperii*), and 16 Sharp-shinned Hawk (*A. striatus*) nest sites in the Jemez Mountains of north-central New Mexico. From our review of the literature, stand % canopy closure, and nest tree height did not consistently follow the expected pattern. Average stand tree density and average stand tree diameter consistently supported the body size predictions. However in several studies, stand densities of goshawk and Cooper's Hawk stands were not significantly different. In addition, there seems to be much variation between studies for mean values for all of the parameters, and the ranges of the mean values overlap among species. This is probably indicative of both habitat variation between study areas and differences in methodology. This review of accipiter habitat studies supports Kennedy's (1988) hypothesis that the correlation between accipiter size and nest stand and nest site structural size is not a widespread phenomenon for all vegetation parameters and may not be adequate for predicting suitable accipiter nesting habitat in all areas.

**Key Words:** *Accipiter cooperii*; *Accipiter gentilis*; *Accipiter striatus*; Cooper's Hawk; nesting habitat; Northern Goshawk; Sharp-shinned Hawk.

The three North American *Accipiter* species (Northern Goshawk [*A. gentilis*], Cooper's Hawk [*A. cooperii*] and Sharp-shinned Hawk [*A. striatus*]) are sympatric predators in many forested areas in North America (Palmer 1988:304–378, Reynolds 1989). In western coniferous forests Reynolds et al. (1982), Moore and Henny (1983) and Fischer (1986) reported a general correlation of accipiter size and tree size (used as an index of successional stage) of nesting stands and nest trees used by sympatric *Accipiter* species. Kennedy (1988) also observed this correlation for nest tree size and accipiter size in New Mexico. However, in the northeastern U.S., Bosakowski et al. (1992) found Cooper's Hawks nesting in trees with greater diameter than goshawks. In addition, Kennedy (1988) and Bosakowski et al. (1992) found no significant differences for basal area (BA), tree densities, or mean diameter at breast height (dbh) between goshawk and Cooper's Hawk nesting stands in their study areas.

There are two plausible explanations for these equivocal results: (1) a correlation between accipiter size and nest stand and nest tree sizes is not a widespread phenomenon; or (2) a strong correlation does exist but it cannot be detected because of small sample sizes (goshawk N = 11, Cooper's Hawk N = 12 [Kennedy 1988]; goshawk N = 16, Cooper's Hawk N = 19 [Bosakowski et al. 1992]). Our primary study objective is to review the literature to determine if accipiters consistently use nesting habitat in which

their body size is positively correlated with nest tree height and average stand tree diameter and inversely correlated with tree density and % canopy closure. We include in this review summary habitat data collected at 42 goshawk, 52 Cooper's Hawk, and 16 Sharp-shinned Hawk nest sites in north-central New Mexico during 1992 and 1993 (Siders and Kennedy, unpubl. data). These data were collected in the same area studied by Kennedy (1988), and thus allow us to determine if her results are maintained when sample sizes of goshawks and Cooper's Hawks are more than doubled and Sharp-shinned Hawk nest sites are included.

### APPROACH

In our literature review, we tried to include all published studies, M.S. theses, and Ph.D. dissertations on accipiter nesting habitat characteristics within the United States. We included habitat studies of single *Accipiter* species if the study was conducted in an area where the species was probably nesting sympatrically with congeners. To be included in this review, a study had to have data on one or more of the following parameters: average stand tree density, average stand tree diameter, average stand % canopy closure, and average nest tree height. Of these studies, coniferous forest habitat was the predominant forest cover type, with Bosakowski et al. (1992) and Joy (1990) as the only predominantly deciduous forest cover type for goshawk and Cooper's Hawk.

In reviewing the literature, we encountered various definitions of nest site and/or nest stand, indicating

TABLE 1. COMPARISON OF *Accipiter* NEST STAND TREE DENSITY (TREES/HA) AMONG U.S. STUDIES

Location	Northern Goshawk (N)	Cooper's Hawk (N)	Sharp-shinned Hawk (N)	Source
California, N	749.0 (12)			Saunders (1982)
California, NW	427.0 (10)			Hall (1984)
Missouri		1137.8 (33)	1370.0 (15)	Wiggers and Kritz (1991)
Montana-Idaho	1135.0 (17)			Hayward and Escano (1989)
New Mexico	959.3 (11)	723.9 (12)		Kennedy (1988)
New Mexico	1054.8 (42)	1129.0 (52)	1815.6 (16)	Siders and Kennedy (unpubl. data)
New York-New Jersey	540.1 (16)	633.4 (19)		Bosakowski et al. (1992)
Oregon, E	482.0 (7)	1159.0 (5)	1594.0 (5)	Reynolds et al. (1982)
Oregon, E	1007.4 (34)	1802.5 (31)	2312.0 (15)	Moore and Henny (1983)
Oregon, NW		656.0 (4)	1296.0 <sup>1</sup> (3)	Reynolds et al. (1982)
			652.0 <sup>2</sup> (2)	Reynolds et al. (1982) <sup>3</sup>
Utah	720.0 (10)	1900.0 (17)	4003.0 (9)	Fischer (1986)
Minimum	427.0	656.0	652.0	
Maximum	1135.0	1802.5	2312.3	

<sup>1</sup> Second growth stands.

<sup>2</sup> Old growth stands.

<sup>3</sup> Goshawk and Cooper's hawk nest stands were not separated into second growth and old growth.

differences in the usage of these terms. We defined a nest stand as the area surrounding a nest tree, including vegetation and topographic features used by a nesting pair during the entire nesting season, exclusive of foraging areas (Reynolds et al. 1982). We defined a nest site as the actual tree in which the nest was placed. In compiling the data from other studies, these definitions were used to avoid confusing nest site and nest stand level comparisons.

In addition to the literature, we included in this comparison unpublished data from our ongoing research on accipiter habitat in the Jemez Mountains and adjacent Pajarito Plateau in north-central New Mexico. In the 1992 and 1993 nesting seasons, we collected habitat data at all known goshawk (N = 42), Cooper's Hawk (N = 52) and Sharp-shinned Hawk (N = 16) nest stands that had not been drastically altered by timber harvest or other disturbance since the sites were identified as active. Each of these nest sites had been occupied (minimally, hawks observed constructing nests during courtship) at least once between 1984-1993.

To estimate the four vegetative parameters of interest, we established 0.08-ha (corrected for slope) circular plots around nest trees. On each plot we measured nest tree height and diameter at breast height (dbh) of all trees ( $\geq 2.54$  cm dbh) using standard forest measurement techniques (Wenger 1984). To determine % canopy closure, we divided the plot into four quadrants using the four cardinal directions for quadrant boundaries. We measured % canopy closure using a convex spherical densiometer (Lemmon 1956, 1957). Four canopy closure measurements were taken (facing NE, SE, SW, and NW) at each of five locations (center, and at one-half the radius of the plot to the NE, SE, SW, or NW) and averaged for each stand. We determined stand tree density by counting all trees ( $\geq 2.54$  cm dbh) within the 0.08-ha plot (converting this value to number of trees per ha).

In this comparison, we present mean values of nest tree height, stand tree density, stand tree diameter, and stand % canopy closure for each species in each study.

We compared these data qualitatively to determine if accipiters consistently use nesting habitat in which their body size is positively correlated with nest tree height and average stand tree diameter and inversely correlated with average stand tree density and stand % canopy closure. The database cannot be evaluated statistically because sampling techniques and plot sizes varied between studies.

## RESULTS AND DISCUSSION

Accipiter nest habitat studies in the U.S. indicate that there is a trend of increasing average stand tree density with increasing accipiter body size (Table 1). However, in three studies (Kennedy 1988, Bosakowski et al. 1992, Siders and Kennedy, unpubl. data) average stand densities for goshawk and Cooper's Hawk stands were not significantly different. It is also interesting to note that Kennedy's average stand densities are lower than the average stand densities we recorded. This is probably due to her small sample sizes and the inclusion of a few riparian cottonwood (*Populus fremontii*) nest stands, which typically have lower stand densities.

This potential effect of sample size on descriptions of accipiter nesting habitat characteristics is also evident in the two studies conducted in the same area in eastern Oregon (Reynolds et al. 1982, Moore and Henny 1983). Both of these studies appear to differentiate between goshawks and Cooper's Hawks by roughly a factor of two in stand density, and between Cooper's Hawks and Sharp-shinned Hawks by 25-30% differences in stand density. Yet, similar to the two New Mexico studies, stand densities for the study with larger sample sizes (Moore and Henny 1983) consistently report larger stand densities than the

TABLE 2. COMPARISON OF *Accipiter* NEST STAND AVERAGE CANOPY CLOSURE (%) AMONG U.S. STUDIES

Location	Northern Goshawk (N)	Cooper's Hawk (N)	Sharp-shinned Hawk (N)	Source
California, N	76.9 (12)			Saunders (1982)
California, NW	94.0 (10)			Hall (1984)
Colorado	95.0 (2)	95.0 (4)	94.0 (14)	Joy (1990)
Missouri		80.9 (31)	82.3 (14)	Wiggers and Kritz (1991)
New Mexico	65.7 (42)	61.6 (52)	77.5 (16)	Siders and Kennedy (unpubl. data)
New York–New Jersey	90.0 (16)	88.7 (19)		Bosakowski et al. (1992)
Oregon, E	59.8 (7)	64.0 (5)	68.3 (5)	Reynolds et al. (1982)
Oregon, NW		75.0 (4)	80.3 <sup>1</sup> (3)	Reynolds et al. (1982)
			89.7 <sup>2</sup> (2)	Reynolds et al. (1982) <sup>3</sup>
Utah	68.4 (10)	83.1 (17)	81.6 (9)	Fischer (1986)
Minimum	59.8	61.6	68.3	
Maximum	95.0	95.2	97.9	

<sup>1</sup> Second growth stands<sup>2</sup> Old growth stands<sup>3</sup> Goshawk and Cooper's hawk nest stands were not separated into second growth and old growth.

study with the smaller sample sizes (Reynolds et al. 1982).

The relationship between stand % canopy closure and accipiter body size is unclear (Table 2). For all three species, average % canopy closure varied from approximately 60% to 95% throughout the range of the studies. In some studies stand % canopy closure was inversely related to body size (Reynolds et al. 1982, Wiggers and Kritz 1991), but in other studies this was not the case. In the eastern U.S., Bosakowski et al. (1992) found goshawks and Cooper's Hawks nesting in stands with similar % canopy closures. In Colorado, Joy (1990) found that all three species were using stands with similar % canopy closures. In Utah, Fischer (1986) found Cooper's Hawks and Sharp-shinned Hawks using stands with similar % canopy closures but with higher % canopy closures than stands used by goshawks. In our study,

Cooper's Hawks used stands with more open canopies than did the goshawk which nested in more open stands than did Sharp-shinned Hawks. The values for goshawk and Sharp-shinned Hawk stands in our study are within the range of previously recorded averages for this variable, but the Cooper's Hawk value is the lowest reported stand % canopy closure.

The data on average stand tree diameter supports the prediction that this parameter is positively correlated with accipiter body size (Table 3). The range in stand tree diameters for goshawks was almost a factor of two greater than the reported ranges of its congeners. This is a result of Hall's (1984) study in northwestern California where she reported average stand diameters of 46.0 cm. In contrast, average stand tree diameters for the goshawk and Cooper's Hawk nest stands in our study are the lowest reported

TABLE 3. COMPARISON OF *Accipiter* NEST STAND AVERAGE TREE DIAMETER (DBH-CM) AMONG U.S. STUDIES

Location	Northern Goshawk (N)	Cooper's Hawk (N)	Sharp-shinned Hawk (N)	Source
California, N	27.0 (12)			Saunders (1982)
California, NW	46.0 (10)			Hall (1984)
Missouri		21.8 (33)	20.8 (15)	Wiggers and Kritz (1991)
New Mexico	22.0 (11)	20.0 (12)		Kennedy (1988)
New Mexico	14.8 (42)	13.5 (52)	12.5 (16)	Siders and Kennedy (unpubl. data)
Oregon, E	27.4 (7)	21.3 (5)	18.3 (5)	Reynolds et al. (1982)
Oregon, E	22.1 (34)	15.0 (31)	12.9 (15)	Moore and Henny (1983)
Oregon, NW		24.4 (4)	21.3 <sup>1</sup> (3)	Reynolds et al. (1982)
			27.4 <sup>2</sup> (2)	Reynolds et al. (1982) <sup>3</sup>
Utah	27.5 (10)	14.7 (17)	10.0 (9)	Fischer (1986)
Minimum	14.8	13.5	10.0	
Maximum	46.0	24.4	27.4	

<sup>1</sup> Second growth stands.<sup>2</sup> Old growth stands.<sup>3</sup> Goshawk and Cooper's hawk nest stands were not separated into second growth and old growth.

TABLE 4. COMPARISON OF *Accipiter* NEST SITE AVERAGE NEST TREE HEIGHT (M) AMONG U.S. STUDIES

Location	Northern Goshawk (N)	Cooper's Hawk (N)	Sharp-shinned Hawk (N)	Source
California, N	34.4 (13)			Saunders (1982)
California, NW	43.0 (12)			Hall (1984)
Colorado	26.0 (2)	23.0 (4)	19.0 (14)	Joy (1990)
Montana-Idaho	26.0 (17)			Hayward and Escano (1989)
New Mexico	25.9 (11)	24.1 (12)		Kennedy (1988)
New Mexico	28.6 (42)	20.8 (52)	15.9 (16)	Siders and Kennedy (unpubl. data)
New York-New Jersey	24.1 (16)	25.2 (19)		Bosakowski et al. (1992)
Oregon, E	33.5 (22)	22.6 (15)	11.0 (10)	Reynolds et al. (1982)
Oregon, NW		22.3 (18)	27.1 <sup>1</sup> (6)	Reynolds et al. (1982)
South Dakota	18.3 (21)			Bartelt (1974)
Utah	22.4 (10)	12.2 (17)	8.5 (9)	Fischer (1986)
Minimum	18.3	12.2	8.5	
Maximum	43.0	24.1	27.1	

<sup>1</sup> Second growth stands.

values. In addition, average stand diameter for the three species in our study area are not significantly different (Siders and Kennedy, unpubl. data). We cannot evaluate how much of these differences in nest stand parameters between our study and other studies can be attributed to differences in methodology and/or habitat variation.

Most of the studies that included nest tree height found that the taller nest trees were used by the larger species and the shorter nest trees were used by the smaller species (Reynolds et al. 1982 for eastern Oregon, Fischer 1986, Kennedy 1988, Joy 1990, Siders and Kennedy, unpubl. data), but not in all cases (Reynolds et al. 1982 for northwestern Oregon) (Table 4). Similar to stand tree diameters, mean nest tree heights were more variable for goshawks than their congeners.

The goshawk, Cooper's Hawk, and Sharp-shinned Hawk are morphologically similar species at three different sizes. Studies that compare habitat characteristics of all three *Accipiter* species are few, and some of these studies have indicated a relationship between the size of the species and the size of elements of its habitat. However, from our review of the literature, not all habitat characteristics follow this pattern for all studies. Stand % canopy closure did not follow the expected pattern in four studies. Stand density trends did follow the expected pattern in most studies; however, differences between goshawk and Cooper's Hawk stands were non-significant in three studies. Nest tree height did not follow the expected pattern in northwestern Oregon (Reynolds et al. 1982). Average stand tree diameter was the only parameter that consistently supported the prediction of increasing habitat scale with increasing body size. In addition, there seems to be much variation among

studies for mean values for all the parameters, and the ranges of the mean values overlap between species. This is probably indicative of both habitat variation among study areas and differences in methodology, particularly sample size. Our review of accipiter habitat studies supports Kennedy's (1988) hypothesis that the correlation between accipiter size and nest stand and nest site structural size is not a widespread phenomenon for all vegetation parameters and may not be adequate for predicting suitable accipiter nesting habitat in all areas.

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