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GOSHAWK NEST-SITE CHARACTERISTICS IN WESTERN MONTANA AND NORTHERN IDAHO[1]

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Descriptions of Northern Goshawk (*Accipiter gentilis*) nest sites are limited to Oregon (Moore 1980, Reynolds et al. 1982), California (Hall, unpubl.), South Dakota (Bartelt, unpubl. report), Colorado (Shuster 1980), Alaska (McGowan 1975), New York/New Jersey (Speiser and Bosakowski 1987), and West Germany (Dietzen 1978). In these studies, nesting habitat varied from conifer to deciduous forest and from even-aged to multi-storied stands. Within any region, however, the literature suggests goshawk nest-site selection is predictable and depends on available habitat and local climate. No one has examined nest-site characteristics in the northern Rocky Mountains. We surveyed goshawk nesting habitat in western Montana and northern Idaho to compare nest-site use with characteristics reported in the literature.

STUDY AREA

The geographic area considered in this report is restricted to western Montana and northern Idaho. This broad region encompasses a wide variety of climatic regimes and forest types on east and west sides of the Continental Divide, but can be divided into two zones based on the relative influence of maritime climate. The panhandle of Idaho and northwest Montana experience abundant rain and snowfall and moderate temperatures from maritime air masses, resulting in growth of large trees and many coastal plant species (e.g., *Thuja plicata, Tsuga heterophylla, Pinus monticola,* and *Larix occidentalis*) (Arno 1979). This area corresponds to Bailey's (1976) Cedar-Hemlock subdivision and Crowley's (1972) Columbian Rockies. Hereafter we will refer to this region as Columbian Highlands.

Our second region includes portions of Bailey's (1976) Douglas-fir and grama-needlegrass-wheatgrass subdivisions. Here, the colder, drier continental climate east of the Continental Divide, and substantially modified Pacific influence in west-central Montana and central Idaho, supports forest stands of smaller trees and poorly developed shrubs. We will refer to this heterogeneous region as the Rocky Mountain Forest.

METHODS

After interviewing biologists knowledgeable of goshawk nest sites, we visited a sample of accessible nest sites from both the Columbian Highlands and the Rocky Mountain Forest to collect specific data on habitat characteristics. Knowledge of nest-site locations varied between national forests, and restrictions on travel and time prevented a uniform dispersion of sample nest sites. Nest characteristics were measured in 1983.

Vegetation characteristics measured at each nest included tree density in four size classes (7.6–17.8 cm, 17.8–30.4 cm, 30.4–60.9 cm, >60.9 cm) from a 0.04-ha circular plot centered on the nest. We also measured basal area (using a relescope), canopy closure (from four samples using a forest densiometer), number of tree canopy layers, stand age, and shrub and ground cover. Aspect, slope, and topographic position were also recorded. The nest site was further characterized by describing the nest tree and nest placement, including tree species, nest height, tree height, diameter at breast height (dbh), bole height, presence/absence of a flight corridor to the nest, and presence/absence of a canopy opening at the nest. A flight corridor was defined as an unobstructed path at least 2 m diameter extending 5 m from the nest.

Other more general site characteristics were measured on maps or aerial photographs, estimated at the site, or from the U.S. Forest Service timber stand data base. Variables included distance to open water present in May or June, distance to an unforested opening larger than 1.2 ha, percent of unforested land within 3.7 km, and the number of forest openings larger than 2 ha within 3.7 km of the nest.

RESULTS

Typical goshawk nesting habitat within the western portion of our study area may be described as mature to overmature conifer forest with a closed canopy (75–85% cover) on a moderate slope (15–35%) facing north, at or near the bottom of the hillside. Nest sites often occupied one of the older stands in the area. Relatively large diameter trees and wide spacing of trees and foliage allowed flight beneath the upper canopy (Tables 1, 2). Water and a large forest opening were both generally within 0.5 km of the nest.

The typical nest was placed next to the bole of a live conifer in the lower one-third of the living crown. Nest height therefore varied with tree height but typically

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TABLE 1. Nest-stand characteristics of 17 Northern Goshawk nests from two climatic regions of western Montana and northern Idaho, 1983.

Variable	$\bar{x}$ (±95% bound)	CV (%)	Range
	Rocky Mountain Forest (n = 9)		
Tree density (0.04-ha plot)			
7.6–17.8 cm dbh	29.0 (±12.91)	58	6–60
17.8–30.4 cm dbh	18.0 (±6.25)	46	1–29
30.4–60.9 cm dbh	4.4 (±2.50)	74	1–10
>60.9 cm dbh	0.3 (±0.53)	212	0–2
Total	52.5 (±15.42)	39	23–92
Canopy cover (%)	78 (±5.69)	10	65–90
Basal area (m^2/ha)	40.9 (±6.00)	17	29.4–48.9
	Columbian Highlands (n = 8)		
Tree density (0.04-ha plot)			
7.6–17.8 cm dbh	19.0 (±15.03)	97	9–64
17.8–30.4 cm dbh	10.6 (±4.06)	47	3–16
30.4–60.9 cm dbh	7.0 (±2.58)	45	1–11
>60.9 cm dbh	0.8 (±0.72)	118	0–2
Total	37.4 (±13.31)	44	21–75
Canopy cover (%)	80 (±3.62)	5	75–87
Basal area (m^2/ha)	40.4 (±6.57)	20	29.3–53.8
	Combined (n = 17)		
Tree density (0.04-ha plot)			
7.6–17.8 cm dbh	24.6 (±9.23)	73	6–64
17.8–30.4 cm dbh	14.5 (±3.95)	53	1–29
30.4–60.9 cm dbh	5.7 (±1.75)	60	1–11
>60.9 cm dbh	0.6 (±0.41)	135	0–2
Total	45.4 (±10.06)	43	21–92
Canopy cover (%)	80 (±2.71)	7	65–90
Basal area (m^2/ha)	40.6 (±3.75)	18	29.3–53.8

was 12.5 m high in a 25 m tall tree with an obvious clear flight corridor leading to the nest (Table 3). The nest tree had an open canopy structure to allow nest access and a whorl of large (3–8 cm diameter) branches supporting the nest.

Goshawk nesting habitat varied largely due to changes in available habitat. Marked differences in nest sites appeared between those in the wet Columbian Highland region and those in the drier Rocky Mountain Forest. Forest stand structure in the Rocky Mountain Forest was limited to relatively small diameter, predominantly even-aged timber with little shrub development. Here nest sites all occupied even-aged stands in contrast to the predominantly multi-storied stands characteristic of the Columbian Highland. Density of trees 17.8–30.4 cm diameter were significantly ($P < 0.05$, t-test) higher in the Rocky Mountain Forest as more trees were needed to create the developed overstory canopy which was the recurrent feature at all nest sites (Table 1). Shrub development varied widely across the Columbian Highland nest sites.

Choice of nest tree characteristics also varied considerably (Table 3); nest trees on the Rocky Mountain Forest were consistently smaller in diameter and shorter than Columbian Highland nests due to the absence of large trees. In the Rocky Mountain Forest the largest trees were often wolf-trees growing in open situations which lacked the closed canopy and stand structure which goshawks appeared to prefer elsewhere.

Despite the varied habitat used by goshawks for nesting, several forest characteristics were constant. These consistent habitat features have also been recognized

TABLE 2. Stand characteristics at 17 Northern Goshawk nests located in two climatic regions of western Montana and northern Idaho, 1983.

Columbian Highlands		Rocky Mountain Forest	
Variable	Frequency (%)	Variable	Frequency (%)
No. canopy layers		No. canopy layers	
1	50	1	67
2	25	2	22
3	25	3	11
Stand age		Stand age	
Sawtimber[1]	12	Sawtimber	11
Mature[2]	38	Mature	89
Old forest[3]	50	Old forest	0

[1] Dominant trees less than 23 cm dbh.
[2] Dominant trees greater than 35 cm but less than 50 cm dbh.
[3] Dominant trees greater than 50 cm dbh.

TABLE 3. Nest-tree characteristics at 17 Northern Goshawk nests located in two climatic regions of western Montana and northern Idaho, 1983.

Variable	$\bar{x}$ (±95% bound)	CV (%)	Range
Rocky Mountain Forest (n = 9)			
Nest-tree height (m)	22 (±4.96)	28	12–32
Nest height (m)	10 (±1.75)	21	7–14
Nest-tree dbh (cm)	42 (±14.31)	42	25–79
Columbian Highlands (n = 8)			
Nest-tree height (m)	31 (±8.73)	30	23–48
Nest height (m)	14 (±1.83)	14	12–17
Nest-tree dbh (cm)	58 (±18.93)	37	25–97
Combined (n = 17)			
Nest-tree height (m)	26 (±4.41)	33	12–48
Nest height (m)	12.5 (±1.46)	23	7–17
Nest-tree dbh (cm)	50 (±10.57)	41	25–97

in other studies. Canopy closure was by far the most uniform habitat characteristic with a coefficient of variation (CV) of 7%. Basal area at goshawk nest sites was also consistent (CV = 18%). The range of values (29–54 m^2/ha) indicated goshawks will nest in a variety of situations, but 60% of the nest sites had basal areas between 39 and 46 m^2/ha. Finally, we found a large forest opening within 1 km of all goshawk nests and within 0.5 km of half the nests.

Goshawks appeared to use nest sites with specific topographic characteristics. A site with an aspect in the southern 180° was used only once, and then in a moist habitat under an old cedar forest. Over 40% of the nest sites occupied northern aspects between 315° and 45°. Goshawk nests were consistently located on the lower one-third or bottom of slopes with gentle to moderate inclines. Eighteen percent of nest sites occupied midslopes, 12% were on the upper one-third of the slope, 29% on the lower one-third, and 41% on the toe or bottom. The slope at nest sites never exceeded 50% and few nests were on level ground. Frequency of nest sites in slope gradient classes were: 6% on slopes of 0–10 percent, 24% on slopes of 11–20 percent, 24% on slopes of 21–30 percent, 35% on slopes of 31–40 percent and 12% on slopes over 40 percent.

Mature and older forests appear to most commonly achieve the proper stand structure for goshawk nest sites. Sixty-five percent of the nest sites were classified as mature and 24% as old forest (Table 1). Of 11 U.S. Forest Service biologists that we interviewed all classified goshawk nest sites in their forest as mature to overmature or oldgrowth.

Nesting trees must provide suitable support for a large nest and allow access to and from the nest. Nest trees were generally dominant or codominant, although often not the largest tree in the stand. A substantial flight corridor to the nest was visible in 96% of nests, and an opening in the canopy adjacent to the nest tree occurred for 76% of the nests. Goshawks built nests at or below the nest-tree crown in 70% of the cases. Only 12% of the nests were placed above the lower one-third of the crown.

DISCUSSION

Our survey of goshawk nesting habitat in western Montana and northern Idaho quantified habitat characteristics in forest stands chosen by goshawks for nest sites. The design of the survey was not intended to test for habitat selection. Our results were similar to those reported by other researchers. Mean canopy closure for our study (80% ± 3%) did not differ significantly from results of Reynolds et al. (1982) for seven nests in Oregon, and of Hall (unpubl.) for nine nests in California ($P > 0.05$, test of binomial proportions). In northeastern Utah, Hennessy (1978) measured less canopy coverage (63% ± 6%) than ours, but in northeastern Oregon, Moore (1980) found slightly greater canopy cover (88% ± 3%) (95% confidence intervals for all cases). Basal area of coniferous nest sites in Colorado did not differ significantly ($P > 0.05$) from those in our region (Shuster 1980), but in California (Hall, unpubl.) and northeastern Oregon (Moore 1980) significantly ($P < 0.05$) greater basal areas were recorded. Hennessy (1978), Anderson (1979), Hall (unpubl.), Reynolds et al. (1982), and Speiser and Bosakowski (1987) all indicate mature to overmature forest stands are preferred for nesting by goshawks. North, or northern to eastern exposures were also preferred by goshawks in Oregon (Anderson 1979, Moore 1980, Reynolds et al. 1982), California (Hall, unpubl.), Utah (Hennessy 1978), New Jersey (Speiser and Bosakowski 1987), and Colorado (Shuster 1980). Only in Alaska (McGowan 1975) were southern aspects preferred to northern exposures (southern = 64%, northern = 36%). Reynolds (1978), Reynolds et al. (1982), and others also note the choice of benches and low topographic positions as well as gentle to moderately steep slopes.

In summary, our sample of nest sites located over a broad geographic region encompassing a wide variety of forest habitats, reveals several consistent nesting habitat characteristics. Interpretation of these results requires caution, however, because the majority of nest sites were located during timber sale operations and thus may be biased toward nest stands located in large timber.

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FECAL SAC REMOVAL: DO THE PATTERN AND DISTANCE OF DISPERSAL AFFECT THE CHANCE OF NEST PREDATION?[1]

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The classic experiment of Tinbergen et al. (1963) on eggshell removal in gulls demonstrated the significance of removing conspicuous objects from around the nest; predators used the color of broken white eggshells as cues for locating and depredating nests when the shells were left nearby. A comparable principle of reduced predator attraction can be extended to the removal of fecal sacs (feces enclosed in a mucous covering), which may attract predators by their odor or appearance (Herrick 1900, Skutch 1976, Welty 1982). However, despite many anecdotal reports of birds transporting nestling fecal sacs from their nests, it has yet to be determined whether the presence of sacs near the nest increases predation of those nests. An alternative hypothesis suggests that removal of feces keeps the nest dry and free of arthropod colonization (Herrick 1900, Blair and Tucker 1941, Welty 1982). Although there is much variability in the degree to which bird species maintain their nests (Welty 1982), the frequency of fecal sac removal in such a diverse group of species suggests that there is selective pressure for sac disposal.

Weatherhead (1984) assumed that fecal sacs attract predators to nests and predicted that birds would disperse sacs widely so that they would not accumulate near the nest. Petit and Petit (1987) and Weatherhead (1984, 1988) showed that Prothonotary Warblers (*Protonotaria citrea*) and Tree Swallows (*Tachycineta bicolor*), respectively, did not disperse fecal sacs widely around their nests. Nevertheless, Weatherhead's hypothesis of fecal sac dispersal raises an intriguing question: if fecal sacs attract predators, is there an optimal pattern and distance of dispersal such that cues to predators are minimized?

The purposes of this study were to determine (1) if predators are attracted by avian feces, and (2) if the pattern and distance of fecal sac dispersal are important in concealing the location of the nest from predators.

METHODS

Experiments were conducted in four large (>10 ha) woodlots in Wayne County, Ohio, between 22 July and 15 August 1986. Although most birds in Ohio have completed nesting by late July, we felt that the timing

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