

NEST-SITE PREFERENCE OF NORTHERN GOSHAWKS IN SOUTHCENTRAL WYOMING

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Abstract: In 1992, we studied the nest-site preference of goshawks (*Accipiter gentilis atricapillus*) nesting in lodgepole pine (*Pinus contorta*) forests of the Medicine Bow National Forest, southcentral Wyoming. For 39 active pairs of goshawks, we described nesting habitat at 3 spatial scales: nest tree, nest-tree area (0.04 ha circle centered at nest tree), and nest stand (homogeneous forest stand surrounding nest). Nest stands ranged from 0.4 ha to 13.0 ha ($\bar{x}$ = 2.7 ha, SE = 0.4). We compared habitat characteristics at nest-sites to those measured at random sites. The mean diameter at breast height (dbh) of nest trees was larger ($P < 0.001$) than the mean dbh of trees in either the nest-tree area or the nest stand. Nest trees also were taller ($P < 0.001$) and had greater dbh ($P < 0.001$) than trees in random stands. Slopes at goshawk nests were more ($P = 0.04$) moderate ($\bar{x}$ = 11%, SE 1.1, range 1 to 34%) compared to those available. Aspects at goshawk nests were similar ($P = 0.61$) to those available. The tree density in goshawk nest stands was lower ($P = 0.045$) than random stands. However, nest stands had a higher ($P < 0.001$) density of large trees compared to random stands. Trees in nest stands also were taller ($P < 0.001$) with greater ($P = 0.006$) heights to live canopy compared to trees in random stands. The mean density of small trees at nest stands was less than ($P = 0.001$) one-half those present in random stands. Nest stands were not old-growth in the classic sense of being multi-storied stands with large diameter trees, high canopy closure, and abundant woody debris. Rather, nest stands were in even-aged, single-storied, mature forest stands with high canopy closure ($\bar{x}$ = 65%, SE 1.4) and clear forest floors. We recommend changes in procedures for identifying mature and old-growth lodgepole pine forests and describe silvicultural methods for creating goshawk nest stands.

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Northern goshawks (hereafter referred to as goshawk) often nest in old-growth or mature forests (Moore and Henny 1983, Speiser and Bosakowski 1987, Hayward and Escano 1989) that may be affected by forest management (Reynolds 1983, Kennedy 1988, Crocker-Bedford 1990). Lodgepole pine is the third most extensive commercial forest type in the Rocky Mountains (Lotan and Critchfield 1990) and is distributed across the breeding range of goshawks throughout western United States. Little nest-site information is available for goshawks nesting in the Rocky Mountains (Shuster 1980, Hayward and Escano 1989, Young and Bechard 1994), especially in lodgepole pine forests. Potential conflicts between timber harvest and maintenance of viable goshawk populations concerns various publics (Clair 1992, Hitt 1992). In response, the U. S. Fish and Wildlife Service placed the goshawk on the Category 2 list of the Endangered Species Act in 1991 and several regions of the U. S. Forest Service classify the goshawk as a "Sensitive" species. This classification requires that biologists consider their habitat needs when making management rec-

ommendations. Before biologists can assess potential effects of management on goshawks, they must identify important nest-site characteristics according to forest-cover type. This information is needed for the lodgepole pine forest-cover type.

Few goshawk studies have quantified habitat availability when describing nest sites so nest-site preference is poorly understood (Hall 1984, Speiser and Bosakowski 1987, Hargis et al. 1994). Efforts to identify important nest-site characteristics have been further hampered by observers restricting nest searches to habitats they assume a priori are preferred (i.e., mature or old-growth forests) resulting in biased habitat characterizations.

In 1992, we studied the nest-site preference of goshawks nesting in lodgepole pine and mixed lodgepole-aspen (*Populus tremuloides*) forests of southcentral Wyoming. Our study describes the nesting habitat of goshawks at varying spatial scales (from nest tree to nest stand) and identifies habitat characteristics important in nest-site preference.

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STUDY AREA

We located nests on the Medicine Bow National Forest in the Sierra Madre Mountains (1,981 to 3,366 m) and the Medicine Bow Mountains (2,438 to 3,353 m) in southcentral Wyoming. Principal forest series in both ranges included subalpine fir (*Abies lasiocarpa*), Engelmann spruce (*Picea engelmannii*), and lodgepole pine (Marston and Clarendon 1988). Lodgepole pine forests with scattered quaking aspen stands were dominant forest types at lower elevations with spruce-fir forests at higher elevations (Alexander et al. 1986). Sagebrush grasslands were adjacent to forested lands. The floral composition of this area was described in detail in Alexander et al. (1986). The climate on the study area was montane with precipitation ranging from 81 cm at 2,440 m to 122 cm at 3,350 m (Marston and Clarendon 1988). At lower elevations about 50% of precipitation was snowfall compared to 75% at higher elevations.

METHODS

Locating Goshawk Nests

We quantified nest-site characteristics at 39 active goshawk territories. We located 43% of nest-sites by searching for nests on sample units systematically distributed across the survey area. Each survey unit consisted of a large rectangular plot (1,950 × 805 m) in which we placed 2 parallel transects 260 m apart (Kennedy and Stahlecker 1993). We randomly selected the starting location of transects along the short axis of each sampling unit to control for periodic influences in the landscape. Along each transect (1,800 m), we played goshawk attack calls at 7 stations spaced at 300-m intervals. We staggered transects in sampling units to maximize cover-

age (Joy et al. 1994). We located most transects (about 95%) in lodgepole pine or mixed lodgepole pine and aspen forests; spruce fir forests were uncommon on the study area and received little sampling. When we sighted a goshawk, we conducted ground searches until the nest was located. We located the remaining nests from a variety of sources including falconers, timber and wildlife inventory crews, and sightings by the public.

To study nest-site preference, we sampled 33 randomly chosen sites in the nest-search area with a Geographical Information System. We considered the tree nearest the random point the nest tree, the immediate area (0.04-ha circle) surrounding the tree the random nest area, and the forest stand containing the tree the random nest stand. We used the same sampling protocols at random points as those used at nests. We considered use in greater proportion to availability as evidence for a habitat preference. Because goshawks nest in forested environments, we did not sample non-forested random points.

Quantifying Habitat Characteristics

We measured habitat variables at 3 spatial scales: nest tree, nest-tree area, and nest stand. Nest tree variables included tree species, dbh, height, and height to live crown, nest height, nest aspect on tree, nest distance from tree trunk, percent slope and elevation. We determined percent slope with a clinometer and aspect with a compass. We estimated elevations from topographical maps. We did not include high elevation mountain tops in the random sample, so elevation effects may be underestimated. We selected these variables on the basis of their ability to describe forest structural characteristics, their current use by forest managers, and their importance in goshawk literature.

We defined the nest-tree area as a 0.04-ha circular plot centered at the nest tree. We selected this plot size to include the immediate surrounding trees that may affect conditions at the nest. Logger's tapes oriented in each cardinal direction divided the circular plot in 4 quadrants. Variables measured in the nest-tree area included tree density in 5 size classes (sapling < 6.4-cm diam, 6.4 ≤ small tree < 12.5, 12.5 ≤ medium tree < 22.6, 22.6 ≤ large tree < 40.4, extra large tree ≥ 40.4, U. S. Dep. Agric. 1993), total trees, mean tree height, and mean canopy height. We determined mean tree height and mean canopy height by averaging the mea-

surements of 4 randomly selected trees (1/quad-rant). We calculated tree basal area by summing the area of all tree boles present in the plot. We determined canopy cover by using line-intercept sampling (Bonham 1989:108); we averaged readings from 2 20-m transects extending in cardinal directions to determine canopy coverage. We did not sample a 1.5 m length on either side of the nest tree to avoid double counting canopy where transects crossed. We averaged 5 Daubenmire plots taken at 5-m intervals on canopy coverage transects to determine percent plant ground cover and wood litter (>2.54-cm diam., Daubenmire 1959). We estimated percent shrub cover and counted the number of seedlings (<1 m tall) on a 0.004-ha circular plot centered 1.5 m north of the nest tree. Partially through the study, we identified by field observation that wood litter and height to live canopy potentially were important habitat variables. Therefore, we quantified wood litter at 24 goshawk nest sites and 16 random sites and height to live canopy at 12 nest sites and 9 random sites.

Nest stands of goshawks can be delineated based on unique vegetative characteristics (Hall 1984, Reynolds et al. 1982, Kennedy 1988). In the field, we delineated the perimeter of nest stands based on homogeneous forest structure. We quantified habitat variables at approximately 8 sample points in each stand. We randomly selected the first sample point between the stand edge and 40 m and established other sample points at 40-m intervals distributed throughout the nest stand. At each sample point, we used a variable-radius plot to determine tree density (in the 5 dbh size classes as above) and tree basal area. We calculated tree density and basal area on variable plots according to Avery (1975). In addition, we measured average tree height, height to live canopy, slope, shrub cover, total seedlings, percent plant ground cover, and wood litter using the same procedures employed at nest-tree areas. We determined canopy coverage by using a 20-m line transect that was randomly oriented at each sample point. We characterized the stand as the average from the sample plots because the stand was the sampling unit.

Statistical Analyses

We tested the hypothesis (H) that goshawk selected species of nest trees in proportion to

their availability using the χ^2 test of homogeneity (Marcum and Loftsgaarden 1980, Jelinski 1991). If H was rejected, we determined preference for a given tree species for an overall α of 0.10 (Mendenhall 1975:402); we used a Bonferroni approach for determining individual confidence intervals (individual $\alpha = 0.03$, Miller 1966:67). If the confidence interval for the difference between available proportion and utilized proportion included zero, the species of tree was used in proportion to its availability (Marcum and Loftsgaarden 1980). If both end-points of the confidence interval were positive, then the tree species was used significantly less than available; if both end points were negative, then the tree species was used significantly more than available.

Continuous habitat variables for nest trees, nest-tree areas, and nest stands were non-normally distributed. Therefore, we used multiresponse permutation procedures (MRPP) to compare used versus random habitat characteristics. MRPP is a distribution-free statistical procedure based on Euclidean distance-functions that has greater reliability and power for detecting differences in skewed distributions than variance-based statistics (Zimmerman et al. 1985, Mielke 1986). We compared nest-tree dbh and height with the average value for trees in nest stands and nest stands with paired MRPP tests using BLOSSOM software (Slauson et al. 1991). We calculated the mean aspect of goshawk nest sites, random sites, and nest placement relative to the bole of nest trees using circular statistics according to Batschelet (1981:11); we used a Rayleigh test to determine if angular variables were randomly distributed (Batschelet 1981: 55). We used a version of MRPP for circular data to test for differences in aspect between nest and random sites (Slauson et al. 1991).

RESULTS

Nest Tree Characteristics and Preference

Goshawks (39 active pairs) nested in 3 species of trees that included: 38% aspen, 59% lodgepole pine, and 3% subalpine fir (Table 1). The species composition of nest trees was similar to those available with the exception of a single occurrence of both Engelmann spruce and water birch (*Betula occidentalis*) in the random sample. We excluded both species from the χ^2 comparisons because of low cell counts. We rejected the hy-

pothesis of homogeneity of use among tree species ($\chi^2 = 10.1$, 2df, $P = 0.006$) suggesting goshawks did not select nest trees in proportion to their availability. Simultaneous confidence interval tests indicate that goshawks avoid subalpine fir for nest trees compared to their availability; both aspen and lodgepole pine were used in proportion to their availability (Table 1).

Structural and physiographic characteristics of goshawk nest trees differed ($P < 0.001$) from available trees. Goshawks selected larger nest trees, both in terms of height ($P < 0.001$) and dbh ($P < 0.001$) compared to "nest trees" in the random stands (Table 2). In addition, mean nest-tree dbh was greater ($P < 0.001$) than mean-tree dbh in either the nest-tree area or the nest stands. Nest trees also were taller ($P = 0.001$) than trees in the nest-tree area, but their height was similar to the mean tree height in nest stands..

The canopy height of nest trees was higher ($P < 0.001$) than available trees. Goshawks preferred nest trees that had high canopies with tree boles that lacked lower branching. Nests were built at about one-half nest-tree height. Only 10% of nests were constructed >1 m from the nest-tree bole (range 0–2 m).

The elevation of nest sites and random sites was similar ($P = 0.58$, Table 2). We did not locate nests in the higher elevation ($>2,750$ m) forests dominated by spruce-fir, but little search effort was expended in this habitat. Goshawks preferred ($P = 0.04$) nest trees on moderate slopes compared to those available. The aspect at goshawk nests were: 30% northerly, 31% easterly, 18% southerly, and 23% westerly. Aspects at nests were similar ($P = 0.61$) to those available. However, nest aspect relative to the nest tree bole was not random ($P = 0.04$). Goshawks disproportionately constructed nests with southerly exposures (39%); nests were seldom (13%) built on the north side of nest trees.

Nest-tree Area Characteristics

Goshawk nest-tree areas differed ($P < 0.001$) from available sites. There was a higher ($P < 0.001$) density of large trees compared to random sites, but the total number of trees was similar ($P = 0.32$, Table 2). Tree basal area at nest-tree areas was greater ($P = 0.017$) than random sites. In addition, trees in nest-tree areas were taller ($P < 0.001$) and had higher heights to live canopy ($P = 0.009$) compared to random sites. Canopy cover in the immediate nest stand

Table 1. Frequency by species of nest trees used by northern goshawks in southcentral Wyoming compared to those available, 1992.

	Goshawk nest trees (n = 39)	Random tree in random stands (n = 31)	Confidence interval ^a of individual differences in the proportion of use
Aspen	15 (38%)	10	-0.31–0.19
Lodgepole pine	23 (59%)	12	-0.46–0.05
Subalpine fir	1 (3%)	9	0.08–0.45 ^b

^a Chi-square homogeneity test statistic = 10.1, 2 df, $P = 0.006$.

^b Differed from random ($P < 0.05$).

was high but was similar ($P = 0.09$) to random sites. Wood litter (>2.54 -cm diam.) was less ($P = 0.03$) at nest-tree areas compared to random sites.

Nest Stand Characteristics

The size of nest stands ranged from 0.4 to 13.0 ha ($\bar{x} = 2.7$ ha, SE 0.4). Goshawks selected nest stands that differed ($P < 0.001$) from random stands (Table 2). Goshawk nest stands supported a lower total tree density compared to random stands ($P = 0.045$). However, nest stands had a higher ($P < 0.001$) density of trees in the large size class. Trees present in nest stands were taller ($P < 0.001$) with greater heights to live canopy ($P = 0.006$) than random stands. The density of small trees at nest stands was less ($P = 0.001$) than half those present in random stands.

Goshawks selected nest stands with moderate gradients that were less ($P = 0.049$) than those available. The percent plant ground cover was similar at both nest and random stands but seedling-tree density at nest stands was much lower ($P = 0.001$). Nest stands had less ($P = 0.003$) woody debris present on the forest floor than did random stands.

DISCUSSION

Nest Trees

Goshawks nesting in southcentral Wyoming prefer the largest trees available as nest trees. Nest trees were larger in dbh than trees in either the nest-tree area or the nest stand. Other researchers also have noted that goshawks nest in the largest trees available. In California, goshawks nested in old-growth Douglas-fir (*Pseudotsuga menziesii*) that were older, less dense, and more structurally complex than surrounding trees in the nest stand (Hall 1984). Likewise,

Table 2. Habitat characteristics of goshawk nest trees, nest areas (0.04 ha circular plot centered at nest tree), and nest stands compared to those available in southcentral Wyoming in 1992.

Variable	Goshawk nest sites (n = 39)			Random sites (n = 33)			P-value
	Mean	SE	Range	Mean	SE	Range	
Nest tree dbh (cm)	31.6	1.3	17.0–50.5	23.3	1.8	2.5–45.7	$P < 0.001$
Nest tree height (m)	21.4	0.6	12.0–28.2	15.7	1.1	2.1–25.0	$P < 0.001$
Height to live canopy (m)	11.3	0.7	1.7–18.5	6.7	0.8	0.5–16.0	$P < 0.001$
Nest height (m)	11.9	0.4	5.1–15.8	n.a. ^a	n.a.	n.a.	
Nest position (% of nest tree)	56.2	1.7	28.6–80.2	n.a.	n.a.	n.a.	
Elevation (m)	2561	12.8	2390–2731	2578	28.7	2262–3024	$P = 0.585$
Slope (%)	11	1	1–34	16	2	1–64	$P = 0.046$
Nest area (0.04-ha plot)							
Tree density (trees/0.04-ha plot)							
Sapling (<6.4 cm dbh)	0.6	0.2	0–5	0.7	0.2	0–5	n.a. ^b
Small (6.4–12.5 cm dbh)	11.9	1.9	0–64	16.2	2.7	0–53	$P = 0.121$
Medium (12.5–22.6 cm dbh)	21.3	2.1	0–51	22.1	2.7	0–66	$P = 0.389$
Large (22.6–40.4 cm dbh)	19.2	1.1	1–32	12.6	1.3	0–28	$P < 0.001$
Extra large (>40.4 cm dbh)	0.9	0.2	0–5	1.3	0.3	0–8	$P = 0.465$
Total trees (trees/0.04-ha plot)	53.8	3.4	14–132	52.9	5.4	1–132	$P = 0.323$
Average tree height (m)	19.3	0.5	13–25	13.8	0.9	3–22	$P < 0.001$
Height to live canopy (m)	10.2 ^c	1.0	6–16	6.6	0.5	4–9	$P = 0.009$
Basal area (m ² /ha)	50.8 ^d	2.1	18–92	42.5	3.4	0–96	$P = 0.017$
Canopy cover (%)	66.7	2.0	38–90	60.0	3.8	0–90	$P = 0.089$
Shrub cover (%)	5.8	1.4	0–35	10.0	2.8	0–55	$P = 0.174$
Total seedlings (13.5 m ²)	12.8	2.2	0–51	18.0	2.8	0–59	$P = 0.146$
Plant ground cover (%)	17.6	3.1	1–75	20.8	3.7	0–83	$P = 0.556$
Wood litter >2.53 cm (%)	5.0 ^e	1.2	0–24	10.8	2.8	0–44	$P = 0.030$
Nest stand							
Tree density (trees/ha)							
Sapling (<6.4 cm dbh)	34.2	14.4	0–337	71.5	36.6	0–1029	$P = 0.619$
Small (6.4–12.5 cm dbh)	212.9	25.3	0–547	452.5	68.2	0–1413	$P = 0.001$
Medium (12.5–22.6 cm dbh)	558.0	46.6	148–1277	696.2	88.4	113–1842	$P = 0.164$
Large (22.6–40.4 cm)	475.3	17.2	254–668	315.8	20.1	103–553	$P < 0.001$
Extra large (>40.4 cm dbh)	18.2	3.2	0–75	25.9	5.6	0–143	$P = 0.392$
Total tree density (trees/ha)	1298.6	65.4	729–2196	1561.9	156.4	356–3438	$P = 0.045$
Basal area (m ² /ha)	49.7	1.2	34–65	45.5	2.3	12–69	$P = 0.071$
Average tree height (m)	20.2	0.4	14–25	15.9	0.7	10–24	$P < 0.001$
Height to live canopy (m)	10.2 ⁽²⁾	0.7	7–15	6.6	0.8	3–9	$P = 0.006$
Canopy cover (%)	65.2	1.4	44–85	64.1	2.8	27–86	$P = 0.328$
Slope (%)	12.2	1.1	3–30	17.5	2.5	2–63	$P = 0.049$
Shrub cover (%)	2.3	0.6	0–18	3.9	1.0	0–17	$P = 0.194$
Total seedlings (13.5 m ²)	9.7	1.2	0–30	17.0	2.2	0–52	$P = 0.001$
Plant ground cover (%)	18.0	2.4	2–60	18.8	2.5	1–54	$P = 0.860$
Wood litter >2.53 cm (%)	3.9 ⁽⁴⁾	0.6	0–12	8.3	1.4	1–18	$P = 0.003$

^a Random trees lack nests so comparison not applicable.^b Data too sparse for test.^c Sample size: n = 12 goshawk nest sites, n = 9 for random sites.^d Calculated by summing bole areas of trees present on 0.04 ha plots.^e Sample size: n = 24 goshawk nest sites, n = 16 for random sites.

Saunders (1982) noted that the mean diameter of nest trees was greater ($\bar{x} = 74.2$ cm, range 43.7–121.9 cm) than trees in the nest stand ($\bar{x} = 27.1$ cm, range 16.1–44.8 cm) and in the immediate nest area ($\bar{x} = 33.2$ cm, range 11.9–67.1 cm).

Beebe (1974) stated that goshawks nest in any species of tree as long as it provides the nest secure anchorage. Tree species with forked (deciduous trees) or whorled branching (conifer) that adequately buttress goshawk nests are suit-

able nest trees (Reynolds et al. 1982, Speiser and Bosakowski 1989). We found that goshawks nest in aspen (38%) and lodgepole pine (59%) in proportion to their availability. We found no evidence that goshawks preferred deciduous trees over conifers, but they seemingly avoided subalpine fir. Speiser and Bosakowski (1987) reported that goshawks nesting in New York and New Jersey nested primarily in deciduous hardwoods (82%), despite a substantial number of conifers at nest sites. In our study, aspen usually

occurred in thin linear stands in the bottom of draws, surrounded by a lodgepole pine nest stand. Boles of aspen and lodgepole pine nest trees usually have few lower branches below the canopy, which seemingly is preferred by nesting goshawks on our study area. Subalpine fir had more branching below the canopy compared to lodgepole pine or aspen, which may explain why goshawks avoided building nests in this species. In Alaska, paper birch (*Betula papyrifera*) was selected 94% of the time in stands where ≥ 2 suitable nest-tree species were present (McGowan 1975). McGowan assumed birch trees were preferred because they provide more stable nest foundations than aspen.

Canopy cover in the nest-tree area was high but did not differ from the canopy closure of random sites. The canopy closure in nest-tree areas ranged from 38 to 90% ($\bar{x} = 66.7\%$, $SE = 2.0$). Hayward and Escano (1989) found that high canopy closure at nest sites was the most uniform habitat characteristic ($CV = 7\%$) for goshawks nesting in northern Idaho and western Montana, which suggests it may be an important factor in nest site preference. Most U. S. studies have found that canopy closure at goshawk nests ranges between approximately 60 and 95% (Siders and Kennedy 1994). However, in eastern California, canopy coverage immediately around nests on the Inyo National Forest was only 29% ($SD 12.6$) which is low compared to most studies (Hargis et al. 1994).

We found the aspect of goshawk nest stands was similar to those available. Nest stands with southern exposures on our study area were structurally similar to north-facing stands by supporting large trees with closed canopies. We did not find goshawks nesting on more typical dry south slopes that supported open forest stands. Some studies have reported that goshawks prefer nesting on northern exposures (Moore and Henny 1983, Hall 1984, Hayward and Escano 1989), but others have detected no preference (Crocker-Bedford and Chaney 1988, Kennedy 1988). Some populations may prefer microsites on north slopes that support denser vegetation with cooler temperatures for nesting (Reynolds et al. 1982).

Nest Stands

Our results suggest that goshawks, nesting in lodgepole pine forests, prefer forest stands that are composed primarily of large, mature trees; these stands contain few small-diameter trees

compared to random stands. Nest stands were usually in single-storied forests that had closed canopies and high lower-canopy heights. Forest floors of nest stands were clear, having few seedlings and little wood litter. Other studies also have found that goshawks prefer nesting in mature forests (Moore and Henny 1983, Hayward and Escano 1989). Goshawks nesting in New York and New Jersey selected extensively forested areas that contained more mature timber than was available in the region (Speiser and Bosakowski 1987). These sites also had reduced sapling growth. However, in Oregon, goshawks nested in dense stands of mature or old-growth conifers that ranged from those containing a few mature trees but with numerous understory conifers, to those with closed mature canopies and sparse understory (Reynolds et al. 1982). Only 4% of Oregon nests were in mature lodgepole pine stands or mixed lodgepole/ponderosa pine stands.

Our study area had little spruce/fir compared to many other national forests and little search effort was expended in this habitat type. However, discussions with falconers who have spent years searching for nests on the Medicine Bow National Forest and our limited search efforts suggest little nesting occurs in this habitat type. Additional surveys are needed, in the Rocky Mountain region, to determine the importance of spruce/fir forests to nesting goshawks relative to other forest types.

MANAGEMENT RECOMMENDATIONS

Goshawks nesting in southcentral Wyoming appeared to prefer single storied, mature nest stands that have high canopy closure and clear forest floors. These stand characteristics are not old-growth in the classic sense of being multi-storied forests composed of large diameter trees with high canopy closure and great structural diversity from abundant woody debris. Land use agencies often use scorecards as the basis for classifying and protecting mature and old-growth forests. High scores are assigned to stands that are structurally complex like mature and old-growth forests of the Pacific Northwest. However, goshawk nest stands in lodgepole pine forests in our study area are assigned low scores because they lack structural complexity (Raphael et al. 1992). Thus, the mature lodgepole pine habitat preferred by nesting goshawks is often not identified and managed as a unique component of the forest ecosystem. Scoring pro-

cedures need modification so that mature and old-growth forests are evaluated relative to the structural characteristics of dominant forest types (e.g. ponderosa pine [*Pinus ponderosa*], lodgepole pine, spruce/fir). This would improve current provisions for protecting goshawk nesting habitat in lodgepole pine forests.

A major disturbance, like a stand replacement fire, followed by less than normal regeneration due to climatic conditions or site characteristics may produce lodgepole pine stands similar to those used by nesting goshawks (C. Edminster, Rocky Mt. For. and Range Exp. Stn., pers. commun.). It is possible that precommercial thinning could be used to create forest stands similar to those found in goshawk nest areas. Stands could be thinned from below (leaving large trees while removing trees of small dbh) but with sufficient canopy cover to prevent a flush of regeneration (Reynolds et al. 1992). In south-central Wyoming, lodgepole pine stands are often thinned to a 3.1- × 3.1-m spacing that yields a density of about 1,077 trees/ha (J. Mastel, Medicine Bow Nat. For., pers. commun.) Thinning in this manner results in a tree density well below the 95% CI for the density of trees present in nest areas (1,298 trees/ha ± 128.1). Thinning levels that are optimal in terms of timber production may need to be reduced when creating nest areas.

Possibly, 3-step shelterwood treatments (Daniel et al. 1979:446) could be used to create nest areas. Usually, about one-third of tree basal area is removed during each of the 3 entries. During the initial entry, the stand could be slightly opened to test for wind firmness and to remove unhealthy trees. Regardless, if precommercial thinning or 3-step shelterwood treatments are used, young spruce/fir can be removed if they are codominant with lodgepole pine in order to favor establishing mature lodgepole pine stands. We cannot offer timber harvest specifications for creating goshawk nesting habitat in lodgepole pine forest because site productivity is strongly influenced by local environmental conditions (Lotan and Critchfield 1990). Forest simulation models, like GENGYM (General Growth and Yield Model, Edminster et al. 1990), may prove useful, given specific site conditions, in prescribing silvicultural techniques that create goshawk nest habitat. Many silvicultural techniques produce nest stands for the short-term (50–100 yrs). Forest landscapes need to have several nest stands distributed throughout gos-

hawk home ranges; younger-aged stands need to be maintained as future nest areas in order to provide goshawk nest habitat over the long-term (Reynolds et al. 1992, Graham et al. 1994).

Most descriptions of goshawk nesting habitat are based on nest searches conducted in suitable (i.e. old-growth) habitat. Thus, our existing knowledge of goshawk nest site preferences may be biased toward this habitat type. We recommend that either systematic or random transects be used when surveying for nesting goshawks, so all habitats are sampled regardless of structural characteristics.

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