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NEST-SITE SELECTION OF RED-SHOULDERED AND RED-TAILED HAWKS IN A MANAGED FOREST

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ABSTRACT.—We compared nest-site macro- and microhabitat selection of Red-shouldered (*Buteo lineatus*) and Red-tailed hawks (*B. jamaicensis*) and examined potential relationships between habitat selection and nest success in a managed forest in central Georgia. We located 12 Red-shouldered and 10 Red-tailed hawk nests during the 1994 breeding season. Circular plots (1 km^2) were mapped around each hawk nest and 100 random points, and selected macrohabitat characteristics within the plots were measured and compared. Red-shouldered Hawk nest-site macrohabitat was characterized by significantly more bottomland hardwood habitat, less older age (>50 yr) pine habitat, and larger nest-site stands than random plots. Red-tailed Hawk nest plots contained significantly more agriculture habitat, more young (6–20 yr) pine habitat, less upland hardwood habitat, less total amount of edge, fewer number of stands, and larger average stand size than random plots. Red-shouldered Hawk nest sites (0.04 ha) had more large (>69 cm DBH) trees and lower percent total canopy cover than random points. Red-tailed Hawk nests were placed close to habitat edges and openings in the canopy, and nest sites had taller trees, larger (>69 cm) trees, and greater percent understory cover than random points. Successful Red-tailed Hawk nests were placed in shorter trees than unsuccessful nests. On the study site, large floodplain forests offering mature trees were important to breeding Red-shouldered Hawks, and mature pine forest edges near openings created by silvicultural and agricultural practices were important to breeding Red-tailed Hawks. *Received 7 April 1995, accepted 15 Nov. 1995.*

Forest management practices in Georgia often are directed towards increasing the production of pine timber. Silvicultural treatments result in forest modifications that include alterations in horizontal and vertical structural diversity, stand diversity, size class distribution, and vegetative species composition (Nelson and Titus 1988). Hardwood species are usually removed from the overstory in managed pine stands. The remaining stands of pine probably provide little habitat that is suitable for raptors (Edwards 1978). Declines in Red-shouldered Hawk (*Buteo lineatus*) populations elsewhere in its range have been attributed to alterations of nesting habitat, especially riparian habitat, and replacement by the Red-tailed Hawk (*B. jamaicensis*) which is more xeric-adapted (Stewart 1949, Henny et al. 1973).

Nest-site selection of the Red-shouldered and the Red-tailed hawk seldom has been studied at the landscape level. Few studies have described nest-site habitat selection of sympatric populations of the Red-shouldered and the Red-tailed hawk (Titus and Mosher 1981, Bednarz and Dinsmore 1982), and none have described nest-site selection for either of the two

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species in the southeastern United States. We conducted a study in a managed forest (1) to determine whether Red-shouldered and Red-tailed hawks establish nest sites in proximity to specific micro- and macrohabitat types; (2) to determine how silvicultural practices could create or modify these specific habitat types; (3) to describe potential relationships between reproductive success and nesting habitat; and (4) to determine whether habitat partitioning exists between the two species.

STUDY AREA AND METHODS

Field investigations took place at Bishop F. Grant Memorial Forest, a 5718 ha wildlife management area (WMA) owned by the Univ. of Georgia School of Forest Resources and operated in cooperation with the Georgia Dept. of Natural Resources. The WMA is located in Putnam County approximately 14.5 km north of Eatonton, GA. The property lies within the southern Piedmont physiographic province, a region of broad, gently sloping topography with occasional steep or strongly sloping terrain around the major drainage basins. A majority of the existing upland habitat types are dominated by loblolly pine (*Pinus taeda*). Present silvicultural treatments in the pine forests range from thinning and prescribed burning to clear-cutting and replanting. Bottomland hardwood habitats dominate along the property's three largest creeks (Glady Creek, Big Indian Creek, and Little River), and upland hardwood habitats exist in some areas along the drainage basins associated with these creeks. The Univ. of Georgia Agricultural Experiment Station grazes cattle on several large pastures that lie within the WMA.

We used a number of techniques to locate active Red-shouldered and Red-tailed hawk nests during the 1994 breeding season. We searched for old nests during the preceding winter months and later returned to check for signs of activity. Because taped calls of conspecific vocalizations have proven effective in locating nesting raptors (Rosenfield et al. 1988, Kimmel and Yahner 1990), Red-shouldered Hawk alarm calls were broadcast from a cassette recorder near potential nest sites. Vocalizations were played for 15-s periods distributed evenly over 5 min. Broadcasting was repeated every 10–20 min while an investigator moved through the wooded area (Mosher et al. 1990). When Red-shouldered Hawks were present, they normally responded to the vocalizations either by calling or flying towards the broadcasts. We made extensive nest searches in areas where birds responded. Because Red-tailed Hawks are relatively conspicuous visually, we located nests by searching areas where birds were seen perched or soaring. To prevent bias, nest searches also were conducted in all forested stands (trees >20 yrs) in areas where birds were not seen or heard. Stands were searched on foot by walking transects that were spaced to permit observation of most tree crowns. These searches began in late April and were continued through mid-June. Occupied nests of both species were monitored every 7–10 days and outcomes were recorded. Nests that fledged at least one young were considered successful.

Macrohabitat analysis.—We classified habitat types on a digital database developed with the geographical information system (GIS) software package ARC/INFO (Environmental Systems Research Institute 1987). Pine habitats were separated into five types based on age (numbers indicate age of forest in years): <6PINE; 6–20PINE; 21–30PINE; 31–50PINE; >50PINE. Three additional habitats types included in the analysis were bottomland hardwoods (BOTTOM), upland hardwoods (UPLAND) and agricultural land such as pastures and fields (AGR). Once nests were located and verified as occupied, they were recorded on the GIS database within the habitat types in which they occurred. To characterize available habitat, we selected 100 random points from a UTM coordinate grid using a random number generator. Since hawks require large trees as nest substrates, only random points that fell within forested habitat greater than 20 years old were selected for analysis.

When analyzing macrohabitat preference, it is important to know the scale at which selection occurs. Sedgwick and Knopf (1992) analyzed nesting habitat within three concentric circles of increasing size using the nest site as the center. Lehmkuhl and Raphael (1993) also assessed owl habitat pattern within three concentric circles centered on foraging locations. Using a similar technique and a GIS, we mapped concentric circles of increasing size around each nest site and random point. The central circle, or mesoplot, was 1 km^2 (radius = 564 m) which was approximately equal to the smallest Red-shouldered Hawk home range (D. L. Howell, pers. comm.). We selected the smallest home range size to minimize sampling outside of territories (Sedgwick and Knopf 1992). The innermost circle (radius = 399 m), or microplot, had an area approximately half that of the home range. An outer circle (radius = 798 m), or macroplot, encompassed twice the area of the mesoplot. For comparison and because home range size of Red-tailed Hawks in the Southeast is unknown, circles of the same size were generated around Red-tailed Hawk nests.

We measured macrohabitat characteristics of nest plots and random plots with the GIS. Area of each habitat type, amount of edge (TOTEDGE), average patch size (AVGSIZE), and number of patches within circles (#STAND) were compared for each circle size. The patch size containing the plot center (STSIZE) for each nest site and random point also was tested for differences.

Microhabitat analysis.—To quantify available habitat, we used the same random points as for the macrohabitat analysis. Field locations of the UTM coordinates selected were found using a global positioning system. At the end of the nesting season (July–Aug.), we measured nest-site vegetation using a modification (Noon 1981) of the James and Shugart (1970) technique. In this study, we defined the nest site as a 0.04 ha circular plot with the nest tree as its center. Distance to water (DISTWAT), distance to a road (DISTROAD), distance to a break in the overstory canopy (DISTOP), and distance to a change in habitat type (DISTEDGE) were determined with the GIS. Except for the nest-tree-specific variables (Table 1), the sampling was the same at random points as at nest sites. A spherical densiometer (4 samples per site) was used to measure percent canopy cover and an ocular tube (20 samples per site) was used to determine percent ground cover and percent understory cover. Heights of four dominant trees in the 0.04 ha plot were determined using a clinometer and their average was used as the site canopy height. For each species, only random points that fell within the same habitat as nests were used in comparative analysis. Limiting the random sites prevented comparing nest sites to habitats where hawks were known not to nest.

Statistics.—We used Wilcoxon rank-sum tests to compare nest sites and random points, Red-shouldered and Red-tailed hawk nest sites, and successful and unsuccessful nest sites of each species. Nonparametric analyses were used because some sample sizes were small and most data were non-normally distributed. Since nonparametric statistics were used, non-normal, percentage, and count data did not require transformation (Zar 1974). All statistical analyses were performed using the Statistical Analysis System (SAS Institute Inc. 1982).

RESULTS

Macrohabitat analysis.—Because plot scale had little effect for the two species (Moorman 1995), we used mesoplot (1 km^2) values for all analyses. Ten Red-shouldered Hawk nests were located in bottomland hardwood habitat and two were found in upland hardwood ridges bordering bottomland forest. Two of these nests were located in areas where hawks previously were not seen or heard. Red-shouldered Hawk nest sites were

TABLE 1

LIST OF ADDITIONAL NEST SITE AND RANDOM POINT VARIABLES AND EXPLANATION OF THEIR MNEMONICS

Variable	Description
3–8cm(#)	Number of stems within the 0.04 ha plot with DBH between 3 and 8 cm
9–15cm(#)	Number of stems within the 0.04 ha plot with DBH between 9 and 15 cm
16–23cm(#)	Number of stems within the 0.04 ha plot with DBH between 16 and 23 cm
24–38cm(#)	Number of stems within the 0.04 ha plot with DBH between 24 and 38 cm
39–53cm(#)	Number of stems within the 0.04 ha plot with DBH between 39 and 53 cm
54–69cm(#)	Number of stems within the 0.04 ha plot with DBH between 54 and 69 cm
>69cm(#)	Number of stems within the 0.04 ha plot with DBH greater than 69 cm
BASALAREA	Total basal area per hectare
SHRUBDEN	Estimate of the number of shrubs per hectare
CANHT(m)	Average height of four dominant trees in the 0.04 ha plot
GRCOVER(%)	Percent ground cover determined with an ocular tube
CANCOVER(%)	Percent total canopy cover determined with a spherical densiometer
UNCOVER(%)	Percent understory cover determined with an ocular tube
NESTHT(m)	Height of the nest determined with a clinometer
NETREEHT(m)	Height of the nest tree determined with a clinometer
NETREEDBH(cm)	DBH of the nest tree
PERNESTHT	Percent of the nest height of the nest tree height
NEARNGHBR(m)	Distance to nearest nest of the same species

located in larger stands ($\bar{x}$ = 194.15 ha) than random points ($\bar{x}$ = 63.8 ha) (Table 2). Nest plots had significantly more BOTTOM ($\bar{x}$ = 28.43 ha) and less >50PINE ($\bar{x}$ = 16.61 ha) than random plots ($\bar{x}$ = 9.08 ha and 33.94 ha, respectively).

Eight Red-tailed Hawk nests were in >50PINE habitat, one was in 30–50PINE habitat, and one was located in a loblolly pine within UPLAND habitat. One of the ten nests was located in an area where Red-tailed Hawks previously had not been observed. Nest plots had more AGR ($\bar{x}$ = 31.71 ha) and less UPLAND ($\bar{x}$ = 16.92 ha) and 6–20PINE ($\bar{x}$ = 7.87 ha) than random plots ($\bar{x}$ = 7.49 ha, 23.79 ha, 13.79 ha, respectively). In addition, Red-tailed Hawk nest plots had less TOTEDGE, less #STAND, and a greater AVGSIZE (Table 2).

Red-shouldered and Red-tailed hawk nest-site macrohabitats were sep-

TABLE 2

MEAN ± ONE STANDARD ERROR OF MESOPLOT VARIABLES MEASURED AT RED-SHOULDERED HAWK NESTS, RED-TAILED HAWK NESTS, AND 100 RANDOM POINTS

Variable	Red-shouldered Hawk (1.0 km^2)	Red-tailed Hawk (1.0 km^2)	Random (1.0 km^2)
STSIZE(ha)	194.15 ± 42.32[ac]	39.66 ± 11.13	63.80 ± 7.81
BOTTOM(ha)	28.43 ± 3.21[ac]	4.07 ± 2.06	9.08 ± 1.35
UPLAND(ha)	26.67 ± 3.24[c]	16.92 ± 2.50[b]	23.79 ± 0.89
AGR(ha)	4.89 ± 1.53[c]	31.71 ± 7.62[b]	7.49 ± 1.10
<6PINE(ha)	4.18 ± 2.15	8.29 ± 3.84	5.26 ± 0.87
6–20PINE(ha)	13.78 ± 3.27	7.87 ± 4.63[b]	13.79 ± 1.10
21–30PINE(ha)	2.03 ± 1.15	0.37 ± 0.36	1.59 ± 0.44
31–50PINE(ha)	3.43 ± 2.22	5.04 ± 2.91	5.07 ± 0.83
>50PINE(ha)	16.61 ± 3.18[a]	25.74 ± 5.06	33.94 ± 1.66
TOTEDGE(km)	25.00 ± 1.39[c]	20.10 ± 1.77[b]	25.40 ± 0.39
#STAND	25.58 ± 3.01	17.30 ± 2.53[b]	22.96 ± 0.57
AVGSIZE(ha)	4.46 ± 0.45	7.45 ± 1.42[b]	4.60 ± 0.14
N	12	10	100

[a] Significant differences ($P \leq 0.05$) between Red-shouldered Hawk nest plots and random plots according to Wilcoxon rank-sum tests.

[b] Significant differences ($P \leq 0.05$) between Red-tailed Hawk nest plots and random plots according to Wilcoxon rank-sum tests.

[c] Significant differences ($P \leq 0.05$) between Red-shouldered Hawk and Red-tailed Hawk nest plots according to Wilcoxon rank-sum tests.

arated by significant differences in several variables (Table 2). Red-tailed Hawk macrohabitat was characteristic of upland habitat; Red-shouldered Hawk macrohabitat represented bottomland habitat. Red-shouldered Hawk nests were located in larger stands ($\bar{x}$ = 194.15 ha) and nest plots had more BOTTOM ($\bar{x}$ = 28.43 ha), more UPLAND ($\bar{x}$ = 26.67 ha), less AGR ($\bar{x}$ = 4.89 ha), and more TOTEDGE ($\bar{x}$ = 25.0 km) than Red-tailed Hawk nest plots ($\bar{x}$ = 39.66 ha, 4.07 ha, 16.92 ha, 31.71 ha, 20.1 km, respectively).

We found no significant differences between successful and unsuccessful nesting macrohabitats for Red-shouldered or Red-tailed hawks. Four of 12 Red-shouldered Hawk nests failed to fledge at least one young. One nest was abandoned during incubation and one was damaged during a severe storm. The causes of nest failure were unknown for the other two. Five of the 10 Red-tailed Hawk nests were successful in fledging young. Causes of nest failures were not known.

Microhabitat analysis.—One Red-shouldered Hawk pair nested in a loblolly pine, but the remaining 11 pairs placed nests in deciduous trees. Four were in American sycamores (*Platanus occidentalis*), two in sweetgums (*Liquidambar styraciflua*), two in southern red oaks (*Quercus fal-*

cata), one in a water oak (*Q. nigra*), one in a green ash (*Fraxinus pennsylvanica*), and one in an eastern cottonwood (*Populus deltoides*). Red-shouldered Hawks only nested in hardwood habitat, so only random points located in hardwood habitat were used in comparative analyses. Red-shouldered Hawk nest sites had significantly more large trees (>69 cm) and lower CANCOVER than other sites within hardwood habitat (Table 3).

All Red-tailed Hawk pairs nested in loblolly pines. Nest sites were located in either pine or upland hardwood-pine habitat, so only random points located in these habitat types were used in statistical comparisons. Red-tailed Hawks built their nests significantly closer to edges and closer to openings in the canopy than random points (Table 3). Nest sites had greater UNCOVER and more understory trees (9–15 cm) than random points. Nest sites had more large trees (>69cm) and more tall trees (CANHT) than other points within potential nesting habitat.

Red-shouldered Hawk nests were placed closer to water ($\bar{x}$ = 68 m) and farther from edges ($\bar{x}$ = 57.3 m) and openings ($\bar{x}$ = 139.1 m) than Red-tailed Hawk nests ($\bar{x}$ = 355.3 m, 14.9 m, 19.6 m, respectively). Red-shouldered Hawk nest sites had greater CANCOVER and lower SHRUBDEN than Red-tailed Hawk nests (Table 3). We also compared nest-tree variables and nearest neighbor distances between the two species (Table 4). Red-tailed Hawks nested higher (NESTHT) and higher in the tree (PERNESTHT) than Red-shouldered Hawks. Nearest neighbor distances ranged from 448 m to 4195 m for Red-shouldered Hawks and from 1389 m to 2971 m for Red-tailed Hawks. Red-shouldered Hawk nearest neighbor distances generally were smaller ($\bar{x}$ = 1322 m) than those of Red-tailed Hawks ($\bar{x}$ = 1827 m), but one pair nested in a solitary location (4195 m from its nearest neighbor). When nest-site habitat variables were compared, successful Red-tailed Hawk nests were determined to be in significantly ($P = 0.02$) shorter trees ($\bar{x}$ = 32.0 m, N = 5) than unsuccessful ($\bar{x}$ = 37.9 m, N = 5) nests.

DISCUSSION

The effects of plot scale were minimal for both Red-tailed and Red-shouldered hawks. Degree of differences gradually decreased with increase in circle scale, but some differences existed at the largest scale. Because the size of the mesoplot circle was based on actual Red-shouldered Hawk home ranges, final results and discussions of management implications may be most appropriately based at this scale. Red-tailed Hawk home range analysis is needed for the heavily forested Southeast. Once home range size is determined, applicability of our plot sizes could

TABLE 3

MEAN ± ONE STANDARD ERROR OF MICROHABITAT VARIABLES MEASURED AT RED-SHOULDERED AND RED-TAILED HAWK NEST SITES AND THEIR CORRESPONDING RANDOM POINTS

Variable	Red-shouldered Hawk (N = 12)	Random (N = 46)	Red-tailed Hawk (N = 10)	Random (N = 59)
DISTWAT(m)	68.0 ± 21.2[c]	163.8 ± 28.4[d]	355.3 ± 64.6	260.0 ± 19.9[d]
DISTEDGE(m)	57.3 ± 16.2[c]	43.9 ± 6.1[d]	14.9 ± 2.2[b]	39.4 ± 4.6[d]
DISTOP(m)	139.1 ± 39.8[c]	104.4 ± 11.7[d]	19.6 ± 2.4[b]	98.2 ± 11.8[d]
DISTROAD(m)	274.1 ± 56.0	183.8 ± 17.2[d]	169.7 ± 23.2	117.4 ± 13.6[d]
3–8cm(#)	19.9 ± 3.4	21.4 ± 2.0	14.2 ± 4.9	19.4 ± 2.9
9–15cm(#)	9.3 ± 1.6	9.3 ± 0.7	10.3 ± 1.7[b]	6.0 ± 0.7
16–23cm(#)	4.0 ± 0.7	5.1 ± 0.4	5.6 ± 0.7	4.0 ± 0.5
24–38cm(#)	3.4 ± 0.5	4.4 ± 0.4	3.9 ± 0.9	3.7 ± 0.3
39–53cm(#)	2.7 ± 0.4	2.2 ± 0.2	2.3 ± 0.5	2.4 ± 0.2
54–69cm(#)	0.8 ± 0.2	0.8 ± 0.1	0.4 ± 0.2	0.5 ± 0.1
>69cm(#)	0.7 ± 0.2[a]	0.2 ± 0.1	0.2 ± 0.1[b]	0.0 ± 0.0
BASALAREA	37.6 ± 3.5	33.3 ± 1.8	29.0 ± 3.0	24.6 ± 1.3
SHRUBDEN	1822.9 ± 338.7[c]	3421.2 ± 452.9	5862.5 ± 1147.1	6883.5 ± 691.8
CANHT(m)	34.5 ± 2.1	33.4 ± 0.6	32.7 ± 1.0[b]	29.4 ± 0.5
GRCOVER(%)	38.0 ± 0.07	33.0 ± 0.03	44.0 ± 0.06	53.0 ± 0.03
CANCOVER(%)	87.0 ± 0.01[ac]	91.0 ± 0.00	81.0 ± 0.02	71.0 ± 0.02
UNCOVER(%)	58.0 ± 0.05	59.0 ± 0.02	51.0 ± 0.06[b]	29.0 ± 0.03

[a] Significant difference ($P \leq 0.05$) between Red-shouldered Hawk nest sites and their corresponding random sites.
[b] Significant difference ($P \leq 0.05$) between Red-tailed Hawk nest sites and their corresponding random sites.
[c] Significant difference ($P \leq 0.05$) between Red-shouldered and Red-tailed hawk nest sites.
[d] Sample size = 50.

TABLE 4

MEAN ± ONE STANDARD ERROR OF NEST-TREE VARIABLES AND NEAREST NEIGHBOR DISTANCES MEASURED AT RED-SHOULDERED AND RED-TAILED HAWK NEST SITES

Variable	Red-shouldered Hawk (N = 12)	Red-tailed Hawk (N = 10)
NESTHT(m)	21.32 ± 1.49[a]	28.22 ± 1.18
NETREEHT(m)	37.17 ± 2.72	34.97 ± 1.33
NETREEDBH(cm)	67.17 ± 7.02	53.70 ± 2.63
PERNESTHT	56.0 ± 0.02[a]	81.0 ± 0.02
NEARNGHBR(m)	1322.99 ± 317.12	1827.47 ± 193.00

[a] Significant difference ($P \leq 0.05$) between Red-shouldered and Red-tailed hawk nests according to Wilcoxon rank-sum tests.

be addressed. However, for the purpose of this study, Red-tailed Hawk nest circle mesoplot values probably sufficed for comparative analyses.

Habitat studies are often based on nests located without a random or complete search of the study site because of the time required to locate nests. Instead, raptor nests are usually located in an area where the birds previously were seen or heard. We were able to locate an additional one Red-tailed Hawk nest and two Red-shouldered Hawk nests because we searched in areas where there were no previous hawk observations. However, these nests were not in habitat types different than the other nests in our study and probably did not alter the results of our tests.

Red-shouldered Hawk nesting habitat was characterized by greater area of bottomland habitat with nests located in large stands. Both Bednarz and Dinsmore (1981, 1982), in Iowa, and Bosakowski et al. (1992), in New Jersey, determined quantitatively that bottomland and other wetlands are important habitats for breeding Red-shouldered Hawks. Stewart (1949), Henny et al. (1973), Portnoy and Dodge (1979), and Woodrey (1986) also reported riparian forests as the predominant nesting habitat. Bednarz and Dinsmore (1981) suggested a critical floodplain forest size of 250 ha, which was much larger than the 100 ha proposed by Robbins (1979). Bednarz and Dinsmore (1982) also suggested that upland habitat surrounding smaller floodplain forests may provide sufficient habitat for Red-shouldered Hawks and act as a buffer against Red-tailed Hawk encroachment. Red-tailed Hawks historically have been described as open country raptors often found in association with agriculture and forest clearings (Bent 1937). All of the Red-tailed Hawks nested at or near the edge between forested habitat and either pasture or recently clearcut habitat. We often observed pairs foraging at the edge of expansive cow pastures or from snags in relatively large (40 and 264 ha) clearcuts. Red-tailed Hawk nests were located near these foraging sites. Therefore, nest plots had a lower amount of edge and fewer and larger stands than random plots. Bednarz and Dinsmore (1982) also reported that Red-tailed Hawks seemed to prefer larger hunting areas with less interspersion.

Because Red-shouldered Hawks were associated with bottomland habitats and Red-tailed Hawks with upland sites, differences in nest-site macrohabitat characteristics were not surprising. Red-shouldered Hawks selected large areas of hardwood habitat, and Red-tailed Hawk nesting macrohabitat had more agricultural area. Red-shouldered Hawk nest plots also contained more edge. In their comparison of Red-shouldered and Red-tailed hawk macrohabitats, Bednarz and Dinsmore (1982) also determined that edge and number of feeding areas were important to Red-shouldered Hawks, which used numerous small marshes interspersed with forest when foraging.

If the primary step in choosing a nest site is habitat type selection, then it is important to determine what cues within that habitat type are involved in final nest-site selection. Within nesting habitat, larger trees (>69 cm) and lower percent canopy cover were the structural differences between Red-shouldered Hawk nest sites and random sites. Outside of the Southeast, nesting Red-shouldered Hawks also are associated with mature forest in or near wetland habitat. Pairs nested closer to water (Titus and Mosher 1981, Bosakowski et al. 1992) and in microhabitats characterized by larger, more mature trees (Titus and Mosher 1981, Morris and Lemon 1983, Woodrey 1986) than random sites. In Ohio, Woodrey (1986) described Red-shouldered Hawk nests as having greater percent canopy cover in association with more large trees. Because our nest sites also were characterized by more large overstory trees, a lower total canopy cover may be the result of a reduced number of understory and midstory trees in nest sites.

All Red-tailed Hawk nests were in loblolly pines in either pine or upland hardwood-pine habitat. No other study has shown an exclusive use of conifers as nest trees (Bent 1937, Fitch et al. 1946, Seidensticker and Reynolds 1971, Titus and Mosher 1981). Because deciduous trees were readily available, loblolly pines may have some important structural characteristics preferred by Red-tailed Hawks. Perhaps the loblolly pine's straight growth form or open canopy provides easier access to the nest (Bednarz and Dinsmore 1982).

The large diameter trees and well-developed understory at Red-tailed Hawk nest sites are characteristic of mature pine microhabitats. Nest sites were closer to openings and edges, had a greater canopy height, and had taller trees than other sites within pine and hardwood-pine habitat. Each of these characteristics favors easy nest access. Other studies also determined that nest access was important in Red-tailed Hawk nest-site selection. Speiser and Bosakowski (1988) determined that Red-tailed Hawks nested closer to forest openings and on steeper slopes than random sites. Titus and Mosher (1981) and Bednarz and Dinsmore (1982) also found that pairs nested on steeper slopes.

Red-shouldered Hawks nested in sites with greater percent canopy cover and lower shrub density, which are both probably correlates of the habitat in which the birds nested. Floodplain forests tended to have a sparser shrub layer and a more dense canopy than upland pine habitat. By placing nests high in the nest tree near forest canopy openings, Red-tailed Hawks may have improved access from above. However, Red-shouldered Hawks placed nests low in the canopy, maybe improving access from below, where these agile flyers typically approach the nest. Nesting low in the canopy may protect Red-shouldered nestlings from insolation and adverse weather (Bednarz and Dinsmore 1982), and predation by large avian species (Morris et al. 1982, Woodrey 1986).

Each species selected mature forests offering more nest sites with larger trees when compared to available areas. Therefore, it may be important to leave some stands of older, larger trees in both pine and hardwood habitats to maintain these species. Encroachment by Red-tailed Hawks on Red-shouldered Hawk breeding territories was probably of minimal importance. In the study site, silvicultural activities were limited to upland pine habitat, and bottomland corridors were left undisturbed. The number of nesting Red-shouldered Hawks was relatively high and nest density was only slightly smaller than the highest recorded density (0.22/100 ha; Bosakowski et al. 1992). Although many intraspecific confrontations were observed for the species during the study, no interspecific competition for territory was noted. The minimum distance between a Red-shouldered and a Red-tailed hawk nest was 650 m, and the Red-shouldered Hawk nest successfully fledged young. Bednarz and Dinsmore (1982) suggested that forest clearing and development of pastures along drainage areas might shift the competitive advantage from Red-shouldered to Red-tailed hawks. Bryant (1986) also reported that selective cutting in woodlots and failure to maintain uncut buffer zones around traditional Red-shouldered Hawk nest sites may result in local extirpation of the species. We also agree that contiguous floodplain forests must be left relatively undisturbed to conserve this species. Large bottomland corridors should exclude Red-tailed Hawks because they provide poor canopy access from above. However, pine timber management on upland sites probably does not adversely affect nesting Red-shouldered Hawks and silvicultural and agricultural practices provide the edges and openings important to nesting Red-tailed Hawks.

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