Figure 1. Two examples of triple or quadruple primary crotches in deciduous trees, the preferred nesting substrate for Northern Goshawks in eastern mixed forests.

NEST TREES SELECTED BY NORTHERN GOSHAWKS ALONG THE NEW YORK-NEW JERSEY BORDER

ROBERT SPEISER AND THOMAS BOSAKOWSKI

During the past two decades, research has begun to elucidate essential parameters of Northern Goshawk (*Accipiter gentilis*) nesting habitat in North America (McGowan 1975, Allen 1978, Hennessey 1978, Shuster 1980, Reynolds *et al.* 1982, Moore and Henny 1983, Hall 1984, Speiser and Bosakowski 1987). The role of the nest tree in site selection often has been overlooked or emphasized less than other habitat variables. In this paper, we examine the nest trees used by Northern Goshawks for nesting on the southeast margin of their range. This area provides an unique opportunity to examine nest tree selection in an ecotone between northern and southern tree associations. Here we attempt to explain why certain trees were chosen by Northern Goshawks for nest building and what advantages were gained by selecting these trees. These findings could lead to better forest management practices for nesting Northern Goshawk populations in the Northeast.

STUDY AREA AND METHODS

Goshawk nests were located in hilly, mostly forested terrain within 30 km of the New York-New Jersey border, and is included by Bull (1964) as part of the New York [City] Area. This area includes Orange and western Rockland Counties in New York and northern Sussex, northern Morris and northwestern Passaic Counties in New Jersey. Here, the range of the Northern Goshawk ends along the coastal plain. Nesting in this area has been documented since 1964 following a southern range extension (Speiser and Bosakowski, 1984).

A total of 32 nests were found at 18 different breeding areas (*sensu* Grier 1982) from 1977 to 1987. Detailed descriptions of the study area, field work and methods are reported elsewhere (Speiser and Bosakowski 1984, 1987). This paper includes data on 10 additional nests. The total number of trees and species composition within a 21.5 m radius (= 0.145 ha) centered on the nest tree were recorded at 26 nest sites. Tree diameters at breast height (DBH) were measured with calipers (<50 cm DBH) or from circumferences (>50 cm DBH). Heights were measured with a homemade triangulation instrument (Bakst 1967), accurate to 0.3 m. Other standard forestry procedures followed those

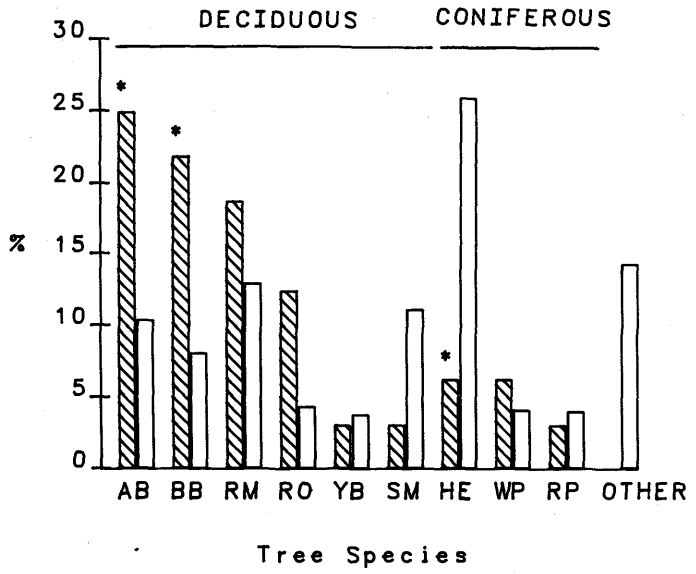

Figure 2. Frequency distribution of tree species used for nesting (shaded bars) by Northern Goshawk versus mean relative density of trees in all nest sites (open bars). Asterisks indicate a significant difference between use and availability (Fisher Exact Test, $p < 0.05$). AB = American Beech, BB = Black Birch, RM = Red Maple, RO = Red Oak, YB = Yellow Birch, SM = Sugar Maple, HE = Eastern Hemlock, WP = White Pine, RP = Red Pine.

outlined in Husch and Beers (1982). Canopy cover and shrub cover were estimated visually at the nest sites and were rounded to the nearest 5 percent. Suitability of other trees for nest substrate in the nest site was estimated by inspection from the ground.

RESULTS

A total of 9 tree species were used for 32 nests: Black Birch (*Betula lenta*) 25%, American Beech (*Fagus grandifolia*) 22%, Red Maple (*Acer rubrum*) 19%, Red Oak (*Quercus rubra*) 13%, Eastern Hemlock (*Tsuga canadensis*) 6%, White Pine (*Pinus strobus*) 6%, Sugar Maple (*Acer saccharum*) 3%, Yellow Birch (*Betula alleghaniensis*) 3%, and Red Pine (*Pinus resinosa*) 3%. On the basis of availability of tree species in the 26 quantified nest site plots (Fig. 2), Black Birch and American Beech were used as nest trees significantly more often than expected from their relative frequency (Fisher Exact Test: $p = 0.013$, $p = 0.017$, respectively)

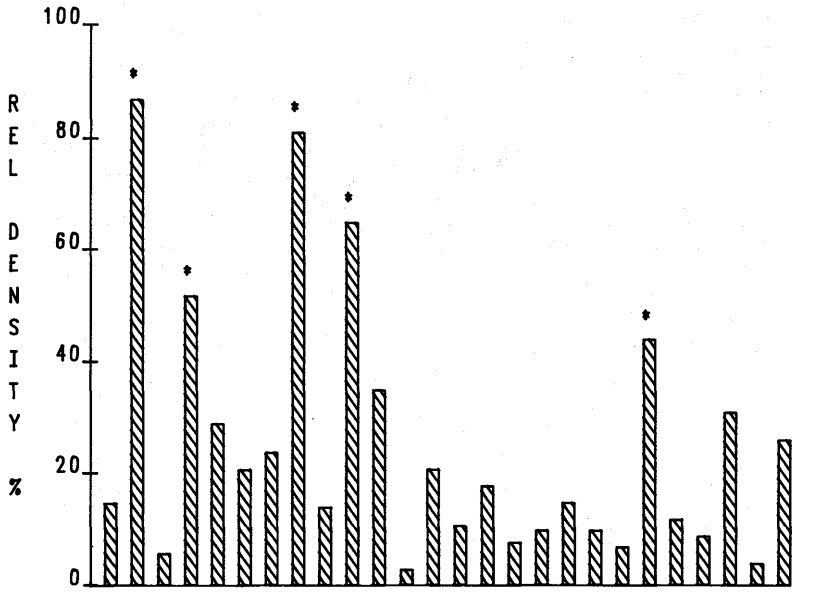

Figure 3. Relative frequency of the nest tree species in 26 quantified nest site plots of Northern Goshawk. Asterisks indicate nest sites where the nest tree was the dominant tree species in the plot (0.145 ha).

whereas Eastern Hemlock was used significantly less often ($p = 0.007$). At individual nest sites, Northern Goshawks selected the dominant (highest relative frequency at the nest site) tree species for nesting in only 5 cases (Fig. 3).

In our study, the majority (58%) of nests were constructed in primary crotches (Fig. 1), with the remainder in secondary crotches (21%) or in limb axils (21%). Comparison of nest sites and adjacent forest showed that the branching structure preferred for nest placement (triple or quadruple crotch) was very uncommon. Only one nest site contained more than one tree with a triple-quad primary crotch.

All nest trees were alive when they were used for nesting. The nest tree was the largest tree (DBH) in the nest site plot in 4 instances. Nest tree diameters ranged from 19 to 63 cm (mean = 39.7, SD = 10.78, N = 29). Nest tree heights ranged from 14.3 to 41.6 m (mean = 23.6, SD = 6.02, N =29). The height of nests above ground ranged from 7.4 to 20.4 m (mean = 12.6, SD = 2.84, N =29). Of these 3 variables, nest tree height

Figure 4. Example of typical open understory around a goshawk nest tree in eastern mixed forest of the northern New Jersey Highlands. Note unobstructed view between camera and person standing next to the nest tree (arrow).

had the highest linear least-squares correlation with tree diameter (r = 0.827) while nest height and tree diameter had the lowest correlation (r = 0.745). The correlation between nest tree height and nest height fell between these values (r = 0.775). All three correlations were similar, suggesting that nest height was related to the height and girth of the nest tree. Nest height above ground as a percentage of nest tree height ranged from 38-74% (mean = 54.5, SD = 8.80, N = 29). The minimum canopy cover in a nest site was 65%; 76% of the sites had at least 80% cover. The shrub layer surrounding the nest tree was greater than 10% cover in only one case.

One nest was inspected closely. It was comprised of sticks mostly 4.5 to 6.0 mm in diameter. The nest cup was lined with hemlock bark strips and the entire nest was liberally draped with sprigs of hemlock foliage. All other active nests observed in the study area contained greenery, usually hemlock or white pine sprigs.

DISCUSSION

It is apparent from nest tree analysis that Northern Goshawks were selective in choosing suitable nest trees. The primary feature associated with nests is the presence of triple or quadruple crotches for stable nest support. This factor is apparently not significant in Western coniferous forests (Reynolds *et al.* 1982, Moore and Henny 1983, Hall 1984) but has important management implications in the Eastern Deciduous Forest Biome. If suitable nest trees can be identified within an otherwise suitable stand, these stands and trees can be protected from harvest or other disturbance to help assure an adequate supply of Northern Goshawk nest sites. Newton (1979) mentions that in a survey of nest trees for White-tailed Eagles (*Haliaeetus albicilla*) in Finland, only one in a thousand trees were suitable for nesting.

Deciduous hardwood trees were favored (84%) for nest trees despite the availability of conifers at many nest sites. *Betula* and *Fagus* probably were preferred for nesting because large triple or quadruple crotches occur more frequently in these genera owing to their highly deliquescent growth forms. Conifers have a different growth form than hardwoods and rarely produce large, relatively open tree crotches. Thus, when nesting in eastern mixed forests, Northern Goshawks more often use deciduous hardwoods (Todd 1940, Allen 1978, this study) in contrast to regions where conifers predominate (Reynolds et al. 1982, Moore and Henny 1983, Hall 1984). Northern Goshawk nests constructed in primary crotches were bulkier than those in secondary crotches and limb axils and nest durability was also greater. Nests in primary crotches often remained in good condition and were identifiable 8 years following their last use, while nests in secondary crotches usually disintegrated after 3-4 years. This difference suggests that building nests in primary crotches is adaptive because nests in primary crotches also should be expected to collapse less often during occupancy.

Because of the preference for primary crotches, nests were almost always situated below or in the bottom quarter of the canopy. Thus, variability of nest heights probably was a function of variable canopy heights in the study area since nest height remained strongly correlated with the height and girth (DBH) of the nest tree. The height of the nest appears to be less important than is the type of nest support and relative position in the canopy.

Nest trees were often relatively isolated in the nest site despite the typically continuous canopy cover of the nest site. Another large tree (50+ cm DBH) was within 3 m of the nest tree trunk in only one instance.

Most nest trees had at least one cardinal direction in which there were few or no neighboring trees within 15 m, although the canopy usually remained unbroken (Fig. 4). This resulted in part from the large size of nest trees and in part from the overall habitat selected, usually mature and old growth forest (Speiser and Bosakowski 1987). Understory trees and the shrub layer were usually sparse or absent, leaving relatively open flyway space below the canopy. In addition, the nest trees often had a small (although rarely large enough to create a break in the canopy) open area directly adjacent on at least one side. This feature also has been observed by other investigators (Shuster 1980, Reynolds *et al.* 1982, Hall 1984) and suggests the importance of an unobstructed flight path to the nest. The apparent value of this open flyway space was evident upon numerous observations of nest defense by the adults when we intruded upon active nest sites.

Active Northern Goshawk nests always displayed greenery. Newton (1979) reviewed the theories of greenery utilization by nesting raptors. Pre-incubation greenery is thought to serve as a signal marker of ownership, warning other raptors. We suggest that during the nestling stage the greenery enhances the comfort level for downy young by virtue of its softening effect as well as covering feces and decaying prey remains in the nest.

Northern Goshawks clearly selected certain tree species as nest trees. If the choice was independent of tree species, then Northern Goshawks should nest most often in the most dominant tree species. This only occurred at 19% percent of nest sites. Instead, Northern Goshawks overutilized Black Birch and American Beech and underutilized Eastern Hemlock. The preference of Black Birch for nesting is noteworthy since it has seldom been reported as a nesting tree for the Northern Goshawk (Table 1). This shift away from more traditional nest tree species following the southern range extension of the Northern Goshawk suggests that the choice is not fixed by imprinting (Hilden 1965) or early experience (Klopfer 1963). Rather, nest tree selection probably is the result of a preference for certain structural characteristics (e.g., large open triple/quad crotch) which may occur more frequently in particular tree species. The fact that Northern Goshawks in the East have nested in a variety of other tree species (Table 1) also shows that these hawks are flexible as to the type of nest tree species they select. Newton (1976) suggested that nest site preferences are not fixed genetically and changes in preferences can become established in a population through conditioning or imprinting. Thus, Northern Goshawks slowly spreading southward into the temperate deciduous forests of the New

York area could be expected modify their habitat and nest tree use. This process was called "tradition drift" by Wilson (Temple 1978) and can change population traits and niche dimensions more rapidly than genetic drift.

If the limited supply of suitable nest trees dictates the ultimate location of a nest within a suitable forest stand, then the importance of other nesting habitat features may be obscured by the characteristics of suitable nest trees. This would introduce an additional source of variation into the study of nest-site habitat selection by Northern Goshawks.

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Table 1. Northern goshawk nest tree species in eastern North America.

Source	Location	Description
Knight, cited in Bent (1937)	Maine	often in birch or maple, occasionally in pine, spruce or fir
Todd (1940)	Pennsylvania	mostly beech; others include oak,pine, hemlock, Black Birch, maples
Bull (1974)	New York	mostly deciduous trees (85%); beech favored (40%)
R. Parris (*pers. comm.*)	New York (Tug Hill Plateau)	mostly in Sugar Maples
Allen (1978)	New York	Yellow Birch (33%), beech (33%), Sugar Maple (17%), Black Cherry[a] (8%)
Root and Root (1978)	Connecticut	White Pine (30%), Red Oak (15%), Black Birch (10%), Red Maple (10%), beech (10%), hemlock (10%), Yellow Birch (5%), Red Pine (5%), White Birch[b] (5%)
S. Postupalsky (pers. comm.)	Michigan	mostly deciduous: aspens, White Birch, Yellow Birch, beech, Sugar Maple, basswood[c], White Pine, Jack Pine[d]

a-*Prunus serotina*, b-*Betula papyrifera*, c-*Tilia americana*, d-*Pinus banksiana*