HABITAT ASSOCIATIONS OF SYMPATRIC RED-TAILED HAWKS AND NORTHERN GOSHAWKS ON THE KAIBAB PLATEAU

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Abstract: We investigated habitat association of sympatric red-tailed hawks (*Buteo jamaicensis*) and northern goshawks (*Accipiter gentilis*) at 2 spatial scales centered on nest sites: (1) fine-scale patterns of forest structure and topography within 16-m radius circles (0.08 ha), and (2) midscale patterns of forested and nonforested areas, forest fragmentation, and topography within 2,085-m-radius circles (1,367 ha). Nonforested areas were defined as any area lacking >20% canopy closure within a 30 × 30-m cell. At both scales, red-tailed hawk associations were more variable and goshawk associations less variable. At the fine scale, goshawks were consistently associated with open understories, tall trees, and gentle slopes ($\bar{x}$ = 9.6°, SD = 6.9) while red-tailed hawks were associated, on average, with steep, north-facing slopes ($\bar{x}$ = 17.4°, SD = 8.1) and dense understories. At the midscale, goshawks were consistently associated with patches of continuous forest and level terrain within 645 m of nest sites. Red-tailed hawks were associated with nonforested areas located within 105–645 m of nest sites and steep slopes within 105 m of nest sites. Forest fragmentation was greater around red-tailed hawk nest sites, and forested regions were more aggregated around goshawk nest sites when compared with the other species. These patterns indicate that on the Kaibab Plateau, red-tailed hawks will gain habitat at the midscale and goshawks will lose habitat at both scales if forests are fragmented and mature forest structure is altered.

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Northern goshawks (hereafter referred to as goshawk) in North America breed in a variety of forest types, with nest sites typically found in association with mature to old-growth forest structure; foraging and winter habitat are poorly studied but appear to be more diverse and not as strongly dependent on mature forest structure (Squires and Reynolds 1997). The U.S. Forest Service designated goshawks as a "sensitive species" throughout the species' western range based on concerns related to the impact of forest management practices on goshawk breeding habitat. The status of goshawk populations in the western United States remains the subject of concern and debate (Kennedy 1997, DeStefano 1998, Smallwood 1998). In North America, red-tailed hawks are abundant, ubiquitous, and typically associated with nonforested areas in various environments including coniferous and deciduous forests (Preston and Beane 1993). Several investigators have suggested that red-tailed hawks may be replacing goshawks as forests are cleared and fragmented (Crocker-Bedford 1990, Kenward 1996, Erdman et al. 1998). The relationship and habitat associations for sympatric *Accipiter* species (Reynolds et al. 1982, Reynolds and Meslow 1984, Bosakowski et al. 1992), sympatric *Buteo* species (Schmutz et al. 1980, Janes 1994, Bosakowski et al. 1996), and sympatric *Buteo* and *Accipiter* species (Titus and Mosher 1981, Selás 1997, Sánchez-Zapata and Calvo 1999) have been the subject of numerous investigations; yet the relationship and habitat associations of sympatric red-tailed hawks and goshawks has not been studied.

Our objective was to provide descriptive information on the habitat associations of sympatric red-tailed hawks and goshawks during the breeding season. We focused our investigation on forest structure at nest sites and forest fragmentation and the presence of nonforested areas around nest sites to clarify how these species will be impacted by forest alterations in the western United States.

STUDY AREA

Red-tailed hawks and goshawks occur sympatrically on the Kaibab Plateau in northern Arizona, USA. Vegetation within our study area on the plateau consisted of ponderosa pine (*Pinus ponderosa*) forest between elevations of 2,075 and 2,500,

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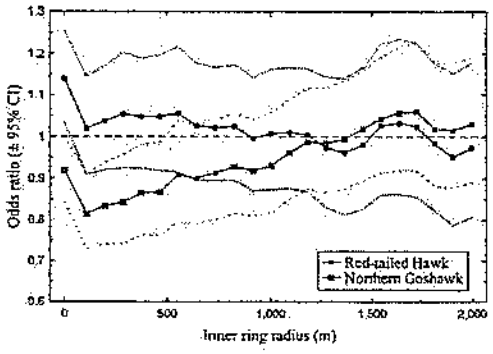

Fig. 4. Estimated change in odds and 95% confidence intervals associated with a 1° increase in slope within 23 concentric ring plots (midscale) at 90-m intervals centered on red-tailed hawk ($n = 41$) and goshawk ($n = 62$) nests and random sites ($n = 62$) on the Kaibab Plateau, Arizona, USA, in 2000.

age goshawk nest site contained a forested area centered at the nest site with small nonforested areas dispersed around the perimeter of the plot (Fig. 5B).

DISCUSSION

The associations at the fine scale can be interpreted based on behaviors unique to the 2 species. Typically, red-tailed hawks enter nests from above the canopy and goshawks enter nests from below the canopy. Researchers have argued that open and unobstructed access to nests from above the canopy is an important factor in red-tailed hawk nest-site habitat selection (Orians and Kuhlman 1956, Titus and Mosher 1981, Bednarz and Dinsmore 1982). Therefore, forest structure below red-tailed hawk nests is secondary, and features related to the nest tree and topography are primary. Nests located high in tall trees on steep, north-facing slopes would presumably allow easy access to nests, a favorable microclimate within the nest with reduced solar radiation, and a clear view of the surrounding area. In contrast, goshawk nest sites were associated with characteristics of mature forest structure. This result is consistent with numerous investigations documenting high canopy closure, mature trees, and open understories at goshawk nest sites (Reynolds et al. 1982, Speiser and Bosakowski 1987, Hayward and Escano 1989, Squires and Ruggiero 1996). These features presumably would allow easier access to nests, unhindered movement through the surrounding forest, a clear view of the forest floor, and a suitable microclimate within the nest.

At the midscale, red-tailed hawks displayed more variation overall and were associated with nonforested areas between 105 and 645 m of the nest site and steeper slopes within 105 m of the nest site. At the midscale, patterns documented within 105 m of the nest site mirrored patterns documented at the fine scale, thus supporting the conclusion that steep slopes are an important factor and forest structure is secondary at, and immediately surrounding, the nest site. Studies examining red-tailed hawk habitat associations have documented both a strong association (Mindell and Samuel 1984, Speiser and Bosakowski 1988, Moorman and Chapman 1996) and no apparent association with nonforested areas (Titus and Mosher 1981). These discrepancies likely result from differences in forest structure and landscape pattern among study areas. Our results support the conclusion that red-tailed hawks nesting in forested environments are capable of tolerating a broad array of forest structures and that fragmented forest structure and nonforested areas appear to play a central role in these associations.

Goshawks were consistently associated at the midscale with regions of continuous forest centered at the nest site. The negative association with nonforested areas extended to 645 m and was strongest within 375 m of the nest site. This forested area corresponds to the post-fledging family area (PFA; Reynolds et al. 1992) estimated at 168 ha or a circle with a radius of 732 m (Kennedy et al. 1994). The PFA, characterized by mature forest structure, is the area where adults forage during the breeding season and young develop their hunting skills. In addition, our results indicate an association with gentle slopes that extend to 555 m from goshawk nest sites. This pattern is consistent across the fine scale and midscale but is not consistent with findings of other investigations (Squires and Reynolds 1997). The predominance of gentle terrain on the Kaibab Plateau and the presence of mature forest structure with open understories in regions with gentle slopes might explain this pattern.

In summary, the patterns of goshawk and red-tailed hawk habitat associations were distinctly different at both the fine and midscale. Goshawks were considerably more specialized at both scales and presented consistent patterns of continuous forest structure on level terrain at both scales. Red-tailed hawks presented greater variation at both scales, with differing central tendencies from goshawks. The pattern at the fine scale suggested that habitat selection for red-tailed hawks

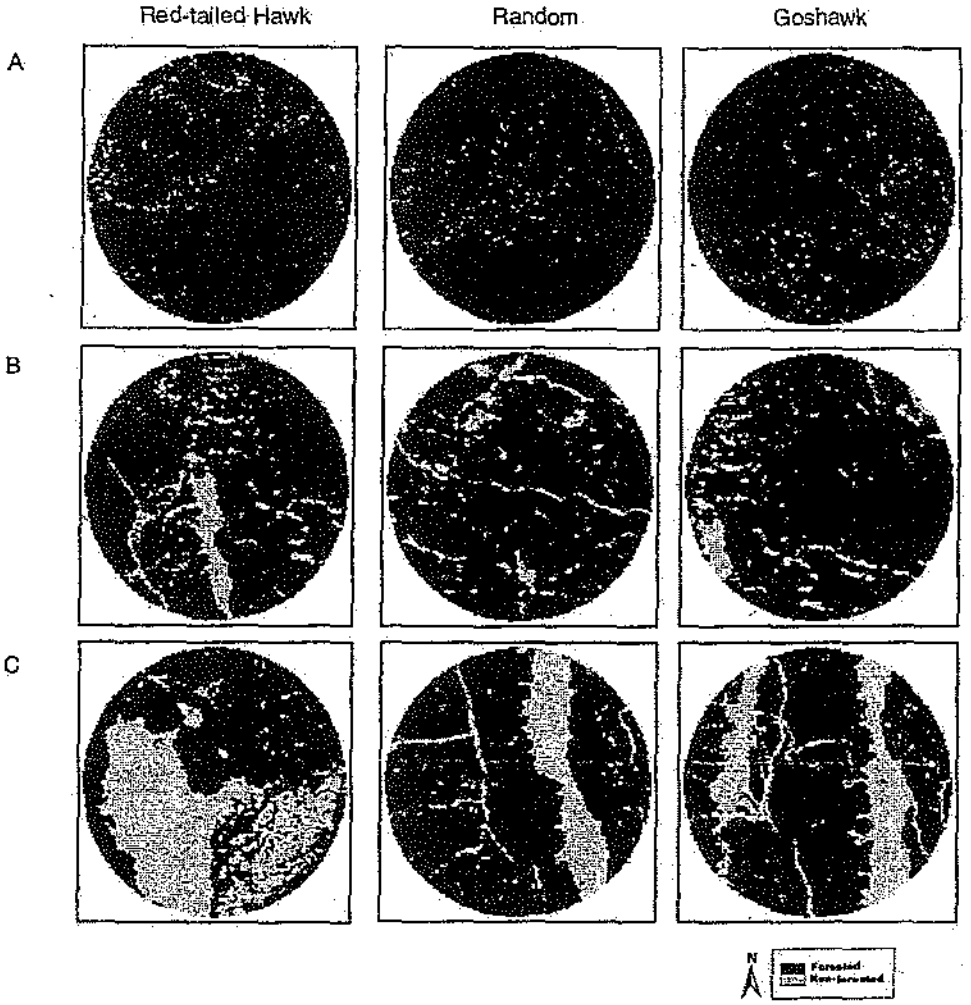

Fig. 5. Classified Landsat images (10 Oct 1999; 30 × 30-m cells) of sites that represented the (A) minimum, (B) that most closely approximated the mean, and (C) represented the maximum for 6 landscape indices measured in 2,085-m radius circles (midscale) centered on red-tailed hawk ($n = 41$) and goshawk ($n = 62$) nests and random sites ($n = 62$) on the Kaibab Plateau, Arizona, USA, in 2000.

was not based on consistent patterns of forest structure, as was found at goshawk nest sites, but with features related to nest position and access. Thus, selection was occurring primarily for the nest tree and its relationship to the surrounding topography for red-tailed hawks and for features within and below the canopy for goshawks. Patterns at the midscale suggested that habitat selection for red-tailed hawks was based on the presence of nonforested areas and fragmented forest structure around the nest site and steep slopes at the nest site. For goshawks, patterns at the midscale suggested that selection was occurring exclusively for regions of continuous forest on level terrain centered at the nest site.

MANAGEMENT IMPLICATIONS

Our study reaffirms that the habitat associations of goshawks during the breeding season are regionally consistent within a particular environment. This allows resource managers to identify areas containing goshawk breeding habitat and develop management guidelines to protect them (e.g., Reynolds et al. 1992). However, successfully

managing for a species' unique habitat requirements is becoming more difficult in the western United States due to a variety of economic, political, ecological, and social pressures placed on forests and forest managers. An ecological factor that we examined is the presence of a very successful generalist, the red-tailed hawk, which introduces a variety of concerns for goshawk management. One is the possibility of competition for habitat or prey between the 2 species. Another is the encroachment of red-tailed hawks into goshawk territories. If goshawk habitat is altered beyond the range of association documented in our study, it could transition into red-tailed hawk habitat. Both factors could reduce the number of goshawk breeding territories within a region and potentially negatively impact the goshawk population. Our study did not attempt to examine the consequences of competition or habitat alteration; nevertheless, when sympatric, these 2 species coexist in a relationship defined in large part by available habitat. Red-tailed hawks, or any other bird-of-prey, are not likely to represent a serious competitive threat to goshawk populations because of the goshawk's unique habitat associations and highly aggressive behavior. The real issue is one of habitat; if the habitat requirements of a species are not available, that species will have difficulty fulfilling its ecological role. In this case, the threats to goshawk breeding habitat are more severe because of the goshawk's specialization on features that have economic value and features that are threatened by catastrophic wildfires. Thus, to increase the likelihood that goshawk populations persist in the western United States, an important management goal should be to retain goshawk breeding habitat within the goshawk's range of association. This study and many others have attempted to document these associations for particular regions and environments. In addition, an understanding of the forces that are acting to alter forests in the western United States and the potential long-term outcomes of these processes to forest ecosystems need to be incorporated into management strategies.

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