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SUSTAINING FOREST HABITAT FOR THE NORTHERN GOSHAWK: A QUESTION OF SCALE

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Abstract. The nest area, post-fledging family area, and foraging area are critical home range components for maintaining Northern Goshawk (*Accipiter gentilis*) populations. Each of these forest components has a specific purpose in the life history of the Northern Goshawk and each contains several important attributes, ranging from forest structure to forest floor characteristics. The way in which home range components in a forest regenerate, develop, and die is highly variable, both temporally and spatially. Therefore, forests need to be regenerated and tended to ensure that a portion of a goshawk's home range is in old forests indefinitely. This can be best accomplished by analyzing and managing large tracts of forests as sustainable ecological units rather than managing smaller tracts of forests as individual home ranges.

Key Words: Accipiter gentilis; ecosystem analysis; forest management; home ranges; Northern Goshawk; sustainability; vegetative structural stage.

The Northern Goshawk (*Accipiter gentilis*) is a top-level consumer that occupies many forest types in the western United States. However, in some localities there are indications that populations are declining because of habitat loss due to tree harvesting (Herron et al. 1985, Crocker-Bedford 1990). Because little information exists on the number of breeding pairs in these forests, it is prudent to identify and conserve goshawk habitat to prevent populations from declining or individuals from becoming isolated. The identification and conservation of every goshawk home range is important (Reynolds et al. 1992). Forest management recommendations that sustain forest composition and structure necessary for goshawk habitat have been developed (Reynolds et al. 1992). These recommendations were primarily for use in the southwestern United States but they are being adapted for use in other areas of the West.

The nesting home range of goshawks contains three components: the nest area, the post-fledging family area, and the foraging area, each with its individual characteristics and management requirements. Forest management recommendations for the goshawk were developed on the premise that considerable information was available on nesting habitats (Schnell 1958, Reynolds and Meslow 1984). Throughout the western United States goshawks are known to nest and hunt successfully in a wide variety of forest types and structures (Fischer 1986, Kenward and Widén 1989), indicating that foraging habitat may be as closely tied to prey availability as to forest structure or composition. Another important component of goshawk habitat is the area surrounding the nest that is used by fledglings until they are no longer dependent on the adults for food. This intensively used area has been termed the post-fledging family area or PFA (Reynolds et al. 1992). If goshawks winter on or near their nesting home ranges, it should be possible to maintain goshawk populations by maintaining these three habitat components. This paper describes the difficulties of implementing the goshawk recommendations (Reynolds et al. 1992) and provides suggestions for analyzing and managing sustainable ecological units rather than individual goshawk home ranges.

NESTING HOME RANGE COMPONENTS

Nest areas have been thoroughly studied and are readily identified by vegetation structure (Reynolds et al. 1982, Reynolds 1983). Nest areas include one or more forest stands, several nests, and several landform characteristics. The size and shape of nest areas depend on topography, and on the availability of dense patches of large trees ranging in size from 8 to 12 ha. Within a given forest type, characteristics of nest areas can vary depending on forest productivity (defined as the amount of vegetation a site can support and how quickly it accumulates). Nest areas within highly productive forests have more trees and denser canopies than nest areas in less productive forests. Similarly, tree ages in a nest area can be highly variable, depending on forest type. For example, aspen (*Populus tremuloides*) and lodgepole pine (*Pinus contorta*) are much shorter-lived than western hemlock (*Tsuga heterophylla*) or western redcedar (*Thuja plicata*).

Surrounding the nest area is the PFA and foraging area mosaic. The PFA is a 170-ha (range = 120–240 ha) mosaic of large trees, large snags, midaged forests, small openings with a herbaceous understory, and large, downed logs. The foraging area is 2200 ha (range = 2000–2400 ha)

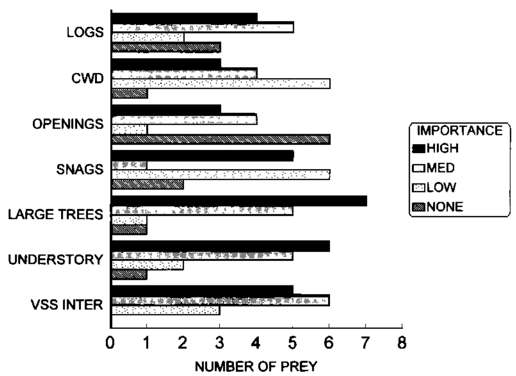

FIGURE 1. Relative importance of special habitat attributes for maintaining sustainable populations of 14 selected northern goshawk prey (Reynolds et al. 1992). Logs = downed logs >45 cm in diameter; CWD = coarse woody debris >7.5 cm in diameter; opening = breaks in forest canopy; snags = dead trees >45 cm in diameter and >9 m tall; large trees = live trees > 45 cm in diameter; understory = presence of herbaceous and shrubby species; VSS inter = interspersion of vegetative structural stages.

of forest that provides the food base for nesting goshawks. This area contains the habitat for larger birds and mammals that serve as prey. A wide variety of these animals are found in the diets of goshawks. They vary from mourning doves (*Zenaida macroura*) and Steller's jays (*Cyanocitta stelleri*) to chipmunks (*Tamias* spp.) and red squirrels (*Tamiasciurus hudsonicus*). The foraging area provides conditions for these animals to thrive, and also provides opportunities for the goshawk to hunt and capture them.

The foraging area is similar in structure to the PFA, with large trees, openings, snags, and downed logs interspersed throughout. An important component of both the PFA and foraging area is the development of hypogeous (underground) fungi, whose fruiting bodies provide food for many small animals. Many of these fungi are also ectomycorrhizal symbionts that play an important role in the uptake of water and nutrients by forest plants. Moreover, these organisms have a positive relationship with the amount of organic materials (e.g., humus, decayed wood) in the forest floor and surface mineral soils (Harvey et al. 1987). Therefore, maintaining ectomycorrhizae habitat through forest management practices will contribute to both the maintenance of forest vegetation and populations of small animals in both the PFA and foraging area.

RECOMMENDED FOREST CONDITIONS

Goshawks prey on over 50 species of birds and mammals throughout their western range. Reynolds et al. (1992) selected 14 prey species that were of particular importance to the goshawk in the Southwest. Using the habitat characteristics associated with high, medium, and low populations of these 14 species, they summarized the importance of snags, downed logs, woody debris, openings, large trees, understory vegetation, and interspersion of forest vegetative structural stages (VSS) in goshawk foraging areas. VSS is a generalized description of forest age and tree size (diameter) from seedling to old forests (see Thomas et al. 1979, Reynolds et al. 1992 for further discussion on forest structural stages). The six VSS for southwestern forests were defined as grass/forb/shrub, seedling, young forest, midaged forest, mature forest, and old forest. Large trees, understory herb and shrub development, and the interspersion of the VSS were the most important characteristics for maintaining high and medium populations of goshawk prey (Fig. 1).

Also important to the prey are the amount and characteristics of the VSS in the foraging area. Reynolds et al. (1992) determined that midaged to old forests were the most important of the VSS for maintaining medium and high populations of goshawk prey (Fig. 2). The prey needed to maintain medium and high populations of goshawks required a minimum of a 2800 ha landscape of midaged, mature, and old forests, interspersed with openings and patches of small trees (saplings and young trees). This analysis showed the importance of VSS, but did not quantify the distribution of the VSS needed in the PFA and foraging area.

DISTRIBUTION OF VSS

The structure of naturally occurring forests depends on the rate of regeneration, growth, and mortality of forest vegetation and all of the interactions affecting these processes. In western hemlock and similar forest types, it usually takes less than 3 years for new seedings to become established after a disturbance (Haig et al. 1941). Trees may take more than 25 years, however, to become established in some ponderosa pine (*Pinus ponderosa*) forests (Pearson 1950). Forest growth is also highly variable, depending on forest type, site quality, and forest density (Schmidt 1988, Edminster et al. 1991). Natural life expectancy can be as brief as 10 years for Gambel oak (*Quercus gambelii*) to more than 450 years for Engelmann spruce (*Picea engelmannii*), even though 80-year-old Gambel oak and 600-year-old Engelmann spruce have been reported (Brotherson et al. 1983, Alexander and Shepperd 1990). Fire, insects, and diseases also play important roles in the longevity of western forests.

Although late-seral and old forests are preferred for goshawk habitat, forest vegetation is not constant but is dynamic and ever changing. Moreover, trees are mortal. They die, regenerate, and grow, making it impossible to maintain all, or even a majority of a forest in late-seral and old stages. Because of the dynamic nature of forests, transitional structural stages must be present to continuously replace these old forests. Therefore, to sustain goshawk habitat in southwestern ponderosa pine forests, approximately 10 percent of the forest needs to be regenerated every 20 years. This assumes 20 years for tree establishment and a moderate level of forest density control occurring naturally by either fire, wind, snow, or by human management. Because of tree growth rates, approximately 19% can be maintained as young forest, 17% as midaged forest, 20% as mature forest, and 24% as old forest in which trees over 200 years old may exist (Bassett et al., this volume).

In shorter-lived lodgepole pine and aspen forests or in a western hemlock forest where longevity is longer the VSS distribution required to sustain these forests would be different than those required for a ponderosa pine forest. Because the VSS distribution required to perpetuate a forest varies by forest type and density, Reynolds et al. (1992) generalized the distribution of VSS for forests in the Southwest. These generalized VSS distributions are 10% in regeneration openings, 10% in saplings, 10% in young forests, 20% in midaged forests, 20% in mature forests, and 20% in old forests. Therefore, the distribution of VSS for sustaining goshawk habitat in the Southwest was not related to the goshawk or its prey, but was based on the forest productivity, dynamics, and biological limitations.

Combining the habitat attributes (e.g., snags, downed logs) (Fig. 1) and the desired VSS distribution (Fig. 2), a desired forest structure for maintaining a prey base for goshawks was determined. This information, in combination with the knowledge of the nesting habitat preferred by the goshawk, led to recommended management and forest conditions for the nesting home range components of nest, PFA, and foraging areas (Reynolds et al. 1992).

SUSTAINING GOSHAWK HABITAT

Because of the suspected loss of goshawk habitat (Crocker-Bedford 1990), sustaining the recommended VSS distribution is the management objective for most areas that contain goshawks. Present forest conditions can be compared to the desired distribution of VSS for each nesting home range, and appropriate management strategies can be developed to sustain the desired forest structure. For example, if the present conditions of a foraging area in a single-species forest (e.g., ponderosa pine) had an excess of mature and old forest compared to the desired VSS distribution, regeneration could be planned to ensure a continual movement of trees through the VSS (Fig. 3). Alternatively, if young and midaged forests were in excess, these VSS could be thinned, freeing them to grow into the mature and old forest size-classes (Fig. 3). These examples of management options for sustaining goshawk habitat are for single-species forests with relatively simple structures.

During the past 200 years most of the forests of the Southwest have been influenced by fire suppression, timber harvest, and grazing by both domestic animals and wildlife (Dieterich 1983, Brawn and Balda 1988, Stein 1988). These influences have affected forest successional processes, creating forests that often have high tree densities, multiple forest canopies, and species compositions outside the range of natural variability, making them susceptible to disease and insect attack, and to forest replacing wildfires (Habeck and Mutch, 1973). If the recommended VSS distribution for the goshawk is applied based on the proportion of the foraging area in the various vegetative structural stages without regard to species composition, treatments could create an unstable forest environment. For example, if the present forest conditions showed an excess of mature and old ponderosa pine over a smaller size class of white fir (*Abies concolor*) and there was a shortage of midaged and young trees compared to the desired forest structure, the preferred treatment could be to remove the large ponderosa pine, making the distribution conform to the desired VSS. But the consequences of these actions would be a justification to harvest the large trees, creating a forest prone

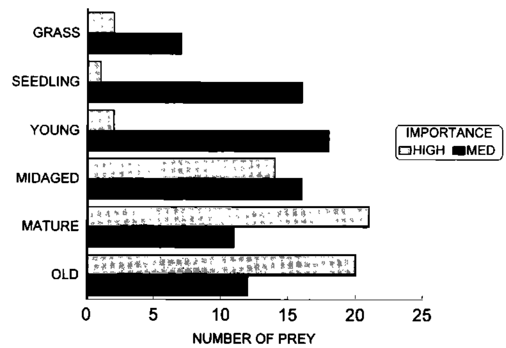

FIGURE 2. Relative importance of vegetative structural stages for habitat of selected prey species (Reynolds et al. 1992). The VSS were defined as grass = grass/forb/shrub and trees <2.5 cm in diameter; seedling = 2.6–13 cm trees; young = 14–30 cm trees; midaged = 31–46 cm trees; mature = 47–61 cm trees; old = >62 cm trees.

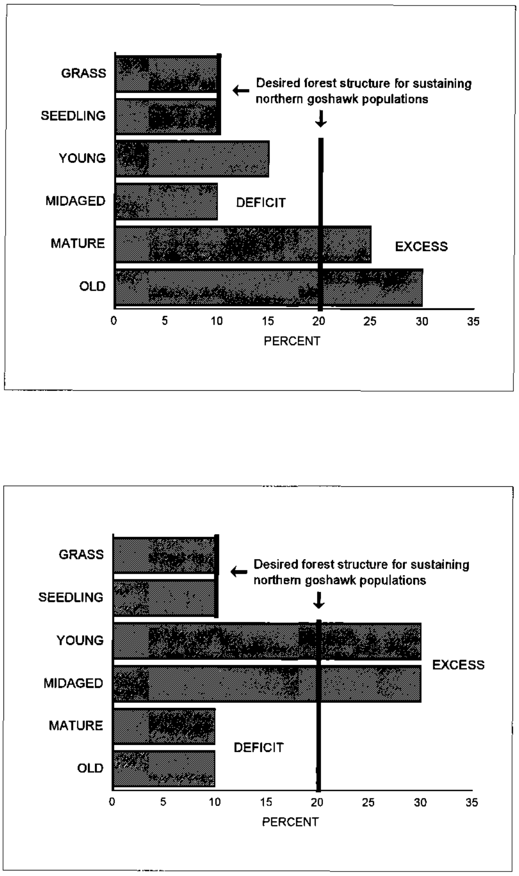

FIGURE 3. The top figure illustrates the distribution of the vegetative structural stages (VSS) for a hypothetical goshawk foraging area compared to the desired distribution as presented by Reynolds et al. (1992). The example shows an excess of trees in the mature and old-forest classes and a deficit in the young and midaged forest classes. Management activities in a forest with this structure could be designed to develop more young and midaged forests through regenerating a portion of the mature and old classes. The lower figure illustrates a forest structure that would benefit from thinning of the young and midaged VSS encouraging the development of mature and old VSS.

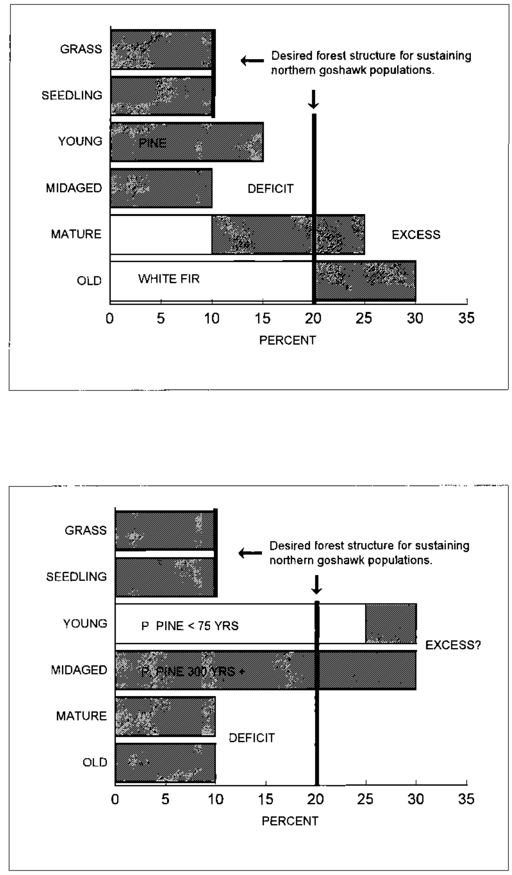

FIGURE 4. The distribution of the vegetative structural stages (VSS) for a hypothetical goshawk foraging area compared to the desired distribution as presented by Reynolds et al. (1992). The top example shows an excess of trees in the mature and old forest classes but a portion of these classes are white fir, a species prone to disease and insect attack. If the ponderosa pine were removed, leaving these trees, an undesirable and unstable forest susceptible to insect and disease attack and stand replacing fires would result. The bottom example shows an excess of trees in the young and midaged VSS but a portion of the trees are older than the life expectancy for ponderosa pine. If these trees were thinned, they probably would not grow to become large old trees.

to insect and disease attack, overcrowding, catastrophic wildfire, and other changes outside the range of natural variability (Habeck 1990) (Fig. 4).

In addition, the VSS classes are based on tree diameter and assume a good correlation between tree diameter and age, (e.g., the larger the tree is, the older it is). This is not always the case, as tree growth can stagnate when forest densities remain high for long periods (50 years or more). Small-diameter lodgepole pine, ponderosa pine, western hemlock, and western redcedar trees can easily be old (Pearson 1950, Lotan and Perry 1983, Graham 1988). If the VSS distribution had an excess of "young and midaged" trees that were actually old, thinning these old trees in the expectation they will become large old trees would not sustain the desired forest (Fig. 4)

Goshawks are habitat generalists and live in a variety of forest types such as aspen, lodgepole pine, ponderosa pine, western hemlock, western redcedar, Douglas-fir (*Pseudotsuga menziesii*), and several other western forest types. For example, the VSS distribution for maintaining a lodgepole forest might contain 5% in openings, and because of the biological limitations of this forest type only 10% might be maintained in old forests. To insure that at least 440 ha of a foraging area is always in old forests, a larger amount of younger and midaged transitional vegetation structures would be needed, increasing the total size of the foraging area. Therefore, forest type, length of the regeneration period, tree growth rate, and tree longevity will dictate how much area is required to insure enough old forest is available to supply the prey base for a goshawk family.

SPATIAL ARRANGEMENT OF FORAGING AREAS

Reynolds et al. (1992) recognized that the extent of overlap between foraging areas for adjacent pairs of goshawks is unknown. When PFAs are closely arranged, it is impossible to establish separate 2200-ha foraging areas for each PFA. In this situation, managers tend to reduce the size of the foraging areas but continue to prescribe a balanced VSS distribution on areas as small as 600 ha. This approach simplifies the application and verification of the VSS recommendations, but does not consider that the rationale for the VSS distribution is to regenerate and provide transitional vegetation structures to maintain a large component of old forests in each foraging area. Also, this approach divides the forest into small, discrete units that may be isolated from other portions of the forest limiting the ability for goshawks to forage for food. In addition, there is probably some physical, biological, or climatic reason why the nest areas were clustered.

A better approach to managing adjacent nest areas and associated foraging areas that overlap is to group them into larger management units, balancing the VSS distribution for the entire unit, yet maintaining the integrity of the recommendations. For example, if three nest areas were grouped, a 7000-ha unit might be formed; six nest areas could be grouped to form a 12,000-ha unit. These management units could be variable in size with boundaries defined by vegetation changes, physiographic differences, or some other well-defined structural division. This approach would be better than trying to manage an ever-changing forest of small, potentially fragmented foraging areas.

FOREST DYNAMICS

The forests of the West are changing every day. In the 10,000 years since the Pleistocene, over 2000 fires could have burned in a ponderosa pine forest if the fire return interval was five years, and over 20 forest-replacing fires could have occurred if the interval was 500 years. Surface fire intervals in much of the ponderosa pine and lodgepole pine forests were less than five years, but in the lodgepole pine forests stand replacement fires occurred every 40 to 100 years (Arno 1980). Likewise, the sizes of forest patches caused by fires varied, as did such things as the frequency of large scale bark beetle epidemics. To a limited extent, the natural range of these processes can be determined for many western forests. By understanding the range of natural conditions to which the goshawk, its prey, and all of the other plants and animals in an ecosystem are adapted, better management strategies can be devised. Not only will they sustain the goshawk but they may also perpetuate the ecosystem components associated with the goshawk.

ECOSYSTEM ANALYSIS

Instead of managing goshawk home ranges or even groups of goshawk home ranges, it would be more ecologically sound to develop management strategies for large geographic areas (approximately 100,000 ha). The goshawk recommendations produced by Reynolds et al. (1992) were an attempt to manage forests on a landscape level, but they have been criticized for not considering many of the other animals and plants in the ecosystems of the Southwest.

Determining the historical variation of vegetation structures for large geographic areas in the Southwest and comparing them to the existing conditions might offer a rational, ecological method of planning management of these forests. This comparison could consider abiotic and biotic components at various scales (e.g., watershed to river basin) and time period (e.g., 100 years in the past to 100 years in the future). Using these types of coarse filter analyses the Nature Conservancy has estimated that 85 to 90 percent of the species might be saved this way (Hunter et al. 1988).

Therefore, instead of analyzing 2200-ha goshawk foraging areas independently or grouping home ranges, it would be more ecologically sound to manage and analyze landscapes. Small 2200-ha forest landscape units would not contain many ecosystem processes and are not large enough to contain the natural range of variation of insect outbreaks or stand-replacing fires. Also, the 2200-ha foraging areas may be too small to support a goshawk family year-round. Therefore, if the goshawk is going to be sustained in the West, more than nesting home ranges need to be considered. Entire ecological units need to be analyzed and managed across vegetation types, land ownership, and political boundaries.

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