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# Management Recommendations for the Northern Goshawk in the Southwestern United States

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# Executive Summary

The northern goshawk (*Accipiter gentilis atricapillus*) (hereafter called the "goshawk") is the largest North American member of the genus *Accipiter*, which includes both the sharp-shinned hawk (*Accipiter striatus*) and the Cooper's hawk (*Accipiter cooperii*). It breeds in coniferous, deciduous, and mixed forests throughout much of North America.

The goshawk is a forest habitat generalist that uses a variety of forest types, forest ages, structural conditions, and successional stages. It preys on small- to medium-sized birds and mammals (robins and chipmunks to grouse and hares), which it captures on the ground, in trees, or in the air. A single goshawk may consume one-to-two prey per day.

The principal forest types occupied by the goshawk in the Southwest are ponderosa pine, mixed-species, and spruce-fir. There is a concern that populations and reproduction of the goshawk are declining in these forests and elsewhere in the western United States. These declines may be associated with forest changes caused by timber harvesting. However, fire suppression, livestock grazing, drought, and toxic chemicals may be involved. Because of the concerns over the effects of timber harvesting, the goshawk was listed as a "sensitive species" by the Southwestern Region of the Forest Service, U.S. Department of Agriculture in 1982.

## The Northern Goshawk Scientific Committee

The Northern Goshawk Scientific Committee (GSC) was established by the Regional Forester of the Southwestern Region in the fall of 1990. Its charter was to develop a credible management strategy to conserve the goshawk in the southwestern United States. This report describes the process used, findings, and recommendations of the scientific committee. In developing the recommendations, we used available information on goshawk biology, behavior, diet, and habitat. Information about goshawk foraging habitat was augmented with information on the habitat and foods of its main prey species. From this the GSC developed a set of "desired forest conditions" that, in their best estimate, will sustain goshawk populations in the Southwestern Region.

Because information on goshawk biology is limited, and our ability to produce and sustain certain forest conditions over long periods is unknown, the development of the "desired forest conditions" for the goshawk and its prey required certain assumptions:

1) goshawks and their prey populations are limited by the availability of their foods and habitats,
2) the availability of abundant, sustainable prey populations reduces the probability that food is limiting,
3) extreme fluctuations of goshawk populations caused by changes in the abundance of one or more prey will be dampened when a wider variety of prey species are available,
4) the foods and habitats of goshawk prey in southwestern forests are similar in adjacent regions, and
5) the forest attributes and age-classes of southwestern forests described herein can be sustained with scientific management.

These assumptions reveal areas where research is needed on goshawk and forest ecology.

The following are key concepts fundamental to the GSC recommendations:

- Forests within goshawk nesting home ranges should be an interspersed mosaic of structural stages -- young to old forests -- to increase the diversity of habitat for goshawks and their many prey species. Six vegetation structural stages (VSS) were used to describe regeneration, growth, and development of forests in the Southwest (Fig. 1). The proportions of the VSS and their interspersion in the forest is how the GSC described the forest mosaic.
- The extent to which southwestern forests were modified by Native Americans before European settlement is not well known. Since European settlement, management practices (such as timber harvesting, livestock grazing, and fire control) have changed the structure and species composition of forests. Today, much forested area consists of dense "thickets" of small-diameter trees (Fig. 2). Forests containing these thickets are prone to catastrophic, tree-killing fire, and insect and disease outbreaks. Because of inter-tree competition for moisture, nutrients, and light, these thickets will not mature into large trees. To accelerate the

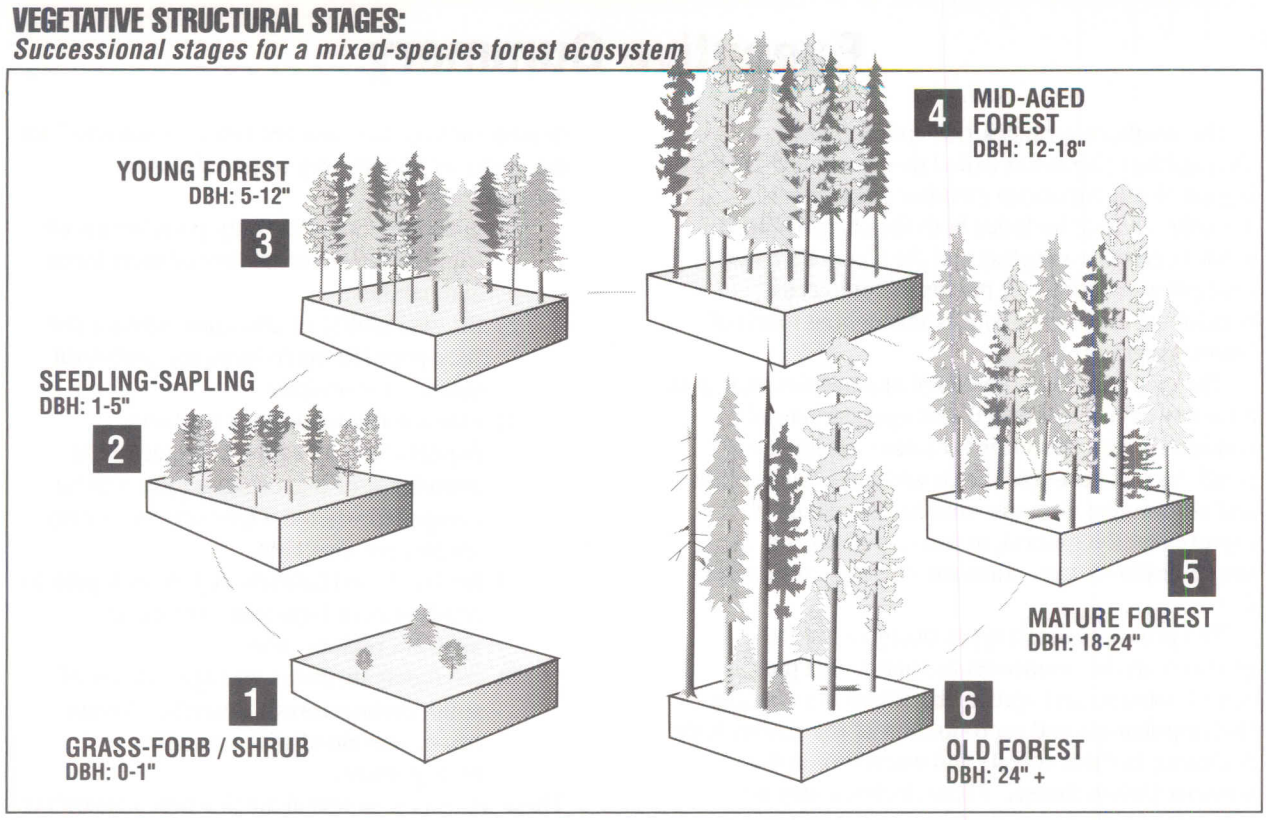



**Figure 1. Forest vegetation structural stages and their associated diameter breast height (DBH) ranges.**



**Figure 2. Dense "thicket" of small-diameter trees.**

development of mature forests and large trees, tree cutting and prescribed fire should be used to thin forest stands, concentrating growth on the remaining trees.

- Large trees, snags, and large downed logs provide important habitats for many plants and animals, and provide organic matter to the soil resource. Every acre of a goshawk nesting home range should contain a few large trees in clumps that are never removed. These trees live out their lives, die (become snags), fall, and decompose.
- Forest regeneration, growth, and development varies among locations because site specific productivity differs greatly throughout the Southwest. Therefore, no single management prescription is likely to develop or sustain the desired forest conditions on all sites within a landscape. In fact, the desired forest conditions may not be attainable on sites with low productivity, and may be easily attained on sites with high productivity.

## Components of the Nesting Home Range

Three components of a goshawk's nesting home range (about 6,000 acres) were identified: nest area, post fledging-family area (PFA), and foraging area. The size of these home range components has been determined from behavioral and radio-telemetry studies of goshawks.

The **nest area** (approximately 30 acres), which may include more than one nest, is typically located on a northerly aspect in a drainage or canyon, and is often near a stream. Nest areas contain one or more stands of large, old trees with a dense canopy cover (Fig. 3). A goshawk pair occupies its nest area from early March until late September. The nest area is the center of all movements and behaviors associated with breeding from courtship through fledging. Most goshawks have two to four alternate nest areas within their home range; alternate nest areas may be used in different years, and some may be used for decades.

The **post fledging-family area** (PFA) (approximately 420 acres) surrounds the nest area. Because of its size, it typically includes a variety of forest types and conditions. The PFA appears to correspond to the territory (defended area) of a



**Figure 3. Nest areas contain one or more stands of large, old trees with a dense canopy.**

goshawk pair, and represents an area of concentrated use by the family from the time the young leave the nest until they are no longer dependent on the adults for food (up to two months). These areas are important for fledglings; they provide hiding cover and prey on which to develop hunting skills. PFAs have patches of dense trees, developed herbaceous and/or shrubby understories, and habitat attributes (snags, downed logs, small openings) that are critical for many goshawk prey (Fig. 4).

The **foraging area** is approximately 5,400 acres in size, and surrounds the PFA. Hunting goshawks evidently use available habitats opportunistically. This opportunism suggests that the choice of foraging habitat by goshawks may be as closely tied to prey availability as to habitat structure and composition. Goshawks hunt from tree perches by scanning lower portions of the forest (ground, lower canopy) for prey. Because of visual limitations in dense forest environments, an open understory enhances detection and capture of prey (Fig. 5). Raptor (hawks, falcons, owls) populations are often limited by availability and abundance of their prey. The recommendations presented here are based on information available on how foraging goshawks use their habitat, and was supplemented with information on the habitats, foods, and cover of important goshawk prey.

## Goshawk Prey

A comparison of goshawk diets from disparate areas within North America showed that, while as many as 50 species are eaten, about 20 are common in the diets. Fourteen species were important in the diet of southwestern goshawks. Information on the distribution, habitat, special habitat needs, home range size, and populations of these 14 prey species were gleaned from the literature. A synthesis of this information provided a set of "desired forest conditions" that would result in sustainable populations of each prey. Because no single prey species is likely to be abundant enough to support goshawks, especially during the winter and extreme environmental fluctuations (periods of drought), habitats for and populations of all 14 prey are necessary.

Selected goshawk prey include squirrels, rabbits, woodpeckers, jays, and grouse. Specific habitat attributes used by these species include: snags,

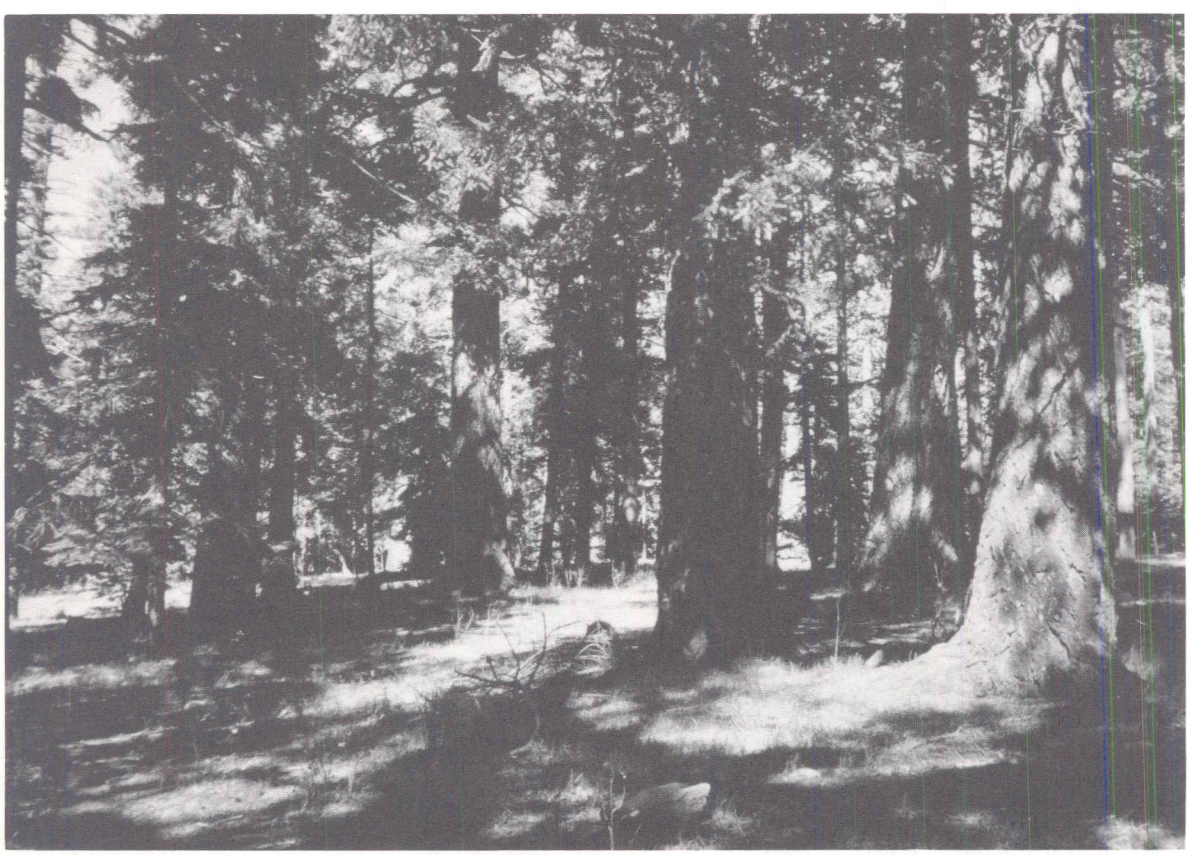


**Figure 4. PFAs have patches of dense trees, developed herbaceous and/or shrubby understories, and habitat attributes (snags, downed logs, small openings) that are critical for many goshawk prey.**



**Figure 5. Because of visual limitations in dense forest environments, an open understory enhances detection and capture of prey by goshawks.**

downed logs, woody debris, large trees, openings, herbaceous and shrubby understories, and an intermixture of various forest vegetative structural stages. Prey populations within goshawk foraging areas will be abundant and sustainable when:

1) the specific habitat attributes are provided,
2) forests contain large trees and have relatively open tree understories,
3) forest openings are small (1/3 - 2 acres) to medium (2-4 acres) in size,
4) patches of dense, mid-aged forests are scattered throughout, and
5) the majority of forests are in the "mid-aged," "mature," and "old" structural stages.

## Present Forest Conditions

Southwestern forests have been altered from pre-settlement conditions by fire suppression, timber harvesting, livestock grazing, mining, and recreational uses. Prior to fire suppression in the western United States, ponderosa pine forests were burned by low-intensity surface fires at 2- to 15-year intervals. Fires burned at lesser frequencies in mixed-species forests (5-22 years). These fires maintained forests that were relatively open and dominated by mature trees by regularly burning and killing small trees. In spruce-fir forests, fire intervals were much longer (60-400 years) and fires were often catastrophic, stand-replacing events.

Habitat changes resulting from fire suppression in ponderosa pine and mixed-species, and to a lesser extent spruce-fir forests, are:

1) the replacement of open, single-storied stands by dense multistoried stands through tree regeneration,
2) loss of natural openings by tree invasion, and
3) changes in the abundance and composition of plant species in both the understory and overstory due to plant succession.

Accumulated fuels and dense forest conditions resulting from fire suppression have also increased the potential loss of goshawk habitat through catastrophic wildfire and epidemic infestations of insects and diseases. Increased shading from the dense regeneration has also reduced herbaceous and shrubby understories that provide important foods and cover for goshawk prey. Livestock and wildlife

browsing and grazing have accentuated this loss. In addition to these changes, timber harvesting, which began in the 1800s, has focused on large trees, resulting in few remaining mature and old forests and associated habitat attributes.

## Management Recommendations

The present conditions in southwestern ponderosa pine and mixed-species forests reflect the extent of human interference with natural processes. Given the improbability of returning to the previous frequencies of natural disturbances, some active management (mainly thinning and prescribed fire) will be necessary to produce and maintain the desired conditions for sustaining goshawks and their prey. In some spruce-fir forests, natural processes are still functioning and little or no management may be necessary to maintain the desired conditions.

These recommendations were specifically designed to provide breeding season habitat for the goshawk and its prey. It is not known whether goshawks in the Southwest winter on their nesting home ranges; if they do winter there, then these recommendations will provide habitat and food year-round.

### Nest Areas (30 acres each)

Three suitable nest areas should be maintained per home range. In addition, three replacement nest areas per home range should be in a development phase, using intermediate treatment and prescribed fire. Suitable areas may be lost because of insect epidemics, catastrophic fire, or other factors. Nest areas are typified by one or more stands of mature or old trees and dense forest canopies. No adverse management activities should occur at any time in suitable nest areas. Desired forest conditions for the nest stands and management recommendations for maintaining and developing nest stands within nest areas are presented in Tables 1 and 2.

### Post Fledging-Family Areas (PFA) (420 acres)

The PFA contains a variety of forest conditions and prey habitat attributes. Interspersed small openings, snags, downed logs, and woody debris are critical PFA attributes. To sustain the desired canopy cover, size of trees, and the specified portions of different forest ages within the PFA, regeneration of 10 percent of the PFA may be required every 20 years. Other management tools, such as prescribed fire and removing understory trees, are suggested for sustaining other critical elements of goshawk habitat (Table 2).

Small openings in the forest are desired habitat for some prey species and are required for forest regeneration (Fig. 6). If forested openings are 1.0 acre or greater in Ponderosa pine and mixed species, then 3 to 6 large mature and/or reserve old trees per acre should be left in groups. If spruce-fir forest openings are 0.5 acres or greater, a group of 6 reserve trees are required per 0.5 acres. Reserve trees are not necessary in smaller openings; this component can be met in adjacent forested areas. Ponderosa pine and other seral conifers can be planted, and, depending on forest type, aspen and oak regeneration are encouraged. Snags, downed logs, and woody debris should be present throughout the PFA.

All management activities in the PFA should be limited to the period from October through February. Prescribed burning is the preferred method for management of woody debris. Thinning from below (removing understory trees) is preferred for maintaining desired forest structures, and a variable spacing of trees is preferred for developing groups of trees with interlocking crowns. Road densities should be minimized, and permanent skid trails should be used in lieu of permanent roads. Forage utilization should average 20 percent by weight and should not exceed 40 percent in any area to maintain grass and forb layer. Browse utilization should average 40 percent by weight (Table 2). These recommendations are designed to provide foods (leafy material, berries) and cover for goshawk prey.

### Foraging Area (5,400 acres)

Both the desired conditions and the management recommendations for the foraging area are similar to the PFA. The distribution and proportion of vegetative structural stages and the requirements for habitat attributes such as reserve trees, snags, and downed logs are the same as the PFA. Because the foraging area need not provide hiding cover for fledgling goshawks, a more open canopy is preferred -- 40 percent in the mid-aged forests and 40 to 60 percent in the mature and old forests, depending on the forest type. Openings (up to 4 acres), for herbaceous and shrubby understory development and tree regeneration, are desired in ponderosa pine and mixed-species forests; smaller openings are desired in spruce-fir forests (Table 1). Specific management recommendations to obtain the desired conditions for the foraging area are identical to the PFA (Table 2).

**Table 1. Desired forest conditions in three forest types for sustaining northern goshawks and their principal prey species in the Southwest.**

| Attribute | Home-Range Components | | | | | | |
|---|---|---|---|---|---|---|---|
| | Nest Area[a] | Post Fledging-Family Area | | | Foraging Area | | |
| | | Ponderosa Pine | Mixed-Species | Spruce-fir | Ponderosa Pine | Mixed-Species | Spruce-fir |
| VSS distribution[b] | | | | | | | |
| grass/forb/shrub VSS 1 (%) | 0[c] | 10[c] | 10[c] | 10[c] | 10[c] | 10[c] | 10[c] |
| seedling-sapling VSS 2 (%) | 0 | 10 | 10 | 10 | 10 | 10 | 10 |
| young forest VSS 3 (%) | 0 | 20 | 20 | 20 | 20 | 20 | 20 |
| mid-aged forest VSS 4 (%) | 0 | 20 | 20 | 20 | 20 | 20 | 20 |
| mature forest VSS 5 (%) | 100 | 20 | 20 | 20 | 20 | 20 | 20 |
| old forest VSS 6 (%) | 100 | 20 | 20 | 20 | 20 | 20 | 20 |
| Canopy cover | | | | | | | |
| mid-aged forest VSS 4[c] | NA[d] | 1/3 60+<br>2/3 50+ | 60+ | 60+ | 40+ | 1/3 60+<br>2/3 40+ | 1/3 60+<br>2/3 40+ |
| mature forest VSS 5 (%) | 50-70+ | 50+ | 60+ | 70+ | 40+ | 50+ | 60+ |
| old forest VSS 6 (%) | 50-70+ | 50+ | 60+ | 70+ | 40+ | 60+ | 60+ |
| Years to mid-aged VSS 6 | 200-300 | 200-250 | 200-300 | 200-300 | 200-250 | 200-300 | 200-300 |
| Opening size | | | | | | | |
| maximum size (acre) | NA | 2 | 2 | 1 | 4 | 4 | 1 |
| width--maximum (ft) | NA | 200 | 150 | 125 | 200 | 200 | 125 |
| Reserve trees[e] | | | | | | | |
| number of groups/acre | A[f] | 1 | 1 | 2[h] | 1 | 1 | 2[h] |
| number (per group) | NA | 3-5 | 6 | 6 | 3-5 | 6 | 6 |
| opening threshold[g] (acres) | NA | >1 | >1 | >0.5 | >1 | >1 | >0.5 |
| Snags (no/acre) | NR[i] | 2 | 3 | 3 | 2 | 3 | 3 |
| Downed logs (acre) | NR | 3 | 5 | 5 | 3 | 5 | 5 |
| Woody debris (tons/acre) | NR | 5-7 | 10-15 | 10-15 | 5-7 | 10-15 | 10-15 |

[a] *Suitable nest areas only; attribute values may vary by forest type.*
[b] *VSS; Vegetation Structural Stages, a forest description based on the tree diameter distribution within a stand. For example, if the majority of the stems of a stand (based on basal area) were located in the 12-18 inch diameter class, the stand would be classified as a VSS 4. General diameter limits are: VSS 1= 0-1" DBH; VSS 2= 1-5" DBH; VSS 3= 5-12" DBH; VSS 4= 12-18" DBH; VSS 5= 18-24" DBH; VSS 6 = 24"+ DBH. DBH = Diameter at Breast Height (4.5 ft.).*
[c] *Proportion of the area.*
[d] *NA; not applicable.*
[e] *Reserve trees; standing trees left after harvesting that will be allowed to become snags and downed logs.*
[f] *A; applicable, clumpiness, or groups of large trees is also desirable.*
[g] *When threshold size is exceeded, reserve trees are necessary.*
[h] *One group per 0.5 acres.*
[i] *NR; not required, but presence of these features are not detrimental.*

**Table 2. Management recommendations for sustaining habitat for northern goshawks and its principal prey species in the Southwest.**

| Attribute | Home Range Components[a] | | |
|---|---|---|---|
| | Nest Area | PFA | Foraging Area |
| Number of areas | 6 | 1 | 1 |
| Suitable[a] | 3 | NA | NA |
| Replacement[a] | 3 | NA | NA |
| Size (acre) | 30 (Total =180) | 420 | 5,400 |
| Management season[b] | Oct-Feb | Oct-Feb | Year-long |
| Regeneration of forest | | | |
| Conifer | None | Yes | Yes |
| Aspen & Oak | None | Yes | Yes |
| Planting | None | Yes | Yes |
| Thinning from below[a] | Non-uniform spacing | Non-uniform spacing | Non-uniform spacing |
| Transportation system | | | |
| Road | Minimum density | Minimum density | Minimum density |
| Skid trails | Permanent | Permanent | Permanent |
| Forage utilization[a] (%) | 20/40[c] | 20/40[c] | 20/40[c] |
| Woody debris treatment | In Order of Preference | | |
| Prescribed burning[a,d] | 1 | 1 | 1 |
| Lopping & Scattering[a] | 2 | 2 | 2 |
| Hand piling[a] | 3 | 3 | 3 |
| Machine grapple piling[a] | None | 3 | 3 |
| Dozer piling[a] | None | 4 | 4 |

[a] *Refer to glossary of terms.*
[b] *For PFAs surrounding active nest areas, months in which management activities are allowed.*
[c] *Average forage utilization (percent by weight) in herbaceous layer/shrub layer; utilization should not exceed 40% of grasses and forbs and 60% of shrubs.*
[d] *Not applicable in spruce-fir forest type.*



**Figure 6. Small openings in the forest are desired habitat for some goshawk prey species and are required for forest regeneration.**

## Related Benefits of Achieving Desired Forest Conditions

A large-scale, geographic approach is necessary when managing forests for a wide-ranging species such as the goshawk. An inherent danger in managing large areas for a single species is that other resources, including other wildlife species, may be harmed in the process. In developing these guidelines, the GSC used a landscape ecology approach that provides habitats and food chains for a broad variety of wildlife species. The approach also provides forage and timber, and benefits forest health. Vegetation management -- albeit in a manner that mimics the effects of natural forest disturbances -- is an integral part of these recommendations. It is a helpful tool for developing and maintaining desired forest conditions for goshawks and their prey.

Recurring fires, productive soils, forest productivity and health, eugenics, woody debris, large snags and downed logs, microorganisms, invertebrates and vertebrates-- all elements of functioning forest ecosystems -- are provided for when the desired future conditions are achieved. Managing forests at the landscape scale shifts the focus from more traditional single-species and stand-level management to management of ecosystems. As a result, the management recommendations for the northern goshawk in the southwestern United States are recommendations for maintaining biodiversity, with healthy forests relatively safe from catastrophic fires and pests. These recommendations offer a design that can be adapted for sustaining productive forests at the landscape level.

# Introduction

The northern goshawk (*Accipiter gentilis atricapillus*) was listed as a "sensitive species" by the Southwestern Region of the USDA Forest Service in 1982 (USDA Forest Service 1991). Information is available to identify and manage the nesting habitat of this forest hawk in numerous studies throughout the subspecies' range. Nesting habitat, however, comprises only a minor fraction of a home range of a pair of goshawks. Diets of the goshawk have also been described, and studies have shown that the home range of nesting pairs can be as large as 10 square miles (Table 3). In spite of this, little information exists on the forest types, ages, and conditions in which goshawks prefer to hunt. Thus, for the great majority of a pair's home range, little information is available to identify and manage its habitat.

This report describes the process used, findings, and recommendations of the scientific committee. In developing the recommendations, available information on goshawk biology, behavior, diet, and habitat was used. To augment what is known about goshawk foraging habitat, information on the habitat and foods of its main prey species was employed. This information was synthesized to develop a set of "desired forest conditions" that, in our best estimate, will sustain goshawk populations in the Southwestern Region.

The development of the set of desired forest conditions for the goshawk and its prey required certain assumptions:

1) biotic and abiotic factors limiting goshawk populations,
2) the numerical relationship between goshawk and prey populations,
3) the extent to which the foods and habitat of prey species in forests outside the Southwest are applicable to the Southwest, and
4) our ability to produce and sustain a long-term (250 years or more) intermixture of openings, trees, stands, and forests ranging in age from newly regenerated to old.

The following assumptions reveal areas where research is needed on goshawk and forest ecology:

1) goshawk and their prey populations are limited by the availability of their foods and habitats,
2) the availability of abundant, sustainable prey populations reduces the probability that food is limiting goshawk populations,
3) extreme fluctuations of goshawk populations caused by changes in the abundance of one or more prey will be dampened when a wider variety of prey species are available,
4) foods and habitats of goshawk prey in southwestern forests are similar in adjacent regions, and
5) the forest attributes and age-classes of southwestern forests described herein can be sustained with management.

As new research information becomes available, and as our understanding of the goshawk and its habitat use and preferences increase, these management recommendations will be refined.

**Table 3. Estimates of mean home range size among northern and Europeon goshawks.**

| Species | Acres | Explanation | Source |
|---|---|---|---|
| Northern goshawk | 524 | plots of sight records | Craighead and Craighead 1956 |
| | 4890 | 1.6 mile radius of foraging | Eng and Gullion 1962 |
| | 6086 | 1.7 mile 1/2 x distance between nests | Reynolds 1983 |
| | 5203 | 95% harmonic mean radio-telemetry | Kennedy 1990 |
| | 4752 | 95% harmonic mean radio-telemetry | Austin in prep. |
| European goshawk | 6177 | 16 pairs/154 square miles | Kramer 1955 |
| | 7907 | 14 pairs/174 square miles | van Beusekom 1972 |
| | 7413 | 1 pair over many years | Brull 1964 |
| | 4928[1] | radio-telemetry, woodland, augmented[2] | Kenward and Widen 1989 |
| | 10880 | radio-telemetry, woodland, augmented[2] | Kenward and Widen 1989 |
| | 14080 | radio-telemetry, boreal coniferous forest | Kenward and Widen 1989 |

[1] *This home range was determined during the winter.*

[2] *Goshawk home ranges were augmented with live prey.*

# Background

There is concern that goshawk populations and reproduction may be declining in the Southwestern Region and elsewhere in western North America (Herron et al. 1985, Bloom et al. 1986, Kennedy 1989, Crocker-Bedford 1990, Patla 1990, Zinn and Tibbitts 1990, Reiser 1991). It has been suggested that population declines are associated with tree harvests, but other factors (toxic chemicals, drought, lack of fire, disease, and tree harvest on prey species) could be involved, perhaps synergistically (Snyder et al. 1973, Reynolds 1989, Smith et al. 1991).

The principal forest types occupied by the goshawk in the Southwestern Region are ponderosa pine (about 74% of the non-reserved forested area), mixed-species (about 23%), and spruce-fir (about 3%) (Appendix 1, Table 1; page 49). These southwestern forests, especially the ponderosa pine and mixed-species forest types, have undergone structural and compositional changes during the past 100 years due to livestock grazing, extensive tree harvests, and suppression of historically frequent surface fires (Rasmussen 1941, Cooper 1960, Moir and Dieterich 1988, Covington and Moore 1991). Given:

1) the suspected declines in goshawk productivity and populations,
2) the extent to which southwestern forests have changed in the past century, and
3) the lack of an understanding of how goshawk habitat is affected by forest management activities.

Then, the identification and conservation of goshawk habitat is prudent to prevent population declines or isolation of individuals and subpopulations.

At this time, because of the limited number of known breeding individuals, the identification and conservation of every goshawk home range is important.

The goshawk is the largest North American member of the genus *Accipiter*, which includes both the sharp-shinned hawk (*A. striatus*) and the Cooper's hawk (*A. cooperii*) (Storer 1966, Wattel 1973, Reynolds and Wight 1978, Reynolds and Meslow 1984). Both adult and juvenile goshawks are about the same size as a red-tailed hawk (*Buteo jamaicensis*). The adult goshawk plumage is blue-gray on the back and wings, while the breast has fine gray streaks and black feather shafts on a background of dull white or gray. Juvenile goshawks have brown backs and wings, while the under parts have drop-shaped chocolate colored markings on a rich cream-colored background (Brown and Amadon 1968, Wattel 1973).

Like other members of the genus *Accipiter*, the goshawk is a bird of coniferous, deciduous, or mixed forests. Special morphological adaptations that give members of the genus the necessary maneuverability to hunt in forests include short, rounded wings and a long tail. The goshawk preys on small to medium birds and mammals--from robins and chipmunks to grouse and hares--which it captures on the ground or in the air. A single goshawk requires about 4.2 to 5.3 ounces of food per day or the equivalent of about 1 or 2 birds per day (Brown and Amadon 1968).

The northern goshawk is holarctic in distribution. In North America it occurs primarily in boreal forests, but it also occurs far to the south in montane forests of the western United States and Mexico. The most widespread subspecies (*A. g. atricapillus*) occurs from the northeastern United States across the boreal forests of Canada to Alaska, and southward through the upland forests of western United States. Two other weakly differentiated subspecies are recognized in North America: *A. g. laingi* in forests on islands and along the coast of extreme northwestern United States and Canada to southeast Alaska, and *A. g. apache* in montane areas in extreme southern portions of Arizona and New Mexico to northern Mexico (Wattel 1973, Hubbard 1978). The goshawk is partly migratory in the northern portion of its range; in winters of food shortages, large southward migrations occur (Mueller and Berger 1967). At high elevations in montane areas, some goshawks descend to lower elevations into woodlands, riparian areas, and scrublands during winter (Kennedy unpublished data, Reynolds pers. obs.). There is evidence that some goshawks in the Southwest winter on or near their nesting home range (Kennedy unpublished data, Reynolds unpublished data).

In North America, the goshawk is a forest habitat generalist, occurring in all major forest types (coniferous, deciduous, and mixed). These forests, because of natural and man-caused disturbances (fires, diseases, insects, logging), contain a wide variety of forest ages and successional stages. The extent, however, to which goshawks use these different forest conditions is poorly known (Reynolds 1989). However, because of its relatively large body size and wing span, the goshawk seldom uses young, dense forests (Fischer 1986). In these habitats, there are few large trees in which the goshawk can place its large nest, and there is insufficient space in and below the canopy to facilitate flight and capture of prey.

Goshawk nesting habitat has been the focus of considerable research throughout its range. In general, nest sites have large trees, dense canopies,

and, in the southern portion of the hawk's range, are typically on slopes with northerly aspects (Bartelt 1974, McGowan 1975, Hennessy 1978, Shuster 1980, Reynolds et al. 1982, Saunders 1982, Moore and Henny 1983, Hall 1984, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Kennedy 1988, Hayward and Escano 1989). Tree species composition of nesting habitat is highly variable among nest sites within a region as well as across the subspecies' range.

Although goshawks are wide-ranging predators of more than 50 species of forest birds and mammals (Appendix 2, page 51), little is known about the structure and composition of habitats used by foraging goshawks (Schnell 1958, Reynolds and Meslow 1984, Reynolds 1989, Mannan and Boal 1990, Kennedy 1991). There is some evidence, however, that foraging goshawks use habitat opportunistically. First, because large forest areas vary spatially in composition and structure, goshawks are more often than not confronted with a mosaic of forest types and conditions in their daily foraging movements. Second, areas, dominated by different but homogenous forest types or ages (e.g., Douglas-fir, ponderosa pine; mature, young) have successfully supported nesting pairs. Third, direct observations of foraging goshawks show that they do indeed hunt in many forest types and conditions (Fischer 1986; Kenward and Widen 1989; Widen 1989; Kennedy unpublished data; Reynolds pers. obs., Reiser pers. obs.). Thus, the wide variation in habitats occupied by goshawks suggests that foraging habitat may be as closely tied to prey availability as to habitat structure or composition (Reynolds 1989, Kenward and Widen 1989,).

If goshawk populations have declined in the Southwest as a result of timber harvest, then nest-site protection -- the only component of goshawk home ranges protected in the Southwest since the early 1980s (Reiser 1991) -- may be insufficient for maintaining goshawk populations. In addition to habitat loss, goshawk declines could be related to decreases in prey populations, which in turn may be associated with changes in the composition and/or structure of the forests resulting from fire suppression, tree harvests, and livestock grazing. If goshawk populations are a barometer of their prey populations, then forest management should feature prey habitats as well as the habitats of the predator.

# Goshawk Populations and Prey Species

## Factors Limiting Goshawk Populations

For some raptor species, the idea that breeding density is limited, rather than undergoing random fluctuations, is based on four main findings:

1) many raptor populations are stable in numbers and distribution for long periods of time (Newton 1989, 1991);
2) surplus non-breeding adults are present in many populations and breed only when a territory with suitable habitat becomes available (Newton 1979, Village 1983, Bowman and Bird 1986);
3) some populations extirpated by deforestation over large areas have returned along with forest reestablishment (Rowan 1921, 1922, Newton 1979, Ratcliffe 1980); and
4) in areas where nest sites are not limiting, nesting pairs are regularly spaced, suggesting that food resources are being protected by exclusive territories (Ratcliffe 1972, Tubbs 1974, Newton 1988, 1991, Reiser and Ward unpub. data).

Two important resources, food and nesting habitat, are frequently the principal factors limiting raptor densities (Newton 1979, 1989, 1991, Village 1990).

Evidence that raptor populations can be limited by a shortage of nest sites (snags, cliffs, large trees) includes:

1) raptors are absent or rare in areas in which nest sites are rare; and
2) where nest sites are limiting, raptor populations have been increased when artificial nest sites were provided (Cave 1968, Reese 1970, Rhodes 1972, Hammerstrom et al. 1973, Village 1983, Newton 1989).

In areas where nest sites are readily available, raptor densities are often limited by food abundance (Village 1990, Newton 1991). Two lines of evidence of food limits to populations include:

1) raptor populations are stable where their prey populations are stable (e.g., sparrowhawks and kestrels) (Newton et al. 1986, Newton 1989, Village 1990); and
2) raptor populations fluctuate when and

where their prey populations fluctuate (McGowan 1975, Newton 1989, 1991, Grant et al. 1991).

Furthermore, the density of raptors during winter and the following nesting season can be influenced by winter food availability (Newton 1979, Village 1990).

## Diet Breadth and Population Stability

The composition and abundance of species in the diet of a goshawk population may determine population stability. In Alaska, goshawks feed on relatively few species, and diets are dominated by the snowshoe hare (*Lepus americanus*) (McGowan 1975). A 10-year cycle in Alaskan snowshoe hare abundance (Keith 1963) was reflected in similar cycles in the number of active goshawk nests and the production of nestlings (McGowan 1975). For example, near Fairbanks, hare populations peaked in 1971 but declined in 1972 and 1973. In 1971 high hare numbers were associated with high goshawk nesting success -- a mean of 2.5 nestlings per nest. However, the mean number fledged in both 1972 and 1973 decreased to 1.8 nestlings per nest. Furthermore, the number of nests in McGowan's study area was 7 in 1971 and 1 in 1974 (McGowan 1975).

In the conterminous United States, there is no evidence that goshawk populations undergo extensive fluctuations. This is probably because:

1) no single prey species in these areas is abundant enough to dominate goshawk diets, and
2) the more southerly hawks feed on a wider variety of prey (Reynolds and Meslow 1984, Kennedy 1991).

Thus, even though one or more prey species may undergo population fluctuations, the effects of these fluctuations are more likely to be buffered by populations of other prey species that are not simultaneously affected.

## Prey Species

Goshawks are predators of forest birds and mammals. Diets varied moderately among studies of nesting goshawks in California, New York, Oregon, New Mexico, and Arizona (Schnell 1958, Reynolds and Meslow 1984, Mannan and Boal 1990, Kennedy 1991) (Appendix 2, page 51). This dietary variation likely reflected differences in the composition, abundance, and availability of birds and mammals in the forests of these states. Goshawk diets can change seasonally or annually reflecting:

1) differences in the timing or extent of migration, hibernation, or periods of inactivity among prey species,
2) the eruptive and cyclic nature of populations of some prey, and
3) differences in food preferences among individual goshawks.

Despite differences in goshawk diets over wide geographic areas, some prey species tend to be consistently common in their diets. When combined, these commonly-eaten prey totaled more than three quarters of the individuals consumed (Schnell 1958, Meng 1959, Reynolds and Meslow 1984, Mannan and Boals 1990, Kennedy 1991) (Appendix 2, page 51). In addition, most of these species were of relatively large body size and therefore contributed disproportionately to the total biomass consumed by goshawks.

A comparison of goshawk diets identified 14 prey species (or groups of similar species) that are particularly important to goshawks in the Southwest (Table 4). Information on the distribution, habitat, special habitat needs, home range, and population density of these selected prey species were gleaned from the literature (Appendix 3, page 53). This information was used to identify a set of "desired forest conditions" needed to provide abundant and sustainable populations of each of these species. Our rationale was to supplement the limited information on goshawk foraging habitat preferences by identifying the forest type(s), composition(s), and structure(s) in which each of 14 selected prey attain sustainable and abundant populations.

The majority of the important prey species reside mainly on the ground and in the lower portions of the tree canopy. Therefore, much of the goshawk's hunting activity (prey searching and pursuit) is oriented towards these forest layers (Reynolds and Meslow 1984). Consequently, in areas that have tall

**Table 4. Selected northern goshawk prey in the Southwest.**

| Birds | Mammals |
|---|---|
| American robin | Chipmunks (*Tamias* spp.) |
| Band-tailed pigeon | Cottontails (*Sylvilagus* spp.) |
| Blue grouse[1] | Mantled ground squirrel |
| Hairy woodpecker | Red squirrel |
| Mourning dove | Tassel-eared squirrel |
| Northern flicker | |
| Red-naped sapsucker | |
| Steller's jay | |
| Williamson's sapsucker | |

[1] *Not presently known from northern goshawk diet studies in the Southwest, but likely to occur when studies are expanded or extended into specific geographic areas.*

and very dense understories, goshawk populations may effectively be diminished because:

1) impaired ability of goshawks to visually scan for prey,
2) restricted flight access to prey, and/or
3) greater escape cover for prey.

# Conservation of the Northern Goshawk: Approach

To identify, describe, and ultimately manage goshawk habitat in the Southwestern Region, three critical spatial components of a goshawk's nesting home range were identified: nest area, post-fledging family area (PFA), and foraging area.

The description of goshawk habitat in each of these components is based on the biology and ecology of goshawks and their main prey species. In contrast to our knowledge of the summer nesting biology of the goshawk, almost nothing is known of its winter ecology. Therefore, the habitat descriptions herein focus on the nesting home range and habitat. However, there is limited radio-telemetry evidence that adult goshawks in New Mexico winter on or near their nesting home ranges (Kennedy unpub. data, Reynolds pers. obs.). If this proves true for goshawks in the Southwest in general, then providing nesting habitat will also provide some winter habitat needs.

## Nest Area

Nest areas are easily identified by their unique vegetation structure. Nest areas include one or more forest stands, several nests, and several landform characteristics. Nest areas are occupied by breeding goshawks from early March until late September, and are the focus of all movements and activities associated with nesting (Reynolds 1983). Boundaries of nest areas were determined by observing the behavior of the adults, the movements and behavior of newly fledged young, and the locations of prey plucking areas and roosts (Reynolds et al. 1982). The size (20-25 acres) and shape of nest areas depend on topography and the availability of patches of dense, large trees (Reynolds 1983).

Suitable nesting habitat is critical in the reproductive biology of goshawks. Nest areas are often used more than one year, and some are used intermittently for decades (Reynolds 1983, Crocker-Bedford 1990). Many pairs of goshawks have two to four alternate nest areas within their home range. All previously occupied nest areas may be critical for maintaining nesting populations because they contain the habitat elements that attracted the goshawks originally. Additionally, replacement nest areas are required because goshawk nest stands are subject to loss from catastrophic events and natural decline.

Goshawk nest stands have a relatively high tree canopy cover and a high density of large trees (Bartelt 1974, McGowan 1975, Hennessy 1978, Shuster 1980, Reynolds et al. 1982, Saunders 1982, Moore and Henny 1983, Hall 1984, Speiser and Bosakowski 1987, Crocker-Bedford and Chaney 1988, Kennedy 1988, Hayward and Escano 1989) (Table 5). Most nest stands are either on slopes with northerly exposures (NW to NE) or in drainages or canyon bottoms protected by such slopes. Studies suggest that the dense vegetation in these stands provide relatively mild and stable micro-environments, as well as protection from predators of goshawks (other goshawks, great-horned owls, red-tailed hawks, coyotes, bobcats, raccoons, humans) (Reynolds et al. 1982, Moore and Henny 1983). Information on tree height, diameter, and canopy closure of goshawk nest areas in interior ponderosa pine and mixed-species forests is provided by Reynolds et al. (1982), Moore and Henny (1983), Crocker-Bedford and Chaney (1988), Kennedy (1988), and Patla (1990).

The structure of the vegetation within nest areas is associated with the forest type, and tree age, size, and density, and the developmental history of the stand. Within the Southwestern Region, nest areas occur within a range of forest growth-site potentials (Table 5). Nest areas in locations with low growth potential will have smaller (diameter and height) trees than locations with high potential. Table 5 presents **minimum** attributes required for goshawks on locations with "low" and "high" site productivity.

## Post-fledging Family Area (PFA)

In a radio-telemetry study of the post-fledging behavior of goshawks, Kennedy (1989, 1990) described an area used by the adults and young from the time the young leave the nest until they are no longer dependent on the adults for food. This "post-fledging family area (PFA)" surrounds the nest area and, although it generally includes a variety of forest conditions, the vegetation structure resembles that found within nest stands. PFAs vary in size from

**Table 5. Structural attributes for suitable northern goshawk nest stands in the Southwest[1].**

| Forest Cover Type[2] | Piñon-Juniper | Interior Ponderosa Pine | | Mixed-Species | | Aspen | Engelmann Spruce-Subalpine Fir |
|---|---|---|---|---|---|---|---|
| Site Index[3] | | <55 | ≥55 | <50 | ≥50 | | |
| Trees/Acre[4] | 60-100 | 40 | 30 | 45 | 35 | 20 | 35 |
| Mean DBH/DRC (in.)[5] | 12 | 16 | 22 | 15 | 20 | 16 | 20 |
| Age (yrs.)[5] | 200+ | 200+ | 200+ | 200+ | 200+ | 80+ | 150+ |
| Total BA (sq. ft/acre)[6] | 60 | 120 | 140 | 110 | 130 | 50 | 140 |
| Overstory canopy cover (%) | 60+ | 50+ | 60+ | 50+ | 60+ | 60+ | 70+ |
| VSS[7] | 5A-6 | 5B-6 | 5B-6 | 5B-6 | 5B-6 | 5B-6 | 5B-6 |

[1] *The entire nest area may not support all of these structural attributes.*

[2] *Forest cover types, SAF codes (Eyre 1980); Ponderosa pine 237; Mixed-species 209, 210, 211, 216; Aspen 217; Engelmann spruce-Subalpine fir 206; Piñon-juniper 239.*

[3] *Site Index (SI) = base age of 100 years; SI used for interior ponderosa pine = ponderosa pine; SI used for mixed-species = Douglas-fir.*

[4] *Number of live trees in the main canopy.*

[5] *Arithmetic average of the ages of dominant and codominate trees in the stand; DBH = diameter at breast height; DRC = diameter at root crown.*

[6] *BA = basal area.*

[7] *VSS = Vegetation Structural Stage.*

300 to 600 acres (mean = 415 acres) and may correspond to the territory (a defended area) of a pair of goshawks (Kennedy 1989). PFAs provide the young hawks with cover from predators, and sufficient prey to develop hunting skills and feed themselves in the weeks before juvenile dispersal. Thus, forests in the PFAs should contain overstories with a canopy cover greater than 50%, and well-developed understories and habitat attributes (e.g., snags, nest trees, foods) critical in the life-histories of goshawk prey species.

## Foraging Area

It is difficult to identify and describe goshawk foraging habitat because of the size of the home range and the dearth of information on what habitats are preferred.

As in most raptors, there are differences in the duties of the goshawk sexes during nesting: males hunt for the family while females stay close to the nests -- first to incubate eggs, then to brood and protect young. Information on nesting home range size and habitats used while foraging must therefore primarily come from studies of foraging males. The extent to which the foraging areas of adjacent pairs overlap is unknown.

Goshawks prey on birds and mammals in the larger body-size classes available to forest-dwelling hawks (Storer 1966, Reynolds and Meslow 1984). Generally speaking, because larger species of vertebrates have less dense populations than smaller species, predators of large prey must hunt over large areas in order to meet their energy requirements (Schoener 1983). This body size/home range size relationship is demonstrated in the North American *Accipiter*: the smallest, the sharp-shinned hawk, feeds on small birds and has nesting home ranges of about 1,200 acres; the Cooper's hawk, which feeds on birds and mammals of intermediate size, has home ranges of about 4,000 acres; and the northern goshawk, the largest *Accipiter*, has ranges of about 5,000-6,000 acres (Reynolds 1983, Kennedy 1989) (Table 3).

The size of nesting home ranges of goshawks has been estimated by:

1) repeatedly observing adult males leaving their nest areas above the forest canopy and noting the distance and direction traveled (Reynolds 1983);
2) Assuming home ranges are circular and using one-half the mean distance between nests as the radius of the home range (Newton et al. 1977, Reynolds 1983);
3) plotting the locations where some prey species were trapped and marked and whose remains were subsequently found at goshawk nests (Eng and Gullion 1962); and
4) monitoring the movements of adults using radio-telemetry (Kennedy 1991,

Austin in prep).

Radio-telemetry is the most accurate of these estimates, but radio-tracking of such a wide-ranging bird in mountainous terrain is most difficult. The task is made more difficult because goshawks, as well as other *Accipiters*, are short-sit-and-wait-short-flight predators (Fischer 1986, Kenward 1982, Kennedy 1991). That is, goshawks search their immediate surroundings for prey from a tree-perch for a short period (seconds) and then make a short flight to a new perch (Kenward 1982, Widen 1985). This searching behavior is an adaptation to living in forests where the area searched from a single perch is limited. Because of visual limitations, perches are changed frequently. Goshawks move rapidly through their home range in this manner, making it difficult to triangulate on radio-marked hawks.

Limited radio-telemetry evidence suggests that goshawks prefer mature forests for foraging. For example, Fischer (1986) found that a radio-tagged male in Utah preferentially foraged in "mature" Douglas-fir/white fir stands. Widen (1989), studying radio-marked goshawks (*A. g. gentilis*) in winter in intensively managed conifer forests in Sweden, found that both sexes of goshawks preferentially foraged in forests greater than 60 years of age. Application of this information in management recommendations is limited because of the small sample size in Utah, and uncertainties as to the similarities in foraging behavior of European and North American goshawks.

Additional information on the composition and structure of goshawk foraging habitat was gleaned from information on the habitat requirements of goshawk prey species. This approach is justified because:

1) raptor populations are often limited by prey populations, and
2) choice of foraging habitat by goshawks is predicated, at least in part, on habitats where prey are abundant and accessible.

We designed foraging areas consisting of forest conditions that would provide a high overall diversity and abundance of prey. Because not all 14 selected prey species occur in each of the forest types in the Southwest, three separate designs -- for ponderosa pine, mixed-species, and spruce-fir -- were required (Table 6). Sufficient prey habitats are provided so there is food to support goshawks in all seasons, especially during winter when fewer prey are available, and in years when prey populations are low due to factors such as drought or deep snow cover. Because no single prey species will be abundant enough to support goshawks, especially during winter, habitats for all 14 prey species are provided.

# Synthesis of Desired Forest Conditions

Forests can be described by either:

1) community associations or
2) forest cover types (Daubenmire and Daubenmire 1968, Larson and Moir 1986, Larson et al. 1987, Bassett et al. 1987).

An integrative approach, combining vegetation and forest growth, has been developed for the Southwest (after Thomas et al. 1979) and is a generalized description of forest age and tree size from seedling to old forests. To describe the southwestern forests we defined 6 vegetation structural stages (VSS) that were based primarily on tree diameters (Fig. 1). These stages are:

- VSS 1, areas dominated by grasses, forbs, and shrubs;
- VSS 2, forests dominated by seedlings and saplings;
- VSS 3, young forests;
- VSS 4, mid-aged forests;
- VSS 5, mature forests; and
- VSS 6, old forests.

## Nest Area

Nest areas are a key component of goshawk home ranges. In each of the three southwestern forest types, goshawks nest in older-aged stands that have a high density of large trees, high tree canopy cover, and high basal areas (Table 5, Fig. 7, and Fig. 8). Nest areas are usually on cool, shady slopes or canyon sides, and are often near streams.

## Post-fledging Family Area (PFA)

Post-fledging family areas (PFAs) contain patches of dense, large trees that provide protection for fledglings and small trees for hiding cover near the ground. Because newly fledged young have poorly developed flight, their spatial movements tend to be centered around the nest. With time, fledglings become proficient foragers and are fed less and less by their parents. To provide learning opportunities, prey should be abundant throughout the PFA; thus prey habitat should be intermixed with dense hiding

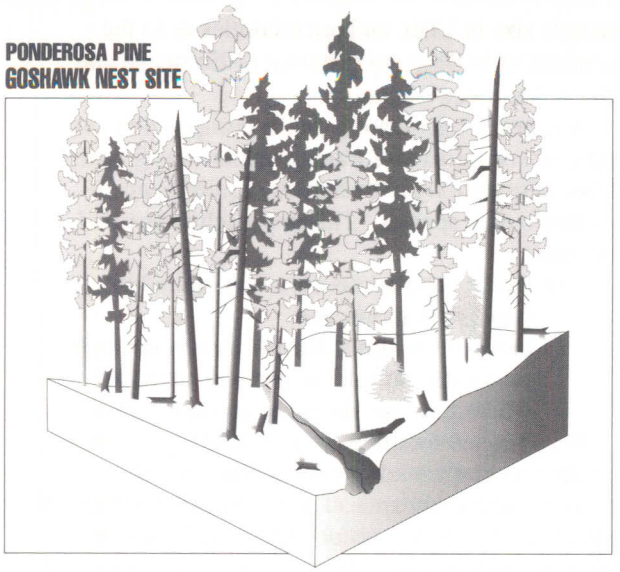



**Figure 7. Northern goshawk nesting habitat within a ponderosa pine forest, depicting tree density, canopy cover, and landform in the vicinity of the nest tree.**

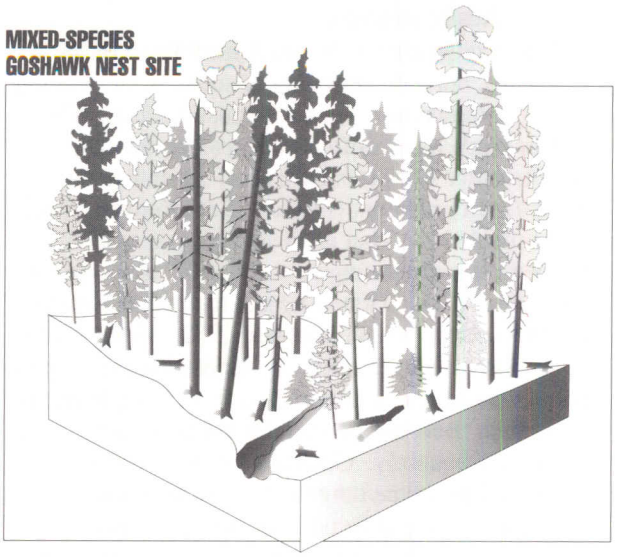



**Figure 8. Northern goshawk nesting habitat within a mixed-species forest, depicting tree density, canopy cover, and landform in the vicinity of the nest tree.**

cover. Features of prey habitat in the PFA include:

1) large (>18 inches DBH) feeding and/or nesting trees for tree squirrels,
2) large (>18 inches DBH and >30 feet tall) snags and/or trees with exposed heartwood for nest cavity excavation by woodpeckers,
3) patches of mid-aged forests with high canopy cover (up to 70%) that provide mesic conditions for fungi (important foods for all the mammalian prey),
4) small (<2 acres) openings in the tree canopy to produce herbaceous and shrubby foods for the herbivorous prey, and
5) large (>12 inches in diameter and >8 feet long) downed logs and other woody debris that provide hiding, feeding, denning, and nesting sites used by goshawk prey.

The PFA is an intermixture of forest conditions intermediate between the high foliage volume and canopy cover of the nest stands and the more open foraging habitats.

## Foraging Area

The foraging area comprises the largest portion of the goshawk nesting home range and therefore typically includes a greater diversity of landforms, forest cover types, and vegetation structural stages. Table 6 summarizes the importance of snags, downed logs, woody debris, openings, large trees, herbaceous and shrubby understories, and interspersion of VSS to the selected prey species of the goshawk. This information was based on a literature review of the life history, habitats, and foods of each prey species (Appendix 3, page 53).

Snags provide critical resources for many species of birds, mammals, invertebrates, and plants. Among the selected species of goshawk prey, all of the woodpeckers use snags for feeding, nesting, or both. Four mammalian prey use snags for nesting (when cavities are available) and cone caching. Several birds use snags for perches. The level of importance of snags as a habitat attribute is "medium" to "high" for 6 species, "low" for 6 species, and "not important" for 2 species (Table 6).

Downed logs (>12 inches in diameter and 8 feet long) provide cover, feeding and nest sites for a great variety of species. Among goshawk prey, downed logs are important feeding sites for several woodpeckers and as den sites for chipmunks, mantled ground squirrels, and cottontail rabbits. Downed logs are an important element in red squirrel cache sites and in blue grouse courtship sites. The level of importance of downed logs is "medium" to "high" for 9 species, "low" for 2 species, and of no importance to 3 species.

Woody debris is any downed woody material larger than 3 inches in diameter. Woody debris provides cover and feeding sites for a variety of vertebrates. The character, amount, and distribution of woody debris may affect the kinds and abundance of animals in an area (Dimock 1974). The level of importance of woody debris is "medium" to "high" for 7 goshawk prey species, "low" for 6 species, and of no importance to 1 species.

**Table 6. Importance of special habitat attributes for maintaining sustainable populations of selected northern goshawk prey[1].**

| | | Habitat Attributes[2] | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Species | Forest Types[3] | Snags | Downed Logs | Woody Debris | Opening | Large Trees | Herb, Shrub Understory | Interspersion of VSS |
| American robin | PP,MS,SF | none | none | low | medium[a,b,c] | low | high | high |
| Band-tailed pigeon | PP,MS | low | none | none | high[a,b,c] | medium | medium | medium |
| Blue grouse | MS,SF | none | medium | medium | high[a,b] | high | high | high |
| Chipmunks | PP,MS,SF,PJ | medium | high | high | medium[a,b] | medium | high | medium |
| Cottontails | PP,MS,PJ | low | medium | high | medium[a,b,c] | none | high | high |
| Hairy woodpecker | PP,MS.SF | high | medium | medium | none | high[4] | none | medium |
| Mantled ground squirrel | PP,MS,SF | low | high | high | medium[a,b] | medium | high | medium |
| Mourning dove | PP,MS,PJ | low | none | low | high[a,b] | medium | high | high |
| Northern flicker | PP,MS,SF,PJ | high | high | low | low[a,b,c,] | high[4] | medium | high |
| Red-naped sapsucker | PP,MS | high | low | low | none | medium[4] | medium | medium |
| Red squirrel | MS,SF | high | high | medium | none | high | medium | low |
| Steller's jay | PP,MS,SF | low | low | low | none | high | low | low |
| Tassel-eared squirrel | PP,MS | low | medium | low | none | high | low | medium |
| Williamson's sapsucker | PP,MS | high | medium | medium | none | high | medium | low |
| Total none | | 2 | 3 | 1 | 6 | 1 | 1 | 0 |
| Total low | | 6 | 2 | 6 | 1 | 1 | 2 | 3 |
| Total medium | | 1 | 5 | 4 | 4 | 5 | 5 | 6 |
| Total high | | 5 | 4 | 3 | 3 | 7 | 6 | 5 |

[1] *Importance values (none, low, medium, high) were based on interpretation of data available in literature. See Appendix 3 for additional information.*

[2] *snags = dead trees ≥ 18 inches DBH and ≥30 feet high;*

*downed logs = ≥12 inches diameter and 8 feet long;*

*woody debris = ≥3 inches diameter of woody material on the forest floor;*

*opening = a break in the forest canopy, a = small opening (<2 acres); b = medium (2-4 acres); and c = large (>4 acres);*

*large trees = live ≥18 inches DBH, large tree component is required for nest trees, feeding trees, and roost trees;*

*herb, shrub understory = presence or absence of herbaceous and shrubby species;*

*interspersion of vegetation structure stage (VSS) = the degree of intermixing of VSS measured on the scale of each prey species (low = relatively large contiguous patches of the same or similar VSS's; high = an intermixture of relatively small patches of dissimilar VSS's; medium = moderate degree of intermixture of dissimilar VSS's).*

[3] *Forest type: PP= ponderosa pine; MS=mixed-species;SF=spruce-fir; PJ=piñon-juniper.*

[4] *Large trees are a source of snags used for nesting.*

Openings, and associated herbaceous and shrubby vegetation, provide important food and cover for a number of goshawk prey species. Only three species (band-tailed pigeon, mourning dove, and blue grouse) have a high importance value for openings; blue grouse for nesting and brood-rearing, and the pigeon and dove for feeding. The level of importance of openings is "medium" to "high" for 7 prey species, "low" for 1 of the species, of no importance to 6 species. Because pigeons and doves typically travel long distances to feed in agricultural or other large non-forested areas, large openings in the forest are not required for them. Therefore, a forest containing small to medium (<4 acres) openings would benefit the blue grouse, chipmunks, and mantled ground squirrels while minimizing the effects on other interior forest prey species.

Large trees (>18 inches in diameter) provide important nesting, denning, feeding, and roosting sites for goshawk prey such as tree squirrels, large woodpeckers, and blue grouse. Large trees also are good cone producers, providing a source of seed for many species of goshawk prey (Appendix 1, Table 2; page 49). Because large trees are the source for large snags and downed logs, they are as important to woodpeckers as are large snags. Large trees also provide hunting perches and nest trees for goshawks. The level of importance of large trees is "medium" to "high" for 12 goshawk prey species, "low" for 1 species, and of no importance to 1 species.

Herbaceous and shrubby understories provide important foods (seeds and berries), and cover for many of the selected prey. Well developed understories occur in forests with canopy sufficiently open to allow the necessary light to reach the forest floor; closed canopied forests are often limited in the quantity of these plant foods. The level of importance of herbaceous and shrubby understories is "medium" to "high" for 11 goshawk prey species, "low" for 2 species, and of no importance to 1 species.

Interspersion measures the degree of intermixing of vegetation structural stages. Only the red squirrel responds negatively to interspersion of structural stages; its populations reach a maximum in unbroken old forests. Other goshawk prey populations either:

1) respond positively to high interspersion (e.g., blue grouse), or
2) are little affected by high levels of interspersion (e.g., chipmunks).

The level of importance of interspersion is "medium" to "high" for 11 goshawk prey species, "low" for 3 species, and of no importance to no species.

Table 7, identifies the VSSs and canopy cover classes in which selected species of goshawk prey occur at high, medium, and low populations (on the condition that the "special habitat attributes" identified in Table 6, are provided in amounts that do not limit prey populations). Although some species of goshawk prey occur at medium to low population levels in each of the structural stages, it is evident that the older age classes have the most species at an abundant population level (12 of 14 species).

Several species (such as American robin and mourning dove) are generalists and occur at medium populations in most structural stages, while others, including the red squirrel are specialists and occur in a limited number of structural stages. One species (blue grouse) requires both openings and older forests, interspersed with one another, to attain high populations during all seasons. A total of 12 species attain high or medium populations in older forests (VSS 4-6); of these 12 species, 5 occur only at low densities in the young forests (VSS 2-3) (Table 7).

Canopy cover influences population levels of goshawk prey in different ways. For example, 6 species of goshawk prey occur at greater densities in open forests (<40% cover). Seven species occur at high populations in closed forests ( >60% cover), but only 1, the red squirrel, requires closed older forests to attain high populations. The other 6 attain high populations in cover class B (40-60% cover) as well (Table 7). Of the 14 selected prey, only 4 species use closed canopy areas in the younger VSS.

All small mammals, and the majority of birds, of selected prey species are either granivores or herbivores -- feeding on seeds, berries, and foliage of plants that occur in openings in forests and in forest understories (Appendix 3, page 53). Many of these prey also depend heavily on seeds of conifers; for example, tree squirrels climb trees for cones and chipmunks and ground squirrels scavenge cones or seeds from the ground or steal cones from caches of others.

All mammalian prey species except cottontails depend heavily on fungi during summer and fall, and the physiological condition in which tree squirrels and chipmunks begin the winter may be dependent on the amount of fungi eaten (C. Smith 1968, Maser et al. 1978). Fungi are best produced in conifer stands with canopy cover greater than 60%. In ponderosa pine forests the best fungi-producing stands are mid-aged with high canopy cover (States 1985, States et al. 1988, Uphoff 1990).

Other additional elements in goshawk foraging areas in the Southwest include:

1) dwarf mistletoe infected trees that provide good nesting and feeding sites for many vertebrates (Hawksworth 1961, 1973, Bennetts 1991),
2) large quaking aspen that provide feeding and cavity nests that help maintain high densities of large woodpeckers (Scott et al. 1977), and
3) oaks, especially Gambel oak, that provide nest sites and food (Scott et al. 1977, Bock and Larson 1986, Uphoff 1990).

With the exception of red squirrel habitat, multi-storied stands do not appear to be an important structural element in the habitat of the selected goshawk prey.

In summary, goshawk foraging habitat in the three forest types consists of forests with relatively open understories and large trees. Large trees are required for hunting perches, and openness provides opportunity for detection and capture of prey by goshawks. These forests have small to medium openings (<4 acres) and patches of dense mid-aged forests. Openings are scattered to:

1) enhance the availability of food and habitat resources of prey that use them, and
2) limit the effect of large openings on the distribution and abundance of prey species that use interior forests.

For the most part, forests in the older age classes are relatively open (40-60% canopy cover) with increased sunlight and moisture reaching the forest floor. These forests have well-developed herbaceous and shrubby understories. Large tree components (live trees, snags, and downed logs) are scattered

**Table 7. Desired forest conditions within northern goshawk home ranges that contribute to various population levels of selected prey.**

| Prey Species | Forest Types[2] | Vegetation Structural Stage[1] and Canopy Cover | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1[3] | 2 | | | 3 | | | 4 | | | 5 | | | 6 | | |
| | | | A[4] | B | C | A | B | C | A | B | C | A | B | C | A | B | C |
| American robin | PP,MS,SF | X[5] | X | X | | X | X | | X | XX | | X | XX | | X | XX | |
| Band-tailed pigeon | PP,MS | X | X | | | | | | | X | | | X | | | X | |
| Blue grouse | MS,SF | XX | XX | X | | X | XX | | X | XX | XX | X | XX | XX | X | XX | XX |
| Chipmunks | PP,MS,SF, PJ | X | X | X | | X | X | | XX | XX | | XX | XX | X | XX | X | X |
| Cottontailst | PP,MS,PJ | XX | X | X | | X | X | | XX | X | | XX | X | | XX | X | |
| Hairy woodpecker | PP,MS.SF | | | | | | X | X | X | X | X | XX | XX | XX | XX | XX | XX |
| Mantled ground squirrel | PP,MS,SF | X | X | X | | X | X | | XX | XX | | XX | XX | | XX | X | |
| Mourning dove | PP,MS,PJ | X | X | | | X | | | X | X | | X | X | | X | X | |
| Northern flicker | PP,MS,SF, PJ | X | X | X | X | X | X | X | XX | XX | XX | XX | XX | X | XX | XX | X |
| Red-naped sapsucker | PP,MS | | | | | | | | | X | X | | XX | XX | | XX | XX |
| Red squirrel | MS,SF | | | | | | | | | X | XX | | X | XX | | XX | XX |
| Steller's jay | PP,MS,SF, PJ | X | X | X | | X | X | | X | X | | X | XX | X | X | XX | X |
| Tassel-eared squirrel | PP,MS | | | | | | X | XX | | XX | XX | | XX | XX | | XX | XX |
| Williamson's sapsucker | PP,MS | | | | | | | | | X | X | | XX | XX | | XX | XX |
| Total X | | 7 | 8 | 7 | 1 | 8 | 8 | 2 | 5 | 8 | 3 | 4 | 4 | 3 | 4 | 5 | 3 |
| Total XX | | 2 | 1 | | | | 1 | 1 | 4 | 6 | 4 | 5 | 10 | 6 | 5 | 9 | 6 |

[1] *Vegetation structural stage: 1 = grass/forbs/shrubs; 2 = seedling/sapling; 3 = young forest; 4 = mid-aged forest; 5 = mature forest; 6 = old forest. See glossary for additional information.*

[2] *Forest type; PP = ponderosa pine, MS = mixed-species, SF = spruce-fir, PJ = piñon-juniper.*

[3] *Diameter breast height limits: 1 = 0-1"; 2 = >1-5"; 3 = >5-12"; 4 = >12-18"; 5 = 18-24"; 6 = higher density of older and larger trees per unit area.*

[4] *Canopy cover: A = 0-40%; B = 40-60%; C = > 60%.*

[5] *Blank = low populations or no use; X = important for maintaining medium populations of species; XX = important for maintaining high populations of species.*

throughout the foraging area. The large tree component, often occurring in clumps with interlocking crowns, provides a myriad of unique hiding, feeding, denning, and nesting sites used during some part of the annual cycle of all selected goshawk prey species. Goshawk foraging habitat will have sustainable and abundant prey when the majority of forests are in older age classes.

# Present Forest Conditions

Forests in the southwestern United States occupied by goshawks are diverse in species composition and structure. Southwestern forests include ponderosa pine, mixed-species, and Engelmann spruce-subalpine fir. The extent to which goshawks use piñon-juniper woodlands is unknown. History of land-use in these conifer forests is highly variable. Timber harvesting, fire suppression, livestock grazing, recreation, and mining have altered the vegetation from pre-European settlement times.

Before the arrival of European settlers, ponderosa pine forests throughout western North America were burned every 2-15 years by low-intensity, lightning-caused, non-catastrophic surface fires (Cooper 1960, 1961, Avery et al. 1976, Gruell et al. 1982, Dieterich 1980, 1983, McCune 1983, White 1985, Swetnam 1988, Covington and Moore 1991). Similar fires in mixed-species forests occurred at frequencies between 5-22 years. Fire intervals varied from a more frequent burning in dry, low elevation sites to a lower frequency in moist, high elevation sites (Weaver 1951, Ahlstrand 1980, Wright 1988). However, wildfire suppression since the late 1800s has greatly reduced fire frequency; in many areas fire has been entirely eliminated (Weaver 1961, Dieterich 1983, McCune 1983, Stein 1988, Keane et al. 1990). Livestock grazing helped decrease the fire frequencies by reducing the amount of herbaceous fuels (Brawn and Balda 1988).

Surface fires typically maintained open forest conditions by continually destroying small trees. As a result of fire suppression, many ponderosa pine and mixed-species forests became dense due to increased seedling survival. Furthermore, the lack of fire has resulted in the conversion of many ponderosa pine stands to Douglas-fir and true firs (Barrett et al. 1980). The reduced fire-related mortality of young trees not only increased stocking levels, but increased competition for limited soil moisture and nutrients (Gruell et al. 1982, Moir and Dieterich 1988). Evidence suggests that, with increased stocking and competition:

1) tree vigor decreases, and
2) the frequency and intensity of epidemics of insects, root diseases, and dwarf mistletoe increases.

These factors result in higher tree mortality in the older age-classes (Weaver 1943, Fellin 1979, Williams and Marsden 1982, Ryker and Losensky 1983, Byler 1984, Anderson et al. 1987, Swetnam and Lynch 1989, Covington and Moore 1991).

Also, the increased number of small, young trees in present day forests result in a continuous "ladder" of fuels that carry fires from the ground to the tallest trees (Madany and West 1980). This, combined with a build-up of surface fuels, produces a high hazard for catastrophic, tree-killing fires. Under pre-settlement conditions, catastrophic crown fires were apparently rare (Brawn and Balda 1988, Covington and Moore 1991).

Spruce-fir forests, in contrast to ponderosa pine and mixed-species, have lower fire frequencies (63-400 years) (Arno 1980, Romme 1980). However, the effect of fire suppression on tree densities is unknown (Alexander 1974, 1987). Lightning, windfall, insects, and diseases have maintained a wide variety of conditions in these forests (Stromberg and Patten 1991).

Grazing of domestic livestock has been a major use in southwestern ponderosa pine and mixed-species forests since the mid 1800s (Rassmussen 1941, Cooper 1960). Dense grass cover lowers the establishment and survival of pine and fir seedlings (Brawn and Balda 1988). Heavy livestock grazing reduced ground cover, which allowed for the establishment of "dog-hair" thickets (Stein 1988). Furthermore, fire suppression, by allowing the encroachment of trees into openings and increasing shading, has reduced forage production. Although the effects of grazing in spruce-fir forests are poorly known, impacts are probably less than in the other forest types. Grazing in high-altitude meadows, however, has changed plant community composition and structure.

Tree harvest activities have caused additional structural and compositional changes in each southwestern forest type. Older forests, because of the economic value of the standing crop, have been the focus of traditional timber harvesting. Today, fewer older forests with large trees exist. Due to fire management practices and fuel-wood harvesting, snags are less abundant in present-day forests. The effects of removing old trees and snags are long-term; crop rotation periods of less than 150 years do not allow trees sufficient time to become large live trees, snags, and downed logs.

The land-use history of southwestern forests, particularly fire suppression and timber harvesting, and the lack of stand treatments directed at controlling damaging forest insects and diseases, has resulted in declining forest health (Parker 1991). Evidence indicates that dwarf mistletoes (*Arceuthobium* spp.) and root diseases (*Armillaria* spp., *Heterbasidion annosum*) are increasing in forests of the Southwest (Parker 1991, Maffei and Hawksworth in review). Similarly, because of high stand densities, the potential for epidemic outbreaks

of bark beetles (*Dendroctonus* spp.) is present in many ponderosa pine and mixed-species forests (Hedden et al. 1981, USDA Forest Service 1988, Rogers and Conklin 1991). The threat of western spruce budworm (*Choristoneura occidentalis*) outbreaks is also increasing in the multi-storied stands being perpetuated in the mixed-species forests (USDA Forest Service 1985, Swetnam and Lynch 1989) (Appendix 5, page 79).

The individual and cumulative effects of these forest modifications on the habitat of goshawks and their prey are poorly understood. However, we believe these modifications affect habitat use by the goshawk and the availability (abundance and vulnerability) of goshawk prey. Specifically:

1) in areas of thick tree regeneration, access to prey may be limited (Reynolds 1989),
2) increased tree canopy cover results in a loss of herbaceous and/or shrubby foods (Cooper 1960, Stein 1988) and therefore, reductions in populations of the many herbivorous prey of the goshawk,
3) reductions in the amount of older forests reduces the abundance of those prey that require large trees (Szaro and Balda 1979b, Patton et al. 1985, Sullivan and Moses 1986, Brawn and Balda 1988),
4) reductions of large snags decreases the abundance of those prey dependent on them (Balda 1975, Brawn and Balda 1988), and
5) creating large openings in forests results in the reduction of the abundance of fruiting fungi, and lower populations of prey that feed on fungi (States 1985, Pederson et al. 1987).

# Management Recommendations for the Home Range

The present forest conditions above reflect the extent of human influence on natural processes. Several types of active management such as thinning and prescribed fire should speed the process of producing and maintaining the desired conditions for sustaining goshawks and their prey. For example, if wild stands of ponderosa pine are not thinned naturally (by fire) or artificially (by tree cutting) they typically stagnate and will not develop into large, mature trees (Appendix 4, Table 5; page 84). When thinned regularly, trees can reach 10 inches in diameter within 80 years, depending on forest site. In some forests (such as spruce-fir), natural processes are still functioning, and little or no active management will be necessary to reach the desired conditions (Stromberg and Patten 1991).

There are three key components in the goshawk's home range: nest areas, post-fledging family area, and foraging area. Management objectives, desired conditions, and management recommendations based on goshawk nest habitat and foraging behavior, and the food and habitat of selected goshawk prey for each home range component has been specified.

Across the Southwestern Region there is considerable variation in site-specific growth potential. This variation is associated with elevation, slope, aspect, soil, available moisture and nutrients, and disturbance history. Therefore, sites have widely varying capabilities to produce the desired forest conditions; on certain sites desired conditions cannot be attained, while on others the conditions can be exceeded. Although high growth-potential sites have the greatest capabilities to produce nest areas, low potential sites may still provide foraging habitat with enough time.

Because trees and forests require many years to grow, and because much research is needed to improve our understanding of goshawk habitat use, it is prudent to minimize the possibility of immediate loss of goshawk habitat. Therefore, the following management recommendations are conservative; that is, they are designed to produce forest conditions that will sustain goshawk populations by minimizing long-term loss of their habitat due to unfavorable environmental conditions such as long periods of drought. Therefore, the largest areas (acres) reported in the literature (Table 3, page 9), rather than the average or the smallest, were used when developing the management recommendations for the nest area, PFA, and foraging area.

The opportunities to produce, maintain, and enhance goshawk habitat may not be equally applied on all forested lands because of "reserved forest land" designations, such as wilderness, research natural areas, National Parks, and "area limitations" related to slope and soil type. Desired conditions might be achieved in some of these areas through the application of allowable management tools (fire, hand-thinning).

## Nest Area

### Management Objectives, All Forest Types

√ Provide long-term nesting habitat for goshawks in

a landscape.

### Desired Conditions

√ ***Size***: Approximately 30 acres (3 suitable and 3 replacement totaling 180 acres per home range).

√ ***Location***: Along drainages, base of slopes, and on northerly aspects.

√ ***Stand structure***: See Table 5, page 14.

### Management Recommendations

√ Maintain at least 3 suitable nest areas per home range. Selection priority:

1) the active nest area; and
2) the most recently used historical nest areas.

When possible, all historical nest areas should be maintained.

√ Provide at least 3 replacement nest areas (in addition to the 3 suitable nest areas) per home range.

√ All nest areas are best located approximately 0.5 miles from each other (Fig. 9).

√ No adverse management activities in nest areas at any time.

√ Minimal human presence in active nest areas during the nesting season, March 1 - September 30.

√ Preferred treatments for maintaining stand structure in nest areas:

- ***In suitable nest areas:*** thin unwanted understory trees, with non-uniform spacing, in using prescribed fire (except for spruce-fir), and/or hand operated tools.
- ***In replacement nest areas***:

1) thin from below (remove trees from the understory), with non-uniform spacing in the three youngest VSS to maintain low densities to promote faster tree growth and crown development, and
2) allow for stand density increases in the three older VSS to develop interlocking crowns (Fig. 10).

√ Replacement nest areas should be first selected from stands in the PFA that resemble vegetation and landform of suitable nest areas.

- ***To decrease fuel hazards***, in order of priority:

1) Use periodic prescribed fires (except in spruce-fir).
2) Lopping and scattering of thinning debris is preferred if prescribed fire cannot be used.
3) Piling of debris should be limited. When necessary, hand piling should be used to minimize compaction within piles and to minimize displacement and destruction of the forest floor and the herbaceous layer.
4) Grapple or dozer piling is not recommended.

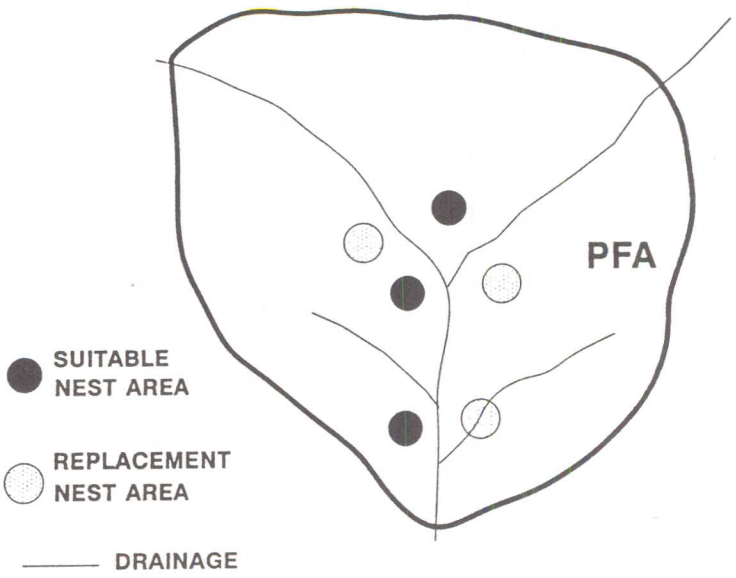



**Figure 9. Schematic diagram of suitable and replacement nest areas within a post-fledging family area. The foraging area surrounds the PFA.**

√ Manage road densities at the lowest level possible to minimize disturbance in the nest area. Where timber harvesting has been prescribed to achieve desired forest condition, use small, permanent skid trails in lieu of roads.

√ Wildlife and livestock utilization of grasses and forbs should average 20% by weight and not exceed 40% in any area, and shrub utilization should average 40% by weight and not exceed 60% in any area. These levels of utilization should maintain native food and cover for many of the prey species (Schmutz 1978, Wasser 1982).

## Post-fledging Family Area (PFA)

### Management Objectives

√ Provide hiding cover (from predators, siblings, and weather) for goshawk fledglings.

√ Provide habitat for prey and foraging opportunities for the adults and fledgling goshawks during the fledgling-dependency period.

### Desired Conditions, All Forest Types

√ ***Size***: Approximately 420 acres (not including the acres in suitable and replacement nest areas). Although portions of natural and permanently created openings close to forest edges may be

**INTERMEDIATE TREATMENT:**
*Thinning from Below*

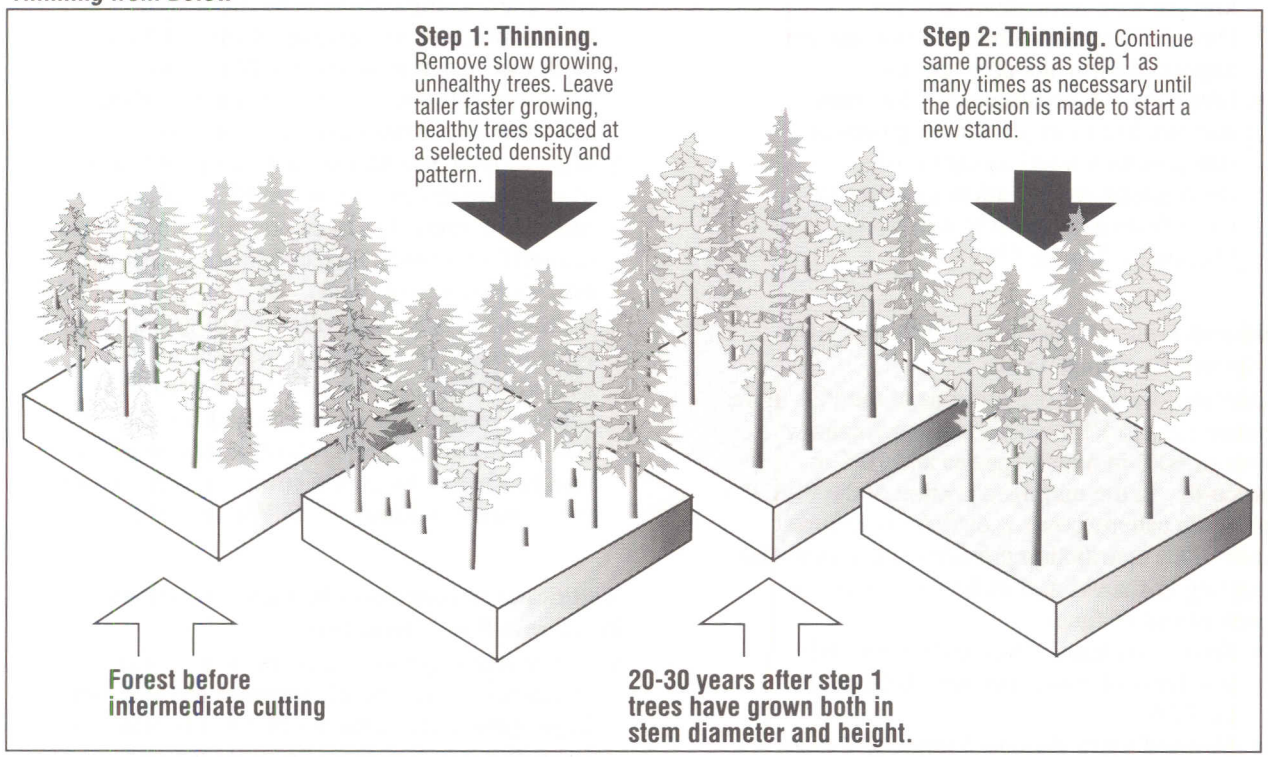



**Figure 10. Thinning from below (removing trees from the understory) to achieve desired forest conditions.**

utilized for foraging by goshawks, these areas are not counted as part of the PFA. Also, do not count created openings (such as forest health, fire) greater then two acres in size as part of the PFA.

√ ***Location***: Approximately centered around suitable and replacement nest areas (Fig. 9).

√ ***Stand structure:*** A mosaic of vegetation structural stages (VSSs) interspersed throughout the PFA in small patches.

- The majority (60%) of the PFA should be in the three older VSSs (4, 5, 6), approximately 20% in each. Of the remaining 40%, 20% should be in young forest (VSS 3), and 10% in the seedling/sapling (VSS 2), and 10% in grass/forb/shrub stages (VSS 1). The approximate proportions that can be maintained in the different VSS classes depend on:

1) the years required for tree establishment and development,
2) diameter growth rates, and
3) tree longevity (Appendix 5, page 82).

The number of years spent in each VSS will depend on the intensity of management (Appendix 5, page 82).

- The large-tree component throughout the PFA should include: snags, downed logs, and mature and old, live trees in clumps or stringers with interlocking crowns.
- A developed herbaceous and/or shrub understory throughout the PFA should emphasize native species, especially grasses.

√ ***Woody debris:*** Present throughout the PFA.

√ ***Soil conditions:*** Developed, intact forest soils with emphasis on organic surface layers (humus, litter and soil wood) within the natural turnover rates. These conditions should provide for the sustainability of mycorrhizae.

**Additional Desired Conditions, Ponderosa Pine Forest Type**

√ ***Stand structure:*** The portions of the PFA in the mature and old VSSs have a minimum canopy cover of 50%. One-third of the area in the mid-aged portion has a minimum canopy cover of 60%, and the remaining two-thirds has a minimum canopy cover of 50%. This distribution provides hiding cover for fledgling goshawks and moist forest soils for development of fungi.

- ***Snags***: At least 2 large (≥18 inch DBH, ≥30 feet tall) snags per acre throughout the PFA. These dimensions meet the minimum requirements for the majority of prey species.
- ***Downed Logs***: At least 3 large (≥12 inch

diameter mid-point, ≥8 feet long) downed logs per acre throughout the PFA. Downed logs of this number and size are important for many prey species.

- ***Live trees:*** A minimum of 3-5 mature and old, live trees per acre in groups or stringers with interlocking crowns. Interlocking crowns allow squirrels to move from tree crown to tree crown (Appendix 3, page 53).

**Additional Desired Conditions, Mixed-species and Spruce-fir Forest Types**

√ ***Stand structure:*** Those portions of the PFA in the mature and old VSS have a minimum canopy cover of 60% in mixed-species and 70% in spruce-fir. In the mid-aged portion of the PFA, the minimum canopy cover is 60% for both forest types. This distribution provides hiding cover for fledgling goshawks and moist forest soils for development of fungi.

- ***Snags***: At least 3 large (≥18 inch DBH, ≥30 feet tall) snags per acre throughout the PFA.
- ***Downed logs:*** At least 5 large (≥12 inch diameter mid-point, ≥8 feet long) downed logs per acre throughout the PFA .
- ***Live trees:*** Because the mixed-species (upper elevations) and spruce-fir forest types contain red squirrel habitat, a higher density of mature and old trees with interlocking crowns in clumps is required. A minimum of 1 group of 6 mature and old trees per acre in mixed-species, and at least 1 intact group (with at least 6 mature or old trees per group) per half-acre (2 groups per acre) in spruce-fir is required (Appendix 3, page 53).

**Management Recommendations, All Forest Types**

√ In cases where the PFA of one goshawk pair overlaps the foraging area of another pair, the management recommendations for the PFA take precedence.

√ No adverse management activities in PFAs during the nesting season, March 1 - September 30. Minimize human presence during nesting.

√ Preferred treatment for maintaining stand structure in the PFA: Thin from below (Fig. 10). In the three youngest VSSs, these treatments should result in lower stand densities (basal areas) to promote fast tree growth, crown development, herb and/or shrub development. Treatments should also allow for irregular spacing of trees in the three older VSS's, allow stand densities (basal areas) to increase (Appendix 5, Table 5; page 84). Provide for or preserve existing clumps of trees with interlocking crowns in the three older VSSs by avoiding uniform spacing of trees. Other treatments (such as sanitation, liberation, improvement) could be used when and where appropriate to create desired conditions.

√ Manage road densities at the lowest level possible to minimize disturbance in the PFA. Where timber harvesting has been prescribed to achieve desired forest conditions, use small, permanent skid trails in lieu of roads.

√ Wildlife and livestock utilization of grasses and forbs should average 20% by weight and not exceed 40% in any area, and shrub utilization should average 40% by weight and not exceed 60% in any area. This level of utilization should maintain native foods and cover for many of the prey species (Schmutz 1978, Wasser 1982).

**Additional Management Recommendations, Ponderosa Pine Forest Type**

√ Create small openings (2 acres or less) with regeneration cuts. Small openings are preferred to large openings because the PFA is a transition in vegetative structure from the nest area (no openings) to the foraging area with medium-sized openings (see Foraging Area). Openings should be irregular in shape and no greater than 200 feet in width to assure goshawk foraging opportunities in openings within them. If openings are greater than 1 acre, identify and retain 3 to 5 mature and old trees per acre (reserve trees) with interlocking crowns. In openings less than 1 acre, the large-tree component can be met in adjacent forested areas. Interlocking crowns provide squirrel habitat and food, minimize blowdown, and increase drought resistance. Scatter openings throughout the PFA wherever possible to develop the desired interspersion of structural stages (Fig. 11 and Fig. 12).

√ Encourage aspen and oak regeneration. These trees are desirable for woodpeckers and other prey species (Appendix 3, page 53). Animal exclosures may be necessary to develop and maintain tree regeneration.

√ Planting of ponderosa pine, in addition to relying on natural regeneration, is recommended.

√ Leave 5 - 7 tons per acre of woody debris (greater than 3 inches in diameter) and downed logs distributed across areas, after timber harvesting, for small animal habitat and to maintain long-term productivity (Harvey et al. 1987, Graham et al. in press). Treatments, in order of priority:

1) Use periodic prescribed fires to regenerate where needed and to develop desired stand conditions, recycle

**REGENERATION METHOD:**
*Shelterwood with Reserve Trees*

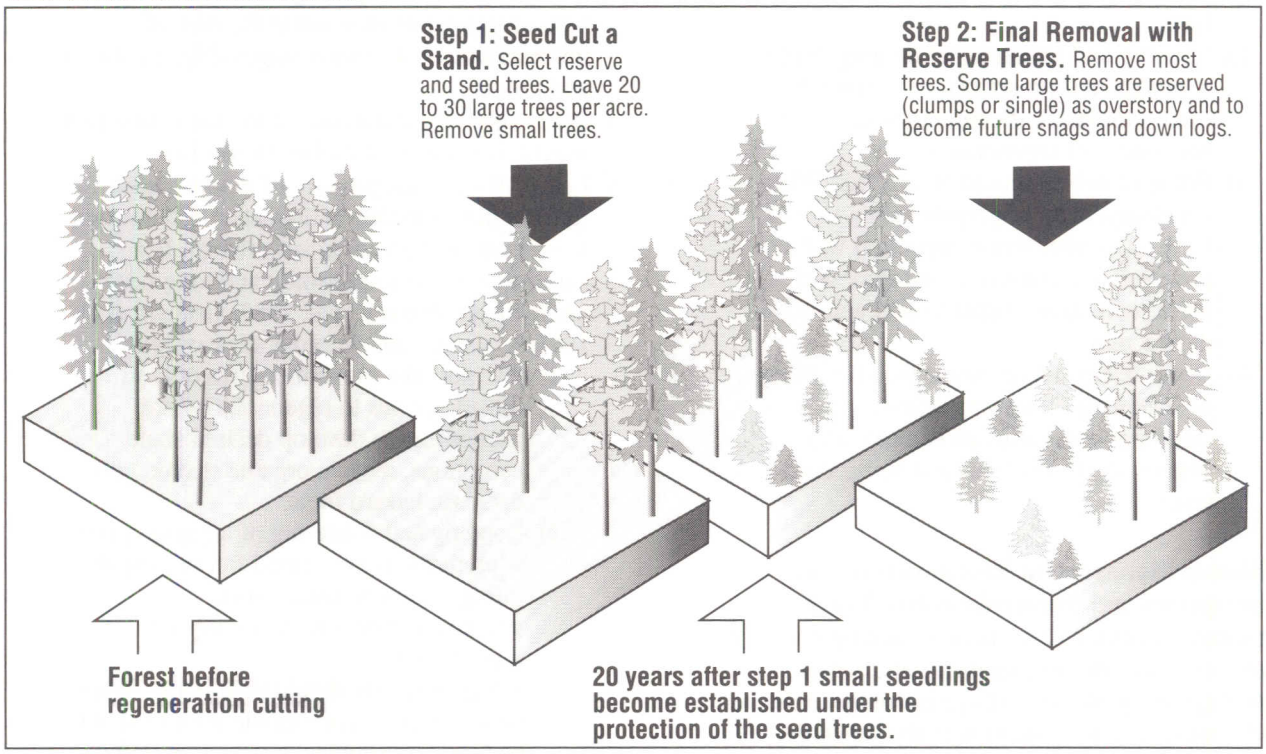



**Figure 11. The shelterwood regeneration method with reserve trees is appropriate in both post-fledging family areas and foraging areas.**

**REGENERATION METHOD:**
*Group-selection*

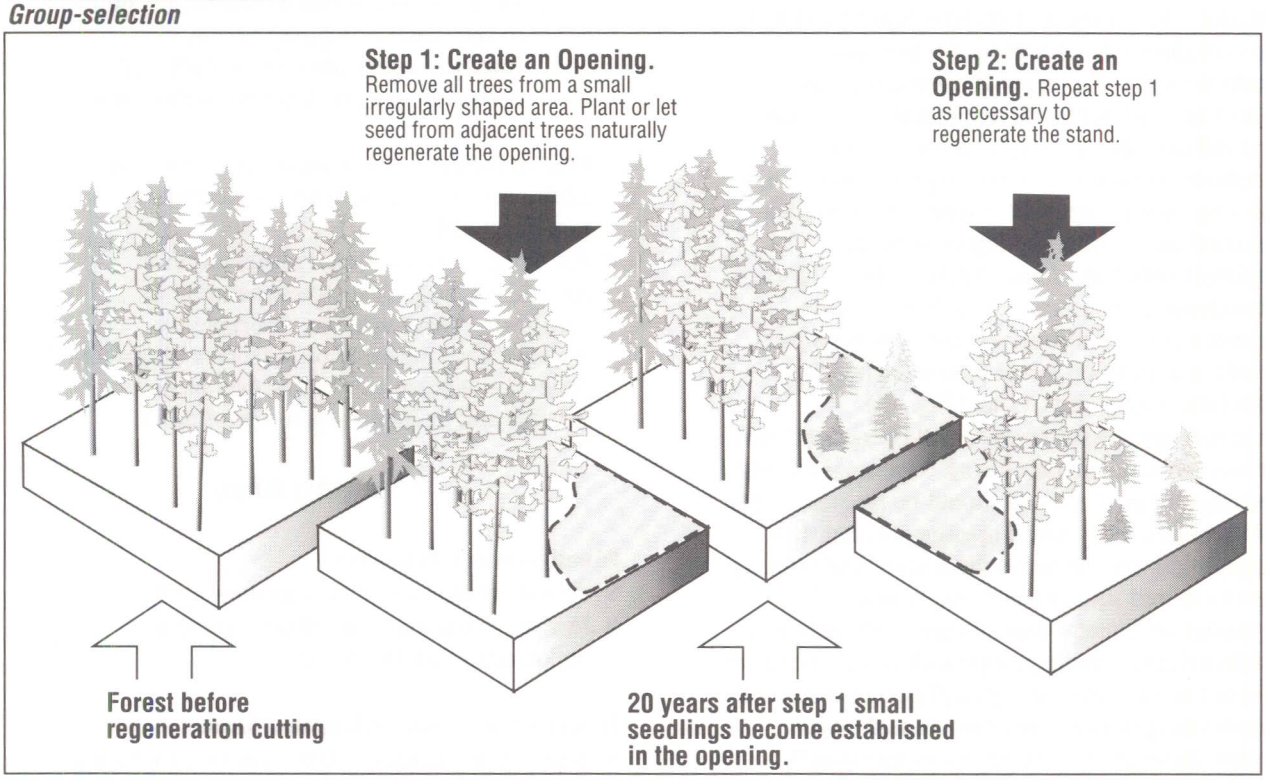



**Figure 12. The group-selection regeneration method is appropriate in both post-fledging family areas and foraging areas.**

organic matter, and decrease hazard fuels.

2) Lopping and scattering of logging debris is preferred if prescribed fire cannot be used. Some scarification may be necessary for regeneration.
3) Piling of debris should be limited. When necessary, hand or grapple piling should be used to minimize compaction within piles and to minimize forest floor and herbaceous layer displacement and destruction.
4) Dozer use is not recommended for piling or scattering of logging debris. Improper dozer use can displace and destroy the forest floor and herbaceous layer.

**Additional Management Recommendations, Mixed-species and Spruce-fir Forest Types**

√ In mixed-species forests, create small openings (2 acres or less) with regeneration cuts. Small openings are preferred to large openings in the PFA because it is a transition in the vegetative structure from the nest area (no openings) to the foraging area with medium sized openings (see Foraging Area). Openings should be irregular in shape and no greater than 150 feet in width to minimize the amount of squirrel habitat lost and provide desirable conditions for tree and understory development. If openings are greater than 1 acre, identify and retain at least 6 mature and old trees per acre (reserve trees) with interlocking crowns. In openings less than 1 acre, the large tree component can be met in adjacent forested areas. Interlocking crowns provide squirrel habitat and food, minimize potential of blowdown, and increase drought resistance. Scatter openings throughout the PFA wherever possible to develop the desired interspersion of structural stages (Fig. 11 and Fig. 12).

√ In spruce-fir forests, create small openings (1 acre or less) with regeneration cuts. Openings should be irregular in shape and should be no greater than 125 feet in width. Small openings, rather than large, minimize the detrimental effects of opening forests on red squirrel food and habitat. If openings are greater than 0.5 acres, identify and retain at least 1 intact group (with at least 6 mature and old reserve trees per group) per 0.5 acres with interlocking crowns. No trees should be cut within these groups. In openings less than 0.5 acres, the large-tree component can be met in adjacent forested areas. Interlocking crowns provide squirrel habitat and food, minimize potential of blowdown, and increase drought resistance. Scatter openings throughout the PFA wherever possible to develop the desired interspersion of structural stages (Fig. 11, Fig. 12, and Fig. 13).

√ In red squirrel habitat, center the intact tree groups around existing food caches (middens).

√ Leave 10 - 15 tons per acre of woody debris (greater than 3 inches in diameter) and downed logs distributed across areas, after timber harvesting, for animal habitat and long-term productivity (Harvey et al. 1987, Graham et al. 1991c). Treatments, in order of priority:

1) Use periodic prescribed fires only in mixed-species to regenerate where needed and to develop desired stand conditions, recycle organic matter, and decrease hazard fuels.
2) Lopping and scattering of logging debris is preferred if prescribed fire or grapple piling cannot be used. Some scarification may be necessary for regeneration.
3) Piling of debris should be limited. When necessary, hand or grapple piling should be used to minimize compaction within piles and to minimize forest floor and herbaceous layer displacement and destruction.
4) Dozer use is not recommended for piling or scattering of logging debris. Improper dozer use can displace and destroy the forest floor and herbaceous layer.

√ Planting of appropriate seral tree species, in addition to relying on natural regeneration, is recommended.

√ Encourage aspen and oak regeneration in mixed-species and aspen regeneration in spruce-fir. These trees are desirable for woodpeckers and other prey species (Appendix 3, page 53). Animal exclosures may be necessary to develop and maintain aspen regeneration.

## Foraging Area

**Management Objectives**

√ Provide quality habitat for goshawk prey.

√ Provide conditions that enhance foraging opportunities for the goshawk.

**Desired Conditions, All Forest Types**

√ *Size*: Approximately 5400 acres (not including nest areas and PFA acres). Although portions of natural and permanently created openings close to forest edges may be utilized for foraging by goshawks, these areas are not counted as part of

**REGENERATION METHOD:**
***Irregular Group Shelterwood***

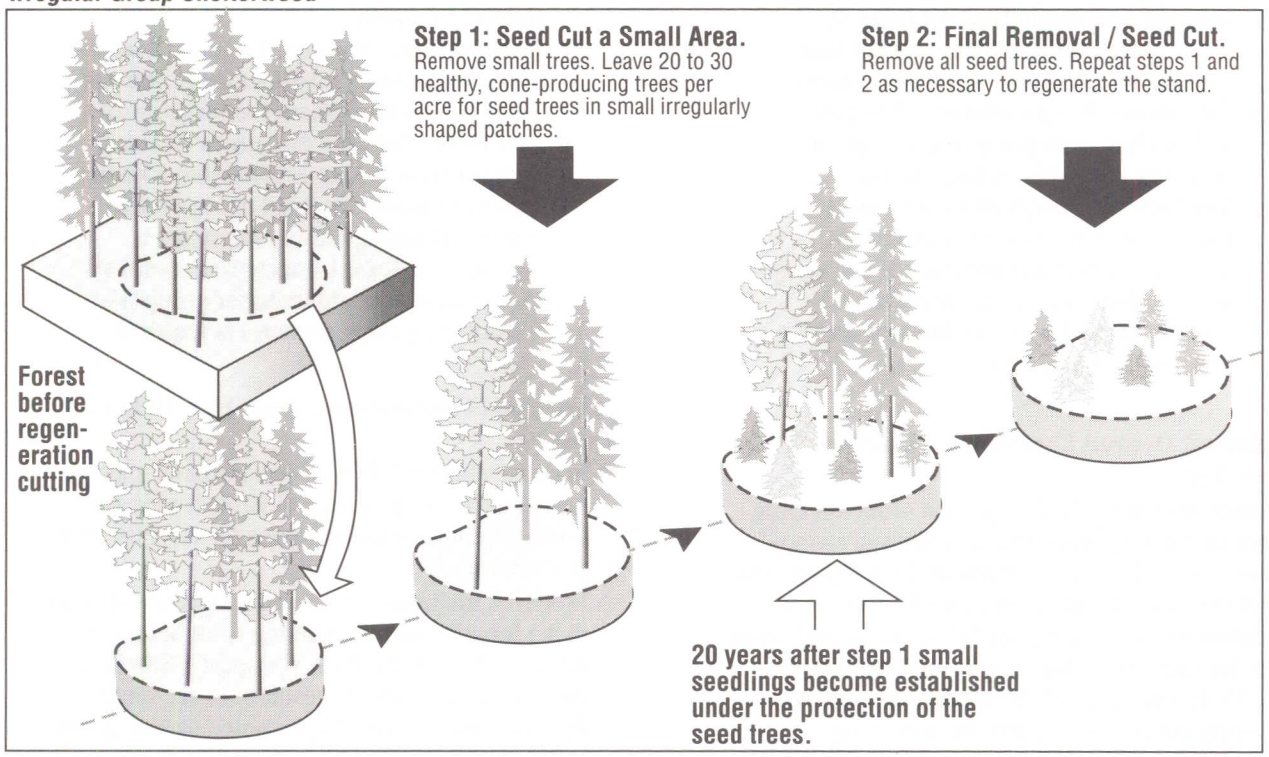



**Figure 13. The irregular group shelterwood regeneration method is appropriate in both post-fledging family areas and foraging areas.**

the foraging area. Also, do not count created openings (such as forest health, fire) greater then four acres in size as part of the foraging area.

√ ***Location***: Foraging areas surround nest areas and PFAs.

√ ***Stand structure:*** A mosaic of vegetation structural stages interspersed throughout the foraging area in small patches.

- The majority (60%) of the foraging area should ultimately be in the three older VSSs (4, 5, 6), approximately 20% in each. Of the remaining 40%, 20% should be in young forest (VSS 3) and 10% in the seedling/sapling (VSS 2) and 10% in grass/forb/shrub (VSS 1). The approximate proportions that can be maintained in the different VSS classes depend on:

1) the years required for tree establishment and development,
2) diameter growth rates, and
3) tree longevity (Appendix 5, page 82). The number of years spent in each VSS will depend on the intensity of management (Appendix 5, page 82 ).

√ The large-tree component throughout the foraging area should include: snags, downed logs, and mature and old live trees in clumps or stringers with interlocking crowns.

√ A developed herbaceous and/or shrub understory should emphasize native species, especially grasses, throughout the foraging area.

√ ***Woody debris:*** present throughout the foraging area.

√ ***Soil conditions:*** developed, intact forest soils with emphasis on organic surface layers (humus, litter, and soil wood) within natural turnover rates. These conditions should provide for the sustainability of mycorrhizae.

**Additional Desired Conditions, Ponderosa Pine Forest Type**

√ ***Stand structure:*** The portions of the foraging area in the mature and old VSS should have a minimum canopy cover of 40%. This level helps provide moist forest soils for the development of fungi.

- ***Snags:*** At least 2 large (≥18 inch DBH, ≥30 feet tall) snags per acre throughout the foraging area. These dimensions meet the minimum requirement for the majority of prey species.

- ***Downed Logs:*** At least 3 large (≥12 inch diameter mid-point, ≥8 feet long) downed logs per acre throughout the foraging area. Downed logs of this number and size are important for many prey species
- ***Live trees:*** A minimum of 3-5 mature and old live trees per acre in groups or stringers with interlocking crowns. Interlocking crowns allow squirrels to move from tree crown to tree crown. These groups of mature and old live trees will produce snags, supply perch and roost trees, and goshawk hunting perches (Appendix 3, page 53).

**Additional Desired Conditions, Mixed-species Forest Type**

√ ***Stand structure:*** In that portion of the foraging area that is VSS 6, there is a minimum canopy cover of 60%. In the portion of the foraging area that is in the mature stage (VSS 5), there is a minimum canopy cover of 50%. In the portion of the foraging area that is in the mid-aged stage (VSS 4), one-third of the area has a minimum canopy cover of 60%, and the remaining two-thirds has a minimum canopy cover of 40%. These levels provide moist forest soils for sustaining fungi.

- ***Snags***: At least 3 large (≥18 inch DBH, ≥30 feet tall) snags per acre throughout the foraging area.
- ***Downed logs:*** At least 5 large (≥12 inch diameter mid-point, ≥8 feet long) downed logs per acre throughout the foraging area.
- ***Live trees:*** Because the mixed-species forest type contains red squirrel habitat, a higher density of mature and old trees in groups with interlocking crowns is required. A minimum of 6 mature and old trees per acre in groups or stringers with interlocking crowns is required. Interlocking crowns allow squirrels to move from tree crown to tree crown (Appendix 3, page 53).

**Additional Desired Conditions, Spruce-fir Forest Type**

√ ***Stand structure:*** In the portions of the foraging area in the two oldest VSSs (5, 6), there is a minimum canopy cover of 60%. In the portion of the foraging area in the mid-aged stage (VSS 4), one-third of the area has a minimum canopy cover of 60%, and the remaining two-thirds has a minimum canopy cover of 40%. These levels provide moist forest soils for development of fungi.

- ***Snags:*** At least 3 large (≥18 inch DBH, ≥30 feet tall) snags per acre throughout the foraging area.
- ***Downed logs:*** At least 5 large (≥12 inch diameter mid-point, ≥8 feet long) downed logs per acre throughout the foraging area.
- ***Live trees:*** Because the spruce-fir forest type contains red squirrel habitat, a higher density of mature and old trees per acre with interlocking crowns in groups is required. At least 1 intact group (with at least 6 mature or old trees per group) per 0.5 acre (2 groups per acre) is required.

**Management Recommendations For All Forest Types**

√ In cases where the PFA of one goshawk pair overlaps the foraging area of another pair, the management recommendations for the PFA take precedence.

√ Preferred treatment for maintaining stand structure in the foraging area is thinning from below (Fig. 10, page 23). In the three youngest VSSs (1, 2, 3), these treatments should result in lower stand densities (basal areas) to promote fast tree growth, crown development, and herb and/or shrub development. Treatments should also allow for irregular spacing of trees, in the three older VSSs, allow stand densities (basal areas) to increase (Appendix 5, Table 5; page 84). Provide for or preserve existing clumps of trees with interlocking crowns in the three older VSSs by avoiding uniform spacing of trees. Other treatments (such as sanitation, liberation, improvement) could be used when and where appropriate to create desired conditions.

√ Manage road densities at the lowest level possible to minimize disturbance in the foraging area. Where timber harvesting has been prescribed to achieve desired forest conditions, use small, permanent skid trails in lieu of roads.

√ Wildlife and livestock utilization of grasses and forbs should average 20% by weight and not exceed 40% in any area, and shrub utilization should average 40% by weight and not exceed 60% in any area. This level of utilization should maintain native foods and cover for many of the prey species (Schmutz 1978, Wasser 1982).

**Additional Management Recommendations, Ponderosa Pine Forest Type**

√ Create small to medium openings (up to 4 acres) with regeneration cuts. Openings of this size in the foraging area are preferred by the majority of the prey species. Openings should be irregular in shape and no greater than 200 feet in width to

assure goshawk foraging opportunities in openings. If openings are greater than 1 acre, identify and retain 3 to 5 mature and old trees per acre (reserve trees) with interlocking crowns. In openings less than 1 acre, the large-tree component can be met in adjacent forested areas. In addition, interlocking crowns provide squirrel habitat, minimize blowdown, and increase drought resistance. Scatter openings throughout the foraging area wherever possible to develop the desired interspersion of structural stages (Figs. 11, 12; page 25).

- √ Encourage aspen and oak regeneration. These trees are desirable for woodpeckers and other prey species (Appendix 3, page 53). Animal exclosures may be necessary to develop and maintain tree regeneration.
- √ Planting of ponderosa pine, in addition to relying on natural regeneration, is recommended.
- √ Leave 5 - 7 tons per acre of woody debris (greater than 3 inches in diameter) and downed logs distributed across areas, after timber harvesting, for animal habitat and to maintain long-term productivity (Harvey et al. 1987, Graham et al. 1991c). Treatments, in order of priority:
  1) Use periodic prescribed fires to regenerate where needed and to develop desired stand conditions, recycle organic matter, and decrease hazard fuels.
  2) Lopping and scattering of logging debris is preferred if prescribed fire cannot be used. Some scarification may be necessary for regeneration.
  3) Piling of debris should be limited. When necessary, hand or grapple piling should be used to minimize compaction within piles and to minimize forest floor and herbaceous layer displacement and destruction.
  4) Dozer use is not recommended for piling or scattering of logging debris. Improper dozer use can displace and destroy the forest floor and herbaceous layer.

**Additional Management Recommendations, Mixed-species Forest Type**

- √ Create small to medium openings (up to 4 acres) with regeneration cuts. Openings in the foraging areas are needed because several prey species require openings for feeding and breeding. Openings should be irregular in shape and no greater than 200 feet in width to assure goshawk foraging opportunities. If openings are greater than 1 acre, identify and retain at least 6 mature and old trees per acre (reserve trees) with interlocking crowns. In openings less than 1 acre, the large-tree component can be met in adjacent forested areas. Interlocking crowns provide squirrel habitat, minimize blowdown, and increase drought resistance. Scatter openings throughout the foraging area wherever possible to develop the desired interspersion of structural stages (Figs. 11, 12; page 25).
- √ Encourage aspen and oak regeneration. These trees are desirable for woodpeckers and other prey species (Appendix 3, page 53). Animal exclosures may be necessary to develop and maintain tree regeneration.
- √ Planting of appropriate seral tree species in addition to relying on natural regeneration is recommended.
- √ Leave 10 - 15 tons per acre of woody debris (greater than 3 inches in diameter) and downed logs distributed across areas, after timber harvesting, for animal habitat and to maintain long-term productivity (Harvey et al. 1987, Graham et al. 1991c). Treatments, in order of priority:
  1) Use periodic prescribed fires to regenerate where needed and to develop desired stand conditions, recycle organic matter, and decrease hazard fuels.
  2) Lopping and scattering of logging debris is preferred if prescribed fire cannot be used. Some scarification may be necessary for regeneration.
  3) Piling of debris should be limited. When necessary, hand or grapple piling should be used to minimize compaction within piles and to minimize forest floor and herbaceous layer displacement and destruction.
  4) Dozer use is not recommended for piling or scattering of logging debris. Improper dozer use can displace and destroy the forest floor and herbaceous layer.

**Additional Management Recommendations, Spruce-fir Forest Type**

- √ Create small openings (up to 1 acre) with regeneration cuts. Openings should be irregular in shape and no greater than 125 feet in width. Small openings minimize the detrimental effects of opening the forest on red squirrel food and habitat. If openings are greater than 0.5 acres, identify and retain at least 1 intact group (with at least 6 mature and old reserve trees per group) per half-acre with interlocking crowns. No tree cutting should occur

within groups. In openings less than 0.5 acres, the large-tree component can be met in adjacent forested areas. Interlocking crowns provide squirrel habitat, minimize potential of blowdown, and increase drought resistance. Scatter openings throughout the foraging area wherever possible to develop the desired interspersion of structural stages (Figs. 11, 12, 13; pages 25, 27).

√ Encourage aspen and seral tree species regeneration. Aspen is desirable for woodpeckers and other prey species (Appendix 3, page 53). Animal exclosures may be necessary to develop and maintain tree regeneration.

√ In red squirrel habitat, center the intact tree groups around existing food cache locations (middens).

√ Leave 10 - 15 tons per acre of woody debris (greater than 3 inches in diameter) and downed logs distributed across areas, after timber harvesting, for animal habitat and to maintain long-term productivity (Harvey et al. 1987, Graham et al. 1991c). Treatments, in order of priority:

1) Lopping and scattering of logging debris is preferred if prescribed fire cannot be used. Some scarification may be necessary for regeneration.
2) Piling of debris should be limited. When necessary, hand or grapple piling should be used to minimize compaction within piles and to minimize forest floor and herbaceous layer displacement and destruction.
3) Dozer use is not recommended for piling or scattering of logging debris. Improper dozer use can displace and destroy the forest floor and herbaceous layer.

# Related Benefits of Achieving Desired Forest Conditions

Achieving the desired forest conditions will benefit other aspects of forest health, forest productivity, forest protection, and the habitat of many native plants and animals.

## Landscape Ecology

Landscape ecology focuses on a mosaic of forest structural stages and the biological and physical processes that influence the development of a dynamic system (Risser et al. 1984). At the landscape scale, disturbance and the interactions among patches, such as the redistribution of nutrients, organisms, and structural diversity, occur at different spatial and temporal scales (Forman and Godron 1986, Risser et al. 1984).

Providing habitat for the many goshawk prey species results in a mosaic of interspersed vegetative structural stages in large landscape units. Through time, as the various structural stages age, a constant redistribution of the habitats of goshawks and their prey will occur. Extending the goshawk recommendations beyond these units will provide a long-term, sustainable mix of forest-age classes in the landscape, and will ensure that both established and dispersing goshawks will be able to find and settle into favorable habitats. Managing forests at the landscape scale shifts the focus from the more traditional single-species management, and stand level management, to management of ecosystems.

## Species Associated with Old-Growth

Forest plants and animals in the Southwest are adapted to the forest conditions that prevailed from the end of the Pliestocene (10,000 years ago) until European settlement.

The plant associations found in the ponderosa pine and mixed-species forests are habitat for a wide variety of species. At least 57 mammals and 128 bird species occur in them, and populations of about one quarter of these bird species are declining (Diem and Zeveloff 1980, Hoover and Wills 1984). More than a quarter of these vertebrates use the mature and old forests (Hoover and Wills 1984). Several species depend to a large extent on either mature ponderosa pine, such as Grace's warbler, flammulated owl, and spotted bat, or mature mixed-species forests, such as Townsend's warbler, wood thrush, and Mexican spotted owl (Reynolds and Linkhart 1987, Ganey 1989, Siegel 1989, Reynolds and Linkhart 1992). Retention of large trees and the maintenance of older stands provides forests that resemble the pre-settlement conditions -- forests to which these vertebrates are adapted.

## Susceptibility to Catastrophic Crown Fire

Prior to European settlement, naturally caused low-intensity surface fires burned under ponderosa

pine and mixed-species forests at frequencies from 2 to 22 years (Weaver 1951, Dieterich 1983, McCune 1983, Covington and Moore 1991). These episodic surface fires kept the forest floor relatively free of excessive fuels, and the understory relatively open by killing young trees. These pre-settlement forests were composed of older age-classes whose trees had clear trunks, and crowns that were above the reach of surface fires (Cooper 1960). These pre-settlement forests were "crown-fire resistant." Catastrophic fires, in which overstory trees were killed over large areas, appear to have been rare (Brawn and Balda 1988, Covington and Moore 1991).

In the past 100 years the frequency of low intensity surface fires has been reduced by fire suppression. Fire suppression and harvesting of large trees have resulted in high fuel abundance, dense understories, and stands of young, small trees with crowns close to the surface fuels (Greull et al. 1982, Stein 1988). Ponderosa pine and mixed-species forests are now more than ever threatened by catastrophic crown fires (Barrows 1978).

Attaining the desired forest conditions decreases the hazards of catastrophic crown fire in the ponderosa pine and the mixed-species forests by:

1) maintaining a more open canopy,
2) reducing tree-understory fuel ladders, and
3) increasing the growth rate of trees and reducing the length of time that stands are at risk to catastrophic fires.

## Large Snags and Downed Logs

Long-term maintenance of large trees assures a renewable source of future large snags and downed logs. Under previous timber management systems, trees often did not have sufficient time to grow to the dimensions of large snags and downed logs before they were removed.

Downed logs provide an important component to the habitat of many species; they serve as sites for perching, feeding, nesting, food storage, and cover. Habitat offered by snags and downed logs influences the abundance and distribution of many species of wildlife. For example, at least 41 species of birds are known to use tree cavities in the southwestern forest types (Scott and Patton 1975).

## Forest Productivity

Organic materials provide habitat for microorganisms and many plants and animals (Harvey et al. 1978, Maser et al. 1978, Harvey et al. 1987). It is critical that adequate organic material be cycled in ecosystems, especially after forest management activities (Graham et al. 1991b). In unmanaged forest ecosystems, organic materials were recycled by fire, disease, and decomposition. By providing a constant supply of organic material by proper management of logging debris, snags, and downed logs, site productivity can be maintained (Graham et al. 1991c). Organic materials in soil surface layers (humus, litter, soil wood) are also essential for maintaining ecosystem function and sustainability.

Because productive soils are essential to functioning ecosystems, including plant and animal populations, these recommendations offer a means to satisfy concerns that are fundamental to the health of the land and the soil-plant-herbivore-predator relationships.

## Maintenance of Mycorrhizal Communities

Mycorrhizae play an important role in the interactions between the soil, plants, and animals, especially small mammals. In forest ecosystems, ectomycorrhizae provide the main nutrient absorbing pathways (Harvey et al. 1976, Read 1991).

Within the organic surface soil layers, where ectomycorrhizae are concentrated, they are directly involved with the mobilization of nutrients (Harvey et al. 1976, Harley 1978, Harley and Smith 1983). Ectomycorrhizal roots not only capture and store phosphate ions (Harley and Smith 1983), they have the ability to mobilize nitrogen from protein (Abuzinadah and Read 1986, 1989). Nitrogen is generally considered the most important growth-limiting nutrient in many forest ecosystems (Baath and Soderstrom 1979).

Mycorrhizal fungi are also important food sources for small mammals (Tevis 1952, 1953, Stephenson 1974, Fogel and Trappe 1978, Maser et al. 1978, Uphoff 1990). Many of the major fungal taxa eaten by squirrels and chipmunks are hypogeous ectomycorrhizae (e.g., *Rhizopogon* spp., *Hysterangium* spp., *Gautieria* spp., *Geopora* spp., and Hydnangiales) (Maser et al. 1978, States et al. 1988).

Although some epigeous mycorrhizal disperse their spores via air currents, hypogeous fungi are dependent upon small mammals for spore dispersal. Small mammals ingest fungi, defecate, and thereby spread viable spores throughout forests and openings. The mycorrhizae then inoculate seeds and plant roots. This interrelationship between host plants, fungi, and small mammals helps maintain healthy forest ecosystems (Marks and Kozlowski 1973, Maser et al. 1978). Thus, mycorrhizal fungi function not only as important food for goshawk

prey, but they also form the foundation of a healthy forest ecosystem. These goshawk management recommendations ensure abundant mycorrhizal communities by providing for a continuing supply of woody debris, downed logs, and requisite soil conditions throughout the landscape.

### Forest Products

Managing southwestern forests to attain the desired conditions should provide a variety of forest products. The recommendations call for intensive management through understory treatments of forest stands to produce large trees quickly. These intermediate treatments provide small saw-logs and wood material for small product and fiber-based industries. In addition to providing goshawk habitat, large trees not permanently protected will make excellent saw-logs.

### Forage Production

In addition to supplying small mammal habitat, the open forest conditions generated by understory thinning will produce more forage for wildlife and livestock across the landscape.

## Research Needs

Current knowledge of certain aspects of goshawk biology and forest growth and development are limited. The overall effects of forest management practices on goshawks have not been measured. Therefore, several assumptions were necessary to develop these recommendations. These assumptions highlighted key research needs.

- √ A greater understanding of forest regeneration, growth, and development, both temporally and spatially, is needed to assure the sustainability of the desired forest conditions.
- √ The desired forest conditions require small forest openings, large reserve trees, and a high interspersion of forest age classes. What impact will these conditions have on the long-term growth, development, and sustainablity of these forests? What role will insects, diseases, wildfires, and other natural disturbances play in sustaining the desired conditions?
- √ Improved techniques for monitoring and inventorying forests at large geographic and temporal scales, and the application of this information, are needed to improve the forest-development models used in these recommendations.
- √ Goshawk demography is poorly known. Research is needed to determine population size and structure, rate and direction of population change, age-specific fecundity and survival, life span, mate and territory fidelity, and adult and juvenal dispersal.
- √ Characteristics of summer and winter home ranges and habitat use by foraging goshawks are poorly understood. Research is needed to determine the seasonal and annual variation in home range size, shape, location, and the composition of forests within goshawk ranges. Foraging behavior, activity budgets, and habitat-use patterns also need to be determined.
- √ Diets of goshawks by forest type, the numerical response of goshawk populations to prey abundance, and the habitat relationships of some of those prey are poorly known. Research is needed to determine the seasonal, annual, and inter-goshawk variation in dietary composition and the abundance of prey by topography, forest structure, and forest type.

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# References


Abuzinadah, R.A.; Read, D.J. 1986. The role of proteins in the nitrogen nutrition of ectomycorrhizal plants. I. Utilization of peptides and proteins by ectomycorrhizal fungi. New Phytol. 103: 481-493.

Abuzinadah, R.A.; Read, D.J. 1989. The role of proteins in the nitrogen nutrition of ectomycorrhizal plants. V. Nitrogen transfer in birch (*Betula pendula*) grown in association with mycorrhizal and non-mycorrhizal fungi. New Phytol. 112: 61-68.

Ahlstrand, G.M. 1980. Fire history of a mixed conifer forest in Guadalupe Mountains National Park. Proceedings of the fire history workshop. October 20-24, 1980, Tucson, Arizona. Gen. Tech. Rep. RM-81, 142p. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Alexander, R.R. 1974. Silviculture of subalpine forests in the central and southern Rocky Mountains: The status of our knowledge. Res. Pap. RM-121, 88p. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Alexander, Robert R. 1987. Ecology, silviculture, and management of the Engelmann spruce-subalpine fir type in the Central and Southern Rocky Mountains. Gen. Tech. Rep. RM-162. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Alexander, Robert R.; Shepperd, W.D. 1990. Engelmann spruce. In: Silvics of North America. Washington: U.S. Department of Agriculture, Forest Service, Agriculture Handbook 654, Volume 1, Conifers.

Alexander, Robert R.; Shearer, R.C.; Shepperd, W.D. 1990. Subalpine fir. In: Silvics of North America. Washington: U.S. Department of Agriculture, Forest Service, Agriculture Handbook 654, Volume 1, Conifers.

Allen, Arthur W. 1984. Habitat suitability index models: eastern cottontail. Washington: U.S. Fish and Wildlife Service, U. S. Department of Interior. FWS/OBS-82/10.66. 23 p.

Allen, S.A.; Lancia, R.A.; Betsill, C.W. 1982. Habitat preferences of cottontail rabbits in an intensive farm and a traditional farm. Annual Conference Southeast Fish and Wildlife Agencies. 36: 614-626.

Allred, William Sylvester. 1989. The effects of Abert squirrel herbivory on ponderosa pines. Flagstaff, AZ: Northern Arizona University. Ph.D. dissertation.

American Ornithologist's Union. 1983. Checklist of North American birds, Sixth edition. Lawrence, KS: Allen Press, Inc. 877 p.

Anderson, L.C.; Carlson, C.E.; Wakimoto, R.H. 1987. Forest fire frequency and western spruce budworm out breaks in western Montana. Forest Ecology. Management. 22: 251-260.

Arizona Game and Fish Department. 1982. Small game strategic plans 1980-1985. Phoenix, AZ: Arizona Game and Fish Department.

Armleder, H.M. 1980. Habitat use and movements of hens and broods in relation to the demography of blue grouse. Toronto: University of Toronto. M. Sc. F. thesis.

Arno, S.F. 1980. Forest fire history in the northern Rockies. Journal of Forestry. 78: 460-465.

Avery, C.C.; Larson, F.R.; Schubert, G.H. 1976. Fifty-year records of virgin stand development in southwestern ponderosa pine. Gen. Tech. Rep. RM-22. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.

Baath, E.; Soderstrom, B. 1979. Fungal biomass and fungal immbolization of plant nutrients in Swedish coniferous forest soils. Rev. Ecol. Biol. Soil. 16:477-489.

Balda, R.P. 1975. The relationship of secondary cavity nesters to snag densities in western coniferous forests. Wildlife Habitat Tech. Bull. 1. U.S. Department of Agriculture, Forest Service Southwest Region.

Barrett, J.W.; McDonald, P.M.; Ronco, F., Jr.; Ryker, R.A. 1980. Interior ponderosa pine. In: Eyre, F.H., ed. Forest Cover Types of the United States and Canada. Washington: Soc. Am. For.: 114-115.

Barrows, J.S. 1978. Lightning fires in southwestern forests. Missoula, MT: U.S. Department of Agriculture, Forest Service, Northern Forest Fire Laboratory. [Unpub.]

Bartels, Molly A.; Thompson, Doug P. [In press]. *Spermophilus lateralis*. Mammalian Species.

Bartelt, Paul E. 1974. Management of the American goshawk in the Black Hills National Forest.

Vermillion, SD: University of South Dakota. 102 p. M.S. thesis.

Bassett, D.; Larson, M.; Moir, W.H.; Fletcher, R.; Ahuja, S.; Muldabin, E.; Williams, M. 1987. Forest and woodland habitat types (plant associations) of Arizona south of the Mogollon Rim and Southwestern New Mexico, Edition 2. Albuquerque, NM: U.S. Department of Agriculture Forest Service, Southwestern Region.

Bendell, J.F. 1955. Disease as a control of a population of bluegrouse, *Dendragaopus obscurus fulignosus* (Ridgeway). Canadian Journal of Zoology. 33: 195-223.

Bendell, J.F.; Elliott, P.W. 1966. Habitat selection in Blue Grouse. The Condor. 68: 431-446.

Bendell, J.F.; Elliott, P.W. 1967. Behavior and the regulation of numbers in blue grouse. Ottawa: Canadian Wildlife Service Report Series--No. 4. 76 p.

Bennetts, R.E. 1991. The influence of dwarf mistletoe infestation on bird communities in Colorado ponderosa pine forests. Fort Collins, CO: Colorado State University. 83 p. M.S. thesis.

Best, T.L.; Smartt, R.A. 1986. Feeding ecology of mourning doves (*Zenaida macroura*) in southeastern New Mexico. Southwestern Naturalist. 31: 33-38.

Bloom, P.H.; Stewart, G.R.; Walton, B.J. 1986. The status of the northern goshawk in California, 1981-1983. California Department of Fish and Game, Wildlife Management Branch, Adm. Rep. 85-1.

Bock, C.E.; Larson, D.L. 1986. Winter habitats of sapsuckers in southeastern Arizona. The Condor. 88: 246-247.

Bowman, R.; Bird, D.M. 1986. Ecological correlates of male replacement in the American kestrel. The Condor. 88: 440-445.

Boyce, J.S. 1961. Forest pathology, Edition 3. New York: McGraw-Hill Book Co.

Braun, Clait E. 1973. Distribution and habitats of band-tailed pigeons in Colorado. In: Proceedings of Western Association State Game & Fish Commission. 53: 336-344.

Brawn, Jeffrey D.; Balda, Russell P. 1988. The influence of silvicultural activity on ponderosa pine forest bird communities in the southwestern United States. In: Jackson, Jerome A., ed. Bird Conservation 3. The University of Wisconsin Press: The International Council for Bird Preservation, United States Section.

Brink, C.H.; Dean, F.C. 1966. Spruce seed as a food of red squirrels and flying squirrels in interior Alaska. Journal of Wildlife Management. 30: 503-512.

Brotherson, J.D.; Rushfort, S.R.; Evenson, W.E.; Johansen, J.R.; Morden, C. 1983. Population dynamics and age relationships of eight tree species in Navajo National Monument, Arizona. Journal of Range Management. 36: 250-256.

Brown, D.E. 1984. Arizona's Tree Squirrels. Phoenix, AZ: Arizona Game and Fish Department. 114 p.

Brown, James H. 1971. Mechanisms of competitive exclusion between two species of chipmunks. Ecology. 52(2): 305-311.

Brown, J.L. 1963. Aggressiveness, dominance and social organization in the steller jay. The Condor. 65: 460-484.

Brown, J.L. 1974. Alternate routes to sociality in jays-with a theory for the evolution of altruism and communal breeding. American Zoology. 14: 63-80.

Brown, J.L; Brown, E.R. 1985. Ecological correlates of group size in a communally breeding jay. The Condor. 87: 309-315.

Brown, L.; Amadon, D. 1968. Eagles, hawks and falcons of the world. McGraw-Hill Book Co. 945 p.

Brull, H. 1964. Das Leben deutscher Greifvogel. Stuttgart: Fisher Verlag.

Bryant, J.P.; Kuropat, P.J. 1980. Selection of winter forage by subartic browsing vertebrates: the role of plant chemistry. Annu. Rev. Ecol. Syst. 11: 262-286.

Buchanan, J.B.; Lundquist, R.W.; Aubry, K.B. 1990. Winter populations of Douglas' squirrel in different-aged Douglas-Fir Forests. Journal of Wildlife Management. 54:577-581.

Bull, E.L.; Partridge, A.D. 1986. Methods of killing trees for use by cavity nesters. Wildlife Society Bulletin.

Burt, W.H. 1934. The mammals of southern Nevada. Transactions of the San Diego Society of Natural History. 7: 375-428.

Burt, W.H.; Grossenheider, R.P. 1964. A Field Guide to the Mammals. Boston: Houghton Mifflin Company. 284 p.

Byler, J.W. 1984. Status of disease pests in the interior Douglas-fir and grand fir types. In: Proceedings of the Symposium on Silvicultural Management Strategies for Pests of the Interior Douglas-fir and Grand Fir Types. Pullman, WA:

Washington State University Cooperative Extension: 45-50.

Cade, B.S. 1985. Winter habitat preferences and migration patterns of Blue Grouse in Middle Park, Colorado. Fort Collins, CO: Colorado State University. [M.S. thesis]. 101 p.

Cade, Brian S.; Hoffman, Richard W. 1990. Winter use of Douglas-fir forests by blue grouse in Colorado. Journal of Wildlife Management. 54(3): 471-479.

Cameron, D.M., Jr. 1967. Gestation period of the golden-mantled ground squirrel (*Citellus lateralis*). Journal Mammalogy. 48: 492-493.

Carleton, W.M. 1966. Food habits of two sympatric Colorado scurids. Journal of Mammalogy. 47: 91-103.

Cave, A.J. 1968. The breeding of the kestrel, *Falco tinnunculus L.*, in the reclaimed area Oostelijk Flevoland. Netherlands Journal of Zoology. 18: 313-407.

Cayot, L.J. 1978. Habitat preferences of the mountain cottontail. Fort Collins, CO: Colorado State University. M.S. thesis.

Chapman, J.A.; Hockman, J.G.; Edwards, W.R. 1982. Cottontails. In: Chapman, J.A.; Feldhamer, G.A.; eds. Wild mammals of North America. Baltimore and London: John Hopkins University Press: 83-123.

Cockrum, E.L. 1982. Mammals of the southwest. Tucson, AZ: The University of Arizona Press.

Conklin, D.; Ferguson, B.; Pope, L. 1991. Snag recruitment projects: Luna Ranger District, Gila National Forest. Forest Pest Management Rep. R3-91-4. Albuquerque, NM: U.S. Department of Agriculture, Southwestern Region. 8 p.

Conner, R.C.; Born, J.D.; Green, A.W.; O'Brien, R.A. 1990. Forest Resources of Arizona. Res. Bull. INT-69. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 92 p.

Coon, R.A.; Nichols, J.D.; Percival, H.F. 1981. Importance of structural stability to success of mourning dove nest. Auk. 98: 389-391.

Coons, J.S. 1984. Elevational zonations and monthly changes in the bird community on San Francisco Mountain, Arizona. Flagstaff, AZ: Northern Arizona University. M.S. thesis.

Cooper, C.F. 1960. Changes in vegetation, structure, and growth of southwest pine forests since white settlement. Ecological Monographs. 30: 129-164.

Cooper, C.F. 1961. Pattern in ponderosa pine forests. Ecology. 42: 493-499.

Covington, W. Wallace; Moore, Margaret M. 1991. Changes in forest conditions and multiresource yields from ponderosa pine forests since European settlement. Phoenix, AZ: Water Resources Operations, Final Report, Salt River Project. 51 p.

Craighead, John J.; Craighead, Frank C., Jr. 1956. Hawks, owls, and wildlife. New York: Dover Publications, Inc. 443 p.

Crawford, John A.; Van Dyke, Walt; Meyers, S. Mark; Haensly, Thomas F. 1986. Fall diet of blue grouse in Oregon. Great Basin Naturalist. 46(1): 123-127.

Crocker-Bedford, D. Coleman. 1990. Goshawk reproduction and forest management. Wildlife Society Bulletin. 18(3): 262-269.

Crocker-Bedford, D. Coleman; Chaney, B. 1988. Characteristics of goshawk nesting stands. In: Glinski, R.L. et al., eds. Southwest raptor management symposium and workshop. Washington: National Wildlife Federation: 210-217.

Curtis, Paul D.; Braun, Clait E. 1983. Radiotelemetry location of nesting band-tailed pigeons in Colorado. The Wilson Bulletin. 95(3): 464-466.

Daniel, T.W. 1980. The Middle and Southern Rocky Mountain Region. In: Regional Silviculture of the United States, Second Edition. New York: John Wiley and Sons.

Daubenmire, R.; Daubenmire, J.B. 1968. Forest vegetation of eastern Washington and northern Idaho. Tech. Bul. 60. Washington Agriculture Experiment Station. 104 p.

Davis, C.A.; Sintz, G.K. 1973. Nesting of mourning doves at San Simon Cienega, southwestern New Mexico. Res. Rep. 265. New Mexico State University Agriculture Experiment Station: 1-8.

Davis, Russell; Brown, David E. 1989. Role of Post-Pleistocene dispersal in determining the modern distribution of Abert's squirrel. Great Basin Naturalist. 49(3): 425-434.

DeCalesta, D.S. 1971. A literature review on cottontail feeding habits. Colorado Division Game Fish Parks, Spec. Rep 25.

Dickson, J.G.; Conner, R.N.; Williamson, J.H. 1987. Snag retention increases bird use of a clear-cut. Journal of Wildlife Management. 47: 799-804.

Diem, K.L.; Zeveloff, S.I. 1980. Ponderosa pine bird communities. In: DeGraff, R.M., tech. coord. Management of western forests and grasslands for nongame birds. Gen. Tech. Rep. INT-86. Ogden, UT: U.S. Department of Agriculture,

Forest Service, Intermountain Forest and Range Experiment Station: 170-197.

Dieterich, J.H. 1980. Chimney Spring forest fire history. Res. Pap. RM-220. Fort Collins, CO: U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station.

Dieterich, J.H. 1983. Fire history of southwestern mixed-conifer: a case study. Forest Ecology Management. 6: 13-31.

Dimock, E.J., III. 1974. Animal populations and damage. In: Environmental effects of forest residues management in the Pacific Northwest: A state-of-knowledge compendium. Gen. Tech. Rep. PNW-24. Portland, OR: Pacific Northwest Forest and Range Experiment Station. 0-1 to 0-28 p.

Drewien, Roderick C.; Vernimen, Richard J.; Harris, Stanley W.; Yocom, Charles F. 1966. Spring weights of band-tailed pigeons. Journal of Wildlife Management. 30(1): 190-192.

Dunning, J.B., Jr. 1984. Body weights of 686 species of North American birds. West. Bird Banding Association Monographs. No. 1.

Edminster, Carleton B.; Mowrer, H. Todd; Mathiasen, Robert L.; Schuler, Thomas M.; Olsen, William K.; Hawksworth, Frank G. 1991. GENGYM: A variable density stand table projection system calibrated for mixed conifer and ponderosa pine stands in the Southwest. Res. Pap. RM-297. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experimental Station. 32 p.

Egeline, S. 1986. Wildlife relationships and forest planning. In: DeGraff, R.M.; Tilghman, N.G.; eds. Management of western forests and grasslands for nongame birds. Gen. Tech. Rep. INT-86. U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 379-389.

Eng, Robert L.; Guillion, Gordon W. 1962. The predation of goshawks upon ruffed grouse on the Cloquet Forest Research Center, Minnesota. Wilson Bulletin. 74: 227-242.

Eyre, F.H. 1980. Forest cover types of the United states and Canada. Washington: Society of American Foresters. 148 p.

Farentinos, Robert C. 1972a. Social dominance and mating activity in the tassel-eared squirrel (*Sciurus aberti ferreus*). Animal Behavior. 20(2): 316-326.

Farentinos, R.C. 1972b. Observations on the ecology of the tassel-eared squirrel. The Journal of Wildlife Management. 36(4): 1234-1239.

Farentinos, R.C. 1979. Seasonal changes in home range size of tassel-eared squirrels (*Sciurus aberti*). Southwest Naturalist. 24(1): 49-62.

Farentinos, R.C.; Capretta, P.J.; Kepner, R.E.; Littlefield, V.M. 1981. Selective herbivory in tassel-eared squirrels: Role of monoterpenes in ponderosa pines chosen as feeding trees. Science. 213: 1273-1275.

Fechner, G.H. 1990. Blue spruce. In: Silvics of North America. Washington: U.S. Department of Agriculture, Forest Service, Agriculture Handbook 654, Volume 1, Conifers.

Fellin, D.G. 1979. A review of some relationships of harvesting, residue management, and fire to forest insects and disease. In: Proceedings of the Symposium on Environmental Consequences of Timber Harvesting. Gen. Tech. Rep. INT-90. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station: 335-416.

Fellin, D.G.; Dewey, J.E. 1982. Western spruce budworm. USDA Forest Service. Forest Insect and Disease Leaflet 53. 10 p.

Findley, J.S. 1987. The natural history of New Mexican mammals. Albuquerque, NM: University of New Mexico Press.

Findley, J.S.; Harris, A.H.; Wilson, D.E.; Jones, C. 1975. Mammals of New Mexico. Albuquerque, NM: University of New Mexico Press.

Fischer, D.L. 1986. Daily activity patterns and habitat use of *Accipiter* hawks in Utah. Provo, Utah: Brigham Young University. Ph.D. dissertation.

Ffolliott, P.F. 1990. Small game habitat use in southwestern ponderosa pine forests. In: Krausman, P.R.; Smith, N.S.; eds. Managing wildlife in the southwest. Proceedings of the symposium. 1990 October. Phoenix, AZ: Arizona Chapter of the Wildlife Society: 107-117.

Ffolliott, P.F.; Patton, D.R. 1975. Production-rating functions for Abert squirrels in southwestern ponderosa pine. Wildlife Society Bulletin. 3: 162-165.

Fogel, R.D.; Trappe, J.M. 1978. Fungus consumption (mycophagy) by small mammals. Northwest Science. 52: 1-31.

Forman, R.T.T.; Godron, M. 1986. Landscape Ecology. New York: Wiley.

Frandsen, C.D. 1980. Density, habitat, and behavior of blue grouse. Toronto: University of Toronto. M.S. thesis. 142 p.

Franzreb, K.E. 1977. Bird population changes after timber harvesting of a mixed forest in Arizona. Res. Pap. RM-184. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 26 p.

Franzreb, K.E.; Ohmart, R.D. 1978. The effects of timber harvesting on breeding birds in a mixed-conifer forest. The Condor. 80: 431-441.

Ganey, J.L. 1989. Home-range characteristics of spotted owls in Northern Arizona. Journal of Wildlife Management. 53: 1159-1165.

Goodwin, Derek. 1967. Pigeons and doves of the world. London: Trustees of the British Museum (Natural History), Publication No. 663. 446 p.

Goodwin, John G., Jr.; Hungerford, C. Roger. 1979. Rodent population densities and food habits in Arizona ponderosa pine forests. Res. Pap. RM-214. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p.

Gordon, Kenneth. 1943. The natural history and behavior of the western chipmunk and the mantled ground squirrel. Corvallis, OR: Oregon State College, Studies in Zoology. 5: 1-104.

Graham, R.T. 1990. Western white pine. In: Silvics of North America. Washington: U.S. Department of Agriculture, Forest Service, Agriculture Handbook 654, Volume 1, Conifers.

Graham, R.T.; Minore, D.; Harvey, A.E.; Jurgensen, M.F.; Page-Dumroese, D.S. 1991a. Soil management as an integral part of the silvicultural systems. In: Harvey, A.E.; Neuenshewander, L.F.; compilers. Proceedings--Management and productivity of western-montane forest soils. Gen. Tech. Rep. INT-280. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station: 59-64.

Graham, R.T.; Harvey, A.E.; Page-Dumroese, Deborah S.; Jurgensen, M.F. 1991b. Importance of soil organic matter in the development of interior Douglas-fir: In: Baumgartner, D.M. and J.E. Loten (eds.). Interior douglas-fir: the species and its management. Pullman, WA: Washington State University. 85-91.

Graham, R.T.; Harvey, A.E.; Jurgensen, M.F.; Page-Dumroese, D.S; Tonn, Jonalea R.; Geier-Hayes, Kathy.; Jain, Terrie.B. 1991c. Coarse woody debris in the northern Rocky Mountains, U.S. Department of Agriculture, Forest Service, Intermountain Research Station, research paper in press.

Grant, C.V.; Steele, B.B.; Bayn, R. L. 1991. Raptor population dynamics in Utah's Uinta Basin: the importance of food resource. Southwestern Naturalist. 36:265-280.

Grand, J.B.; Mirarchi, R.E. 1988. Habitat use by recently fledged mourning doves in east-central Alabama. Journal of Wildlife Management. 52: 153-157.

Griffing, J.P.; Davis, C.A. 1974. Mourning dove foods in an uncultivated area of New Mexico. Journal of Wildlife Management. 38: 375-376.

Grinnell, J.; Dixon, J. 1918. Natural history of the ground squirrels of California. Monthly Bulletin of the State Commission of Horticulture (California). 7: 597-708.

Gruell, G.E.; Schmidt, W.C.; Arno, S.F.; Reich, W.J. 1982. Seventy years of vegetative change in a managed ponderosa pine forest in western Montana: Implications for resource management. Gen. Tech. Rep. INT-130. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 42 p.

Gurnell, John. 1984. Home range, territoriality, caching behavior and food supply of the red squirrel (*Tamiasciurus hudsonicus fremonti*) in a subalpine lodgepole pine forest. Animal Behavior. 32(4): 1119-1131.

Hager, D.C. 1960. The interrelation of logging, birds, timber regeneration in the Douglas-fir region of northwestern California. Ecology. 41: 116-125.

Haldeman, J.R. 1968. Breeding birds of a ponderosa pine forest and a fir, pine, aspen forest in the San Francisco Mountains, Arizona. Flagstaff, AZ: Northern Arizona University. M.S. thesis.

Hall, E.R. 1981. The mammals of North America, Second ed. New York: John Wiley and Sons. 1: 1-600+0.

Hall, Joseph G. 1981. A field study of the Kaibab squirrel in Grand Canyon National Park. Wildlife Monographs. 75: 6-54.

Hall, P.A. 1984. Characterization of nesting habitat of goshawks (Accipiter gentilis) in Northwest California. Arcata, CA: Humboldt State University. [Unpublished M.S. thesis].

Hammerstrom, F.; Hammerstrom, F.H.; Hart, J. 1973. Nest boxes: an effective management tool for kestrels. Journal of Wildlife Management. 37: 400-403.

Harley, J.L. 1978. Ectomycorrhizas as nutrient absorbing organs. Proceedings of the Royal Society of London Series B. 203: 1021.

Harley, J.L.; Smith, S.E. 1983. Mycorrhizal Symbiosis. London: Academic Press.

Harris, S.W.; Morse, M.A.; Longley, W.H. 1963. Nesting and production of the mourning dove in Minnesota. American Midland Naturalist. 69: 150-172.

Harvey, A.E.; Larsen, Michael J.; Jurgensen, M.F. 1976. Distribution of ectomycorrhizae in a mature Douglas-fir/larch forest system in western Montana. Forestry Science. 22: 393-398.

Harvey, A.E.; Jurgensen, M.F.; Larsen, M.J. 1978. Seasonal distribution of ectomycorrhizae in a mature Douglas-fir/larch forest soil in western Montana. Forestry Science. 24: 205-208.

Harvey, A.E.; Jurgensen, M.F.; Larsen, M.J.; Graham, R.T. 1987. Decaying organic materials, a management opportunity. Gen. Tech. Rep. INT-225. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 15 p.

Hatt, R.T. 1927. Notes on the ground-squirrel, Callo-spermophilus. Occasional Papers of the Museum of Zoology, University of Michigan. 185: 1-22.

Hatt, R.T. 1929. The red squirrel: its life history and habits, with special reference to the Adirondacks of New York and the Harvard Forest. Roosevelt Wildlife Bulletin. 2: 1-146.

Hawksworth, F.G. 1961. Dwarf mistletoe of ponderosa pine in the southwest. Tech. Bul. 1246. U.S. Department of Agriculture: 112.

Hawksworth, Frank G. 1973. Dwarf mistletoe and its role in lodgepole pine ecosystems. In: Baumgartner, David M., ed. Management of Lodgepole Pine Ecosystem Symposium Proceedings; 1973 October; Pullman, WA. Pullman, WA: Washington State University. 342-358.

Hawksworth, F.G.; Geils, B.W. 1989. How long do mistletoe-infected ponderosa pines live? Western Journal of Applied Forestry. 5: 47-48.

Hawksworth, F.G.; Weins, D. 1972. Biology and classification of dwarf mistletoe (*Arceuthobium*). Washington: U.S. Department of Agriculture, Forest Service, Agricultural Handbook 401. 234 p.

Hayward, G.D.; Escano, R.E. 1989. Goshawk nest-site characteristics in western Montana and northern Idaho. The Condor. 91: 476-479.

Hedden, R.; Barras, S.; Coster, J. 1981. Hazard-rating system in forest insect pest management: symposium proceedings. Gen. Tech. Rep. W0-27. Washington: U.S. Department of Agriculture, Forest Service. 166 p.

Hennessy, Stephen P. 1978. Ecological relationships of accipiters in northern Utah--with special emphasis on the effects of human disturbance. Logan, UT: Utah State University. 66 p. M.S. thesis.

Hermann, R.K.; Lavender, D.P. 1990. Douglas-fir. In: Silvics of North America. Washington: U.S. Department of Agriculture, Agriculture Handbook 654, Volume 1, Conifers.

Herron, G.B.; Mortimore, C.A.; Rawlings, M.S. 1985. Nevada raptors, their biology and management. Biology Bulletin No. 8. [Reno, NV: Nevada Department Wildlife]. 114 p.

Hines, J.E. 1986. Social organization, movements, and home ranges of blue grouse in fall and winter. Wilson Bulletin. 98: 419-432.

Hitchcock, R.R.; Mirarchi, R.E. 1986. Dispersal of recently fledged mourning doves from nest sites. Wilson Bulletin. 98: 581-585.

Hoffmeister, Donald F. 1986. Mammals of Arizona. Tucson, AZ: University of Arizona Press and the Arizona Game and Fish Department. 602 p.

Hoffman, R.W. 1981. Population dynamics and habitat relationships of Blue Grouse. Colorado Division of Wildlife Final Report proj. W-37-R-34:103-171.

Hoover, M., and D. Wills. 1984. Managing forested lands for wildlife. Published by Colorado Division Wildlife. In coop. with Rocky Mountain Region, Denver, CO. 459 pp.

Hopkins, M.N.; Odum, E.P. 1953. Some aspects of the population ecology of breeding mourning doves in Georgia. Journal of Wildlife Management. 17: 132-143.

Horton, S.P.; Mannan, R.W. 1988. Effects of prescribed fire on snags and cavity-nesting birds in southeastern Arizona pine forests. Wildlife Society Bulletin. 16: 37-44.

Howe, F.P.; Flake, L.D. 1988. Mourning dove movements during the reproductive season in southeastern Idaho. Journal of Wildlife Management. 52: 477-480.

Hubbard, J. 1978. Revised check-list of the birds of New Mexico. N.M. Ornith. Soc. Publ. No. 6.

Hunter, Malcolm L., Jr. 1989. What constitutes an old-growth stand? Journal of Forestry. 89(8): 33-35.

Keane, R.E.; Arno, S.F.; Brown, J.K. 1990. Simulating cumulative fire effects in ponderosa pine/Douglas-fir forests. Ecology. 71: 189-203.

Keith, L.B. 1963. Wildlife's ten-year cycle. Madison, WI: University of Wisconsin Press.

Keith, James O. 1965. The Abert squirrel and its dependence on ponderosa pine. Ecology. 46: 150-163.

Kemp, G.A.; Keith, L.B. 1970. Dynamics and regulation of Red squirrel (*Tamiasciurus hudsonicus*) populations. Ecology. 51: 76-779.

Kennedy, P.L. 1988. Habitat characteristics of Cooper's hawks and northern goshawks nesting in New Mexico. Pages 218 - 227 in R. L. Glinski et al., eds. Proceedings of the Southwest Raptor Symposium. National Wildlife Federation Sci. and Tech Series No. 12.

Kennedy, Patricia L. 1989. The nesting ecology of Cooper's hawks and northern goshawks in the Jemez Mountains, NM: a summary of results, 1984-1988. U.S. Department of Agriculture, Forest Service, Sante Fe National Forest. [Unpublished Final Report, P.O. No. 43-8379-8-346]. 21 p.

Kennedy, Patricia L. 1990. Home ranges of northern goshawks nesting in north central New Mexico. Abstract. In Klausmen P.R. and N.S. Smith eds. managing wildlife in the Southwest. Arizona Chapter of the Wildlife Society. 259 p.

Kennedy, Patricia L. 1991. Reproductive strategies of northern goshawks and Cooper's hawks in north-central New Mexico. Logan, UT: Utah State University. 222 p. Ph.D. dissertation.

Kenward, Robert E. 1982. Goshawk hunting behavior, and range size as a function of food and habitat availability. Journal of Animal Ecology. 51: 69-80.

Kenward, Robert E. 1983. The causes of damage by red and gray squirrels. Mammal Review. 13: 159-166.

Kenward, Robert; Widen, Per. 1989. Do goshawks *Accipiter gentilis* need forests? Some conservation lessons from radio tracking. In: Meyburd, B.-U.; Chancellor, R.D.; eds. Raptors in the modern world. London: World working group on birds of prey and owls: 561-567.

Kilgore, B.M. 1971. Response of breeding bird populations to habitat changes in a giant sequoia forest. American Midland Naturalist. 85: 135-152.

Knight, R.L.; Smith, D.G.; Gaudet, D.M.; Erickson, A.W. 1984. Nesting ecology of mourning doves in fruit orchards in northcentral Washington. Northwest Science. 58: 230-236.

Kramer, V. 1955. Habicht und Sperber. Nueu Brehm Bucherei Heft 158. Ziemsen Verlag, Wittenberg Lutherstadt.

Krauch, H. 1926. The determination of increment in cut-over stands of western yellow pine in Arizona. Journal of Agricultural Research, Volume 32, No. 6. Washington, D.C.

Krauch, H. 1956. Management of Douglas-fir timberland in the Southwest. Station Paper 21. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 59 p.

Krugman, S. L.; and Jenkinson, J. L. 1974. *Pinus* L. Pine. In Seeds of Woody Plants in the United States, USDA Forest Service, Agriculture Handbook 450. Washington, D. C.

Laacke, R.J. 1990. White fir. In: Silvics of North America. Washington: U.S. Department of Agriculture, Forest Service, Agriculture Handbook 654, Conifers.

Larson, M.; Moir, W.H. 1986. Forest and woodland habitat types (plant associations) of Southern New Mexico and Central Arizona (North of the Mogollon Rim). Edition 2. USDA Forest Service, Southwestern Region, Albuquerque, NM.

Larson, M.; Moir, W.H.; Fletcher, R. 1987. Forest and woodland habitat types (plant associations) of Northern New Mexico and Northern Arizona. Edition 2. USDA Forest Service, Southwestern Region, Albuquerque, NM.

Layne, J.N. 1954. The biology of the red squirrel, *Tamiasciurus hudsonicus loquax* (Bangs), in central New York. Ecology Monographs. 24: 227-267.

Li, P.; Martin, T.E. 1991. Nest-site selection and nesting success of cavity-nesting birds in high elevation forest drainages. Auk. 108: 405-418.

Lynch, A.M. 1990. Oldest Douglas-fir tree in the Southwest. Memo to Christina Gonzalez, Acting Forest Supervisor, Carson National Forest. Reply to 4500. Dated March 5, 1990.

Madany, M.H.; West, N.E. 1980. Fire history of two montane forest areas of Zion National Park. Proceedings of the fire history workshop. October 20-24, 1980, Tucson, Arizona. Gen. Tech. Rep. RM-81. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 142 p.

Maffei, H. M.; Hawksworth, F.G. In review. Trends in distribution of ponderosa pine dwarf mistletoe over thirty years in the National Forests of the

Southwest. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Mannan, R.W.; Meslow, E.C. 1984. Bird populations and vegetation characteristics in managed and old-growth forests in northeastern Oregon. Journal of Wildlife Management. 48: 1219-1238.

Mannan, R.W.; Boal, C.W. 1990. Goshawk diets in logged and unlogged ponderosa pine forests in northern Arizona. Progress report, challenge cost-share agreement, University of Arizona and Kaibab National Forest. 10 p.

Mannan, R. William; Smith, Andrew A. 1991. Identification of distinguishing characteristics of vegetation around Mount Graham red squirrel middens. Tucson, AZ: University of Arizona, School of Natural Resources, Final Report Draft 0305040. 27 p.

Marks, G.C.; Kozlowski, T.T. 1973. Ectomycorrhizae: their ecology and physiology. New York: Academic Press.

Markstrom, D.C.; McElderry, S.F. 1984. White fir, an American wood. USDA Forest Service FS-237.

Martin, A.C.; Zim, H.S.; Nelson, A.L. 1951. American Wildlife and Plants, A Guide to Wildlife Food Habits. New York: Dover Publications, Inc. 500 p.

Martin, T.E. 1988. On the advantage of being different: nest predation and the coexistence of bird species. Proceedings of the National Academy of Science. 85: 2196-2199.

Maser, C.; Trappe, J.M.; Nussbaum, R.A. 1978. Fungal-small mammal interrelationships with emphasis on Oregon coniferous forests. Ecology. 59: 799-809.

McClure, H.E. 1946. Mourning doves in Nebraska and the west. Auk. 63: 24-42.

McCune, B. 1983. Fire frequency reduced two orders of magnitude in the Bitterroot Canyons, Montana. Canadian Journal of Forestry Research. 13: 212-218.

McGowan, Jerry D. 1975. Distribution, density, and productivity of goshawks in interior Alaska. Alaska Department of Fish and Game. Federal Aid in Wildlife Restoration, Project Report W17-3, 4, 5, 6.

McKay, D.O.; Verts, B.J. 1978. Estimates of some attributes of a population of Nuttall's cottontail. Journal of Wildlife Management. 42: 159-168.

McKee, Edwin D. 1941. Distribution of the tassel-eared squirrels. Plateau 14: 12-20.

McKeever, Sturgis. 1964. The biology of the golden-mantled ground squirrel, *Citellus lateralis*. Ecological Monographs. 34(4): 383-401.

McPeek, G.A.; Jacoby, G.E.; McComb, W.C.; Moriarty, J.J. 1987. Bark-Foraging bird abundance unaffected by increased snag availability in a mixed mesophytic forest. Wilson Bulletin. 99: 253-257.

Medin, D.E. 1985. Breeding bird responses to diameter-cut logging in west-central Idaho. Res. Pap. INT-355. Ogden, UT: U.S. Department of Agriculture, Intermountain Forest and Range Experiment Station. 12 p.

Meng, H. 1959. Food habits of nesting Cooper's hawks and goshawks in New York and Pennsylvania. Wilson Bulletin. 71: 69-174.

Moir, W.H.; Dieterich, J.B. 1988. Old-growth ponderosa pine from succession in pine-bunchgrass forests in Arizona and New Mexico. Natural Areas Journal. 8: 17-24.

Moore, Kevin R.; Henny, Charles J. 1983. Nest site characteristics of three coexisting accipiter hawks in northeastern Oregon. Raptor Research. 17(3): 65-76.

Morrison, M.L.; With, K.A.; Timossi, I.C. 1986. The structure of a forest bird community during winter and summer. Wilson Bulletin. 98: 214-230.

Morrison, M.L.; With, K.A. 1987. Interseasonal and intersexual resource partitioning in hairy and white-headed woodpeckers. Auk. 104: 225-233.

Morrison, M.L.; With, K.A.; Timossi, I.C.; Block, W.M.; Milne, K.A. 1987. Foraging behavior of bark-foraging birds in the Sierra Nevada. The Condor. 89: 201-204.

Mueller, H.C.; Berger, D.D. 1967. Some observations and comments on the periodic invasions of goshawks. Auk. 84: 183-191.

Mullally, D.P. 1953. Hibernation in the golden-mantled ground squirrel, *Citellus lateralis bernnardinus*. Journal of Mammalogy. 34: 65-73.

Mussehl, T.W. 1963. Blue grouse brood cover selection and land use implications. Journal of Wildlife Management. 27: 547-556.

Neff, Johnson A. 1951. Inventory of band-tailed pigeon populations in Arizona, Colorado, and New Mexico: 1951. Denver: U.S. Fish and Wildlife Service. Unpublished report [available at Rocky Mountain Forest and Range Experiment Station Library]. 37 p.

Neff, Johnson A. 1952. Inventory of band-tailed pigeon populations in Arizona, Colorado, and New Mexico, with notes on Utah: 1952. Denver:

U.S. Fish and Wildlife Service. Unpublished report [available at Rocky Mountain Forest and Range Experiment Station Library]. 26 p.

Newton, I. 1979. Population ecology of raptors. Vermillion, SD: Buteo Books.

Newton, I. 1988. Individual performance in Sparrowhawks: the ecology of two sexes. Proc. 19th Intern. Ornithol. Cong., Ottawa. pp 125-154.

Newtonm, I. 1989. Keynote address: population limitation in raptors. Pages 3-12. Proceedings of the northeast raptor management symposium and workshop. Natl. Wildl. Fed. Sci. Tech. Ser. 13., Natl. Wildl. Fed., Wash. D.C.

Newton, I. 1991. Population limitation in birds of prey: a comparative approach. In: Perrins, C.M.; Lebreton, J.D.; Hirons, G.J.M.; eds. Bird population studies, Relevance to conservation and management. Oxford: Oxford University Press: 3-21.

Newton, I.; Wyllie, I.; Mearns, R.M. 1986. Spacing of sparrowhawks in relation to food supply. Journal of Animal Ecology. 55: 361-370.

Newton, I.; Marquiss, M.; Weir, D.N.; Moss, D. 1977. Spacing of Sparrowhawk nesting territories. Journal of Animal Ecology. 46: 425-41.

Niederleitner, Joe F. 1987. Use of early successional, midsuccessional, and old-growth forests by breeding blue grouse (*Dendragapus obscurus fuliginosus*) on Hardwicke Island, British Columbia. Canadian Journal of Zoology. 65: 151-155.

Otvos, I.S.; Stark, R.W. 1985. Arthropod food of some forest-inhabiting birds. Canadian Entomologist. 117: 971-990.

Oliver, W.W.; Ryker, R.A. 1990. Ponderosa pine. In: Silvics of North America. Washington: U.S. Department of Agriculture Forest Service, Agriculture Handbook 654, Volume 1, Conifers.

Parker, D.L. 1991. Here's my perspective on the health of forests in Region 3. USDA Forest Service, Southwestern Region, Albuquerque, NM. Southwestern Region News, May 1991.

Patla, S. 1990. Northern goshawk monitoring project report, 1989 Targhee National Forest, St. Anthony, Idaho. Final Rep., USDA Forest Service, Targhee National Forest, P.O. No. 43-02S2-8-1931. 22pp.

Patton, D.R. 1975. Abert squirrel cover requirements in southwestern ponderosa pine. Res. Note 272. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 3p.

Patton, David R. 1984. A model to evaluate abert squirrel habitat in uneven-aged ponderosa pine. Wildlife Society Bulletin. 12: 408-414.

Patton, David R.; Green, Win. 1970. Abert's squirrels prefer mature ponderosa pine. Res. Note RM-169. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p.

Patton, David R.; Vahle, J.R. 1986. Cache and nest characteristics of the red squirrel in an Arizona mixed-conifer forest. Western Journal of Applied Forestry. 1: 48-51.

Patton, David R.; Wadleigh, Richard L.; Hudak, Howard G. 1985. The effects of timber harvesting on the Kaibab squirrel. Journal of Wildlife Management. 49(1): 14-19.

Pearson, G.A. 1950. Management of ponderosa pine in the southwest as developed by research and experimental practices. Washington, D.C.: U.S. Dep. Agric. Monogr. 6. 218p.

Pederson, Jordan C.; Farentinos, R.C.; Littlefield, Victoria M. 1987. Effects of logging on habitat quality and feeding patterns of Abert squirrels. Great Basin Naturalist. 47: 252-258.

Pederson, Jordan C.; Hasenyager,R.N.; Heggen, A.W. 1976. Habitat requirements of the Abert squirrel (*S. aberti navajo*) on the Monticello district, Manti-Lasal National Forest of Utah. Publ. No. 76-9, Utah State Div. of Wildl. Resources.

Pederson, Jordan C.; Welch, B.L. 1985. Comparison of ponderosa pine as feed and nonfeed trees for Abert squirrels. Journal of Chemistry Ecology. 11: 149-157.

Pekins, P.J. 1988. Winter ecological energetics of blue grouse. Logan, UT: Utah State University. 143 p. Ph.D. dissertation.

Pekins, Peter J.; Lindzey, Frederick G.; Gessaman, James A. 1991. Physical characteristics of blue grouse winter use-trees and roost sites. Great Basin Naturalist. 51(3): 244-248.

Perala, D.A. 1990. Quaking aspen. In: Silvics of North America. Washington: U.S. Department of Agriculture, Agriculture Handbook 654, Volume 2, Hardwoods.

Phillips, A.; Marshall, J.; Monson, G. 1964. Birds of Arizona. Tucson, AZ: University of Arizona Press. 212 p.

Pils, C. M.; Martin, M.A.; Petersen, L.R. 1981. Experimental cottontail habitat management on

the Brooklyn wildlife Area. Dept. Nat. Resources Res. Rep. 108:1-18.

Preston, F.W. 1946. Nesting height of birds building in shrubs. Ecology. 27: 87-91.

Preston, F.W.; Norris, R.T. 1947. Nesting heights of breeding birds. Ecology. 28: 241-273.

Preston, R.J., Jr. 1961. North American trees. Ames, IA: The Iowa State University Press.

Putera, J.A.; Woolf, A.; Klimstra, W.D. 1985. Mourning dove use of orchards in southern Illinois. Wildlife Society Bulletin. 13: 496-501.

Ramsden, D.J.; Lyon, L.J.; Halvorson, G.L. 1979. Small bird populations and feeing habitats-western Montana in July. American Birds. 33: 11-16.

Randall, R.N. 1955. Mourning dove studies in central North Dakota. Journal of Wildlife Management. 19:157-159.

Rasmussen, D. Irvin. 1941. Biotic communities of the Kaibab plateau, Arizona. Ecological Monographs. 11(3): 229-275.

Ratcliffe, D.A. 1972. The peregrine population of Great Britain in 1971. Bird Study. 19: 117-156.

Ratcliffe, D.A. 1980. The peregrine falcon. Vermillion, SD: Buteo Books.

Ratcliffe, Thomas D.; Patton, David R.; Ffolliott, Peter F. 1975. Ponderosa pine basal area and the Kaibab squirrel. Journal of Forestry. May: 284-286.

Read, D.J. 1991. Mycorrhizas in ecosystems. Experientia. 47: 376-390.

Reese, J.G. 1970. Reproduction in a Chesapeake Bay osprey population. Auk. 87: 747-759.

Reiser, M.H. 1991. Status of the northern goshawk (*Accipiter gentilis atricapillus*) in the Southwestern region. USDA Forest Service Report, Southwestern Region, Albuquerque, NM. 11pp + appendices.

Remington, T.E. 1990. Food selection and nutrional ecology of blue grouse during winter. Madison, WI: University of Wisconsin. 116 p. Ph.D. dissertation.

Reynolds, H.G. 1963. Western goshawk takes Abert's squirrel in Arizona. Journal of Forestry. 61(11): C.1.

Reynolds, Richard T. 1983. Management of western coniferous forests habitat for nesting accipiter hawks. Gen. Tech. Rep. RM-102. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 7 p.

Reynolds, Richard T. 1989. Accipiters. In: Proceedings of the Western raptor management symposium and workshop; 1987 October 26-28, Boise, ID. Washington: National Wildlife Federation, Scientific and Technical Series No. 12: 92-101.

Reynolds, Richard T.; Linkhart, B.D. 1987. The nesting biology of flammulated owls in Colorado. In Biology and conservation of northern forest owls. Gen. Tech. Rep. RM-142. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. p 239-254.

Reynolds, Richard T.; Linkhart, Brian D. 1992. Flammulated owls in ponderosa pine: evidence of preference for old growth. In: Old-growth forests in the Southwest and Rocky Mountain regions: proceedings of a workshop; 9-13 March 1992, Portal, AZ. Gen. Tech. Rep. RM-213. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 166-169.

Reynolds, R.T.; Meslow, E.C. 1984. Partitioning of food and niche characteristics of coexisting *Accipiter* during breeding. Auk. 101: 761-779.

Reynolds, Richard T.; Wight, Howard M. 1978. Distribution, density, and productivity of accipiter hawks breeding in Oregon. Wilson Bulletin. 90(2): 182-196.

Reynolds, Richard T.; Meslow, E. Charles; Wight, Howard M. 1982. Nesting habitat of coexisting *Accipiter* in Oregon. Journal of Wildlife Management. 46: 124-138.

Rhodes, L.I. 1972. Success of osprey nest structures at Martin National Wildlife Refuge. Journal of Wildlife Management. 36: 1296-1299.

Risser, P. G., Karr, J. R., and R. T. T. Formann. 1984. Landscape ecology: direction and approaches. Ill. Nat. Hist. Surv. Spec. Publ. No. 2. 16pp.

Rogers, T., and D. Conklin. 1991. Annual Southwestern Region pest conditions report, 1991. USDA Forest Service, Southwestern Region, Albuquerque, NM. Forest Pest Management Report R-3 91-5. 30pp.

Romme, W. H. 1980. Fire frequency in subalpine forests of Yellowstone National Park. Proceedings of the fire history workshop. October 20-24, 1980, Tucson, Arizona. USDA Forest Service Gen. Tech. Rep. RM-81. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 142p.

Ronco, Frank, Jr.; Edminster, Carleton B.; Trujillo, David P. 1985. Growth of ponderosa pine thinned to different stocking levels in Northern Arizona. Res. Pap. RM-262. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 15 p.

Ronco, F.P., Jr. 1990. Pinon pine. In: Silvics of North America. Washington: U.S. Department of Agriculture, Agriculture Handbook 654, Volume 1, Conifers.

Rowan, W. 1921-22. Observations on the breeding habits of the Merlin. British Birds. 15: 122-129, 194-202, 222-231, 246-253.

Rusch, Doris A.; Reeder, William G. 1978. Population ecology of Alberta red squirrels. Ecology. 59(2): 400-420.

Ryker, R.A.; Losensky, J. 1983. Ponderosa pine and Rocky Mountain Douglas-fir. In Silvicultural systems for the major forest types of the United States. Agricultural Handbook No. 445. p 53-55.

Saunders, L.B. 1982. Essential nesting habitat of the goshawk *Accipiter gentilis*) on the Shasta-Trinity National Forest, McCloud District. Chico, CA: California State University. 57 p. M.S. thesis.

Savard, J.P.L.; Falls, J.B. 1981. Influence of habitat structure on the nesting height of birds in urban areas. Canadian Journal of Zoology. 59: 924-932.

Schmutz, Ervin M. 1978. Estimating range use with grazed-class photo guides. Tucson, AZ: Cooperative Extension Service and Agricultural Experiment Station, The University of Arizona, Bulletin A-73. 14 p.

Schoener, Thomas W. 1983. Simple models of optimal feeding territory size: a reconciliation. The American Naturalist. 121: 608-629.

Schnell, Jay H. 1958. Nesting behavior and food habits of goshawks in the Sierra Nevada of California. The Condor. 60: 377-403.

Schroeder, Richard L. 1984. Habitat suitability index models: blue grouse. Washington: U.S. Fish and Wildlife Service, U.S. Department of the Interior. FWS/OBS-82/10.81. 20 p.

Scott, V.E.; Patton, D.R. 1975. Cavity-nesting birds of Arizona and New Mexico Forests. Gen. Tech. Rep. RM-10. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 52 p.

Scott, V.E.; Evans, K.E.; Patton, D.R.; Stone, P.L. 1977. Cavity-nesting birds of North American forests. Washington, D.C.: U.S. Department of Agriculture, Forest Service, Agric. Handbook 511.

Scott, V.E.; Whelan, J.A.; Svoboda, P.L. 1980. Cavity-nesting birds and forest management. In R. M. DeGraff (tech coord.) Workshop Proceedings: Management of Western Forest and Grasslands for Nongame Birds. U.S. For. Serv. Gen. Tech. Rep. INT-86. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 311-324.

Scott, V.E.; Crouch, G.L. 1988. Summer birds and mammals of aspen-conifer forests in west-central Colorado. Res. Pap. RM-280. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 5 p.

Scribner, K.T.; Warren, R.J. 1990. Seasonal demography and movements of cottontail rabbits on isolated playas. Journal of Wildlife Management. 54(3): 403-409.

Sedgwick, James A. 1987. Avian habitat relationships in pinyon-juniper woodland. Wilson Bulletin. 99(3): 413-431.

Severson, Kieth E. 1986. Spring and early summer habitats and foods of male blue grouse in Arizona. Journal of the Arizona-Nevada Academy of Science. 21: 13-18.

Shuster, William C. 1980. Northern goshawk nest site requirements in the Colorado Rockies. Western Birds. 11: 89-96.

Siegel, James Joshua. 1989. An evaluation of the minimum habitat quality standards for birds in old-growth ponderosa pine forests, northern Arizona. Tucson, AZ: The University of Arizona. 94 p. M.S. thesis.

Smith, C.C. 1968. The adaptive nature and social organization in the genus of tree squirrels *Tamiasciurus*. Ecology Monographs. 38: 31-63

Smith, C.C. 1970. The coevolutions of pine squirrels (*Tamiasciurus*) and conifers. Ecology Monographs. 40: 349-371.

Smith, E.L.; Speich, S.M.; Alford, C.L.; Ruther, S.A. 1991. Draft final report investigation of goshawk reproduction, relative to timber harvest and environmental patterns, on the North Kaibob Ranger District in Northern America. Dames and Moore Professional Limited Partnership, No. 20070-001-505, Tucson, AZ.

Smith, Michael C. 1968. Red squirrel responses to spruce cone failure in interior Alaska. Journal of Wildlife Management. 32(2): 305-317.

Snyder, Noel F.R.; Snyder, Helen A.; Lincer, Jeffrey L.; Reynolds, Richard T. 1973. Organochlorines, heavy metals, and the biology of North American accipiters. BioScience. 23(5): 300-305.

Soutiere, E.C.; Bolen, E.G. 1972. Role of fire in mourning dove nesting ecology. In: Proceedings of Tall Timbers Fire Ecology Conference.

Speiser, Robert; Bosakowski, Thomas. 1987. Nest site selection by northern goshawks in northern New Jersey and southeastern New York. The Condor. 89: 387-394.

States, Jack. 1985. Hypogeous, mycorrhizal fungi associated with ponderosa pine:sporocarp phenology. In: Molina, Randy, ed. Proceedings of the 6th North American conference on mycorrhizae; 1984 June 25-29; Bend, OR. Corvallis, OR: Forest Research Laboratory: 271-272.

States, Jack S.; Gaud, William S.; Allred, W. Sylvester; Austin, William J. 1988. Foraging patterns of tassel-eared squirrels in selected ponderosa pine stands. In: Szaro, R.; Severson, K.; Patton, D.; eds. Management of Amphibians, Reptiles and Small Mammals in North America; Proceedings of a symposium. Gen. Tech. Rep. RM-166. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station: 425-431.

Stauffer, D.F.; Best, L.B. 1980. Habitat selection by birds of riparian communities: evaluating effects of habitat alterations. Journal of Wildlife Management. 44: 1-15.

Stauffer, D.F. 1983. Seasonal habitat relationships of ruffed and blue grouse in southeastern Idaho. Moscow, ID: University of Idaho. Ph.D. dissertation. 108 p.

Stauffer, D.F.; Peterson, S.R. 1985. Ruffed and blue grouse habitat use in southeastern Idaho. Journal of Wildlife Management. 49: 459-466.

Stauffer, D.F.; Peterson, S.R. 1986. Seasonal microhabitat relationships of blue grouse in southeastern Idaho. Great Basin Naturalist. 46: 117-122.

Steele, R. 1990. Limber pine. In: Silvics of North America. Washington: U.S. Department of Agriculture Forest Service, Agriculture Handbook 654, Volume 1, Conifers.

Stein, S.J. 1988. Explanations of the imbalanced age structure and scattered distribution of ponderosa pine within a high-elevation mixed coniferous forest. Forest Ecology Management. 25: 139-153.

Stephenson, R.L. 1974. Seasonal food habits of the Abert's squirrel, *Sciurus Aberti*. J. Ariz. Acad. Sci. 9, 1974. Proc Suppl.

Stephenson, Richard L.; Brown, David E. 1980. Snow cover as a factor influencing mortality of Abert's squirrel. Journal of Wildlife Management. 44(4): 951-955.

Storer, Robert W. 1966. Sexual dimorphism and food habits in three North American accipiters. The Auk. 83: 423-436.

Stromberg, J.C.; Patton, D.T. 1991. Dynamics of the spruce-fir forests on the Pinaleno Mountains, Graham, County, Arizona. Southwestern Naturalist. 36(1): 37-48.

Sullivan, Thomas P. 1990. Responses of red squirrel populations to supplemental food. Journal of Mammology. 71(4): 579-590.

Sullivan, Thomas P.; Moses, Richard A. 1986. Red squirrel populations in natural and managed stands of lodgepole pine. Journal of Wildlife Management. 50(4): 595-601.

Sullivan, Thomas P.; Jones, Browen; Sullivan, Druscilla S. 1989 Population ecology and conservation of the mountain cottontail, *Sylvilagus nuttalli nuttalli*, in southern British Columbia. Canadian Field - Naturalist. 103:335-342..

Swetnam, T.W. 1988. Fire history and climate in the southwestern United States. In: Krammes, J.S., tech. coord. Effects of fire management of southwestern natural resources. Gen. Tech. Rep. RM-191. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 293 p.

Swetnam, T.W.; Lynch, A.M. 1989. A tree-ring reconstruction of western spruce budworm history in the southern Rocky Mountains. Forestry Science. 35: 962-986.

Szaro, R.C.; Balda, R. 1979a. Bird community dynamics in a ponderosa pine forest. Studies in Avian Biol. No. 3.

Szaro, R.C.; Balda, R. 1979b. Effects of harvesting ponderosa pine on nongame bird populations. Res. Pap. RM-212. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

Szaro, R.C.; Balda, R. 1982. Selection and monitoring of avian indicator species: an example from a ponderosa pine forest in the Southwest. Gen. Tech. Rep. RM-89. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 8 p.

Szaro, R.C.; Balda, R. 1986. Relationships among weather, habitat structure and ponderosa pine

forest birds. Journal of Wildlife Management. 50: 253-260.

Tevis, Lloyd, Jr. 1952. Autumn foods of chipmunks and golden-mantled ground squirrels in the northern Sierra Nevada. Journal of Mammalogy. 33(2): 198-205.

Tevis, Lloyd, Jr. 1953. Stomach contents of chipmunks and mantled ground squirrels in northeastern California. Journal of Mammalogy. 34(3): 316-324.

Tevis, Lloyd, Jr. 1956. Invasion of a logged area by golden-mantled ground squirrel. Journal of Mammalogy. 37(2): 291-292.

Thomas, J.W.; Anderson, R.G.; Maser, C.; Bull, E.L. 1979. Snags. In Wildlife habitats in managed forest, the Blue Mountains of Oregon and Washington (J.W. Thomas, ed.). USDA For. Serv. Agric. Handb. 553. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 60-77.

Thompson, I.D.; Davidson, I.J.; O'Donnell, S.; Brazeau, F. 1989. Use of track transects to measure the relative occurrence of some boreal mammals in uncut forest and regeneration stands. Canadian Journal of Zoology. 67: 1816-1823.

Tkacz, B.M.; Baker, F.A. 1991. Survival of *Inonotus tomentosus* in spruce stumps after logging. Plant Disease. 75: 788-790.

Trent, T.T.; Rongstad, O.J. 1974. Home range and survival of cottontail rabbits in southwestern Wisconsin. Journal of Wildlife Management. 38(3): 459-472.

Tubbs, C.R. 1974. The buzzard. London: David and Charles.

Tyler, J. D., and G. L. Jenkins. 1979. Notes on some fall foods of mourning doves in southwestern Oklahoma. Proc. Oklahoma Acad. Sci. 59:82-84.

Uphoff, K.C. 1990. Habitat use and reproductive ecology of red squirrels (*Tamiasciurus hudsonicus*) in central Arizona. Tempe, AZ: Arizona State University. M.S. thesis.

U. S. Fish and Wildlife Service. 1954. Inventory of band-tailed pigeon populations in Arizona, Colorado, and New Mexico, 1953. U. S. Fish and Wildlife Service, Branch of Game Management, Albuquerque, New Mexico. Unpub. Rep. 34pp.

U. S. Fish and Wildlife Service. 1957. Survey of Band-tailed pigeon populations in Arizona, Colorado, New Mexico, and Utah. Unpub. Rep.

USDA Forest Service. 1985. Radial growth losses in Douglas-fir and white fir caused by western spruce budworm in northern New Mexico: 1700 to 1983. USDA Forest Service, Southwestern Region, Albuquerque, NM. Forest Pest Management Report R-3 86-2.

USDA Forest Service. 1988. Bark beetles. USDA Forest Service, Southwestern Region, Albuquerque, NM. FSH Cutting Methods Handbook 2409.26a, Chapter 60, Amendment No. 8.

USDA Forest Service. 1991. Threatened, endangered and sensitive species of plants and animals. Manual 2600, U.S. Department of Agriculture, Forest Service.

Vahle, J.R. 1978. Red squirrel use of southwestern mixed coniferous habitat. Tempe, AZ: Arizona State University. M.S. thesis.

Vahle, J. Robert; Patton, David R. 1983. Red squirrel cover requirements in Arizona mixed conifer forests. Journal of Forestry. 81(1): 14-15, 22.

van Beusekom, C.F. 1972. Ecological isolation with respect to food between sparrowhawk and goshawk. Ardea. 60: 72-96.

Vander Wall, S.; Balda, R.P. 1981. Ecology and evolution of food-storage behavior in conifer-seed-caching corvids. Zeitschrift fuer Tierpsychologic und Futtermittelkunde. 56: 217-242.

Vander Wall, S.; Balda, R.P. 1983. Remembrance of seeds stashed. Natural History. 92: 60-65.

Van Hooser. In Press. Forest Resources of New Mexico. For Res. Bull. Ogden, UT: USDA Forest Service, Intermountain Research Station.

Van Lear, D. H., et al. 1983. Forest management of a loblolly pine plantation. Pp 252-258 *in* Ballard, R. and S. P. Gessel, eds. IUFRO symposium on forest site and continuous productivity. USDA Forest Service Gen. Tech. Rep. PNW-163.

Village, A. 1983. The role of nest-site availability and territorial behavior in limiting the breeding density of Kestrels. Journal of Animal Ecology. 52: 635-645.

Village, A. 1990. The kestrel. London: T & A D Poyser.

Warren, E.R. 1942. The mammals of Colorado: their habits and distribution. Norman, OK: University of Oklahoma Press. 330 p.

Wasser, Clinton H. 1982. Ecology and culture of selected species useful in revegetating disturbed lands in the West. FWS/OBS-82/56. Washington: U.S. Department of the Interior,

Fish and Wildlife Service, Office of Biological Services, Western Energy and Land Use Team. 347 p.

Wattel, Jan. 1973. Geographic differentiation in the genus *Accipiter*. Cambridge, Mass: Publications of the Nuttall Ornithological Club, No. 13. 231 p.

Weaver, H. 1943. Fire as an ecological and silvicultural factor in the ponderosa pine region of the Pacific slope. Journal of Forestry. 41: 7-14.

Weaver, H. 1951. Fire as an ecological factor in the southwestern ponderosa pine forests. Journal of Forestry. 49: 93-98.

Weaver, H. 1961. Ecological changes in the ponderosa pine forest of Cedar Valley in southern Washington. Ecology. 42: 416-420.

White, A.S. 1985. Presettlement regeneration patterns in a southwestern ponderosa pine stand. Ecology [The Ecological Society of America]. 66(2): 589-594.

Widen, Per. 1985. Breeding and movements of goshawks in boreal forests in Sweden. Holarctic Ecology. 8:273-279.

Widen, Per. 1989. Hunting habitats of goshawks *Accipiter gentilis* in boreal forests of central Sweden. Ibis. 131: 205-213.

Williams, R.E.; Marsden, M.A. 1982. Modeling probability of root disease center occurrence in northern Idaho forests. Canadian Journal of Forestry Research. 12: 876-882.

Winternitz, B.L. 1976. Temporal change and habitat preference of some montane breeding birds. The Condor. 78: 383-393.

Wood, R.E. 1983. Mortality caused by root diseases and associated pests on six National Forests in Arizona and New Mexico. Forest Pest Management Report: R3-83-13. Albuquerque, NM: U.S. Department of Agriculture Forest Service, Southwestern Region. 31 p.

Wright, H. A. 1988. Role of fire in the management of southwestern ecosystems. In: Krammes, J.S., tech. coord. Effects of fire management of southwestern natural resources. Gen. Tech. Rep. RM-191. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 293 p.

Yahner, R.H. 1983. Site-related nesting success of mourning doves and American robins in shelterbelts. Wilson Bulletin. 95: 573-580.

Young, H. 1955. Breeding behavior and nesting of the eastern robin. American Midland Naturalist. 53: 329-352.

Zinn, L.J.; Tibbitts, T.J. 1990. Goshawk nesting survey. North Kaibob Ranger District, Kaibob National Forest, Arizona. Final Report #07-90-02 Nongame and Endangered Wildlife Program. Phoenix, AZ: Arizona Game and Fish Dept. 36 p.

Zwickel, Fred C.; Bendell, James F. 1985. Blue grouse--effects on, and influences of, a changing forest. Forestry Chronicle. 61: 185-188.

# Appendix 1. Description of ponderosa pine, mixed-species, and spruce-fir forest cover types

## Ponderosa Pine Forest Cover Type

Ponderosa pine (*Pinus ponderosa* var. *scopulorum*) is one of the most widely distributed forest cover types in the western United States (Table 1). Ponderosa pine is found in pure stands as a climax species or in mixed-species stands as a seral species. For the most part, seed production of ponderosa pine is predictable (Table 2). In a climax situation, natural regeneration of ponderosa pine establishes best on drier sites with some canopy cover. In a seral situation, seedlings establish readily in small openings on more moist sites. Ponderosa pine is a moderately shade- intolerant species, requiring nearly full sunlight for establishment and growth.

Seedling establishment can be expected to occur within 10 years after opening the canopy and forest floor disturbance. Seedlings develop best under partial shade.

**Table 1. Acres of reserved and nonreserved timberland on Southwestern National Forests and the proportion of nonreserved acres by forest cover types.[1]**

| Forest Cover Type | Percent nonreserved | National Forest Timberland, Acres | | |
|---|---|---|---|---|
| | | New Mexico | Arizona | Total |
| Ponderosa Pine | 73.6 | 1,639,548 | 2,212,420 | 3,851,968 |
| Mixed-species* | 22.9 | 946,516 | 253,322 | 1,199,838 |
| Spruce-fir | 3.5 | 105,444 | 76,671 | 182,115 |
| Total nonreserved acres | 100.0 | 2,691,508 | 2,542,413 | 5,233,921 |
| Total reserved acres | | 1,240,722 | 1,404,642 | 2,645,364 |
| Grand total | | 3,932,230 | 3,947,055 | 7,879,285 |

** Includes Douglas-fir, limber pine, white fir, spruce, other softwoods, and aspen forest types.*

[1] *Conner et al. 1990, Van Hooser et al. unpublished.*

**Table 2. Heavy cone crop interval years and optimum age of seed production for tree species in ponderosa pine, mixed-species, and spruce-fir forests.**

| Species | Interval of Heavy Crop (Years) | Age of Optimum Seed Production | Reference |
|---|---|---|---|
| Blue spruce | 2-3 | 50-150 | Fechner 1990 |
| Corkbark fir | 3-4 | 150-200 | Alexander et al. 1990 |
| Douglas-fir | 7 | 200-300 | Hermann and Lavender 1990 |
| Engelmann spruce | 2-5 | 150-250 | Alexander and Shepperd 1990 |
| Gambel oak | 4-5 | Sprouts vegetatively | Daniel 1980 |
| Limber pine | 2-4 | Unknown | Steele 1990 |
| Ponderosa pine | 3-4 | 60-160 | Minore 1979, Oliver & Ryker 1990 |
| Southwestern white pine | 3-7 | Unknown | Krugman & Jenkinson 1974 |
| Subalpine fir | 3-4 | 150-200 | Alexander et al. 1990 |
| White fir | 3-9 | Unknown | Laacke 1990 |
| Aspen | NA[1] | Suckers vegetatively | Perala 1990 |

[1] *NA: Not applicable.*

## Mixed-Species Forest Cover Type

Douglas-fir (*Pseudotsuga menziesii* var. *glauca*) and white fir (*Abies concolor*) are the dominant species of the mixed-species forest cover type. Blue spruce (*Picea pungens*), aspen (*Populus tremuloides*) and limber pine (*Pinus flexilis*) are the major associates found in the cover type. Other species that may occur in minor amounts are subalpine fir (*Abies lasiocarpa* var. *lasiocarpa*), corkbark fir (*Abies lasiocarpa* var. *arizonica*), Engelmann spruce (*Picea engelmannii*), southwestern white pine (*Pinus strobiformis*), ponderosa pine, aspen, and Gambel oak (*Quercus gambelii*). Most often this type has a rich diversity of vegetation, including three or more tree species, and an abundant understory (Krauch 1956, Fyre 1980).

Tree species have different shade tolerance levels, regeneration requirements, and growth characteristics. Shade-tolerant species have the ability to establish and grow in the shade of other larger trees. Shade tolerance of the species, in decreasing order, is (Daniel 1980):

1. subalpine fir
2. Engelmann spruce
3. corkbark fir
4. white fir
5. Douglas-fir
6. blue spruce
7. southwestern white pine
8. limber pine
9. ponderosa pine
10. aspen
11. Gambel oak

Shade-tolerant tree species express their presence and dominance as mixed-species stands grow older and/or become more dense. There is a gradual change in species composition to the more shade-tolerant species.

Natural regeneration usually occurs easily and frequently in the mixed-species type. The more shade-tolerant species are favored when openings in the forest canopy are small. When larger openings (4 acres) are created the intermediate and shade-intolerant species are favored. Aspen and Gambel oak regenerate vegetatively and occur frequently in larger openings.

Relative seed production of trees (Krugman and Jenkinson 1974, Alexander et al. 1990, Alexander and Shepperd 1990, Hermann and Lavender 1990, Oliver and Ryker 1990), in the mixed-species type in decreasing order, is:

1. blue spruce
2. Douglas-fir
3. Engelmann spruce
4. corkbark fir
5. white fir
6. ponderosa pine
7. southwestern white pine

In general, natural seedling establishment in the mixed-species type occurs within a 10-year period except for blue spruce, Engelmann spruce, subalpine fir, and corkbark fir, which can require up to 20 years for establishment. Aspen and Gambel oak generally require one growing season to become established.

## Engelmann Spruce-Subalpine Fir (Spruce-fir) Forest Cover Type

Spruce-fir forests are especially prone to wind damage. The dominant tree species in the spruce-fir forest cover type are Engelmann spruce and subalpine fir. Minor tree species include Douglas-fir, blue spruce, white fir, aspen, corkbark fir, limber pine, and bristlecone pine (*Pinus aristata*).

In general, natural regeneration can require up to 20 years in the spruce-fir type after the forest canopy is opened and the forest floor disturbed. Because solar radiation is more intense and there are fewer frost-free days at higher elevations, regeneration is slow even with good seed production (Alexander and Sheppard 1990, Alexander et al. 1990). Shade in the form of down logs or large trees is critical for seedling establishment and early growth.

# Appendix 2. Vertebrates in the diets of nesting northern goshawks from various locations in North America

**Species are listed in approximate order of decreasing size and potential contribution to the biomass consumed by the goshawks.**

| | Number of Prey (% in the diet) | | | | |
|---|---|---|---|---|---|
| Species[1] | Schnell 1958[2] | Meng 1959[3] | Reynolds & Meslow 1984[4] | Mannan & Boals 1990[5] | Kennedy 1991[6] |
| Great-horned owl | | | 1 (0.5) | | |
| Mallard | 3 (4) | | 2 (1) | | |
| Cat (*Felis* spp.) | | | | | 1 (1) |
| Black-tailed jackrabbit | | | | 2 (1) | |
| Snowshoe hare | 1 (1) | | 24 (1) | | |
| **Blue grouse** | | | 5 (2) | | |
| Unknown grouse | | | 1 (0.5) | | |
| **Cottontails** | | 7 (4) | 3 (1) | 16 (12) | 25 (20) |
| Gray squirrel | | 4 (2) | 5 (2) | | |
| Common raven | | | | | 3 (3) |
| Prairie falcon | | | | | 1 (1) |
| Ruffed grouse | | 5 (3) | 2 (1) | | |
| **Pigeon (Columba spp.)** | 1 (1) | | | | 2 (2) |
| Common crow | | 83 (45) | | | |
| **Tassel-eared squirrel** | | | | 7 (5) | 9 (9) |
| Cooper's hawk | | | 1 (0.5) | | 2 (2) |
| Bushy-tailed woodrat | | | 1 (0.5) | | |
| Pileated woodpecker | | | 1 (0.5) | | |
| Rock squirrel | | | | 3 (2) | |
| **Tree squirrel spp.** | | | | | 7 (7) |
| Belding's ground squirrel | 3 (3) | | 4 (2) | | |
| Woodrat spp. | | | 1 (0.5) | | |
| Mountain quail | 1 (1) | | 9 (4) | | |
| Dusky footed woodrat | | | 1 (0.5) | | |
| **Squirrel *(Tamiasciurus spp.)*** | 5 (6) | 58 (31) | 13 (6) | 2 (1) | 3 (3) |
| Black-billed magpie | | | 1 (0.5) | | |
| Screech owl | | | 1 (0.5) | | |
| Northern flying squirrel | | | 15 (7) | | |
| **Mantled ground squirrel** | 6 (7) | | 17 (7) | 21 (16) | 2 (2) |
| **Northern flicker** | | | 15 (7) | 5 (4) | 15 (14) |
| Townsend's ground squirrel | | | 2 (1) | | |
| **Mourning dove** | | | 7 (3) | | 1 (0.7) |
| American kestrel | | 3 (2) | | | 1 (1) |

*Continued on next page.*

***Appendix 2 (continued) - Vertebrates in Diets of Nesting Northern Goshawks***

| Species[1] | Number of Prey (% in the diet) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Schnell 1958[2] | | Meng 1959[3] | | Reynolds & Meslow 1984[4] | | Mannan & Boals 1990[5] | | Kennedy 1991[6] | |
| **Steller's jay** | 22 | (25) | | | 29 | (13) | 7 | (5) | 9 | (9) |
| Scrub jay | | | | | | | | | 1 | (1) |
| Clark's nutcracker | | | | | | | 3 | (3) | | |
| Belted kingfisher | | | | | | | 2 | (2) | | |
| Blue jay | | | 7 | (4) | | | | | | |
| Lewis' woodpecker | | | | | 1 | (0.5) | | | | |
| Unknown mammal | 5 | (6) | | | 6 | (3) | 5 | (5) | 28 | (21) |
| Townsend chipmunk | | | | | 3 | (1) | | | | |
| Meadowlark | | | | | 4 | (2) | | | | |
| Unknown jay | | | | | 1 | (0.5) | 2 | (2) | | |
| Northern saw-whet owl | | | | | 1 | (0.5) | | | | |
| Northern pygmy-owl | | | | | | | 1 | (1) | | |
| **American robin** | 27 | (31) | | | 20 | (9) | 7 | (7) | | |
| Varied thrush | | | | | 4 | (2) | | | | |
| Gray jay | | | | | 5 | (2) | | | | |
| **Hairy woodpecker** | | | | | 1 | (0.5) | | | 3 | (2) |
| Blackbird spp. | | | 15 | (8) | | | | | 14 | (10) |
| Unknown bird | 1 | (1) | | | | | | | | |
| California mole | 1 | (1) | | | | | | | | |
| **Chipmunks (*Tamias* spp.)** | 5 | (6) | 3 | (2) | 7 | (3) | 2 | (2) | | |
| **Williamson's sapsucker** | | | | | 2 | (2) | 2 | (1) | | |
| Weasel | 1 | (1) | | | | | | | | |
| Woodpecker spp. | | | | | 4 | (2) | | | | |
| **Red-naped sapsucker** | | | | | 1 | (0.5) | | | | |
| Black-headed grosbeak | | | | | 1 | (0.5) | | | | |
| Evening grosbeak | | | | | | | 1 | (1) | | |
| **Least chipmunk** | | | | | 1 | (0.5) | | | | |
| Western bluebird | | | | | | | 2 | (2) | 18 | (13) |
| Western tanager | 4 | (5) | | | 2 | (1) | | | | |
| Hermit thrush | | | | | | | 1 | (1) | | |
| Dark-eyed junco | | | | | 2 | (1) | | | 1 | (0.7) |
| Unknown sparrow | | | | | | | 1 | (1) | | |
| Yellow-rumped warbler | 1 | (1) | | | | | | | | |
| Unknown | | | | | | | | | 7 | (5) |
| Totals | 88 | | 185 | | 227 | | 105 | | 135 | |

[1] *Highlighted species = selected prey of the northern goshawk.*
[2] *California*
[3] *New York and Pennsylvania*
[4] *Oregon*
[5] *Arizona*
[6] *New Mexico*

# Appendix 3. Natural history, habitat, and management recommendations for selected goshawk prey species

The habitat and food needs of selected goshawk prey species were determined by a literature review. In the following, each species' distribution, habitat, food, special habitat needs, home range, populations, and recommendations for improving their habitat are described and summarized. This information was used to identify "special habitat attributes" (Table 6, page 17) and "vegetation structural stages" (Table 7, page 19) needed by the prey that formed the basis for developing the desired forest conditions for each species. Our assumption was that these desired conditions provide opportunities for sustaining abundant goshawk prey populations.

For some goshawk prey, natural history information from southwestern forests was limited; for these species, data from other forest types and/or geographic areas supplemented data from the Southwest. When possible, data from adjacent geographic areas and similar forest types were used preferentially over data from distant areas. We assumed that the foods and habitats used by these goshawk prey outside the Southwest approximated the food and habitat needs within southwestern forests.

## American Robin
*(Turdus migratorius)*

The American robin is a moderately sized passerine about 10 inches in length and weighing about 0.2 pounds (Kilgore 1971, Ramsden et al. 1979). The American robin comprised 6.6% of the diet of northern goshawks (227 prey remains and pellets from 59 nests) in eastern Oregon (Reynolds and Meslow 1984), and 5.6% of 36 prey deliveries to 7 nests of goshawks in north-central New Mexico (Kennedy 1991). No robins were noted in prey deliveries to 8 goshawk nests on the North Kaibab in northern Arizona (Mannan and Boal 1990).

### Distribution

The American robin is a common and widespread songbird throughout the United States (including Alaska), most of Canada and Mexico (Martin et al. 1951).

### Habitat

This wide-ranging passerine inhabits woodlands, hardwood and coniferous forests, riparian areas, shelterbelts, and wooded suburban areas and parks (Franzreb and Ohmart 1978, Stauffer and Best 1980, Savard and Falls 1981, Yahner 1983, Siegel 1989). In the West and Southwest, the robin is found throughout the ponderosa pine forest type, higher elevation mixed-conifer forests, and aspen and willow stands (Winternitz 1976, Franzreb and Ohmart 1978, Siegel 1989). Robins were not detected in censuses above 9,000 feet in the San Francisco Mountains of north-central Arizona (Coons 1984).

### Food

In the mixed-species and ponderosa pine forests in California, coleopterans (beetles) were the most common food item from stomach analyses of American robins (Otvos and Stark 1985). Additionally, caterpillars, earthworms, flies, sowbugs, snails, spiders, termites, millipedes, and centipedes are consumed (Martin et al. 1951). Animal food is primarily consumed during the spring, while during fall, plants are the primary food source. Mistletoe, wild grape, and a variety of other berries are consumed (Martin et al. 1951).

### Special Habitat Needs

The American robin requires no particular habitat attributes other than its use of trees for nest placement. Robins show a preference for nesting in coniferous trees early in the breeding season (April through June), and then nest more often in deciduous trees later in the summer (June through July) (Savard and Falls 1981, Yahner 1983). Winternitz (1976) observed robins most frequently in pure ponderosa pine stands (36%) and in aspen-willow stands (27%). Robins nested in ponderosa pine trees in proportion to their occurrence (33%), but utilized aspen-willow in greater proportion to their occurrence (13%).

In non-urban areas, mean heights of American robin nests ranged from 7.4 feet to 15.4 feet (Preston 1946, Preston and Norris 1947, Young 1955, Stauffer and Best 1980, Savard and Falls 1981). In riparian habitats in Iowa, the mean height of nest trees was 32.2 feet. In riparian habitat, canopy cover was "good" above robin nests and "fair" below the nests (Stauffer and Best 1986). Savard and Falls (1981) noted that vertical distribution of foliage was more important in determining nest height than was foliage volume. More nests were located in the foliage layer just below the layer with the greatest volume regardless of tree type (conifer or

deciduous). Cover was also considered an important variable in robin nest site selection by Preston (1946).

**Home Range**

No home range information on the American robin was found.

**Population**

Mixed-species forests across the West and Southwest supported similar densities of breeding birds. In control (unlogged or old-growth) plots, breeding densities ranged from 2.0 to 7.5 birds per 100 acres. Logged sites in mixed-species forests supported breeding densities of 2.0 to 12.8 birds per 100 acres. Timber management practices ranged from understory thinning to overstory removals in these studies (Franzreb 1977, Mannan and Meslow 1984, Medin 1985, Scott and Crouch 1988).

Nesting densities of robins ranged from 2.3 to 20.0 breeding birds per 100 acres in old-growth ponderosa pine stands. Haldeman (1968) also noted that American robins were more abundant in an old-growth ponderosa pine forest (Pearson Natural Area, Arizona) than in logged ponderosa pine stands where densities ranged from 0.5 to 9.4 breeding birds per 100 acres. Selectively logged ponderosa pine stands that still had old-growth conditions (at least 14 trees ≥20 inches DBH, and basal area ≥90 square feet per acre) averaged 3.3 breeding birds per 100 acres over 2 years (Siegel 1989). Sites that were clearcut had the lowest densities of breeding birds, 0.5 birds per 100 acres (Haldeman 1968, Szaro and Balda 1979).

American robin densities were also found to be positively correlated with the percentage of aspen overstory. Stands with aspen basal areas greater than 64% of the total basal area contained higher densities of birds per 100 acres (Scott and Crouch 1988).

**Management Effects**

Robins appear to be abundant in unlogged and logged forests with residual large trees. Robin densities were low in clearcut areas (Szaro and Balda 1979, Stauffer and Best 1980, Medin 1985). Partial overstory removals, selective tree harvesting, and understory thinning increased or maintained breeding densities similar to densities found in old-growth forests (Franzreb 1977, Stauffer and Best 1980, Mannan and Meslow 1984, Medin 1985, Scott and Crouch 1988, Siegel 1989).

**Habitat Management Recommendations**

√ **Habitat generalists**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- Some evidence for higher densities in forests with large trees

√ **Nesting**
- VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- Preferred nest placement is in forests with higher canopy cover
- Nests in trees over a wide range of tree sizes
- Nests are generally 7-16 feet high

√ **Foraging**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- Forage primarily on the ground
- Little foraging in young forests with moderate to closed canopies
- Mistletoe berries important
- Insects important

√ **Other important habitat attributes**
- Moderately open overstory (VSS 3, VSS 4, VSS 5 and VSS 6) with herbaceous, shrub, and deciduous species in understory are the best habitat.
- Snags and downed logs are not important.
- Woody debris may be important in providing food (e.g., insects)
- Small openings probably improve habitat by providing diversity in shrub and herbaceous species.

## Band-tailed Pigeon
*(Columba fasciata)*

The band-tailed pigeon is a relatively large pigeon (0.9 pounds) (Drewien et al. 1966) that occurs throughout many forested mountain ranges of western North America southward into northwestern South America (Goodwin 1967).

Two subspecies are recognized north of Mexico: *C. f. monilis* occurs west of the crest of the Cascade and Sierra Nevada Ranges along the West Coast from California to British Columbia; *C. f. fasciata* is the interior subspecies, which is sparsely distributed in Arizona, New Mexico, Colorado, Utah, Texas, and into central Mexico.

The band-tailed pigeon is migratory, occurring in the northern parts of its range from March to December. Clutch size is usually one, and one brood is produced per year. In the Southwest, the pigeons arrive on the nesting areas in late June and nest from early July to early August. The southward migratory movements begin soon after completion of nesting--mid-August to mid-September. Available evidence suggests that pigeons tend to return to their previous nesting areas (Neff 1951). Goshawks are known to feed on band-tailed pigeons on the Colorado Plateau in the Southwest and in northern

Mexico (Marshall 1957, Kennedy 1991, Reynolds pers. obs.). The wide-ranging movements of the band-tailed during the spring and summer months may make it less available to the goshawk. Observations from Colorado indicate that the pigeon does not begin to appear in goshawk diets until late summer (Reynolds pers. obs.) when most goshawk diet studies typically end. Thus, the importance of this prey species in the Southwest has not been ascertained.

**Distribution**

Neff (1951) summarized the distribution of band-tailed pigeons in the southwestern United States as occurring in the foothill and mountain areas in the Transition and Upper Sonoran life zones.

**Habitat**

During spring and summer the band-tailed pigeon ranges widely, but nests mostly in forests at high elevations. In late summer the pigeon is more readily observed as it concentrates in favored feeding areas. Braun (1973) categorized 1,370 observations of flocks of band-tailed pigeons in Colorado by the vegetation the flocks were located in. Thirty-one percent of the observations were in areas dominated by small grains (wheat, barley, field peas, oats, and corn), 30% were in areas dominated by oak (*Quercus gambelii*), 18% were in areas dominated by ponderosa pine, and 12% were in areas dominated by spruce-fir-aspen and lodgepole pine forests. Only 4% of the observations were associated with piñon-juniper woodlands. Band-tailed pigeons were often observed perched in snags at feeding sites and mineral seeps.

**Food**

Band-tailed pigeons prefer berries and acorns but rely heavily on waste grain available in cultivated and livestock feeding areas (Braun 1973). Neff (1952) and U. S. Fish and Wildlife Service (1954) compiled monthly reports of the diet of pigeons in Arizona, Colorado, and New Mexico from observers in the three-State region:

| | |
|---|---|
| March: | Pine nuts |
| April: | Grain stubble |
| May: | Oats, manzanita berries, oak blossoms, cottonwood buds, mulberries |
| June: | Cherries, spruce buds, mulberries, oak blossoms, grains, pine seed, pine buds, oak leaf buds |
| July: | Cherries, choke cherries, mulberries, wheat, wild currents, juniper berries, acorns |
| Aug: | Acorns, cherries, wheat, stubble, barley, elderberries, wild raspberries, manzanita |
| Sept: | Acorns, fruit, grain stubble, piñon nuts |
| Oct: | Limber pine seed, piñon nuts, spruce seed, acorns |

**Special Habitat Needs**

Nesting habitat requirements of band-tailed pigeons are poorly known. However, pigeons are commonly found in areas dominated by ponderosa pine-Gambel oak, ponderosa pine, Engelmann spruce, Douglas-fir, lodgepole pine, and limber pine from May to September (Braun 1973). In Colorado band-tailed pigeon nests have been found in lodgepole pine (3 nests) (Curtis and Braun 1983) and in large Douglas-fir (2 nests) (Reynolds pers. obs.). The presence of water appears to be important to pigeons in Colorado, but lack of water is not limiting due to the great mobility of band-tails (Braun 1973).

**Home Range**

No information on home range was found on the band-tailed pigeon.

**Population**

Rasmussen (1941) reported that the abundance of band-tailed pigeons on the North Kaibab Plateau was not as high as earlier in the century when they were seen in "great flocks". Rasmussen (1941) suspected the decline was related to the decrease of berry producing shrubs during the 1920s when the range was severely depleted by the rapidly increasing Kaibab deer herd and domestic livestock. Numbers of band-tailed pigeons in Arizona, Colorado, New Mexico, and Utah during the 1950s were reported to be low (Neff 1951, 1952; U.S. Fish and Wildlife Service 1954, 1957; Arizona Game and Fish Dept. 1982). Populations have increased since the 1950s, and appear to be stable (Arizona Game and Fish Dept. 1982).

**Management Effects**

Little is known of the effects of vegetation management on the band-tailed pigeon or its habitat. However, any management practice (e.g., grazing, some activities associated with tree harvests) that reduces the abundance and composition of herbaceous and shrub food plants will likely affect the distribution and abundance of pigeons. Some forestry practices that may enhance band-tailed pigeon habitat include:

1) regeneration and protection of acorn producing Gambel oaks,
2) creation of openings up to 10 acres in mixed-species forests to increase berry

producing shrubs, and
3) maintenance of least 3 snags per acre to provide adequate roosting sites (Arizona Game and Fish Dept. 1982).

**Habitat Management Recommendations**

√ **Lower elevation conifer forest generalists**
- VSS 1, VSS 2, VSS 4, VSS 5, and VSS 6

√ **Nesting**
- Large trees in ponderosa pine-oak (large diameter oak) and mixed-species forests
- VSS 4, VSS 5 and VSS 6

√ **Foraging**
- VSS 1, VSS 2, and in open canopy VSS 4, VSS 5 and VSS 6
- Acorn-producing oaks, berry-producing shrubs, and conifer seeds are important

√ **Other important habitat attributes**
- Snags are important for perching near feeding areas and mineral seeps
- Downed logs and woody debris are not important
- Forests with openings (or open overstory) to allow development of berry-producing shrubs and acorn-producing trees are important

## Blue Grouse

*(Dendragapus obscurus)*

(Dusky Grouse)

The blue grouse is a large (length 18.5-19.6 inches, weight 1.9-2.6 pounds) grouse that inhabits deciduous and coniferous forests in western North America. In the interior mountains of Oregon, blue grouse made up 2% of the prey items of nesting northern goshawks; however, because they were one of the largest prey taken, they contributed more than 10% of the diet by weight (Reynolds and Meslow 1984). The blue grouse has been recorded in the diets of goshawks nesting on the North Kaibab Plateau, Arizona and in Colorado (Reynolds pers. obs.).

**Distribution**

This grouse is widely distributed in the mountain regions of the Interior West (Rocky Mountains). In Arizona, blue grouse are restricted to high-elevation mixed-species forests in small, isolated populations (Severson 1986, Vahle pers. comm.). They are common in the White Mountains, less common in the Chuska Mountains and in the North Kaibab Plateau, and rare in the San Francisco Mountains (Phillips et al. 1964).

**Habitat**

Structural diversity is a major determinant of habitat suitability for blue grouse (Hoffman 1981, Stauffer and Peterson 1985, Schroeder 1984, Severson 1986). Structure of habitat is more important than species composition. In a habitat model, Schroeder (1984) specified optimal summer habitat as 20-50% tree cover, 10-30% shrub cover 1.6 feet high, and 40-75% herbaceous cover 7.9-11.8 inches high. Important forest cover types include spruce-fir, Douglas-fir, and ponderosa pine (Cade 1985, Cade and Hoffman 1990). Mixed-species forests (dominated by Douglas-fir) are probably the most important habitat type in high elevation sites (>9,000 feet) in Arizona (Severson 1986, Vahle pers. comm.).

Blue grouse nest in the lower portions of their range along forested edges of meadows and openings, and migrate to higher elevations in winter (Bendell and Elliott 1966). Adult male territories tend to occur on hillsides and ridge tops (Bendell and Elliott 1967). Blue grouse require open conditions for breeding and older forests are necessary during the winter. When these conditions are long distances apart, blue grouse will only be found in the nesting or overwintering sites depending on the season (Cade and Hoffman 1990). If wintering and breeding habitats are interspersed, then blue grouse may be abundant year round. Adjacency or interspersion of these two cover types is preferred when high blue grouse densities are desired. In coastal populations, openings created by fire or logging contained the highest densities of breeding blue grouse (Bendell and Elliott 1967). Winter habitat preferred by blue grouse was early seral stages and mature forests (Bendell and Elliott 1967). Dense, second-growth conifer stands generally were avoided (Hines 1986).

**Food**

Blue grouse forage in conifer trees, on the forest floor, along ridge tops, and in openings. Major food items are (Schroeder 1984):

| | |
|---|---|
| Spring: | Needles, buds, and new cones of conifers (85%); |
| Summer: | Fruits and seeds (45%), green leaves (25%), and insects (10%); |
| Fall: | Conifer needles (50%), green leaves (25%), and fruits and seeds (20%); and |
| Winter: | Deciduous buds (5%), and seeds (5%). |

The three major foods used in eastern Arizona (April-June) were Douglas-fir needles, Arizona peavine (*Lathyrus arizonicus*) and many other forbs.

**Special Habitat Needs**

Blue grouse prefer coniferous and aspen forest edges, forest openings, and meadows with well-developed herbaceous and shrub layers that provide the necessary food and cover. Coniferous forests are used throughout the year, where they feed primarily on conifer needles. Conifer needles are the most important winter food item (Mussehl 1963, Armleder 1980, Zwickel and Bendell 1985, Cade 1985, Crawford et al. 1986, Severson 1986, Niederleitner 1987).

Zwickel and Bendell (1985) believe that the level of canopy cover is the key element in the abundance of blue grouse. The amount and diversity of understory vegetation appears inversely proportional to overstory shading, especially at the highest level of canopy cover (Frandsen 1980).

In Colorado, wintering blue grouse preferred Douglas-fir trees for feed-trees, although some individuals used lodgepole pine or spruce-fir forests. Remington (1990) found blue grouse did little winter foraging in Engelmann spruce and subalpine fir. Grouse consistently used the largest Douglas-fir trees for feeding. Preferential use of large conifers during winter has also been reported by Stauffer and Peterson (1986), Pekins (1988), and Pekins et al. (1991). Preference for large conifers is likely related to thermoregulatory benefits (Pekins 1988) and food selection (Bryant and Kuropat 1980, Cade 1985).

In spring, the largest trees in blue grouse roosting sites in Arizona averaged 20.3 inches DBH (13-33 inches, n=21 sites); 71.4% of these roost trees were Douglas-fir. These roosting sites contained an average of 9.7 trees (1-35 trees) (Severson 1986).

Openings in the forest, meadows adjacent to forests, or openings in the shrub layer are three habitat components important in male territories. Within territories, small (0.1 - 1.0 acres) dense thickets adjacent to openings were also important for escape or hiding cover. These thickets were generally 20-40 years of age (5-8 inches DBH). Douglas-fir thickets provided better cover than ponderosa pine (Schroeder 1984). Males also used spaces under logs and stumps as resting, hiding, and courtship display sites (Schroeder 1984, Vahle pers. comm.). Breeding females used stumps and logs for concealment.

**Home Range**

Winter home ranges for 21 radio-marked blue grouse averaged 41.5 acres (7.4 to 105.0 acres). Home ranges of 18 juvenile females and one adult female overlapped extensively. Two juvenile males only had minor overlap with the other radio-tagged individuals (Hines 1986). Daily movements were greatest in late summer, averaging over 656 feet. During the fall (September through November), movements were between 328 and 410 feet per day. From winter until spring migration, daily movements ranged from 164 to 246 feet (Hines 1986). Cade (1985) observed fall migrations of 1.8 to 17.4 miles to wintering areas in high-elevation lodgepole pine and spruce-fir forests.

**Population**

Populations of blue grouse are probably cyclic, especially in the north of their range. Density of blue grouse in Colorado has been estimated at 52 birds per square mile, but on Vancouver Island, British Columbia, blue grouse may be as dense as 230 birds per square mile (Bendell 1955).

**Management Effects**

Excessive grazing can have localized, detrimental effects on breeding and brood-rearing habitat (Stauffer 1983, Zwickel and Bendell 1985). Availability of large winter feeding trees appears to be an important limiting factor. Partial harvesting is the most compatible prescription for maintaining suitable winter habitat. At least 16 large (>9 inches DBH) conifers should be left per acre in all cutting areas (Cade 1985). Severson (1986) called for maximizing interspersion of vegetation within blue grouse habitat. Maintaining uneven-aged stands dominated by Douglas-fir with an intermixture of aspen is also important. Roost sites should be managed as groups (5-10 trees with interlocking crowns) of large Douglas-fir or Douglas-fir/white fir. These groups should be irregularly spaced within the area (Severson 1986).

Age of the forest does not seem to be an important limiting factor to reproduction. The key element associated with breeding and brood rearing is the extent to which forest canopy remains open, open canopies allow sufficient light penetration for the development of herbaceous and shrub species (Zwickel and Bendell 1985).

**Habitat Management Recommendations**

√ **Higher elevation conifer forest generalists**

- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- 5-10 large trees in groups with interlocking crowns important for roost sites
- Interspersion of openings (VSS 1 and 2), and moderately dense VSS 3, and large trees of VSS 4, VSS 5, and VSS 6 are important for nesting, feeding, hiding cover, and winter roosting and feed-trees, respectively.

√ **Nesting**
- VSS 1, VSS 2, in forested meadow edges, openings with structural diversity, and adjacent thickets of VSS 3 are very important
- Well developed herbaceous and shrub layers in openings, and in VSS 4, VSS 5, and VSS 6 are very important
- Minimize grazing and browsing to maintain herbaceous and shrub layers

√ **Foraging**
- Breeding season - VSS 1; open canopy VSS 2, VSS 4, VSS 5, and VSS 6
- Winter - closed canopy VSS 4, VSS 5, and VSS 6
- Summer - forest edges and openings with well developed herbaceous and shrub layers adjacent to dense thickets for hiding cover
- Winter - primarily mature forests with large Douglas-fir

√ **Other important habitat attributes**
- Downed logs and woody debris are very important for resting and nesting sites, hiding cover, courtship display sites

## Chipmunks
*(Tamias spp.)*

Cliff Chipmunk (*T. corsalis*)
Colorado Chipmunk (*T. quadrivattus*)
Gray-collared Chipmunk (*T. cinereicollis*)
Gray-Footed Chipmunk (*T. canipes*)
Least Chipmunk (*T. minimus*)
Uinta Chipmunk (*T. umbrinus*)

Five species of chipmunks occur in southwestern conifer forests, or conifer forest-edge habitat. These species weigh 1.4 to 3.2 ounces and are more closely related to ground squirrels than to tree squirrels. In general, high populations of chipmunks are found in open sunny forests that have an abundance of herbaceous and shrubby plants and many logs, stumps, snags, rocks, and cliffs for lookout points and shelter. In general, the nests or dens of these species are underground, in old logs, among rocks, and in cavities in snags. Chipmunks are omnivorous--they feed on seeds, nuts, fruits, bulbs, roots, herbage, insects, and other animal matter (Gordon 1943, Brown 1971). Chipmunks regularly climb into bushes for seeds, fruits, leaves, and flower parts (Gordon 1943). Conifer seeds are obtained by cutting cones from trees, from cones that have fallen to the ground, or by robbing cones from red squirrel caches.

Two to 13% of goshawk diets in the western United States consisted of a variety of chipmunk species (Appendix 2, page 51). It is difficult to distinguish among chipmunk species in dietary remains and determine which species may be important prey of goshawks in the Southwest. Therefore, the following management recommendations are a composite of habitat needs of these species. These species are segregated along habitat-elevational gradients from piñon-juniper to spruce-fir. Key recommendations for ponderosa pine, mixed-species, and spruce-fir forests are based on the chipmunk species that predominate in these 3 forest types.

### Cliff chipmunk

This species of chipmunk occurs in Arizona from the Arizona Strip, southeastward through the Mogollon Plateau to the White Mountains, and on isolated mountains such as Hualapai, Weaver, Bradshaws, Trumbull, Graham, Santa Catalina, Rincon, Chiracahua Mountains, and Defiance Plateau (Hoffmeister 1986). In New Mexico, the cliff chipmunk occurs in the western half of the state in the Sandia, Datil, Mogollon, Mimbres, Animas, Peloncillo, Guadalupe, Magdalena, San Mateo, and Black Mountains (Findley et al. 1975).

This is a medium to large chipmunk that occurs in extensive conifer forests. The cliff chipmunk is found in a variety of forest types (ponderosa pine, sparse juniper and chaparral, scrub oak and manzanita), and elevational ranges (from 9,400 feet in the Pinaleno Mountains to as low as 3,200 feet near the Colorado River), but only where large rocks or cliffs are present (Hoffmeister, 1986).

### Colorado chipmunk

The Colorado chipmunk is a medium to large chipmunk that occurs in northeast Arizona (Hoffmeister 1986), and the northern half of New Mexico (Sandia, Manzano, Gallinas, San Antonio, Chuska, Zuni, Taos, and Sangre de Cristo Mountains) (Findley et al. 1975). This species is found in association with piñon-juniper woodlands, but also in rocky and bushy areas through the ponderosa pine zone and occasionally in the spruce-fir forests (Hoffmeister 1986). Summer home range for adult female and male Colorado chipmunks was 2.6 and 3.2 acres, respectively (Wadsworth 1972 as cited in Hoffmeister 1986).

### Gray-collared chipmunk

This medium to large chipmunk is found in Arizona from the San Francisco Mountains, along the highest parts of the Mogollon Plateau, to the White Mountains (Hoffmeister 1986). In New Mexico, the gray-collared chipmunk occurs in the

southern portion of the State; in the Mogollon, Organ, Mimbres, Magdalena, San Mateo, and Elk Mountains (Findley et al. 1975).

The gray-collared chipmunk occurs in ponderosa pine and spruce-fir forests, and is commonly found up to timberline in the San Francisco Mountains. It seems to occur in more open forests (Hoffmeister 1986). The gray-collared is the least likely of any of the forest chipmunks to descend below the ponderosa pine forest zone (Findley et al. 1975). This chipmunk often nests in woodpecker holes.

In Arizona, Goodwin and Hungerford (1979) found the gray-collared in dense stands of mature ponderosa pine, whereas the cliff chipmunk was found only in the open (thinned) stands of ponderosa pine. In addition, Lowe (1975) found that the gray-collared chipmunk was abundant in mature ponderosa pine forest west of Flagstaff at elevations between 7,400 and 8,000 feet.

**Gray-footed chipmunk**

This chipmunk occupies the same spectrum of habitats as the Colorado chipmunk, but in some areas the gray-footed extends to the lower ponderosa pine zone. In New Mexico, this chipmunk occurs in the south-central portions of the State; in the Guadalupe, Capitan, Gallinas, Jicarilla, Sacramento, and White Mountains (Findley et al. 1975). In mixed-species forests of the Sacramento Mountains in southern New Mexico, Ward (unpublished data) estimated densities of 0.08 to 1.63 gray-footed chipmunks per acre on trapping grids, while in ponderosa pine forests, he estimated densities of 0.28 to 0.87 chipmunks per acre. In general, the gray-footed chipmunk was associated with mesic mixed-species forests. No gray-footed chipmunks were trapped in piñon-juniper woodlands (Ward unpublished data).

**Least chipmunk**

This is the smallest chipmunk in the Southwest. In Arizona this chipmunk occurs on the Kaibab Plateau, the Chuska-Lukachukai, and the White Mountains. In New Mexico, this chipmunk occurs in the San Juan, Jemez, Sangre de Cristo, and Sacramento Mountains (Findley et al. 1975).

The least chipmunk inhabits coniferous forests of the higher mountains of Arizona and New Mexico. It prefers spruce-fir forests, and is found in openings, often associated with rocky or mesic habitats (Hoffmeister 1986).

**Uinta chipmunk**

This is a medium-sized chipmunk that occurs only on the North Kaibab Plateau in Arizona (Hoffmeister 1986). This species occurs in ponderosa pine, white fir, subalpine fir, blue spruce, and quaking aspen stands.

In comparing two areas, Ruffner (in Hoffmeister 1986) found that chipmunk population density was highest in areas that had fewer trees per acre (243 versus 490), a greater cover due to conifer seedlings (34% versus 19%), and more downed logs and woody debris (11% versus 2%). There were no important differences in herbaceous cover or overstory cover between the two areas.

The Uinta chipmunk is more arboreal than any other chipmunk in the Southwest. Important foods are conifer seeds, fungi, raspberries, and insects. Nests are under roots of conifers and in cavities in trees and snags (Hoffmeister 1986).

**Habitat Management Recommendations**

The following is a composite recommendation for the five chipmunk species:

√ Conifer forest generalists
- VSS 1 open canopy VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- In VSS 1: need developed herbaceous layers and talus or rock fields
- In VSS 4, VSS 5, and VSS 6, forests may be open or moderately closed depending on the species

√ **Nesting**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- In VSS 1, VSS 2, and VSS 3 only when snags, downed logs, and woody debris are abundant or contains rocky habitat (talus slopes, rock fields, cliffs)
- Cavities are important nesting sites

√ **Foraging**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- In VSS 1, VSS 2, and VSS 3 only when snags, downed logs, woody debris, and well-developed herbaceous and shrubby layers are abundant or includes rocky habitats (talus slopes, rock fields, cliffs)
- Need cone-producing trees.

√ **Other important habitat attributes**
- Snags are important for nesting and escape cover.
- Downed logs and woody debris are important for nesting, lookout points, shelter, escape cover, and travel corridors.
- Berry-producing shrubs, seed-producing trees (oaks and conifers), caches, and fungi are important food sources.

## Cottontails
(*Sylvilagus* spp.)

Desert Cottontail (*S. auduboni*)
Eastern Cottontail (*S. floridanus*)
Mountain Cottontail (*S. nuttalli*)

Due to their medium size (14.8-15.6 inches in length and average weight of 3.3 pounds) and widespread distribution, several species of cottontails are common prey throughout the range of the goshawk (Reynolds and Meslow 1984, Reynolds 1989, Kennedy 1991). Mannan and Boal (1990) observed 16 cottontail prey deliveries (11.9%) to nests in northern Arizona. Twenty percent of prey remains collected at goshawk nests in north-central New Mexico were cottontails (Kennedy 1991). Because it is difficult to distinguish among cottontail species in dietary remains and because of differences in the habitats occupied, it is difficult to determine which species may be important prey of goshawks in the Southwest. Therefore the following management recommendations are a composite of the habitat needs of these species. These species are segregated along habitat-elevational gradients from grasslands to spruce-fir. During the nesting season, when goshawks are in coniferous forests, the eastern and mountain cottontails are more likely to occur in goshawk diets. During the winter, desert cottontails could also be consumed by goshawks in piñon-juniper woodlands and other low elevation habitats. Key recommendations for ponderosa pine, mixed-species, and spruce-fir forests are based on the cottontail species that predominate these plant communities.

### Distribution

All three species of cottontail occur in the Southwest. Desert cottontails are widespread and abundant in low- and mid-elevation habitats throughout the Southwest. Eastern cottontails are found in mountainous areas of southwestern New Mexico and southeastern Arizona (Findley et al. 1975, Cockrum 1982, Findley 1987). Mountain cottontails are found in mountainous regions north of the Mogollon Rim (Cayot 1978, Cockrum 1982). In New Mexico, mountain cottontails occur in the Jemez, San Juan, Sangre de Cristo, and Chuska Mountains (Findley 1987).

### Habitat

According to Findley (1987), desert cottontails are primarily located in grassland, shrubland, and woodland habitats in the upper Sonoran and Sonoran zones in New Mexico. In Arizona, desert cottontails are found at elevations below 6,000 feet in brushy areas as well as xeric forest habitats (e.g., ponderosa pine) (Cockrum 1982, Ffolliott 1990).

In New Mexico, the eastern and mountain cottontails chiefly inhabit montane forests, from lower elevation ponderosa pine forests to higher elevation mesic forests (mixed-species, spruce-fir) (Findley 1987). According to Cockrum (1982), eastern cottontails in Arizona are restricted to oak woodlands associated with riparian habitats.

In Colorado, mountain cottontails decreased in abundance as elevation increased from 6800 feet to 8900 feet (Cayot 1978). At higher elevations, mountain cottontail abundance tended to be greater on southeast aspects where ponderosa pine was more common and bitterbrush (*Purshia tridentata*) ground cover increased to 50% (Cayot 1978). Prevalence of bare ground, common juniper (*Juniperus communis*), and downed timber were negatively associated with mountain cottontail abundance.

In southern British Columbia, within the ponderosa-pine-bunchgrass plant association, which includes grassland, sagebrush, riparian, ponderosa pine parkland, open Douglas-fir forest, and lodgepole pine forest, mountain cottontails preferred habitats dominated by sagebrush (Sullivan et al. 1989).

### Food

Cottontail diets vary greatly among species, geographic region, and availability of palatable plants (Chapman et al. 1982). In a given geographic area, cottontails may eat more than 100 plant species but food preferences vary locally (DeCalesta 1971). A wide variety of vegetation is acceptable, provided basic nutritional requirements are met (Chapman et al. 1982). Herbaceous vegetation is typically selected during the growing season, and the bark, buds, and twigs of woody vegetation are consumed during the remainder of the year. Use of woody vegetation during the fall and winter is assumed to relate to reduced availability of herbaceous vegetation and not a preference for woody vegetation (Chapman et al. 1982). In southern portions of the Southwest where winter climates are mild, herbaceous vegetation may provide an adequate year-round source of food (Allen 1984).

### Special Habitat Needs

All three species of cottontail prefer habitat with well-developed shrub and herbaceous understory for food and escape cover (Cayot 1978, Pils et al. 1981, Allen et al. 1982). Most eastern cottontail nests are located in grass cover, dense brush, and downed logs (Allen 1984). No information on nest sites for the desert and mountain cottontail was available. However, mountain cottontails preferred crevices in

outcrops as daytime retreats in a sagebrush-juniper habitat in Oregon (McKay and Verts 1978). McKay and Verts (1978) concluded that mountain cottontail abundance in this habitat type was strongly influenced by the abundance of these daytime retreats. Conversely, in Colorado, Cayot (1978) found no relationship between the presence of rocks and mountain cottontail abundance.

**Home Range**

Home ranges of 25 radio-tagged eastern cottontails in a 14-acre woodlot in southwestern Wisconsin varied by season, sex and individual (Trent and Rongstad 1974). Adult male home ranges increased from an average of 6.8 acres in the spring to an average of 9.9 acres in early summer, and had decreased significantly to an average of 3.8 acres by late summer. Adult female home ranges were largest (average 4.3 acres) in spring, then decreased significantly to an average of 2.1 acres in early summer and remained about this size until mid-January. Additionally, fall home range sizes of four juveniles did not differ from 10 adults, and showed no difference according to sex (Trent and Rongstad 1974).

No information was found on home range sizes for desert and mountain cottontails.

**Population**

Cottontail populations are characterized by substantial seasonal and annual fluctuations. Scribner and Warren (1990) estimated winter densities of two populations of eastern cottontails in Texas to be 3.2 and 4.9 individuals per acre. After reproduction and juvenile dispersal, the densities in these two areas peaked at 10.9 and 11.3 individuals per acre, respectively.

Fall density of eastern cottontails in southwestern Wisconsin woodlots was estimated to be 3.6 individuals per acre (Trent and Rongstad 1974). In this population, annual survivorship was estimated to range between 0.15 and 0.2 depending on the estimation technique. Fall and winter eastern cottontail densities over a 5-year period in southern Wisconsin ranged from 7.4 to 23.7 individuals per acre and 3.7 to 12.9 individuals per acre on controlled and experimentally managed 50-acre woodlots, respectively (Pils et al. 1981).

Population densities of mountain cottontails in ponderosa pine-bunchgrass habitat in southern British Columbia varied annually, from 0.09 to 0.17 individuals per acre. McKay and Verts (1978) found that mountain cottontail population densities varied annually from 0.03 to 1.03 individuals per acre in shrub-juniper habitat in central Oregon.

**Management Effects**

Although habitat studies have not been conducted on eastern cottontails in the southwestern U.S., there is evidence that small areas of brush (in strips 100 feet wide) can provide cottontail habitat (Allen et al. 1982). Additionally, they suggest establishing brush areas at the edges of fields or meadows and forested areas by felling trees within 30 feet of the edge. However, their results also suggest that narrow brushy field borders may be useless for enhancing cottontail habitat if the adjacent wooded area provides only minimal or poor habitat (e.g. areas lacking in shrub and herbaceous understory for food and escape cover).

The effectiveness of experimental habitat management on eastern cottontail abundance was monitored in southern Wisconsin woodlots between 1976-1979 by Pils et al. (1981). Brush pile construction, planting of shrubs, and sowing of food patches were the primary management practices implemented in a 50.2-acre experimental woodlot to increase cottontail numbers. Half-acre portions of the woodlot were clearcut to encourage early successional growth and to construct loose brush piles. They also established food, nesting, and escape cover plots through plowing and disking, planting, mowing, and controlled burning. Cottontail populations were higher on the 50-acre control plot than on the experimental plot during the pre-habitat management and experimental periods. Abundance on both the control and experimental plots showed a downward trend during the 4-year period. Greater vulnerability of experimental populations to hunting because of improved hunter access and less dense total cover were presented as the major reasons habitat management efforts did not result in measurable population increases as compared to the control (Pils et al. 1981). The authors recommended that future habitat management practices should include denser concentrations of brush piles and food patches.

No information was found on specific management recommendations for southwestern populations of any of three cottontails.

**Habitat Management Recommendations**

The following are composite recommendations for the three cottontail species:

√ **Forest and woodland generalists**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6

√ **Nesting**
- VSS 3, VSS 4, VSS 5, and VSS 6
- Large downed woody debris, base of snags and rocks important for eastern and desert cottontail. The importance of these

attributes for mountain cottontail is unknown.

√ **Foraging**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- Well developed herbaceous and shrub layers are important
- Downed logs and woody debris are important for escape cover, particularly in areas with poorly developed shrub understory, for desert and eastern cottontail. The importance of these attributes for mountain cottontail is unknown.

√ **Other important habitat attributes**
- Small openings or sufficiently open overstories that allow development of herbaceous and shrub layers improves foraging habitat.

## Hairy Woodpecker
*(Picoides villosus)*

The hairy woodpecker averages 2.2 ounces (Li and Martin 1991) and is approximately 9 inches in length. It is widely distributed throughout forested habitats in the United States, and as a result of its abundance and distribution, regularly occurs in the diet of the goshawk (Reynolds and Meslow 1984, Mannan and Boal 1990, Kennedy 1991).

### Distribution
Hairy woodpeckers are year-round residents of nearly all forest types from central Canada to the southern United States (Scott et al. 1977).

### Habitat
This species is one of the most common woodpeckers in the Southwest, particularly in riparian habitats and in ponderosa pine, mixed-species, and spruce-fir forests (Hubbard 1978).

### Food
Hairy woodpeckers prefer to feed on insects on dead or diseased trees. Approximately 80% of the diet is animal matter -- larval and adult beetles, ants and caterpillars are most frequently eaten. Coleoptera (primarily Buprestidae and Scolytidae beetles) comprised an average of 63.8% of the diets of male and female hairy woodpeckers in California. Hymenoptera (mainly carpenter ants) were the second most common diet item in both sexes (Otvos and Stark 1985). This insectivorous diet was supplemented with fruit, grains, and nuts (Scott et al. 1977). Hairy woodpeckers (both sexes) also fed on seeds of ponderosa pine (Otvos and Stark 1985).

The sexes of this species selected different foraging sites throughout the year (Morrison and With 1987). According to Scott et al. (1977), males foraged in trees away from the nest for large insects (usually borers). Females foraged close to the nest on the surface of trees, shrubs, or on the ground for small insects and plant material.

In the western Sierra Nevada during the breeding season, Morrison et al. (1987) and Morrison and With (1987) found that both sexes of the hairy woodpecker concentrated their foraging activities on trunks of trees at heights from 33 to 39 feet. During the winter, this species forages higher.

In a mixed-conifer area in the Sierra Nevada, Morrison et al. (1986) found that foraging hairy woodpeckers used lower and upper strata of the tree canopy and areas with smaller diameter trees (4-12 inches DBH).

### Special Habitat Needs
Live trees in open woodlands with deciduous understory are preferred nesting sites of hairy woodpeckers. This species excavates a nest entrance 1.6 to 1.8 inches in diameter. Because this is the nest cavity size preferred by other cavity nesters such as starlings (*Sturnus vulgaris*), competition for nest sites may occur (Scott et al. 1977).

Hairy woodpeckers will often excavate the nest entrance so it is hidden, such as on the underside of a limb. Nest heights vary from 15 to 45 feet, but are typically 35 feet high. This species will often use the same nest hole for several years (Scott et al. 1977).

Of 8 hairy woodpecker nests located in 3 study areas (ponderosa pine, subalpine fir, and aspen) by Scott et al. (1980), 2 were in aspen snags and 6 were in live aspen trees. Nest heights averaged 33 feet (range 22-50 feet), nest tree heights averaged 59 feet (range 35-70 feet) and nest tree DBH averaged 15 inches (range 10-23 inches) (Scott et al. 1980). Hairy woodpeckers showed a nest site preference for ponderosa pine snags with DBH of ≥20 inches in an area of the Santa Catalina Mountains in southeastern Arizona (Horton and Mannan 1988).

In the western Sierra Nevada, hairy woodpeckers showed high use of white fir and ponderosa pine for feeding trees throughout the year (Morrison et al. 1987, Morrison and With 1987). In this area, the hairy woodpecker foraged on live trees and snags with similar frequency, but about 70% of their foraging time was on dead substrate within the tree. The average DBH of the feeding trees was 17.4 inches (Morrison et al. 1987). The feeding trees of males and females did not differ in size during the breeding season, nor did trees used in winter differ from those used in the breeding season (Morrison and With 1987).

**Home Range**

No home range information on the hairy woodpecker was found.

**Population**

Scott and Crouch (1988) found that hairy woodpecker densities were negatively correlated with aspen basal area in west-central Colorado. Densities were almost twice as high in stands with 1% of total basal area in aspens (10 birds per 100 acres) compared to stands with more than 1% aspen basal area (3 to 5 birds per 100 acres).

Studies of woodpecker density responses to snag availability have been mainly correlative and not experimental. Dickson et al. (1987) demonstrated experimentally that snag density (2.2-3.8 snags >7.8 inches DBH per acre) in clearcuts of pine-hardwood forests in east Texas influenced the breeding densities of some woodpeckers, including the hairy woodpecker. Hairy woodpeckers were found exclusively on clear-cut plots with hardwood snags (averaging 0.8 birds per 100 acres) and were absent from snagless plots.

McPeek et al. (1987) experimentally doubled the density of snags greater than 3.9 inches DBH and greater than 16.3 feet tall in a hardwood forest in Kentucky, from 6.0 snags per acre in 1981 to 13.3 snags per acre in 1983. Snag densities on the control areas averaged 7.3 snags per acre. Winter densities of hairy woodpeckers were not significantly different between experimental (3.6-7.6 birds per 100 acres) and control (1.6-6.0 birds per 100 acre) areas. McPeek et al. (1987) concluded that no numerical response in winter was observed because:

1) the birds did not heavily depend on snags as a feeding substrate,
2) food was not limiting to these woodpeckers, or
3) they fed more heavily on fruits and seeds.

Breeding densities of hairy woodpeckers also did not differ significantly between control (1.2-1.6 birds per 100 acre) and experimental (0.8-3.6 birds per 100 acre) areas. Territoriality and/or high site fidelity of hairy woodpeckers during the breeding season may have contributed to the lack of a numerical response following treatment.

**Management Effects**

Snags are an important habitat component for many woodpeckers and other cavity-nesting species. Low snag availability resulting from timber harvest, fuelwood removal, or intense surface fires may adversely affect populations of these snag-dependent goshawk prey (Balda 1975, Thomas et al. 1979). Additionally, even-age management, short stand rotation, and removal of cull trees reduces snag densities, especially large diameter snags (McPeek et al. 1987). Snag availability in managed stands can be increased by:

1) leaving snags during timber harvest, and
2) creating snags using herbicides, topping, or girdling (Bull and Partridge 1986).

Szaro and Balda (1982) studied the effects of timber harvest on breeding bird densities in ponderosa pine forests on the Coconino National Forest, Arizona. During all years of the study, hairy woodpeckers were found in all types of harvested stands except clear-cuts, including:

1) untreated areas where trees had not been removed for 60 years;
2) light harvests in which large trees and dense thickets were selectively removed;
3) moderate harvests in strips alternating with strips of cleared areas and unharvested areas; and
4) heavy cuts where areas were severely thinned, and slash was piled in regularly spaced windrows.

Hairy woodpecker densities averaged about 3 pairs per 100 acres, and did not differ among treatments (Szaro and Balda 1982, 1986).

**Habitat Management Recommendations**

√ **Forest generalists - coniferous and deciduous**
- VSS 3, VSS 4, VSS 5, and VSS 6

√ **Nesting**
- VSS 4, VSS 5, and VSS 6 (may nest in younger VSS if many large snags are present)
- Cavities in snags or live deciduous trees averaging 15 inches DBH and 60 feet high

√ **Foraging**
- VSS 3, VSS 4, VSS 5, and VSS 6
- May forage on the ground during the nesting season
- Forages primarily on tree trunks averaging 17 inches DBH and > 30 feet high

√ **Other important habitat attributes**
- Mixed-species forests have higher hairy woodpecker populations
- Woodpecker populations are typically higher during insect (mainly tree beetle) epidemics
- Snags are important for nesting and foraging
- Downed logs and woody debris are important as a source of insects

## Mantled Ground Squirrel
*(Citellus lateralis)*

(Golden-mantled ground squirrel)

The mantled ground squirrel is a common mammal of the mountainous areas of western United States, southern British Columbia, and Alberta. This ground squirrel was important in all goshawk diet studies in the western United States (Schnell 1958, Reynolds and Meslow 1984, Mannan and Boal 1989, Kennedy 1991) (Appendix 2, page 51). This importance is related to its abundance and size (0.29 to 0.62 pounds). Weights, however, fluctuate considerably from a maximum just prior to hibernation to a minimum at emergence from hibernation.

### Distribution
In the Southwest the mantled ground squirrel occurs in woodlands to above timberline in northern New Mexico (Sangre de Cristo, Jemez, Chuska Mountains) (Findley et al. 1975) and from northern to east-central Arizona (Kaibab Plateau to Mogollon Rim to White Mountains) (J. Hall 1981).

### Habitat
The mantled ground squirrel is found in sunny habitats in forested or sparsely shrubby areas from the edge of the piñon belt to above timberline. It may be found on rocky slopes adjoining grasslands and on forest floors, in areas of scattered chaparral, and along forested margins of mountain meadows. It also occurs in recently burned pine forests where an abundance of stumps and fallen trees provide shelter, and the open habitat produces an abundance of berry producing shrubs and flowering plants (Bartels and Thompson, in press). The mantled ground squirrel is most abundant in open, pure or mixed stands of ponderosa pine, limber pine, lodgepole pine, Engelmann spruce, Douglas-fir, and quaking aspen. It is either absent or occurs sparsely in dense spruce-fir forests (Hatt 1927, McKeever 1964).

### Food
The principal foods are fungi and leaves of herbs (up to 90% of the diet) (McKeever 1964, Maser et al. 1978). During spring, the main food is young, succulent leaves, but as the season progresses and the leaves dry, hypogeous fungi become the main food. Flowers of many herbaceous plants are also consumed. In fall, conifer seeds become an important component of the diet. In California, arthropods and fruits were not an important part of the diet, but this may reflect the lack of local availability (McKeever 1964). In other areas the ground squirrel feeds on the seeds of ponderosa pine, white pine, Douglas-fir, spruce, and acorns of various oaks (Grinnell and Dixon 1918, Gordon 1943, Hoffmeister 1986). Conifer seed can contribute up to 33% of the diet in the fall (McKeever 1964). Shrubs whose fruits are eaten include *Rosa*, *Amelanchier*, *Rubus*, *Ribes*, *Grossularia*, *Purshia*, *Prunus*, and *Ceanothus* (Gordon 1943, Mullally 1953). Herbs consumed include *Lupinus*, *Capsella*, *Penstemon*, *Verbascum*, *Fritillaria*, *Galium*, *Swertia*, *Cirsium*, *Ceanothus*, *Bromus*, *Aconitum*, *Menzelia*, and *Trifolium* (Grinnell and Dixon 1918, Hatt 1927, Gordon 1943, Tevis 1952, Carleton 1966, Hoffmeister 1986). Animal foods include a variety of insects, eggs and the young of birds, voles and chipmunks, lizards, and almost any carcass (Warren 1942, Tevis 1953, Cameron 1967, Bartels and Thompson in press).

### Special Habitat Needs
Mantled ground squirrels dig their burrows beneath rocks or logs, or against the base of live trees or snags (Burt 1934, Gordon 1943, Mullally 1953). These habitat attributes are critical for breeding and hibernating. The mantled ground squirrel hibernates below ground from late November until March or April (McKeever 1964).

### Home Range
No home range information was found on the mantled ground squirrel.

### Population
In California, squirrels were much more abundant in ponderosa pine than in lodgepole pine or in red or white fir forests. This association was correlated with the abundance of herbaceous vegetation--herbaceous ground cover was most abundant in ponderosa pine, moderate in lodgepole, and lowest in fir forests (McKeever 1964). Logging in the dense fir forests was accompanied by an invasion of ground squirrels (Tevis 1956).

### Management Effects
Open areas should be maintained in pine and mixed-species forests for development of herbaceous and shrub species. Areas with more closed canopy for the production of fungi (see the management section for tassel-eared squirrel), and large downed logs are also important. The best seed trees should be maintained in the overstory.

### Habitat Management Recommendations
√ **Conifer forest generalists**
- VSS 1; open canopy VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6

√ **Nesting**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- Rocks, stumps, large downed logs and snags (hollows at the base) are important

√ **Foraging**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- Herbaceous and shrub layers and deciduous species in the understory are very important
- Cones, fungi, berry-producing shrubs, and herbs are critical foods

√ **Other important habitat attributes**
- Best habitat is open sunny forest with large-diameter downed material with developed herbaceous and shrub layers. Cone-producing trees are important and dense forests are avoided.
- Snags, downed logs, and woody debris provide hollows for nesting and escape cover.

## Mourning Dove
*(Zenaida macroura)*

The mourning dove is moderately-sized, averaging 12 inches in length and weighing 0.5 pounds. Reynolds and Meslow (1984) found that mourning doves made up 3% of the diet of goshawks in eastern Oregon; the ninth most common prey item there.

### Distribution
The range of the mourning dove extends from southern Canada throughout the United States, Mexico, and into Central America. This species nests in every state in the conterminous U.S. It may also breed as far north as southeastern Alaska (Martin et al. 1951, Am. Ornithol. Union 1983).

### Habitat
Within its extensive range, this dove inhabits farm and ranchlands, deserts, grasslands and prairies, woodlands, and forests (Soutiere and Bolen 1972). In the Southwest, the mourning dove frequents grasslands, piñon-juniper woodlands, oak woodlands, ponderosa pine forests, and less frequently in mixed-species habitats above 7,000 feet, (Davis and Sintz 1973, Franzreb 1977, Sedgwick 1987). Within the ponderosa pine belt, elevations below 7,000 feet are preferred. Piñon-juniper woodlands are used extensively for nesting, as are riparian areas (R. Tomlinson pers. comm.).

### Food
Mourning doves are ground feeders, whose diet consists almost 100% of plant material. Only traces of insect or other animal foods have been found in diet studies. Seeds and grains are the primary components of their diets (Martin et al. 1951, Griffing and Davis 1974, Tyler and Jenkins 1979, Best and Smartt 1986).

### Special Habitat Needs
Mourning doves prefer forest edges. In contiguous forests, stream borders or boundaries between forest types is preferred. Broad or abrupt borders between fields and forests were not as favorable as narrow, finger-like forest edges (Hopkins and Odum 1953). In forested or woodland habitats, mourning doves often nest in association with small openings, 1 to 5 acres in size (R. Tomlinson pers. comm.).

Although mourning doves are considered habitat generalists, they do have specific nesting requirements (Stauffer and Best 1980, Sedgwick 1987). Coon et al. (1981) found that the structural stability of the nest, which was influenced by nest placement, determined the probability of nest success. Preferred nest sites are horizontal limbs. Nests placed on limbs away from the trunk provide an unobstructed flight path (Harris et al. 1963, Davis and Sintz 1973, Coon et al. 1981, Yahner 1983, Knight et al. 1984, Putera et al. 1985). In southwestern New Mexico, the average DBH of 41 nest trees was 18.6 inches, while the average DBH of all woody plants in the vegetation plots was only 13.8 inches (Davis and Sintz 1973). Haldeman (1968) observed that mourning doves nested in "large yellow-barked ponderosa pines" and in "large" mixed-conifer trees. Two studies in Iowa had average nest tree DBHs of 17.4 and 20.3 inches (McClure 1946; Jumber et al. 1956 in Davis and Sintz 1973). In California, 13 inches was the average DBH for nest trees, and in Nebraska, nest trees averaged 10.2 inches DBH (McClure 1946). Nest trees tend to be taller than surrounding trees (Davis and Sintz 1973). Davis and Sintz (1973) generally characterized nest trees in southwestern New Mexico as tall (average = 26 feet) sturdy trees, with most nests placed 8-12 feet above ground. Nest trees (N=40) were common where tree cover was patchy to moderately dense (78%); and less common in areas with dense or open canopy cover (22%). In piñon-juniper woodlands of Colorado, Sedgwick (1987) found that mourning doves were associated with areas containing:

1) large trees (33-40 inch DBH), and
2) dead and dying trees.

Soutiere and Bolen in Texas (1972) found that nesting doves used the largest mesquite trees available for nesting.

An important center of activity associated with fledgling mourning doves are "reference areas" (RAs) (Hitchcock and Mirarchi 1986). In eastern juniper (Juniperus *virginiana*) and loblolly pines (*Pinus taeda*), trees in RAs tended to have large, dense crowns (width average 26.3 feet; 76% average crown density). RAs are small sites (3.3 square feet) which are used by fledgling mourning doves for loafing and for feeding interactions with parents, primarily the male (Hitchcock and Mirarchi 1986). The RAs are within 150 feet of the nest tree and are used up to 27 days after hatching. An average of 3 RAs are used during the fledgling-dependency period (≤30 days). Fledglings 27 days of age and older move to and from feeding sites in juvenile flocks. At 27 to 30 days old, fledglings begin to abandon their RAs and may fly up to 0.9 mi from the nest site (Hitchcock and Mirarchi 1986).

RAs were located on the ground or on limbs of trees. These sites were characterized by "dense overhead canopies interspersed with openings" (Hitchcock and Mirarchi 1986). Ground sites were used more often than expected by fledglings older than 13 days. The average DBH of RA trees was 13.3 inches, while roost trees had an average DBH of 13.7 inches. Trees used as RAs and as roost sites had open-grown forms. Ground RAs were open (≥50% of the ground was unvegetated). Basal area of the overstory was low (average 48 square feet per acre) and stem densities averaged 267 stems per acre (Grand and Mirarchi 1988).

### Home Range

In Missouri, adult mourning doves moved up to 4.8 miles from nest sites to feeding sites (Sayre et al. 1980 in Howe and Flake 1988). In the desert situation of southeastern Idaho, Howe and Flake (1988) observed that adult mourning doves moved an average 2.3 miles from nest sites to feeding or loafing areas and 1.1 miles to watering areas. In Idaho, maximum daily movements ranged from 0.7 to 2.4 miles per day for 5 radio-tagged adult mourning doves (Howe and Flake 1988).

### Population

In a wooded floodplain in southwestern New Mexico, nesting densities reached 3.3 nests per acre, whereas 18.2 nests per acre were located in a small isolated shelterbelt in central North Dakota (Randall 1955, Davis and Sintz 1973). In fruit orchards in north-central Washington, Knight et al. (1984) noted the number of nesting pairs of mourning doves ranged from 0 to 6.6 pairs per 100 trees checked. The highest densities were in semi-cultivated orchards that had minimal human disturbance.

The average density of breeding birds was similar in dense old-growth ponderosa pine stands (1.2 breeding pairs per 100 acres) to logged stands with residual trees meeting old-growth ponderosa pine standards (14 trees ≥20 inches DBH, and basal area >90 square feet per acre) (1.1 breeding pairs per 100 acres), whereas open old-growth ponderosa pine stands averaged 1.4 breeding pairs per 100 acres (Siegel 1989). The Pearson Natural Area (old-growth ponderosa pine) near Flagstaff, Arizona, contained 7 pairs per 100 acres, whereas in an old mixed-species forest on the San Francisco Mountains near Flagstaff, only 3 pairs per 100 acres were observed (Haldeman 1968). In old-growth mixed-species forests in northeastern Oregon, no breeding birds were detected in 2 of 3 years. In the year breeding birds were detected, densities were less than 0.1 per 100 acres. In thinned mixed-species forests, densities averaged 0.5 breeding birds per 100 acres (Mannan and Meslow 1984). No breeding birds were counted in mixed-species forests in east-central Arizona; only presence was detected (Franzreb 1977).

### Management Effects

For nest areas, irregularly shaped forest openings or forested areas that range from patchily distributed to moderately dense trees appear to be most appropriate (Hopkins and Odum 1953, Davis and Sintz 1973). Trees with an open-grown form provide better limb structure for nesting (Knight et al. 1984). Based on studies in non-cultivated areas, nest trees should be at least 17 inches DBH (Davis and Sintz 1973).

To manage for ground and tree RAs, Grand and Mirarchi (1988) recommended "...conifer stands with low basal areas and stem densities, large amounts (>50%) of unvegetated ground, and dense clumps of vegetation in strata less than 10 feet in height. Prescribed fires in open pine stands would also help to maintain these conditions." The presence of hardwoods also provides additional roost sites. Grand and Mirarchi (1988) felt that the maintenance of open conifer stands might be important to fledgling survival.

Because mourning doves occur in extremely low densities in mixed-species forests, this habitat type should not be managed for mourning doves.

### Habitat Management Recommendations

√ **Lower elevation conifer forest generalists; little use of mixed-species and spruce-fir**

- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6

√ **Nesting**
- VSS 4, VSS 5, and VSS 6
- Large trees >17 inches DBH
- Open to moderately dense canopy cover around nest trees and reference areas

√ **Foraging**
- VSS 1; open VSS 2, VSS 3, VSS 4, and VSS 5
- Primarily ground feeders on seeds
- Irregularly shaped open areas with clumps of trees

√ **Other important habitat attributes**
- Snags are used as perch sites
- Downed logs and woody debris are of little to no importance
- Openings that can be used as nest, roost or foraging sites should be small to moderate in size, and irregular in shape with scattered trees in the openings

## Northern Flicker
*(Colaptes auratus)*

The northern flicker is a relatively large woodpecker (length = 12.5-14 inches), weighing about 4.8 ounces (Kennedy 1991, Li and Martin 1991). Because of its widespread distribution in forested habitats throughout the US, conspicuous markings, and behavioral displays, it is a common prey of the goshawk. In north-central New Mexico this species comprised 14.3% of 106 prey remains collected at goshawk nests from 1984 to 1988 (Kennedy 1991). On the North Kaibab Plateau in Arizona, this species comprised 3.7% of 135 prey deliveries to 7 nests (Mannan and Boal 1990).

### Distribution
The northern flicker is a common resident in mountainous areas and lowland valleys throughout the Southwest (Hubbard 1978).

### Habitat
During the nesting season, northern flickers are common throughout North America in open woodlands, fields, and meadows. Scott et al. (1977) reported that flickers typically nest in forest edge habitats. In extensive forests they nest only in and around openings. Northern flickers had dense populations (7 birds per 100 acres) in mixed-species stands in which 98% of overstory trees were aspen; stands with less aspen had fewer flickers (1 to 4 birds per 100 acres) (Scott and Crouch 1988).

### Food
According to Scott et al. (1977), 60% of the northern flicker's diet is animal matter; of this, 75% is ants (Scott et al. 1977). Remaining animal matter includes beetles, wasps, caterpillars, crickets, and larval forms of many species. In a California ponderosa pine forest, 87% of the total food volume consumed by northern flickers was Hymenoptera species (*Liometopum* sp., *Prenolepis imparis*, *Formica* sp., *Lasius* sp.). Homoptera comprised an additional 9% (Scott et al. 1977, Otvos and Stark 1985). Plant material commonly found in flicker diets includes seeds of annuals, cultivated grains, and the fruits of shrubs and trees (Scott et al. 1977).

### Special Habitat Needs
Flickers excavate nest holes, 2.75 inch diameter entrances, in dead limbs or trees of many species (*Populus*, *Pinus*, *Quercus*, and *Juniperus*). Nests are sometimes as high as 100 feet, but are usually between 10 and 30 feet above the ground (Scott et al. 1977). In the Santa Catalina Mountains, Arizona, the northern flicker preferred ponderosa pine snags greater than 20 inches DBH in stands that had never been logged (Horton and Mannan 1988). In a mixed-species forest along the Mogollon Rim in Arizona, 36 nests were located in aspen trees (57% snags, 14% dead portions of live trees, and 29% live trees). Average nest height and DBH were 53.5 feet and 17.7 inches, respectively. Areas around nests contained an average of 2.7 snags per 0.1 acre (1.8 aspen snags and 0.9 conifer snags) (Li and Martin 1991).

Scott et al. (1980) characterized 29 nests located in 3 forest types (ponderosa pine, subalpine spruce-fir, and aspen) in the Rocky Mountains. Eight were in ponderosa pine snags, 6 were in aspen snags, 14 were in live aspen, and 1 was in another unidentified conifer snag. The nest height averaged 36 feet (10-67 feet), the nest tree height averaged 64 feet (24-91 feet), and the nest tree DBH averaged 16 inches (10-30 inches) (Scott et al. 1980).

### Home Range
No home range information was found on the northern flicker.

### Population
Northern flickers exhibited little numerical response to a variety of harvesting methods in mixed-species and ponderosa pine forests in the western United States. Only in areas that were clearcut did the flicker show a negative population response (Kilgore 1971, Franzreb and Ohmart 1978, Szaro and Balda 1979b, Mannan and Meslow 1984, Medin 1985). On the North Kaibab Plateau, flicker breeding densities were highest in dense old-growth (6.7 pairs per acre), intermediate in light harvested "old-growth" (6.4 pairs per acre), and lowest in open

old-growth ponderosa pine (3.4 pairs per acre) (Siegel 1989).

**Management Effects**

Szaro and Balda (1982) studied the effects of timber harvest on breeding bird densities in ponderosa pine forests on the Coconino National Forest, Arizona. During all years of the study, northern flickers were found in all types of harvested stands, except clear-cuts, including:

1) untreated areas where trees had not been removed for 60 years;
2) light harvests in which large trees and dense thickets were selectively removed;
3) strips of moderate harvest alternating with strips of cleared areas and unharvested areas; and
4) heavy cuts where areas were severely thinned and slash was piled at regularly spaced windrows.

Northern flicker densities averaged about 3 pairs per 100 acres and in ponderosa pine did not differ among treatments. No density values were available for clear-cuts (Szaro and Balda 1982, 1986).

**Habitat Management Recommendations**

√ **Habitat generalists**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6

√ **Nesting**
- VSS 4, VSS 5, and VSS 6 (may nest in younger VSS if high density of snags present)
- Typically nests along forest edges of openings
- Large diameter aspen are especially important for nesting
- Snags ≥16 inches

√ **Foraging**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6

√ **Other important habitat attributes**
- Snags are important for nesting and feeding
- Downed logs are an important source of insect prey

## Red-Naped Sapsucker
*(Sphyrapicus nuchalis)*

The red-naped sapsucker is a medium-sized woodpecker, 8.5 inches in length and weighing approximately 1.6 to 1.8 ounces (Dunning 1984, Li and Martin 1991). This species is 1 of 4 *Sphyrapicus* spp. found in forested habitats in the United States. Because of their abundance in forested habitats, members of this genus occur commonly in the diet of the goshawks (Reynolds and Meslow 1984, Kennedy 1991).

**Distribution**

The red-naped sapsucker is found throughout the intermountain west, but does not occur in the Pacific Northwest. In the Southwest, this species commonly breeds in mountainous terrain north of the Mogollon Rim. South of the Mogollon Rim it is an uncommon summer resident. It is a casual summer visitor in the lowlands of southern New Mexico and Arizona. During winter, it is rare north of the Mogollon Rim, but is locally common in the southern parts of the Southwest (Hubbard 1978).

**Habitat**

The red-naped sapsucker usually is abundant in riparian areas of mixed-species forests with a hardwood component. It is also found in ponderosa pine, aspen, mixed-species, lodgepole pine, and in mixed stands of fir-larch-pine (Scott et al. 1977). During the breeding season in northern Arizona, however, this species was not reported in pure stands of ponderosa pine (Szaro and Balda 1979a, 1986).

In the Huachuca Mountains in southeastern Arizona, red-naped sapsuckers wintered in the following habitats:

1) riparian woodlands associated with grasslands,
2) oak savannah and oak woodland,
3) oak-juniper woodland, and
4) pine-oak woodland (Bock and Larson 1986).

The average elevation of the birds wintering in this area was 5,476 feet (Bock and Larson 1986).

**Food**

Red-naped sapsuckers feed on sap throughout the year, but the amount taken and tree species used varies seasonally (Scott et al. 1977, Bock and Larson 1986). Ants comprise 80% of the animal matter in their diet (Scott et al. 1977). Other insects include beetles and wasps, but no wood-boring larvae have been recorded in their diet. Although plant material makes up a small portion of their overall diet, the fruits of some deciduous shrubs and trees can be important diet components when insect populations are low (Scott et al. 1977, Bock and Larson 1986).

**Special Habitat Needs**

Red-naped sapsuckers nest in cavities in snags or live trees with rotten heartwood (Scott et al. 1977). Nests have been found in a variety of deciduous and coniferous tree species, but in many areas aspen is the preferred nest tree (Scott et al. 1977). The nest

height varies from 5 to 7 feet above ground and the same nest is often used repeatedly, although a new cavity is excavated each year. Li and Martin (1991) located 20 nests in the Mogollon Rim country of central Arizona. All were found in aspen trees (20% snags, 25% dead portions of live trees, and 55% in live trees). The average nest tree height was 43.6 feet and the average nest tree DBH was 14.6 inches. Snag densities averaged 2.3 per nest plot (0.1 acre), 1.7 aspen snags and 0.6 conifer snags.

Scott et al. (1980) characterized 6 nests located in 3 forest types (ponderosa pine, subalpine spruce-fir, and aspen) in the Rocky Mountains. Five were in live aspen and 1 in an unidentified conifer snag. The average nest height was 39 feet (25-60 feet), average tree height was 62 feet (45-80 feet), and the average DBH of the nest trees was 16 inches (14-19 inches).

This species regularly uses 1 to 2 trees in its territory for foraging. These feeding trees generally show signs of damage (porcupines, logging) (Scott et al. 1977). Red-naped sapsuckers drilled sap holes in all tree species available in their winter habitat in the Huachuca Mountains, Arizona including: oak (45.7% of sap trees), juniper (4.9% of sap trees), pine (11.1% of sap trees) and a variety of deciduous species (19.8% of sap trees) (Bock and Larson 1986).

### Home Range

No home range information was found on the red-naped sapsucker.

### Population

McPeek et al. (1987) experimentally doubled the density of snags greater than 3.9 inches DBH and greater than 16.3 feet tall in a hardwood forest in Kentucky, from 6.0 snags per acre in 1981 to 18.3 snags per acre in 1983. Snag densities on the control areas averaged 7.3 per acre. Winter densities of sapsuckers were not significantly different between experimental (0.4-1.2 birds per 100 acre) and control (0.4-0.8 birds per 100 acre) forests. McPeek et al. (1987) concluded that no numerical response was observed in winter because:

1) the birds did not depend on snags as feeding substrate,
2) food was not limiting to these woodpeckers, or
3) they fed more heavily on fruits, seeds, and sap.

### Management Effects

Due to this sapsucker's preference for aspen nest trees, maintenance or regeneration of aspen is important. Development of oak and other deciduous trees in the understory for feeding and nesting will also benefit the red-naped sapsucker. High snag densities appear to improve red-naped sapsucker habitat.

### Habitat Management Recommendations

√ **Forest generalists (lower elevations), commonly mixed with aspen**
- VSS 4, VSS 5, and VSS 6
- Riparian and forests with oak understory very important, particularly in the winter

√ **Nesting**
- VSS 4, VSS 5, and VSS 6
- Snags or live decadent trees (wounded, decayed heartwood), especially aspen, very important
- Nest tree diameter 15-16 inches DBH and 39-44 feet in height

√ **Foraging**
- VSS 4, VSS 5, and VSS 6
- Decadent trees (wounded, decayed heartwood) very important

√ **Other important habitat attributes**
- Snags, especially aspen, are important
- Downed logs and woody debris are sources of insect food
- Deciduous understory (aspen, oak) is important for nesting and foraging

## Red Squirrel

*(Tamiasciurus hudsonicus)*

(Mount Graham Red Squirrel)

The red squirrel is a small tree squirrel, total length 12-14 inches, weight 0.4-0.5 pounds (Burt and Grossenheider 1964, Hoffmeister 1986). Within certain habitats, the red squirrel is commonly used as prey by the goshawk. Rusch and Meslow in Canada (pers. comm. in Rusch and Reeder 1978) estimated that a total of 306 red squirrels were taken by a pair of goshawks during three breeding seasons, and that goshawks may take a greater number during winter when the variety of prey species is reduced. In the Jemez Mountains of northern New Mexico, the red squirrel comprised 5.6% of 36 prey deliveries to 7 goshawk nests and 17.5% of 63 pellets analyzed from 8 goshawk nests (Kennedy 1991). In eastern Oregon, the Douglas squirrel (*Tamiasciurus douglasi*) comprised 5.7% of the diet of goshawks (Reynolds and Meslow 1984). In northern Arizona, 1.5% of 135 prey deliveries to 7 goshawk nests were red squirrels (Mannan and Boal 1990).

### Distribution

This sciurid is a forest-dependent mammal that ranges from Alaska through most of Canada into the hardwood and coniferous forests of the upper midwestern, northeastern, and Appalachian states.

The red squirrel also is found throughout the coniferous forest of the Rocky Mountains and south into the mountains and higher elevation plateau areas of Arizona and New Mexico (Martin et al. 1951, Hoffmeister 1986, Sullivan 1990).

**Habitat**

In the western United States, the red squirrel is found almost exclusively in conifer forests, including spruce-fir, Douglas-fir, and lodgepole pine. Mature stands of conifers are preferred. In the Southwest, Engelmann spruce or a mixture of spruce and Douglas-fir are the most important and commonly inhabited forest types (Vahle 1978). The red squirrel is less common in mixed forests of ponderosa pine and Douglas-fir, and rarely in pure ponderosa pine stands (Rasmussen 1941, Gurnell 1984, Hoffmeister 1986, Sullivan and Moses 1986). However, Uphoff (1990) found that lower elevation mixed-species/ deciduous habitat supported high densities of red squirrels. Her study area was located on the Mogollon Rim in central Arizona (elevation 7500 feet). The ridge and drainage system contained a mixture of ponderosa pine, southwestern white pine, Douglas-fir, white fir, and Gambel oak. Riparian understories were dominated by big-toothed maple, quaking aspen, and New Mexican locust.

**Food**

Conifer seeds are the year-round dietary staple. Some commonly eaten and preferred seeds in the Southwest include Douglas-fir, blue spruce, Engelmann spruce, and white fir (C. Smith 1968, Rusch and Reeder 1978, Gurnell 1984, Hoffmeister 1986, Patton and Vahle 1986, Sullivan and Moses 1986). Ponderosa pine seeds were occasionally noted as being used on the North Kaibab Plateau, Arizona (Rasmussen 1941). Although ponderosa pine seeds had the highest quantity of energy per seed out of 7 species of conifers, they were taken second most frequently in feeding trials (91 of 108 trials = 84%) (C. Smith 1968).

Because seed crops fluctuate widely from one year to the next, cones caches not only provide a stable food source during the following winter, but they may also serve as the primary winter food source through an additional 1 or 2 years of cone crop failure (M. Smith 1968).

Meristematic buds are an important winter and spring food supplement, especially in years when cone crops fail (M. Smith 1968, Rusch and Reeder 1978). Leaf buds were eaten in early July in mixed-species forests in Arizona (Uphoff 1990). Conifer pollen is eaten from late spring to mid-summer depending on tree species. However, pollen is available for only 2 or 3 weeks during this period.

Fungi are available from spring through fall. Fungi are harvested and placed in forks of tree branches and logs for drying and storage. These stored mushrooms are eaten sparingly throughout the winter (Hatt 1929, C. Smith 1968, M. Smith 1968, Rusch and Reeder 1978). In southern British Columbia, C. Smith (1968) identified 42 species of fungi eaten by red squirrels. Preferred species included those in the genera *Suillus*, *Rhizopogon*, and *Chroogumphus*. In an analysis of 5 red squirrel stomachs from Oregon, Maser et al. (1978) noted that basidiomycetes fungi were taken most frequently and that fungi made up 77% of diet volume. In the Mogollon Rim country of central Arizona, the most common hypergeous fungi gathered by squirrels were *Fistulina hepatica*, *Cortinarius rufolivuccus* and *Pleurotus porrigens* (Uphoff 1990). These fungi were stored in secondary food caches, while hypogeous fungi, such as, *Geopora cooperi* and puffballs, would be eaten immediately upon discovery. Fungi were the most commonly eaten summer food by females in central Arizona. This food source was utilized from the beginning of the rainy season in mid-June through September (Uphoff 1990, Reiser pers. obs.).

Red squirrels also eat fruits, seeds, sap, acorns and nuts of angiosperm trees and shrubs (cottonwood, maple, wild rose, blueberry, raspberry, wild strawberry, bracken fern). They also chew on animal bones, and eat insects, soil, and feces (Hatt 1929, Layne 1954, Brink and Dean 1966, C. Smith 1968, M. Smith 1968, Rusch and Reeder 1978, Uphoff 1990). Red squirrels also regularly eat passerine bird eggs (Martin 1988, Uphoff 1990).

**Special Habitat Needs**

Food caches (middens) are of paramount importance to red squirrels. Without these middens, winter starvation is inevitable (M. Smith 1968, Kemp and Keith 1970). A large centrally located (primary) midden is the most prominent feature of red squirrel territories. These primary middens, along with several secondary middens, provide the energy requirements of a single squirrel for half of the year (Rusch and Reeder 1978, Gurnell 1984, Patton and Vahle 1986). Cache sites are in moist, shaded areas. At cache sites, groups of mature trees and shading from additional understory and overstory vegetation maintains the humidity necessary to prevent the cones from opening.

These mesic areas also support other foods sensitive to desiccation, such as fungi, conifer buds, grasses, berries, and insects. These foods are important to juvenile red squirrels learning to forage on their own (Uphoff 1990).

Vahle and Patton (1983) found that 90% of 141 cache sites had canopy cover greater than 60%, and received additional shading from surrounding uneven-aged groups of trees. Canopy cover in a 33-foot-radius plot centered on primary middens averaged 89% (n=144) for Mount Graham red squirrels (Mannan and Smith 1991). One or more large (≥20 inches DBH) snags, fallen logs, and/or live trees act as support structures for the primary midden (Vahle and Patton 1983). Basal areas at middens in old-growth mixed-species forests were higher (197 square feet per acre) than on randomly chosen sites (142 square feet per acre). Midden sites had more larger trees (≥20 inches DBH) than non-midden sites. Midden plots (0.1 acre) in the White Mountains contained an average of 3 large, dominant trees (≥20 inches DBH) (Vahle and Patton 1983, Patton and Vahle 1986). Mannan and Smith (1991) averaged almost 4 trees (≥16 inches DBH) per midden site.

Territory size has been linked with food requirements. The number of cones required to sustain a single red squirrel for a year ranges from 42,000 to 131,000, thus 9 to 25 large, mature, cone-producing trees per territory are necessary (C. Smith 1968, Rusch and Reeder 1978, Gurnell 1984, Patton and Vahle 1986).

In Douglas-fir, 200- to 300-year-old trees are the best seed producers. These old trees may produce 20 to 30 times more seed than trees that are 50 to 100 years old (Hermann and Lavender 1990). White fir begin producing cones around 40 years of age and continue beyond 300 years of age. Dominant trees in the 12 to 35 inch DBH range are the best and most reliable cone producers (Laacke 1990). Engelmann spruce begin to produce abundant cone crops once they have reached a DBH greater than 15 inches, and are 150 to 200 years old. This spruce is a long-lived species that does not fully mature until 300 years of age, and may live upwards of 600 years (Alexander and Shepperd 1990). Blue spruce is also a slow growing, but long-lived species (>600 years). However, its best seed producing years range between 50 and 150 years (Fechner 1990).

Nest trees have crowns that interlock with 2 or more adjacent trees (Vahle and Patton 1983). In a mixed-species forest in Arizona, nest trees averaged 14 inches DBH (3-35 inches). Average distance between nest trees and the primary middens was 15 feet (0-80 feet; 186 nests) (Vahle and Patton 1983). In a mixed hardwood forest in New York, Layne (1954) found leaf nests in trees whose DBH ranged from 4 to 16 inches, and DBH of trees with cavity nests ranged from 12 to 36 inches.

**Home Range**

Home range estimates for adult red squirrels range from 0.7 to 2.0 acres in a lodgepole pine forest (n=9), from 0.5 to 11 acres in a mixed hardwood-conifer forest (n=13) (Layne 1954, Gurnell 1984). Most researchers report estimates of territory size, and Gurnell (1984) found that territories were about 60% to 100% of the squirrels' home range. In two spruce-fir and hemlock-cedar sites in British Columbia, adult territories were contiguous and non-overlapping and averaged 2.2 acres (10 low elevation sites) to 1.3 acres (5 high elevation sites) (C. Smith 1968). Squirrel home ranges decreased in size as the number of trees greater than 10 inches DBH increased. These territories had the highest densities of cones available to the squirrels (C. Smith 1968). Territories, estimated from observations of 23 marked individuals, in mixed white spruce, black spruce, jack pine, and aspen and poplar forests ranged from 1 to 2 acres (Kemp and Keith 1970). Rusch and Reeder (1978) estimated territories of 0.6 to 1.6 acres in similar habitat. In a low elevation mixed-species/deciduous forest, Uphoff (1990) estimated minimum defended territories of 0.07 acres.

**Population**

Spring density of adult red squirrels over a 50 year period tended to be similar within a variety of conifer forests: densities averaged 1.1 squirrels per acre in spruce forests, 0.7 in mixed-species forests, and 0.4 in pine forests (Rusch and Reeder 1978, their Table 13). Since these studies spanned 50 years, a wide variety of overwintering conditions and cone production was encountered.

Vahle and Patton (1983) estimated population densities from 0.4 to 1.0 squirrel per acre in old growth mixed-species forests, while Ward (unpublished data) estimated red squirrel densities of 0.03 to 0.32 per acre in mixed-species forests of the Sacramento Mountains, New Mexico. In mixed-species/deciduous drainages, squirrel densities averaged 1.7 per acre in a 45 foot corridor down the center of the drainages (primarily occupied by females). Densities declined to 0.61 squirrel per acre in a corridor located on the upper slopes of drainages, where there were equal numbers of male and female territories. Ridgetops in mixed-species forests were more frequently occupied by males (Uphoff 1990).

Densities in a lodgepole pine forest were estimated at 0.3 adult red squirrels per acre (Gurnell 1984). Squirrels were more abundant in both unthinned and managed young (20 years of age)

stands of lodgepole pine, than in thinned (20 year) stands (0.5 versus 0.2 squirrel per acre, respectively). Unthinned young stands had similar densities to mature (110-year-old) stands of lodgepole pine.

In mature stands, 100% of adult females attained breeding condition, while only 56% did so in young stands. Survival was significantly higher in mature stands. Similar densities in young unthinned stands were thus maintained by higher recruitment rates into the young stands (Sullivan and Moses 1986). The suboptimal habitat of the unthinned young stands seemed to serve as a dispersal sink for yearling and young squirrels from the surrounding mature forests (Sullivan and Moses 1986). Red squirrel tracks were generally more abundant in uncut forests than in 1- to 33-year-old clear-cuts (Thompson et al. 1989).

Old-growth forest stands (250-730 yr) of Douglas-fir and western hemlock in the Cascade Range of Washington supported densities of Douglas squirrels that were 3 times higher than in young forest stands (42-165 yr). Young forests were dominated by Douglas-fir. Old-growth forests supported 0.25 squirrels per acre, while the young forest stands supported 0.07 squirrels per acre. Cone crops for both Douglas-fir and western hemlock were rated "very poor" and "extremely poor" for the first 2 years of this 3 year study (Buchannan et al. 1990). Like red squirrels, Douglas squirrel populations are similarly limited by food supply (C. Smith 1968, 1970).

**Management Effects**

Vahle and Patton (1983) and Patton and Vahle (1986) recommended maintaining areas with closely spaced groups of trees of different ages and sizes. Stands of trees greater than 15 inches DBH are necessary to provide cone producing trees and nest trees. For Douglas-fir, 200- to 300-year-old trees are the best cone producers (Hermann and Lavender 1990). Additionally, one or more large tree components (>20 inches DBH), consisting of snags, fallen logs, and live trees, are necessary for primary middens. Closed canopies (basal areas ≥200 square feet per acre) are also important for maintaining mesic conditions for middens and suitable cover for nesting. To provide adequate conifer seed for food, 3 to 4 large (≥18 inches DBH) trees are needed per acre (Vahle 1978).

In mixed-species forests in canyons of the Southwest, other habitat components may exceed conifers in their importance for the red squirrel. Females in these areas typically produce 2 litters (versus 1 litter at higher elevations) per breeding season because of a greater abundance of summer foods (fungi, berries, bird eggs) and superior nest sites (Uphoff 1990). Because these productive canyon areas are limited in number in the Southwest, they are particularly important squirrel habitat.

**Habitat Management Recommendations**

√ **Mixed-species and spruce-fir specialist**
- Closed canopy VSS 4, VSS 5, and VSS 6

√ **Nesting**
- Closed canopy VSS 4, VSS 5, and VSS 6 with interlocking crowns around nest sites
- Nests are close to middens
- Nest sites have high canopy cover and the best sites are mesic

√ **Foraging**
- VSS 5 and VSS 6 (infrequent use of VSS 4)
- Middens have high canopy cover and are mesic, preserving cones
- High canopy cover provides mesic conditions for greater fungi production

√ **Other important habitat attributes**
- Snags (>18 inches DBH) and downed logs (16-20 inches diameter) very important; smaller woody debris less important
- High canopy cover provides escape cover for squirrels
- Large mature cone-bearing trees, abundant fungi, and multistoried stands with many plant species in all forest layers constitute superior squirrel habitat
- Medium to large forest openings degrade the mesic microclimate in adjacent forests, and thereby reduce the quality of red squirrel habitat

## Steller's Jay

*(Cyanocitta stelleri)*

Steller's jays are a relatively large songbirds averaging 11.5 inches total length, weighing 0.25 pounds (Kilgore 1971). Steller's jays are a common resident of ponderosa pine and mixed-species forest, and occur often in goshawk diets. In eastern Oregon, 7.5% of goshawk prey remains were Steller's jays (Reynolds and Meslow 1984). Over 11% of the prey deliveries to 7 goshawk nests in north-central New Mexico were Steller's jays (Kennedy 1991). In northern Arizona, this corvid comprised 5.2% of 135 prey deliveries to 7 goshawk nests (Mannan and Boal 1990). Steller's jays were the most common prey in remains collected at a goshawk nest in piñon-juniper (K. Keel, A. Alexander and H. Reiser pers. obs.).

### Distribution

The Steller's jay is found in coniferous forests throughout the west from southeast Alaska to the mountains of central Mexico, and from the Pacific Coast to the Rocky Mountains (Martin et al. 1951).

### Habitat

In the Pacific Northwest, the Steller's jay is commonly associated with open old forest conditions (Egeline 1986). Steller's jays are present year-round in the San Francisco Mountains, Arizona. In the San Francisco Mountains, however, jays are more abundant in old-growth ponderosa pine during the winter (8400-8500 feet elevation), but are more abundant in mixed-pine forests (8800-9500 feet) during the rest of the year (Coons 1984). In the San Francisco Mountains, Steller's jays also occur in mixed forests of Douglas-fir and limber pine interspersed with stands of quaking aspen (Haldeman 1968). This corvid is also common in ponderosa pine, Douglas-fir, and spruce-fir forests between 7500-8500 feet in the mountains of east-central Arizona (Franzreb and Ohmart 1978). In the mountains of southeastern Arizona, Steller's jays tend to occupy forests above 6000 feet, which is the lower elevational limit of ponderosa pine forests (Brown and Brown 1985).

In the Southwest, Steller's jays occur in ponderosa pine stringers that extend into piñon-juniper woodlands; the ponderosa pine as well as the adjacent woodlands are used (Reiser pers. obs.). Piñon-juniper woodlands are heavily used during fall when this corvid harvests piñon pine seeds (Vander Wall and Balda 1983).

### Food

Although the Steller's jay is a food generalists, during spring over 75% of its diet consists of insects. In a mixed-species forest dominated by ponderosa pine in California, 93% of food items were Coleoptera, of which 80% were Dyslobus spp. (Otvos and Stark 1985). Other insect foods included grasshoppers, wasps and other arthropods (Martin et al. 1951, Brown 1974). Summer diets were 50% animal and 50% plant foods, while fall and winter diets ranged from 70 to 90% plant material (nuts, acorns, fruits, berries, but primarily seeds of piñon, southwestern white pine, whitebark pine, and limber pine) (Martin et al. 1951, Hagar 1960, Brown 1974, Vander Wall and Balda 1983). The Steller's jay caches pine seeds during the fall to augment its winter diet. Unlike other members of the corvid family (Clark's nutcracker, piñon jay), the Steller's jay usually does not undergo eruptive movements when local pine crops fail (Vander Wall and Balda 1983).

### Special Habitat Needs

Steller's jays forage in a variety of habitats. However, because of the jay's reliance on pine seeds during fall and winter, forests containing trees that produce large and predictable cone crops are required. Piñon pine trees do not begin producing large quantities of seed until 75 to 100 years of age, after which they will continue to produce abundant seeds for several centuries (Ronco 1990). Western white pine produces regular cone crops after 70 years of age (Graham 1990).

On an open, lightly harvested ponderosa pine site (8,000 feet elevation) in north-central Arizona, the number of Steller's jays ranged from 14 to 23 individuals per 100 acres during summer (Coons 1984). However, the number of breeding jays in an open, old-growth ponderosa pine forest in northern Arizona had only 1.0 to 2.8 pairs per 100 acres (Siegel 1989). With the exception of clearcuts, Szaro and Balda (1982) noted that Steller's jays were found throughout ponderosa pine forests.

### Home Range

Among North American corvids, the Steller's jay is intermediate on a continuum between species that defend classic territories (regular spacing of nests) and species that nest colonially. Steller's jays maintained "areas of dominance" around their nests of 0.2 to 0.9 acre, and these areas were non-overlapping. Nevertheless, adjacent home ranges (2.1 to 3.4 acres) overlapped extensively (Brown 1963, Brown 1974).

Additionally, Steller's jays flew up to 2 miles to forage on seasonally abundant foods (pine seeds, acorns, berries). Steller's jays, like many other corvids, spend fall collecting and caching pine seeds and acorns. Piñon pine seeds were often carried from the piñon-juniper woodlands to the jay's breeding territories, which were in ponderosa pine and mixed-species forests (Vander Wall and Balda 1981, Vander Wall and Balda 1983).

### Population

Studies show that the abundance of nesting Steller's jays is not associated with forest type or levels of tree harvesting. For example, in unlogged mixed-species forests in north-central and east-central Arizona, densities of breeding jays ranged from 10 to 25.6 pairs per 100 acres. Densities at higher elevations in unlogged mixed-species forests were lower (5 to 13 pairs per 100 acres) (Haldeman 1968, Franzreb 1977, Coons 1984). Similar breeding densities were found in unlogged ponderosa pine and mixed-pine forests (ponderosa, limber and southwestern white pine) (1.1 to 23 breeding pairs per 100 acres) (Haldeman

1968, Szaro and Balda 1979b, Coons 1984, Siegel 1989).

Individual tree removal in mixed-species forests appeared to have no effect on breeding populations of Steller's jay in east-central Arizona (average 20.7 pairs per 100 acres) (Franzreb 1977). In ponderosa pine stands in northern Arizona, densities of jays ranged from 0 (in clearcut areas) to 7.5 pairs per 100 acres (in unharvested areas) (Szaro and Balda 1979b, Siegel 1989). Densities of jays on the North Kaibab Plateau were lower in dense old-growth ponderosa pine (1.4 pairs per 100 acres) than in areas that were thinned but whose residual stands contained large trees (1.9 pairs per 100 acres) (Siegel 1989).

**Management Effects**

Some harvesting practices, such as thinning and partial overstory removal, when compared to control plots had little or no effects on the abundance of Steller's jays. Clearcuts and shelterwood cuts (few residual large trees), however, resulted in large declines of jay populations (Kilgore 1971, Franzreb and Ohmart 1978, Szaro and Balda 1979a, Mannan and Meslow 1984).

Abundant and well distributed seed-producing trees of oak, and limber, southwestern white, and piñon pines, are important to the Steller's jay.

**Habitat Management Recommendations**

√ **Coniferous forest generalists**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6

√ **Nesting**
- VSS 4, VSS 5, and VSS 6 have highest breeding densities

√ **Foraging**
- VSS 1, VSS 2, VSS 3, VSS 4, VSS 5, and VSS 6
- Abundant cone- and mast-producing trees are important for summer and winter foods
- During fall, large piñon trees are an important source of food

√ **Other important habitat attributes**
- Downed logs and woody debris are important as habitats for insect food

## Tassel-Eared Squirrel

*(Sciurus aberti)*

(Abert's Squirrel, Kaibab Squirrel)

The tassel-eared squirrel is a relatively large tree squirrel (total length=19-21 inches, weight=1.5-2 pounds). Its body size and wide distribution in ponderosa pine forests in the Interior West make it an important prey of the goshawk. This squirrel made up 5.2% of diets of nesting goshawks on the North Kaibab Plateau (Mannan and Boal 1990), and 8.6% of 105 prey remains that were collected at 8 goshawk nests in the Jemez Mountains of New Mexico (Kennedy 1991). Because of their large size, the contribution of this squirrel to the above diets exceeded 10% of the total biomass consumed.

**Distribution**

The tassel-eared squirrel is a forest-dwelling mammal that ranges from southern Wyoming into Utah, Colorado, Arizona, and New Mexico (McKee 1941, Davis and Brown 1989).

**Habitat**

Tassel-eared squirrels are primarily restricted to ponderosa pine-dominated forests, although they are occasionally observed in piñon pine woodlands, Douglas-fir, and spruce-fir forests (Rassmussen 1941, Keith 1965, Patten and Green 1970, Patten 1975, Pederson et al. 1976, J. Hall 1981, Brown 1984, Pederson and Welch 1985, Hoffmeister 1986, Davis and Brown 1989).

**Food**

Food of the tassel-eared squirrel consists almost exclusively of items produced by ponderosa pine or fungi symbiotic with it (J. Hall 1981). Fungi are a major food item during summer and fall (Stephenson 1974, J. Hall 1981, States et al. 1988); in Arizona up to 98% of the diet is hypogeous fungi (Maser et al. 1978). The occurrence of fungi in the habitat of this squirrel is correlated with canopy cover and summer rains (States 1985, Pederson et al. 1987).

Apical buds and staminate cones of ponderosa pine are major food items during the winter and early summer, respectively (Keith 1965, Stephenson 1974, J. Hall 1981). Seeds of ovulate cones are a nutritious food source, but cone availability varies from year to year (J. Hall 1981). In contrast, phloem (cortical tissue of subterminal twigs), a dietary staple of tassel-eared squirrels, is always available (J. Hall 1981, Farentinos et al. 1981). Due to its low nutritional value, diets dominated by inner bark reduce squirrel survival during adverse weather (Patton 1974). In fact, several authors (Kenward 1983, States et al. 1988) have demonstrated a loss of body mass after squirrels switch from fungi to inner bark during winter.

In ponderosa pine stands with high densities of Gambel oak, acorns can comprise up to 40% of the squirrel's diet during fall (Stephenson 1974). In areas where oaks produce abundant acorn crops, squirrel densities may be higher than in areas without oak (Reiser pers. obs.). Also, cavities in large

diameter oaks are sometimes used for nesting (Vahle pers. comm.).

**Special Habitat Needs**

Squirrels show strong preferences for large trees for feeding and nesting (Keith 1965, Pederson et al. 1976, J. Hall 1981, Farentinos et al. 1981). For example, Patton and Green (1970) found that 90% of 538 feeding trees were between 11 and 30 inches DBH (average=19 inches DBH). In Utah, diameter of feeding trees averaged 16.6 inches (Pederson et al. 1976). In Ffolliott and Patton's (1975) production rating criteria for feed-trees, 20-inch-DBH trees had the highest value. In a study of winter feeding, States et al. (1988) found that 82% of the mature "yellow pines," which constituted 10% of their study stand, were fed upon, while only 61% of all young "black-jacks" (>4 inches DBH) were fed upon. In another study, the squirrels preferred to forage in trees with a DBH range of 8-16 inches (Allred 1989). Trees 8 to 16 inches DBH comprised 77% of all feed-trees, but represented only 31% of trees available in the study stand.

Squirrels did not utilize trees smaller than 4 inches, probably because the smaller branches did not support their weight. In contrast, larger trees (8-28 inches) had more foliage and offered the squirrels more terminal shoots and ovulate cones (Allred 1989). However, Keith (1965) suggested that forests of "over mature" ponderosa pine make poor squirrel habitat, and Patton's (1984, Figure 2) description of "poor" habitat for squirrels supported this supposition. Ratcliff et al. (1975) found basal area of ponderosa pine was the most consistent variable associated with an index of squirrel density (r=0.88).

Tassel-eared squirrel nests tend to be in groups of trees with interlocking crowns, and nest trees are often larger than the average stand DBH (Rasmussen 1941, Patton 1984). In Utah, nest tree diameters averaged 18.9 inches (Pederson et al. 1976). In Ffolliott and Patton's (1975) production rating criteria for nest trees, 15 inch DBH trees had the highest value.

The "best" squirrel habitat appears to have some mature ponderosa pine trees with areas having canopy cover greater than 60% (Keith 1965, Patton and Green 1970, Patton 1975, Pederson et al. 1976, J. Hall 1981, Patton 1984). Mature trees often produce the most cones (Larson and Schubert 1970), and abundant truffle foods are often associated with young pine stands with canopy cover greater than 65% (States 1985).

**Home Range**

Estimates of squirrel home range size vary by sex and age of squirrel, season (winter versus summer), and method of study (observations of marked individuals versus radio-telemetry). Keith (1965) studied squirrel movements near Flagstaff, Arizona. Although he did not give the number of squirrels studied, average home range (summer and fall) was 18 acres; home range size decreased in winter. Farentinos (1972a, 1979) reported average summer ranges for 3 males at 7.4 acres in 1972 and 6.4 acres for 8 males in 1979; average winter range sizes for males was 18.4 acres and for females was 14.4 acres. The average summer range of 3 males in 1970 was 10.9 acres (J. Hall 1981); an additional male and female over a 2 year period had home ranges of 18 and 34.8 acres, respectively. In Utah, Pederson et al. (1976) radio-tracked squirrels during summer on home ranges before and after timber harvests. Seven home ranges in this study averaged 6.2 acres before harvest, and three of these home ranges averaged 32.0 acres after harvest. Patton et al. (1985) also studied home range size before and after tree harvest. Within his study, average home range sizes were considerably larger than reported elsewhere: 66.7 acres before harvest and 123 acres after harvests (1 female, 4 males).

**Population**

Available evidence suggests that populations of tassel-eared squirrels fluctuate both in the short- and long-term (Pearson 1950, Keith 1965, Farentinos 1972b, J. Hall 1981). Factors causing these fluctuations are not clear. Predation, immigration, quantity and quality of food, timber harvest, tree density and age, sylvatic plague, and winter snow cover have all been suggested (Stephenson and Brown 1980). Patton (1984) developed a table that associated 5 habitat capabilities (poor, fair, good, very good, optimum) (see his Fig. 2) to support a given density of squirrels over the long-term. Of the 3 "best" habitat classes, "good" supported 0.14 squirrel per acre, "very good" supported 0.37, and "optimum" supported 0.99.

**Management Effects**

Pederson et al. (1976) investigated the effects of timber harvests on the tassel-eared squirrel in the Abajo Mountains of southeastern Utah. Their recommendations for minimizing effects of harvest included: 1) retaining "a large percentage" of trees with DBH of 12 to 19 inches and tree heights of 45 to 75 feet, 2) preserving undisturbed areas within a 150-foot radius of nests for nesting and feeding activities, and 3) avoid piling and burning of logging slash. The latter destroys the litter layer and the microclimate necessary for fungi (Pederson et al. 1987).

Both Patton (1984) and States et al. (1988) agree that prime squirrel habitat is comprised of stands containing a combination of tree age-classes whose size, density and grouping provide all the necessary seasonal foods, cover, and nesting sites. It is especially important to maintain groups of trees with interlocking crowns--an important feature of tassel-eared squirrel nesting habitat.

Large-diameter feed-trees also should be dispersed through the squirrel's home range (Patton and Green 1970). Ponderosa pine trees between the ages of 60 and 160 years produce more viable seeds than younger or older trees. In California, trees with DBHs greater than 25 inches were the best seed producers. Ponderosa pines continue to produce abundant seed up to 350 years of age (Oliver and Ryker 1990).

**Habitat Management Recommendations**

√ **Ponderosa pine specialist**
- VSS 3, VSS 4, VSS 5, and VSS 6

√ **Nesting**
- VSS 4, VSS 5, and VSS 6
- Groups of trees with interlocking crowns are very important

√ **Foraging (considered a food specialist)**
- VSS 3, VSS 4, VSS 5, and VSS 6
- Large-diameter trees important for cone production
- Areas of shaded overstory (>60%) necessary for fungi production

√ **Other important habitat attributes**
- Snags may sometimes be used for nest trees (Vahle pers. comm.)
- Downed logs and woody debris are important for food substrate and cover
- Large openings are detrimental because they force squirrels, moving from tree to tree, to travel longer distances on the ground. Retention of trees with interlocking crowns may serve as travel ways and escape corridors.

## Williamson's Sapsucker
*(Sphyrapicus thyroideus)*

Williamson's sapsucker is a medium-sized woodpecker, 9 inches in length and averaging 1.7 ounces in weight (Dunning 1984). The Williamson's sapsucker is widely distributed in conifer forests throughout the western United States.

**Distribution**

In the Southwest, the Williamson's sapsucker is a common year-round resident in the mountainous terrain north of the Mogollon Rim. South of the Mogollon Rim, it may be rare or locally common in wooded areas and forests at middle and lower elevations (Hubbard 1978).

**Habitat**

In the Rocky Mountains, the Williamson's sapsucker prefers forests of mixed-species and hardwoods (mainly ponderosa pine, Douglas-fir, spruce-fir, and aspen) (Scott et al. 1977). During the breeding season, this species was not found in pure stands of ponderosa pine in northern Arizona (Szaro and Balda 1979b, 1986).

In the Huachuca Mountains in southeastern Arizona, Bock and Larson (1986) found Williamson's sapsuckers wintering in oak-juniper and pine-oak woodlands. Females and males wintered at different elevations and habitats; females occurred at a significantly lower elevation (5,558 feet versus 6,120 feet for males) and more frequently in oak and oak-juniper woodlands. Wintering males frequented the pine-oak woodlands (Bock and Larson 1986).

In southwestern Colorado, densities of Williamson's sapsuckers were not associated with the amount of aspen in mixed-species stands (Scott and Crouch 1988).

**Food**

Their diet is approximately 85% animal matter (mainly ants) and 15% plant matter (mainly tree cambium) (Scott et al. 1977). Analysis of 5 sapsucker stomachs in California showed that 2 species of Formicidae (*Camponotus* spp. and *Liometopum* spp.) made up 70% of total volume of food items. Coleoptera comprised an additional 17.5% of the total volume (Otvos and Stark 1985). Like the red-naped sapsucker, the Williamson's sapsucker feeds on sap throughout the year (Scott et al. 1977, Bock and Larson 1986). Bock and Larson (1986) also noted that female Williamson's sapsuckers were attracted to fruit crops in southeastern Arizona during winter, especially berries of madrone trees.

**Special Habitat Needs**

The choice of tree species for nesting varies between regions. In the Southwest, the species exhibited a preference for aspen (Scott et al. 1977). In Arizona, 17 of 21 nests were in aspen snags, 3 were in live aspens with dead tops, and 1 nest was in a live aspen (Scott et al. 1977). Along the Mogollon Rim, in central Arizona, Li and Martin (1991) found 97% of 36 nest sites in aspen snags which averaged 15 inches DBH. Average nest tree height was 40.7 feet. Nest plots (0.1 acre) contained an average of

2.4 aspen snags and 0.5 conifer snags (Li and Martin 1991). Of 57 nests in Colorado, 49 were in aspen, and many of the nest trees were infected with *Phellinus* fungus. In areas without suitable aspen nest trees, pines were used for nesting (Scott et al. 1977).

In three forest types in Colorado and Arizona (ponderosa pine, spruce-fir, and aspen), 21 of 26 nest cavities were in dead aspen, 1 was in a live aspen, and 4 were in unidentified dead-topped conifers (Scott et al. 1980). The average nest height was 39 feet (range 25-60 feet), average nest tree height was 62 feet (range 45-80 feet), and the average nest tree DBH was 16 inches (range 14-19 inches).

During winter in the Huachucua Mountains, Arizona, male and female Williamson's sapsuckers used different feeding trees. Females drilled for sap only in oak and madrone trees, whereas males drilled for sap predominantly in Chihauhau pine (81.8% of the sap trees), juniper (12.1%), and madrone (6.1%) (Bock and Larson 1986).

### Home Range

No home range information on the Williamson's sapsucker was found.

### Population

In unlogged old-growth ponderosa pine stands, Williamson's sapsucker breeding densities during a 2-year study were much higher in dense stands (5.7 pairs per 100 acres) compared to open stands (1.0 pairs per 100 acres). Densities in open old-growth stands were similar to selectively harvested old-growth stands (1.7 pairs per 100 acres) (Siegel 1989).

### Management Effects

Williamson's sapsucker populations remained stable or decreased in response to various logging practices (see Medin 1985, Table 3). Franzreb and Ohmart (1978) observed no differences in breeding densities in unlogged and logged areas with many large residual trees; densities averaged 3.9 pairs per 100 acres in this 2-year study.

Dense, mature forests are necessary for maintaining high densities of Williamson's sapsuckers (Siegel 1989). Due to the woodpecker's preference for quaking aspen nest trees, regenerating and maintaining aspen trees and stands is important. Development of oak and other deciduous trees in the understory for feed-trees may also benefit the Williamson's sapsucker.

### Habitat Management Recommendations

√ **Conifer forest generalists**
- VSS 4, VSS 5, and VSS 6
- Prefers dense stands of large trees, commonly mixed with quaking aspen

√ **Nesting**
- VSS 4, VSS 5, and VSS 6
- Aspen very important, particularly snags
- Nest trees 15-16 inches DBH and 62 feet high; nests average 39-41 feet high

√ **Foraging**
- VSS 4, VSS 5, and VSS 6
- Deciduous trees are important as a sap source
- Snags are important for insect prey

√ **Other important habitat attributes**
- Woody debris and downed logs are important foraging sites

# Appendix 4. Forest Health

Forest health is a function of many of biotic and abiotic factors. Insects and diseases are essential components of ecosystems. They provide food (insects, fungi, mistletoe), structural diversity (snags, downed logs, witches brooms), and nest sites (tree cavities, witches brooms) for many wildlife species. Fire suppression and logging of large trees has increased the frequency and intensity of epidemics of insects, root diseases, and dwarf mistletoes. These epidemics may prevent forests from reaching the older age classes by reducing growth and increasing tree mortality. The distribution of pest-affected or pest-susceptible stands should be considered in ecosystem management. Pest prevention and suppression strategies, or in some cases no action, should be utilized where appropriate to develop or maintain the desired forest conditions for goshawks and their prey.

## Dwarf Mistletoe

Dwarf mistletoes are common on conifers in the Southwest, and were identified as early as 1909 as one of the primary causes of mortality in ponderosa pine (Krauch 1926, Hawksworth and Weins 1972, Hawksworth and Geils 1989).

Dwarf mistletoes can alter the structure of forests by reducing growth and increasing tree mortality. Some of these changes, as well as the mistletoe plant itself, benefit wildlife (Bennetts 1991). Over time, however, mistletoe related changes can be detrimental to some goshawk prey species. For example, ponderosa pine stands severely infected with southwestern dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cryptopodum*) become stagnated and may not develop beyond the young forest stage (VSS 3) or may revert, because of high mortality, to the grass/forb/shrub stage (VSS 1).

Management recommendations for developing the desired forest conditions could include application of sanitation cuts and thinnings to reduce the detrimental effects of mistletoe in the post-fledging family areas and foraging areas. It makes good sense to select reserve trees that are free of or only lightly infected with dwarf mistletoe. Because mistletoe in large trees infects nearby understory trees, the understory might not reach the larger tree sizes. When necessary, infected trees can be killed and left standing by using intense basal fires, or by girdling (Conklin et al. 1991).

## Root Diseases

Fungal root diseases are common in many mixed-species and spruce-fir forests and in some pines in the Southwest (Wood 1983). Root diseases generally result in spreading centers of tree mortality, and all VSS are susceptible. Root diseases survive for decades in roots of stumps and snags, and can infect susceptible trees through root contact (Tkacz and Baker 1991). A recommended means for reducing root disease is to patch-cut disease centers and regenerate with resistant species (such as aspen) or ponderosa pine in mixed-species forests.

## Western Spruce Budworm

The western spruce budworm (*Choristoneura occidentalis*) is a widely distributed defoliator of mixed-species forests (Fellin and Dewey 1982). The spruce budworm can seriously affect the growth of young trees under a canopy. Affected trees display less vigorous growth, less foliage volume, and reduced cone production. Mature trees severely defoliated by budworm are predisposed to one or more species of tree-killing bark beetles.

The 2- to 4-acre openings and understory tree removal in mixed-species forests will make stands less susceptible to spruce budworm by allowing the regeneration of intolerant species such as ponderosa pine.

## Bark Beetles

Bark beetles, including engraver beetles (*Ips*), western pine beetle (*Dendroctonus brevicomis*), and mountain pine beetle (*D. ponderosae*) are periodically destructive to ponderosa pine in the Southwest. Spruce can be killed by spruce beetle (*D. rufipennis*) and Douglas-fir by Douglas-fir beetle (*D. pseudotsugae*). Bark beetles typically attack trees that are weakened by disease, overcrowding, defoliation, injury, or drought.

Thinning to reduce overcrowded conditions in young to old forests will reduce the susceptibility of trees to bark beetle epidemics.

# Appendix 5. Vegetation structural stage determination and management options

## Vegetation Structural Stage Determination

Vegetation structural stage (VSS) is a method of describing the growth stages of a stand of living trees. It is based on tree size (DBH) and total canopy cover. Overall, the VSS is dependent on the time it takes seedlings to become established and subsequent growth rates. Life expectancy of trees determines how long the oldest VSS can be maintained.

The time required for seedling establishment depends on:

1) cone crop frequencies ( Appendix 1, Table 2; page 49),
2) cone development,
3) seed production and distribution,
4) proper conditions for germination,
5) root system establishment, and
6) climatic conditions.

Seedling establishment varies from 10 years in ponderosa pine and mixed-species, to 20 years in spruce-fir after a canopy is opened and a forest floor is disturbed (Pearson 1950, Alexander 1974).

Tree diameter growth rates vary with:

1) initial diameter (starting point),
2) site productivity,
3) climatic conditions, and
4) level of management.

Ponderosa pine and mixed-species forest types have similar diameter growth rates, ranging from 0.2 to 2.5 inches per decade (Edminister et al. 1991) (Tables 1, 2). Spruce-fir forests usually have growth rates of 0.2 to 1.4 inches per decade (Table 3).

Pathological age of trees is the ages (years) when growth slows, significant decay develops, and mortality is high (Boyce 1961). Pathological age ranges from 10 years in Gambel oak to 250-450 years in Engelmann spruce (Table 4). However, individual trees can live much longer. In southwestern tree species, longevity ranges from 80 years in Gambel oak to >2000 years in limber pine (Table 4).

Site productivity and growth rates vary widely among forest types of the Southwest. The following site indices (SI) and basal areas per acre (BA/A) were chosen to typify each forest type (Tables 1, 2, 3):

1) Ponderosa pine: 70 SI, 60 BA/A
2) Mixed-species: 70 SI, 80 BA/A
3) Spruce-fir: 80 SI, 100 BA/A

## Management Options for Developing Vegetation Structural Stages

To develop the VSS proportions in goshawk home ranges many options are available. To achieve the desired forest conditions, some form of stand regeneration and tree density control (e.g., fire, insect and disease, understory thinning) is needed. Depending on management intensity (minimal, moderate, and intensive), the desired forest conditions can be obtained at varying rates (Tables 1, 2, 3, 5).

Intensity of forest treatments (thinning) influences the growth rates of trees . For example, because of competition, trees in unthinned ponderosa pine stands will not grow more than 11 inches in diameter over a 220 year period (Table 5). As a result, these unthinned stands will remain in a "young VSS" (DBH) even though they are 200 years old. Table 5, illustrates how trees and forests change (mean diameter, basal are, tree per acre, and VSS) through time under five different management intensities.

**Table 1. Estimated diameter growth rates, age in vegetation structural stage (VSS), accumulated age, and proportion of landscape in each VSS for the ponderosa pine forest cover type (site index = 70, basal area = 60 sq ft/ac).**

| Structural Stage (SS) and Diameter (inches) | Grass/Forb/Shrub 0-1 | Seedling-Sapling 1-5 | Young Forest 5-12 | Mid-aged Forest 12-18 | Mature Forest 18-24 | Old Forest 24+ |
|---|---|---|---|---|---|---|
| **Minimal Managment** | | | | | | |
| Diameter growth/decade (inches) | 0 | 1.33 | 1.52 | 1.48 | 1.3 | 1 |
| Years (Acc-yrs)[1] | 20 (20) | 30 (50) | 46 (96) | 41 (137) | 46 (183) | 50 (233) |
| Percent in SS | 9 | 13 | 20 | 17 | 20 | 21 |
| **Moderate Management** | | | | | | |
| Diameter growth/decade (inches) | 0 | 1.91 | 1.76 | 1.64 | 1.4 | 1.10 |
| Years (Acc-yrs) | 20 (20) | 21 (41) | 40 (81) | 37 (117) | 43 (160) | 45 (204) |
| Percent in SS | 10 | 10 | 19 | 17 | 20 | 24 |
| **Intensive Management** | | | | | | |
| Diameter growth/decade (inches) | 0 | 2.5 | 2 | 1.8 | 1.5 | 1.2 |
| Years (Acc-yrs) | 20 (20) | 16 (36) | 35 (71) | 33 (104) | 40 (144) | 50 (194) |
| Percent in SS | 10 | 8 | 18 | 17 | 21 | 26 |

[1] *Years (Acc-yrs): Number of years in structural stage (SS) and accumulated years (Acc-yrs).*

**Table 2. Estimated diameter growth rates, age in vegetation structural stage (VSS), accumulated age, and proportion of landscape in each VSS for the mixed-species forest cover type (site index = 70, basal area = 80 sq ft/ac).**

| Structural Stage (SS) and Diameter (inches) | Grass/Forb/Shrub 0-1 | Seedling-Sapling 1-5 | Young Forest 5-12 | Mid-aged Forest 12-18 | Mature Forest 18-24 | Old Forest 24+ |
|---|---|---|---|---|---|---|
| **Minimal Managment** | | | | | | |
| Diameter growth/decade (inches) | 0 | 0.82 | 1.02 | 1.20 | 1.1 | 1.03 |
| Years (Acc-yrs)[1] | 20 (20) | 49 (69) | 69 (137) | 50 (187) | 55 (242) | 44 (290) |
| Percent in SS | 7 | 17 | 24 | 17 | 19 | 17 |
| **Moderate Management** | | | | | | |
| Diameter growth/decade (inches) | 0 | 1.08 | 1.27 | 1.34 | 1.2 | 1.07 |
| Years (Acc-yrs) | 20 (20) | 37 (57) | 55 (112) | 45 (157) | 50 (207) | 47 (254) |
| Percent in SS | 8 | 15 | 22 | 18 | 20 | 18 |
| **Intensive Management** | | | | | | |
| Diameter growth/decade (inches) | 0 | 1.33 | 1.52 | 1.48 | 1.3 | 1 |
| Years (Acc-yrs) | 20 (20) | 30 (50) | 46 (96) | 41 (137) | 46 (183) | 50 (233) |
| Percent in SS | 9 | 13 | 20 | 17 | 20 | 21 |

[1] *Years (Acc-yrs): Number of years in structural stage (SS) and accumulated years (Acc-yrs).*

**Table 3. Estimated diameter growth rates, age in vegetation structural stage (VSS), accumulated age, and proportion of landscape in each VSS for the spruce-fir forest cover type (site index = 80, basal area = 100 sq ft/ac).**

| Structural Stage (SS) and Diameter (inches) | Grass/Forb/Shrub 0-1 | Seedling-Sapling 1-5 | Young Forest 5-12 | Mid-aged Forest 12-18 | Mature Forest 18-24 | Old Forest 24+ |
|---|---|---|---|---|---|---|
| **Minimal Managment** | | | | | | |
| Diameter growth/decade (inches) | 0 | 1.00 | 1.02 | 1.00 | 0.9 | 0.8 |
| Years (Acc-yrs)[1] | 20 (30) | 40 (70) | 69 (139) | 60 (199) | 67 (265) | 63 (328) |
| Percent in SS | 6 | 13 | 22 | 19 | 21 | 20 |
| **Moderate Management** | | | | | | |
| Diameter growth/decade (inches) | 0 | 1.75 | 1.51 | 1.40 | 1.2 | 0.9 |
| Years (Acc-yrs) | 30 (30) | 23 (53) | 49 (99) | 43 (142) | 50 (192) | 56 (248) |
| Percent in SS | 8 | 14 | 23 | 17 | 19 | 19 |
| **Intensive Management** | | | | | | |
| Diameter growth/decade (inches) | 0 | 2.5 | 2 | 1.8 | 1.5 | 1 |
| Years (Acc-yrs) | 20 (30) | 16 (46) | 35 (81) | 33 (114) | 40 (154) | 50 (204) |
| Percent in SS | 10 | 8 | 18 | 17 | 21 | 26 |

[1] *Years (Acc-yrs): Number of years in structural stage (SS) and accumulated years (Acc-yrs).*

**Table 4. The oldest and pathological ages (years) for several tree species in the Southwest.**

| Species | Oldest Age | Pathological Age (Age of Decline) | Reference |
|---|---|---|---|
| Ponderosa pine | 650 | 145-200 | Pearson 1950; White 1985; Covington and Mooore 1991 |
| Interior Douglas-fir | 400 | 150 | Hermann and Lavendar 1990 |
| Interior white fir | 300-360 | 150 | Markstrom and McElderry 1984; Hunter 1989 |
| Subalpine fir/Cork bark fir | 250 | 130 | Hunter 1989 |
| Engelmann spruce | 500-600 | 250-450 | Alexander and Shepperd 1990 |
| Blue spruce | > 600 | Unknown | Fechner 1990 |
| Eastern white pine | > 450 | 160-170 | Hunter 1989 |
| Southwestern white pine | Intermediate between eastern and western white pine | | |
| Western white pine | 500 | 300-400 | Graham 1990 |
| Limber pine | > 2000 | 200-300 | Preston 1961; Lynch 1990; Steele 1990 |
| Aspen | > 200 | 40-120 | Hunter 1989; Perala 1990 |
| Gambel oak | > 80 | 10 | Brotherson et al. 1983 |

**Table 5. Projected basal areas, trees per acre, and tree diameters from growth rates for unthinned and extensively thinned stands, Fort Valley Experimental Forest[1]**

| Treatment | | | Age[2] | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Thin from below, age | Leave basal area[3] | | 0 | 20 | 40 | 60 | 80 | 100 | 120 | 140 | 160 | 180 | 200 | 220 |
| No Treatments | | BA[4] | 0 | 2.7 | 114.2 | 175.7 | 199.9 | 212.9 | 213.7 | 214.9 | 218.5 | 223.7 | 216.3 | 212.2 |
| | | TPA | 500 | 500 | 500 | 493.7 | 476.1 | 463.0 | 439.9 | 416.3 | 402.0 | 397.0 | 373.3 | 346.5 |
| | | DBH | 0 | 1.0 | 6.5 | 8.1 | 8.8 | 9.2 | 9.4 | 9.7 | 10.0 | 10.2 | 10.3 | 10.6 |
| 40 | 40 | BA | 0 | 2.7 | 40.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 60 | 100 | | | | | | | | | | | | | |
| 80 | 100 | | | | | | | | | | | | | |
| 100 | 100 | TPA | 500 | 500 | 171.4 | 162.6 | 112.2 | 81.2 | 60.7 | 47.5 | 38.2 | 31.2 | 25.9 | 21.9 |
| 120 | 100 | | | | | | | | | | | | | |
| 140 | 100 | | | | | | | | | | | | | |
| 160 | 100 | | | | | | | | | | | | | |
| 180 | 100 | DBH | 0 | 1.0 | 6.5 | 10.6 | 12.8 | 15.0 | 17.4 | 19.7 | 21.9 | 24.3 | 26.6 | 28.9 |
| 200 | 100 | | | | | | | | | | | | | |
| 220 | 100 | | | | | | | | | | | | | |
| 40 | 30 | BA | 0 | 2.7 | 30.0 | 88.9 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| 60 | 100 | | | | | | | | | | | | | |
| 80 | 100 | | | | | | | | | | | | | |
| 100 | 100 | TPA | 500 | 500 | 128.0 | 128.0 | 96.8 | 71.6 | 54.5 | 43.1 | 35.0 | 28.8 | 24.1 | 20.5 |
| 120 | 100 | | | | | | | | | | | | | |
| 140 | 100 | | | | | | | | | | | | | |
| 160 | 100 | | | | | | | | | | | | | |
| 180 | 100 | DBH | 0 | 1.0 | 6.6 | 11.3 | 13.8 | 16.0 | 18.3 | 20.6 | 22.9 | 25.2 | 27.6 | 29.9 |
| 200 | 100 | | | | | | | | | | | | | |
| 220 | 100 | | | | | | | | | | | | | |
| 40 | 40 | BA | 0 | 2.7 | 40.0 | 50.0 | 60.0 | 79.9 | 79.0 | 89.8 | 100.0 | 110.0 | 120.0 | 130.0 |
| 60 | 50 | | | | | | | | | | | | | |
| 80 | 60 | | | | | | | | | | | | | |
| 100 | 70 | TPA | 500 | 500 | 171.4 | 79.0 | 50.6 | 38.1 | 31.3 | 27.4 | 24.9 | 23.3 | 22.2 | 21.6 |
| 120 | 80 | | | | | | | | | | | | | |
| 140 | 90 | | | | | | | | | | | | | |
| 160 | 100 | | | | | | | | | | | | | |
| 180 | 110 | DBH | 0 | 1.0 | 6.5 | 10.8 | 14.7 | 18.4 | 21.6 | 24.5 | 27.1 | 29.4 | 31.5 | 33.2 |
| 200 | 120 | | | | | | | | | | | | | |
| 220 | 130 | | | | | | | | | | | | | |
| 40 | 30 | BA | 0 | 2.7 | 30.0 | 80.0 | 80.0 | 80.0 | 79.7 | 80.0 | 80.0 | 80.0 | 80.0 | 80.0 |
| 60 | 80 | | | | | | | | | | | | | |
| 80 | 80 | | | | | | | | | | | | | |
| 100 | 80 | TPA | 500 | 500 | 128.0 | 114.1 | 72.9 | 50.4 | 36.7 | 28.0 | 22.0 | 17.7 | 14.5 | 21.1 |
| 120 | 80 | | | | | | | | | | | | | |
| 140 | 80 | | | | | | | | | | | | | |
| 160 | | | | | | | | | | | | | | |
| 180 | 80 | DBH | 0 | 1.0 | 6.6 | 11.3 | 14.2 | 17.1 | 20.0 | 22.9 | 25.8 | 28.8 | 31.8 | 34.8 |
| 200 | 80 | | | | | | | | | | | | | |
| 220 | 80 | | | | | | | | | | | | | |
| 40 | 30 | BA | 0 | 2.7 | 30.0 | 40.0 | 50.0 | 60.0 | 70.0 | 79.9 | 90.0 | 100.0 | 110.0 | 120.0 |
| 60 | 40 | | | | | | | | | | | | | |
| 80 | 50 | | | | | | | | | | | | | |
| 100 | 60 | TPA | 500 | 500 | 128.0 | 55.9 | 35.9 | 27.4 | 22.8 | 20.2 | 18.5 | 17.4 | 16.7 | 16.2 |
| 120 | 70 | | | | | | | | | | | | | |
| 140 | 80 | | | | | | | | | | | | | |
| 160 | 90 | | | | | | | | | | | | | |
| 180 | 100 | DBH | 0 | 1.0 | 6.6 | 11.4 | 16.0 | 20.0 | 23.7 | 27.0 | 29.9 | 32.5 | 34.8 | 36.8 |
| 200 | 110 | | | | | | | | | | | | | |
| 220 | 120 | | | | | | | | | | | | | |
| | VSS[5] | | 1 | 2 | 3 | | 4 | 5 | | | | 6 | | |

[1] *Ronco et al. 1985, Edminster et al. 1991.*
[2] *Conditions displayed in age class are a reflection for the end of each time period.*
[3] *Leave basal area: Basal area in square feet per acre after thinning.*
[4] *BA = Basal area/acre in square feet, TPA = trees/acre, DBH = Diameter Breast Height.*
[5] *VSS = Vegetation structural stage.*

# Appendix 6. The Scientific Committee

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# Appendix 7. Glossary of Terms

**Active nest**---A goshawk nest known to have contained an egg. A nest need not have successfully produced fledglings to be considered active.

**Active nest area**---A goshawk nest area containing an active nest.

**Adverse management activity**---Any activity that could adversely modify goshawk behavior, reproductive effort, or habitat.

**Alternate nest area**---Goshawk home ranges often contain two or more nest areas, only one of which will be active in a given year. All alternate nest areas are historical nest areas.

**Basal Area (BA)**---Basal area is the cross section at breast height (4.5 feet above ground level) or at the root crown of a tree or trees, usually expressed as square feet per acre. A measure of stand density.

**Breeding season**---The period from March 1 through September 30, which includes courtship, incubation, nestling, and fledgling-dependency periods.

**Blowdown**---Trees fallen over in a forest, usually exposing the root system.

**Brood**---Family of young in a nest. Brood size is the number of a young in nest.

**Canopy cover**---The percentage of a fixed area covered by the crowns of plants delimited by a vertical projection of the outermost perimeter of the spread of the foliage.

**Climax species**---Plant species occurring in a relatively stable community.

**Clumpiness**---The occurrence of trees in groups.

**Clutch**---Eggs in a nest. Clutch size is the number of eggs in a nest.

**Codominant tree**---Trees in the upper levels of a forest canopy, not quite as tall as the tallest trees. Together with the tallest trees (dominants) the codominants comprise the main canopy of the stand.

**Diameter at breast height (DBH)**---The outside bark diameter of a tree measured at breast height, 4.5 feet above the forest floor on the uphill side of the tree.

**Diameter root crown (DRC)**---The outside bark diameter of tree measured 2 inches above the break between root collar and the normal taper of the stem. Root collar is the region where root and stem merge. If the tree is multistemmed, the EDRC (equivalent diameter root crown) is calculated and the tree represents one tree.

**Dominant tree**---The tallest tree in a forest. Together with the codominants, the dominant trees comprise the main canopy of the stand.

**Downed log**---Fallen trees or portions of fallen trees.

**Epigeous**---Living or occurring near the soil surface.

**Estivation**---Lowering of the metabolic rate by animals in response to heat stress and/or drought.

**Failed nest**---An active nest in which the eggs or nestlings are lost (e.g., to predators, weather) or abandoned by the adult(s). No young fledged.

**Fire hazard fuels**---Leaves, needles, branches, and tree boles usually less than 3 inches in diameter that dry rapidly and burn easily.

**Fledgling**---A young bird that has left its nest but is unable to completely care for itself.

**Fledgling-dependency period**---The period beginning when the young leave the nest to when they are no longer dependent upon adults for food (about 30-60 days for goshawks).

**Foraging area**---Areas where prey are searched for, pursued by and captured by goshawks.

**Foraging habitat**---Forest lands and lands in openings within 100 feet of a forest edge. To be considered foraging habitat, a patch of forest must be 1 acre or larger. Roadside, streamside, and shelterbelt strips of trees must have a width at least 200 feet to be foraging habitat. Unimproved roads and trails, streams, and clearings in forest areas are classified as foraging habitat if they are less than 200 feet wide.

**Forest cover type**---Also referred to as forest type, cover type, or type. A descriptive classification of a forest based upon the tree species occupying an area (Eyre 1980). Forest cover types are named after predominant tree species. Predominance is determined by basal area, and the name is confined to one or two tree species (ponderosa pine, aspen, piñon-juniper, cottonwood-willow, Engelmann spruce-corkbark fir). The mixed-species conifer forest cover type is not a recognized forest cover type because it includes elements of several cover types (bristlecone pine, interior Douglas-fir, white fir, blue spruce, and limber pine).

**Forest lands**---Lands at least 10 percent stocked by trees of any size, including lands that formerly had such tree cover and that could be naturally or artificially regenerated.

**Fuel ladder**---Combustible materials that carry fires from the surface into the tree canopies. Important in the production of catastrophic fires.

**Grapple piling**---Piling of woody debris using a backhoe equipped with a grapple, or equipped with a bucket that is capable of opening and holding pieces of debris.

**Ground cover**---Cover produced by herbaceous (including grass and ferns) and shrubby plants.

**Group selection**---A regeneration method in the uneven-aged silvicultural system in which trees are removed in small groups. The purpose is to create a stand with 3 or more age classes.

**Historical nest**---A nest known to have been active in the past.

**Historical nest area**---A nest area containing one or more historical nests. An alternate nest area is an historical nest area. Historical nest areas are important because they may contain the habitat elements that attracted the birds originally.

**Home range**---The area that an animal habitually uses during nesting, resting, bathing, foraging, and roosting. Adjacent pairs of goshawks may have overlapping home ranges; the extent of overlap is unknown. A nesting home range contains nest areas (active and historical), the post-fledging family area, and the foraging area.

**Hypogeous**---Living or occurring below the soil surface.

**Improvement cut**---A cut done in either even- or uneven-aged stands where the residual trees are of pole size or larger.

**Interspersion of vegetative structural stage**---The degree of intermixing of vegetative structural stages. A low intermixing of the VSS would mean relatively large, contiguous areas of similar VSS; high intermixing would mean relatively small groups of all VSS.

**Intact group**---A group of trees delineated by mature and old trees, but containing all other trees (sizes and ages), shrubs, and ground cover.

**Intermediate tree**---A tree occupying a position below the crowns of dominant and codominant trees.

**Intermediate treatment**---The treatment (cutting) of trees from a stand between the time of regeneration and final harvest. Treatments include cleaning, thinning, liberation, improvement, salvage, and sanitation cuttings. Treatments other than removal (pruning, fertilization, prescribed fire) can also be called intermediate.

**Liberation treatment**---Removing the larger trees from a stand when the favored trees are saplings or smaller.

**Lopping and scattering**---A method to disperse logging debris, and to reduce it to a specific height (usually 2-3 feet) above the ground.

**Main canopy**---The dominants and codominants (overstory trees) in a stand.

**Mesic** habitats---Forests that are more moist and cool. Mesic habitats are usually located along drainages, at base of slopes, or on northerly exposures.

**Middens**---Food cache sites for red squirrels.

**Mixed-conifer**---Mixed-conifer forests are similar to mixed-species forest cover type. See **Forest cover type**.

**Multi-storied stand**---A forest stand having more than one horizontal layer of vegetation.

**Mycorrhizae**---Symbiotic fungi on plant roots that function in the absorption of water and nutrients from the soil.

**Natural opening**---An opening in the forest canopy not created by management activities.

**Nest**---A platform of sticks on which eggs are laid. Most goshawk nests are placed within the lower two-thirds of tree crowns, often against the trunk but occasionally on a limb up to 10 feet from the trunk.

**Nest area**---The nest tree and stand(s) surrounding the nest that contain prey handling areas, perches, and roosts. Nest areas are often on mesic sites (northerly facing slopes, along streams).

**Nest attempt**---An attempt to nest. Evidenced by courtship behavior in a nest area, new nest construction, reconstruction of an old nest, eggs, or nestlings.

**Nest stand**---The stand of trees that contains the nest tree.

**Nest tree**---The tree containing the nest.

**Nesting home range**---The home range of a pair of nesting goshawks. See **Home range**.

**Nesting season**---The period from the beginning of courtship behavior until the fledgling(s) are no longer dependent on adults for food.

**Nonreserved forest land**---Forest land not withdrawn from tree utilization through statute or administrative designation.

**Opening**---A break in the forest canopy that may be covered by grasses, forbs, shrubs, tree seedlings; or areas with sapling-sized trees and larger that are stocked less than 10 percent.

**Overstory**---The uppermost canopy layer of a forest.

**Permanent skid trail**---A pathway over which logs are removed. These trails are a permanent extension of the existing forest transportation system.

**Plucking post**---A perch used by a goshawk while removing feathers and fur from prey. Plucking posts can be in a tree, downed log, stump, or on the ground. Plucking posts are identified by feather and fur remains of prey.

**Post-fledging family area**---The area of concentrated use by the goshawk family after the young leave the nest.

**Protocol**---A formalized methodology to monitor resources.

**Regeneration method**---The silvicultural treatment of a stand that is employed to establish a new stand of trees.

**Replacement nest area**---Forest areas with physiographic characteristics and size similar to suitable goshawk nest areas. Replacement areas can have young to mature forests that can be developed into suitable nest areas.

**Reserved forest land**---Forest land withdrawn from tree utilization through statute or administrative designation.

**Reserved trees**---Old and mature trees retained in a management area forever. These trees are a recruitment source for snags and downed logs.

**Roost**---Tree or groups of trees used by birds or mammals for resting. A roost site consists of all other trees whose crowns overlap or interlock with the roost tree.

**Sanitation cut**---The removal of insect-attacked or diseased trees to maintain the health a stand.

**Scarification**---Soil layer disturbance(s) for the purpose of preparing seed beds and/or stimulating vegetative growth from root structures.

**Seral species**---Plant and animal species that will be replaced over time through forest succession.

**Sensitive species**---Plant and animal species identified by the Regional Forester for which population viability is a concern, as evidenced by: a) significant current or predicted downward trends in population numbers, b) significant current or predicted downward trends in habitats of these species (USDA Forest Service 1991, Manual 2600, Chapter 2670.50, pg. 12).

**Shelterwood**---A regeneration method in the even-aged silvicultural system that establishes new trees or seedlings under overstory trees. Overstory trees provide seed for regeneration, and shade and protection for seedlings. The overstory trees can be removed at one time (final removal) or gradually removed over a long period of time. Uniform shelterwood is applied over an entire stand. Irregular group shelterwood partitions the stand into groups.

**Silvicultural system**---A planned program of treatments during the life of a stand. There are two basic silvicultural systems, the even-aged and uneven-aged.

**Single-storied stand**---Stand of trees having a single canopy layer. See **Multi-storied stands**.

**Site index (SI)**---The capability of the soil or site to produce biomass (trees). Site index is expressed as the height a forest stand will achieve in a standard time-period. In southwestern forests, 100 years is the standard.

**Snag**---A standing dead tree.

**Stand**---An area of trees possessing sufficient uniformity (species composition, age, and physical features) to be distinguishable from trees on adjacent areas.

**Stringer**---A unique linear patch of forest, typically occurring along drainages.

**Successful nest**---A nest from which at least one young is fledged.

**Successional stage**---A recognizable stage that a plant community passes through during its development from seral to climax vegetation.

**Suitable habitat**---Habitat that is currently usable for nesting, roosting, and foraging. Forest habitat need not be occupied by goshawks to be considered suitable.

**Suitable nest area**---An area that includes all of the attributes of a nest area and is, therefore, usable for nesting by goshawks.

**Territory**---An exclusive area defended by a goshawks. An active nest is not an essential element of a territory.

**Thinning from below**---The removal of the slower growing trees in the lower portion of the canopy. This intermediate treatment leaves the taller, faster-growing trees at a selected density and spacing.

**Total basal area (BA)** ---The sum of the basal area of all trees in a stand or area expressed in square feet per acre.

**Total canopy cover**---The overall area covered by the crowns of plants delimited by a vertical projection of the outermost perimeter of the spread of the foliage in all vertical layers.

**Transitory range**---Areas capable of producing animal forage (shrubs, grasses, forbs) when trees are removed (fire, windthrow, timber harvesting)

from forested lands. Transitory range is temporary because of forest regrowth.

**Tree age**---Number of years a tree has lived. May be determined by counting annual growth rings.

**Understory**---Any layer of the forest canopy below the overstory; can consist of trees, shrubs and/or herbaceous layers.

**Unsuitable habitat**---Habitat that does not have the capability of attaining the characteristics of suitable habitat through standard, prescribed management treatments or natural processes.

**Vegetation Structural Stage (VSS)**---A generalized description of forest growth and aging stages based on the majority of the trees in the specific diameter distribution of the stand. For our purposes, 6 growth and aging stages were identified. If the majority of the stems of a stand (based on basal area) were in the 12-18 inch diameter class, the stand would be classified as a VSS 4.

The tree diameter range and description for the vegetation structural stages are:

| Stage | DBH Range (inches) | Description |
|---|---|---|
| 1 | 0-1 | grass-forb-shrub (opening) |
| 2 | 1-5 | seedling/sapling |
| 3 | 5-12 | young forest |
| 4 | 12-18 | mid-age forest |
| 5 | 18-24 | mature forest |
| 6 | 24+ | old forest |

The codes, percentages, and descriptions for canopy cover are as follows:

| Code | Percentage (%) | Description |
|---|---|---|
| A | 0-39 | open |
| B | 40-59 | moderately closed |
| C | 60+ | closed |

**Woody debris**---Any dead and downed woody material composed of branches and tree boles.