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Restructuring the Forest: Goshawks and the Restoration of Southwestern Ponderosa Pine

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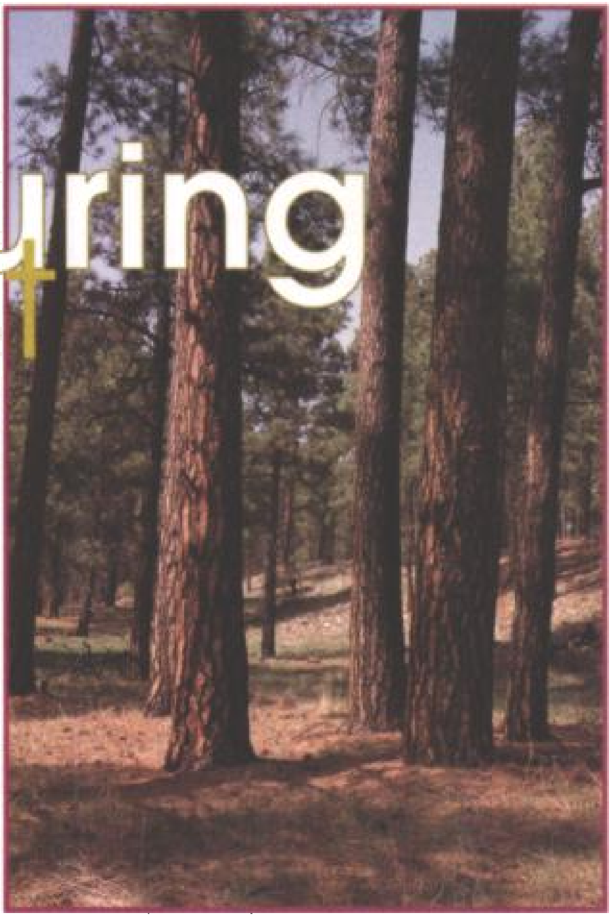

Frederick W. Smith

With adoption of the "goshawk guidelines" in 1996, the Southwest Region of the USDA Forest Service has embarked on an ambitious effort to restore southwestern ponderosa pine forests. The objective is a multiscale mosaic of age and structural classes under an uneven-aged silvicultural system intended to approximate the composition, structure, and landscape patterns of southwestern ponderosa pine forests before there were fundamental changes in natural disturbance regimes. Implementation will require innovative silvicultural approaches to create appropriate forest structures at various spatial levels well into the future.

By James N. Long and Frederick W. Smith

Throughout the West, the appropriateness of many traditional forest management practices is being reassessed, particularly as past practices have influenced wildlife species (Hansen et al. 1991). An important trend in wildlife habitat management is a shift away from a narrow focus on "featured species" toward a broader ecosystem perspective that calls for managing individual stands in context. The identification of a desired future condition at the landscape level requires an assessment of scale and pattern, such as the frequency and size of nature disturbances and the juxtaposition of the various stand types, structural stages, and age classes (Hansen et al. 1993).

Guidelines to manage habitat of northern goshawk *(Accipiter gentilis)* and its prey base (Reynolds et al. 1992, 1996) have been adopted as a management strategy for extensive areas of the Southwest Region of the USDA Forest Service. These guidelines are both a coarse-filter approach to habitat management and a forest restoration strategy. Widespread application of these guidelines will lead to substantial changes in the structure of vegetation of the ponderosa pine *(Pinus ponderosa* var. *scopulorum)* forest of the Southwest.

The Forest and Its Trees

Ponderosa pine dominates the forests of the Southwest. In addition to its huge geographic range, the species has great ecological diversity. On cooler, mesic sites at higher elevations, ponderosa pine is a successful pioneer after stand-replacing fires. On many such sites, it forms part of a mixed-conifer type, and the more shade-tolerant conifers increasingly dominate much

Above: **The retention of existing large trees, such as this clump of old-growth ponderosa pine, is one part of restoration of presettlement structure.**

Photos by Frederick W. Smith

Left: This even-aged stand of ponderosa pine is typical of many VSS 3 stands in the Southwest; high stand density limits individual tree growth and the spatial distribution of stems is very regular. *Right:* This VSS 3 stand has had a diameter limit thinning to reduce density (and thus increase growth of the residual trees) and to create the desired clumps.

of ponderosa pine's cool-moist environmental limits (Steele 1988). Successional displacement of ponderosa pine has been accelerated by the exclusion of fire and the selective removal of overstory pine.

Ponderosa pine is probably best adapted to hot, dry sites. Its climax status under these conditions, despite its shade intolerance, is likely because its potential competitors are less drought tolerant. The emerging view is that regeneration within the extensive southwestern ponderosa pine zone is a type of natural group selection with reserves. Thus, while a single cohort or age class may predominate within a group, a few older trees may contribute considerable age-class diversity.

The dry ponderosa pine zone has experienced profound changes at stand and landscape levels during the past 100 years. Alterations in natural fire regimes have resulted from domestic livestock grazing and active fire suppression. Selective logging (i.e., high grading) of large, old, yellow bark trees in some locations and clearcutting and diameter-limit cutting in others have greatly reduced age and size diversity in many stands. Interruption of the natural fire regime, changes in grazing pressure, and favorable weather and seed crops have resulted in dense regeneration. In the past two decades, an emphasis on even-aged management on national forest lands has resulted in further reductions in structural diversity.

The two most important changes in southwestern ponderosa pine forests are simplification in structure and increased density. Trees tend to be more uniformly distributed, with fewer canopy gaps and more even spacing within groups. Probably the most striking and pervasive change is increased density. This increase is both absolute (there are simply many more trees) and relative (the trees are crowded). Although some animal species benefit from increased stand density, many, particularly those dependent on large trees and snags, are disadvantaged (Dahms and Geils 1997). Because of increased amounts of fuel and increases in their vertical continuity, there is an increase in the destructive potential of wildfires (Covington and Moore 1994).

In the past decade intensive, interdisciplinary research has sought to characterize the composition, structure and functioning of the presettlement forest (Covington et al. 1997; Moore et al. 1999). In an adaptive management approach, initial characterization of the reference condition becomes a model for restoration, and insights gained from restoration activities help refine the reference condition. Stands targeted for restoration of presettlement structure are typically selected because they retain basic components of their original uneven-aged character (e.g., Covington and Moore 1994). The basic strategy for restoration under these circumstances is the retention of existing large, presettlement trees and the aggressive thinning of small, postsettlement trees. The strategy also includes retention of carefully selected small trees as eventual replacements for the large trees.

A bigger challenge is the extensive areas where the mature tree component has been harvested and conversion to second-growth management is well under way (Edminster and Olsen 1996). The emphasis here has been on even-aged management, including aggressive treatment of dwarf mistletoe infections and high volume production. This management strategy included light thinning under the assumption of a regional market for small roundwood. A primary objective was creating relatively even tree-size distributions and homogeneous spatial arrangements to maintain vigorous tree growth and stand volume production. In the 1980s this general management focus was formalized in the land and resource management plans for the various national forests in the Southwest. As a result, large areas of southwestern ponderosa pine are even-aged (Edminster and Olsen 1996).

The Goshawks and Their Prey

Goshawks hunt small birds and mammals as large as snowshoe hares. Habitat generalists, they nest and forage in all the montane and subalpine forest types in the region; a nesting pair will use all forest types and successional stages within their home range. The goshawk's "perch, search, and pounce" hunting style has important implications for forest structure at several scales. This, along with habitat needs of some of the goshawks' prey—e.g., fungi-eating tree squirrels—led to the recommendations for management of northern goshawk habitat in the Southwest (Reynolds et al. 1992, 1996).

The recommendations describe a "wildlife template" (Reynolds et al. 1996) that includes, for example, high-density clumps with interlocking crowns and low-density spaces between clumps. There is also explicit recognition of dynamic stand development and the need for a mixture of young to mature age classes. The desired future condition for southwestern ponderosa pine is thus a mosaic of age and structural classes that provide habitats and food chains for a broad spectrum of wildlife species, including goshawk prey species.

That landscape-scale mosaic has been referenced against historic forest conditions (Reynolds et al. 1996). Despite the apparent emphasis on a single species—the goshawks—this is a coarse-filter approach to habitat management because it attempts to account for this generalist's prey base and because it apparently corresponds fairly closely to conditions prior to fundamental changes in forest structure. An implicit assumption of this coarse-filter approach to land management is that it represents the best practical strategy for conserving a broad array of native species.

In June 1996, land and resource management plans for the national forests in Arizona and New Mexico were amended to incorporate the goshawk guidelines. Although the amendment will be in effect only until the forest plans are revised, it is probable that the guidelines will be incorporated into each of the new forest plans. Essentially, the goshawk guidelines apply wherever guidelines for the management of Mexican spotted owl habitat do not. In effect, the owl guidelines apply in the mixed-conifer type, and the goshawk guidelines apply in the ponderosa pine type. Depending on the outcome of the various plan revisions, the goshawk guidelines may affect management on more than half of the area where timber might be harvested on the national forests of the Southwest.

Table 1. Vegetation structural stages and their prescribed distribution by area and canopy closure under the goshawk guidelines.

Stage	dbh	Description	Proportion of total area	Minimum canopy closure
1	0–1 inches	Grasses, forbs, shrubs (opening)	10%	—
2	1–5	Seedling-sapling	10	—
3	5–12	Young forest	20	—
4	12–18	Midage forest	20	40%
5	18–24	Mature forest	20	40
6	24+	Old forest	20	40

Source: Reynolds et al. 1992.

Table 2. Structural hierarchy of spatial scales under the goshawk guidelines.

Clump 0.1 to 0.5 acres	A relatively small number of trees, mostly of similar age and size. When mature, trees within the clump have interlocking crowns. Each clump is somewhat isolated from adjacent clumps, so trees on the outside of a clump have full crowns, and those in the interior have short crowns.
Group 2 to 4 acres	A regeneration unit in a group selection system. Most stems are in a single age class, but some age and size diversity is desirable. There is a nonuniform distribution of clumps within the group, but most clumps within a group represent a single vegetation structural stage
Landscape 1,000 to 10,000 acres	The unit to which the silvicultural system is applied. The basis of regulation is a mosaic of groups representing a sustainable mix of structural stages from stages 1 to 6 (see *table 1*). This is the approximate size of goshawk home range.

Implementing the guidelines will change the spatial, age, and size class structure of the ponderosa pine forest landscape in ways as dramatic and pervasive as changes during the past century. We review ways in which foresters and wildlife biologists are attempting to implement the goshawk guidelines and discuss the silvicultural challenges.

The Devil in the Details

A goshawk pair's home range is about 6,000 acres. Less than 10 percent of this home range is to be managed as postfledgling family area. This habitat contains closed canopies that provide cover for fledgling goshawks as they develop their hunting skills. Within the 420 acres of the postfledgling family area, three 30-acre nest areas and three 30-acre replacement nest areas will be maintained. More than 90 percent of the home range is to be managed as foraging area. Silviculture is being applied to develop and maintain the desired vegetation mosaic within the postfledgling family area and the surrounding matrix of the home range. Regeneration methods, ranging from group selection with reserves to shelterwood with reserves, are used to regulate age and size class distributions at the landscape level. Thinning, both precommercial and commercial, and prescribed burning are used to create and maintain desired structure at the stand or group level.

The desired future condition is essentially a landscape-level composite of groups at various stages of structural development, ranging from new regeneration to old trees. The characterization of vegetation structural stage (VSS) is based on the predominant diameter distribution of trees in a stand, group, or clump *(table 1)*. For example, if a majority of trees are in the 12- to 18-inch range, the group is VSS 4. For the largest structural stages, the objective of interlocking crowns is expressed as minimum canopy closure guidelines. The dynamic nature of stand development is accounted for by guidance on the relative proportions, by area, of the various stages.

The guidelines incorporate three scales of spatial organization *(table 2)*, and operating at these multiple scales is critical to implementation. The broadest scale is a *landscape* of several thousand acres, corresponding to a home range. The landscape consists of many groups, typically 2 to 4 acres, irregular in shape, often long and narrow and no more than 200 feet across. A *group* consists of *clumps* of two to many closely spaced trees. Within-clump spacing is used to achieve the habitat objective of interlocking crowns. Ideally, clumps are irregularly arranged within the group and are interspersed between small openings and lower-density patches.

An important objective, and important departure from traditional practice, is the clumpy distribution of stems within a 2- to 4-acre group. Traditionally, silviculturists want a fairly uniform distribution of stems to maximize site occupancy and volume production. The goal here, however, is to create a fine-scale mosaic of high-density clumps (the interlocking crowns) with small open spaces and lower stem densities between the clumps. To achieve spatial heterogeneity within a group and maintain minimum canopy closure requirements over the entire group (i.e., averaged over the clumps and the open spaces), the actual densities within clumps will be high.

Efforts to reorganize the spatial arrangement of an area at the group level are most immediately successful where there is already a patchy arrangement of some VSS 5 and 6 groups with large trees. Treatments in these cases include thinning small trees under and around large trees. Such thinning releases the large trees, helps define the large-tree clumps and group boundaries, and restores open spaces between clumps.

It is much more challenging to reorganize spatial arrangement at the group level in areas dominated by a matrix of VSS 3 and 4 trees—the poles and small sawlogs. In such places, the area of young, VSS 1 and 2 groups is in deficit. Restructuring such a landscape and achieving the desired mix of vegetation stages requires first defining, on the ground, a group structure in the matrix and then converting some VSS 3 and 4 groups to VSS 1. These are difficult tasks.

Converting groups of VSS 3 and 4 trees, often with limited commercial return, is the key to transforming large forest areas toward the desired condition. Marking regeneration groups in an otherwise uniform pole timber matrix is labor intensive. It is difficult to define and mark groups of the right size and spacing in the absence of existing structure. One innovative approach involves flagging points on a grid, then marking 120- by 330-foot openings at each grid location. Within each regeneration opening, some large trees are marked for retention. These reserve trees are left primarily as seed sources but will likely be retained beyond the regeneration period to enhance within-group structural diversity. This procedure appears to be a cost-effective beginning to establishing the arrangement of groups. Further refinement of the approach may involve increasing spatial variability. For example, random variation might be used at each grid location to somewhat reduce uniformity in the size and spatial distribution of the regeneration group.

Foresters have traditionally focused on making irregular stands more uniform to promote efficient use of growing space. However, to create the clumpy spatial arrangement desired under the guidelines, innovative thinning approaches are needed, especially in pole-size stands, where it is cost-prohibitive to mark individual trees. One promising treatment is diameter-limit thinning from below. Based on a prethinning cruise, an appropriate diameter limit is assigned to achieve the desired residual diameter distribution. This technique has several advantages: It is cost-effective and it results in clump formation in the thinned stand unless the prethinning stand is unusually homogeneous. Drawbacks are that the small trees are completely removed and that open spaces between clumps are not always created. A second thinning pass through the stand to remove some individual trees, greater than the assigned diameter limit, will enhance the effect.

Although 2- to 4-acre openings are larger than is traditional in group selection systems (Matthews 1989), the approach nevertheless represents a group selection with reserves system that relies on area control for regulation. The proportion of the total landscape occupied by each of the VSS classes *(table 1)* defines the overall management context. Growth of trees in each VSS must occur at a rate that will maintain a roughly stable proportion of vegetation stages distributed across the landscape. For example, as groups of VSS 4 trees grow to VSS 5, the trees in a similar area of VSS 3 groups must grow to VSS 4.

In addition to the deficit in younger age classes of VSS 1 and 2, the typical southwestern ponderosa pine forest lacks the mature structural stages of VSS 5 and 6. Thus, implementation of the guidelines requires silvicultural strategies not only for converting some excess groups of VSS 3 and 4 to regeneration, but also for quickly promoting others into VSS 5 and 6.

The rate of transition of one stage to another is, of course, a function of site quality. It is also very much a function of relative density. Each vegetation stage must therefore be managed within a range of densities that will result in diameter growth that will, in turn, maintain a sustainable transition among structural stages. Density management prescriptions for groups will have to be tested across sites to verify sustainability.

Silvicultural Challenges

Canopy closure requirements in the guidelines are a challenge. There are no widely accepted translations between easily measured and projected stand variables, like basal area or stand density index, and canopy closure. Having to measure canopy closure directly in each group during treatment is unnecessarily time consuming. Allometric relations to estimate canopy closure as a function of tree dbh, stand density index, and stand basal area will be necessary.

Another concern is the crown closure requirements for the VSS 4, 5, and 6 groups. VSS 5 and 6 are deficit in most stands; VSS 3 and 4 groups are typically in excess. Achieving the desired balance of structural stages therefore means growing VSS 3 and 4 trees to VSS 5 and eventually VSS 6. For southwestern ponderosa pine, the objective of interlocking crowns necessitates high relative density, which corresponds to slow individual tree growth; this means a slow transition from VSS 4 to VSS 5.

Implementation of the guidelines requires solutions to that potential bottleneck. Where VSS 4 groups represent more than 20 percent of an area, it seems reasonable that the canopy closure guideline be relaxed so that thinning can promote more rapid development of VSS 5 trees. Another strategy would be to manage VSS 3 groups for rapid growth with an aggressive thinning regime. Under this strategy, excess VSS 3 groups would be thinned to a low relative density, promoting rapid individual tree growth so as to create VSS 5 trees in the shortest possible time. The density management regime would be designed so that groups would achieve 40 percent canopy closure and the desired VSS 5 diameters at about the same time.

Yet another concern is bark beetle outbreaks. Although bark beetles have not been a significant regional problem in the past, the poles that currently dominate large portions of the landscape are getting bigger, and relative densities are increasing. Similar conditions have often been associated with major outbreaks in other pine forests. It is not clear how implementation of the guidelines will affect the risk of bark beetle outbreak. The creation of a fine-grained mosaic of age classes and structural stages should reduce the risk of outbreaks. On the other hand, the high relative densities necessary to meet the canopy closure objectives and the development of VSS 5 and VSS 6 groups, with even greater average diameters, will certainly increase some elements of risk. Although the interactions of hazard ratings with density and structure are not well understood in uneven-aged forests (Edminster and Olsen 1996), the structures resulting from implementation of the goshawk guidelines could create serious problems if bark beetle behavior is the same as in even-aged stands (Olsen et al. 1996).

The use of silviculture as a tool for creating and maintaining structures at multiple scales in southwestern ponderosa pine is a relatively new undertaking. With any major shift in management direction, a comprehensive monitoring program to assess results and guide refinements in future activities will be a key to accomplishing the objectives (Edminster and Olsen 1996).


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Edminster and Olsen (1996) doubt that society can or will subsidize these operations over landscape scales and in perpetuity. This means that successful implementation will depend on either market demand for small-diameter material or offsetting the expense of treating small trees with returns from harvesting larger trees.

In some cases thinning and regeneration operations in small timber may require thinning to waste. Under current management direction, required fuels treatment makes thinning to waste cost prohibitive. Although slash represents a short-term hazard, a long-term reduction in risk is associated with reducing density and ladder fuels. Accepting some increased short-term risk may be the only practical way to achieve the desired future condition, including a long-term reduction in the potential for catastrophic fires.

Traditional definitions of stands, stand boundaries, and inventory and monitoring procedures may not be efficient and cost effective given the scale of management. Fairly large landscapes—more than 1,000 acres—rather than 10- to 100-acre stands are the scale at which a fairly uniform silvicultural prescription will be applied. The landscape may also be a much better unit for inventory and monitoring than the current stand-based approach. The amount of landscape covered by groups in different structural stages is an important statistic in designing and implementing prescriptions to accomplish the objectives. We suspect that considerable efficiencies will result from making multistand strata the basis for most activities, including inventory, prescription development, sale administration, and monitoring.

Conclusions

With adoption of the goshawk guidelines in 1996, the Forest Service embarked on a truly ambitious restoration effort. The guidelines mandate nothing short of fundamentally restructuring southwestern ponderosa pine forests at a regional scale. The underlying management strategy, while superficially another example of a narrow, single-species focus, is in fact a coarse filter approach that includes a mosaic of age and structural classes intended to provide habitats and food chains for a broad spectrum of wildlife species, including goshawk prey species. This landscape-scale mosaic will be created and maintained under an uneven-aged silvicultural system intended to approximate the composition, structure, and landscape patterns existing in southwestern ponderosa pine forests before fundamental changes in natural disturbance regimes and forest structure. A basic assumption is that implementation of the guidelines is the best practical strategy for the conservation of a broad array of native species.

There are, of course, considerable challenges to successful implementation. Not the least of these is that some national forest stakeholders are fundamentally opposed to harvesting on federal lands and will not agree that the means are acceptable, even if the ends are desirable. The silvicultural and managerial challenges and uncertainties are not trivial, but with the support of line officers, committed foresters and wildlife biologists can work these out.

The guidelines are based on a conceptual framework and a desired future condition with multiple scales. Do we know that this is the appropriate framework and that the details of the reference condition are correct and sustainable? The honest answer is, of course, that none of this is certain. What is sure, however, is that past management has fundamentally altered forest structure on a regional scale and that restoration efforts will provide many insights into the functioning of this extremely important forest.

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