Working Papers in Southwestern Ponderosa Pine Forest Restoration

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The Stand Treatment Impacts on Forest Health (STIFH) Model

April 2005

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Ecological restoration seeks to heal degraded ecosystems by reestablishing native species, structural characteristics, and ecological processes. The Society for Ecological Restoration International defines restoration as "an intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability. . . . Restoration attempts to return an ecosystem to its historic trajectory" (Society for Ecological Restoration International 2004).

In the southwestern United States, most ponderosa pine forests have been degraded during the last 150 years; many areas are now dominated by dense thickets of small trees and have lost their once diverse understory. Forests in this condition are highly susceptible to damaging, stand-replacing fires and increased insect and disease epidemics. Restoration of these forests centers on reintroducing frequent, low-intensity surface fires—often after first thinning dense stands—and reestablishing productive understory plant communities. The Ecological Restoration Institute at Northern Arizona University is a pioneer in researching, implementing, and monitoring ecological restoration of southwestern ponderosa pine forests. By allowing natural processes such as fire to resume self-sustaining patterns, we hope to reestablish healthy forests that provide ecosystem services, wildlife habitat, and recreational opportunities.

Every restoration project needs to be site specific, but the detailed experience of field practitioners may help guide practitioners elsewhere. The Working Papers series presents findings and management recommendations from research and observations by the ERI and its partner organizations.

This publication would not have been possible without significant funding from the USDA Forest Service. The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the opinions or policies of the U.S. Government. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government.

1: Restoring the Uinkaret Mountains: Operational Lessons and Adaptive Management Practices

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Treatment Options

This Working Paper is one of a series that describes the planning and implementation of restoration treatments in southwestern ponderosa pine forests. It presents the best scientifically based knowledge currently available about treatment types and effects. But this Working Paper is not a prescription. Restoration decisions need to be made with close attention to local conditions—there is no "one size fits all" approach, and specific prescriptions must be determined according to project objectives. Use this publication as an aid in making informed decisions about how to restore more natural conditions, and greater health, to the southwestern ponderosa pine forests.

Treatment Type

Stand Treatment Impacts on Forest Health (STIFH) restoration treatments—multi-aged group selection prescription.

Treatment Objectives

The STIFH restoration treatments seek to promote forest sustainability by creating a balanced distribution of tree size classes in a clumpy spatial arrangement that emulates historic forest conditions. This involves focused thinning in diameter classes that have an over-abundance of trees—usually the smaller to mid-sized diameter classes. The thinning treatment is primarily designed to reduce the continuity of surface and ladder fuels; however, it strives for a broad ecosystem response, including positive changes in understory cover, wildlife habitat, and hydrological functions. It aims to create aesthetically pleasing forests in which old yellow-barked pines, larger blackjack pines, and oaks become very visible within and among clumps.

Steps

Overstory Trees:

- The diameter at breast height (dbh) of all trees in the treatment area is systematically estimated. These data are used to create a bar chart that illustrates the frequency distribution of the trees in each size class (Figure 1). Most contemporary ponderosa pine forests have a high abundance of small to mid-sized diameter trees and few large-diameter trees.
- A target basal area is chosen. Because forests are continually growing, the target should be chosen with future conditions in mind. If a forest is treated to a basal area of 50 ft^2/acre today it will likely grow to 80 ft^2/acre within 20 years. Looking at historical data for the treatment site is invaluable in determining an appropriate target basal area; read more about this in *Working Paper 7: Establishing Reference Conditions for Southwestern Ponderosa Pine Forests*. At the Fisher West site, a target basal area of 50 ft^2/acre was chosen because it combined fire risk reduction with a low likelihood of social or political controversy.
- The target basal area is converted into a desired size distribution across diameter classes. This requires choosing the optimal number of trees to be left standing in each size class after thinning. This number is known as the *target value*. Target values are site-specific and depend on a stand's starting condition and the target basal area after treatment. Distributions should slope down to the right to account for tree mortality and the natural slowing of diameter growth with increased size.

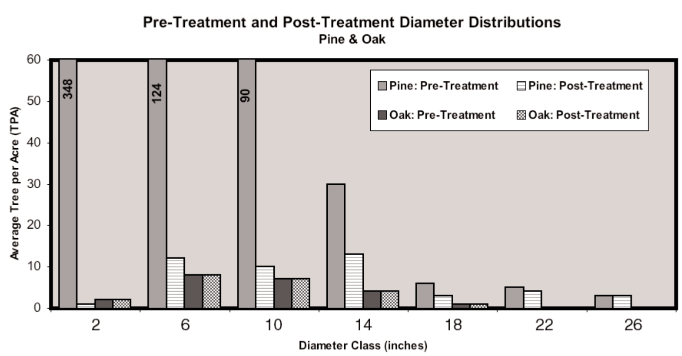

Figure 1. Pre- and post-treatment diameter class distributions of pine and oak trees at the STIFH Fisher West plot; note that no thinning of oaks was done.

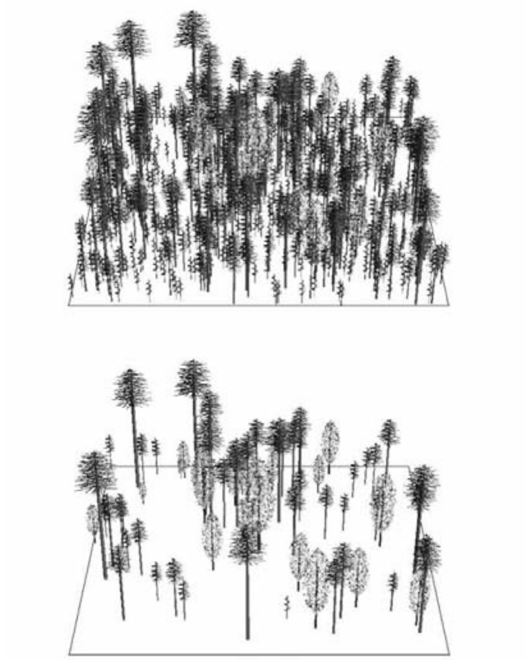

Figure 2. Simulation, created using the USDA Forest Service Stand Visualization System, showing pre- and post-treatment tree densities at a representative acre in the Fisher West stand. Trees with rounded crowns are oaks. Because the spatial distribution shown represents average stand density rather than a specific stand, tree locations are approximate.

- The target value is used to determine how many trees to remove from each size class. Putting the frequency data into a bar graph will help make it obvious where thinning efforts should be focused. At the Fisher West plots, for example, far more trees were removed from the 2-inch diameter class than from any other size class.
- Spatial patterns are evaluated in determining which trees to remove. At the Centennial Forest, markers used presettlement spatial patterns—evidenced by stumps, logs, and old trees—as a reference in selecting which trees to remove and which to retain. Trees retained were generally clumped together, with openings of variable size between groups of variable size (Figure 2). Every prescription is site specific, but creating groups of trees that provide cover and thermal protection for wildlife is an important component of this prescription, as is creating open meadows for wildlife foraging.
- Extra trees in middle-sized diameter classes are left in order to meet the target basal area if there are few large-diameter trees. Many southwestern ponderosa pine forest stands have few, if any, large-diameter trees. If too few are present to reach the ideal target value, more trees can be left in smaller size classes to meet the target basal area. At the Fisher West plot, for example, extra trees were left in the 10-inch class to compensate for the scarcity of large trees. The trees were left in tight clumps to better emulate single large trees.

Fire:
Slash from the Centennial Forest thinning treatment was collected into large piles to be burned during the cooler winter months. Although effective, burning slash may harm local soil health and stimulate the growth of invasive species (Korb and Springer 2003). There will also be a broadcast burn one to two years after the slash burning, and plans call for future maintenance burns as fuel loads accumulate.

Understory Vegetation:
Treatment of understory vegetation at the Centennial Forest STIFH restoration sites was minimal. Squirreltail grass (*Elymus elymoides*) was broadcast seeded only in highly disturbed places; no other seeding has taken place or is planned. Deciding on whether to seed or to allow natural regeneration of understory cover depends on several factors, including densities of existing vegetation at the site, richness of the seed bank, soil conditions, and management history (Springer et al. 2001). In either case it is important to control invasive plant species. Read how to do this in *Working Paper 8: Controlling Invasive Plant Species as Part of Restoration Treatments.*

Grazing :
Intermittent grazing of cattle and sheep is planned for the Centennial Forest STIFH restoration sites, but several 1/10th-acre areas have been fenced and protected from grazing. Comparing the fenced and unenclosed areas will allow an assessment of the effects of grazing on understory vegetation.

Where It's Been Done

This treatment has been implemented at the Centennial Forest near Flagstaff, where many experimental restoration treatments are currently being tested (Northern Arizona University 2002).

Results

The initial Centennial Forest STIFH restoration treatments were implemented in 2003 and 2004. Since these treatments are very new, there is little site-specific data indicating how they have influenced specific ecosystem components. However, this prescription is based upon similar prescriptions whose effects have been assessed. For example, the number and placement of remaining trees in the STIFH restoration treatments is similar to that in the presettlement thinning prescription with a 1.5/3 replacement rate (see *Working Paper 9: Restoration of Ponderosa Pine Forests to Presettlement Conditions*). The main difference between these two treatments is the criteria by which trees are selected for removal. The STIFH treatment retains more trees in smaller diameter classes.

Overstory Trees:
It is expected that trees remaining at the STIFH restoration sites will be healthier following treatment, as has been the case at a nearby site treated with similar thinning intensity (Wallin et al. 2004). There will be less competition for water and soil nutrients and a reduced risk of stand-replacing wildfire. Post-treatment stand structure reflects but does not precisely replicate presettlement conditions, with variably sized groups of ponderosa pine distributed throughout the treatment area.

Understory Vegetation:
Preliminary monitoring results show an increase in grasses and forbs at the Centennial Forest treatment sites; however, it is too early to draw definitive conclusions from these data. Monitoring is projected to continue seasonally for several years. Results from similar treatments have shown a positive reaction of understory vegetation to intensive tree thinning (Abella and Covington 2004; Huffman and Moore 2004; Moore and Deiter 1992). This includes increased plant diversity and richness, as well as more plant cover within open areas (Korb et al. 2003). However, invasive plant species have also increased in number and cover at some sites (Abella and Covington 2004). Ponderosa pine seedlings can be expected to regenerate sporadically (Bailey and Covington 2002).

Fire:
The main purpose of this treatment is to substantially minimize the threat of catastrophic wildfire through surface fuel and ladder fuel reduction. Models used during the planning process projected that treating Centennial Forest sites with this prescription will keep fire moving on the ground, rather than in tree crowns, because of the drastically reduced fuel loads and increased distance between clumps of tree crowns. This lowered susceptibility to severe fire should persist for decades rather than years, as is the case with many lighter thinning treatments.

Soils and Hydrology:
Intense thinning is known to make more soil water available to remaining trees (Kaye et al. 1999), but such measurements have not yet been made at the Centennial Forest sites. It is also expected that the combination of thinning and burning will make nutrients more readily available both to remaining trees and to understory vegetation, as has been the case at other restoration sites (Kaye and Hart 1998). Total road density in the project area was halved, which should improve the area's hydrological functioning.

Wildlife:
Given the response of wildlife in similar restoration prescriptions, researchers anticipate an increase in the abundance and diversity of some butterflies (Waltz and Covington 2004) and birds at the STIFH restoration sites. Impacts on wildlife are likely to vary depending upon species, time since treatment, and many other factors (Chambers and Germaine 2003). Future monitoring of treatment sites may aid in understanding of these impacts.

Social Issues:
The STIFH restoration sites have been toured by various groups and organizations. So far the response has generally been positive, as people appreciate the openness and considerable reduction in fire risk this prescription provides.

Costs

The overall cost of implementing this prescription in the Centennial Forest varied from $327 per acre to over $700 per acre, depending on initial stand densities, the market value of removed trees, and other factors. For this particular project, some roads were in need of improvement for the safe movement of machinery, and this added to the overall operational costs.

Discussion

There are many benefits to using this treatment option for forest restoration. The prescription is easily modeled; it is based on historic forestry practices, ensuring credibility; many smaller trees are left standing, which creates a stable age structure; and trees left standing can be grouped to emulate presettlement conditions and create benefits for many wildlife species. Because of the resulting open stand structure, stand-replacing fire and severe bark beetle outbreaks should be rare in treated stands in the future. It is important to emphasize the key role that fire must play in future maintenance: without regular fires or thinning designed to emulate fire, thinned stands will grow progressively denser over time.

Current conditions play an important role in determining what stands will look like after treatment. A thinned stand with some old yellow pines will look unlike one that lacks large, old trees, and may play a different ecological role. As always, local conditions and objectives should dictate replacement rates and thinning methods.

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Series Editor Peter Friederici

NAU Printing Services/G56420/5M/02-05

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