Can We Create and Sustain Late Successional Attributes in Interior Ponderosa Pine Stands? Large-Scale Ecological Research Studies in Northeastern California

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Abstract—Conflicts over changing demands on our increasingly scarce stands of late successional ponderosa pine could be abated by increasing the proportion of stands with late successional attributes in the forest land base. However, we don't know whether these attributes can be developed through the management of younger stands. Nor do we know whether late successional stands can be managed to perpetuate these values through time. To answer these questions, two long-term large-scale studies were begun to study ecosystem responses to a series of silvicultural treatments that include timber harvest and prescribed fire. In one study, treatments are designed to test several pathways toward late successional forest attributes in a young, even-aged stand. In the other study a treatment is aimed at sustaining an existing late successional stand and contrasting the response of that ecosystem with that of a young, even-aged stand. Although not yet completely installed, the stand structure in one treatment resembles two late successional stands with periodic fire.

Conflicts over changing demands on our increasingly scarce stands with late seral structures often leave forest managers faced with difficult decisions. One obvious way to abate these conflicts would be to increase the number of stands in the forest land base with late seral attributes, such as large trees, snags, large down woody debris, multiple canopy layers, associated shrub, herb, and grass components and canopy gaps. However, it is not known which active management strategy could speed development of these attributes in younger stands, nor is it known whether we can manage late seral structures to perpetuate their values through time. In addition to concerns about esthetics, biodiversity, and sustainable productivity, stands with late seral attributes often contain the most valuable timber and critical wildlife habitat.

To address these questions, we began two long-term large-scale studies in the interior ponderosa pine (*Pinus ponderosa*) forests of northeastern California. The primary objective of the study on the Goosenest Adaptive Management Area (GAMA) is to accelerate late successional attributes in a young-growth stand (Ritchie and Harcksen 1999). One of the objectives of the study located on the Blacks Mountain Experimental Forest (BMEF) is to sustain late successional attributes in stands threatened by the absence of fire (Oliver and Powers 1998). The inception of effective fire control about 1930 at both BMEF and GAMA has resulted in dense stands with a higher proportion of white fir. Before 1930, the median fire return interval at BMEF was about 7 years (personal communication with C. N. Skinner, September 19, 2000). Although data are not yet available for GAMA, we expect the interval to be similar. Neither site has experienced wildfire since 1930. Many stands have suffered severe mortality from competition exacerbated by drought. At BMEF, intense competition has accelerated the demise of the large old trees. Similar shifts in species composition and stand structure resulting from fire suppression have been reported in the San Bernardino Mountains of southern California (Minnich and others 1995). At GAMA, the resulting buildup of fuels has caused fire hazard to become so extreme that long-term protection of the forests seems virtually impossible.

Both sites are ideally suited for a large-scale, ecological research project. Both sites provide enough land for operational-scale studies on areas dedicated to research. Plots can be large enough to monitor treatment effects on small mammals and passerine birds. But the large size of each unit, a minimum of 100 acres, made spatial control on the ground necessary to integrate data collected at different scales across disciplines. It was accomplished by a permanently monumented grid on 328-ft (100-m) centers throughout each unit to which all measurements and other activities are referenced.

We struggled as a team with treatment descriptions and how to translate our idea of what an interior ponderosa pine forest looked like when fire was part of the ecosystem. Although we knew of the aggregated stand structure existing in late seral ponderosa pine stands from silvicultural studies at BMEF (Hallin 1959) and from studies in northern Arizona (Cooper 1961; White 1985), we did not attempt to reconstruct them as did Harrod and others (1999) in central Washington. At BMEF, the method was too time consuming for the large area to be treated. At GAMA, no clues to the original structure existed in the young-growth stand. The 50-year records from a Methods-of-Cutting study (Dolph and others 1995) that provided data on stands about 20

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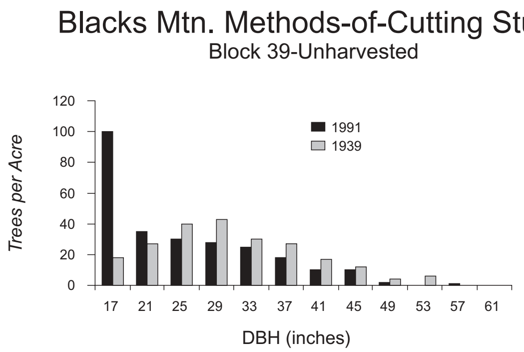

Figure 1—Distribution of tree diameters in 1939 and 1990 in the unharvested plot in Block 39 of the Methods-of-Cutting study on Blacks Mountain Experimental Forest.

years after initiation of effective fire control (fig. 1) were most relevant for diameter distributions, as were data from the Beaver Creek Pinery (fig. 2). This stand of ponderosa pine and California black oak (*Quercus kellogii*) on the west-side of the Sierra Nevada never has had effective fire protection. Although the Beaver Creek Pinery is in an environment very different from BMEF, we believed that the stand structure resulting from three wildfires in the 1990s was instructive.

Goosenest Adaptive Management Area Research Project

The Goosenest Adaptive Management Area, within the Klamath National Forest, lies on the north side of the Medicine Lake Highlands—an area of recent volcanics running east from Mt. Shasta. The entire Adaptive Management Area is clothed in 60- to 80-year-old forest, composed primarily of ponderosa pine and white fir in dense stands containing about 230 trees and 170 ft^2 of basal area per acre. The U.S. Forest Service acquired the area in the 1950s from the Long Bell Lumber Company, the successor to the Weed Lumber Company of Weed, California. Long Bell logged these stands in the 1920s and 1930s via railroad. Very few merchantable trees were left standing. After logging, pine and fir regenerated abundantly. Also at about that time the area was brought under effective wildfire control.

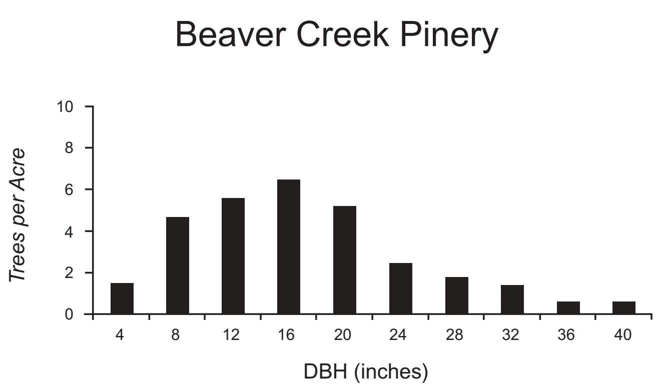

Figure 2—Distribution of tree diameters in the Beaver Creek Pinery.

Project Description

The overall research objective is to test silvicultural practices that may accelerate development of late successional forest characteristics in young growth stands, utilizing partial cutting and prescribed fire. Active management has the potential to reduce the hazard of wildfire and to accelerate development of late successional attributes, but a precise pathway for this development is unknown. Therefore, treatments were designed to place the forest on various stand development trajectories toward what are commonly conceived as late successional attributes (table 1). The pathways to late successional attributes are:

- **No treatment**—In reality this treatment is minimal management because fire prevention and fire suppression activities will continue as before. This provides an inactive management strategy for comparison with the other three pathways.
- **Accelerate late successional large trees without fire**—A major late successional attribute, large trees, should be created most rapidly by this treatment. Trees left following treatment are spaced 18 to 25 ft apart and are the largest, regardless of species. Fuel reduction is by mechanical methods not by prescribed fire, because of the danger of killing the white fir.
- **Accelerate late successional pine without fire**—We recognized that late successional stands in the area had a much greater proportion of ponderosa pine than exists today and that tree spacing was clumpy. To achieve these attributes we left all dominant and co-dominant ponderosa pines regardless of spacing, saving only white firs larger than 30 inches in diameter at breast height (d.b.h.) and those where no pines were present. We further increased the proportion of pine in this initial entry by removing clumps of decadent white fir and regenerating with pine. Our goal is to have ponderosa pine comprise 80 percent of the stems. Prescribed fire is withheld to investigate whether mechanical methods will be an effective surrogate.
- **Accelerate late successional pine with fire**—The same treatment as the previous one plus the restoration of the function of frequent low intensity fires by periodically igniting controlled fires.

Table 1—Treatment contrasts in the Goosenest Adaptive Management Area Research Project in northeastern California.

Treatment contrasts	
Species Emphasis	**Large Tree Emphasis**
Ponderosa pine retention is the most important criterion.	Tree diameter is the most important criterion.
High horizontal diversity—15 percent of area in created openings.	Minimal horizontal diversity—no openings created.
Tree spatial distribution is clumpy.	Tree spatial distribution is homogeneous.

Each strategy is replicated five times on 100 acres in each unit of a well-buffered, fully randomized field design. We anticipate a reentry in 10 years at which time we will evaluate these pathways and may adjust the treatments.

Blacks Mountain Ecological Research Project

Blacks Mountain Experimental Forest is located within the Lassen National Forest in northeastern California. Typical of vast areas of the interior ponderosa pine forest type, BMEF has two major age classes—a scattered overstory of 300- to 500-year-old pines and a dense understory of pines and white fir that originated about when intensive livestock grazing ended and when effective wild fire suppression began. An intermediate age class of 200-year-old trees is largely absent. Portions of BMEF had been harvested by a Methods-of-Cutting study between 1938 and 1947 (Dolph and others 1995), but much surrounding forest remained unlogged. At present an average acre contains 331 trees with a basal area of 144 ft^2.

Project Description

A major objective of the Blacks Mountain project is to determine if existing late seral attributes can be sustained and possibly enhanced by active management. Two forest structures, which we termed High Structural Diversity and Low Structural Diversity, were created with and without cattle grazing and prescribed fire on 12 units of 250 acres each. High Structural Diversity is characterized by the presence of many large, old trees, abundant snags, multiple canopy layers with dense clumps of smaller trees, and many small gaps in the canopy. Low Structural Diversity, created to provide an extreme contrast, is characterized by a single canopy layer of well-spaced pole- and small sawtimber-sized trees and few, large gaps in the canopy. Our objective was not to test the classic silvicultural systems of even-aged and uneven-aged management. Rather, the High Structural Diversity treatment was designed to improve the health and longevity of the large, old trees and create a multilayered forest, but not necessarily three or more age classes of trees. The Low Structural Diversity treatment was designed to provide the extreme contrast needed to determine if forest structure influenced biodiversity and sustainable productivity (table 2).

The entire forest is included in grazing allotments. Thus, six of the 12 units are fenced to exclude livestock. In each unit prescribed fire is introduced to one half and excluded from the other. We anticipate that a series of three burns, closely spaced, will be needed to bring fuels to a maintenance level. Each treatment (structural diversity x grazing) is replicated three times in a randomized block design with fire applied in split plots. Blocking is by proportion of white fir because the proportion varies among units. Fir becomes more common with increasing elevation and is a surrogate for subtle site differences. Although the design does not include untreated controls per se, four Research Natural Areas well distributed within the BMEF will be studied, also, to provide quantitative and qualitative information on undisturbed systems.

Table 2—Treatment contrasts in the Blacks Mountain Ecological Research Project in northeastern California.

Treatment contrasts	
High Structural Diversity	**Low Structural Diversity**
High vertical diversity—Retain/sustain all large old trees by removing competing trees.	Low vertical diversity—Remove all large old trees.
High horizontal diversity—Retain 10 percent to 20 percent in dense clumps. Only plant if openings >2 acres comprise >15 percent of unit.	Low horizontal diversity—Uniformly space at about 20 feet all saplings and poles. Plant all openings >2 acres.
Retain all snags and down logs.	Retain all snags and down logs.

Stand Structure Changes at BMEF

Because both projects required the removal of large volumes of wood over an extensive area—2,600 acres at GAMA and 3,000 acres at BMEF—timber harvest was spread over 3 years with prescribed fire applied the fall following timber harvest. All treatments have not been installed in either project but we do have some posttreatment results from one replication at BMEF.

The diameter distribution of the units in Block I at BMEF before treatment demonstrate the exaggerated reverse "J" shape—typical of interior pine stands developing without fire (fig. 3). Seedlings and saplings make up 61 percent of the stems. When the pole size classes are added, 96 percent of all trees in the stands have originated since fire exclusion. Although not shown in figure 3, much of the seedling, sapling and pole-size components are white fir. The pretreatment inventory at GAMA shows a similar but less exaggerated reverse "J" shape (fig. 4). At GAMA, a cooler and moister site, white fir is more abundant.

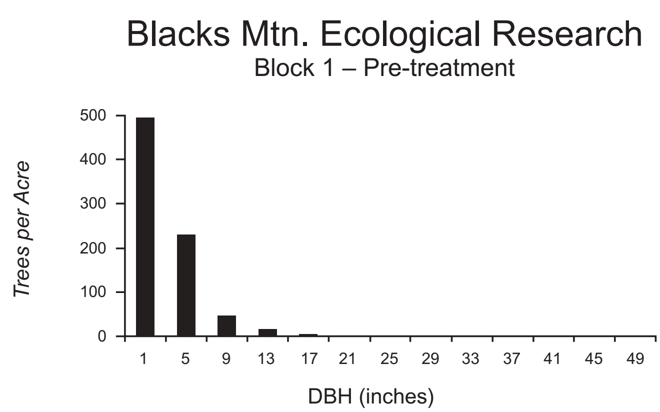

Figure 3—Distribution of tree diameters before installing treatments in Block I of the Blacks Mountain Ecological Research Project. Numbers of trees with diameters greater than 17 inches are too few to show on graph.

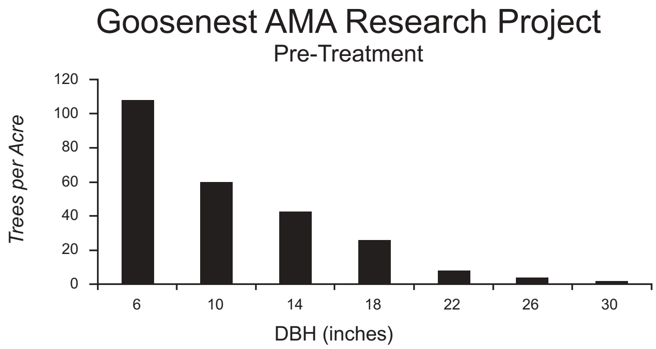

Figure 4—Distribution of tree diameters before installing treatments in the Goosenest Adaptive Management Area Research Project.

In 1999, we measured the trees in BMEF Block I that had all treatments (tree harvest and prescribed fire) installed. The diameter distribution was altered dramatically by both the low structural diversity treatment and prescribed fire. Most of the seedlings, saplings, and small poles are gone, leaving a shape best described as a normal distribution skewed toward the larger diameters (fig. 5). Stand density as measured by basal area was reduced from 122 ft^2 per acre to 40 ft^2 per acre. In sharp contrast, the high structural diversity treatment without fire maintains the reverse "J" shape diameter distribution because more of the smaller size classes remain (fig. 6). Basal area reduction was much less in the high structural diversity treatment—from 122 ft^2 per acre to 90 ft^2 per acre. When prescribed fire was added to the high structural diversity treatment, a skewed normal distribution was formed because fire mortality was restricted to the smaller trees. Basal area per acre was little affected. A similar distribution was reported from reconstruction of historic stands in central Washington (Harrod and others 1999).

We are pleased to discover that the diameter distribution in this first block of the high structural diversity treatment with fire at BMEF has begun to resemble the shape of the diameter distribution of the stand in the Beaver Creek Pinery (fig. 2). It also is beginning to resemble the distribution in 1939 of the unharvested plot in the Methods-of-Cutting study (fig. 1). The major difference is that the modal values for the distributions at Beaver Creek Pinery and the 1939 unharvested plot are higher—16 and 29 inches d.b.h., respectively. The modal value for the diameter distribution of the high structural diversity with fire treatment is only 6 inches d.b.h.—a legacy of the dense understory originating after fire exclusion and the demise of many of the large old trees. With the program of planned periodic reentry of prescribed fire, this modal value should rise.

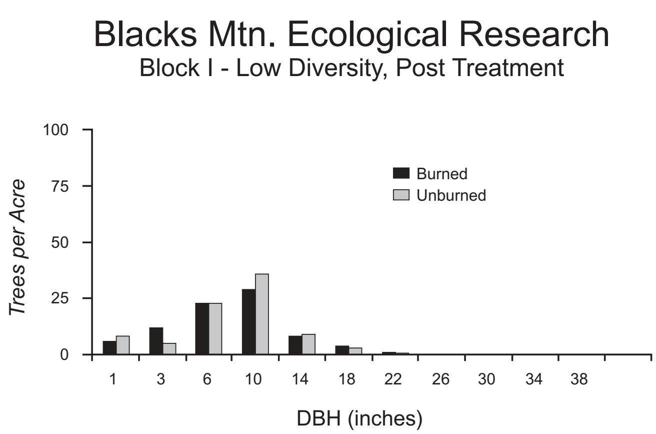

Figure 5—Distribution of tree diameters after installing the low structural diversity treatment in Block I of the Blacks Mountain Ecological Research Project.

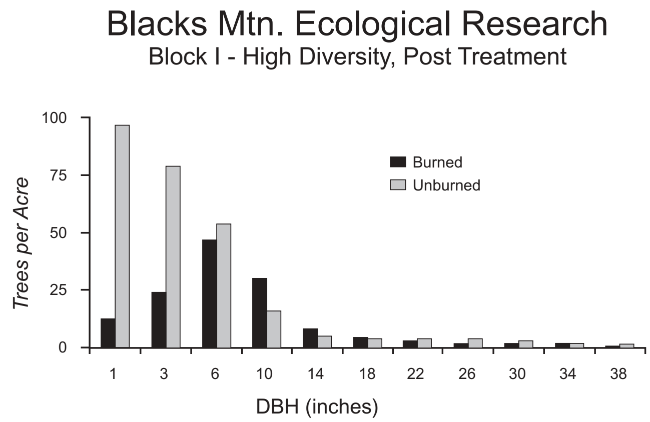

Figure 6—Distribution of tree diameters after installing the high structural diversity treatment in Block I of the Blacks Mountain Ecological Research Project.

Conclusions

At BMEF, because some large old trees are still present, we seem to be recreating a stand structure that resembles interior ponderosa pine stands of a century ago in which fire was an integral component of the ecosystem. Only one block of the replicated experiment has been treated so far, therefore, firm conclusions must remain tentative. At GAMA no large old trees are present. The present stand originated in the absence of fire after the late seral stand was logged off. Here we are testing pathways to achieving late seral attributes. Some pathways may be more effective in achieving late seral attributes and some may achieve them more rapidly than others. Early results from BMEF suggest that prescribed fire is a critical component. Maybe mechanical treatments can achieve similar effects as prescribed fire. We anxiously await results from the fire/fire surrogate study described elsewhere in this conference proceedings.

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