Silvicultural Practices (Commercial Thinning) Are Influencing the Health of Natural Pine Stands in Eastern California

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Abstract.—Overstocked 70- to 90-year-old stands of ponderosa pine on medium to low quality sites were thinned in 1980 to 40, 55, and 70 percent of normal basal area and compared to an unthinned control. Mortality was recorded annually. Growth was measured every 5 years from 1980 to 1994. After 15 years, mortality, primarily from bark beetles and annosus root disease, was reduced by 100, 96, and 92 percent relative to increasing amounts of reserve basal area. Thinned stands averaged six times more cubic-foot growth than unthinned stands. More growth and less mortality could result from treating similar stands on comparable sites.

INTRODUCTION

Loss of trees to insects and diseases is a serious problem in unmanaged, young-growth stands in the eastside pine type of northeastern California (McCambridge and Stevens 1982). The interior ponderosa pine (*Pinus ponderosa* Dougl. ex Laws. var. *ponderosa*) forest type covers about 3.5 million acres of the Modoc Plateau, which is located in the northeastern part of California (Helms 1980). In 1994, the Modoc National Forest, one of several forests located on the Modoc Plateau, had 57,600 acres of mortality caused by new pest infestations. This single-year total represents 2 percent of the total acreage on the Plateau, or 132,758,220 cubic feet of volume. Insects and diseases caused about 75 percent of this mortality. These losses in tree growth and mortality are a direct result of stress.

In many instances, stress, particularly drought stress, is compounded by overstocking. When manipulated, stand density could lead to improved growth rates and discourage the attack of certain insects-especially bark beetles. Research on bark beetles in the western United States indicates that silvicultural practices such as thinning have significantly reduced the impact of insects on forest stands (Hall and Davies 1968).

This paper quantifies the effectiveness of three levels of thinning relative to an uncut control in an overstocked 70- to 90-year-old ponderosa pine stand in northeastern California.

STUDY LOCATION AND ENVIRONMENT

This study, at Poison Lake, is part of a Forest Service Regional Administrative Study on commercial thinning begun in 1974 on several National Forests in northern California. Poison Lake is located in northeastern California on the Eagle Lake District of the Lassen National Forest.

The climate of the study area, which is located at an elevation of about 5600 feet, is characterized by hot, dry summers and cold, moist winters. Temperatures range from –30°F to 110°F with annual mean of 50°F. The growing season is about 120 days. Most precipitation falls as snow and averages about 20 inches per year.

The soils are part of the De Masters/Patio Families. These families consist of moderately deep to deep, well-drained soils formed from weathered

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rhyolite, basalt, and andesite. The area is relatively flat and uniform in terms of aspect, slope, and vegetation, which is primarily ponderosa pine, with an occasional incense-cedar (*Libocedrus decurrens* Torr.). Conifer age ranges from 70 to 90 years. Understory vegetation is sparse and composed of scattered greenleaf manzanita (*Arctostaphylos patula* Greene) and rabbitbrush (*Chrysothamnus* spp.).

METHODS

Beginning in summer 1980, data was recorded annually through the 1994 growing season. The permanent plots in this study are included in the national Forest Pest Management Technology Development Project, Pest Trend-Impact Plots in the West, and as such should continue for several years.

The silvicultural prescription was commercial thinning. Stand characteristics before and after thinning for each treatment and the control were recorded (table 1). Stands to be treated were thinned in summer and fall by removing obviously injured, diseased, and slow-growing trees as well as trees of poor form. In general, only the more vigorous dominant and codominant trees were considered as reserve trees. In a few instances, intermediate trees of good growth and form were left to prevent creating large holes in the treated stands. Incense-cedars, plus all suppressed, most intermediate, and codominant and dominant pine trees with mechanical injury, animal damage, and symptoms of pest damage were removed. Healthy dominants and codominants were harvested if necessary to attain the target basal areas. A general rule was that spacing was considered secondary to leaving vigorous crop trees.

Table 1.—Poison Lake stand characteristics before and after treatment, 1980.

Treatments (% of normal)	Trees		Basal area		Normal[1]
	Before	After	Before	After	
	(no./acre)		(ft^2/acre)		
40	768	60	200	80	200
55	617	93	170	100	190
70	712	131	220	140	210
Control	729	729	190	190	200

[1]*From Meyer, 1938. Indicates complete occupancy of the site by trees.*

The objective of this study was to create treated units thinned to 40, 55, and 70 percent of normal stocking, and an unthinned control. Normal stocking indicates full occupancy of a site by the trees. The normal values for the stands in this study were based on those reported by Meyer (1938). Each of these four treatments, including the control, was replicated three times, in a complete randomized block design. Analysis of varience and Tukey tests (Hamilton 1965) were used to analyze the data. Significance in all tests was at $\alpha = 0.05$.

Leave-tree marking and special logging methods were used to minimize injury to pines. Marking the leave trees makes them easy to see and less susceptable to logging damage (Aho and others 1983a). Special considerations included directional felling, limited size and type of logging equipment, straight-line skid trails, endlining of logs, limited log lengths, and no tree-length skidding. All harvested trees were scaled to determine the volume removed. To minimize insect buildup, logging slash was lopped to a 3-inch top and scattered to a maximum height of 18 inches.

To determine the structure of the stands before and after treatment, all trees 1 inch in diameter at breast height (d.b.h.) and larger were measured for basal area, cubic foot volume, and classified for crown class. Trees were also recorded as merchantable or unmerchantable. An unmerchantable tree would not yield a commercial log at least 8 feet long and 6 inches in diameter inside bark at the small end. Stocking of trees less than 1 inch d.b.h. was estimated from ten randomly selected one-fortieth acre plots in each replication. One percent of the dominant and codomimant trees were randomly selected and measured by dendrometer to determine stand volume, and then remeasured at the end of the fifth and tenth growing seasons to determine growth.

Conifer mortality was recorded annually in October and classified by d.b.h., crown class, and associated pests.

RESULTS

In 1980 before treatment, analysis of variance indicated no significant difference in tree mortality ($p>0.05$). In 1994 the thinned areas differed signifi-

Table 2.—Poison Lake merchantable tree mortality, 15 years after treatment, by normal basal area.

Treatments (% of normal)	Mortality		
	Average (no./acre/year)	Reduction from control (pct.)	Range (no./acre/year)
40	0.0a[1]	100	0
55	0.1a	96	0–0.5
70	0.2a	92	0–0.8
Control	2.5b	0	0–5.2

[1]*Values in each column followed by the same letter do not differ statistically at the 0.05 level.*

cantly in mortality ($p<0.05$) from the control regardless of thinning level (table 2). No significant difference in tree mortality among thinning levels was found ($p>0.05$).

In 1994, or after 15 years, merchantable tree mortality after thinning was almost eliminated. This reduction would have been even more dramatic if all the unmerchantable trees that died in the control were included in the comparison. Bark beetles, alone and in combination with root diseases, were the most common causes of tree mortality. About 30 percent of tree mortality could not be attributed to a specific casual agent, ie. bark beetles, root diseases, etc., because no external signs of damage could be found. In such cases, mortality was attributed to the effect of suppression. Most of the trees in the thinned areas that died were in the intermediate crown class. As noted earlier, these trees were left to prevent large unstocked holes in the stand. Most of the dead trees were later diagnosed as having annosus root disease that was undetected before thinning.

Mortality by d.b.h. class was determined. In the control, 65 percent of mortality was in unmerchantable trees (6 inches or less in d.b.h.). These trees were not potential crop trees, and their loss did not affect the future stocking of the stand. More importantly, 35 percent of the mortality was in merchantable trees. These larger trees would have contributed significantly to the growth of the stand. Several of the largest trees in the control died and this reduced the volume of the stand substantially.

Mortality by crown position for all treatments was also calculated. Eighty-two percent of mortality was in trees of the intermediate and suppressed crown positions. These were usually the smaller, less thrifty trees in the stand and, as noted previously, were not crop trees. In all of the thinned treatments, few if any of these "poor" trees remained. In the control, a large portion of the stocking was in trees of intermediate or suppressed crown positions. But the remaining 18 percent of mortality was trees in the dominant and codominant crown positions and would significantly effect stand growth and yield. Because of limited site resources in the overstocked control, it is doubtful if many of the surviving trees will increase growth enough to make up the loss created by the death of the larger trees.

A factor that can increase pest-induced mortality to trees is injury from the thinning operation. Mortality and loss of tree volume that result from decay initiated by mechanical injuries during the stand management activities can be substantial (Aho and others 1983b), particularily if logged in the spring when the bark is easily dislodged. This was not the case at Poison Lake, however, as these losses were minimized through the use of the specified safeguards. No leave trees were damaged during the thinning operation.

Growth in thinned areas for the first 10 years ranged from 0.61 cubic feet to 1.07 cubic feet per tree per year (table 3). Growth in the control averaged only 0.13 cubic feet per tree per year. The thinning level that produced the most growth, an increase of 713 percent over the control, was 40 percent of normal stocking. The level that produced the least growth was 55 percent of normal (369 percent of control). The 70 percent level produced an intermediate amount of growth (469 percent of control). Taken together, growth of the thinned stands increased an average of 600 percent over the control.

Table 3.—Ponderosa pine growth, Poison Lake, 1980–1990.

Treatments (% of normal)	Growth/tree (ft^3/year)	Gain relative to Control (pct.)
40	1.07	713
55	0.61	369
70	0.74	469
Control	0.13	—

If this growth per tree is expanded to growth on a per acre basis, total stand growth for the 1980–1990 period is highest in the control. This is a direct result of number of trees per acre. The control had 13 times as many trees per acre as the average number of trees in the thinned areas. But this growth is spread over more than 700 trees per acre, many of which are unmerchantable and unthrifty. Mortality will continue to remove these trees from the stand, and the volume represented by them will be lost. Even if they did survive until harvest, they would be too small to be merchantable. Common practice is to eliminate these trees during the slash disposal operation after harvest. In contrast, all the growth on the thinned areas is being put on trees that are already merchantable. When time comes for harvesting these stands, this volume will be removed by the harvesting operation and add value to the total yield from the stand.

DISCUSSION

Thinning significantly reduced ponderosa pine mortality in comparison to unthinned controls in a 70-to 90-year-old stand of eastside pine. The significance of this reduction is increased by the fact that during the period of the study, 1980–1994, a severe drought affected the area. In 7 of the 15 years of the study, precipitation was substantially below normal. Unthinned plots lost more than 2 merchantable trees per acre per year. Thinned plots lost only 0.1 to 0.2 trees per acre per year. These trees were of the intermediate crown position. After they died, most were diagnosed as having annosus root disease. No tree mortality occured at stand basal areas of less than 95 square feet (a value that is slightly less than 55 percent of normal) per acre. This value agrees well with that from an earlier study by Oliver (1979) who showed that the optimum stocking level was about 110 square feet per acre in similar stands, implying that mortality below this level of stocking was minimal.

The three levels of thinning tested in this study reduced mortality and affected growth of the ponderosa pines. After 15 years, thinning of the stand to 40 percent resulted in no mortality. And because the desired leave basal area was relatively low compared to the other treatments, the thinning operation left only rapidly growing trees in this treatment. This complement of rapidly growing trees contributed to the highest per-tree growth performance for the 40 percent treatment, although total growth/acre was penalized by having to remove some of the thrifty dominant and codominant trees in order to reach the desired basal area level. Stands cut to the 70 percent level experienced some mortality, which seemed to be a consequence of leaving less-thrifty trees to reach required stocking levels. Leaving such trees also reduced per-tree growth as compared to the 40 percent treatment, but growth for the 70 percent treatment still ranked intermediate when compared to the other treatments. The 55 percent level experienced less mortality than the 70 percent level and more mortality than the 40 percent level, and ranked last in volume growth compared to the other thinning treatments.

Although overall tree mortality in the treated stands was low, a pattern between cause and timing was evident: if the casual agent was bark beetles, the trees died within 2 years of thinning; if root disease followed by bark beetle attack was the cause, the trees died several years later.

Because of the low incidence of annosus root disease before thinning, no preventative measures were applied to thinned stands in this study. A manager contemplating thinning stands where this disease is prevalent should consider using borax as a means of preventing new infestations.

The notion that pests kill only unthrifty, slow-growing trees is dispelled by this study. Over 30 percent of the mortality in the study was to merchantable trees, almost all in the control. Almost a fifth of the mortality was to dominant and codominant trees, again in the control.

Thinning not only reduces stand mortality and increases growth, but it also yields a positive return to the landowner. Timber sale budget data from the USDA-Forest Service Pacific Southwest Region show that the average bid price for pine of this size and form class is $22 per cunit (1 cunit = 100 cubic feet). Timber management costs for sale preparation and administration were $11 per cunit. Consequently, net revenues realized from thinning stands similar to those in this study amount to $11 per cunit. Data from these plots indicate that a

typical acre of well-stocked eastside pine thinned to 55 percent of normal basal area will yield 800 cubic feet. Fifty-five percent was selected for two reasons: (1) it is the thinning standard recommended for eastside pine by the Forest Service in California, and (2) it provides a conservative estimate of the gain from thinning. Multiplying 8 cunits times $11 per cunit equals $88 per acre - the net yield per acre from thinning.

Improved average growth of thinned stands, 70 to 90 years old, (600 percent of control growth) has strong implications for managers. A manager can apply an additional thinning which would increase the total yield of the stand during the rotation. When applied to the tens of thousands of acres of stands of this age in California, the increase in yield would be substantial.

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