RIS copy

USDA

United States
Department
of Agriculture

Forest Service

**Pacific Southwest
Research Station**

Research Paper
PSW-RP-234

# Vegetation Trends in a Young Ponderosa Pine Plantation Treated by Manual Release and Mulching

**Philip M. McDonald Gary O. Fiddler**

## Publisher:

Albany, California
Mailing address:
PO Box 245, Berkeley CA
94701-0245

510 559-6300

http://www.psw.fs.fed.us

**July 1997**

## Pacific Southwest Research Station

Forest Service
US Department of Agriculture

## Abstract

McDonald, Philip M.; Fiddler, Gary O. 1997. **Vegetation trends in a young ponderosa pine plantation treated by manual release and mulching.** Res. Paper PSW-RP-234. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 15 p.

On an above-average site in northern California, a complex plant community was treated by manual release in 2- and 5-foot radii, one and three times. Mulching with a small (3-foot square) paper / asphalt mulch and a control were additional treatments. Results for a 10-year period are presented for shrubs, a subshrub (whipplea), ferns, forbs, and grasses. No single category of competing vegetation dominated during the study, and competition to planted ponderosa pines was from all vegetation combined. In spite of large amounts of competing vegetation, the pines dominated in all trials, especially if the treated area was large and the treatment was often. Ponderosa pine seedlings in plots grubbed to a 5-foot radius three times had statistically larger diameters and heights than counterparts in almost all other treatments. The cost of applying this treatment was $402 per acre, the highest of all treatments, but reasonable compared to similar application in other plant communities. Much information on density, foliar cover, and height of each category of vegetation is presented, which in turn portrays changes in a developing plant community in a young ponderosa pine plantation.

*Retrieval Terms*: cost, manual release, mulches, northern California, plant community dynamics, pine seedlings

## The Authors

**Philip M. McDonald** and **Gary O. Fiddler** are research forester and supervisory forester, respectively, assigned to the Station's Silviculture Laboratory (2400 Washington Ave., Redding, CA 96001).

# Vegetation Trends in a Young Ponderosa Pine Plantation Treated by Manual Release and Mulching

**Philip M. McDonald** **Gary O. Fiddler**

**Pacific Southwest Research Station**

USDA Forest Service
Research Paper
PSW-RP-234

**July 1997**

## Contents

# In Brief

McDonald, Philip M.; Fiddler, Gary O. 1997. **Vegetation trends in a young ponderosa pine plantation treated by manual release and mulching.** Res. Paper PSW-RP-234. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 15 p.

*Retrieval Terms*: cost, manual release, mulches, northern California, plant community dynamics, pine seedlings

The primary focus of this 10-year (1984-1993) study was to quantify and compare the density and development of shrubs, a subshrub (whipplea), forbs, ferns, and grasses in a control, mulched plot, and plots that were manually released to a 2- and 5-foot radius one and three times. Mean height, diameter at 12 inches above mean groundline, and needle length of planted ponderosa pines also were studied. Changes in plant diversity over time and due to treatment were part of the study.

Development of competing vegetation in this study did not follow the typical pattern of early and increasing dominance by hardwoods and woody shrubs. The most likely reason for this was that a species of vetch from dormant seeds in the soil, many other forbs that blew in on the wind, and cheatgrass, which originated either from seed in the soil or from windblown seed, became so numerous and developed so quickly that they probably limited the density and development of the woody species. Not only did the forbs and grasses become more numerous, they also increased in number of species. The largest increase was in forbs (90 percent), followed by grasses (75 percent). More than 60 percent more species of all categories were present at the end of the study than at the beginning. By the end of the study, 46 plant species were present, causing this plantation to rank highest in plant diversity in our National Administrative Study. The previous high was 41 species.

Another way in which this study differed from others was the trend in plant density in the control. In other studies, we have found that plant density tended to increase in the control for the first few years and then decrease as plants grow taller and wider. But in this study, total plant density in the control in 1989 was 47,190 plants per acre and in 1993 was 223,503 plants per acre or an increase of 374 percent. The reason was probably the high density of forbs and grasses. The wet spring of 1993 could have been a factor. The early and continuing large number of forbs and grasses had major implications for development of the ponderosa pine seedlings. They had to survive and develop in a competitive environment that was relatively benign. Competition was not by a single overwhelming species or category of vegetation. In addition, the forbs and grasses probably did not have root systems as deep as those of the hardwoods and shrubs, and consequently more soil moisture was available during the growing season.

Although this relatively benign environment was positive for pine seedling growth in all treatments, it tended to limit differences between the treatments and the control. By 1988, however, ponderosa pine seedlings in the plots grubbed to a 5-foot radius three times had significantly larger diameters at 12 inches above mean groundline than counterparts in the mulched plots—a phenomenon that continued to the end of the study in 1993. Pine height also excelled in this multi-grubbed treatment and in plots grubbed to a 5-foot radius one time. In

1993, height in both of these treatments differed significantly from pines in all other treatments (2-foot radius one and three times, 3-foot square mulches, control), which did not differ significantly from each other. Plainly, too small a treatment area remains too small no matter how many times it is treated. Similarly, a larger area is effective if treated only once—but this once must be immediately after planting. Another caveat is that the treated area must equal or exceed the minimum effective area that we defined in earlier studies. That minimum is a 5-foot radius.

A fundamental adage in vegetation management is that a conifer seedling grows best when it becomes established before the competitors, is separated from the competitors in the sense of having space above- and belowground in which to expand, and the competitors are at least temporarily weak. Another adage is that plant species in addition to conifer seedlings are desirable in many ways (Walstad and Kuch 1987). The multi-grubbed 5-foot-radius treatment in this study fulfilled these conditions. At the study's end, the 33 naturally established species in it, plus planted ponderosa pine, amounted to 182,345 plants per acre, and covered 71 percent of the ground to the point that they cast a solid shadow. Of this 71 percent cover, 91 percent was by ponderosa pines that averaged 14.3 feet in height and 4.7 inches in diameter—values that exceeded average Forest Service growth rates in California. Equally important was that these rapidly growing pines have high potential to become a forest, which probably was the prelogging condition.

# Introduction

Conifer plantations characteristically occupy areas that have been severely disturbed by wildfire or timber harvest, often where slash was windrowed and usually burned, and where most remaining vegetation has been uprooted and removed. Soil surfaces in these areas often are bare and temporarily devoid of most plants and animals. Available site resources, however, are high because large quantities of organic material are incorporated into the soil through harvesting and site preparation, and large amounts of moisture are absorbed by this organic matter. Warm temperatures and added moisture cause a rapid buildup of microorganisms that decompose organic material and liberate nutrients.

In this unstable and rapidly changing environment, the plant community is dynamic—increasing rapidly in number of species and number of plants, and changing as plants of some species become numerous and decline. The capability of all this vegetation to capture soil moisture and nutrients increases as well, and often exceeds that of young conifer seedlings (McDonald and Fiddler 1989). Most often the vegetation manager has no choice but to release the plantation from this competition or risk its failure.

To increase knowledge on a plant community that is common in young conifer plantations in California and Oregon, data were collected and information assimilated on the growth dynamics and competitive relationships of vegetation reoccupying a bulldozed brushfield in northern California. Planted ponderosa pine (*Pinus ponderosa* Dougl. ex Laws. var. *ponderosa*) seedlings were part of the plant community. As part of a National Forest Service Administrative Study on alternative release methods (Fiddler and McDonald 1984), data were gathered from 1984-1993 on vegetation developing naturally in an untreated control and on vegetation manipulated deliberately by one mulch and four manual release treatments.

Mulching is the spreading of material around the base of a plant to mitigate adverse temperatures or moisture loss, control weeds, or enhance soil structure and fertility. Mulches have a place in vegetation management, but must have at least a 5-foot radius and be intact for at least 3 years to enhance conifer seedling growth in complex shrub and forb communities (McDonald and Helgerson 1990).

Manual release is the physical removal of competing vegetation by grubbing, snipping, or cutting with hand tools or a chain saw. In general, manual release is applied only in herbaceous plant communities or those shrub communities where the plants arise from seed. It is usually ineffective for plants that originate from rhizomes or root crowns. Manual release usually involves treating the same area twice because most plant propagules do not germinate or begin growth all at once. Rather, some commit to above-ground growth one year; some commit the next, etc. in a declining progression over time. Treating twice generally ensures that the number of remaining plants, while often numerous, will be below the critical competition threshold.

Many variations of manual release have been examined in our National Administrative Study. In one area we grubbed 2-, 4-, and 6-foot radii around Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco var. *menziesii*) seedlings in two applications 2 years apart. After 5 years, mean conifer stem diameter at 12 inches above mean groundline and height increased as size of treated area increased. Treating a 6-foot radius produced Douglas-fir growth that was comparable to treating an entire plot with herbicide (McDonald and Fiddler 1986). In another area, we chain-sawed and grubbed all competing vegetation in entire plots two times (years 1 and 5) and three times (years 1, 2, and 5). After 5 years, planted Douglas-fir seedling diameter at 12 inches above mean groundline was significantly larger in both treated plots than in the control (McDonald and others 1994). In a third area, we grubbed a 4-foot radius around ponderosa pine seedlings one, two, and three times at 2- to 3-year intervals. We also grubbed entire plots two times. After 10 years, only pines in the entire grubbed plot differed significantly in mean diameter and height from counterparts in the control (McDonald and Fiddler 1996). In a fourth study we grubbed a 2- and 4-foot radius around ponderosa pine seedlings and also expanded a 2-foot radius to 4 feet and a 4-foot radius to 6 feet after 2 years. Only pines in the expanded 4-foot radius were significantly larger in diameter and height relative to the control after 5 years (McDonald and Fiddler 1990).

For all these studies, treatment costs ranged from $90 to $1696 per acre depending on the kind and amount of vegetation, amount of area treated, and number of times the treatment was applied. These studies also support the earlier finding (Fiddler and McDonald 1984) that manual release must be done soon after planting and consist of a treated area with at least a 5-foot radius.

This paper portrays changes in the density and development of planted ponderosa pines, shrubs, forbs, ferns, and grasses that were present in six trials that involved various treated areas and number of times treated. It also quantifies the diameter, height, and needle length of ponderosa pine seedlings in these treatments and shows differences among them. Treatment costs and biological responses then are combined to show cost effectiveness—a measure that provides managers with options suited to their particular goals, constraints, and budgets.

# Methods

## *Location and Site Characteristics*

The study area is located on the Yolla Bolla Ranger District of the Shasta-Trinity National Forests about 45 airline miles southwest of Redding, California. The area was logged in the early 1970's, and the remaining stand consisted of a scattered overstory of large Douglas-fir, sugar pine (*Pinus lambertiana* Dougl.), and ponderosa pine trees that had high potential to produce seed. A more extensive lower stratum was composed of mostly shade-tolerant Douglas-fir, California white fir (*Abies concolor* var. *lowiana* [Gord.] Lemm.), and hardwoods that occurred in small groves and as single trees. The hardwoods were Pacific madrone (*Arbutus menziesii* Pursh) and giant chinkapin (*Castanopsis chrysophylla* [Dougl.] A. DC.), with canyon live oak (*Quercus chrysolepis* Liebm.) a distant third. Shrubs of the genera *Arctostaphylos, Rubus, Ribes,* and *Symphoricarpos* were scattered between trees and in small openings.

Because of the potential for heavy competition to planted conifer seedlings from hardwoods and shrubs, site preparation and plantation release were judged as necessary. After harvest in 1983 the hardwoods and logging slash were pushed into piles with a brushrake-equipped bulldozer and burned in the fall. Very little soil was windrowed, and after 3 years the windrows were barely visible.

The plant community when the study began consisted mostly of plants that originated from dormant seeds in the soil and from windblown seeds. A few hardwood root masses escaped site preparation, and clumps of rapidly growing sprouts from them contributed to the plant community. In addition to the planted ponderosa pine seedlings, bracken fern (*Pteridium aquilinum* (L.) Kuhn var. *pubescens* L. Underw.) was the most abundant species in the study area. The early community was characterized by many species and large numbers of plants in several categories such as shrubs, ferns, forbs, and grasses. Grass genera were *Bromus, Festuca, Elymus,* and *Stipa* (now classified as *Achnatherum* by Hickman [1993]).

Ponderosa pine seedlings from a local seed source were raised in a private nursery at Aberdeen, Washington and outplanted in augured holes in spring

1984 as 1-1 bare-root seedlings. Spacing was 8 by 8 feet. An excellent job of planting was done, and survival in the fall of 1984 was about 95 percent.

The study area is traversed annually by migratory deer (*Odocoileus hemionus columbianus*). The herd passes through the area to lower elevations in the fall and to upper areas in the spring. Passage normally is fairly rapid, but sometimes is delayed by spring storms. When this happens, the animals concentrate in the area and eat whatever is available, including the tops of ponderosa pine seedlings.

Site quality of the study area is above average with height of dominant mixed conifers averaging about 80 feet in 100 years (Dunning and Reineke 1933). The soil, which is closely related to the Marpa series, is moderately deep, well drained, and formed in material weathered from shale or sandstone. It has a gravelly loam texture grading to gravelly clay loam with depth, and is about 32 inches deep. The elevation is about 3,800 feet, the slope is 20 percent, and the aspect is northeast. The area is remarkably uniform with respect to slope, aspect, and soil. Precipitation averages about 55 inches per year, with 40 percent falling as snow. For the 1984-1993 period, precipitation was below normal in 7 years, normal in 2, and above normal in 1. Wet springs, which aid vegetation growth, occurred about every other year. The mean January temperature is about 36 °F, and the mean July temperature is about 70 °F. The frost-free season is 170 days.

## *Study and Design*

The experimental design was completely randomized with one-way treatment structure. Six treatments, including the control, were each replicated three times. A replicate (plot) consisted of about one-seventh acre on which were about 50 ponderosa pine seedlings surrounded by two or more rows of buffer (seedlings receiving similar treatment). Treatments and treatment dates were:

- Manual release
  - 2-foot radius one time, grubbed March 1984;
  - 2-foot radius three times, grubbed March 1984, June 1985, June 1986;
  - 5-foot radius one time, grubbed March 1984;
  - 5-foot radius three times, grubbed March 1984, June 1985, June 1986;
- Mulching
  - 3-foot square, installed March 1984;
- Control

Treatments were not considered complete until repeat applications had been performed.

The manual release treatments were designed to test the effect of removing both a large and small amount of competing vegetation from around the conifer seedlings and also to test the effect of treatment intensity by grubbing one and three times. Vegetation was grubbed below the root crown and clipped if leaning into the 2- and 5-foot radii. The 3-foot square mulch was designed to provide year-long freedom from competing vegetation, and thus provide contrast to the grubbed radii treatments that allow at least some competition between applications. The mulch was made of fiberglass strands and asphalt sandwiched between layers of kraft paper. It was estimated to be effective for 2 to 3 years. Unfortunately, it lasted for only 1 year, and after 2 years only strands of fiberglass and tiny lumps of tar could be found.

The cost of installing each treatment both initially and for retreating was based on hourly records from similar studies in the National Administrative

Study and the current wage—$8.74 per hour—the rate for a WG-1 laborer, U.S. Department of Labor, as of June 1993. No allowance for travel, equipment, or overhead was included.

### Sampling

In each plot, 30 healthy ponderosa pine seedlings, identified as potential crop trees, were randomly chosen and permanently tagged. As their name implies, these were well-developed seedlings that had good potential of becoming harvestable trees. Small, misshapen, and chlorotic seedlings were not included because their chance of being alive and present at the time of first thinning was small. On each of the sample seedlings, stem diameter and height were measured. Diameters were recorded at 12 inches above mean groundline, and needle length was measured to the nearest 0.1 inch. Seedlings were checked periodically for injury from both biotic and abiotic agents.

Sampling intensity for evaluating vegetation other than ponderosa pine seedlings was five randomly selected subplots in each plot. Subplots were centered around pine seedlings in all treatments. To measure competing vegetation in the control and mulched plots, a square milacre (0.001 acre) and a square 3-foot metal frame, respectively, were used. For radius plots, sampling took place only in the treated area.

All vegetation other than ponderosa pine was sampled for density in terms of number of plants per milacre plot and expanded to a per-acre basis. Because new entities of whipplea and bracken fern arise from belowground structures, defining a "plant" was necessary. Excavation and pulling on stems showed rhizome length to vary widely in depth and length of internodes. Consequently, single stems and small clumps of stems were counted as one plant. Determining the density of the shorter grasses also was difficult. In places, the plants were so numerous and so close together that it was almost impossible to determine individual plants. Foliar cover (the sum of shadows that would be cast by leaves and stems of individual species expressed as a percentage of the land surface [Daubenmire 1968]) and average dominant height (average of the three tallest stems measured from mean groundline to bud) also were measured.

Unfortunately, limitations in budget and staffing affected early sampling, and only partial data sets were obtained for ponderosa pine and other vegetation.

To test for treatment effects and significant differences among treatments, one-way analysis of variance of treatment means (fixed effect model, Steel and Torrie 1980) and Tukey tests were applied (SAS Institute Inc. 1988). Statistical significance in all tests was at $\alpha= 0.05$. Data were gathered from permanent plots measured periodically, and where analyses of means from repeated measurements are concerned, the data are not truly independent. The $\alpha$ levels or type I errors given for various tests apply to each measurement and year separately.

To quantify plant diversity on study plots, species were noted whenever the plantation was visited. All species were recorded at the beginning and end of the study.

## Results

### Plant Diversity

Early in the study, the plant community consisted of 1 species of conifer from seed, 3 hardwoods, 8 shrubs, 12 forbs, 4 grasses, and bracken fern.

At the end of the study in 1993, the number of species in the study area had increased from 29 to 46—a 59 percent gain. The plant community consisted of 2 species of conifer seedlings (not ponderosa pine), 4 species of hardwoods, 9 shrubs, 23 forbs, 7 grasses, and bracken fern. Two species, both early seral invaders, were present in 1985 but not in 1993. Species not present in 1985 but represented in 1993 included 1 naturally seeded conifer, 1 hardwood, 1 shrub, 12 forbs, and 3 grasses. Number of species by treatment in 1993 was:

| | |
|---|---|
| Manual release | |
| 2-foot radius one time | 21 |
| 2-foot radius three times | 23 |
| 5-foot radius one time | 25 |
| 5-foot radius three times | 33 |
| Mulching | |
| 3-foot square | 18 |
| Control | 30 |

The fewer number of species in the 2-foot radius grubbed one time and the 3-foot-square mulch probably relate to the smaller amount of treated surface area, short time that it was disturbed, and high overall density of vegetation present.

### *Ponderosa Pine*

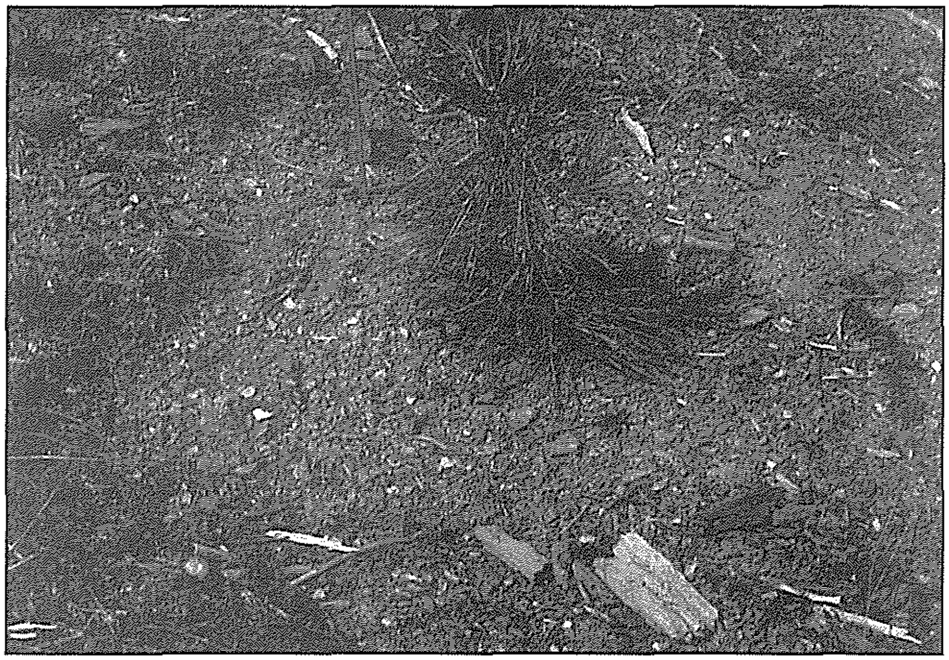
Mortality of ponderosa pine was more a steady decrease than a surge of dying seedlings. By 1989, survival by treatment ranged from a low of 84 percent in the mulch treatment to a high of 96 percent in three of the four grubbed treatments. By 1993 a few seedlings had died in each treatment except grubbing to a 5-foot radius three times. In 1993, survival by treatment was:

| | |
|---|---|
| Grubbing to a 2-foot radius, one time | 84 percent |
| Grubbing to a 2-foot radius, three times | 93 percent |
| Grubbing to a 5-foot radius, one time | 92 percent |
| Grubbing to a 5-foot radius, three times | 96 percent |
| Applying a 3-foot square mulch | 81 percent |
| Control | 84 percent |

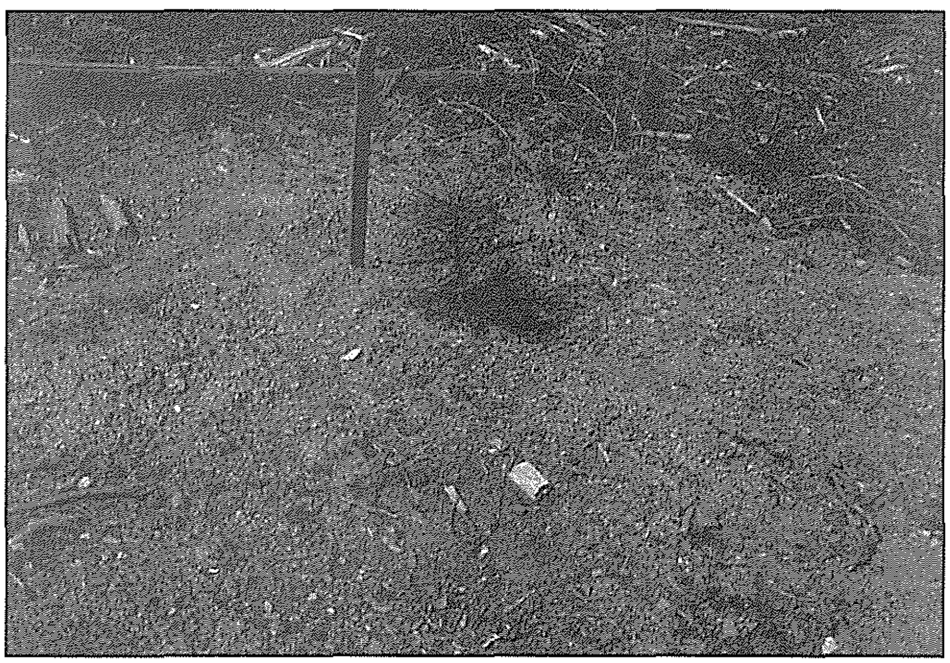
Survival did not differ significantly among treatments during the study. Damage to seedlings was caused by various agents. In 1984 and 1986 seedlings were browsed by deer; in 1989 some had dead tops from a late spring frost. However, few seedlings died from these causes. Because dead seedlings were mostly standing upright with brown needles, mortality probably was caused by competition and, ultimately, drought.

In April 1986, the pine seedlings were beginning to react to the treatments and the developing plant community in them (*fig. 1*). Statistically significant differences among treatments for ponderosa pine were first denoted in 1988.

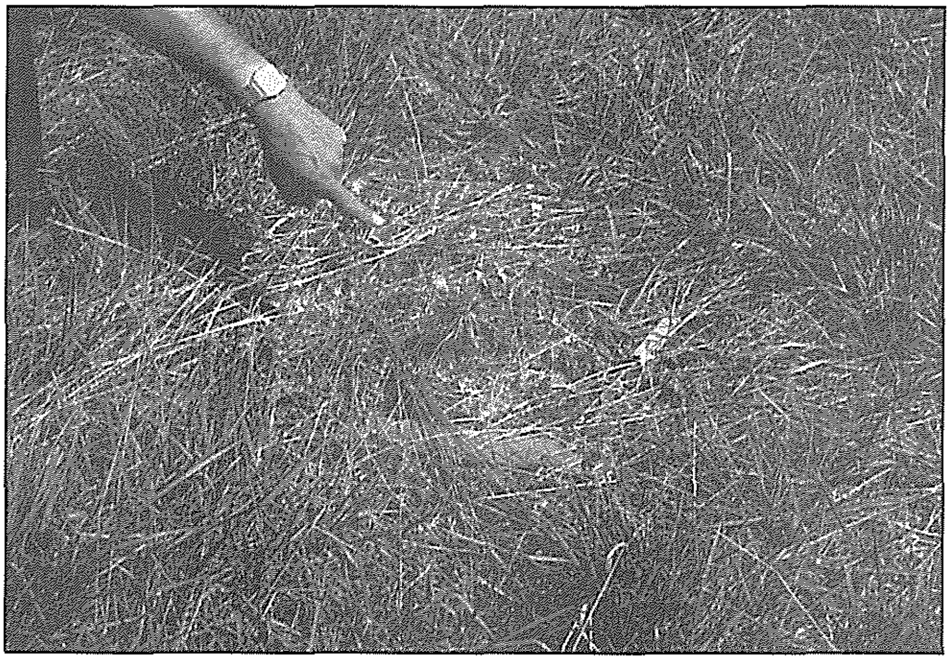
**Figure 1**—Ponderosa pine seedlings in the various treatments in April 1986: (A) 2-foot radius grubbed two of the scheduled three times, (B) 5-foot radius grubbed two of the scheduled three times, (C) 3-foot square mulch with only the fiberglass strands showing, and (D) control. Note the dense herbaceous vegetation where not grubbed, and particularly the many half-developed vetch plants in the control.



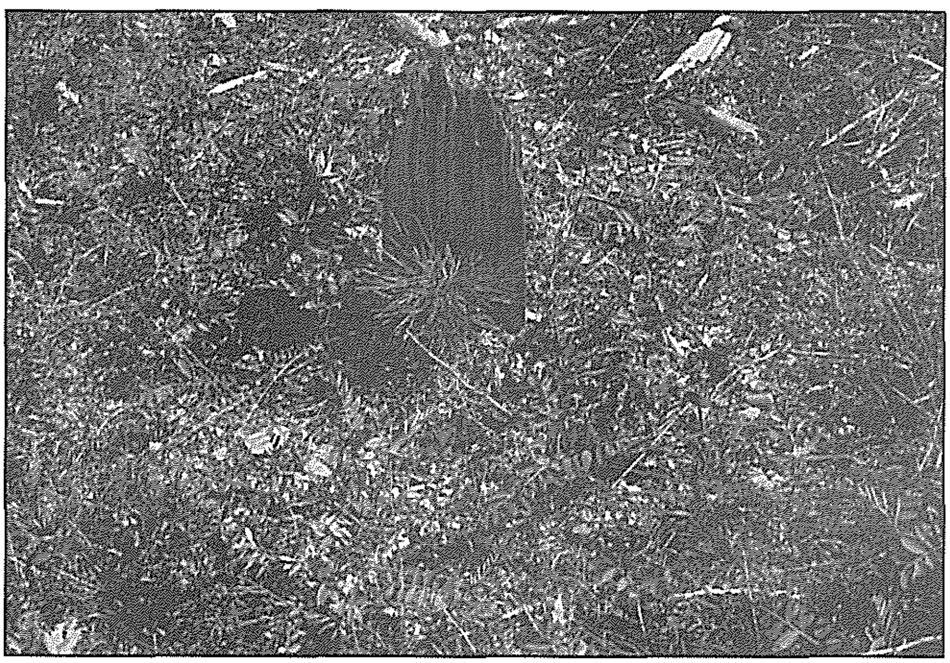
A



B



C



D

Mean stem diameter, measured at 12 inches above mean groundline, was the first variable to show statistical significance. In 1988, mean stem diameter of pines grubbed to a 5-foot radius three times (*fig.* 2) was significantly larger than that of counterparts in the mulched treatment (*table 1*). In fall 1993 or at the end of the 10th growing season, pine seedlings in plots grubbed to a 5-foot radius both one and three times had significantly larger stem diameters than pines in the mulched treatment. This also proved true for average pine height in 1993, the first time that statistical significance for this variable was found.

Significant differences in needle length showed a similar trend. Mean needle length of pines in plots released to a 5-foot radius three times was longer than that of pines in all other treatments in both 1989 and 1993 (*table 1*).

### *Shrubs*

The most abundant shrub species in the study area were from the genera *Rosa*, *Rubus*, and *Symphoricarpos*, which were evenly distributed in all treatments. After one growing season, mean foliar cover of all shrubs in the control was 3,740 $ft^2$ per acre (*table* 2). After five growing seasons, cover decreased to 2,000 $ft^2$ per acre, but then increased to 3,333 $ft^2$ per acre after 10 seasons (*table* 2). This increase in cover was accompanied by an increase in density from 800 plants per acre in 1989 to more than 5,000 plants per acre in 1993. Average height of shrubs in the control decreased from 2.5 to 1.5 feet during the 1989-1993 period.

Average shrub density in 1993 ranged from 3,586 plants per acre in plots grubbed to a 5-foot radius three times to more than 13,200 plants per acre in

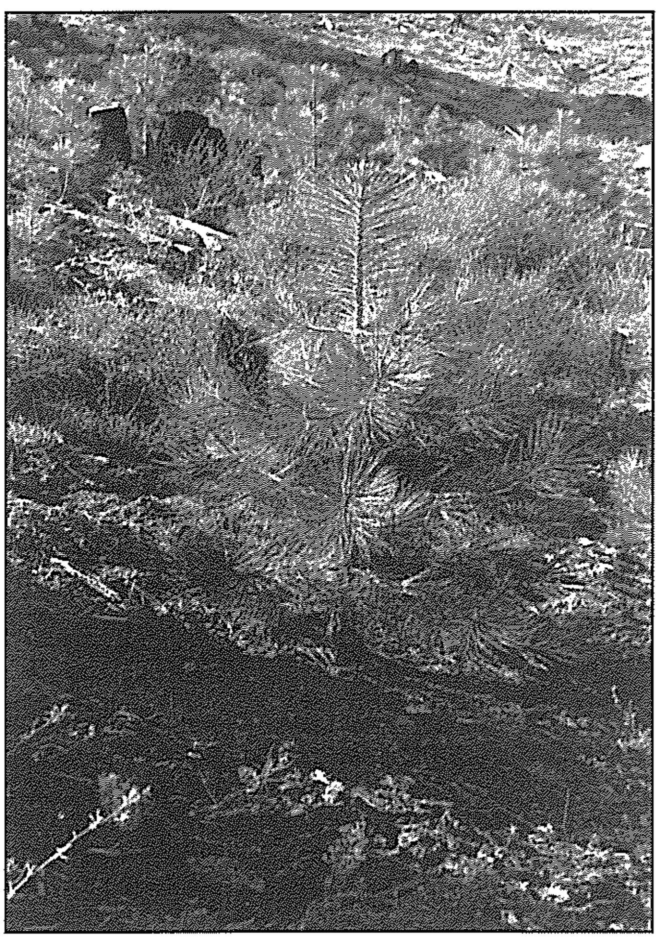


**Figure 2**—This 5-year-old ponderosa pine, released by grubbing a 5-foot radius around it three times, is growing well in diameter and height.

*Table 1—Average diameter, height, and needle length of ponderosa pine seedlings by treatment, Yolla Bolla Ranger District, Shasta-Trinity National Forests, 1984-1993*

| Year | Treatment | Diameter | Height | Needle length |
|---|---|---|---|---|
| | | *inches* | *ft* | *inches* |
| 1984 | Control | - | 0.61 | - |
| | Standard error | - | 0.04 | - |
| 1986 | Control | 0.89 | 1.43 | - |
| | Standard error | 0.06 | 0.10 | - |
| 1988 | Manual release | | | |
| | 2-ft radius one time | 1.13 ab[1] | 2.56 a | - |
| | 2-ft radius three times | 1.46 ab | 3.12 a | - |
| | 5-ft radius one time | 1.80 ab | 3.64 a | - |
| | 5-ft radius three times | 1.97 a | 4.01 a | - |
| | Mulching | | | |
| | 3-ft square | 1.08 b | 2.47 a | - |
| | Control | 1.30 ab | 3.03 a | - |
| | Standard error | 0.18 | 0.39 | - |
| 1989 | Manual release | | | |
| | 2-ft radius one time | 1.16 a | 3.25 a | 6.6 a |
| | 2-ft radius three times | 1.48 ab | 3.97 a | 7.1 ab |
| | 5-ft radius one time | 1.91 ab | 4.81 a | 7.8 ab |
| | 5-ft radius three times | 2.18 b | 5.51 a | 8.1 b |
| | Mulching | | | |
| | 3-ft square | 1.08 a | 3.20 a | 6.7 ab |
| | Control | 1.36 ab | 4.04 a | 7.1 ab |
| | Standard error | 0.21 | 0.42 | 0.3 |
| 1993 | Manual release | | | |
| | 2-ft radius one time | 3.04 ac | 8.45 a | 7.3 ab |
| | 2-ft radius three times | 3.32 ac | 9.19 a | 6.5 a |
| | 5-ft radius one time | 4.18 ab | 11.52 b | 7.1 ab |
| | 5-ft radius three times | 4.68 b | 14.27 c | 7.7 b |
| | Mulching | | | |
| | 3-ft square | 2.64 c | 7.85 a | 6.7 ab |
| | Control | 3.12 ac | 9.64 a | 7.2 ab |
| | Standard error | 0.28 | 1.12 | 0.2 |

[1]For each year, treatment means followed by the same letter do not differ significantly at the 0.05 level.

*Table 2—Average density, cover, and height, with standard errors (SE), of shrubs, whipplea, bracken fern, forbs, and grasses in the control. Yolla Bolla Ranger District, Shasta-Trinity National Forests, 1984-1993*

| Year | Density | SE | Cover | SE | Height | SE |
|---|---|---|---|---|---|---|
| | *plants/acre* | | *ft²/acre* | | *ft* | |
| **Shrubs** | | | | | | |
| 1984 | - | - | 3,740 | 923 | - | - |
| 1989 | 800 | 600 | 2,000 | 1,510 | 2.5 | 0.5 |
| 1993 | 5,133 | 481 | 3,333 | 2,736 | 1.5 | 0.7 |
| **Whipplea** | | | | | | |
| 1984[1] | - | - | - | - | - | - |
| 1989 | 600 | 416 | 867 | 769 | 1.2 | 0.8 |
| 1993 | 2,400 | 1,249 | 1,800 | 1,419 | 0.4 | 0.1 |
| **Bracken Fern** | | | | | | |
| 1984 | - | - | 10,900 | 520 | - | - |
| 1989 | 7,733 | 3,830 | 1,200 | 611 | 1.5 | 0.2 |
| 1993 | 6,533 | 2,095 | 667 | 406 | 1.9 | 0.5 |
| **Forbs** | | | | | | |
| 1984 | - | - | 16,180 | 2,594 | - | - |
| 1989 | 3,467 | 3,269 | 133 | 133 | 0.7 | 0.4 |
| 1993 | 137,200 | 78,056 | 1,133 | 1,035 | 1.8 | 0.1 |
| **Grasses** | | | | | | |
| 1984 | - | - | 6,780 | 911 | - | - |
| 1989 | 34,000 | 9,304 | 3,067 | 2,070 | 2.8 | 0.1 |
| 1993 | 71,667 | 25,193 | 733 | 546 | 3.2 | 0.1 |

[1]Recorded under forbs in 1984.

mulched plots (*table 3*). The only statistical difference noted for density was between the high values in mulched plots and lower values in plots of all other treatments. In general, foliar cover was low in all treatments and did not differ statistically among them. Average height ranged from 0.6 to 1.7 feet and also did not differ among treatments.

*Table 3—Average density, cover, and height of shrubs, whipplea, bracken fern, forbs, and grasses by treatment, Yolla Bolla Ranger District, Shasta-Trinity National Forests, 1993*

| Treatment | Density | Cover | Height |
|---|---|---|---|
| | *plants/acre* | *ft²/acre* | *ft* |
| **Shrubs** | | | |
| Manual release | | | |
| 2-ft radius one time | 5,777 a[1] | 0 a | 0.6 a |
| 2-ft radius three times | 6,009 a | 1,387 a | 1.2 a |
| 5-ft radius one time | 4,251 a | 665 a | 0.9 a |
| 5-ft radius three times | 3,586 a | 702 a | 1.7 a |
| Mulching | | | |
| 3-ft square | 13,229 b | 323 a | 0.7 a |
| Control | 5,133 a | 3,333 a | 1.5 a |
| Standard error | 1,466 | 1,270 | 0.4 |
| **Whipplea** | | | |
| Manual release | | | |
| 2-ft radius one time | 11,555 ab[1] | 2,311 a | 0.5 a |
| 2-ft radius three times | 7,857 ab | 0 a | 0.5 a |
| 5-ft radius one time | 1,700 a | 924 a | 0.5 a |
| 5-ft radius three times | 1,257 a | 628 a | 0.5 a |
| Mulching | | | |
| 3-ft square | 14,843 b | 1,291 a | 0.5 a |
| Control | 2,400 ab | 1,800 a | 0.4 a |
| Standard error | 2,723 | 1,084 | 0.1 |
| **Bracken Fern** | | | |
| Manual release | | | |
| 2-ft radius one time | 7,857 a[1] | 231 a | 1.4 a |
| 2-ft radius three times | 693 a | 0 a | 1.2 a |
| 5-ft radius one time | 6,987 a | 1,146 a | 1.9 a |
| 5-ft radius three times | 702 a | 74 a | 1.6 a |
| Mulching | | | |
| 3-ft square | 14,843 a | 968 a | 1.6 a |
| Control | 6,533 a | 667 a | 1.9 a |
| Standard error | 5,679 | 537 | 0.3 |
| **Forbs** | | | |
| Manual release | | | |
| 2-ft radius one time | 124,101 a[1] | 231 a | 1.6 a |
| 2-ft radius three times | 131,496 a | 462 a | 1.9 a |
| 5-ft radius one time | 91,197 a | 591 a | 2.0 a |
| 5-ft radius three times | 87,574 a | 444 a | 2.2 a |
| Mulching | | | |
| 3-ft square | 132,939 a | 645 a | 1.3 a |
| Control | 137,200 a | 1,133 a | 1.8 a |
| Standard error | 50,204 | 559 | 0.2 |
| **Grasses** | | | |
| Manual release | | | |
| 2-ft radius one time | 113,239 a[1] | 231 ab | 2.3 a |
| 2-ft radius three times | 97,524 a | 0 a | 2.9 a |
| 5-ft radius one time | 118,182 a | 1,553 b | 3.1 a |
| 5-ft radius three times | 88,572 a | 813 ab | 3.7 a |
| Mulching | | | |
| 3-ft square | 137,779 a | 0 a | 2.6 a |
| Control | 71,667 a | 733 ab | 3.2 a |
| Standard error | 29,071 | 303 | 0.3 |

[1]For each species and combination, treatment means in each column followed by the same letter do not differ statistically at the 0.05 level.

### *Whipplea*

Called a subshrub by Hickman (1993), whipplea (*Whipplea modesta* Torrey) is a semi-prostrate, slightly woody perennial common to cutover areas in the Klamath Mountains and Coast Ranges in California and Oregon. It originates from dormant seed in the soil and develops best on good sites where the A horizon has been disturbed but not destroyed (Popenoe and others 1983). High levels of organic matter and soil nutrients are optimal for this species. As a pioneer species, whipplea is abundant and dynamic in sunlight and / or partial shade, but becomes sparse and weak in a shady environment.

In our control plots from 1989 to 1993, whipplea increased in density from 600 to 2,400 plants per acre, and in foliar cover from 867 to 1,800 $ft^2$ per acre (*table* 2). Mean height decreased from 1.2 to 0.4 feet during this period. In 1993 whipplea density ranged from 14,843 plants per acre in mulched plots to 1,257 plants per acre in plots grubbed to a 5-foot radius three times. Whipplea density was lowest in plots grubbed to a 5-foot radius one and three times and significantly lower than in plots treated by mulches (*table 3*). Whipplea cover was generally low and did not differ significantly among treatments. Average height in all treatments was about 0.5 feet with little variation.

### *Bracken Fern*

Bracken fern is found from the Arctic Circle to the Equator and is common on every continent (Minore 1966). It is particularly adapted to disturbed areas but retains a presence in all stages of succession. In our study, after one growing season, bracken fern in the control averaged almost 10,900 $ft^2$ of foliar cover. Five years later this cover had decreased to about 1,200 $ft^2$ per acre and after another 5 years had decreased further to 667 $ft^2$ per acre (*table* 2). Among treatments, bracken fern density in 1993 was highest in mulched plots (14,843 per acre) and lowest in plots grubbed to a 2-foot radius three times (693 per acre) (*table* 3). Density was generally lowest in treatments that had been grubbed three times irrespective of plot size. Foliar cover, in general, was low for this species. Height ranged from 1.2 to 1.9 feet in 1993, and, like density and cover, did not differ statistically during the study.

### *Forbs*

The forb population in the study area was characterized by dominance of a single species early in the study, the decline of this species, and its replacement by many other species. Very early in the study a species of vetch (*Vicia* spp.) became abundant in all treatments. It just appeared, almost overnight, probably from dormant seeds in the soil (*fig. 1D*). It was a major contributor to the large amount of cover noted in 1984 (*table* 2). Diary records show that the period between 1984 and 1989 was characterized by a continuously increasing number of forb species. Individual species often were clumpy in distribution, and plants tended to be short and thin, with little foliar cover. A September 11, 1989 diary entry also denoted the large decline in vetch: "Vetch is now only a remnant, and although over 1-foot tall is not the serious competitor we originally thought it would be."

By fall 1993, the large number of forbs in the control, including many new invaders, had increased in density by almost 40 times and in cover by almost 9 times over values in 1989. Average height had increased by more than two times (*table* 2). Among treatments in 1993, forbs were more dense in the control (137,200 plants per acre) and had more foliar cover (1,133 $ft^2$ per acre) than in any other treatment (*table* 3). Forbs in both 5-foot-radius treatments had the lowest density, an intermediate amount of cover, and were taller (2.0 and 2.2 feet) than in any other treatment. However, at no time during the study did mean forb density, foliar cover, or height differ statistically among treatments.

### *Grasses*

Like the forbs, certain species increased and declined within the 10-year study period. Diary records indicate that cheatgrass became present very early in the study, peaked in density and cover in 1989, and declined to a few short, scattered plants by 1993. Other grasses, particularly three species of fescue (*Festuca* spp.), a species of needlegrass (*Achnatherum* spp.), blue wildrye (*Elymus glaucus* Buckley), and a tall brome (*Bromus* spp.), found the environment of the treated plots to be favorable. These species are all perennials and mostly taller than cheatgrass. They comprised the bulk of the grass data in 1993. As a whole, grasses more than doubled in density in the control from 1989 to 1993, but decreased dramatically in cover, while increasing only slightly in height (*table* 2). In 1993 grasses in the control had a lower density than in any other treatment (*table* 3), although not statistically so. In general, the grasses were more dense in those treatments that were grubbed only in 1984 and allowed to recover over time. Here, mean density values ranged from more than 113,000 to more than 118,000 plants per acre. The treatment with the highest density was mulching and supported almost 138,000 plants per acre by the end of the study (*table* 3). We noticed that the grasses were quite dense along the edge of the mulch and leaned over it. Apparently when the mulches decayed, the grass seeds effectively colonized the area. In all treatments, foliar cover was low or zero, as in mulched plots and those grubbed to a 2-foot radius three times. Like mean density, mean height did not differ significantly among the treatments during the study.

## *Production and Cost*

Not surprisingly, grubbing a 5-foot radius one and three times were the most expensive treatments. Grubbing a 2-foot radius was relatively inexpensive, regardless of number of times performed:

| *Treatment* | *Laborer hours/acre* | *Dollars/acre* |
|---|---|---|
| Manual release | | |
| 2-foot radius, one time | 11 | 96 |
| 2-foot radius, three times | 21 | 184 |
| 5-foot radius, one time | 24 | 210 |
| 5-foot radius, three times | 46 | 402 |
| Mulching | | |
| 3-foot square | 15 | 131 |
| Control | 0 | 0 |

# Discussion and Conclusions

After site preparation, the study area consisted of mostly bare ground, planted ponderosa pines, a few hardwood sprouts, and bracken ferns. These species, plus many more with plants from buried seeds and seeds that blew in on the wind, quickly invaded the plantation. By the end of the first growing season, several categories of vegetation, including shrubs, forbs, ferns, and grasses, were well represented. Together, they supported a total foliar cover of 37,600 $ft^2$ per acre or 86 percent of the ground surface. A species of vetch virtually exploded throughout the plantation and was a major contributor to this total. Cheatgrass and whipplea were just becoming established, especially in the control.

After 5 years, the makeup of the plant community was changing—probably influenced most by the burgeoning ponderosa pines that were rapidly expanding in height and width. Some species were declining, others were increasing. A notable decline was in bull thistle (*Cirsium vulgare* [Savi] Ten.), which typically peaks and declines after 3 or 4 years (McDonald and Fiddler 1996, Randall 1990). Vetch and cheatgrass had also declined. A surprise was the manzanitas, which were fewer and smaller than anticipated. An increasing category of vegetation was forbs, both from species already present and from recent invaders.

After 10 years, the density of all vegetation, including ponderosa pines, was 223,503 plants per acre in the control and 182,345 plants per acre in the most effective treatment (5-foot radius, grubbed three times). Corresponding total foliar cover values (including those for ponderosa pine that were based on seedlings in the milacre plots) were 28,266 $ft^2$ per acre in the control and 31,125 $ft^2$ per acre in plots grubbed three times to a 5-foot radius. Of these values, 73 percent of total foliar cover in the control and 91 percent of that in the multi-grubbed 5-foot-radius plots was ponderosa pine.

"Replacement" vegetation, which becomes established after treatment, is of particular interest to ecologists and vegetation management specialists. It may contain some beneficial species as in the case of the nitrogen-fixing vetch, or it may encourage species that would become a vector for a destructive animal like pocket gophers (*Thomomys* spp.). Pocket gophers can destroy a young conifer plantation (Crouch 1986). Not only can individual species of replacement vegetation influence future plant community composition and dynamics, but the sheer amount of vegetation may be beneficial as well. Consequently, it is possible that the high number of forbs, ferns, and grasses in this study interfered with the establishment of highly competitive shrub species from seeds in the soil.

The replacement role of bracken fern in this study was limited. We and others (Radosevich and others 1978 as an example) have noticed that plant diversity is greatly reduced in dense bracken stands. This may be caused by both chemical and physical interference. Chemical interference is through allelopathy, which is a process whereby toxic metabolites from one plant species interfere with a critical function in the life cycle of another species. Bracken fern has known allelopathic capability (Ferguson and Boyd 1988, Stewart 1975). This fern also is recognized as having roots, rhizomes, and fronds that develop rapidly (McDonald and others 1994) and fully occupy an area (Minore 1966). In this study, bracken was present from the beginning to the end of the study, and most abundant in treatments that had been disturbed early and then allowed to develop naturally. In general, plant diversity and pine growth were not greatly affected by bracken fern.

The diameters and heights of ponderosa pine in the majority of treatments, including the control, indicate growth rates that are below the standard for average potential crop trees (Fiske 1986). This standard, based on average diameter and height of 10-year-old seedlings on sites of similar quality, is 3 inches and 10 feet, respectively. Only seedlings in the most intensive treatments—the two 5-foot-radius treatments—met both the diameter and height standards.

In 1992, McDonald and others showed that ponderosa pine needle length was a good indicator of pine growth, and thus was a useful gauge of the treatments in the future. More specifically, 1-year-old needles, measured 2 to 4 years after treatment, were strongly related to treatment response for at least 7 years after treatment. Seven years was the longest timespan evaluated. In this study, needles measured 4 and 7 years after the treatment was fully installed accurately portrayed pine growth-treatment relationships. In 1989, the longest needles were on pines in the most effective treatments (5-foot radii) and the shortest needles were on pines in the least effective treatments (2-foot radii, mulches, control).

Arraying the 1993 data on pine diameter and height with the data on cost of treatment gives the forest manager a choice of biological and economical tradeoffs. Some managers might opt for the most intensive treatment with 10-year-old ponderosa pine trees that averaged 14.3 feet tall and were more than 4.6 inches in diameter 12 inches above mean groundline, and believe the cost was worth it. Other managers might opt for a less intensive treatment like grubbing a 5-foot radius only once and accepting slightly less growth at a lower cost.

A few managers might even opt to allow the plant community that was present after logging to develop naturally. They would not plant conifer seedlings or release those that they did plant. This do-nothing strategy has serious drawbacks. That not one new ponderosa pine seedling was found in the entire study area for 10 years indicates that no seed source was present or the level of competition was such that seedlings could not become established. And because ponderosa pine was a component of the original forest, its absence denotes an altered ecosystem lacking a key arborescent species. Furthermore, only four conifer seedlings of Douglas-fir and sugar pine were found, which suggests that almost no conifers would have stocked the land. Without planting, the community would have consisted of scattered hardwoods and a dense mass of shrubs, ferns, forbs, and grasses. It would have been in an even more altered condition for many years.

Manual release on different treated areas and for two treatment intensities created several vegetative assemblages, each with different amounts of the principal species, but with generally similar developmental potentials. Regardless of treatment, the future plant community will likely consist of ponderosa pines with a few scattered hardwoods, shrubs, ferns, forbs, and grasses in the understory. It is the growth rate of the pines in the most intensive treatments where differences will occur. Here, the pines are growing faster than planned, which means that the ecosystem manager can achieve the desired forest condition sooner, and that could mean enhanced habitat for animals, a higher degree of pleasing scenery in the roadside zone, and other enhancements. Faster growing trees close crowns sooner, shade out lower branches faster, and create a gap in the fuel ladder between the living crown and the ground—thus lessening the propensity for crown fires. And because these fast-growing trees will need to be thinned sooner than expected, a supply of raw material will come from these stands, and that raw material will be available sooner to local wood-product industries in rural America.

## References


Crouch, G.L. 1986. **Pocket gopher damage to conifers in western forests: a historical and current perspective on the problem and its control.** In: Salmond, T.P., ed. Proceedings of the twelfth vertebrate pest conference; 1986 March 4-6; San Diego, CA. Davis, CA: Univ. California; 196-198.

Daubenmire, R.F. 1968. **Plant communities: a textbook on plant synecology.** New York: Harper and Row; 300 p.

Dunning, Duncan; Reineke, L.H. 1933. **Preliminary yield tables for second-growth stands in the California pine region.** Tech. Bul. 354. Washington, DC: Forest Service, U.S. Department of Agriculture; 24 p.

Ferguson, Dennis E.; Boyd, Raymond J. 1988. **Bracken fern inhibition of conifer regeneration in Northern Idaho.** Res. Paper INT-388. Ogden, UT: Intermountain Research Station, Forest Service, U.S. Department of Agriculture; 11 p.

Fiddler, Gary O.; McDonald, Philip M. 1984. **Alternatives to herbicides in vegetation management: a study.** In: Proceedings, fifth annual forest vegetation management conference; 1983 November 2-3; Sacramento, CA. Redding, CA: Forest Vegetation Management Conference; 115-126.

Fiske, John N. 1986. **Growth standards for average potential crop trees.** Memo on file at Pacific Southwest Research Station, Redding, Calif. 4 p.

Hickman, James C. 1993. **The Jepson manual, higher plants of California.** Berkeley: University of California Press; 1400 p.

McDonald, Philip M.; Fiddler, Gary O. 1986. **Release of Douglas-fir seedlings: growth and treatment costs.** Res. Paper PSW-182. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 9 p.

McDonald, Philip M.; Fiddler, Gary O. 1989. **Competing vegetation in ponderosa pine plantations: ecology and control.** Gen Tech. Rep. PSW-113. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 26 p.

McDonald, Philip M.; Fiddler, Gary O. 1990. **Ponderosa pine seedlings and competing vegetation: ecology, growth, and cost.** Res. Paper PSW-199. Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 10 p.

McDonald, Philip M.; Fiddler, Gary O. 1996. **Development of a mixed shrub-ponderosa pine community in a natural and treated condition.** Res. Paper PSW-RP-224. Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 18 p.

McDonald, Philip M.; Fiddler, Gary O.; Harrison, Henry R. 1994. **Repeated manual release in a young plantation: effect on Douglas-fir seedlings, hardwoods, shrubs, forbs, and grasses.** Res. Paper PSW-RP-221. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 11 p.

McDonald, Philip M.; Helgerson, Ole T. 1990. **Mulches aid in regenerating California and Oregon forests: past, present, and future.** Res. Paper PSW-123. Berkeley, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; 19 p.

McDonald, Philip M.; Skinner, Carl N.; Fiddler, Gary O. 1992. **Ponderosa pine needle length: an early indicator of release treatment effectiveness.** Canadian Journal of Forest Research 22: 761-764.

Minore, Don. 1966. **The growth of *Pteridium aquilinum* (L.) Kuhn var. *pubescens* in relation to geographic source, soil nutrients, and forest site.** Corvallis: Oregon State Univ.; 96 p. Dissertation.

Popenoe, J.H.; Reed, L.J.; Martin, R.W. 1983. ***Whipplea modesta* Torr.: promising native for erosion control in the Redwood Region.** Proceedings of the first biennial conference of research in California's national parks; 1982 September 9-10; Davis, CA. Davis, CA: University of California; 113-124.

Radosevich, Steven R.; Brooks, William H.; Adams, David R.; McHenry, Walter B. 1978. **Bracken fern control with several herbicides.** California Agriculture 32(6): 7-8.

Randall, John M. 1990. **Establishment and control of bull thistle (*Cirsium vulgare*) in Yosemite Valley.** In: van Riper, C. III; Stohlgren, T.J.; Veirs, S.D., Jr; Hillyer, S.C., eds. Examples of resource inventory and monitoring in National Parks of California. Proceedings of the 3rd Biennial Conference on Research in California's National Parks; 1988 September 13-15; Davis, CA; 177-193.

SAS Institute, Inc. 1988. **SAS procedures guide**, release 6.03 edition. Cary, NC: SAS Institute, Inc.

Steel, Robert C.D.; Torrie, James H. 1980. **Principles and procedures of statistics.** 2nd ed. New York: McGraw-Hill Book Company; 218-220.

Stewart, Ronald E. 1975. **Allelopathic potential of western bracken.** Journal of Chemical Ecology 1: 161-169.

Walstad, John D.; Kuch, Peter J. 1987. **Forest vegetation management for conifer production.** New York: John Wiley and Sons; 523 p.

**The Forest Service, U.S. Department of Agriculture, is responsible for Federal Leadership in forestry.**

It carries out this role through four main activities:

- Protection and management of resources on 191 million acres of National Forest System lands
- Cooperation with State and local governments, forest industries, and private landowners to help protect and manage non-Federal forest and associated range and watershed lands
- Participation with other agencies in human resource and community assistance programs to improve living conditions in rural areas
- Research on all aspects of forestry, rangeland management, and forest resources utilization.

**The Pacific Southwest Research Station**

- Represents the research branch of the Forest Service in California, Hawaii, American Samoa, and the western Pacific.



Federal Recycling Program
Printed on Recycled Paper

☆ U.S. GOVERNMENT PRINTING OFFICE: 1997-683-616/99029

United States
Department
of Agriculture

Forest Service

**Pacific Southwest
Research Station**

Research Paper
PSW-RP-234

# Vegetation Trends in a Young Ponderosa Pine Plantation Treated by Manual Release and Mulching