Sierra-Cascade Intensive Forest Management Research Cooperative

Series Report No. 6

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ANNUAL REPORT 2005

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The year 2005 was the sixth year as an organization for the Sierra Cascade Intensive Forest Management Research Cooperative. At the annual business meeting in March, twenty-two new research proposals were submitted to the membership for possible funding. A proposal by Robert Powers and Jianwei Zhang titled "Predicting How Intensive Plantation Silviculture Affects Biomass Production and Carbon Allocation for an Uncertain Future" received the most votes in favor of funding. A limited budget resulted in this being the only new proposal that could be funded.

Two previously funded proposals (Slow Release Fertilization and Stock Type/Fertilization) were remeasured; one for second growing season values and the other for third growing season values. Two other funded proposals (Verbenone and Eucosma) were reevaluated for treatment results in 2005.

The results from three proposals funded by the Co-op were submitted for publication in referreed journals. These include Western Pine Shoot Borer (Gillette et al), Verbenone Evaluation (Gillette et al), and Shrub Competition/Conifer Survival (Lanini).

Five of the studies funded by the Co-op report updated results in this issue of the annual report. These include Stock Type/Fertilization (Fredrickson), Slow Release Fertilization (Fredrickson), Shrub Competition/Conifer Survival (Lanini), Verbenone Evaluation (Gillette), and Seedling Dormancy/Soil Temperatures (Jacobs). In a departure from previous years, an executive summary for these five studies will be presented in the annual report instead of the complete results of the study. The full data sets and analysis are available from the Co-op office in Redding for those interested.

The two sites selected for the Agenda 2020 proposal were planted in the spring. Treatments were started in July and will continue into 2006.

Membership in the Co-op had a net decline during 2005. Six members opted not to remain in the Co-op. The current membership consists of a mixture of landowners, forestry-related industries, and federal agencies.

Two of the original steering committee members had to resign due to increased workloads in their primary jobs. Ed Fredrickson and Joe DiTomaso helped organize the Co-op back in 1999 and their leadership will be missed. The Co-op membership voted in December to fill Joe's position with Gary Nakamura (UC Berkeley); Ed's position will be split between Bob Rynearson (W. M. Beaty and Associates) and Mark Gray (Sierra Pacific Industries). The changes took place January 1, 2006. A meeting with the new steering committee was held later in that month to address the matter of shrinking membership.

The year 2006 looks to be another active one for the Co-op. The Agenda 2020 proposal will require much time in order to finish installing the treatments and to maintain competing species at desired levels. The newly funded proposal of Powers/Zhang will begin to be implemented. The membership will need to decide the future of the Timmer/Jopson proposal as 2006 will mark the fifth growing season for that study. The Stock Type/Fertilization and Slow Release proposals will be due

remeasurements at the end of the growing season. These two studies will need to be evaluated as to future remeasurements and maintenance. The Jacobs proposal should be completed by the end of the year.

2005 MEMBERSHIP

Land Manager Membership:
- Collins Pine Company
- Fruit Growers Supply Co
- Roseburg Resources
- Sierra Pacific Industries, Inc
- Soper-Wheeler Co
- Timber Products Co
- W.M. Beaty & Associates

Associate Corporate Membership:
- BASF
- Cal Forest Nurseries

Affiliate Membership:
- Silver Butte Timber Co
- Wilbur-Ellis Co

Supporting Members:
- California Forestry Association
- PSW Research Station
- University of California, Davis
- USDA Forest Service

Sierra Cascade Intensive Forest Management Research Cooperative
Annual Meeting March 1, 2005

The 2005 annual business meeting was held at Sierra Pacific Industries office in Anderson, CA on March 1, 2005. Sixteen Co-op members and guests attended.

Following introductions some general items of business were covered. Brian Schlaefli led a discussion on the latest status of the Boise Cascade operations. It is still unclear if the new organization will become a member of the Co-op. Jason Warshawer is now employed by Roseburg Resources. He moved over from Soper-Wheeler.

A quick review of the 2004 Annual Report was the next item of business. Copies were mailed to Co-op members on February 22nd. Members of the Co-op in 2004 can be found on page 4.

The 2004 budget was discussed next. The budget can be found on page 83 of the Annual Report. The year ended with a surplus of $22,100.23. Almost all the Co-op funds that were at UC Davis have been obligated. About $4700 is left at Davis. These funds are included in the surplus figure. Attempts to transfer these funds over to the California Forestry Association were unsuccessful so these remaining dollars will be obligated against the next contract let in 2005 and the account at Davis can then be closed. Thereafter all accounting for Co-op funds will be handled by California Forestry Association.

The Chairs of the two Working Groups reported that there had been no meetings of the groups in 2004.

Next on the agenda was a discussion of the 2005 Co-op field trip. The 2004 field trip did not have a very good turnout. The members present were asked if they thought a field trip this year was appropriate. The decision was to conduct a field trip. Two of the three trips sponsored by the Co-op have been centered in Oregon, so the 2005 trip will be conducted in California. It will be held on June 15th. A committee composed of Bob Powers, Bob Rynearson, Jeff Webster, Mark Gray, and Ed Fredrickson was formed to set up the trip. The field trip will be conducted on Forest Service, Sierra Pacific Industries, Roseburg Resources, and W.M. Beaty holdings northeast of Redding in the Pondosa/McCloud area. Possible stops include Mt. Shasta brush fields (long term competition studies), Pondosa compaction study, eucosma study, Agenda 2020 site, National Fire Study site, chemical trials site, Herb Baldwin's auger/machine/hand planting vs. vegetation control study. An agenda will be mailed to the membership as soon as the committee finalizes the planning.

The next item of business was an update on the funded proposals (detailed write-ups can be found in the 2004 Annual Report).

Timmer/Jopson
This proposal was funded in 2000 for the amount of $30,000. Through the end of 2004, $15,002.31 has been spent. Measurement taken in the fall of 2004 represent values at the end of the third growing season. Survival continues to

be high for both fertilization treatments with all species on the three study sites. Overall survival for ponderosa pine ranges from 96-99 percent, white fir from 79-89 percent, and Douglas-fir from 80-90 percent.

After three years in a plantation, seedlings that were treated at the 300 ppm rate are always taller, have larger caliper, and have more volume than seedlings treated at the 50 ppm rate. But the majority of these differences are no longer significant. As far as tree species, white fir is the most influenced by fertilization rate, with tree height being the most influenced dependent variable.

Because the differences between the two treatments are getting less each year, the membership decided to forgo the fourth growing season measurements scheduled for the fall of 2005. The fifth year measurements will be taken in the fall of 2006 as scheduled. The membership will decide the status of this study at next years annual meeting.

A general discussion followed about what to do with a study site if it was determined that the Co-op was no longer going to do research on the site at the present time. In case the Co-op might want to use the site for research at a later date, it was decided that competing vegetation would be controlled on the site at least through year 5 by the landowner.

Newton Study
Mike's study has been funded in two increments of $5000 each. The first funding was in 2002. These funds were to cover the costs of delivering data from Mike's long-term competition studies to Martin Ritchie of PSW for validation and projections using SYSTEM-1 or CONIFERS. Mike met these obligations fully in the fall of 2003.

The second round of funding was approved in 2003. For this, Mike will deliver three products, a) a report on methods and regressions of conifer yields at a variety of ages with various levels of competition; b) a comprehensive report with in-depth analysis of conifer growth responses to initial weed densities and changing levels of weeds; c) a final publication in a referred journal.

Item a) was delivered to the Co-op in August, 2004. The other two items are works in progress.

Western Pine Shoot Borer
This study has approved Co-op funding totaling $12,500. Total spent as of 12/31/04: $11,938.40.

In the 2002 application, 12 grams of active ingredient were used; in the 2004 application, 24 grams were used. The higher amount effectively shut down pine tip moths.

3M is no longer making the product.

The thinning that was done around the test plots on Beaty ground might affect the study results, since thinning usually increases insect attacks. Third year growth measurements need to be taken to qualify this. Fifth year growth measurements will be done, also.

Fifty-acre plots are too small to effectively test this product. Male beetles travel farther but do less damage than the female beetles.

The cooperators are going to get together and discuss the next action to be taken on the study. They are requesting $2000 from the Co-op to fund the 3rd year measurements.

Verbenone
This project has new funding (non-Co-op) to finance 4 new aerial studies – Washington, California, Idaho, and Oregon.

Individual tree treatment did not work on western pine beetles; but did work on mountain pine beetles.

Stock Type/Fertilization
Data analysis was received just prior to the business meeting so there was no time to summarize it for the meeting. Data presented in the Annual Report was discussed instead.

Slow Release
(See Stock Type/Fertilization comments)

Agenda 2020
Bob Powers updated the members on the progress of this study. Planting will take place this spring on both sites. Tom Jopson reported on the progress of raising the shrubs that will be used in the study. The ceanothus species are doing fine; all attempts to raise manzanita have failed. Another attempt will be made this spring at the height of the flowering season.

Root Dormancy/Temperature Influences
This study is in the establishment stage and no results other than those reported in the Annual Report are available as of yet. Tom Jopson stated that he had been sent some preliminary data just prior to our meeting, but had not had time to look at it closely. The study is progressing on schedule.

New Proposals
The next item of business was a discussion of new proposals before the Co-op for possible funding. A steering committee composed of members and invited guests had met on February 17th to generate ideas for possible proposals to be presented to the full membership. Very few new proposals were being submitted to the Co-op and it was hoped this approach of preparing a list of possible proposals might spark the interest of the membership.

A list of seventeen possible proposals was generated by the steering group:

Western pine shoot borer study – follow-up measurements on the existing study

Verbenone study – increased scope of existing study

Financial aspects of existing pine shoot borer study

Viability of frozen seedlings

Glyphosate fine tuning

Aerial comparison of generic Glyphosates

Pre-harvest hack and squirt

Ripping/subsoiling

New product (pesticides) testing

Microsite selections in silvicultural prerscriptions

Seedling reliability – nursery practices

Pre-harvest site preparation

Imazapyr effects on conifer growth

Conifer growth models

Roseburg plots – existing research plots = continue measurements

Autocology guide for local species

Effects of silvicultural practices on soil microbial activity

The steering committee prioritized the list of ideas:

1) Pre-harvest treatments – hack and squirt and site preparation
2) Roseburg plots
3) Glyphosate fine tuning
4) New product testing
5) Silvicultural effects on soil microbial activity
6) Eucosma shoot borer – 2 studies
7) Aerial comparison of generic Glyphosate

The proposals and the priority list were presented to the membership at the March 1st meeting. Then the meeting was opened up for any proposals from the floor.

Bob Powers presented a new proposal on intensive plantation silviculture and how biomass production and carbon allocation may be affected by future climatic changes.

Ron Hague presented a proposal on re-spreading windrows in plantations.

Tom Jopson presented a proposal to study nursery blackout practices. He proposed looking at how tree improvement seed lots respond to nursery practices. How does orchard stock respond to blackout?

Tom Young proposed a study on timing/stock type of same year planting (same year as sown). Concentrate work on ponderosa pine and white fir. Douglas-fir didn't work in previous trials. These previous studies used Q plugs, Styro 2's and 8's. Sowing was in February with out-planting in June; the second test was with sowing in March with an August out-planting.

Brian Schlaefli proposed studying the competitive effects of bull thistle and mullen.

A short discussion was then held as to the amount of funds available for funding new proposals. Approximately $20,000 can be applied to new research each year.

Since all of the proposals could not be funded, a vote was taken to determine the priority in which the membership wanted the available dollars to be applied. The top four proposals would be sent back to the sponsor and full proposals (with costs, work plans, etc.) would be prepared. These proposals would be sent to the voting membership to determine the order of funding. The top four proposals were:

Bob's proposal on intensive plantation silviculture
Pre-harvest site preparation
Pre-harvest hack and squirt

The meeting adjourned at this time.

Sierra Cascade Intensive Forest Management Research Cooperative Proposal 00-04, Stock Type/Fertilization Study

Principal Investigator: Ed Fredrickson

Title: Improving the establishment and growth of Douglas-fir and white fir on dry sites through fertilization and stock type

Year Funded: 2000

Executive Summary:
A study was initiated in 2000 to determine the principal contributions of stock size and fertilization to Douglas-fir (*Pseudotsuga menziesii*) and white fir (*Abies concolor*) survival, growth and total above-ground biomass on dry sites in the interior Sierra Cascade region of northern California and southwest Oregon under vegetation-free conditions. A second objective was to determine the partial contributions of stock size and fertilization on initial root growth and total root volume (dry weights) after the first growing season in the field. The third objective was to determine differences attributable to site based on low and high precipitation zones.

Planting sites were provided by three Co-op members: Roseburg Resources, Sierra Pacific Industries, and Boise Cascade. All sites tested Douglas-fir; Boise Cascade also tested ponderosa pine (*Pinus ponderosa*). Seedling problems eliminated the white fir from the study after the initial planting. All three sites were planted in March, 2003. Wil-Gro briquettes (9-9-4) were used to fertilize the bare root-stock. All sites had adequate soil moisture at the time of planting and there was no snow on the ground. Each site received substantial moisture following the planting.

Root volume measurements will be made at time of lifting and at the end of the first growing season. Seedlings will be measured for caliper and height when planted and at years 1, 2, 3, 4, and 5. Seedling volume will be derived from these measurements. Survival will be noted at the time of remeasurement. Foliar nutrient samples and dry weights per 100 needles will be collected and analyzed at years 1, 3, and 5. Analysis of variance (ANOVAs) of treatment means will be used to test for treatment effects and significant differences among treatments.

Survival: For the Boise **Douglas-fir**, within stock types, there were no differences related to stock or fertilization (Figure 1). When comparing the nonfertilized seedlings, 1+1 seedlings had greater survival than Styro 8 seedlings. Survival of container and plug+1 stock was poor at the Roseburg site. For the bareroot stock, nonfertilized seedlings had better survival than fertilized seedlings. For the containers, the Styro 8 fertilized seedlings had the best survival. At the SPI site, survival of the 1+1 stock was greater than plug+1 seedlings, and when comparing nonfertilized seedlings, survival of the 1+1 stock was greater than Styro 20 survival. Fertilization did not significantly affect survival within

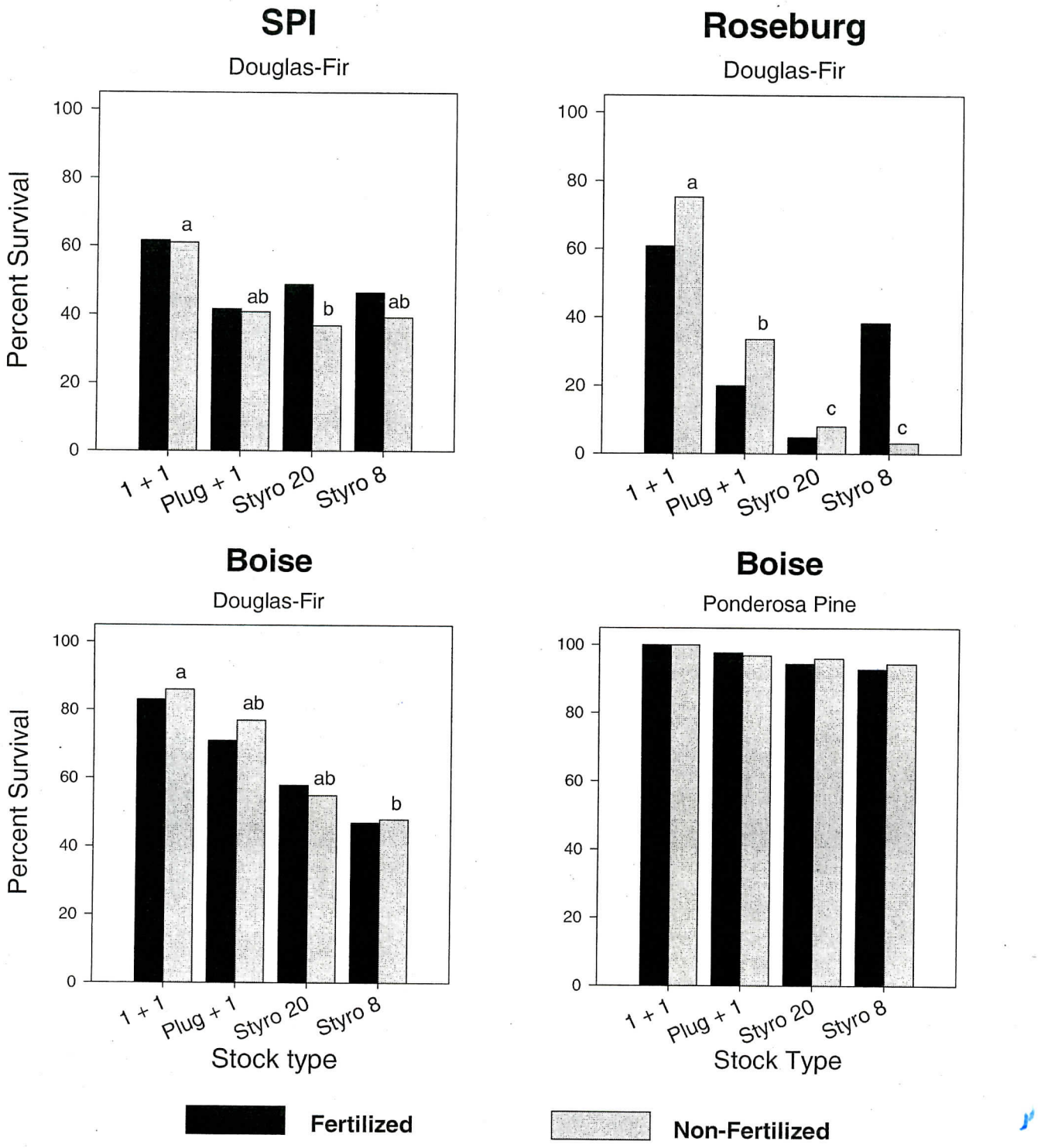
stock type comparisons. Survival of the **ponderosa pine** was good for all stock types (92% +).

Growth: Significant differences among **Douglas-fir** stock types were found for height, caliper, and volume, with rankings varying by site (Figure 2). At the Boise site, there were no differences in size between the bareroot stock types, but the Styro 20 seedlings were significantly taller and larger than the Styro 8 seedlings. In the nonfertilized comparison, the 1+1 seedlings were taller and larger than the Styro 8 seedlings. For the Roseburg and SPI sites, the fertilized 1+1 seedlings were significantly taller and larger than the plug+1 seedlings, and there were no differences between container stock types. At Roseburg, the 1+1 seedlings were taller than all other stock types when comparing the nonfertilized seedlings, and both the bareroot stock types were larger than the container stock types.

For **ponderosa pine**, the plug+1 seedlings were taller and larger than the 1+1 seedlings, and Styro 20 seedlings were taller and larger than Styro 8 seedlings. The bareroot stock types were taller and larger than the container stock types for the nonfertilized comparisons.

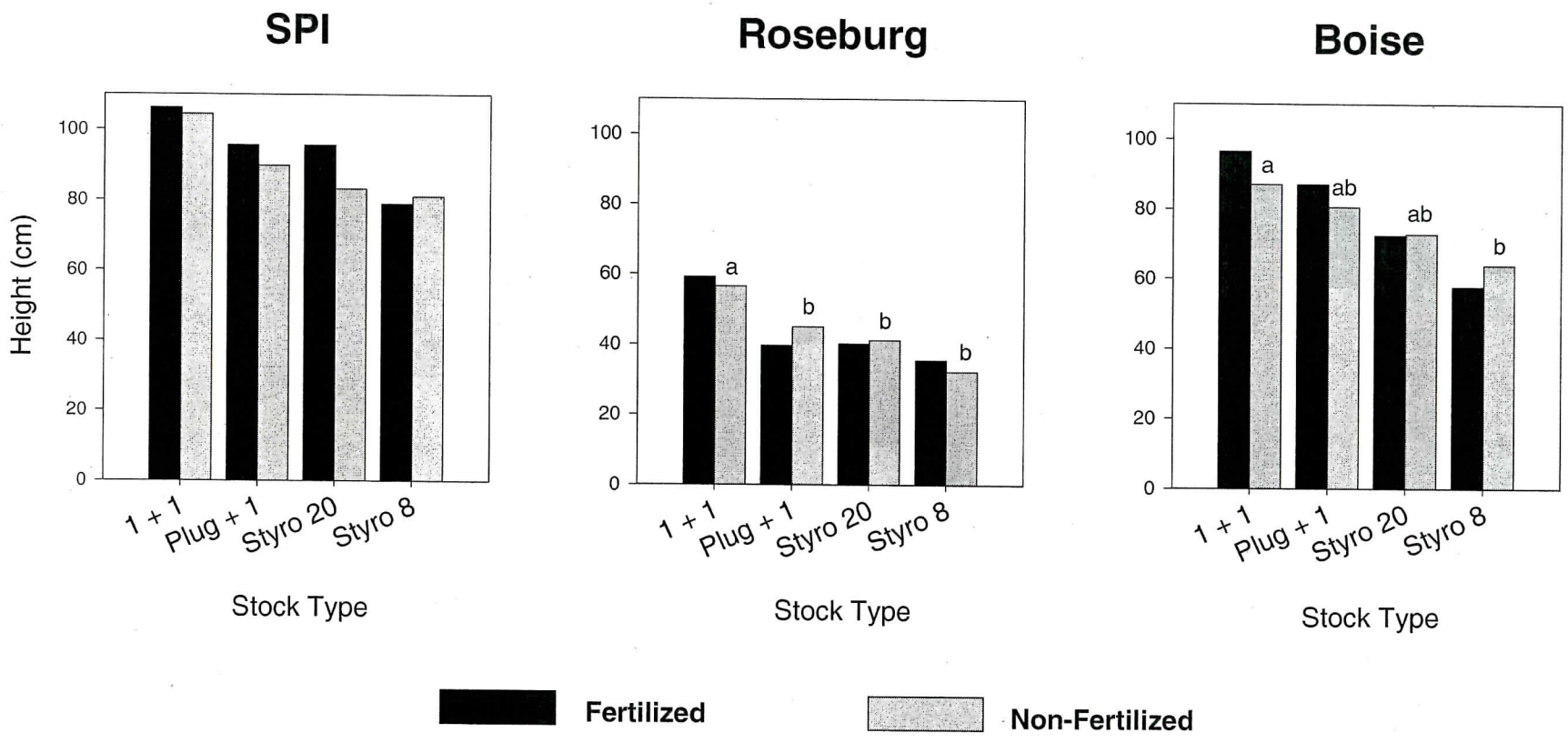
In general, there were no significant effects of fertilization on the size of Douglas-fir when comparisons were made for container and bareroot stock types. For the pine, the fertilized bareroot seedlings were significantly taller than unfertilized seedlings. However, the difference was only 7 centimeters.

Figure 1: Percent survival for Stock Type / Fertilization Study, fertilized vs. non-fertilized, fall 2005.



For each fertilizer rate, site, and stock type, treatment means with the same letter do not differ statistically at the 0.05 level. Means with no letters do not differ.

Figure 2: Mean height of Douglas-Fir seedlings for Stock Type / Fertilization Study by fertilizer rate and stock type, fall 2005.



For each fertilizer rate, site, and stock type, treatment means with the same letter do not differ statistically at the 0.05 level. Means with no letters do not differ.

Sierra Cascade Intensive Forest Management Research Cooperative Proposal 02-02, Slow Release Fertilization Study

Principal Investigator: Ed Fredrickson

Title: Evaluating the effect of slow release fertilizers incorporated into containerized seedlings in Mediterranean climates

Year Funded: 2002

Executive Summary:

A study was initiated in 2002 to evaluate the partial contributions of fertilizer type and rate to seedling survival and growth in the field for Douglas-fir (*Pseudotsuga menziesii*) and ponderosa pine (*Pinus ponderosa*). The influence of site quality and precipitation on seedling response to incorporated slow release fertilization was also to be investigated. The stated purpose of the study was to determine appropriate fertilizer ratios and rates for typical conifer species grown in Mediterranean climates and to evaluate survival and growth responses over a range of site qualities and moisture regimes.

Three sites on Co-op members' lands were chosen for the study: Soper-Wheeler Co., Silver Butte Timber Co., and W.M. Beaty & Associates. All three sites tested Douglas-fir and ponderosa seedlings; the Soper-Wheeler site also tested sugar pine (*Pinus lambertiana*). Continuous-recording weather stations capable of recording soil and air temperature, precipitation, and soil moisture were installed at each site. All seedlings were grown in Styro-10 containers. The fertilizer used was Nutra-Cote 16-10-10 at 0, 1, 2, and 3 grams per cell.

The fall planting was done in October and November, 2003. Conditions were cool and the ground was moist at the Silver Butte site; the soil was dry on the other two sites and it was hot and windy at the time of planting. The spring planting was done in March and early April, 2004. Planting conditions were ideal on all three sites at the time of planting. At the time of each planting, sample seedlings representing all species by landowner were taken to Redding where measurements of caliper and length were taken on 100 trees per species per landowner.

Caliper and height will be measured for all seedlings at the end of each growing season starting in fall 2004. Seedling volume will be derived from these measurements. Survival will be noted at the time of measurement. Analysis of variance (ANOVAs) of treatment means will be used to test for treatment effects and significant differences among treatments.

Survival: At the end of the second growing season (fall 2005), survival for **Douglas-fir** was significantly greater with the spring planting than with the fall planting for all three sites (Figure 1), but fertilization had no effect on survival.

For **sugar pine**, spring planting also resulted in significantly greater survival,

and survival was greater than 90% for both planting times. There was no fertilizer effect on survival.

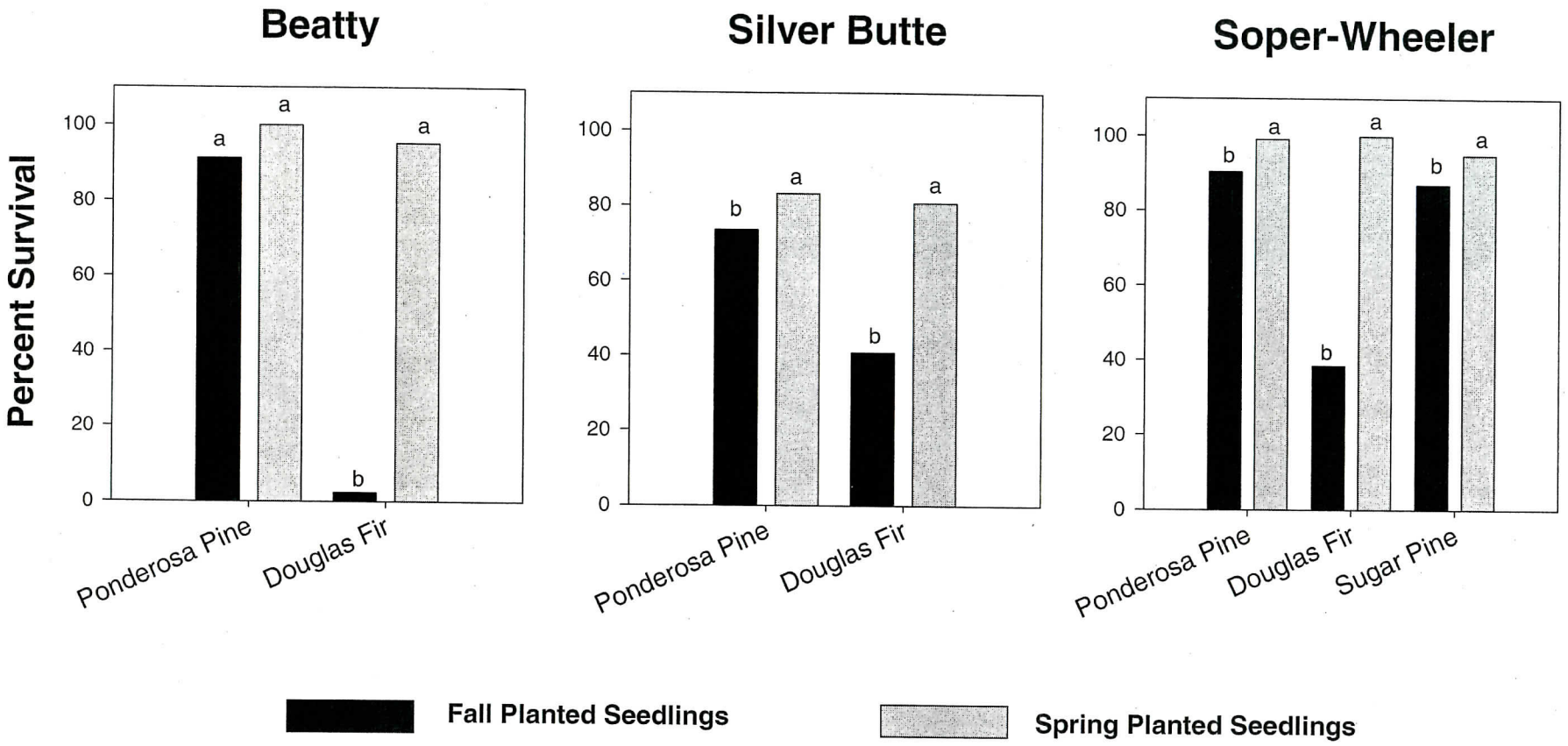
For **ponderosa pine**, at the Beaty site, there was no significant difference in survival between the fall planting and the spring planting. Fertilization did not significantly affect survival for the fall planting comparisons, but there was a trend for greater survival for non-fertilized seedlings. At Silver Butte and Soper-Wheeler, spring planting survival was greater than fall planting survival. Fertilization did significantly affect survival rates at the Soper-Wheeler site, where survival for the 0 and 1 gram fertilizer rates was greater than the 2 and 3 gram rates.

Growth: For **Douglas-fir** at the Silver Butte and Soper-Wheeler sites, spring-planted seedlings were significantly taller than fall-planted seedling (Figure 2). At the Soper-Wheeler site, spring-planted seedlings were also larger in caliper and volume. Survival for the fall-planted seedlings at the Beaty site was too low for comparisons to be made between the planting dates. Fertilization did not significantly affect seedling size at Silver Butte and Soper-Wheeler. For the Beaty spring-planted Douglas-fir, the 1 gram rate had taller seedlings than the 3 gram rate, but the difference was slight.

For **ponderosa pine**, differences in planting time and fertilization did not result in significant differences in seedling size at the Silver Butte site. For the fall-planted seedlings at the Beaty site, the 3 gram fertilization rate resulted in taller seedlings than the 0 and 1 gram rates. There was a similar nonsignificant trend for volume. There were no trends for fertilization for the spring-planted seedlings at Beaty. At Soper-Wheeler, the spring-planted seedlings were larger in both caliper and volume than the fall-planted seedlings, and there were no significant trends with fertilization.

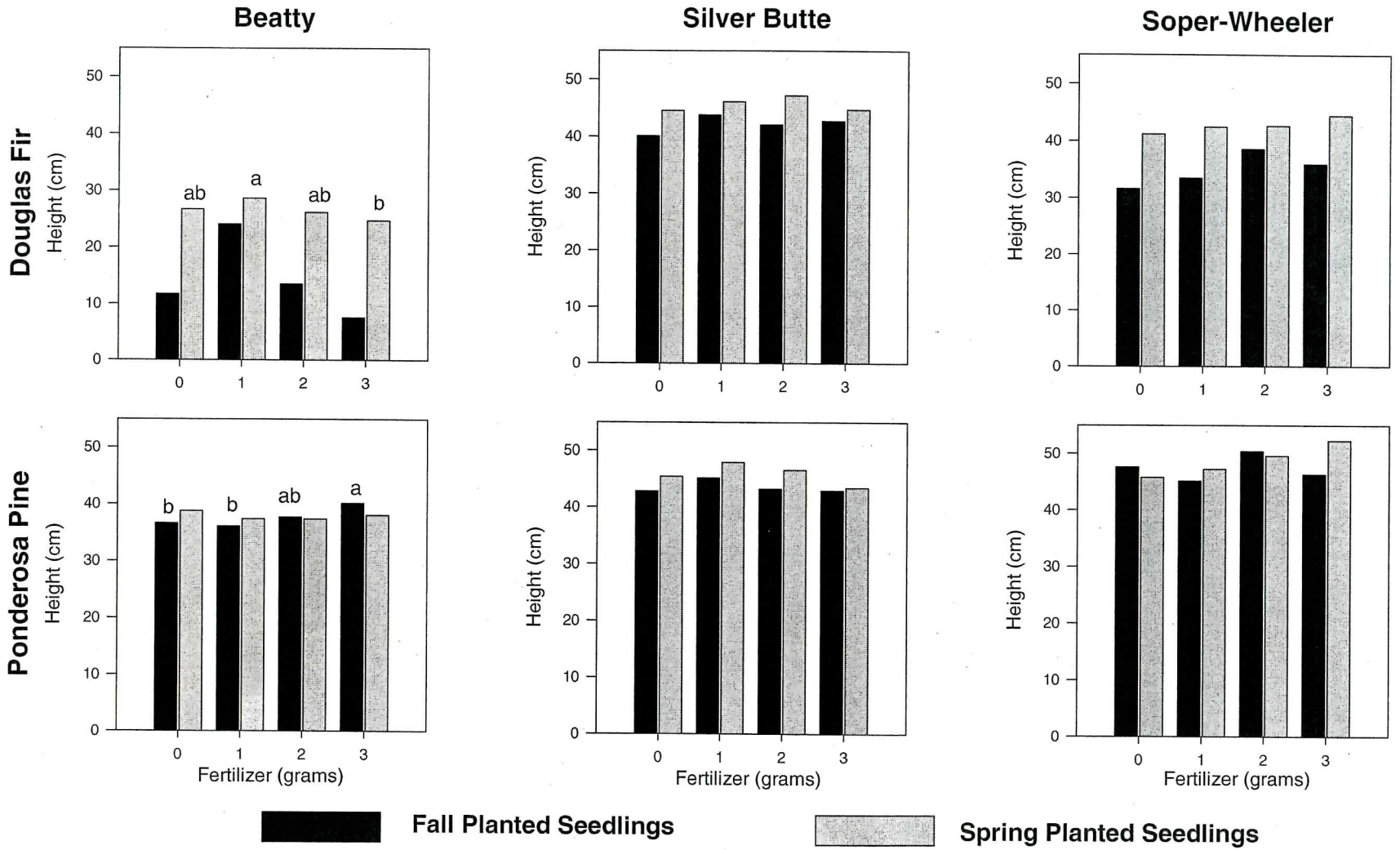
Fertilization and planting time resulted in no significant differences in size of **sugar pine** seedlings.

Figure 1: Percent survival for Slow Release Study, spring vs. fall planting, fall 2005.



For each species and site, treatment means with the same letter do not differ statistically at the 0.05 level.

Figure 2: Height of seedlings for Slow Release Study by fertilizer rate and time of planting, fall 2005.



For each fertilizer rate, site, and planting time combination, treatment means with the same letter do not differ statistically at the 0.05 level. Means with no letters do not differ.

Sierra Cascade Intensive Forest Management Research Cooperative Proposal 04-01, Seedling Dormancy/Root Zone Temperature Study

Principal Investigator: Douglas F. Jacobs

Title: Interrelationship of seedling dormancy status and root zone temperature in determining new root growth capacity of northern California conifer species

Year Funded: 2004

Executive Summary:
A study was initiated in 2004 to examine how potential for new seedling root growth (i.e., extension of current roots and formation of new roots) is affected by both media temperature and changes in seedling phenology as seedlings transition through the dormancy cycle. Though it has been established that root growth of many conifer species is maximized around 20 degrees C, few studies have examined how media temperature may interact with changes in seedling dormancy status during the period from dormancy induction in the fall through dormancy release in spring. Additionally, no studies have examined either of these trends specific to seed sources in northern California. This information will be useful to help match seedling physiological status with site environmental conditions to optimize new root growth immediately following planting.

Three species were included in the experiment, each representing an important component of forest tree seedling production in California. The species were Douglas-fir (*Pseudotsuga menziesii*), consisting of a single seed source (1676 m elevation) that either did or did not receive blackout in the nursery, ponderosa pine (*Pinus ponderosa*) from two seed sources (elevations of 1067 and 1524 m), and a single seed source of California red fir (*Abies magnifica*) from an elevation of 1676 m. Douglas-fir and ponderosa pine from the 1067 m elevation were grown in Styro-8 containers and California red fir and the ponderosa pine from the 1524 m elevation were grown in Styro-15 containers.

Seedling shipments were received from Cal Forest Nursery (Etna, CA) on 7 January 2005, 7 February 2005, 25 February 2005, 23 March 2005, and 19 April 2005. On each date, seedlings of each seed source (5 treatments, 600 seedlings total) were measured for initial root volume, height, and root collar diameter. A subsample of seedlings was evaluated for numbers of new white roots. After initial measurements, seedlings were placed into a hydroponic growing system to evaluate growth potential over a four-week period.

Changes in seedling cold hardiness between January and April 2005 were assessed using the electrolyte leakage method and by determining the LT50 (lethal temperature for 50% of plant material). Seedlings were most cold-hardy in January and least cold hardy in April. Douglas-fir seedlings that received blackout treatments during nursery culture were hardier than those that did not (figure 1), as reflected by the

LT50 tests. Blackout treatments appear useful for increasing cold hardiness, and may improve seedling vigor under given environmental scenarios. Root zone temperature influenced the number and mass of new root (figure 2). Complete results are summarized in the report. Logical future research directions, including initiation of an ongoing follow-up study, are also outlined.

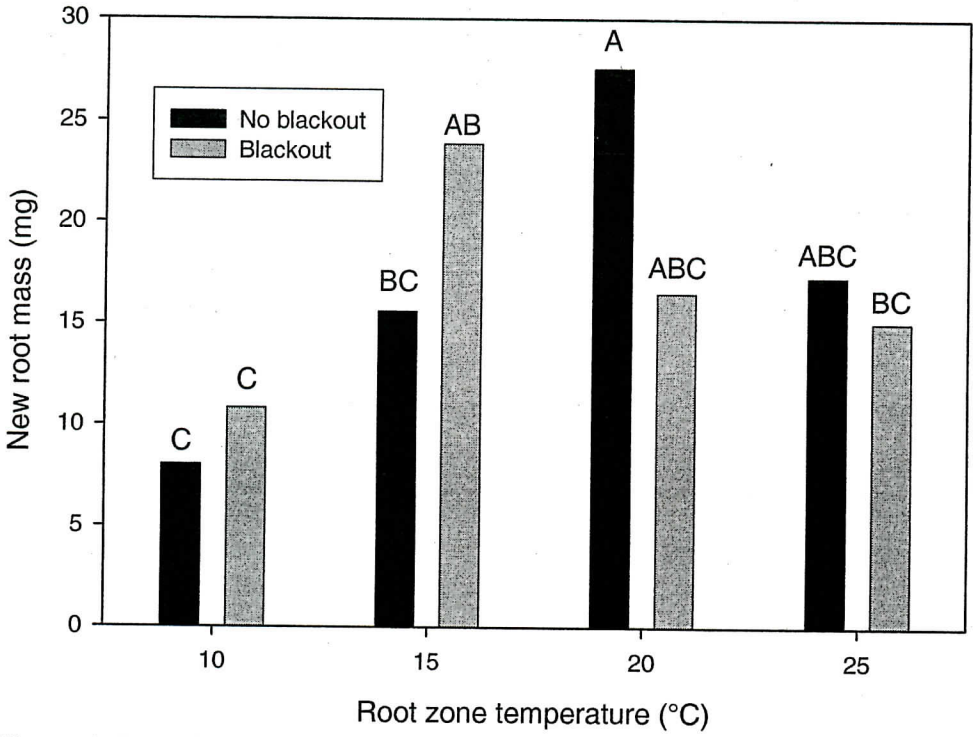


Figure 1. Investigation into the effect of interaction between blackout treatment and root zone temperature on new root mass of Douglas-fir seedlings. Bars represent means and letters represent significant differences within each graph using Tukey's HSD at α=0.05.

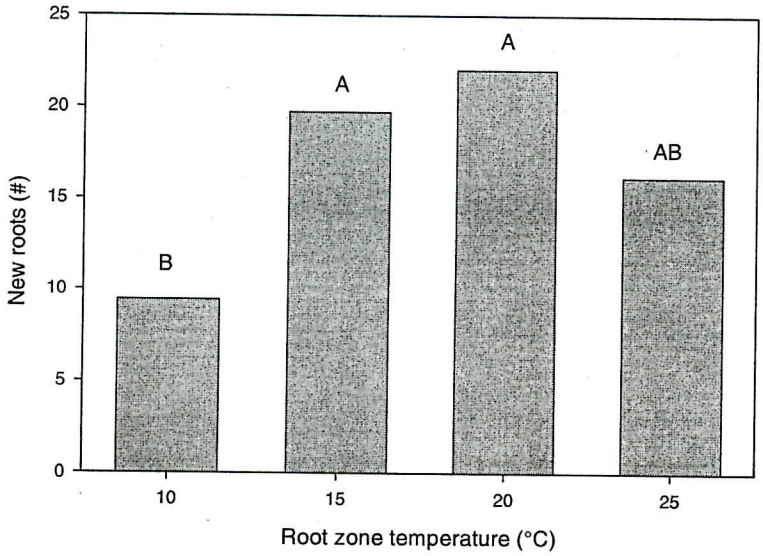


Figure 2. Number of new roots of Douglas-fir seedlings grown at different root zone temperatures. Bars represent means and letters represent significant differences within each graph using Tukey's HSD at α=0.05.

Sierra Cascade Intensive Forest Management Research Cooperative Proposal 00-02, Site Preparation Study

Investigators: Lanini, W. Thomas and Radosevich, Steve R.

Title: Survival and growth of three conifer species following three types of site preparation and three levels of subsequent shrub control: 21 years after planting

Years Funded: 2000, 2002

Executive Summary:

An experiment was established in the fall of 1978 to determine the best type of site preparation for conifer planting on harsh sites. The objectives of the experiment were to compare the survival and growth of transplanted white fir (*Abies concolor*), sugar pine (*Pinus lambertiana*), and ponderosa pine (*Pinus ponderosa*) following site preparation by the use of fire, a rotary masticator (Hydro Ax), and a brush rake. Three levels of subsequent weed control, a single herbicide treatment at one year after planting, two herbicide treatments at one and two years after planting, and no subsequent treatment after planting, were over-laid on the site preparation treatments.

The site preparation portion of the study was installed in September of 1978 on the Tahoe National Forest approximately 15 miles northeast of Foresthill, CA at an elevation of 5000 ft. The study site was occupied by mature shrub species and weedy trees for at least 18 years since the Volcano Fire, and possibly much longer. A rotary masticator cut shrubs off close to ground level, with no disturbance to the soil. On the brush rake treatment, a crawler tractor equipped with a brush rake pushed all the shrubs and trees into piles for later burning. This treatment removed large roots in the process and caused disturbance in the top 12-18 inches of soil. The shrubs in the fire plots were crushed by the tractor prior to burning. Several weeks later, the fire plots were burned. There was no soil disturbance from the burn treatment. In early May of 1979, 1-0 ponderosa pine, sugar pine, and white fir seedlings were transplanted into all the plots. The untreated (no release treatment) plots did not receive any further management. The single release plots received a directed herbicide treatment in the spring of 1980, and the two-release plots received a directed herbicide treatment in the springs of 1980 and 1981.

Survival and tree growth were recorded for the planted seedlings until 1983. In September 2000, twenty-one years following conifer planting, conifer survival, diameter at breast height, and total height were recorded for each surviving tree.

Ponderosa pine survival was significantly affected by the site preparation method. Survival was highest with the brush rake treatment and least on the Hydroax treatment. Survival of ponderosa pine was also significantly greater with herbicide release treatments, compared to not treating. Each additional release treatment increased survival.

Sugar pine survival was so low on all the plots that meaningful results are not possible. Most of the mortality was disease related.

White fir survival was not affected by the site preparation method. Survival was affected significantly by the level of subsequent weed control following site preparation. White fir survival was about equal on the plots receiving no release treatment and the plots receiving two treatments. Survival on these treatments differed significantly from survival on the plots receiving one release treatment, where survival was the lowest.

Ponderosa pine diameter at breast height (dbh) was not affected by site preparation method but increased significantly with release treatments (figure). The diameters of trees in plots receiving a single release treatment or two release treatments did not differ from each other. But both of these treatments resulted in diameters that were significantly greater than diameters in the plots receiving no release treatment.

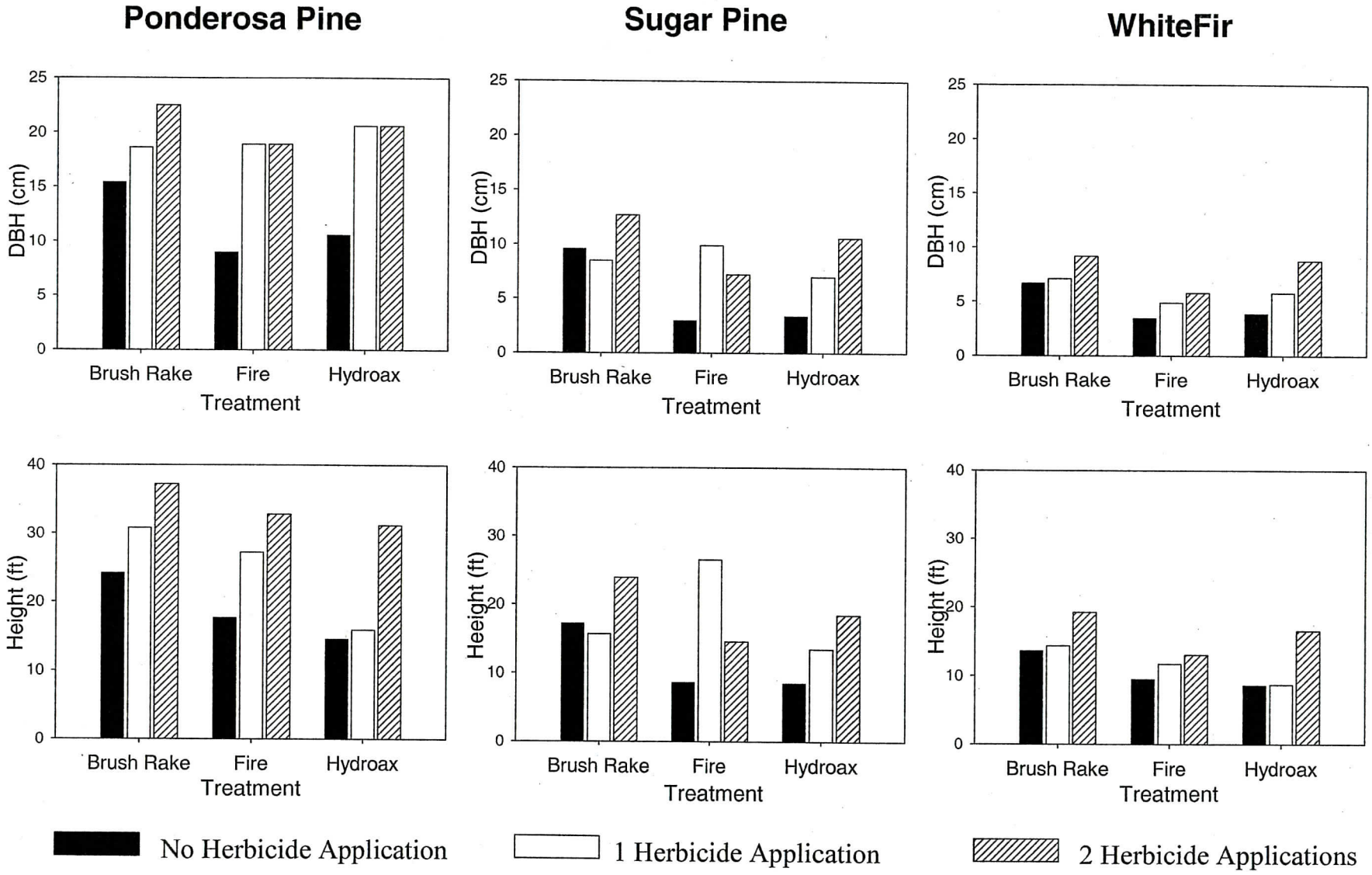
White fir diameter growth was affected by site preparation method, with trees on the fire plots having significantly smaller dbh than those on the brush rake plots (figure). White fir diameter was increased substantially with the release treatments as compared to no release treatments. The more release treatments, the larger the dbh.

Ponderosa pine height was not significantly affected by site preparation method (figure). Trees on the brush rake treatment plots were taller than trees on the other site preparation treatments but not significantly so. Release treatments significantly increased the height of ponderosa pine over that of trees in the untreated plots.

White fir height was not affected by site preparation method (figure). As with ponderosa pine, release treatments significantly increased height.

Conclusions: Twenty-one years after planting, ponderosa pine survival is about 55%, white fir about 24%, and sugar pine less than 5% of the original number of trees. On many of the plots, which received two herbicide treatments, conifers have achieved canopy closure and shrub growth is minimal. However, if tree survival was poor, the shrubs continue to significantly compete with the remaining conifers. It appears that the brush rake treatment reduced shrub re-growth better than fire and Hydroax treatments, which improved survival and growth. Although there was consistent confer growth benefits associated with herbicide treatments, there also appeared to be some conifer injury, based on the reduction in white fir survival. Where survival is high, trees are competing more with each other than with other vegetation.

Average DBH and height of planted conifers relative to site preparation method and number of herbicide applications.



Sierra Cascade Intensive Forest Management Research Cooperative Proposal 04-02, Verbenone Study

Investigators: Gillette, Nancy E., Stein, John D., Owen, Donald R., Webster, Jeffrey N., Mori, Sylvia R., Wood, David L., and Fiddler, Gary O.

Title: Verbenone-releasing flakes protect *Pinus contorta* trees from attack by *Dendroctonus ponderosae* and *Dendroctonus valens*

Year Funded: 2004

Executive Summary:
A study was initiated in 2004 to determine if verbenone, a beetle-produced pheromone, could be effective in limiting damage to pines by *Dendroctonus* spp. bark beetles. Specifically, verbenone contained in a polymer laminate flake as the release device was to be tested against *Dendroctonus ponderosae* and *Dendroctonus valens* species in an attempt to protect *Pinus contorta* from attack by these beetles.

The study was installed on August 12, 2004 on Fruit Growers Supply lands in Siskiyou County, California about 5.6 km NE of the peak of Mt. Shasta at an elevation of 2240m. The forest is a second-growth natural stand consisting of east-side lodgepole pine with a small component of Shasta red fir (*Abies magnifica* var. *shastensis* Lemm). Forty lodgepole pine trees of similar size (DBH) and live crown ratio were selected from among all accessible trees in the stand. Trees selected for the study were a minimum of 50 meters apart. Twenty of the trees were selected at random for treatment from among the forty trees and the remainder served as controls. There was no significant differences in DBH, basal area, and live crown ratio between treated and control trees.

Application of the verbenone was made on August 12, 204 using a modified hydroseeder seed/mulch spraying apparatus at the rate of 11.4 liters/tree carrying 15 g AI/tree. The laminated flakes carrying the verbenone were suspended in a solution of distilled water with Gelva sticker and guar gum. A solution of the formulation without flakes was used on the control trees. Flake and control formulations were sprayed onto trees in a single strip, roughly 30 cm wide, on a single side of each tree from ground level to a height of seven meters. Immediately after treatment, each tree was baited at breast height with a mountain pine beetle lure.

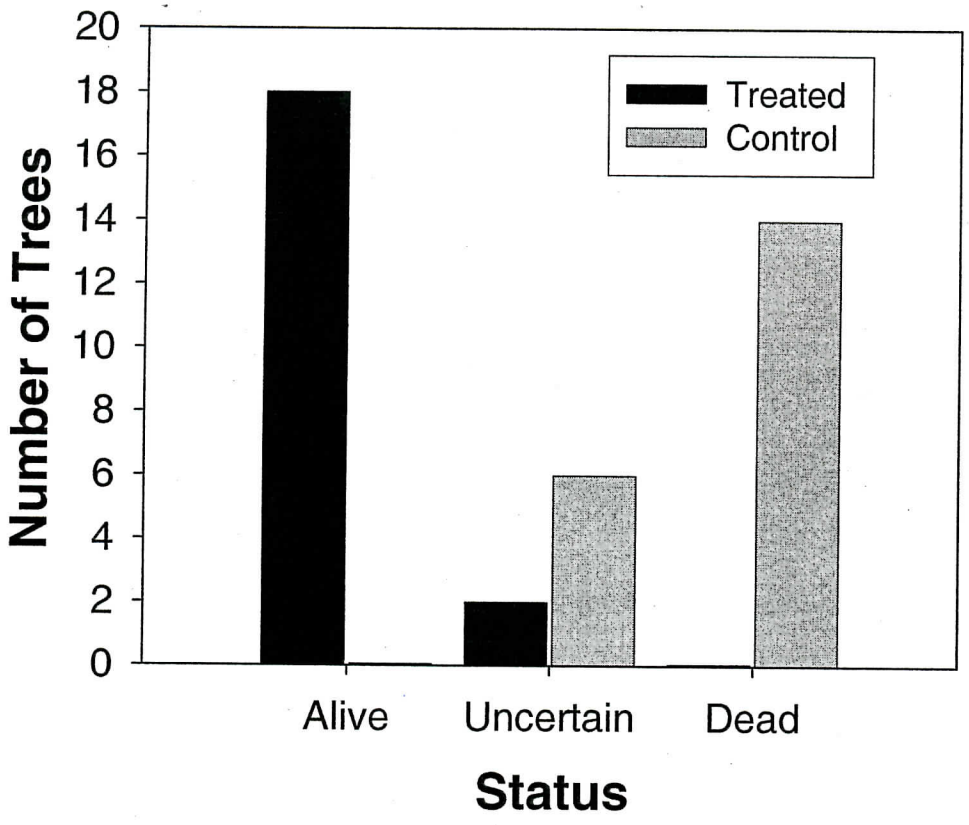
At two, four, six, and eight weeks following treatment, counts were made of the number of resinous *D. ponderosae* and *D. valens* attacks and *D. ponderosae* attacks producing dry frass. At eleven months following treatment, trees were inspected and ranked into one of three categories: (1) obviously dead, (2) obviously alive, or (3) uncertain status.

Treated trees had significantly fewer attacks by *Dendroctonus ponderosae* at two, four, six and eight weeks following application of the flakes. None of the treated trees were attacked by *D. valens*, whereas control trees averaged nearly

two *D. valens* attacks per tree eight weeks after treatment. The dry frass index, used to predict ultimate tree mortality, was significantly higher in control trees than in treated trees for all sampling intervals and for week eight, data analysis showed that the control trees had a significantly poorer prognosis than treated trees. Ten months following treatment, treated trees showed significantly lower mountain pine beetle mortality than control trees (figure). The dry frass index was a highly reliable indicator of ultimate tree mortality.

The investigators feel that the verbenone flake formulation has potential for application for a variety of bark beetle problems in forestry. The flake release device has the potential for aerial application as well as ground applications, and may present fewer environmental concerns than other delivery systems because the active ingredient is enclosed within the flake and may therefore be less accessible to children and wildlife.

Frequency distribution of trees in mortality categories.



There was a significant treatment effect of mortality categories (Pearson's test $P<0.0001$).

Sierra Cascade Intensive Forest Management Research Cooperative
Income/Expense Statement
Calendar Year Report for the Period Jan. 1 to Dec. 31, 2005

Beginning Balance on January 1, 2005		$22,100.23
Total Income (Membership Dues)		$60,000.00
Expenses:		
New Proposal Funding	$18,067.00	
Plot Establishment Contracts	$5,876.57	
Plot Remeasurement Contracts	$7,903.27	
Data Entry/Analysis Contracts	$2,822.50	
Co-op Research Plots GPS Contract	$478.75	
Co-op Manager Expenses	$43,644.68	
Total Expenses		$78,792.77
Year End Balance as of December 31, 2005		$3,307.46

WORKING GROUP MEMBERSHIP

Working Group I
Seed to Establishment

Tom Jopson, Chair
Ed Fredrickson
Jerry Gallagher
Mark Gray
Lewis Howe
Duane Nelson
Tom Young
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