Sierra-Cascade Intensive Forest Management Research Cooperative

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ANNUAL REPORT 2015

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The year 2015 marked the sixteenth year as an organization for the Sierra Cascade Intensive Forest Management Research Cooperative.

Membership remained constant from 2014. The current membership consists of a mixture of landowners, forestry-related industries, State of California and federal agencies. There are currently sixteen member organizations in the Co-op.

Ed Fredrickson made a presentation of results from research supported by the Cooperative at the Forest Vegetation Management Conference in January. Ed reported on his research on Pindar GT (Proposal 14-01). The title of his presentation was "Forestry Site Preparation and Release with Pindar GT". Ed's presentation was well received by the audience.

The annual business meeting was held at the Forest Service office March 3, 2015 in Redding (a summary of the meeting can be found in this Annual Report). Sixteen Co-op members and guests attended. The first item of business was a review of membership status and the budget. The Co-op ended 2014 with a surplus of $24,369. Dues received for 2015 at the time of the annual meeting totaled $54,000, with another $4,000 promised.

Following the discussion on the budget, updates on six recently funded Co-op studies were presented: Proposal 03-01 Agenda 2020; Proposal 12-02 Garden of Eden; Proposal 13-03 Pondosa Remeasure; Proposal 13-01 Matrix Site Prep; Proposal 13-02 Pindar/GoalTender and Proposal 14-01 Pindar Over-the-Top. Executive Summaries of Proposals 13-03 and 14-01 are presented in this Annual Report. A short summary of the progress of Proposal 12-02 Garden of Eden and Proposal 03-01 Agenda 2020 was presented to the membership.

The next item of business at the annual meeting was the presentation of new proposals for possible Co-op funding. One new proposal was presented and the membership discussed one other possible proposal. The Co-op funded the new proposal (Proposal 15-01, Rodeo). The second proposal concerned a stock trial of sugar pine and possibly incense cedar using Tom Landry's guidelines for stock trials. Mark Gray volunteered Sierra Pacific Industry lands for the trial. The membership decided to form a committee consisting of Mark Gray, Scott Worden, Scott Carnegie and Darin McMichael to develop a proposal to be presented to the membership for funding in 2017.

The Elk Horn site in the Garden of Eden proposal was replanted on February 12th. This brought the number of measure trees back up to desired levels.

Spring treatments for the Rodeo study approved at the 2015 annual meeting were applied on April 15 at the Soper Wheeler site and April 22 on the Fruit Growers site.

The Co-op field trip scheduled for July 1st, with most stops located on the Eiler Fire out of Burney, had a good turnout with 15 Co-op member and guests attending. Stops included studies illustrating early Pindar GT applications, Pindar GT and GoalTender applications, windrow re-spreading, and

Milestone applications. The final stop was at an older plantation near the Sierra Pacific Industries mill at Burney. This stop illustrated some attempts at harsh site regeneration.

The late summer treatments of the Rodeo study were applied on August 27 at the Fruit Growers site and on September 1 on the Soper Wheeler site.

Evaluations of first year results from the Rodeo study were conducted on October 16 at the Fruit Growers site and October 22 at the Soper Wheeler site.

Steering Committee member Matt Busse made a presentation of the accomplishments and on-going projects of the Co-op to the California Forestry Association's Board of Directors on December 10th in Sacramento. Matt's report was well received by the group and several CFA staff members expressed an interest in having the Co-op expand its range of research to include California coast forests. This suggestion will be discussed at the annual meeting in 2016.

The year 2016 should be another busy one for the Co-op. New proposals are currently being submitted to the Co-op for funding consideration. Several funded study sites will have second year measurements taken. Based on the interest shown for field trips featuring Co-op study sites, another trip will be planned for 2016. Results from Co-op studies will continue to be presented at the Forest Vegetation Management Conference. Articles on research funded or partially funded by the Co-op are being featured in peer-reviewed journals on a regular basis.

2015 MEMBERSHIP

Land Manager Membership

- California Department of Forestry
- Fruit Growers Supply Co.
- Roseburg Resources Co.
- Sierra Pacific Industries
- Soper-Wheeler Co.
- Timber Products Co.
- W.M. Beaty & Associates, Inc.

Associate Corporate Membership

- Cal Forest Nurseries & Mountain Gate Gardens

Affiliate Membership

- Bayer CropScience
- Dow AgroSciences
- Silver Butte Timber Co.
- Thunder Road Resources

Supporting Members

- California Forestry Association
- PSW Research Station
- University of California
- USDA Forest Service

Sierra Cascade Intensive Forest Management Research Cooperative

Annual Meeting March 3, 2015

The 2015 annual meeting was held at the Forest Service office in Redding, CA on March 3, 2015. Sixteen Co-op members and guests attended.

The 2014 Annual Report was the first item of business. Membership status was discussed. About 90% of the members from 2014 have paid their 2015 dues. Those that have not paid to date indicated that their dues payments are on the way. There are currently sixteen member organizations in the Co-op.

The next item of business was a discussion on the budget. The Co-op ended 2014 with a surplus of $24,369. Dues received for 2015 at the time of the annual meeting totaled $56,000, with another $2,000 promised. To supplement the summary of the 2014 budget found in the Annual Report, spread sheets of the proposed budget/workload for 2015-2019 and the Co-op manager's time/contract costs through the same period were presented to the membership.

Since Co-op members make presentations (featuring data/results from Co-op funded studies) at almost all Forest Vegetation Management Conferences, Bob Amesbury suggested that it might be appropriate for the Conference to contribute to the Co-op. We would need to decide how much Co-op data would be made accessible to the Conference as a result of their contribution. The Co-op could encourage members of the Conference to submit proposals to the Co-op for possible funding. The Co-op membership agreed with this suggestion and the idea will be followed up by Scott Worden who is on the Forest Vegetation Management Conference Executive Board.

Plans for the 2015 Co-op field trip were discussed next. The membership definitely wanted a Co-op field trip in addition to the Weed Tour scheduled for July 15-16th. Two options that were left over from the possibilities discussed for the 2014 field trip were revisited. These included a trip based around the Ponderosa Fire (Matrix and Pindar GT trials; Cajun's sediment study; and operational studies on SPI ground) and a trip to Challenge Experimental Forest (25 year old LTSP site; fuel reduction study; and a Nelder Design study). The membership voted to have a field trip centered on the Day and Idler fires. Ed Fredrickson, Scott Carnegie, and Mark Gray will develop the stops and the agenda. The field trip is scheduled for May 27th.

The next item on the agenda was funded proposal updates. Ed Fredrickson reported on results for Proposal 13-01 Matrix Site Prep, Proposal 14-01 Pindar Over the Top, and Proposal 13-02 Pindar/Goaltender. Short summaries on the progress of Proposal 12-02 Garden of Eden and Proposal 13-03 Pondosa Remeasure were given by Jianwei Zhang. Matt Busse presented the results of the 2014 remeasurement of the brush on the

Agenda 2020 sites (Proposal 03-01). Based on a search of files, pre-study soils data were not collected. Matt is going to use his crew to collect current soil data and conifer measurements during 2015. Results will be presented to the full membership and should serve as a basis for determining how to proceed with this study. Executive summaries for the three studies updated by Ed are found in the 2014 Annual Report. Progress reports on Proposals 03-01 and 13-03 are found in the Annual Report Summary.

Tom Young reported on the status of the Timmer/Jopson study site (00-05). The study site was badly damaged during one of the fires in the Klamath River drainage occurring in 2014. The integrity of the study is no longer maintained with many of the conifers having been killed by the fire. The membership decided to discontinue the study. Fruit Growers Supply is now free to manage the area as the company sees fit. Scott Worden reported that the replication of this study that is located on Soper-Wheeler lands is experiencing problems with the fir trees included in the study. The pine is doing well. The Co-op will look at this replication this summer and report to the membership on conditions there. The third replication of this study was located on Boise Cascade lands in 2000 when they were a member of the Co-op. These lands have changed ownership a couple of times since establishment of the plots and the Co-op has lost contact with the current management.

Following the discussion of funded proposals, one new proposal was presented to the membership for possible funding in 2015. Ed Fredrickson presented a proposal for an herbicide trial using Rodeo over-the-top applications on Ponderosa pine, Douglas-fir and white fir. Mark Gray proposed a stock type trial for cedar and/or sugar pine using the guidelines developed by Tom Landry for stock type trials. He volunteered Sierra Pacific Industries lands for the trials. The membership was very interested in the proposal and decided to form a committee to develop a proposal for consideration of funding in 2017. Representatives from W.M. Beaty & Associates, Soper-Wheeler Co., and Silver Butte Timber Co. will join Mark on the committee.

After questions from members about the new proposal were addressed, it was decided that the voting membership would be canvassed by email to determine if the Co-op would fund the Rodeo proposal.

Scott Carnegie gave an update on the work that has been done by Ryan DeSantis on the Co-op website. Since the 2014 annual meeting, all Co-op publications and Annual Reports have been scanned and uploaded to the website. The current Membership Agreement and the Steering Committee membership have been posted on the website. There are still questions concerning what material on the website will be made accessible to members only. Other questions include how to organize and list publications, renaming funded proposals, etc. Scott Carnegie and the website committee are continuing to work on these items.

The final items of business were motions from Scott Worden concerning the Powers' scholarship fund and the proposed new California reforestation manual. Scott suggested that since Bob was such an important part of the Co-op, we make a one-time donation to the scholarship fund in honor of Bob. The membership present at the annual meeting agreed and it was decided to send an email to the full membership for their opinion on making a donation and the amount of the donation if they approved.

Scott's second motion concerned the proposed rewriting of the California reforestation manual. He felt the Co-op could contribute financially to this effort. A discussion from the membership resulted in this motion being withdrawn due to the lack of a clear understanding of how the rewrite was going to be funded, who was organizing the effort, etc.

The meeting adjourned at this time.

Sierra Cascade Intensive Forest Management Research Cooperative Proposals 13-03 and 14-02 Pondosa Remeasure/Soils

Principal Investigator: Jianwei Zhang

Title: Effect of Thinning and Soil treatments on Ponderosa Pine Plantations: 15 Year Results

Years Approved: 2013/2014

Managing forest plantations for high quality wood products often includes thinning to increase residual tree growth while simultaneously extracting biomass for energy. Ground-based heavy equipment used for thinning has been shown to compact soil and may affect site productivity. In natural forests, fuel reduction thinning or other forest restoration projects also face similar soil disturbance concerns. Numerous studies have shown that compaction persists for decades on skid trails on volcanic and granitic soils. Cumulative impacts of soil compaction over multiple rotations were shown for sandy soils in Australia and for silt loams in Louisiana. Soil compaction clearly persists. But its effect on tree productivity has mixed results; various research has shown a positive effect, no effect, and a negative effect from ground-based timber harvest. The discrepancy appears to relate to soil type and various topographic characteristics.

Whole-tree harvesting raises nutrient concerns as well. When trees are thinned from a plantation or a natural stand, a significant amount of nutrients can be removed, particularly in the nutrient-rich crown foliage. Although the thinning increases nutrient availability for residual trees, subsequent high demand of nutrients due to post-thinning leaf growth may cause temporary depletions of soil nutrients and temporary reductions in net primary productivity. However, many previous growth and yield studies demonstrate that a moderate thinning of an existing ponderosa pine stand would at least maintain the growth, if not increase it, as compared to unthinned stands. Results from the Long-Term Soil Productivity study network showed that young stand growth on whole-tree harvest plots did not significantly differ from growth in stem-only harvest plots across various species, at least for the first ten years.

The Study: The Pondosa study was established on a young plantation following a pre-commercial thinning. Several treatments were imposed, aiming to answer the following questions: (1) Did mechanized thinning compact the soil? (2) Did tillage mitigate it? (3) Did whole-tree harvest deplete the nutrients? (4) Did chip returns and fertilization mitigate nutrient depletion? And (5) was tree growth affected? We hypothesized that (a) mechanical thinning causes soil compaction; compaction reduces infiltration and root growth, and this would be observed as decreased tree growth. (b) Whole-tree harvesting removes sources of soil organic matter and nutrients, ultimately degrading soil fertility and water holding capacity, and therefore reduces tree growth.

The study was installed in 14 or 15-year old ponderosa pine plantations in 1998. The study was located near Pondosa, California at 1,160 to 1,270 m elevation on Roseburg Resources land east of Mr. Shasta. The study site was part of a 2,250 ha pine forest planted between 1981 and 1986 following the 1977 Pondosa Fire. Trees were mechanically planted in rows at about a 2.4 m by 3.0 m spacing. Seedling survival was very high. Crowns had closed after a decade in most of the plantations and a thinning was needed to sustain tree growth and vigor and to reduce fuels in this fire-prone area. These plantations were mechanically thinned after about 15 years using a 3-wheeled Morbark Wolverine shear and grapple skidder. Every third row was entirely removed, as were about half of the trees from the two adjacent rows. This left a residual density of 370-445 trees per ha. The clear-cut rows were concurrently used for traffic lanes for removing the cut tree stems. Biomass of the whole trees was chipped offsite and utilized for cogeneration energy production. The entire operation was a normal management project and the Pondosa study was installed within the project area.

Treatments: Four-main effect treatments were applied to four 0.4-ha plots within each of four blocks. In a second experiment, four sub-effect (after thinning with thinning chips returned) treatments were applied to four 0.1-ha plots adjacent to the main effect plots. The main effect treatments included: control (no treatment); T: thinning only with all biomass removed; T/S: thinning followed by sub-soiling in traffic lanes; and T/F/S: thinning followed by N/P fertilization in traffic lanes and sub-soiling. The sub-effect treatments included: T/C/S/R: thinned trees were chipped, returned and spread on traffic lanes, and then sub-soiled and rototilled; T/C/F/S/R: same as treatment above but traffic lanes also received N and P with the chips prior to the sub-soiling and rototilling; T/S/C/: traffic lanes were sub-soiled, then thinning chips were returned to the surface of the traffic lanes; and T/S/C/F: same as the treatment above except that the traffic lanes also received N and P with the chips.

Measurement sub-plots were established within all the treatment plots and all trees within these measurement plots were tagged. Diameter at breast height was measured in 1998, 2003, and 2013. Measurements for height were taken for every fifth tree using a height pole.

Soil samples were collected from three depths for soil physical and chemical analysis using a volumetric core sampler in 2004. Samples collected in 2014 were for chemical analysis only.

At each measurement, tree condition was recorded for each tree. Any trees with any dead foliage, branches, or bole pitch tubes attributed to insect attack were recorded as insect damage. Mortality was calculated by dividing number of dead trees in the plot by total trees.

Tree growth: Trees varied significantly in density, basal area, and volume among main-effect treatments in 1998 (Table 1). These differences mainly occurred in the control where no trees were removed compared to the other treatments. Generally, control plots had three times the number of trees, and double the basal area and volume as compared to other treatments. Height and QMD were not significantly different among main-effect treatments. None of the variables were statistically significant among sub-effect treatments in 1998.

Differences in PAI-QMD, PAI-height, PAI-BA, and PAI-volume were found to be significant among main-effect treatments (Figure 2). Among sub-treatments, only PAI-QMD varied significantly.

Insect damage and mortality: There were significant main-treatment effects in insect damage and mortality (Figure 3). Insect damage was primarily red turpentine beetle boring into boles of trees. Thin and post-thin treatments showed a significantly higher incidence of insect damage than controls (Figure 3A). Only the T/F/S treatment showed significantly higher mortality than the others including controls (Figure 3C). No difference in either insect damage or mortality was found among the sub-effect treatments (Figure 3B and 3D).

Soil bulk density and porosity: Location effects between traffic lanes and non-traffic lanes were not significant. None of the interactions between location and depth or treatment were significant.

Significant differences between soil depths were found for total bulk density, fine bulk density, and porosity in both main-effect plots and sub-effect plots measured in 2004 (Table 2). Soil at 20-30 cm differed from others in the main-effect plots, whereas in the sub-effect plots the only difference found was between 0-10 cm and 20-30 cm depths. All variables significantly varied only among the sub-effect treatments.

Soil carbon and nutrients: Differences were found to be significant in total P, but not in total N, C, or C/N among main-effect treatments. Yet, N, C, and C/N differed significantly among depths and among year by depth interactions, but P did not. Year effect was significant in N, P, and C/N.

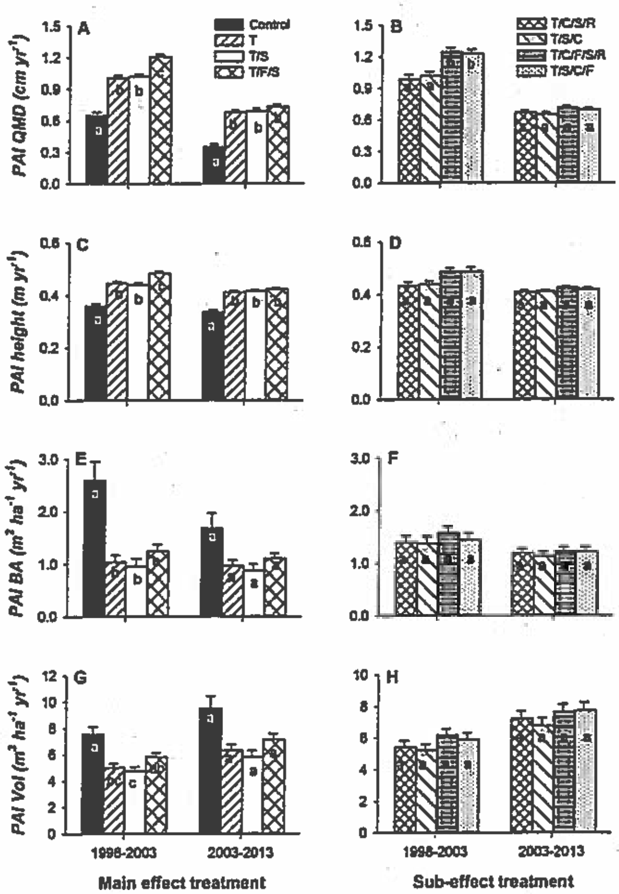
Among the sub-effect treatments, there were significant treatment effects in N and P, as well as depth effect and year affect in N, C, and C/N.

Regardless of main-effect treatments or sub-effect treatments, depth differences in N, C, and C/N generally occurred between 0-10 cm and other depths, with the top layer being more C and N enriched and having higher C/N ratios than lower depths (Table 3). The 2004 soil samples contained more N and P, less C and lower C/N than the 2014 soil.

Conclusions: Results indicate: (1) thinning by itself with no subsoiling did not compact the soil, but increased the growth rate of residual trees, although the periodic annual increment of basal area and volume were still higher in the control than other main-effect treatments; (2) neither subsoiling nor rototilling, both of which might mitigate soil compaction, enhanced tree growth; (3) short-term plantation growth was not improved with chip returns or chips with fertilization; (4) since thinning and soil treatments showed more insect damage and mortality, any management operations that involve cutting or damaging trees or roots should be avoided during active periods of bark beetle flight; (5) both thinning and soil treatments did not reduce carbon sequestration in the mineral soils. A lack of growth benefits from returning thinning chips, rototilling, and direct fertilization appeals to further study.

The complete report and all supporting data, including references, are available at the Co-op's office in Redding.

Figure 2. Periodic annual increment (least square means and standard errors) for QMD, height, basal area, and volume of ponderosa pine grown in main-effect and sub-effect treatment plots including control and various treatment combinations of thinning (T), sub-soiling (S), fertilization (F), chip returns (C), and rototilling (R) during 1998 t0 2003 and 2003 to 2013 growing periods. Means with different letter within either measuring period indicate difference at P<0.05.



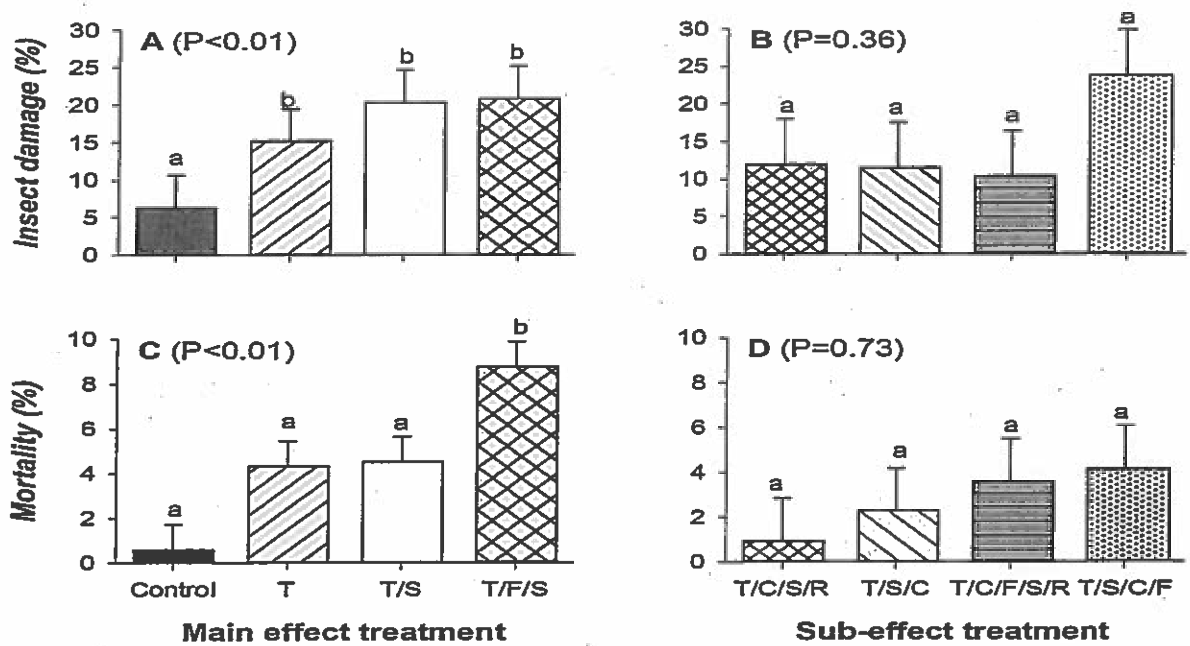


Figure 3. Insect damage and mortality (least square means and standard errors) of ponderosa pine grown in main-effect and sub-effect treatment including control and various treatment combinations as thinning (T), sub-soiling (S), fertilization (F), chip returns (C), and rototilling (R) in 2003. P-values are the probabilities (Pr>F) of testing H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$. Means with different letter indicate difference at $P < 0.05$.

Table 1. Post treatment means and standard errors (μ±SE) and probability (Pr>F) of testing H_0: $\mu_1 = \mu_2 = \mu_3 = \mu_4$ for trees per hectare, quadratic mean diameter (QMD), tree height, basal area (BA), and volume (Vol) measured immediately after treatments were applied in 1998.

Treatment	Trees ha^{-1}	QMD (cm)	Height (m)	BA (m^2 ha^{-1})	Vol (m^3 ha^{-1})
Main-effect					
Control	1354 (67)^a	15.3 (1.0)	5.9 (0.6)	24.6 (2.2)^a	50.9 (9.1)^a
T	429 (8)^b	16.6 (1.0)	6.3 (0.6)	9.4 (1.1)^b	20.7 (4.1)^b
T/S	414 (16)^b	16.4 (0.3)	6.2 (0.4)	8.8 (0.3)^b	18.7 (1.7)^b
T/F/S	453 (13)^b	16.5 (1.0)	6.2 (0.6)	9.8 (1.1)^b	21.1 (4.1)^b
Pr>F	<0.001	0.164	0.144	<0.001	<0.001
Sub-effect					
T/C/S/R	484 (29)	15.8 (0.3)	6.0 (0.4)	9.5 (0.6)	19.6 (2.2)
T/S/C	435 (23)	16.3 (0.8)	6.2 (0.5)	9.1 (1.0)	19.6 (3.7)
T/C/F/S/R	435 (31)	17.1 (1.3)	6.4 (0.6)	10.0 (1.3)	22.4 (5.0)
T/S/C/F	455 (35)	17.4 (0.4)	6.6 (0.4)	10.8 (0.9)	23.9 (2.7)
Pr>F	0.227	0.235	0.307	0.214	0.295

T = thin; S = sub-soiling; F = fertilization with N and P; C = chips returned; R = rototilled. Means with different letter within significant main-effect treatments indicate difference at P < 0.05. No comparisons were conducted within non-significant main- or sub-effect treatments.

Table 2. Treatment means with standard errors (μ±SE) and probability (Pr>F) from ANOVA for total bulk density (D_{bt}), fine bulk density (D_{bf}), and porosity of soils collected at three depths under various treatments in 2004, six years after treatments were applied in 1998.

Treatment		Depth	D_{bt} (Mg m^{-3})	D_{bf} (Mg m^{-3})	Porosity (%)
Main Effect	Control	0-10	1.05 (0.05)	1.01 (0.05)	57.3 (2.3)
		10-20	1.08 (0.03)	1.04 (0.03)	56.3 (1.4)
		20-30	1.11 (0.04)	1.06 (0.04)	55.0 (1.8)
	T	0-10	1.04 (0.03)	0.99 (0.03)	57.7 (1.5)
		10-20	1.08 (0.03)	1.02 (0.03)	56.4 (1.5)
		20-30	1.10 (0.03)	1.05 (0.04)	55.2 (1.5)
	T/S	0-10	1.04 (0.02)	0.99 (0.02)	57.9 (0.9)
		10-20	1.07 (0.02)	1.03 (0.03)	56.6 (1.2)
		20-30	1.10 (0.02)	1.06 (0.02)	55.5 (1.0)
	T/F/S	0-10	1.07 (0.02)	1.00 (0.02)	56.7 (1.0)
		10-20	1.09 (0.02)	1.03 (0.03)	56.0 (1.1)
		20-30	1.13 (0.02)	1.06 (0.03)	54.4 (1.1)
Pr>F	Treatment (Trt)		0.243	0.797	0.245
	Depth		<0.001	<0.001	<0.001
	Trt*Depth		0.999	1.000	0.999
Sub-effect	T/C/S/R	0-10	0.94 (0.06)	0.86 (0.08)	61.9 (2.8)
		10-20	1.03 (0.06)	0.95 (0.08)	58.1 (2.9)
		20-30	1.04 (0.06)	0.96 (0.08)	57.9 (2.9)
	T/S/C	0-10	1.07 (0.03)	1.00 (0.03)	56.7 (1.5)
		10-20	1.08 (0.05)	1.01 (0.06)	56.2 (2.3)
		20-30	1.12 (0.05)	1.05 (0.06)	54.6 (2.4)
	T/C/F/S/R	0-10	0.97 (0.05)	0.89 (0.06)	60.8 (2.3)
		10-20	1.03 (0.07)	0.96 (0.08)	58.4 (2.9)
		20-30	1.03 (0.05)	0.97 (0.06)	58.1 (2.4)
	T/S/C/F	0-10	1.04 (0.04)	0.98 (0.05)	58.0 (1.8)
		10-20	1.03 (0.04)	0.96 (0.05)	58.1 (1.9)
		20-30	1.03 (0.04)	0.97 (0.05)	58.1 (1.8)
Pr>F	Treatment (Trt)		0.001	0.001	0.001
	Depth		0.020	0.031	0.019
	Trt*Depth		0.467	0.369	0.463

T = thin; S = sub-soiling; F = fertilization with N and P; C = chips returned; R = rototilled.

Table 3. Soil total carbon (C), nitrogen (N), C/N ratio, and phosphorus (P) means and standard errors in main-effect and sub-effect treatments measured in six years (2004) and 16 years (2014) after the treatments installed.

Year	Element	Depth (cm)	Main effect treatment				Sub-effect treatment			
			Control	T	T/S	T/F/S	T/C/S/R	T/S/C	T/C/F/S/R	T/S/C/F
2004	C (Mg ha^{-1})	0-10	21.8 (2.3)	23.8 (1.0)	21.1 (1.3)	23.1 (1.4)	20.4 (1.5)	20.9 (0.5)	23.5 (1.0)	28.5 (1.8)
		10-20	15.8 (0.9)	15.7 (0.7)	17.3 (0.8)	17.2 (1.4)	16.2 (1.1)	16.1 (0.9)	20.0 (2.1)	18.8 (1.2)
		20-30	15.2 (1.8)	14.8 (1.5)	14.5 (0.5)	16.7 (1.5)	16.4 (3.4)	12.1 (1.9)	16.1 (1.4)	14.4 (1.7)
	N (Mg ha^{-1})	0-10	1.34 (0.07)	1.39 (0.04)	1.29 (0.05)	1.38 (0.06)	1.27 (0.10)	1.28 (0.04)	1.39 (0.03)	1.63 (0.09)
		10-20	1.12 (0.03)	1.16 (0.04)	1.15 (0.04)	1.20 (0.04)	1.11 (0.03)	1.09 (0.04)	1.30 (0.05)	1.20 (0.05)
		20-30	1.05 (0.06)	1.09 (0.04)	1.08 (0.02)	1.13 (0.05)	1.10 (0.07)	0.95 (0.06)	1.12 (0.03)	1.08 (0.04)
	C/N	0-10	16.2 (1.0)	17.2 (0.8)	16.4 (0.5)	16.6 (0.4)	16.3 (1.1)	16.4 (0.3)	16.9 (0.9)	17.5 (0.7)
		10-20	14.1 (0.7)	13.6 (0.3)	15.0 (0.3)	14.1 (0.8)	14.6 (1.3)	14.8 (0.6)	15.3 (1.3)	15.4 (0.4)
		20-30	14.4 (1.1)	13.4 (0.9)	13.5 (0.5)	14.7 (1.1)	14.6 (2.0)	12.5 (1.2)	14.3 (1.1)	13.2 (1.1)
	P (kg ha^{-1})	0-10	15.5 (3.3)	14.4 (2.1)	12.4 (1.2)	21.8 (5.0)	13.7 (3.7)	12.7 (2.4)	17.6 (2.5)	17.3 (5.1)
		10-20	14.7 (2.6)	11.9 (1.9)	11.8 (1.4)	18.6 (2.2)	14.0 (4.5)	9.7 (4.5)	16.4 (3.5)	14.7 (2.8)
		20-30	14.4 (1.8)	13.2 (1.9)	16.0 (1.5)	21.9 (4.5)	11.2 (1.3)	19.4 (7.1)	20.8 (3.8)	12.8 (1.8)
2014	C (Mg ha^{-1})	0-10	27.7 (5.0)	23.6 (2.4)	22.4 (1.3)	29.6 (4.7)	22.9 (3.1)	34.2 (4.0)	27.7 (4.6)	29.5 (4.9)
		10-20	16.9 (1.6)	19.0 (1.9)	17.3 (1.8)	18.2 (1.8)	19.8 (3.3)	18.4 (2.2)	19.7 (2.5)	23.6 (3.2)
		20-30	10.9 (1.1)	13.2 (2.1)	10.7 (0.8)	11.6 (1.0)	15.8 (4.0)	17.3 (4.2)	19.3 (3.4)	18.6 (3.5)
	N (kg ha^{-1})	0-10	1.27 (0.16)	1.13 (0.08)	1.09 (0.04)	1.34 (0.16)	1.17 (0.18)	1.38 (0.17)	1.34 (0.15)	1.36 (0.14)
		10-20	0.97 (0.07)	0.95 (0.06)	0.97 (0.07)	1.04 (0.08)	1.06 (0.18)	0.98 (0.06)	1.05 (0.11)	1.22 (0.10)
		20-30	0.73 (0.08)	0.81 (0.07)	0.79 (0.04)	0.85 (0.06)	0.79 (0.10)	0.90 (0.09)	0.92 (0.06)	1.00 (0.09)
	C/N	0-10	21.7 (2.5)	20.5 (0.9)	20.7 (0.9)	21.7 (1.0)	19.7 (0.7)	24.9 (0.8)	20.4 (1.6)	21.2 (1.5)
		10-20	17.8 (2.5)	19.7 (1.3)	17.6 (1.1)	17.4 (0.6)	18.7 (0.5)	18.7 (1.6)	18.8 (1.9)	19.3 (1.3)
		20-30	15.0 (0.7)	15.7 (1.6)	13.3 (0.5)	13.8 (0.5)	19.7 (3.6)	19.2 (4.5)	20.9 (3.6)	18.2 (2.0)
	P (kg ha^{-1})	0-10	12.3 (1.4)	10.3 (0.9)	9.9 (0.8)	22.1 (5.1)	9.8 (1.7)	10.1 (1.3)	36.8 (9.7)	17.2 (5.3)
		10-20	11.0 (1.3)	9.8 (0.6)	10.5 (0.8)	11.2 (1.5)	12.3 (2.3)	9.8 (3.2)	36.2 (13.1)	10.5 (1.0)
		20-30	12.1 (2.6)	9.9 (1.2)	10.2 (1.2)	10.2 (1.0)	10.4 (1.6)	10.1 (1.7)	15.2 (2.6)	13.0 (1.3)

T = thin; S = sub-soiling; F = fertilization with N and P; C = chips returned; R = rototilled.

Sierra Cascade Intensive Forest Management Research Cooperative Proposal 15-01
Glyphosate (Rodeo) Over the Top

Principal Investigator: Ed Fredrickson

Title: Efficacy and Conifer Tolerance of Rodeo with and without the Surfactant Penetron with Spring and Late Summer Applications Over the Top of Ponderosa Pine, Douglas-fir and White Fir

Year Approved: 2015

Executive Summary

Over the past several years, much of the attention with new chemicals has focused on new residual soil active products with improved conifer tolerance as potential replacements for atrazine in forestry. While several excellent products have proven effective, the majority of their activity is pre-emergent and often a combination treatment with glyphosate is necessary for complete knockdown of existing vegetation in a post-emergent setting. This is not a problem for pre-plant applications, but can be a potential issue with post-plant timings. The majority of glyphosate products on the market either do not have a broadcast release treatment on the label, or conifer tolerance is lost due to the type of surfactant formulated in the product.

For years foresters had no problems with broadcast applications over the top of western conifers with the original formulation of Roundup. When Roundup went off patent and the formulation was changed, the original tallow amine surfactant (Entry II) was removed and replaced with a different type of adjuvant. The result of this was a loss of conifer tolerance and the aerial release label for Roundup was discontinued. The many generic copies of Roundup that were produced over the years eventually removed their aerial release labels as well and contained surfactants that did not have the same conifer safety as Entry II. Entry II was manufactured as a stand-alone surfactant for several years before being discontinued. The only glyphosate formulations that could be safely applied over the top of existing conifers contained no surfactants in the formulations. This had a negative effect on efficacy, and no tallow-amine surfactant like Entry II was available on the market to add to it.

Currently there is a new surfactant by Loveland Industries on the marked that has recently been registered for use in forestry. Its trade name is Penetron and is supposedly a clone of Entry II. It has yet to be tested in an operational setting. Rodeo is the glyphosate formulation by Dow AgroSciences that is formulated without a surfactant. It does have an aerial release label, but applications over the top of conifers are restricted to plantations that

have been planted for at least a year prior to application. If the formulation of Penetron is true to the old Entry II formulation, it may be possible to make a glyphosate tank mix similar in conifer tolerance and efficacy to the original Roundup formulation. This may be of particular importance now, relevant to the new residual herbicides on the market that require the addition of glyphosate to achieve adequate brownout of existing herbaceous vegetation.

The ideal tank mix partner for early spring applications of either Esplanade F or Pindar GT would be glyphosate. The ability to go over the top of freshly planted seedlings would reduce future treatment needs and reduce application costs significantly. The addition of Rodeo would provide the post-emergent knock down required. The restriction on the Rodeo label currently prohibits applications to seedlings in their first growing season.

The objective of this study is to evaluate the partial contributions of rate, timing and surfactant on conifer tolerance and efficacy for ponderosa pine, Douglas-fir and incense cedar in their first growing season and to generate data to remove the first year restriction on the Rodeo label.

This trial will be replicated on two sites. Due to the inclusion of Douglas-fir and incense cedar, both sites should be in areas where these species naturally occur.

The trial will be a completely randomized block design with four replications per treatment. Plot size will be 12 feet by 36.3 feet (0.01 acres) and the center lines marked on each end with PVC. All plots will be planted prior to the application of herbicides in the spring of 2015. Seedlings and several planters are to be provided by the local cooperating timber company. Ten trees of each species will be planted in rows within the plots. Thunder Road Resources will be on site during planting to supervise.

Treatments will include: 0.75 qt/ac Rodeo; 1.5 qt/ac Rodeo; 0.75 qt/ac Rodeo + 5 oz/ac Penetron; 1.5 qt/ac Rodeo + 5 oz/ac Penetron; 0.75 qt/ac Rodeo + 10 oz/ac Penetron; 1.5 qt/ac Rodeo + 10 oz/ac Penetron; and a non-treated control. Each of these treatments will be applied in the spring and then in the fall.

Half of the plots will be treated several days after planting in the spring of 2015 prior to bud break with the other half being treated in the late summer of 2015 after bud set. All plots will be sprayed at 10 gallons per acre at 30 psi using a calibrated CO2 backpack boom sprayer with a 12 foot boom. All plots will be sprayed with one timed pass.

Evaluations will occur in the fall of 2015 and again in the fall of 2016. Due to the nature of glyphosate damage, no seedling measurements will be taken. All conifer assessments will consist of visual percent survival, percent brownout, and needle and bud damage ratings. Vegetation will be assessed as percent control by species.

All plot installation (with the exception of planting and seedling acquisition), evaluations, statistical analysis, and annual progress reports in the fall of 2015 and 2016 will be completed by Thunder Road Resources.

2015: Two study sites were chosen for this study. The first site is on property owned and managed by Fruit Growers Supply Company out of Hilt, California. The site is located in a recent wildfire approximately 30 miles west of Yreka, Ca. Elevation of the site is approximately 4000 feet on zero slope and a flat aspect. The site had been salvage logged after the fire and tractor piled. No further activity had occurred. The second site is on property owned and managed by Soper Wheeler Company out of Strawberry Valley, California. The site is approximately ten miles northwest of Strawberry Valley. The site is a clear-cut that was logged in 2013, tractor piled and ripped in 2014 and planted in 2015. The area where the trial was placed did not receive chemical treatments of any kind. Elevation of the site is approximately 3500 feet with five percent slope and a very slight southerly aspect.

The study design was the same for both sites with the exception that incense cedar was added to the Soper Wheeler site. Plot size was 10 feet by 25 feet (the original proposal was 12 feet by 36.3 feet). The Soper Wheeler site was planted on April 15 with 10 trees per species per plot of Styro 8 ponderosa pine, Douglas-fir and incense cedar. The Fruit Growers site was planted on April 22 with ten trees per species per plot of Styro 6 ponderosa pine and Douglas-fir. The seedlings were not measured at planting date due to all conifer assessments being strictly visual.

Two spray timings were utilized for this study. The first was an early spring timing applied immediately after planting on April 14 and April 22 and the second was after bud set in the late summer on September 1 and August 27 for the Soper Wheeler and Fruit Growers sites, respectively. All plots were sprayed at ten gallons per acre with a CO_2 powered backpack sprayer equipped with a ten foot boom (the original proposal was a twelve foot boom) and six 80015 nozzles. All applications occurred at 30 psi. The sprayer was calibrated prior to each application and all plots were sprayed with one timed pass.

Evaluations consisted of percent bare ground and percent cover by species for the vegetation assessments and survival, percent brownout and vigor rating for conifer assessments. First evaluations were conducted on October 16 and 22 for the Fruit Growers and Soper Wheeler sites, respectively. Final evaluations will occur in the fall of 2016.

Data were analyzed using SAS statistical software. Vegetation and seedling data were analyzed using analysis of variance. Treatments were compared using a Tukey's test with adjusted probabilities. Analyses utilized PROC MEANS, PROC MIXED and PROC GLIMMIX in SAS. PROC GLIMMIX was used when variances were unequal, and either the Poisson or gamma distribution was used. Where statements are made regarding statistically significant differences in this document, the alpha level is P <= 0.05.

Application timing and Rodeo rate had the largest influence on conifer tolerance at the Fruit Growers site. Surfactant and surfactant rate had a minor influence. Conifer damage was greatest in the spring treatments. Neither herbicide or surfactant rate had any significant influence on survival, percent brownout, or damage rating in the late summer timing for either ponderosa pine or Douglas-fir.

In the spring treatments, the lower rate of Penetron did not significantly affect survival, brownout or damage rating for Douglas-fir seedlings compared to the no surfactant treatments. Adding 10 ounces of Penetron per quart of Rodeo to the high Rodeo rate did significantly increase the damage rating over the no surfactant and the 5 ounce Penetron treatments with Douglas-fir. Adding a surfactant at any rate, did not significantly affect survival, brownout or damage rating for ponderosa pine (Tables 1 & 2).

Douglas-fir had lower survival, higher percent brownout and higher damage ratings over all treatments when the Rodeo rate was increased from 0.75 to 1.5 quarts per acre in the spring. Douglas-fir survival was significantly lower with the high rate of Rodeo and the high rate of Penetron than all other treatments. Douglas-fir brownout was also significantly greater with the high rates of Rodeo and Penetron than the non-treated controls, the low rate of Rodeo alone in the spring and most of the fall treatments with the exception of one. Damage ratings for Douglas-fir were highest again with the high rates of Rodeo and Penetron in the spring and were significantly different from all other treatments. Damage ratings were significantly higher with all spring high rate Rodeo treatments than all fall treatments and non-treated controls with the exception of the high rate of Rodeo in the fall with 5 ounces of Penetron. Rate had a much more pronounced effect on ponderosa pine. Survival decreased and percent brownout and damage ratings increased across all treatments when the Rodeo was increased. Differences due to rate in the no surfactant treatments were not significant for survival or brownout with ponderosa pine. The treatments with surfactant were. Although damage ratings increased with increasing rate for ponderosa pine, the differences were not significant.

Vegetation on the Fruit Growers site was mainly limited to herbaceous vegetation. At the time of treatment in the spring, the majority of herbaceous vegetation had not germinated yet, and by the late summer treatment most of it had senesced for the season. As a result, Rodeo applications did little to affect the presence of vegetation on site for these timings. Only percent ground cover was analyzed because of this. Treatment did not significantly affect percent bare ground, however, spring treatments did have more bare ground on average than fall treatments or the non-treated controls (Table 1).

The factor with the largest influence on conifer tolerance on the Soper Wheeler site was timing. Herbicide and surfactant rate also influenced damage but to a lesser degree. Conifer damage was much greater in the spring treatments. Neither herbicide or surfactant rate had any significant influence on survival, brownout or damage rating for ponderosa pine, Douglas-fir or incense cedar in the late summer timing.

The effects of adding Penetron at any rate in the spring were not statistically significant, but some general trends were apparent. The addition of surfactant to the low rate of Rodeo made little difference in survival, brownout or damage rating for ponderosa pine, Douglas-fir or incense cedar (Tables 3 & 4). Either rate of Penetron added to the high Rodeo rate decreased survival and increased percent brownout and damage ratings for ponderosa pine. Only the high rate of Penetron showed similar trends on Douglas-fir. The addition of Penetron at either rate did not seem to affect incense cedar.

The general trend in the spring showed that increasing Rodeo rate decreased survival and increased percent brownout and damage rating for ponderosa pine, Douglas-fir and incense cedar. However, increasing rodeo rate only produced significant differences for survival in the 10 ounce Penetron treatments.

The vegetation trends on the Soper Wheeler site were similar to the Fruit Growers site. Vegetation present was primarily herbaceous that was affected by the timing of application. Only percent bare ground was analyzed. Treatment did not significantly affect percent bare ground again due to not much vegetation being present at the time of application in the spring, and well into senescence at the late summer timing (Table 3). Treatments in the spring generally did have more bare ground than the late summer treatments, but not significantly.

It appears from the first year data that applications of Rodeo with or without Penetron in the spring produce too much conifer damage to be of practical value. Conifer tolerance did increase significantly by the late summer timing. Applications at this timing at either rate of Rodeo with or without Penetron appear to be possible. This could potentially have significant implications regarding aerial release treatments in first year plantations.

Treatment	% Bare Ground	Doug Fir % Survival	Doug Fir % Brown Out	Doug Fir Damage Rating
0.75 qts Rodeo - Spring	87.5 (3.2) a	95.0 (2.9) a	6.3 (3.8) bc	1.3 (0.3) bc
1.5 qts Rodeo - Spring	91.5 (4.3) a	80.0 (5.8) ab	26.3 (6.6) ab	5.0 (1.5) b
0.75 qts Rodeo + 5 oz Penetron/qt - Spring	95.0 (0.0) a	87.5 (7.5) a	12.5 (7.5) abc	2.8 (1.2) bc
1.5 qts Rodeo + 5 oz Pendetron/qt - Spring	96.8 (0.6) a	82.5 (6.3) ab	23.8 (6.6) abc	5.0 (1.2) b
0.75 qts Rodeo + 10 oz Penetron/qt - Spring	94.3 (1.5) a	92.5 (4.8) a	10.0 (5.4) abc	1.3 (0.3) bc
1.5 qts Rodeo + 10 oz Penetron/qt - Spring	93.0 (2.7) a	60.0 (10.8) b	48.8 (11.6) a	6.8 (1.1) a
0.75 qts Rodeo - Fall	83.8 (5.2) a	97.5 (2.5) a	3.8 (2.4) bc	0.5 (0.3) c
1.5 qts Rodeo - Fall	90.8 (2.7) a	100.0 (0.0) a	0.0 (0.0) c	0.5 (0.3) c
0.75 qts Rodeo + 5 oz Penetron/qt - Fall	87.0 (6.3) a	92.5 (4.8) a	7.5 (4.8) bc	0.8 (0.3) c
1.5 qts Rodeo + 5 oz Pendetron/qt - Fall	78.3 (8.4) a	92.5 (4.8) a	11.3 (4.7) abc	2.5 (1.2) bc
0.75 qts Rodeo + 10 oz Penetron/qt - Fall	86.0 (7.3) a	100.0 (0.0) a	0.0 (0.0) c	0.3 (0.3) c
1.5 qts Rodeo + 10 oz Penetron/qt - Fall	89.5 (2.6) a	95.0 (5.0) a	5.0 (5.0) bc	0.8 (0.5) c
Control	85.5 (7.0) a	95.0 (2.9) a	7.5 (4.8) bc	1.0 (0.7) c

Table 1. Fruit Growers year one percent bare ground and Douglas-fir percent survival and brownout and damage rating for the 2015 Rodeo Release trial. Standard errors are in parenthesis. Means with the same letter are not significantly different ($P<=0.05$).

Treatment	P Pine % Survival	P Pine % Brown Out	P Pine Damage Rating
0.75 qts Rodeo - Spring	72.5 (11.1) ab	43.8 (6.6) ab	5.0 (1.6) ab
1.5 qts Rodeo - Spring	52.5 (16.5) b	58.8 (15.3) a	7.5 (1.2) a
0.75 qts Rodeo + 5 oz Penetron/qt - Spring	87.5 (4.8) a	18.8 (5.5) bc	4.0 (1.2) ab
1.5 qts Rodeo + 5 oz Pendetron/qt - Spring	47.5 (10.3) b	61.3 (10.9) a	8.5 (0.3) a
0.75 qts Rodeo + 10 oz Penetron/qt - Spring	97.5 (2.5) a	8.8 (4.3) cd	3.0 (1.1) abc
1.5 qts Rodeo + 10 oz Penetron/qt - Spring	42.5 (17.0) b	62.5 (17.0) a	8.0 (1.0) a
0.75 qts Rodeo - Fall	97.5 (2.5) a	3.8 (2.4) cd	0.3 (0.3) c
1.5 qts Rodeo - Fall	100.0 (0.0) a	0.0 (0.0) d	0.0 (0.0) c
0.75 qts Rodeo + 5 oz Penetron/qt - Fall	100.0 (0.0) a	0.0 (0.0) d	0.0 (0.0) c
1.5 qts Rodeo + 5 oz Pendetron/qt - Fall	97.5 (2.5) a	2.5 (2.5) d	0.8 (0.5) bc
0.75 qts Rodeo + 10 oz Penetron/qt - Fall	97.5 (2.5) a	2.5 (2.5) d	0.8 (0.3) bc
1.5 qts Rodeo + 10 oz Penetron/qt - Fall	100.0 (0.0) a	1.3 (1.3) d	0.3 (0.3) c
Control	100.0 (0.0) a	1.3 (1.3) d	1.3 (1.3) c

Table 2. Fruit Growers year one ponderosa pine percent survival and brownout and damage rating for the 2015 Rodeo Release trial. Standard errors are in parenthesis. Means with the same letter are not significantly different ($P<=0.05$).

Treatment	% Bare Ground	Doug Fir % Survival	Doug Fir % Brown Out	Doug Fir Damage Rating
0.75 qts Rodeo - Spring	82.5 (5.2) a	97.5 (2.5) a	5.0 (2.0) a	1.0 (0.4) a
1.5 qts Rodeo - Spring	91.3 (2.4) a	92.5 (4.8) a	26.3 (11.4) a	1.3 (0.5) a
0.75 qts Rodeo + 5 oz Penetron/qt - Spring	88.8 (3.2) a	92.5 (7.5) a	12.5 (7.8) a	2.5 (1.2) a
1.5 qts Rodeo + 5 oz Pendetron/qt - Spring	93.8 (1.3) a	90.0 (4.1) a	10.0 (3.5) a	1.8 (0.5) a
0.75 qts Rodeo + 10 oz Penetron/qt - Spring	94.8 (2.0) a	90.0 (10.0) a	11.3 (9.7) a	2.8 (1.8) a
1.5 qts Rodeo + 10 oz Penetron/qt - Spring	91.0 (3.5) a	65.0 (11.9) a	38.8 (12.1) a	4.8 (1.7) a
0.75 qts Rodeo - Fall	91.8 (2.7) a	95.0 (2.9) a	6.3 (2.4) a	1.0 (0.4) a
1.5 qts Rodeo - Fall	93.5 (2.0) a	97.5 (2.5) a	5.0 (3.5) a	0.8 (0.5) a
0.75 qts Rodeo + 5 oz Penetron/qt - Fall	78.8 (14.7) a	90.0 (7.1) a	15.0 (8.7) a	2.3 (1.3) a
1.5 qts Rodeo + 5 oz Pendetron/qt - Fall	89.5 (3.1) a	95.0 (2.9) a	11.3 (2.4) a	2.0 (0.0) a
0.75 qts Rodeo + 10 oz Penetron/qt - Fall	88.8 (4.7) a	90.0 (4.1) a	10.0 (4.1) a	1.0 (0.4) a
1.5 qts Rodeo + 10 oz Penetron/qt - Fall	90.0 (5.3) a	100.0 (0.0) a	20.0 (6.1) a	2.5 (1.2) a
Control	70.0 (14.1) a	77.5 (19.3) a	23.8 (20.6) a	2.5 (2.2) a

Table 3. Soper Wheeler year one percent bare ground and Douglas-fir percent survival and brownout and damage rating for the 2015 Rodeo Release trial. Standard errors are in parenthesis. Means with the same letter are not significantly different ($P<=0.05$).

Treatment	P Pine % Surv	P Pine % Brown Out	P Pine Damage Rating	Inc Cedar % Surv	Inc Cedar % Brown Out	Inc Cedar Damage Rating
0.75 qts Rodeo - Spring	87.5 (12.5) ab	17.5 (12.7) ab	3.8 (1.8) ab	65.0 (5.6) ab	48.8 (17.1) ab	6.3 (1.6) abcd
1.5 qts Rodeo - Spring	77.5 (11.1) abc	26.3 (11.4) ab	4.3 (1.5) ab	47.5 (14.4) b	66.3 (10.7) a	7.0 (1.7) abc
0.75 qts Rodeo + 5 oz Penetron/qt - Spring	75.0 (13.2) abc	28.8 (12.6) ab	5.8 (1.3) ab	57.5 (14.9) ab	63.8 (6.3) a	7.8 (0.6) ab
1.5 qts Rodeo + 5 oz Pendetron/qt - Spring	45.0 (6.5) c	55.0 (6.5) a	8.5 (0.3) a	50.0 (5.8) ab	58.8 (5.2) a	8.5 (0.3) a
0.75 qts Rodeo + 10 oz Penetron/qt - Spring	80.0 (5.8) ab	20.0 (5.8) ab	3.3 (1.9) ab	72.5 (17.0) ab	45.0 (13.2) ab	5.3 (1.9) abcd
1.5 qts Rodeo + 10 oz Penetron/qt - Spring	52.5 (13.1) c	53.8 (12.0) a	7.8 (1.0) a	45.0 (3.2) b	67.5 (11.1) a	8.0 (0.7) ab
0.75 qts Rodeo - Fall	92.5 (4.8) a	8.8 (4.3) b	1.3 (0.3) ab	100.0 (0.0) a	6.3 (6.3) c	0.8 (0.5) d
1.5 qts Rodeo - Fall	97.5 (2.5) a	2.5 (2.5) b	1.0 (0.7) b	95.0 (2.9) ab	8.8 (1.3) abc	1.5 (0.3) cd
0.75 qts Rodeo + 5 oz Penetron/qt - Fall	100.0 (0.0) a	1.3 (1.3) b	1.3 (1.3) b	95.0 (2.9) ab	10.0 (3.5) abc	1.5 (0.5) cd
1.5 qts Rodeo + 5 oz Pendetron/qt - Fall	100.0 (0.0) a	2.5 (1.4) b	0.5 (0.3) b	95.0 (2.9) ab	10.0 (2.0) abc	2.0 (0.0) bcd
0.75 qts Rodeo + 10 oz Penetron/qt - Fall	97.5 (2.5) a	3.8 (3.8) b	0.5 (0.5) b	95.0 (2.9) ab	12.5 (6.0) abc	1.3 (0.5) d
1.5 qts Rodeo + 10 oz Penetron/qt - Fall	100.0 (0.0) a	1.3 (1.3) b	0.3 (0.3) b	100.0 (0.0) a	8.8 (2.4) abc	1.3 (0.3) cd
Control	90.0 (10.0) a	10.0 (10.0) b	2.0 (2.0) b	100.0 (0.0) a	8.8 (5.2) bc	1.0 (0.6) d

Table 4. Soper Wheeler year one ponderosa pine and incense cedar percent survival and brownout and damage rating for the 2015 Rodeo Release trial. Standard errors are in parenthesis. Means with the same letter are not significantly different (P<=0.05).

Sierra Cascade Intensive Forest Management Research Cooperative Proposal 14-01
Pindar GT Over the Top

Principal Investigator: Ed Fredrickson

Title: Over The Top Conifer Tolerance and Post Emergent Vegetation Control with Pindar GT on Sugar Pine, Incense Cedar and Ponderosa Pine Seedlings, Pre and Post Budbreak with and without Surfactant

Year Funded: 2014

Executive Summary:

Over the last several decades, mixed conifer plantations have become more and more common due to better planting stock, disease resistant seed and better vegetation management practices more conducive to herbicide intolerant species. These vegetation management practices are often more costly than standard site preparation applications due to the necessity of having to treat by directed hand treatments opposed to broadcast helicopter or ground applications. Residual herbicides that have tolerance to sensitive species such as sugar pine, incense cedar, western larch, Douglas-fir and white fir are lacking.

Historically, the site preparation herbicide of choice has been hexazinone for most situations. However, if hexazinone sensitive species are present on site such as those listed above, hexazinone either cannot be used or if used, some level of conifer damage is accepted by the land manager as a result of the application. Currently, the cost of hexazinone is becoming prohibitive as well.

Recent trial work since 2011 has shown that applications of Pindar GT (oxyflourfen + penoxulam) can provide both adequate vegetation control and conifer tolerance to hexazinone sensitive species when applied as a pre-emergent application or when glyphosate is added to the treatment to burn down any existing vegetation. Pindar GT has also been shown to be safe when applied as an "over the top" application to established ponderosa pine, Douglas-fir and white fir seedlings immediately after planting. No glyphosate was included in these applications. These trials were still a pre-emergent timing on herbaceous vegetation and brush.

To date, no trial work has been conducted with Pindar GT over the top of sugar pine or incense cedar. There is also no data from a forestry site that evaluate the potential of Pindar GT to control established vegetation without the aid of glyphosate.

The stated objective of this study is to evaluate conifer tolerance of sugar pine, incense cedar and ponderosa pine pre and post bud break with "over the top" applications of Pindar GT with and without surfactant to assess post emergent vegetation control. This proposal is for a trial that would evaluate the conifer tolerance of Pindar GT when applied over the top of sugar pine, ponderosa pine and incense cedar applied at two timings (pre and post bud break). The trial would also evaluate the ability of Pindar GT to control emerged vegetation. Applications would include treatments with and without surfactant,

both to assess the partial contribution of surfactant on vegetation control and conifer tolerance.

This proposal is for two sites, one on the northern end of the sugar pine range and a second site in the southern Sierra Nevada Range. The sites required would be either a recent wildfire or clearcut that has not had any prior chemical vegetation management treatments. The site should be flat to 20 percent slope, not encumbered by slash or large rocks and have good access.

The study design will be a completely randomized block design with four replications. Plot size will be 12' x 36' (0.01 acre). Plots will be planted with 10 trees each of sugar pine, ponderosa pine and incense cedar. Stock type will be dependent on what is operationally planted by the cooperators. Seedlings and three planters will be provided by the timber company supplying the site. Planting will be supervised by Thunder Road Resources.

The trial will consist of two spray timings. The first will be shortly after planting as soon as the herbaceous vegetation germinates, but prior to conifer bud break. If conifer bud break appears to be near and vegetation has not germinated yet, the pre bud break timing will be applied regardless. The second spray timing will be post bud break after a good influx of vegetation has germinated. Treatments will consist of three individual rates of Pindar GT with and without 0.25 percent R-11. All plots will be sprayed at 10 gallons per acre at 30 psi with a 12 foot CO_2 powered backpack boom sprayer. All plots will be sprayed with one timed pass and the sprayer will be calibrated prior to application. All chemicals will be provided by Dow AgroSciences.

All seedlings will be initially measured for caliper and height at planting. Total percent cover and percent cover by species will also be recorded at the time of each application. Plots will be evaluated at the end of the first and second growing seasons. First season evaluations will consist of ocular data only, including percent bare ground and percent cover by species for vegetation assessments. Seedling data collected in first season will be percent survival, percent brownout and needle and bud damage ratings. Second season evaluations will consist of all the above measurements, but seedlings will be measured for caliper and height and stem volumes will be calculated.

A written progress report will be delivered to the group after the first year evaluation prior to the scheduled business meeting to allow time for review. An oral report will be given to the membership at the annual meeting following the first year evaluation. The final written report will be delivered after the second year evaluation, also prior to the next annual meeting at which time a final oral report will be delivered.

2014: Two sites were chosen for this trial. The first is located near Sonora, California in the Rim Fire on land owned and managed by Sierra Pacific Industries. The site is at approximately 4800 feet elevation with five to fifteen percent slope and an easterly aspect. The area was burned by wildfire in the summer of 2013, subsequently logged and ripped in the fall of 2013. No chemical site preparation was applied to the site. The second site is near

Whitmore, California also on land owned and managed by Sierra Pacific Industries. The unit is a clearcut that was logged in the fall of 2013. It had been pre-harvest sprayed with glyphosate and imazapyr in the summer of 2011. No mechanical site preparation was applied to the site. The area is approximately 4900 feet elevation with zero to five percent slope and a slight northerly aspect.

All plots were planted with 10 trees each of ponderosa pine, incense cedar and sugar pine. The Sonora site was planted on March 27th, 2014 and the Whitmore site was planted on April 4th, 2014. Planting stock consisted of styro 5 ponderosa pine, styro 6 incense cedar and styro 8 sugar pine from Cal Forest Nursery on the Whitmore site. The Sonora site was planted with ponderosa pine and incense cedar 1-0 bare root seedlings from Fowler Nursery and styro 8 sugar pine from Cal Forest. There was a nursery issue with the bare root ponderosa pine on the Sonora site. Most of the trees died before the second application, and the ponderosa pine were eliminated from the study on that site. All seedlings were measured at planting for caliper and height.

Two spray timings were utilized in this trial, a pre and post bud break timing. The pre bud break timing was applied the day after planting and the post bud break timing was several weeks later when trees had actively started height growth and new leaders were present. Treatments consisted of three rates of Pindar GT alone at three, four and a half, and six pints per acre, with and without 0.25 % of the non-ionic surfactant R-11 applied at both timings. The Sonora site was sprayed on March 27th, 2014 and May 2nd, 2014, whereas the Whitmore site was sprayed on April 7th, 2014 and May 16th, 2014. No Accord XRT II was included in these applications due to the applications being over the top of freshly planted trees.

Evaluations consisted of the previously mentioned seedling measurements and ocular evaluations at the end of the first growing season including percent bare ground, percent total cover, percent cover by species, percent survival, percent brownout and a seedling vigor rating. Evaluations at the end of the second growing season will include the same, plus caliper, height and stem volume measurements.

Data were analyzed using SAS statistical software. Vegetation and seedling data were analyzed using analysis of variance. Treatments were compared using a Tukey's test with adjusted probabilities. Initial seedling size parameters were used as covariates within the ANOVA' for height, caliper and volume. Analyses for size were weighted by the number of surviving seedlings in each plot. Least squared means for size included adjustments for the covariates, which resulted in some differences from the raw data means. Analyses utilized PROC MEANS, PROC MIXED and PROC GLIMMIX in SAS. PROC GLIMMIX was used when variances were unequal, and either the Poisson or gamma distribution was used. Where statements are made regarding statistically significant differences is this document, the alpha level is $P <= 0.05$.

Of the two sites, the Sonora site had the most vegetative cover (Table 1). At Sonora, all treatments increased percent bare ground and decreased total cover compared to the non-treated controls although not all treatments were significantly different. All treatments had significantly more bare ground than the non-treated controls with the exception of the middle rate of Pindar GT with no surfactant at the post bud break timing. Only the two lower rates of Pindar GT with no surfactant and the two highest rates of Pindar GT with a surfactant at the pre bud break timing had significantly less cover than the non-treated controls. No herbicide treatments significantly differed from each other regarding either percent bare ground or total cover.

All treatments at Sonora significantly reduced the amount of Spanish clover which was the predominant vegetation on the site compared to the non-treated controls with the exception of the lowest rates of Pindar GT applied post bud break either with or without a surfactant. All herbicide treatments had lower cover values for Epilobium sp. and hedge parsley than the non-treated controls but not significantly.

While not significantly different, there is a trend that the pre-emergent application timing provided better control than the post-emergent timing. The addition of surfactant did not make a significant difference in control.

At the Whitmore site, percent bare ground ranged from ninety five to one hundred percent and percent total cover was less than five percent for all treatments, apparently carry over from the pre harvest application of imazapyr and glyphosate in 2011 (Table 3). While there were some significant differences, they appear to be an anomaly based on low variation around the mean. General tends showed that all treatments had slightly more bare ground, less total cover and less bull thistle cover than the non-treated, but only slightly.

Conifer tolerance was excellent for all herbicide treatments at both sites. At Sonora, percent survival of incense cedar did not significantly vary among treatments (Table 2). However, sugar pine survival was significantly higher in all herbicide treatments compared to the non-treated controls by a large margin. There were no significant differences in percent survival among treatments at the Whitmore site for any species (Tables 4 and 5). Over ninety percent survival was observed for all species on this site.

Percent brownout and damage ratings showed significant differences at the Sonora site. All herbicide treatments in the post bud break timing either with or without surfactant had significantly less brownout and damage than the non-treated controls or any of the pre bud break treatments with the exception of the middle rate of Pinder GT without a surfactant for incense cedar. Sugar pine percent brownout was significantly lower in the herbicide treatments compared to the non-treated controls with the exception of the high rate of Pindar GT with no surfactant in the pre bud break timing and the middle rate of Pindar GT with no surfactant in the post bud break timing. Sugar pine damage ratings were lower in the herbicide treatments compaed to the non-treated controls, however, only the middle rate of Pindar GT with no surfactant and the two highest rates with surfactant in the pre bud break timing and the high rate of Pindar GT with no surfactant and the two highest rates with surfactant in the post bud break timing were significantly different. Neither brownout or damage rating significantly differed among treatments at the Whitmore site.

Although the Whitmore site produced little vegetative data, The Sonora site showed some valuable trends. It appears that Pindar GT when used alone may be more effective as a pre-emergent treatment than post. The addition of surfactant to either timing had little if any effect on efficacy. Competing vegetation had a significant effect on sugar pine survival.

The conifer tolerance data in this trial are of particular importance. It appears that Pindar GT has a level of conifer safety that is equal to or better than atrazine. Even at a 2X operational rate, pre or post bud break and with or without a surfactant, conifer tolerance was extremely high for all species. This is especially remarkable considering sugar pine and incense cedar are two of the most intolerant species to hexazinone, which has been the operational standard for decades. The 2013 trial also showed high tolerance for Douglas-fir and white fir, which also tend to be hexazinone intolerant. It does appear that there is a suitable herbicide for herbaceous and pre-emergent woody brush site preparation, where mixed conifer forests are established.

2015: Vegetation had pretty much fully recovered at the Sonora site by the end of the second growing season (Table 6). No herbicide treatments were significantly different from each other for percent bare-ground, annual grass cover or Spanish clover cover. However, the three and six pint rates of Pindar GT applied pre-bud-break with R-11 had the highest percent bare-ground at the end of the second growing season and were the only herbicide treatments with significantly more than the non-treated controls. In general, the pre-bud-break treatments tended to have less vegetation than the post-bud-break treatments at the end of year two.

Marestail cover tended to be higher in the pre-bud-break application timing, but only the low rate of Pindar GT without R-11 and the mid-rate with R-11 had significantly more marestail cover than most of the post-bud-break treatments and the non-treated control. This makes sense as marestail likes disturbed areas with less vegetation. Therefore, higher percent covers in the post-bud-break treatments are less suitable for marestail.

Survival was not affected by treatment for incense cedar (Table 7). Sugar pine survival was significantly better with most herbicide treatments than the non-treated controls. No herbicide treatments were significantly different from each other. Survival tended to be higher in the pre-bud-break applications where control was best. Percent brownout or damage ratings did not differ significantly by treatment for either incense cedar or sugar pine, although the non-treated control had the worst brownout by far for sugar pine.

Neither caliper, height or stem volume were significantly affected by treatment for incense cedar or sugar pine (Tables 8 & 9). Although not significantly different, the non-treated controls had the smallest values for caliper, height and stem volume for both species. The lack of significance is primarily due to variability of initial seedling size which was significant and was used as a covariate in the analysis.

The Whitmore site remained very clean throughout the second growing season (Table 10). The entire clear-cut had very little cover other than bull thistle. The non-treated controls had the least bare-ground, but no herbicide treatments were significantly different from the non-treated controls. Bull thistle cover did not vary significantly by treatment.

Survival, percent brownout, damage rating, height and stem volume for ponderosa pine, sugar pine and incense cedar were not significantly affected by treatment (Tables 10, 11, & 12).

Overall, the Sonora site was the only one that gave a good assessment of vegetation control. The first year data showed better control with pre-bud-break applications compared to post, but by the end of the second growing season, both application timings looked about the same. Vegetation had vigorously re-invaded previously bare plots by the end of the second year.

It appears from this data and other that Pindar GT applied as a pre-emergent treatment will give good season-long control during the first year. When applied here at the post-bud-break timing when weeds were fully emerged, control was not as good. The addition of R-11 only slightly improved control and not significantly. It may be that another type of adjuvant such as a methylated seed oil or silicon-based adjuvant may improve control more, but further testing is necessary.

Conifer tolerance at either site with all species tested here was not negatively affected by Pindar GT rate, application timing, or addition of R-11. The safety observed with all species, even at high rates in a post-bud-break timing with a surfactant, is truly incredible. These data correspond well to other studies that have shown similar tolerance in redwood and western larch, two inherently intolerant conifers.

The 2015 measurements/analysis are the final work on this proposal. The complete report and all supporting data are available at the Co-op office in Redding.

Treatment	% Bare Ground	% Cover Spanish Clover	% Cover Mares Tail	% Cover Ann. Grass
3 pt Pindar GT - Pre	25.0 (11.7) ab	21.3 (5.9) a	25.0 (10.2) a	12.5 (5.8) a
4.5 pt Pindar GT - Pre	18.8 (10.5) ab	1.8 (1.2) a	6.5 (4.6) ab	53.8 (18.2) a
6 pt Pindar GT - Pre	26.3 (18.2) ab	7.0 (3.4) a	10.0 (7.1) ab	40.0 (18.7) a
3 pt Pindar GT + 0.25% R-11 - Pre	10.0 (5.0) ab	11.0 (8.0) a	2.5 (1.4) b	60.0 (17.8) a
4.5 pt Pindar GT + 0.25% R-11 - Pre	32.5 (11.9) a	10.0 (6.8) a	15.3 (8.8) a	23.8 (15.6) a
6 pt Pindar GT + 0.25% R-11 - Pre	45.0 (10.2) a	3.8 (2.4) a	10.3 (6.9) ab	23.8 (11.4) a
3 pt Pindar GT - Post	16.3 (8.5) ab	16.8 (14.4) a	3.0 (2.4) b	42.5 (19.0) a
4.5 pt Pindar GT - Post	12.5 (5.2) ab	6.8 (4.5) a	7.5 (6.0) ab	61.3 (20.0) a
6 pt Pindar GT - Post	23.8 (17.7) ab	0.8 (0.5) a	5.0 (5.0) b	52.5 (23.3) a
3 pt Pindar GT + 0.25% R-11 - Post	28.8 (11.6) ab	8.8 (5.9) a	4.3 (3.6) b	22.5 (6.0) a
4.5 pt Pindar GT + 0.25% R-11 - Post	21.3 (1.5) ab	15.8 (5.9) a	3.8 (2.2) ab	43.8 (14.0) a
6 pt Pindar GT + 0.25% R-11 - Post	32.5 (14.5) ab	6.3 (3.8) a	1.8 (1.2) b	23.8 (3.8) a
Control	6.3 (6.3) b	33.8 (19.0) a	0.25 (0.25) b	50.0 (16.3) a

Table 6. Sonora year two percent bare ground and percent cover means for the 2014 spring over the top Pindar GT release trial. Pre and Post refer to pre and post bud break application timings. Standard errors are in parenthesis. Means with the same letter are not significantly different (P<=0.05).

	Incense Cedar		Sugar Pine	
Treatment	% Surv	% Br Out	% Surv	% Br Out
3 pt Pindar GT - Pre	42.5 (12.5) a	58.8 (12.6) a	67.5 (13.8) a	33.8 (12.8) a
4.5 pt Pindar GT - Pre	57.5 (8.5) a	46.3 (8.3) ab	65.0 (13.2) a	40.0 (14.3) a
6 pt Pindar GT - Pre	50.0 (10.8) a	51.3 (10.5) ab	42.5 (24.6) ab	57.5 (24.6) a
3 pt Pindar GT + 0.25% R-11 - Pre	62.5 (15.5) a	43.8 (17.5) ab	50.0 (17.8) ab	55.0 (16.6) a
4.5 pt Pindar GT + 0.25% R-11 - Pre	60.0 (9.1) a	45.0 (10.4) ab	75.0 (11.9) a	26.3 (12.5) a
6 pt Pindar GT + 0.25% R-11 - Pre	60.0 (9.1) a	41.3 (9.7) ab	82.5 (8.5) a	22.5 (10.5) a
3 pt Pindar GT - Post	77.5 (4.8) a	25.0 (4.6) ab	50.0 (10.8) a	53.8 (11.3) a
4.5 pt Pindar GT - Post	50.0 (17.8) a	50.0 (17.8) ab	50.0 (26.1) ab	50.0 (26.1) a
6 pt Pindar GT - Post	70.0 (8.2) a	33.8 (9.4) ab	52.5 (24.9) ab	48.8 (25.5) a
3 pt Pindar GT + 0.25% R-11 - Post	75.0 (11.9) a	27.5 (13.0) ab	57.5 (13.8) a	47.5 (15.3) a
4.5 pt Pindar GT + 0.25% R-11 - Post	75.0 (11.9) a	26.3 (12.5) ab	52.5 (9.5) a	53.8 (9.0) a
6 pt Pindar GT + 0.25% R-11 - Post	90.0 (0.0) a	11.3 (1.3) b	75.0 (9.6) a	30.0 (7.9) a
Control	47.5 (13.8) a	55.0 (13.7) ab	2.5 (2.5) b	97.5 (2.5) a

Table 7. Sonora year two incense cedar and sugar pine percent survival and brown out, means for the 2014 spring Pindar GT over the top release trial. Standard errors are in parenthesis. Means with the same letter are not significantly different (P<=0.05).

Treatment	IC Caliper mm	IC Height cm	IC Stem Vol cm^3
3 pt Pindar GT - Pre	8.4 (0.5) a	36.6 (3.7) a	33.3 (7.9) a
4.5 pt Pindar GT - Pre	9.6 (0.4) a	41.0 (3.4) a	46.9 (6.6) a
6 pt Pindar GT - Pre	7.3 (1.2) a	37.3 (3.4) a	27.9 (10.1) a
3 pt Pindar GT + 0.25% R-11 - Pre	10.0 (1.6) a	48.8 (4.6) a	65.8 (24.2) a
4.5 pt Pindar GT + 0.25% R-11 - Pre	8.9 (0.7) a	39.4 (2.0) a	40.4 (8.4) a
6 pt Pindar GT + 0.25% R-11 - Pre	9.9 (1.0) a	43.8 (1.8) a	68.4 (12.0) a
3 pt Pindar GT - Post	8.4 (0.5) a	37.7 (2.1) a	35.3 (8.0) a
4.5 pt Pindar GT - Post	10.6 (1.8) a	46.9 (5.5) a	77.9 (30.9) a
6 pt Pindar GT - Post	12.0 (2.9) a	49.7 (8.4) a	125.8 (63.6) a
3 pt Pindar GT + 0.25% R-11 - Post	10.2 (1.7) a	46.0 (5.4) a	78.6 (31.9) a
4.5 pt Pindar GT + 0.25% R-11 - Post	8.6 (0.4) a	39.9 (1.3) a	36.6 (6.2) a
6 pt Pindar GT + 0.25% R-11 - Post	8.3 (0.2) a	36.7 (0.8) a	30.3 (0.8) a
Control	6.3 (1.1) a	33.8 (3.0) a	21.0 (10.3) a

Table 8. Sonora year two incense cedar caliper, height and stem volume for the 2014 spring Pindar GT over the top trial. Pre and Post refer to pre and post bud break application timings. Standard errors are in parenthesis. Means with the same letter are not significantly different (P<=0.05).

Treatment	SP Caliper mm	SP Height cm	SP Stem Vol cm^3
3 pt Pindar GT - Pre	5.8 (0.5) a	23.7 (1.0) a	8.7 (1.9) a
4.5 pt Pindar GT - Pre	5.9 (0.5) a	25.5 (1.4) a	10.9 (2.8) a
6 pt Pindar GT - Pre	7.5 (1.2) a	25.9 (0.01) a	16.0 (4.6) a
3 pt Pindar GT + 0.25% R-11 - Pre	5.1 (0.2) a	24.0 (0.8) a	7.2 (0.7) a
4.5 pt Pindar GT + 0.25% R-11 - Pre	6.4 (0.2) a	23.9 (2.4) a	11.3 (2.0) a
6 pt Pindar GT + 0.25% R-11 - Pre	6.1 (0.5) a	24.1 (2.1) a	10.5 (2.7) a
3 pt Pindar GT - Post	6.3 (0.9) a	25.6 (1.2) a	11.9 (3.5) a
4.5 pt Pindar GT - Post	5.6 (1.2) a	22.9 (3.2) a	9.9 (5.9) a
6 pt Pindar GT - Post	7.1 (1.0) a	26.1 (3.4) a	15.1 (5.7) a
3 pt Pindar GT + 0.25% R-11 - Post	5.7 (0.6) a	24.7 (1.6) a	9.2 (2.2) a
4.5 pt Pindar GT + 0.25% R-11 - Post	5.3 (0.1) a	24.9 (2.1) a	7.4 (0.9) a
6 pt Pindar GT + 0.25% R-11 - Post	5.8 (0.5) a	25.4 (2.2) a	9.5 (1.4) a
Control	3.7 a	16.0 a	2.2 a

Table 9. Sonora year two sugar pine caliper, height and stem volume for the 2014 spring Pindar GT over the top trial. Pre and Post refer to pre and post bud break application timings. Standard errors are in parenthesis. Means with the same letter are not significantly different (P<=0.05).

Treatment	% Bare Ground	% Cover Bull Thistle	% Survival Inc Ced	% Survival Sug Pine	% Survival P. Pine
3 pt Pindar GT - Pre	92.5 (1.4) a	4.8 (1.9) a	100.0 (0.0) a	87.5 (6.3) a	92.5 (4.8) a
4.5 pt Pindar GT - Pre	93.0 (2.7) a	4.5 (2.0) a	97.5 (2.5) a	90.0 (7.1) a	87.5 (7.5) a
6 pt Pindar GT - Pre	94.8 (1.8) a	3.8 (2.2) a	90.0 (4.1) a	77.5 (11.1) a	92.5 (4.8) a
3 pt Pindar GT + 0.25% R-11 - Pre	83.8 (3.8) a	14.5 (4.8) a	87.5 (4.8) a	92.5 (4.8) a	97.5 (2.5) a
4.5 pt Pindar GT + 0.25% R-11 - Pre	93.8 (1.3) a	5.0 (1.8) a	97.5 (2.5) a	82.5 (14.4) a	95.0 (5.0) a
6 pt Pindar GT + 0.25% R-11 - Pre	88.8 (3.8) a	7.3 (3.2) a	97.5 (2.5) a	85.0 (6.5) a	95.0 (2.9) a
3 pt Pindar GT - Post	95.3 (1.0) a	2.5 (1.0) a	95.0 (2.9) a	92.5 (2.5) a	92.5 (2.5) a
4.5 pt Pindar GT - Post	94.5 (1.6) a	4.8 (1.9) a	97.5 (2.5) a	92.5 (2.5) a	95.0 (5.0) a
6 pt Pindar GT - Post	94.5 (1.7) a	2.5 (1.0) a	97.5 (2.5) a	92.5 (4.8) a	97.5 (2.5) a
3 pt Pindar GT + 0.25% R-11 - Post	92.5 (1.4) a	3.3 (1.0) a	97.5 (2.5) a	100.0 (0.0) a	100.0 (0.0) a
4.5 pt Pindar GT + 0.25% R-11- Post	93.75 (1.3) a	2.0 (1.0) a	95.0 (2.9) a	95.0 (2.9) a	95.0 (5.0) a
6 pt Pindar GT + 0.25% R-11 - Post	93.8 (1.3) a	3.5 (0.5) a	100.0 (0.0) a	90.0 (5.8) a	95.0 (2.9) a
Control	81.3 (7.2) a	13.5 (8.9) a	95.0 (5.0) a	97.5 (2.5) a	92.5 (4.8) a

Table 10. Whitmore year two percent bare ground, bull thistle cover and incense cedar, sugar pine and ponderosa pine survival means for the 2014 spring Pindar GT over the top release trial. Standard errors are in parenthesis. Means with the same letter are not significantly different ($P<=0.05$).

Treatment	Inc Cedar Cal mm	Inc Cedar Ht cm	Inc Cedar St Vol cm^3	Sug Pine Cal mm	Sug Pine Ht cm	Sug Pine St Vol cm^3
3 pt Pindar GT - Pre	9.0 (0.2) a	25.8 (1.4) a	23.3 (1.7) a	8.5 (0.6) a	30.8 (2.8) a	25.5 (5.1) a
4.5 pt Pindar GT - Pre	8.0 (0.2) a	26.7 (1.1) a	20.3 (1.3) a	6.5 (0.5) a	23.0 (2.2) a	12.0 (2.5) a
6 pt Pindar GT - Pre	8.4 (0.4) a	26.5 (2.4) a	22.6 (1.9) a	7.3 (0.3) a	25.9 (0.6) a	16.2 (1.9) a
3 pt Pindar GT + 0.25% R-11 - Pre	8.6 (0.9) a	28.5 (2.1) a	25.2 (7.3) a	7.8 (0.1) a	27.9 (1.1) a	18.9 (1.4) a
4.5 pt Pindar GT + 0.25% R-11 - Pre	7.7 (0.6) a	26.7 (3.4) a	20.2 (5.6) a	6.5 (0.6) a	24.4 (1.7) a	13.6 (3.4) a
6 pt Pindar GT + 0.25% R-11 - Pre	7.0 (0.3) a	28.0 (2.1) a	16.3 (2.0) a	6.6 (0.5) a	23.1 (1.8) a	12.0 (1.9) a
3 pt Pindar GT - Post	9.3 (0.9) a	30.8 (3.5) a	30.9 (9.3) a	7.7 (0.3) a	25.5 (1.4) a	18.4 (1.0) a
4.5 pt Pindar GT - Post	7.9 (1.0) a	26.3 (2.6) a	21.5 (7.0) a	7.4 (0.8) a	26.9 (2.6) a	17.6 (4.1) a
6 pt Pindar GT - Post	7.4 (0.9) a	27.8 (2.4) a	20.2 (5.9) a	7.6 (0.8) a	25.7 (2.4) a	17.9 (4.2) a
3 pt Pindar GT + 0.25% R-11 - Post	8.7 (0.6) a	25.4 (1.6) a	24.3 (5.4) a	7.9 (0.8) a	28.8 (2.1) a	23.1 (6.0) a
4.5 pt Pindar GT + 0.25% R-11- Post	9.8 (0.4) a	28.4 (3.3) a	30.8 (5.9) a	8.4 (03) a	28.3 (1.1) a	22.9 (1.7) a
6 pt Pindar GT + 0.25% R-11 - Post	9.3 (0.9) a	28.2 (2.2) a	29.0 (6.4) a	8.3 (0.7) a	30.6 (1.6) a	25.0 (4.6) a
Control	9.6 (1.0) a	31.9 (1.5) a	35.4 (8.2) a	8.7 (0.9) a	30.2 (2.0) a	28.2 (8.8)a

Table 11. Whitmore year two incense cedar and sugar pine caliper, height and stem volume means for the 2014 spring Pindar GT over the top release trial. Standard errors are in parenthesis. Means with the same letter are not significantly different ($P<=0.05$).

Treatment	Ponderosa Pine Caliper mm	Ponderosa Pine Height cm	Ponderosa Pine Stem Vol cm^3
3 pt Pindar GT - Pre	16.7 (1.0) a	42.4 (0.8) a	136.2 (18.4) a
4.5 pt Pindar GT - Pre	13.3 (1.0) a	36.1 (2.5) a	78.9 (15.2) a
6 pt Pindar GT - Pre	13.0 (1.0) a	34.8 (3.4) a	78.0 (21.0) a
3 pt Pindar GT + 0.25% R-11 - Pre	13.9 (2.0) a	37.1 (4.1) a	97.3 (37.4) a
4.5 pt Pindar GT + 0.25% R-11 - Pre	13.0 (1.4) a	36.9 (2.6) a	79.9 (23.5) a
6 pt Pindar GT + 0.25% R-11 - Pre	13.9 (0.9) a	36.4 (1.9) a	81.7 (11.8) a
3 pt Pindar GT - Post	15.1 (1.6) a	39.2 (3.2) a	102.8 (27.1) a
4.5 pt Pindar GT - Post	13.2 (2.0) a	35.6 (3.3) a	82.0 (23.7) a
6 pt Pindar GT - Post	13.7 (1.5) a	36.9 (1.8) a	79.0 (17.5) a
3 pt Pindar GT + 0.25% R-11 - Post	15.0 (2.3) a	42.0 (2.5) a	116.7 (35.2) a
4.5 pt Pindar GT + 0.25% R-11- Post	16.3 (0.6) a	42.8 (1.3) a	125.7 (10.8) a
6 pt Pindar GT + 0.25% R-11 - Post	16.0 (1.5) a	42.4 (1.9) a	128.2 (26.1) a
Control	14.8 (0.7) a	41.3 (2.0) a	100.6 (12.4) a

Table 12. Whitmore year two ponderosa pine caliper, height and stem volume means for the 2014 spring Pindar GT over the top release trial. Standard errors are in parenthesis. Means with the same letter are not significantly different ($P<=0.05$).

Sierra Cascade Intensive Forest Management Research Cooperative
Income/Expense Statement
Calendar Year Report for the Period Jan. 1 to Dec. 31, 2015

Beginning Balance on January 1, 2015	$24,369.00
Total Income (Membership Dues)	$60,000.00
Expenses	
Rodeo Over-the-Top Study	$14,500.00
Pondosa II Study	$1,436.40
G.O.E. Study	$100.00
Co-op Manager Expenses	$35,000.00
Total Expenses	$51,036.40
Year End Balance as of December 31, 2015	$33,332.60

WORKING GROUP MEMBERSHIP

Working Group I
Seed to Establishment

Tom Jopson, Chair
Bob Amesbury
Scott Carnegie
Mark Gray
Scott Worden
Tom Young

Working Group II
Out-planting through Precommercial Thinning

Scott Worden, Chair
Bob Amesbury
Scott Carnegie
Mark Gray
Ken Scott
Tom Young