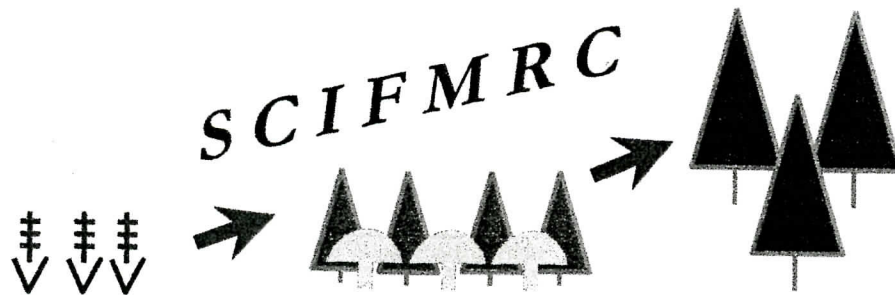


Sierra-Cascade Intensive Forest Management Research Cooperative

Series Report No. 7



<http://wric.ucdavis.edu.sierracascade/>

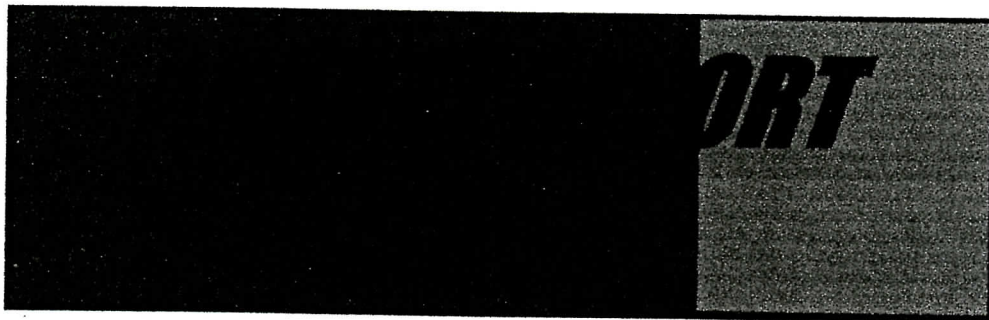


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The year 2006 marked the seventh year as an organization for the Sierra Cascade Intensive Forest Management Research Cooperative.

Membership in the Co-op had a net gain in 2006 with two new members joining the Co-op. No members withdrew from the Co-op during the year. The current membership consists of a mixture of landowners, forestry-related industries, State of California and federal agencies.

The year 2006 was the first one with the new steering committee. Original members Ed Fredrickson and Joe DiTomaso had to resign due to increased workloads in their primary jobs. Gary Nakamura (UC Berkeley) is the new representative from academia. The industry representative position will be shared by Mark Gray (Sierra Pacific Industries) and Bob Rynearson (WM Beauty & Associates). These new members took office January 1st.

At the annual business meeting held in April, a new Chair for Working Group II was selected. Jason Warshawer of Roseburg Resources accepted the position.

Also at the annual meeting, updates were presented for three recently funded Co-op studies. Bob Powers reported on progress on the Agenda 2020 and the 3-PG studies. More detailed information on these two studies will be reported in this 2006 Annual Report. Anthony Davis, a research assistant to senior author Doug Jacobs, presented findings from the Co-op study on dormancy/temperature influences. An executive summary of this study can be found in the 2005 Annual Report.

One new proposal was presented at the annual meeting. Darek Czokajlo, sponsored by Co-op member Bob Amesbury of Timber Products, presented this proposal titled "Investigating the chemical ecology of gouty pitch midge." The Co-op could not support the proposal at this time but several Co-op members, including the Forest Service, expressed interest in supporting the effort on an individual basis much the way Timber Products has done in the last couple of years.

Two previously funded proposals (Western Pine Shoot Borer, Gillette et al.) and (Fertilization, Timmer/Jopson) were remeasured for fifth growing season values. Earlier results from the Gillette study were published in the Canadian Journal of Forest Research in 2006. An executive summary of this publication can be found in the 2006 Annual Report. The data from Timmer/Jopson are being analyzed by the principal investigators and will be submitted to a referred journal for publication. Results from another Co-op funded proposal (Verbenone, Gillette et al.) were published in Agricultural and Forest Entomology in 2006. An executive summary of this publication can be found in the 2005 Annual Report.

Due to decreased income (dues), the membership voted at the April meeting to have the remeasurements which are due on three existing studies (Fertilization, Slow Release, and Stock Type/Fertilization) to be done by the Co-op manager with in-kind help from the host landowners. Annual remeasurements will be discontinued and only 5th year remeasurements will be taken. The Timmer/Jopson fertilization

study was remeasured between August and October 2006. Co-op members Tom Young (Fruit Growers Supply) and Bill Morrison (Soper-Wheeler) helped with these remeasurements. The StockType/Fertilization study will be due remeasurement in the fall, 2007; the Slow Release study in the fall, 2008.

Four of the proposals funded by the Co-op report updated results/progress in this issue of the annual report. These include Fertilization (Timmer/Jopson), Western Pine Shoot Borer (Gillette), Agenda 2020 (Powers) and 3-PG (Powers). As with last year, results will be presented in the form of an executive summary. Full data sets and analysis are available from the Co-op office in Redding.

The Co-op hosted a field trip on June 29th. Nineteen members and guests attended. Field trip stops were located on Roseburg Resources and Sierra Pacific Industries lands. Many of the stops showcased results from work on the Fountain Fire. Ed Fredrickson and Mark Gray did an excellent job in arranging this field trip and presenting information at the various stops. Topics covered included second generation seed orchard stock, aerial pre-harvest treatments, operational fertilizer trials, hack & squirt and fertilization trials, Doug-fir stock trials, and a converted Doug-fir progeny site treated with GA to induce flowering.

Like 2006, the year 2007 looks to be active one for the Co-op. The Agenda 2020 sites will require much time in maintaining the treatments with competing species at desired levels. The 3-PG study will be implemented with the Whitmore site scheduled for evaluation.

The StockType/Fertilization study will be due 5th year remeasurements at the end of the growing season. The membership will need to decide the future of this study as far as remeasurements and maintenance following 5th year remeasurements.

The latest results from the Western Pine Shoot Borer and Timmer/Jopson studies hopefully will be published by the end of the year.

2006 MEMBERSHIP

Land Manager Membership:

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

Associate Corporate Membership:

BASF
Cal Forest Nurseries

Affiliate Membership:

Silver Butte Timber Co.
Wilbur-Ellis Co.
Total Forestry

Supporting Members:

California Forestry Association
PSW Research Station
University of California, Davis
USDA Forest Service

Sierra Cascade Intensive Forest Management Research Cooperative
Annual Meeting April 5, 2006

The 2006 annual business meeting was held at the Forest Service office in Redding, CA on April 5, 2006. Seventeen Co-op members and guests attended.

Following introductions some general items of business were discussed. The Membership was updated on the current makeup of the Steering Committee: Ed Fredrickson's position as industry representative was filled by Mark Gray of Sierra Pacific Industries and Bob Rynearson of W. M. Beaty and Associates; Joe DiTomaso's position as the representative from academia was filled by Gary Nakamura, U.C. The new members took office on January 1st. The latest news on the Boise Cascade buy-out by Forest Capital seems to indicate that the new company will probably not join the Co-op. Bill Morrison has taken over Ron Hague's place as Co-op representative for Soper-Wheeler.

Next on the agenda was a discussion of the vacant Working Group II Chair – Brian Schlaefli filled this position when Boise Cascade was in the Co-op. The membership wanted to continue to have the two Working Groups, so a request was made for a volunteer to serve as the Group II Chair. No one volunteered, so Jason Warshawer of Roseburg Resources was nominated and elected. Jason agreed to serve.

The possibility of a Co-op field trip was the next item discussed. The membership opted to have a field trip on June 29, 2006. The agenda for the 2005 trip (which was not conducted) will be used.

The following members agreed to be on the

field trip committee: Mark Gray, Bob Powers, Bob Rynearson, Jeff Webster, Jason Warshawer, and Duane Nelson. The 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 brushfields (long term competition study), Pondosa compaction study, eucosma study, an Agenda 2020 site, a National Fire Plan study site, chemical trials site, and 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.

A review of the 2005 Annual Report was the next item of business. In a departure from previous Annual Reports, an executive summary was used to update the results of the on going studies funded by the Co-op. Prior to 2005, the entire data sets were analyzed and reported on in the annual update. The membership was informed that these complete data sets are still available at the office in Redding if anyone needs to see them. In the 2005 report, a couple of parameters were highlighted and reported on. All the data will be analyzed for presentation in the final publication on each study – usually at the end of the fifth growing season.

Executive summaries were presented in the Annual Report for five studies funded by the Co-op. Two of them, Verbenone Trials (pg. 23) and Competition/Conifer Survival (pg. 20) are summaries of research papers published in referred journals. These studies were funded by the Co-op and although no current work is being done on them, these

papers represent the final obligations required for the funding that was received. The other three executive summaries update ongoing studies. Results of the studies were high-lighted at the meeting.

The State of the budget was then discussed. The Co-op ended 2005 with a surplus of \$3,307.46 after all pending expenses were covered. Spreadsheets showing the current status of all funded studies and yearly plans for these studies from 2006 through 2011 were handed out to the attendees. Income in the form of dues was projected for this time period. As of the time of the meeting, \$54,000 in dues had been received with another \$10,000 expected soon. Current membership, which translates into dues, is down significantly from past years. All non-renewing members (Boise Cascade, PRT, Dupont, IFA, Dow-Agro, and UAP) were contacted prior to the April 5th meeting to determine under what circumstances they would consider rejoining the Co-op. Suggestions included lower dues levels, providing services/supplies instead of paying dues, and sponsoring studies that were more beneficial to their organization, chemical trials, nursery trials, etc. A short discussion followed about how to increase our membership; nothing was finalized in this regard.

Gary Nakamura suggested that the Co-op start tapping the area of salvage logging for studying. Bob Powers updated the membership on the OSU graduate student paper and the fall-out from it. Gary suggested that the Co-op have research studies ready prior to a fire in order to expedite funding requests. Evidently there are several funding sources, and some of them, such as NSF, have healthy budgets for this type of research. Powers suggested a template for the actions following a fire that could include: do nothing, remove only

large material, remove all material, and a complete set of treatments including site preparation, subsoiling, mastication, etc. The controls could be installed on federal lands and the operational research could be conducted on private industry lands. The Co-op is in a unique position to seek salvage logging funds in that it has a scientific component as well as access to private industry lands on which to install the studies. Proposals about salvage logging could be submitted by the membership to the steering committee who would evaluate them and in turn submit their recommended proposals to the full membership for approval. The Co-op could provide seed money to get the proposals started; hopefully this would lead to full funding by a granting agency.

Using the budget figures from the spreadsheets, the membership then discussed the workload for 2005. The Timmer/Jopson study will be remeasured at the end of the 2006 growing season. This will be the fifth growing season for this study. Contracts have been used in past years to do these remeasurements. Because income (dues) is down, the membership voted to have this work done by the Co-op Manager with in-kind help from the host landowners (Fruit Growers Supply, Soper-Wheeler and Boise Cascade?). Estimated costs for the Manager to remeasure Timmer/Jopson are about \$2500 (six days). Since the three sites that make up this study have not been visited in three years, additional time for the Manager will be needed at these sites prior to the time of remeasurement to facilitate this process (reestablishing of corners, etc.). It is estimated this work will take eight days.

The Eucosma study will need fifth year remeasurements at the end of the 2006

growing season. Heights and diameters will need to be measured in order to figure volumes. Laser poles can be used for the height measurements. With in-kind help from the Co-op members (Beaty and SPI), estimated costs for the manager to do these remeasurements total \$1600 (three days). If contract help is required instead of in-kind help, the additional costs to the Co-op would be \$3100.

The stock type/fertilization study will not be remeasured in 2006. Instead, it will be remeasured at the end of the 2007 growing season, which will be the fifth season for this study. Estimated cost for the Manager to help with the remeasurements is \$3000 (seven days).

The slow release study will not be remeasured in 2006. It will be remeasured at the end of the 2008 growing season, which will be the fifth year for this study. Estimated cost for the Manager to help with the remeasurements is \$3000 (seven days).

As with the Timmer/Jopson study, these last two studies will be remeasured by the Manager with in-kind help from the landowners (stock type/ fertilizer: Roseburg, SPI and Boise Cascade?; slow release: Beaty, Soper-Wheeler, and Silver Butte).

Installation will be started on the 3-PG study in 2006. The Manager's time will not be impacted significantly by this study during 2006, as most of the work is being done by graduate students funded through the study.

The next items of business were updates on three recently funded Co-op studies. Bob Powers reported on progress on the Agenda 2020 study that was planted in the spring of 2005. The various treatments are in the process of being installed (see 2004 Annual

Report for more complete discussion of this study).

Bob then brought the membership up to date on the 3-PG study that is in the initial stages of installation (this proposal was mailed to the membership in March, 2005).

Anthony Davis, a research assistant to senior author Doug Jacobs, presented findings from the Co-op study on dormancy/temperature influences. An executive summary of this study can be found in the 2005 Annual Report.

The final item of business was the presentation of a new proposal by Darek Czokajlo titled "Investigating the chemical ecology of gouty pitch midge". This proposal was sponsored by Co-op member Bob Amesbury of Timber Products Co. A copy of the proposal was included with the mailing of the 2005 Annual Report. The Co-op cannot support this proposal currently, but several Co-op members including the Forest Service expressed interest in supporting the effort on an individual basis much the way Timber Products has done for the last couple of years.

Sierra Cascade Intensive Forest Management Research Cooperative Proposal 02-01
Eucosma Study
Principal Investigator: Nancy Gillette

TITLE: Pheromone-based disruption of *Eucosma sonomana* and *Rhyacionia zozana* (Lepidoptera: Tortricidae) using aerially applied microencapsulated pheromone

Year Funded: 2002

Executive Summary:

Two aerial applications of microencapsulated pheromone were conducted on five 20.2 ha plots to disrupt western pine shoot borer (*Eucosma sonomana* Kearfott) and ponderosa pine tip moth (*Rhyacionia zozana* Kearfott); Lepidoptera: Tortricidae) orientation to pheromones and oviposition in ponderosa pine plantations in 2002 and 2004. The first application was made at 29.6 g active ingredient (AI)/ha, and the second at 59.3 g AI/ha. Baited sentinel traps were used to assess disruption of orientation by both moth species toward pheromones, and *E. sonomana* infestation levels were tallied from 2001 to 2004. Treatments disrupted orientation by both species for several weeks, with the first lasting 35 days and the second for 75 days. Both applications reduced infestation by *E. sonomana*, but the lower application rate provided greater absolute reduction, perhaps because prior infestation levels were higher in 2002 than in 2004. Infestations in treated plots were reduced by two-thirds in both years, suggesting that while increasing the application rate may prolong disruption, it may not provide greater proportional efficacy in terms of tree protection.

The incidence of infestations even in plots with complete disruption suggests that treatments missed some early emerging females or that mated females immigrated into treated plots; thus operational testing should be timed earlier in the season and should comprise much larger plots. In both years, moths emerged earlier than reported previously, indicating that disruption programs should account for warmer climates in timing of applications. The AIs we tested are behaviorally active for 13 other species of *Rhyacionia* and six other species of *Eucosma*, so the approach may have wide application.

In 2002, we were unable to apply the pheromone before the *E. sonomana* and *R. zozana* flights began. In 2004, we made the application before the *R. zozana* flight began but we again missed the beginning of the *E. sonomana* flight. Although we had deployed monitoring traps to time our applications, moth flight had already begun before the roads were passable in the early spring. Timing of applications was assumed to be a trade off between protection from early emerging insects and maintaining sufficient protection over the entire flight period, because we were not sure

that the formulations would last much longer than the insect flight period. A longer lasting formulation such as that applied in 2004, however, may provide sufficient protection even with an earlier application. Operational tests could undoubtedly be conducted before moth flight begins in the spring, but moth flight cannot be reliably quantified without the use of monitoring traps, which depend upon passable roads for their deployment and maintenance. Thus, although it should be feasible to achieve successful disruption and crop protection with this pheromone formulation, it may be difficult to demonstrate that success in an experimental setting in a steep, remote site where access is difficult until roads are dry. We recommend that for operational treatments, land managers apply such pheromone formulations 2-4 weeks earlier than we did, or as soon as possible in late winter, given uncertain weather conditions. Applying treatments earlier will help ensure disruption of moths even with fluctuating climate and consequent unpredictable moth emergence dates.

Although the absolute reduction of infestation was greater in 2002 than in 2004, it appears from the data from sentinel traps that the 2004 treatment disrupted mating more effectively. The greater reduction in infestation in 2002 is probably a result of increased competition for resources in that year, since baseline moth populations were higher that year. The steeper slopes of the responses in 2004 versus 2002 support this explanation.

Regardless of existing moth populations, however, the treatments provided significant pheromone disruption in both

years, especially for *R. zozana* in 2004, and clearly reduced infestations of *E. sonomana* in both years. The assessments of moth infestation were directed solely at *E. sonomana*, because we did not have the resources to assess *R. zozana* infestations as well. However, we plan to take 5-year height and diameter growth measurements, and those will reflect the cumulative effect of excluding both moth species for 2 of the 5 years. Previous cost-benefit analyses (Williams et al. 1989) supported the use of pheromone disruption in terms of increased volume at harvest, and our results provide yet another means of application that is especially promising, because it offers another, simpler method of aerial application, which will allow applications to take place even when roads are impassable in late winter or early spring, when moths are emerging. Other aerially applied formulations, such as laminated flakes, fibers, and pellets, may offer similar advantages. In areas where access by road is not problematic and where the terrain is accessible by field crews on foot, hand applied pheromone disruption techniques, such as lure-tapes, puffers, and attract-and-kill (Daterman et 2001) may also be cost effective.

Pine plantations are routinely thinned to reduce competition among trees for water and sunlight, and *E. sonomana* infestation levels typically increase the year following a thinning (J. N. Webster, personal observation). The probable mechanism for this phenomenon is simply a reduction (normally by about half) in available resource for oviposition, resulting in a concentration of oviposition on fewer available terminals. Although we know of no documentation for this explanation for *E.*

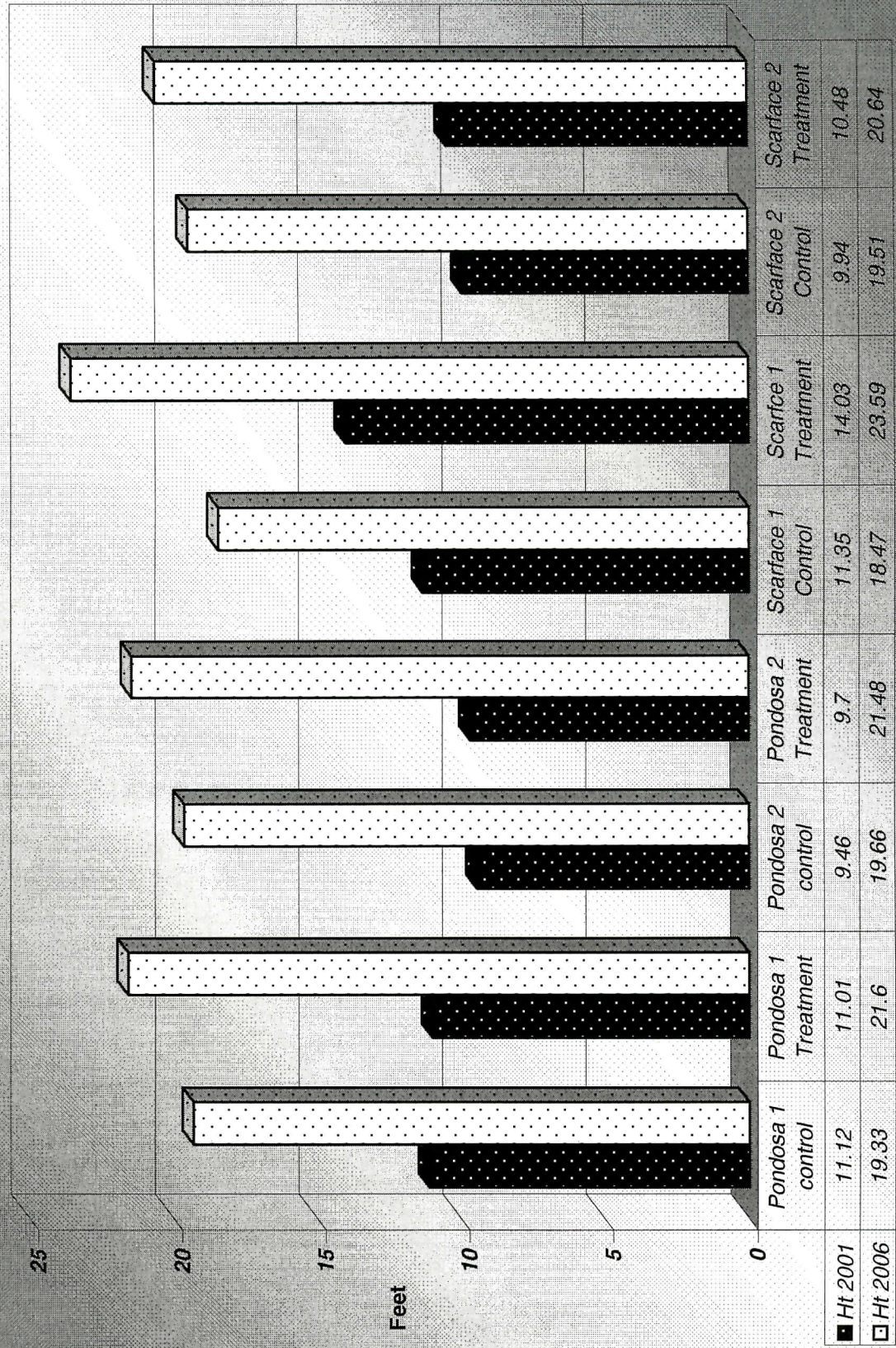
sonomana, this mechanism is known to be important in cone and seed insect population dynamics (Daniel et al. 1979, p. 145). Thus, it could be beneficial to time the application of pheromone disruptions in tandem with stand thinning, to avoid concentrating the oviposition of moths on a smaller number of trees.

Sower and Overhulser (1986) reported that recovery of *E. sonomana* populations usually begins within 1-2 years following treatment, and our results concur. It is thus important to treat every two years or so until trees are large enough to tolerate infestation without severe growth reductions. Large-scale pheromone applications have never been attempted (Wood et al. 2003), but area-wide coordinated treatments should be given serious consideration, because treatments on a large scale would minimize edge effects and delay the recovery of moth populations, thus reducing both immigrating gravid females during the year of treatment and reinvasion of moths in years following the treatment. Such treatments should be doubly effective if timed to coincide with thinning. The active ingredients in the pheromone blend that we evaluated have also shown behavioral activity for 13 other species of *Rhyacionia* and 6 other species of *Eucosma* (Grant et al. 1985, 2002; Skillen et al. 1997; <http://www.pherobase.com>), so this approach may have a broad application for control of other damaging pest species of pine plantations and Christmas tree farms in the Pacific Northwest and in the Southeastern United States.

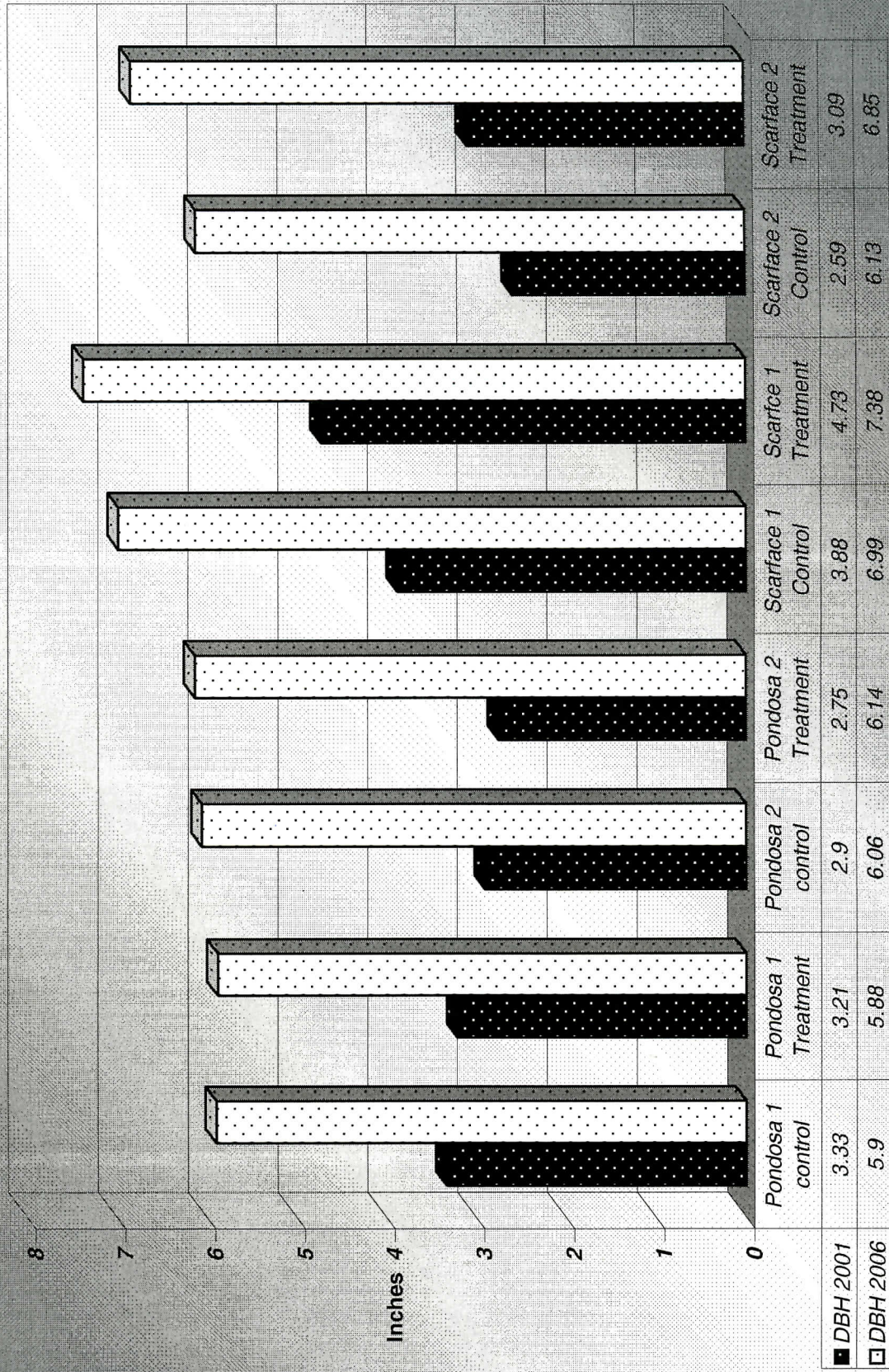
2006: All plots were remeasured in October, 2006 at the end of the fifth growing season. Measurements taken included diameter at 4.5 feet, total height, and height to live crown. Total height and height to live crown were used to determine live crown ratio. Determination was made at the time of measurement as to whether the current years growth had *Eucosma* damage. This data are currently being analyzed and results will be reported in a referred journal when completed.

The figures on the following pages compare treated vs. non-treated conifer heights, diameter, and volume in 2001 and again in 2006.

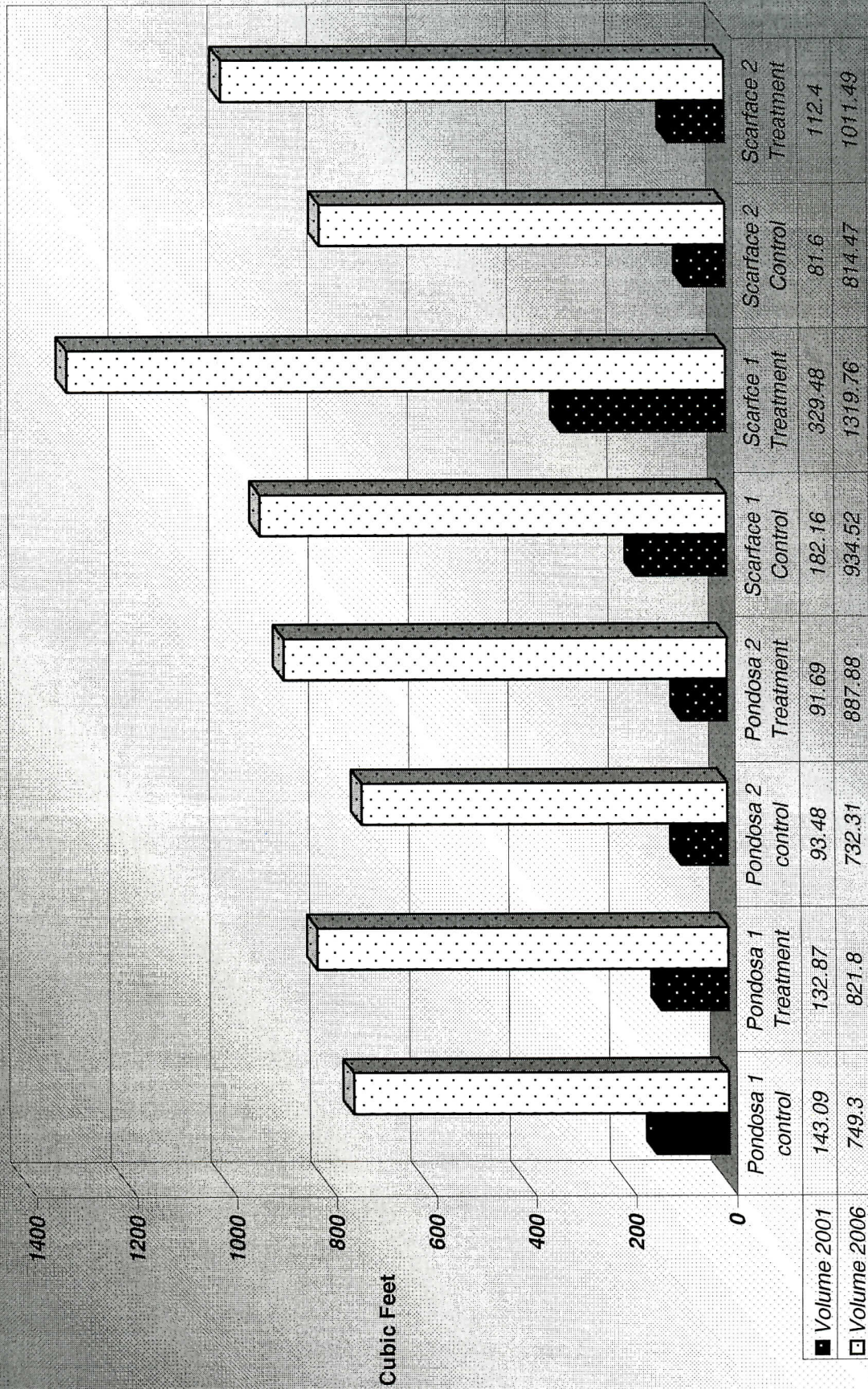
3M Eucosma HT Comparison



3M Eucosma DBH Comparison



3M Eucosma Volume Comparison



**Sierra Cascade Intensive Forest Management Research Cooperative Proposal 03-01
Agenda 2020**

Principal Investigator: Bob Powers

**TITLE: An experiment to evaluate the competitive and ecological effects of understory
vegetation on the productive potential of young Douglas-fir plantations**

Year Funded: 2003

Executive Summary:

As a follow-up to the January 13, 2003 Co-op meeting at which the Agenda 2002 proposal was accepted as a Co-op project, the membership was contacted in order to get suggestions on possible sites for the study (originally the first site was going to be located on Boise Cascade lands but the site nominated was not selected). In response to this request, two companies, Roseburg Resources (Ed Fredrickson) and Sierra Pacific Industries (Mark Gray) offered possible sites.

The Roseburg site consisted of two clearcut blocks located east of Redding near Big Bend. The stands had been harvested in the summer of 2003 and the additional site preparation required for implementation could be done in the fall. The stands harvested were high-site mixed conifer and the topography was almost flat. There were no restrictions on either of the blocks that would hinder the installation of the study. After two confirmation visits the Roseburg blocks were selected as the first Agenda 2020 site.

The SPI site was located northeast of Burney near the intersection of Highway 89 and the Dana Cutoff road. This site consisted of a single block that was scheduled for harvest in the fall of 2003. The stand was mixed conifer growing on a good site. Topography was flat. As with

the Roseburg site, there were no restrictions on this stand that would hinder installation of the Agenda 2020 study. This block was chosen as the second site for the study

As of December, the Roseburg site has been harvested and site preparation has been completed. The SPI site has been harvested with site preparation to follow in 2004. The goal is to install the Agenda 2020 study on both sites during the same time period. Plot layout is scheduled for summer of 2004 with planting to be done in the spring of 2005.

Tom Jopson (Cal Forest Nurseries) has started the collection of manzanita cuttings in order to raise the seedlings (root cuttings) of this species that will be needed for the study. The ceanothus seedlings will be raised from seed that Tom has ordered from the Lawyer Nursery. Both shrubs will be raised by Cal Forest at their Etna, CA. location.

2004: Site preparation was completed on the Sierra Pacific Industries site during the summer of 2004. Plot layout on both sites was completed by September. Some changes were made to the original proposal prior to plot installation. Conifer spacing was changed from 12x12 to 8x8 feet resulting in 168 trees per plot. Of these 168 trees, 80 are measure trees. There will be a total of 8736 seedlings (4368 pine and 4368

Doug-fir) planted per site. There are thirteen treatments replicated four times per site. This makes a total of 52 plots per site. Contracts for marking the planting spots at both sites were let during November. The conifer seedlings for this study are being raised at Cal Forest Nursery. Ceanothus seedlings are growing at Cal Forest Nursery, also. Nursery crews collected plant material in November from the sites in order to start raising the manzanita plants required by the study. The treatments will be installed in the spring of 2005 as originally planned.

2005: The Dana site was planted on March 31. Weather was clear with a slight breeze. Planting started at 6:30 and was completed by 10:00. All planting was done using hoedads. Fourteen planters and one foreman along with two Sierra Pacific Industries inspectors accomplished the planting. The Douglas-fir were Styro 8 stock from Cal Forest Nurseries, 4500 foot elevation, seed zone 521. The ponderosa pine were Styro 6 stock from K & C Silviculture, Oliver, BC.

The two Roseburg sites were planted on the morning of April 1st. It was partially cloudy with no wind. All planting was done with hoedads. Thirteen planters and one foreman along with two Roseburg Resources inspectors accomplished the planting. The Douglas-fir seedlings were Styro 8 stock from Cal Forest Nurseries, 3000 foot elevation, seed zone 521. The ponderosa pine were also Styro 8 stock from Cal Forest Nurseries, 3200 foot elevation, seed zone 521.

In July, the plots receiving complete vegetation control were treated with a directed spray application using Roundup. Both the SPI and Roseburg sites received this treatment. The ceanothus species being

raised at Cal Forest Nurseries for outplanting at the two sites are doing fine.

All attempts to raise manzanita have failed. Another attempt will be made in the spring at the height of the flowering season.

2006: Because of poor survival on the Dana Site, the half of the plot originally planted with Douglas-fir was replanted in the spring of 2006. At this time each planting spot was double planted with a white fir. This replanting was applied to all plots on the site.

In April, the plots receiving complete vegetation control, the fertilization treatment and those plots having some level of either manzanita or ceanothus stocking were treated with 4#/a atrazine applied with a pressurized broom. Both sites were treated at this time. In June these same plots received a directed spray application of 5% Buccaneer mixed with 5% Hasten.

In July, all plots on both sites were monumented and color-coded as to treatment.

On the Dana site, stocking of manzanita is still a problem. As we are still having no success raising this species, attempts will be made in the spring of 2007 to transplant wild seedlings, taken from the buffer around the plots, into the plots requiring manzanita. Other sources may have to be used to supplement the supply of seedlings if there are not enough seedlings in the buffer.

During 2006, two tours were conducted at the Dana site. A stop on the Weed Tour of the California Pest Council took place in July; and a tour for faculty from Oregon State University was conducted in the fall.

**Sierra Cascade Intensive Forest Management Research Cooperative
Proposal 05-01 3-PG Study**

Principal Investigators: Robert Powers and Jianwei Zhang

**TITLE: Investigating carbon partitioning and process modelling in the
Garden of Eden: findings through 2006**

Year Funded: 2005

Executive Summary:

Grants obtained through SCIFMRC as supplemented by Sierra Pacific Industries afforded the following accomplishments in 2006:

1. Biomass estimation equations for boles, branches and foliage for plantation trees through age 15.
2. Estimates of leaf area index (LAI) for three of the plantations.
3. Estimates of forest floor mass for three plantations.
4. Estimates of fine root (<5 mm diameter) biomass for three plantations.
5. Instrumentation for continuous measurements of soil moisture to a depth of 100 cm in three plantations and meteorological data for each site.
6. Pilot trial for estimating continuous water use by plantation trees.
7. Preliminary tests of the 3-PG simulator for one of the plantations.

Work supported by these funds centers on three Garden of Eden plantations that span the full range of site qualities in the study (Elkhorn,

Whitmore, and Feather Falls in order of ascending productivity). These accomplishments are highlighted below.

Biomass Estimation Equations.

Previously, five of the Garden of Eden plantations (Chester, Feather Falls, Jaws, Pongosa, Whitmore) were thinned from below. Only those treatments receiving Insecticide (HI, HFI) were thinned, and only at the point that trees were developing appreciable inter-tree competition as determined by changes in height-diameter trends. Insecticide treatments had no discernable effect in the experiment, and thinning only the "T" treatments allowed us to maintain three replicates of H and HF treatments in an unthinned condition for future comparisons of thinning vs no thinning. Thinning removed half of the trees, leaving the 10 best-formed trees per each measurement plot. Of trees felled in thinning, two well-formed trees of smaller and larger size classes were sectioned in each plot for biomass analysis, providing the basis for biomass estimation equations based upon DBH or DBH x Height. As of this writing, only those equations developed from the Whitmore thinnings have been completed. These were applied to Whitmore stand data to estimate standing biomass at age 15 years for the unthinned C, F, H, and HF treatments

(Fig. 1). Equations from Whitmore and the other four plantations will be compared to see if site-specific equations are necessary, or if equations can be developed that apply universally.

Leaf Area Index Relationships. We estimated LAI in each replicate C, F, H, and HF treatments in the Elkhorn, Feather Falls and Whitmore plantations. Correlations between current LAI and current stand basal area and/or crown cover allowed us to estimate LAI for past years. Comparing X-Y pairs of LAI vs standing volume (*Fig. 2*) indicates that LAI correlates closely with stand production in young plantations. Furthermore, the trend is unaffected by site quality or treatment. As LAI improves with site quality or treatment, production increases in a predictable fashion.

Forest Floor Mass. Using 0.25 m² frames we collected all litter accumulated in the forest floor for C, F, H, and HF treatments at Whitmore (2005) and Elkhorn and Feather Falls (2006) when the plantations had achieved about 2 decades of growth. Such data are useful in estimating the mass of carbon and other nutrients sequestered in litter as affected by treatment and site quality. Net forest floor mass (the amount remaining after decomposition) increased with site quality (Elkhorn the least, Feather Falls the most) and increased with treatments promoting tree growth, most notably fertilization (*Fig. 3*). Similarities between Whitmore and the more productive Feather Falls undoubtedly reflect enhanced decomposition of the forest floor at Feather Falls. Each sample was separated further into woody and foliage components and by pine or

shrub origin (not shown). At Whitmore and Feather Falls, forest floor mass was identical between C and H treatments, meaning that the lack of litter from a shrub understory was balanced by increased inputs from pine litter.

Fine Root Sampling. Using a specialized soil auger, soils were sampled at Elkhorn, Whitmore, and Feather Falls plantations in 2005 and 2006 at depths of 0-15, 15-30, 30-60, and 60-92 cm. Fine roots (generally those less than 5 mm diameter) were separated from soil and analyzed for biomass and nutrient content. The residual mineral soil was also analyzed for nutrient content. Fine root biomass for Whitmore (the only analyses completed as of this writing) indicates that treatments improving tree growth also increased fine root production (*Fig. 4*). We believe that decomposition of fine roots is the primary pathway for increasing soil organic matter and the storage of organic carbon in the mineral soil.

Instrumentation and Estimates of Water Use. Along with continuously recording meteorological stations, dataloggers and sensors were installed in 2006 at the Elkhorn, Feather Falls, and Whitmore Garden of Eden plantations. This allowed us to monitor soil water flux in the C, H, F, and HF treatments to a depth of 1 m. Whitmore also was instrumented for estimating water use using sapflow rate technology. This allowed us to estimate transpiration rate for each treatment through the course of the growing season (*Fig. 5*). Transpiration rate tracked closely with climatic conditions, especially vapor pressure deficit (VPD) and solar radiation (Rn) as recorded by a CDF

meteorological station (*Fig. 6*) at the site. Trends for the extreme treatments at Whitmore are shown in *Figs. 5 and 6* for the 2006 growing season.

Early in the growing season when soil water was abundant and VPD was low (May), transpiration rates were similar for trees in HF and C treatments even though trees on C plots carried much less leaf area than those on HF plots. When VPD and R_n increased and available soil water was still high in July, 2006, HF trees transpired much more water than Control trees. Significant reduction of transpiration coincided with the heat wave occurring in July 2006. Soil water supply could not meet transpirational demand, so trees closed their stomata in avoiding cavitation. High transpiration rates resumed when soil moisture had been replenished by capillary action from surrounding soil and from deeper in the soil profile. By August, high transpiration rates in the HF treatment had depleted soil moisture sufficiently that transpiration rates in the HF treatments were less than those in the C treatments where trees had less leaf area. We conclude that rapidly-growing HF trees will experience high water stress first. Our findings are supported by independent $\delta^{13}\text{C}$ analyses of pine foliage collected on the site over several years of plantation development (Horwath and Powers, unpublished).

These data allow us to estimate how much water is available for the plants and when trees stop growing due to water stress. A quick check of transpirational loss of soil water prorated across an entire year shows that losses at Whitmore are equivalent to total precipitation.

Preliminary Tests of 3-PG. Variables described above are critical for tuning some parameters in 3-PG (Physiological Principles Predicting Growth) model as we have proposed previously. Whitmore data for the first 20 years (1986 – 2006) were employed for our first 3-PG run. We used Whitmore because we have the most detailed climatic data at that site from 1990 to present. Although there are several assumptions that need to be tested in the future, we found that model behaved exceptionally well (*Fig. 7*), and we couldn't resist extrapolating 3-PG projections to age 50 for the Whitmore Garden of Eden. We recognize that these projections are strictly speculative and rest on certain assumptions of future climate. Therefore, we look forward to collecting full-growing season data and carbon allocation data in 2007 through destructive sampling above and below ground. We will test all of our assumptions before recommending 3-PG for general use predicting ponderosa pine behavior across northern California sites.

Tree Biomass at 15 Years, Whitmore Garden of Eden

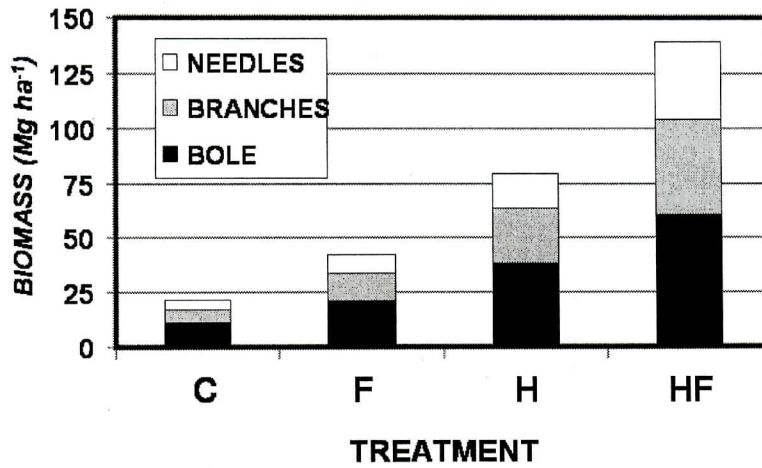


Figure 1. Partitioned standing biomass in planted trees at age 15 for the Whitmore Garden of Eden plantation for Control (C), Fertilized (F), Herbicide (H), and combined (HF) treatments.

LEAF AREA INDEX AND STAND VOLUME LARGELY INDEPENDENT OF SITE QUALITY

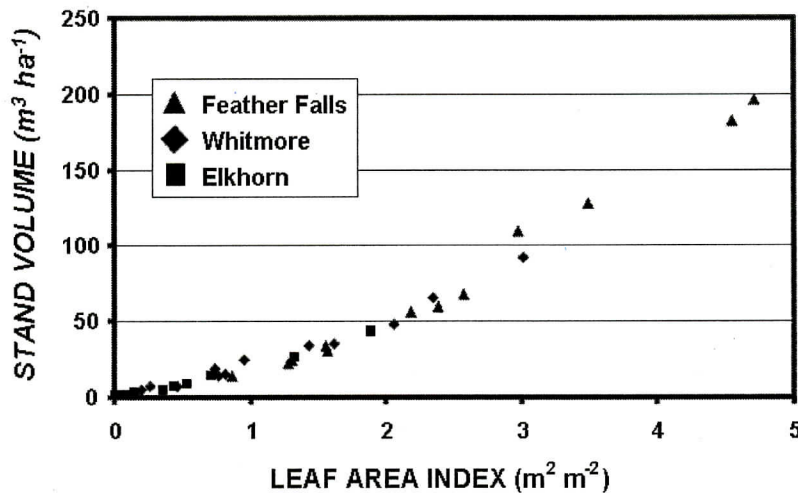


Figure 2. Relationship between LAI and standing volume for three Garden of Eden plantations. All treatments are combined.

FOREST FLOOR MASS 2006

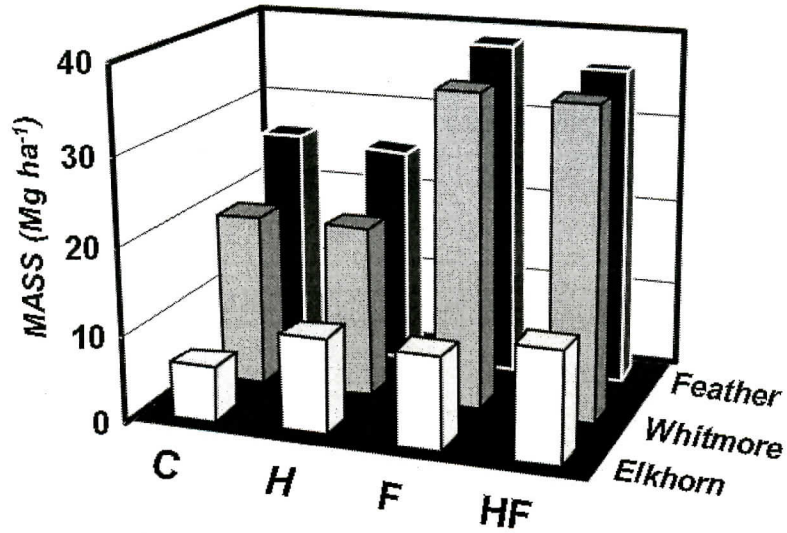


Figure 3. Effect of treatment and site on net forest floor mass present after 2 decades of plantation development.

FINE ROOT BIOMASS AT WHITMORE

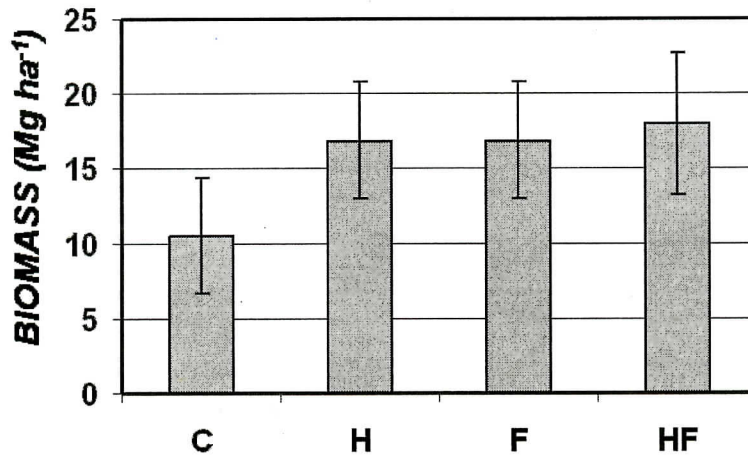


Figure 4. Fine root biomass in relation to treatment at Whitmore as sampled in 2005. Vertical bars represent one standard error of the mean.

**Average Individual Tree Daily Water Use
(Garden of Eden Study)**

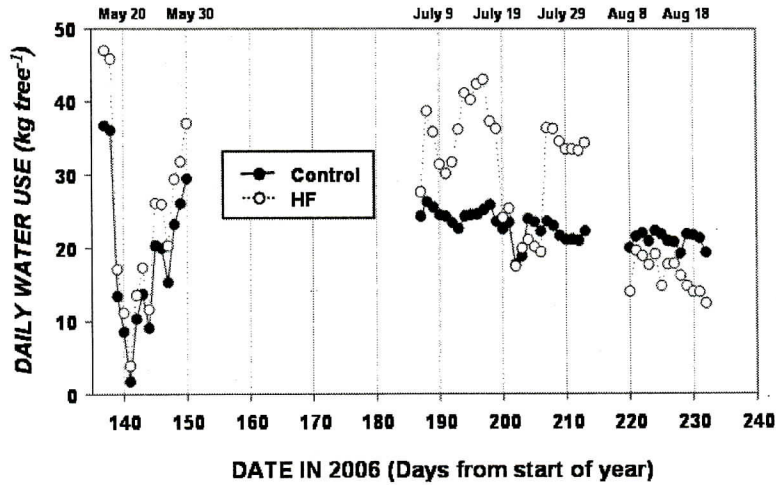


Figure 5. Sapflow analysis of daily water use by individual trees in the Control and HF treatments at Whitmore. Gaps in the data indicate either battery failure or the relocation of instruments in another study. Assuming an annual rate of water use of ~20 kg per tree per day, inflow in precipitation is entirely transpired.

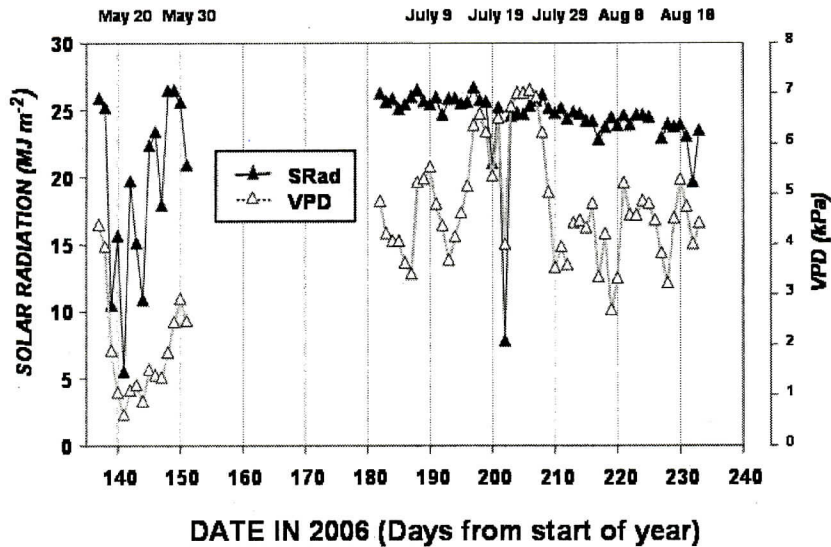


Figure 6. Trends in R_n and VPD at the Whitmore Garden of Eden plantation during the 2006 growing season. Trends in VPD correlate with trends in daily water use by trees (*Fig. 5*).

Whitmore Garden of Eden

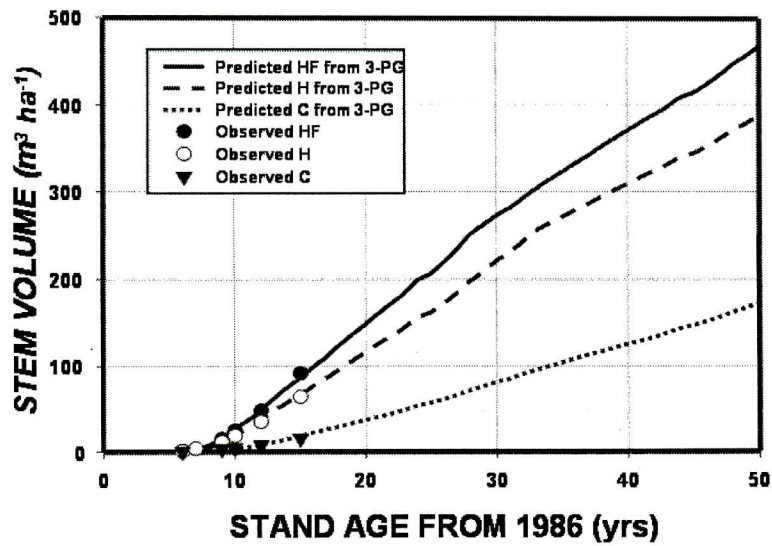


Figure 7. Measured changes in cumulative stand volumes at the Whitmore Garden of Eden plantation for three silvicultural treatments (circles and triangles). 3-PG estimates from climatic and physiological data are shown by the trend lines and extrapolated to age 50 years.

**Sierra Cascade Intensive Forest Management Research Cooperative Proposal 00-05
Timmer/ Jopson Study**

Principal Investigators: Vic Timmer and Tom Jopson

TITLE: Improving seedling nutrition in the nursery to increase seedling performance in the field.

Year Funded: 2002

Executive Summary:

Seedlings grown with constant and sufficient internal nutrient concentrations achieved through exponential fertilization are free of nutrient stress. Seedlings can be produced with balanced, high reserves of nutrients superior to those possible through late-season heavy fertilization. Presumably, balanced, surplus reserves of nutrients at planting affords growth that is rapid enough to offset weed competition and soil drought. Questions to be answered are: (1) what techniques are best for western species? (2) how does nutrition favoring rapid growth affect seedling resistance/ susceptibility to drought, pests, and temperature extremes?

At one or more forest nurseries, seedlings will be raised according to various nutrient regimes including conventional fertilization and exponential fertilization. Growth and nutrient status of the seedlings will be assessed at 2-week intervals during the culture period to chart the progress and adjust nutrient supply schedules. At lifting, seedlings will have nutrient contents that vary incrementally from conventional to very high values, and should identify a treatment optimal for out-planting success. Survival and growth of these seedlings will be followed for at least 5 years, at which time a firm decision can be reached on the best treatment(s) to apply to operational planting.

A trial run using the fertilization rates specified in the proposal was made during 2001 at Cal Forest Nursery in Etna, CA.

Three Co-op members supplied seedlings for the test: Boise Cascade, Fruit Growers Supply Co., and Soper-Wheeler. Three species were grown: Douglas-fir, ponderosa pine, and white fir.

Problems with pH complicated the study while the seedlings were in the nursery. Over all, the constant rate fertilized seedlings outgrew the exponentially fertilized ones. Mortality was excessive with the latter application technique.

The foliar analysis done at Davis showed a range of nitrogen levels in the seedlings, but only in the constant feed application. Timmer believed that nutrient concentrations were too low in the early stages for the exponential treatments, and that seedlings were stunted and not able to catch up to those in the constant feed treatment. A later foliar sample from Scott's Lab showed minor but consistent differences in nitrogen levels among the constant feed treatments. Whole seedling nitrogen concentrations generally increased in proportion to nitrogen concentrations in the constant feed solution.

It was decided to out-plant only the two extreme treatments in the constant feed technique: 50ppm and 300 ppm.

The seedlings were lifted in February. Seedling height and caliper were recorded for each treatment and needles were collected and sent to Scott's Laboratory for analysis.

All plots were established by the last week of March, 2002. Plot corners were marked by metal conduit and planting spots were designated with wire stake flags. All three sites had been planted as of the first week in April. Only ponderosa pine had sufficient numbers of seedlings to be out-planted on the Boise Cascade site. Six replications of the 50 ppm and 300 ppm treatments were out-planted there. Fruit Growers had enough seedlings for 5 replications of each treatment for ponderosa pine and white fir; four replications of Douglas-fir were out-planted. Six replications of each treatment for ponderosa pine and white fir and five replications of Douglas-fir were out-planted on the Soper-Wheeler site.

Measurements for seedling heights and caliper were taken at all three sites in October, 2002. Survival was noted at the time the measurements were being taken.

First year data were analyzed in December, 2002. The experimental design was completely randomized with one-way treatment structure. Two treatments were each replicated 4 to 6 times. To test for treatment effects and significant differences among treatments, one-way analysis of variance of treatment means and Tukey tests were applied. Statistical significance in all tests was the 0.05 level.

Results: Survival at the end of the first growing season was uniformly high for both

treatments with all species on the three sites. Survival was always higher for the 50 ppm treatment when compared to the 300 ppm treatment but not statistically higher. For the study as a whole (all three sites), ponderosa pine survival ranged from 97-100 percent; white fir from 91-100 percent; and Douglas-fir from 94-100 percent.

The seedlings are responding early on to the different levels of fertilization. For the most part, the seedlings that received the largest fertilizer rate (300 ppm) were bigger than those seedlings that received the smaller rate (50 ppm). At the time of their lifting in the nursery, white fir and Douglas-fir showed significant differences in height and volume for all seed lots. Those seedlings receiving 300 ppm treatment were always larger than those receiving 50 ppm. Generally speaking, ponderosa pine seedlings did not show these differences.

After their first growing season, seedlings that were fertilized at the 300 ppm rate are always significantly taller and have significantly more volume than do their counterparts that received the 50 ppm rate. With the exception of ponderosa pine, this is also true for caliper. The percentage differences in height and volume that showed up at time of lifting are continuing to show after one year. The difference in volume is actually increasing. Survival is high regardless of treatment.

2003: The seedlings were remeasured for caliper and height at all three sites in the fall of 2003 at the end of their second growing season. Survival was noted at the time the measurements were being taken.

Survival at the end of the second growing season was still uniformly high for both treatments with all species on the three sites. Unlike at the end of the first growing

season, survival was not always higher for the 50 ppm as compared to the 300 ppm. For the study as a whole (all three sites), ponderosa pine survival ranged from 95-99 percent; white fir from 83-99 percent; Douglas-fir from 85-91. These percentages are lower than those reported at the end of the first growing season, but not significantly so.

After their second growing season, seedlings that were fertilized at the 300 ppm rate are always significantly taller than are their counterparts that received 50 ppm. But the differences are less than at the end of the first growing season. Many of the significant differences among treatments in caliper and volume that showed up at the end of the first growing season are no longer there. The 300 ppm treatment always gives the higher values for these two variables but many of the differences among the two treatments are no longer statistically different. Survival continues to be high for all treatments.

2004: Seedlings were remeasured for caliper and height at all three sites in the fall of 2004 at the end of their third growing season. Survival was noted at the time the measurements were being taken.

Survival continues to be high for both treatments with all species on the three sites. Survival for the 50 ppm treatment is slightly higher than that in the 300 ppm treatment in 5 to 7 comparisons. For the study (all three sites), ponderosa pine survival ranged from 96-99 percent, exactly the same as at the end of the second growing season; white fir from 79-89 percent, down slightly from the end of the second growing season; and Douglas-fir from 80-90 percent, also down slightly from the second growing season numbers.

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. Of the 21 comparisons possible (fertilizer rates/species), only 5 show significant differences. In 2003 that number was 11. There seems to be an influence of site quality (most influence on higher sites) but this generalization has problems. As far as tree species, white fir is the most influenced by fertilization rate. The most influenced dependent variable is tree height. Survival continues to be high on all sites for all treatments.

2005: No measurements taken on this study.

2006: After five years in a plantation, seedlings that were fertilized at the 300 ppm rate are always taller, have larger caliper, and have more volume than their counterparts that were fertilized at the 50 ppm rate. But continuing a trend that started at the end of the second growing season, most of these differences are no longer significant. In fact the only significant difference between treatments on all three sites in the study is found in the white fir planted on the Soper-Wheeler site where the seedlings fertilized at the 300 ppm rate are significantly taller than those fertilized at the 50 ppm rate.

Survival has remained high throughout the life of the study for all species. Percent survival ranges at the end of 2006 for all sites combined were: white fir 72-89%, ponderosa pine 95-96%, and Douglas-fir 77-87%. There was very little difference in survival rates between the two treatments except in the white fir where the 50 ppm treatment had a 7% higher survival rate than counterparts in the 300 ppm treatment.

In summary, significant differences in volume, caliper, and height between the two fertilization rates that were evident at time of lifting continued through the end of the first growing season. The difference in volume actually increased from the time of lifting to the end of that first year. But by the end of the second growing season although the 300 ppm seedlings were still larger and taller than the 50 ppm seedlings, many of the differences were no longer significant. This trend continued through the third growing season with even less significant differences by the end of 2004. No remeasurements were scheduled for the fourth growing season (2005). At the end of the fifth growing season in 2006, there was only the single significant difference among all treatments on all plots and sites.

Study results will be presented to the membership at the 2007 annual meeting. At this time, a decision will need to be made concerning the future status of this study as original plans were to carry it through the fifth growing season (2006).

Sierra Cascade Intensive Forest Management Research Cooperative
Income/Expense Statement
Calendar Year Report for the Period Jan. 1 to Dec. 31, 2006

Beginning Balance on January 1, 2006		\$3,307.46
Total Income (Membership Dues)		\$66,000.00
Expenses:		
New Proposal Funding (3-PG 2 nd Installment)	\$10,802.00	
Plot Establishment Supplies	\$530.00	
Pesticide Application Contracts	\$11,611.90	
Data Entry/Analysis Contracts	\$2,610.00	
Co-op Manager Expenses	\$38,388.10	
Total Expenses		\$63,942.00
Year End Balance as of December 31, 2006		\$5,365.46

WORKING GROUP MEMBERSHIP

Working Group I

Seed to Establishment

Tom Jopson, Chair
Bob Amesberry
Ed Fredrickson
Jerry Gallagher
Mark Gray
Lewis Howe
Bill Morrison
Duane Nelson
Tom Young

Working Group II

Out-planting Through Precommercial Thinning

Jason Warshawer, Chair
Bob Amesberry
Ed Fredrickson
Mark Gray
Lewis Howe
Bill Morrison
Duane Nelson
Bob Powers
Tom Young