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 a 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. zonana* 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.

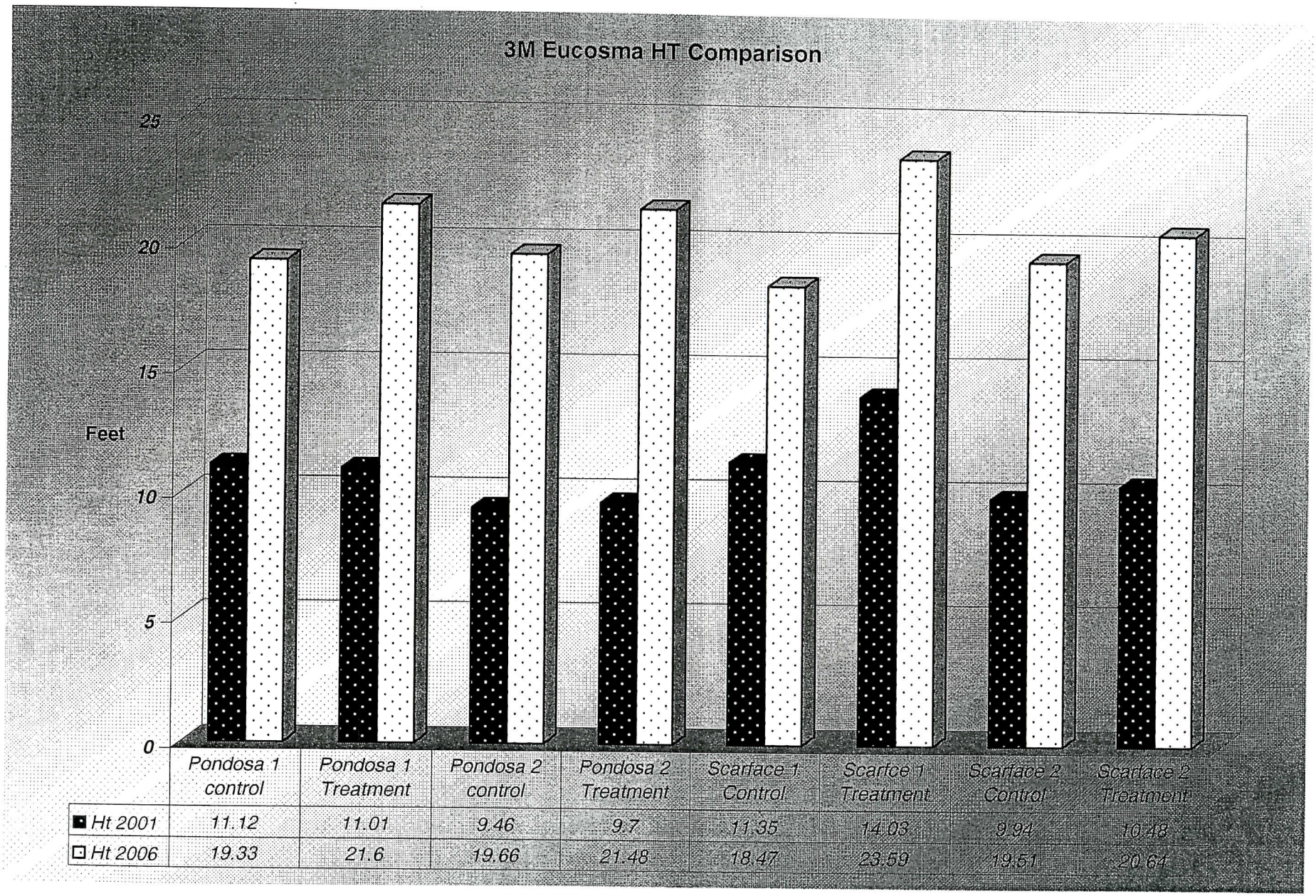
Pine plantations are routinely thinned to reduce competition among trees for water and sunlight, and *E. sonomana* infestation levels typically increase the year following a thinning (J. N. Webster, personal observation). The probable mechanism for this phenomenon is simply a reduction (normally by about 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.*

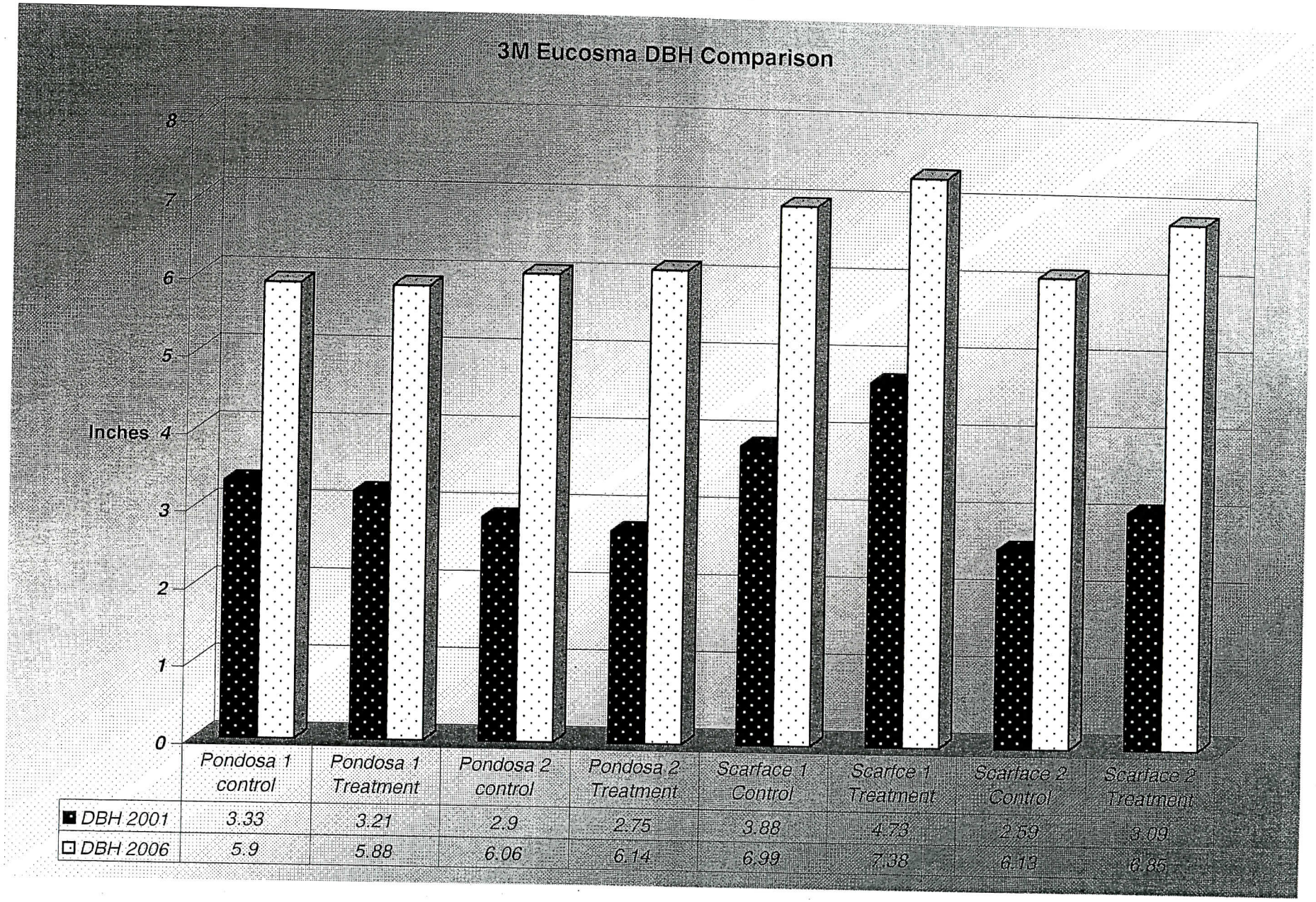
sonomana, this mechanism is known to be important in cone and seed insect population dynamics (Daniel et al. 1979, p. 145). Thus, it could be beneficial to time the application of pheromome disruptions in tandem with stand thinning, to avoid concentrating the oviposition of moths on a smaller number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

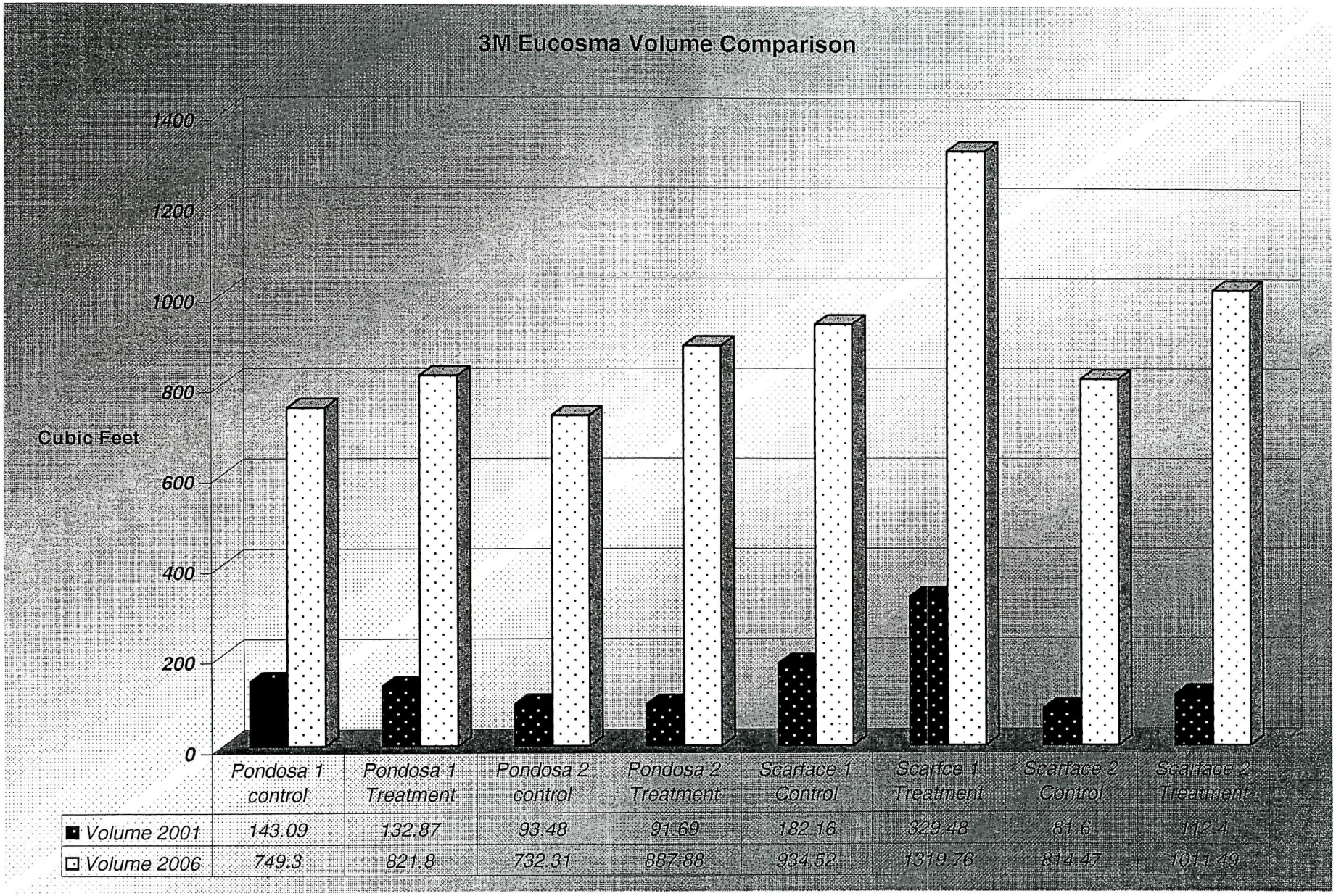
2006: All plots were remeasured in October, 2006 at the end of the fifth growing season. Measurements taken included diameter at 4.5 feet, total height, and height to live crown. Total height and height to live crown were used to determine live crown ratio. Determination was made at the time of measurement 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
Feet
25
20
15
10
5
0
Pondosa 1 control
Pondosa 1 Treatment
Pondosa 2 control
Pondosa 2 Treatment
Scarface 1 Control
Scarfice 1 Treatment
Scarface 2 Control
Scarface 2 Treatment
Ht 2001
11.12
11.01
9.46
9.7
11.35
14.03
9.94
10.48
Ht 2006
19.33
21.6
19.66
21.48
18.47
23.59
19.51
20.64



	Pondosa 1 control	Pondosa 1 Treatment	Pondosa 2 control	Pondosa 2 Treatment	Scarface 1 Control	Scarfce 1 Treatment	Scarface 2 Control	Scarface 2 Treatment
DBH 2001	3.33	3.21	2.9	2.75	3.88	4.73	2.59	3.09
DBH 2006	5.9	5.88	6.06	6.14	6.99	7.38	6.13	6.85


3M Eucosma Volume Comparison
Cubic Feet
1400
1200
1000
800
600
400
200
0
Pondosa 1 control
Pondosa 1 Treatment
Pondosa 2 control
Pondosa 2 Treatment
Scarface 1 Control
Scarface 1 Treatment
Scarface 2 Control
Scarface 2 Treatment
Volume 2001
143.09
132.87
93.48
91.69
182.16
329.48
81.6
112.4
Volume 2006
749.3
821.8
732.31
887.88
934.52
1319.76
814.47
1011.49