Experimental habitat manipulation of wayside aster (*Eucephalus vialis*)

2010 Final Report

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PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and a federal agency. IAE is a non-profit organization dedicated to natural resource conservation, research, and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through 3-4 month internships. Our current activities are concentrated on rare and endangered plants and invasive species.

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EXECUTIVE SUMMARY

Eucephalus vialis, wayside aster, is an herbaceous perennial known only from Lane and Douglas Counties in Oregon. It is listed as a State Threatened species, a Species of Concern by the U.S. Fish and Wildlife Service (ORBIC 2010), and is classified as Bureau Sensitive in Oregon under a Draft Bureau of Land Management (BLM) Special Status Plant Policy. Prior to this study, many populations of this species were observed to have little to no reproduction, plants were often stunted, and recruitment rates were very low. These observed declines in populations and plant vigor may be a result of increasing canopy closure caused by a lack of natural disturbance; fires potentially beneficial to *E. vialis* ceased with the arrival of European settlers to the area. The goal of our study was to discover what factors were limiting the growth, reproduction, and recruitment of *E. vialis* to provide scientifically-backed guidance for management of this species. Over 10 years, we performed three sets of experiments in the Eugene District Bureau of Land Management to test different potential limiting factors. First, we tested the effects of forest canopy thinning. Second, we tested the effects of prescribed fire in the Willamette Valley Oak Savannah Habitat Conservation Project plots (WVOPHCP). Third, we examined factors potentially influencing seedling recruitment and transplant survival at Long Hill. Key findings from these experiments include:

<u>Forest canopy thinning improves plant vigor and reproduction</u>

- Thinning increased light availability, which in turn led to greater plant height, increased probability of flowering, and increased seed set.
- Plant mortality was lower in thinned plots.
- Deer herbivory was very common and reduced plant height and seed set. Deer herbivory was less common in thinned areas.
- Thinning led to increases in the cover of native grasses, forbs, and tall shrubs. Cover of non-native species also increased with thinning, but their total cover remained low.

<u>Small-scale burns have neutral effects</u>

- We did not find any negative effects of burning treatments on *E. vialis*, suggesting that fire may be an appropriate habitat management treatment in sites occupied by *E. vialis*. However, as the fires generally were small and low intensity, these results should be applied with some caution.
- These treatments had little effect on overall species composition. While there was a general increase in non-native cover, this trend started in 2006, and is unlikely to have resulted from burning treatments.

<u>Both transplants and seeding into mineral soil can be used for population reintroduction or augmentation</u>

- Seeds of *E. vialis* have higher germination rates when sown on bare soil. In each year of this study, more seedlings established on soil that had been scraped to the mineral layer than on soil where the litter layer remained undisturbed.
- For seedlings that germinated from sown seed, the long term survivorship rate was 27%.

- Transplanting *E. vialis* is a viable means of reintroduction. Over half of the transplants planted in 2001 survived until 2010. Mortality was highest the first few years after planting, with numbers staying relatively constant after 2004.
- Newly germinated seedlings and transplants may need to be protected from deer herbivory. Severe deer browsing was a likely cause of slow growth and delayed reproduction.

Eucephalus vialis populations responded to reductions in canopy cover through increased stem height and flowering, despite prevalent deer herbivory. Natural recruitment was low, suggesting further intervention is required to ensure population stability. Additionally, both seeding and tranplanting were found to be successful methods of reintroduction. Continued monitoring of these populations will help capture further changes in these populations, especially if thinning treatments continue.

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INTRODUCTION

Objectives

Factors affecting the survival, flowering, and establishment of *Eucephalus vialis* Bradshaw [née *Aster vialis* (Bradshaw) S.F. Blake, Figure 1], also known as wayside aster, are poorly understood. Thus, there is little information available to guide habitat management to promote growth and long term persistence of this rare species. In cooperation with the Eugene District Bureau of Land Management, we investigated three questions to better inform management of *E. vialis* populations.

Figure 1. *Eucephalus vialis* (wayside aster).

1. The effects of forest canopy thinning on *E. vialis*. We compared *E. vialis* survival, growth, and reproduction, community composition, and light environment in18 sites; six of which were thinned between 2002 and 2008.
2. The effects of prescribed fire on *E. vialis*. We collected pre- and post-treatment *E. vialis* and habitat data on plots within the Weiss Road Willamette Valley Oak and Pine Habitat Conservation Project that received thinning and burning treatments.
3. Factors influencing *E. vialis* seedling recruitment and transplant survival. We compared the success of outplanted cultivated *E. vialis* plants versus direct seeding as methods of augmenting existing populations or creating new ones to promote habitat connectivity. We also examined the effects of canopy cover and soil litter on transplant survival and seedling recruitment.

Species status

Eucephalus vialis is an herbaceous perennial listed as a Threatened species by the state of Oregon and a Species of Concern by the U.S. Fish and Wildlife Service (ORBIC 2010). This species is also classified as Bureau Sensitive in Oregon under a Draft Bureau of Land Management (BLM) Special Status Plant Policy.

Natural history

Eucephalus vialis reproduces sexually by seed and vegetatively over short distances (<20 cm) with rhizomes. Flowering usually occurs from mid-July to September. Although seed production is evident, seeds are often nonviable. In one study, seed set was only 0.1% to 4.3% depending on the site, and all plants formed less than one seed per flower head on average (Kaye 2001). Seedling recruitment appears to be limited or nonexistent within certain populations (BLM files, unpublished data). Seeds are primarily wind dispersed, but many remain near the parent plant (Gammon 1986). Vegetative reproduction is common within populations, making it difficult to differentiate individuals in some cases. In 1990, a study of *E. vialis*' breeding system found that the species is sexually self-incompatible, meaning insect transport of pollen between separate individuals is required for seed production (Kaye et al. 1991). In addition, seed set is significantly higher in experimental pollination crosses between plants from different populations than between plants from the same population, suggesting that habitat fragmentation may isolate plants and cause inbreeding depression due to reduced long distance pollination. Because inbreeding depression can occur when pollen flow is restricted to a single site, maintaining as many of the known sites as possible in a reproductive state is important to the long term viability of *E. vialis* (Kuykendall 1991).

It is likely that disturbances such as fire historically maintained the high light conditions that promote population growth in *E. vialis* by improving flower and seed production. The species probably occupied forest edges and gaps in a frequently burned forest system. Today, adjacent timber harvests and occasional windthrows appear to be the primary factors that increase light reaching remnant *E. vialis* populations on the forest floor. In many respects, this species resembles a well studied eastern relative, *Aster acuminatus*, which is also a self-incompatible perennial that reproduces rhizomatously and by seed (Pitelka et al. 1983, Hughes et al. 1988) and which may respond similarly to disturbance (Hughes et al. 1988, Siccama et al. 1970).

Populations of *E. vialis* occur in sites representative of all stages of succession from recent clearcuts to mature forest. Plant vigor and flower production appear to be inversely correlated with canopy cover; the more light that reaches the plants, the greater the species' vigor and flowering (Wogen 1998). It is not clear whether plants move into gaps or whether they are released *in situ* after disturbance events. *Eucephalus vialis* appears to decline as succession proceeds. This is probably due to decreased light, but may also involve competition for nutrients and/or water (Gammon 1986). Numerous *E. vialis* sites occur in stands where canopy closure has occurred due to lack of fire and management. In such stands, plants are generally small and do not produce flowers.

Conservation concerns

A primary factor regulating the long term survival of *E. vialis* populations is the rate at which new individuals are recruited into existing populations and previously unoccupied habitat (Wogen 1998). Currently, new habitats are not being created and colonized in the same way as they were historically, most likely due to the lack of natural disturbances such as fire, combined with unnaturally dense re-stocking of forests immediately following timber harvest. *Eucephalus vialis* typically occurs in areas with a historically high fire frequency due to hot, dry summers and ignition by lightning. Also, prior to Euro-American settlement, native people used fire to maintain open land useful for hunting and plant foraging. Fire suppression since pioneer settlement has altered much of the habitat of *E. vialis*. Many of the sites occupied by this species occur on south-facing slopes in coniferous woodlands that have become closed canopy forests over the past 100 years. Prior to fire suppression efforts, this habitat was most likely open woodland with many forest gaps and higher light levels available on the forest floor. Under a frequent fire return interval of 5 – 25 years, the pre-settlement forest would not reach the stage of complete canopy closure that we see today (Alverson and Kuykendall 1989).

Reintroduction of natural or prescribed fires into the habitat of *E. vialis* is one tool for managing the species, although burning is likely to be difficult at populations adjacent to residential areas and private forest lands. Therefore, processes that mimic the role of fire, such as manual formation of canopy gaps, may be necessary to produce suitable habitat for sustainable *E. vialis* populations. To evaluate the feasibility and effects of this recommendation, one goal of this project was to explore the response of *E. vialis* to manual forest canopy thinning. To determine if *E. vialis* population connectivity can someday be restored, this project also initiated a pilot study to investigate the use of directly-sown seeds and transplanted plugs for population introduction and augmentation.

METHODS

There are three main components of this study:

1. Forest canopy thinning study: This project was designed to test the hypothesis that suppression in *E. vialis* plants is caused by insufficient light levels. Forest canopy treatments occurred in selected plots in 2002, 2005, 2006 and 2008. Pre- and post-treatment monitoring involved collecting data on light levels, basal area of trees within the plot, plant community composition and percent cover, and individual *E. vialis* plant status.

2. Willamette Valley Oak and Pine Habitat Conservation Project (WVOPHCP): This project emphasized oak savannah restoration through the use of fire and selected tree removal. The *E. vialis* plots within the boundaries of this project enjoyed a relatively open forest structure and a higher pre-treatment rate of flowering, when compared to the forest canopy thinning plots. Plot 1, the largest plot, is located within a larger area that received a broadcast burn in September 2003. Plots 4, 5, 7 and 10 received local swamper burns in which brush fires were localized over the plots. Swamper burns are brush/slash fires that are stoked by adding branches and other fuels to the fire and can mimic controlled broadcast burns. A forest canopy thinning plot (#18) was also established on the Weiss Road property.

3. Transplanting and seeding at Weiss Road and Long Hill: At these two sites, *E. vialis* seeds were sown on both untreated ground and ground that was scarified to expose mineral soil. Seeds were also sown on a burned substrate at Weiss Road. Transplants were planted along a light gradient at Long Hill North to evaluate the role of light availability in transplant success.

Forest canopy thinning treatments and data collection

Site selection

Eighteen study plots were established at 12 locations on lands owned by the Eugene District BLM, including locations in the McKenzie and South Valley Resource Areas. One plot was also established on private land near Cougar Mountain. Selection of plot locations was based on four criteria:

1. Presence of suppressed *E. vialis* plants (i.e., individuals that were small and non-reproductive)
2. Presence of at least 10 *E. vialis* individuals (with a few exceptions)
3. Low abundance of invasive species that could potentially expand after the forest canopy disturbance and the use of heavy equipment for tree removal
4. Compatibility of canopy disturbance activities with other management objectives for the site (i.e., spotted owl habitat management, old growth forest protection, riparian forest conservation, etc.)

In a few cases, sites were large enough to accommodate two or more plots that could be treated independently because they were sufficiently far apart (≥0.5 km). Plot locations and descriptions are provided in Table 1.

Plot establishment

Plots at each site were positioned based on the distribution of *E. vialis* and treatable portions of the forest canopy. Plot size was based on the density of plants in the area; generally, plots were made large enough to include 8 to 30 *E. vialis* individuals. Plots ranged in size from 5m x 5 m to 10m x 40 m. Table 1 outlines specific details and physical characteristics of each plot. Corners of the plots were marked with metal conduit posts with red-painted tips. One corner post was designated as the plot origin for use in recording X–Y coordinates of individuals within each plot.

Plot sampling

We visually estimated the percent cover of all woody and herbaceous species in all plots (Figure 2). We also made ocular estimates of canopy cover for each tree species. We measured the diameter at breast height (DBH) of all trees >2.54 cm. Basal area (BA) was calculated with the following formula:

$$\text{BA (m}^2\text{/ha)} = (\pi/40{,}000) * ((\sum \text{DBH}^2)/\text{plot area}) = 0.0000785398 * ((\sum \text{DBH}^2)/\text{plot area})$$

using DBH in centimeters and plot area in hectares. See Appendix 1 for a list of field equipment required for plot sampling.

We tagged and measured each *E. vialis* individual in every plot (Figure 3). The number of stems, length of all stems, number of stems browsed by deer and insects, number of flowering heads (capitula), and number of browsed capitula were recorded for each plant. Plants were determined to be individuals if they were >10 cm away from the nearest stem, unless stems were evidently joined by below ground rhizomes (determined by carefully probing the soil to feel for rhizome connections). All plants were plotted on an X–Y coordinate system and marked with a pre-numbered round tag mounted on a 10-gauge wire stake (Figure 3). Slope, aspect, elevation, and UTM coordinates were recorded at all plots.

For each plant, we used a spherical densiometer and solar pathfinder to measure light availability and canopy cover. If multiple plants were located within approximately 10 centimeters of each other, only one set of measurements was taken for both individuals. Using the densiometer (Lemmon 1956, 1957), four readings were taken directly above each plant at the cardinal directions. These readings were averaged, along with all readings in the plot, for a summary of the light conditions at each plot. This number is comparable to the visual estimate of canopy cover for the entire plot. The solar pathfinder (Swenson and Bielfuss 2001) provided an estimate of light availability during the growing season. Readings were taken at plant height for the months of April through October and averaged both for each plant and the entire plot.

All data collected can be found in the associated Access database "ASVI 2001-2010", including vegetative cover, DBH, *E. vialis* measurements, densiometer and solar pathfinder readings, and site information.

<u>Data analysis</u>

We analyzed several aspects of *E. vialis* plant performance, including number of capitula, probability of flowering, recruitment, and mortality. The average number of capitula produced by each plant before and after treatment was analyzed using a linear mixed effects models (LMM) on log-transformed data, with treatment (control or thinned) and time (before or after treatment) as fixed effects, % of capitula eaten by deer and average % solar radiation as covariates, and plant nested within plot as random effects (to account for spatial nesting of plants within plots and the repeated measures of plants over time). For control plots, years ≤ 2005 were classed as "before" and >2005 as after, as most treated plots were thinned in 2005. Because of complicated interaction effects in the full model, we next analyzed treated and control plots separately. We also tested for affects of thinning on the probability of flowering, by comparing whether or not a plant flowered at least once before or after treatment in control and thinned plots. This analysis was done using a generalized linear mixed effects model (GLMM) with quasibinomial errors, and with the number of plants that did/did not flower as a response variable, time and treatment as fixed effects, and plot as a random effect (to account for repeated measures). Recruitment and mortality were both analyzed similarly, with GLMM with quasibinomial errors time and treatment as fixed effects, and plot as a random effect.

We also compared solar radiation before/after treatment, using the data collected from the solar pathfinder. As initial exploration of the data showed the solar radiation for each individual month was highly correlated to all other months, we used the average of the values for April – October. We analyzed for treatment effects on solar radiation with LMM. We did not use canopy cover in this analysis because initial data exploration showed the solar pathfinder data explained more variance in our response variables. Further, we excluded basal area of the trees within each plot because this data didn't correlate with changes in community composition or plant metrics.

Community composition data was visually examined with non-metric multidimensional scaling (NMDS) ordination methods. We averaged the cover values for each species before and after treatment, and discarded any species which occurred in only one plot. We ordinated all plots, before and after, together, and showed the trajectories from before to after treatment. Explanatory variables were overlaid onto the ordination (slope, aspect, elevation, longitude and latitude, and cover of functional groups); only significant ($p < 0.1$) explanatory variables are shown.

Table 1. Forest canopy thinning plot locations, treatments, and characteristics. Months of plot treatments are noted.

Plot	Plot Name	Treatment	Slope	Aspect	Elev. (m)	UTM (E)	UTM (N)	Plot Size
1	Upper 79th St. upper	none	4	94	345	10511873	4876659	20m x 10m
2	Lower 79th St upslope	none	36	288	369	10509713	4876143	25m x 10m
3	Lower 79th St. Roadside	09/2005	33	240	289	10509553	4876286	20m x 10m
4	Papenfus Upper	03/2005	4	110	394	10506150	4862019	10m x 10m
5	Spores Creek	09/2005	35	197	314	10504000	4885488	40m x 10m
6	Bear Creek	none	35	222	271	10505129	4860114	8m x 10m
7	Mosby Creek inside, plot C	none	4	229	320	10501421	4844852	5m x 5m
8	Mosby Creek outside, plot A	none	19	246	320	10501416	4844850	5m x 5m
9	RFI #9	03/2005	30	180	406	10505450	4907126	10m x 10m
10	Scattered Tracts, North	none	21	4	234	10483386	4854586	20m x 10m
11	Long Hill North	none	12	91	351	10488235	4851575	10m x 40m
12	Long Hill Northeast	none	12	94	314	10488584	4851591	10m x 21m
13	Long Hill Middle	none	14	90	338	10488596	4851152	10m x 10m
14	Papenfus Lower	none	35	196	382	10505997	4861959	20m x 10m
15	PAG	none	19	215	286	10486096	4858025	10m x 10m
16	Cougar Mountain	none	8	240	643	10501900	4856781	10m x 10m
18	Weiss Road forest	12/2002	11	317	295	10488780	4860972	10m x 8m
19	Rowdy Camp	01/2008	9	130	341	10513036	4881614	10m x 22m

Figure 2. *Eucephalus vialis* plot sampling, including measuring species diversity and abundance and characteristics of *E. vialis* individuals.

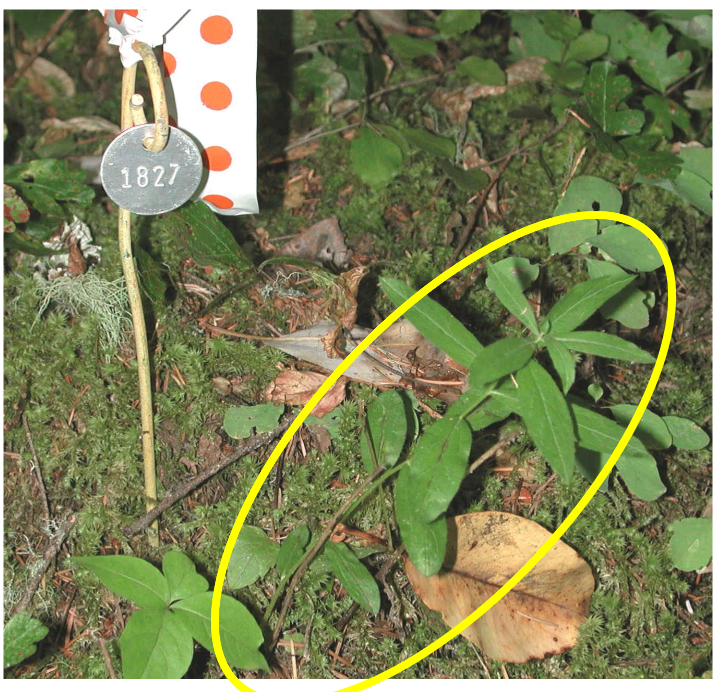

Figure 3. Individual *E. vialis* plants were tagged for long-term tracking. This is a suppressed, non-reproductive individual in a shaded understory.

Willamette Valley Oak and Pine Habitat Conservation Project Plots

<u>Plot establishment and sampling</u>

We established and sampled eleven permanent plots at the Weiss Road #3 site (Figure 4) in August 2002. Plot 1 was 12 m x 28 m, while plots 2 – 11 were 3 m x 4 m. In each plot, all *E. vialis* plants were tagged and their size and location were recorded. Data was recorded as described above for the forest canopy thinning plots. WVOPHCP plot data is summarized in Table 5. Plot 1 received a broadcast burn in September 2003 after *E. vialis* sampling was conducted. Four of the 3 m x 4 m plots (4, 5, 7 and 10) were partially treated with swamper burns.

<u>Data analysis</u>

Data analysis methods were the same as those used in the forest canopy thinning study.

Seeding and Planting

To examine limitations to seedling recruitment, effects of forest canopy on plant growth, and the relative suitability of seed sowing versus outplanting as population restoration tools, we sowed seeds and outplanted greenhouse-grown plants across a light gradient. Our specific hypotheses were:

- Seedling establishment is limited to areas of exposed mineral soil and open canopy. It can therefore be enhanced by artificially exposing mineral soil and sowing seeds. This is based on observations that seedling recruitment is uncommon or absent at some sites, and when it does occur, appears to be associated with mineral soil and an open canopy.
- The forest canopy limits light reaching understory forbs, and therefore limits growth of *E. vialis* plants.
- Greenhouse-grown transplants can be moved to a forested habitat and successfully grown to establish new populations. This is based on the observation that seeds can be germinated and plants can be grown in a greenhouse environment (Kaye 2001).

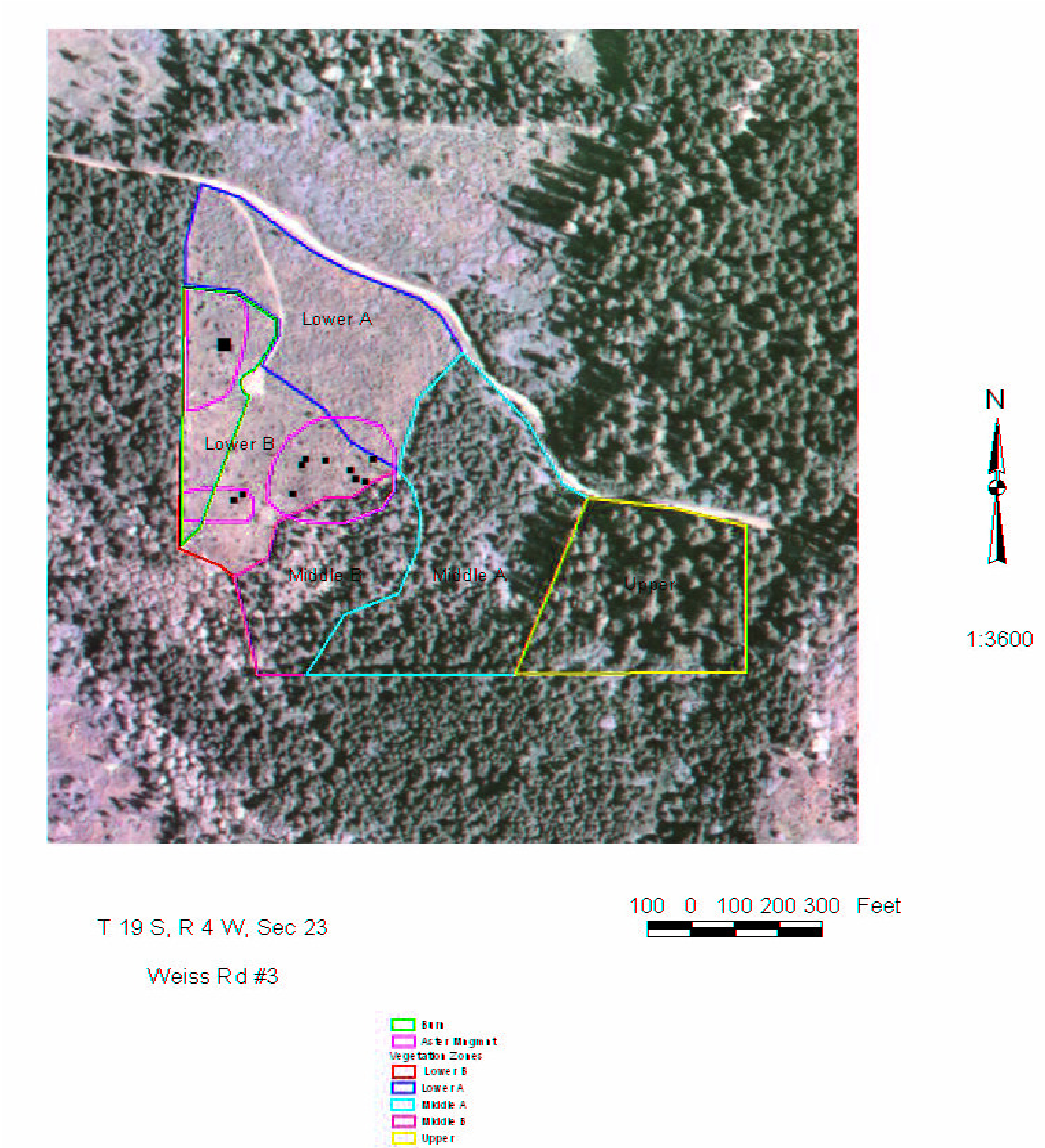

Figure 4. Locations of permanent plots (black squares) at the Weiss Road #3 demonstration site. All plots were placed within *E. vialis* management zones (fuchsia lines) in Lower Zone B. Plot 1 is located in the broadcast burn area (green lines) and is shown as a large black square in the upper left. Plots 2 – 11 are in the area that received swamper burns and are marked with small squares.

Seeding and transplanting plots at Long Hill North

To test the above hypotheses, we outplanted or seeded *E. vialis* into fifteen experimental blocks at the Long Hill North site on 6 December 2001. We chose random locations within a 35 m x 25 m macroplot adjacent to an existing *E. vialis* population (Figure 5); blocks were not located in the *E. vialis* ecological monitoring plot. Additionally, if a random location placed a block where there was obstructing vegetation, we moved it to reduce or preclude interference from trees, roots, and shrubs. Within the macroplot, light regimes ranged from relatively open canopy with light reaching the forest floor to denser canopy with very little light reaching the forest floor. These light regimes were measured with the solar pathfinder and a densiometer from 2002 – 2010.

Each block contained three 1 m^2 treatment plots. Each plot was randomly assigned one of three treatments: seeding with no ground manipulation, seeding with all duff and plant material scraped to the mineral soil, or transplanting of one-year-old greenhouse grown *E. vialis* (Table 2). Seeded plots were each sown with 50 filled *E. vialis* seeds. The duff was removed in the scraped plots with a garden hoe until a layer of red mineral soil was visible. The soil was not disturbed in transplant plots. In the transplant plots, four plants were transplanted into the middle of each quarter of the plot (for a total of 60 plants outplanted at the site). No fertilizer was applied during planting. The ground was sufficiently wet and rain was falling so no additional watering was necessary. These plots were revisited in July or August in 2003 – 2010 to document transplant survival and size and the germination of seeds and survival of seedlings.

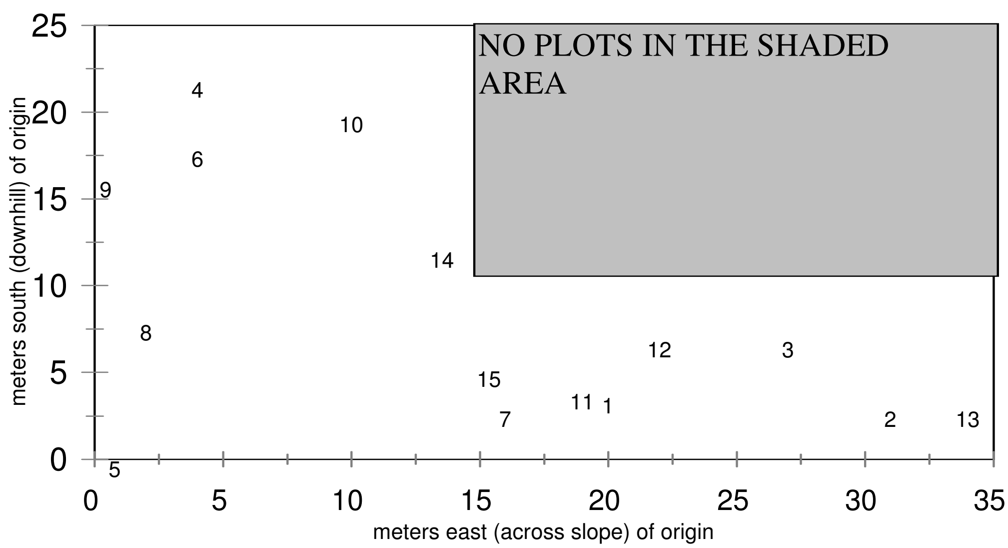

Figure 5. *Eucephalus vialis* seeding and transplant plot locations at the Long Hill North site.

Table 2. *Eucephalus vialis* seeding and outplanting at Long Hill: plot coordinates and treatments.

			Treatments		
Block #	X	Y	South plot	Middle plot	North plot
1	20	4	seed	scrape and seed	transplant
2	31	3	seed	transplant	scrape and seed
3	27	7	scrape and seed	seed	transplant
4	4	22	scrape and seed	transplant	seed
5	1	0	scrape and seed	seed	transplant
6	4	18	scrape and seed	seed	transplant
7	16	3	transplant	scrape and seed	seed
8	2	8	scrape and seed	transplant	seed
9	0	16	seed	transplant	scrape and seed
10	10	20	seed	scrape and seed	transplant
11	19	4	transplant	scrape and seed	seed
12	22	7	transplant	seed	scrape and seed
13	34	3	seed	scrape and seed	transplant
14	14	12	seed	scrape and seed	transplant
15	15	5	scrape and seed	seed	transplant

When analyzing the data, we examined transplants and seeding separately. For transplants, we summarized the number and percentage of surviving plants in each year. We tested for effects of average solar radiation and herbivory on the number and size of transplants using a generalized linear mixed effects model (GLMM), with Poisson errors and plant nested within plot as a random variable. For seeding, we compared the number of plants in scraped and control plots using a repeated measures GLM with Poisson errors.

Seeding plots at Weiss Road

Preliminary results from the seeding plots at Long Hill North showed increased *E. vialis* seedling establishment when the seeds were placed on mineral soil compared to forest duff (Kaye and Cramer 2002). To further evaluate factors that affect seedling establishment, seeding plots were established in 2003 in the WVOPHCP study area at Weiss Road. *Eucephalus vialis* seeds were sown directly into 1 m^2 test plots. The effects of three ground preparation treatments were compared: burned (charred to mineral soil), scraped to mineral soil, and undisturbed (control). The plots were grouped into blocks with three plots each, one of each treatment (a randomized complete block design). The three treatments (burning, scraping, and control) were replicated seven times (7 blocks). Seventy-five *E. vialis* seeds were sown into each of twenty-one plots on 7 February 2003. Due to low establishment, we terminated sampling these plots in 2005.

RESULTS AND DISCUSSION

Forest canopy thinning plots

Project implementation schedule: duration, treatments and sampling plan

Baseline monitoring for this project began in 2001, with treatments originally planned for 2003 – 2004. Due to various circumstances, forest thinning was not initiated at all sites according to the original schedule. Instead, treatments occurred when and where possible, and were therefore not synchronized. To accommodate this delayed and asynchronous treatment pattern while retaining the ability to draw conclusions about *E. vialis* management from this study, plot sampling of both treatment and control plots continued annually through 2010 (Table 4).

In all, six of the eighteen forest canopy thinning plots received treatments. The first plot, Weiss Road, was thinned in December 2002. The RFI and Upper Papenfus plots were thinned in March 2005. Spot fires of piled thinning debris were burned throughout the greater treatment areas of these two plots in November 2005, carefully avoiding the currently existing tagged and monitored plants. Spores Creek and Lower 79th Street received treatments in fall 2005, after data collection for that year had ceased. Treatment at Rowdy Camp occurred in January 2008. Information about the plants in all forest canopy thinning plots can be found in Appendix 3.

Baseline site conditions

Among the eighteen plots included in this study, slope ranged between 4° and 36°. Aspect varied between plots, but only one plot was found on a north-facing slope (Scattered Tracts North). Plots ranged from 234 m to 643 m in elevation (Table 1).

All sites were forested with a dense canopy dominated by *Pseudotsuga menziesii* (Douglas-fir). Understory composition varied from plot to plot; 173 plant species were found during the study. *Acer circinatum* (vine maple), *Corylus cornuta* (beaked hazel), *Gaultheria shallon* (salal), *Holodiscus discolor* (ocean spray), *Toxicodendron diversilobum* (poison oak), *Rosa gymnocarpa* (wood rose), and *Symphoricarpos albus* (common snowberry) were present in most plots. Herbaceous species found in most plots included *Arenaria macrophylla* (big-leaved sandwort), *Lonicera hispidula* (California honeysuckle), *Osmorhiza chilensis* (mountain sweetcicely), *Polystichum munitum* (sword fern), *Rubus ursinus* (Pacific blackberry), *Synthyris reniformis* (snow queen), and *Trientalis latifolia* (Pacific starflower). Moss cover ranged from 10 to 90% throughout the study.

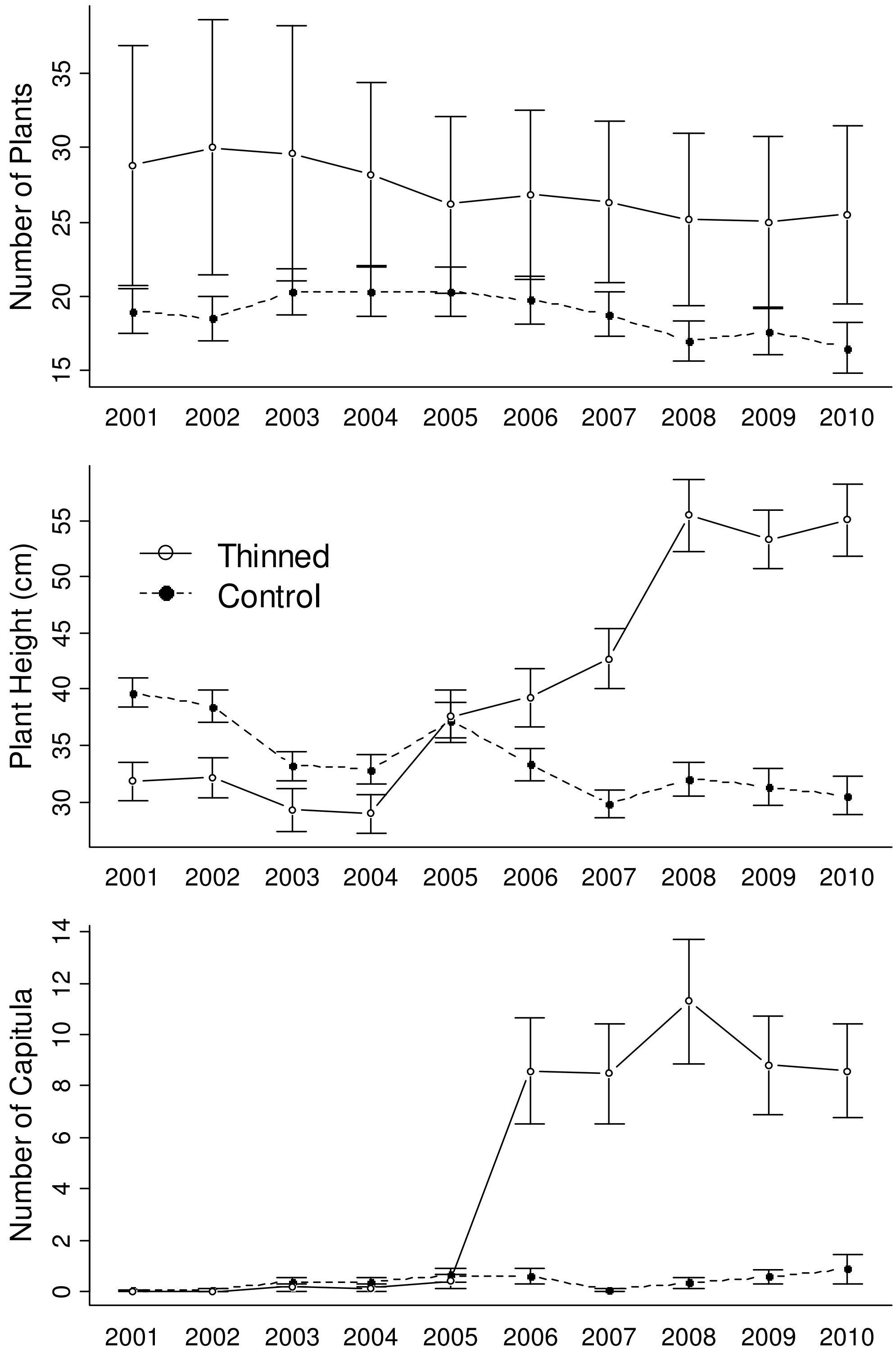

Figure 6. Changes in *E. vialis* over time in response to treatments; plant number per plot (top), plant height (middle), and number of capitula (bottom). Data represent means ± 1 SE.

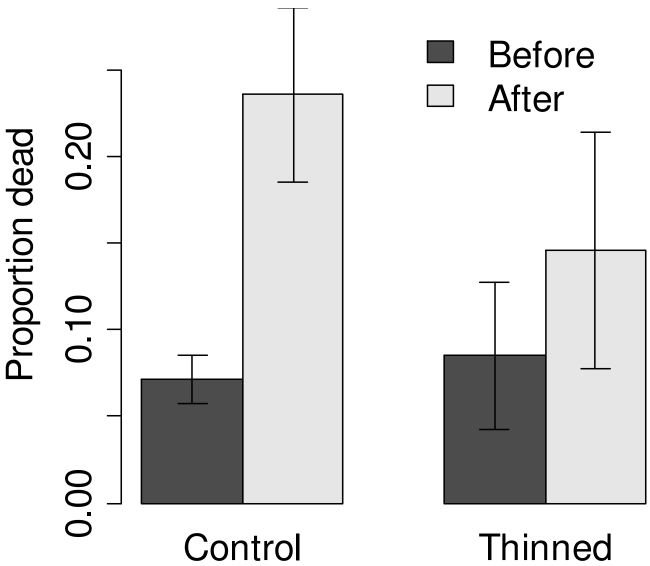

Figure 7. Plant mortality in control and thinned plots before and after treatment.

E. vialis recruitment and mortality in response to treatments

Although the number of plants in each plot varied, the study-wide average was 21.2 plants per plot (Appendix 3). Weiss Road had the lowest average number of plants throughout the study (7.6), while Spores Creek had the highest average (43.8). The number of plants decreased in thirteen plots; Long Hill Middle had the largest decline at 62.5% (10 plants). The number of plants increased in three plots (Rowdy Camp, Long Hill North, and Upper 79th), while two plots had no net change over the course of this study (Lower 79th and Papenfus Upper). Long Hill North had the largest increase at 25% (2 plants).

The number of plants declined an average of three plants per plot by the end of the study, with declines slightly larger in control plots (Figure 6, top panel). Plant mortality increased over the length of the study ($p = 0.002$), but mortality increased significantly more in the control plots than in the thinned plots (Figure 7, $p = 0.036$). Prior to treatment, mortality was the same in control and thinned plots ($p = 0.112$).

Recruitment was very difficult to estimate, because plants were rarely found or identified as seedlings; instead new plants were likely marked when 2 – 4 years old. Additionally, more new plants were found in the first few years of the study than later in the study. This is probably a sampling artifact rather than a real biological trend. It is hard to separate new recruits from established adult plants that were only found after a few years of searching. For example, in the first year of the study, a plant may have been missed because it was heavily browsed, and was only large enough to find in the second or third year. Because of this, we did not analyze data on recruitment in the first five years of the study. Using data from only 2006-2010, we found that recruitment rates were very low and did not differ significantly between control (0.024 ± 0.032 new recruits/plant) and thinned plots (0.043 ± 0.043 new recruits/plant). This pattern is despite increased flowering (and potential seed production) in the thinned plots. The lack of difference in recruitment between treated and control plots could be due to other ecological factors such as lack of bare soil (see results from the Long Hill Seeding and Transplanting experiment below) or sampling error (the length of time required for seedlings to become apparent).

E. vialis plant height and flowering

Plants were taller in thinned plots (Figure 6, middle panel). This is primarily due to the increase in light availability, although there is some suggestion that deer herbivory might be reduced in the thinned plots. Herbivory impacted a relatively large proportion of the population. In 2010, more than one-third (42%) of the plants were browsed by deer and 84% had signs of insect damage. Across the entire study, 37% were browsed by deer, and 58% were damaged by insects. Even though plants were on average much taller with thinning, they still did not reach the average height found in unsuppressed populations (70 cm) by Kaye et al. (1991).

We found that forest canopy thinning increased the probability that *E. vialis* would flower (Table 3). Probability of flowering increased significantly after treatment in the thinned plots only ($p = 0.05$). In the control plots, most plants that did not flower prior to the treatment did not flower after (167 out of 176 non-reproductive plants). In the thinned plots, more of the non-flowering plants flowered after treatment (66 out of 140 non-reproductive plants).

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Table 3. Number of plants flowering at least once before and after treatment in the forest canopy thinning plots. For control plots, years ≤ 2005 were classed as "before" and >2005 as after, as most treated plots were thinned in 2005.

			After	
			Not flowering	Flowering
Control	Before	Not flowering	167	9
		Flowering	4	12
Thinned	Before	Not flowering	74	66
		Flowering	0	6

The number of capitula produced by each plant increased with thinning (Figure 6, bottom panel). When we examined this closely, we found thinning, increased solar radiation, and lower deer herbivory all led to higher capitula production (Figure 8). Because complex 3-way interactions were found, we analyzed control and thinned plots separately (Table 5). In these analyses, we see that capitula number did not increase over time in the control plots, and was instead influenced only by deer browsing and light availability. Control plots had low solar radiation, and plants rarely produced any capitula. Interestingly, we found that deer browsing (combined damage to stems and capitula) was most common in plots with low solar radiation (Figure 8), perhaps indicating a habitat preference by deer for more protected areas. In the thinned plots, we found that capitula number increased over time (after thinning), and was also influenced by solar radiation and deer herbivory. The positive interaction between time and solar radiation (Table 5) is because solar radiation significantly increased with thinning. In the thinned plots, average solar radiation increased from 4% to 15% after treatment ($p < 0.0001$).

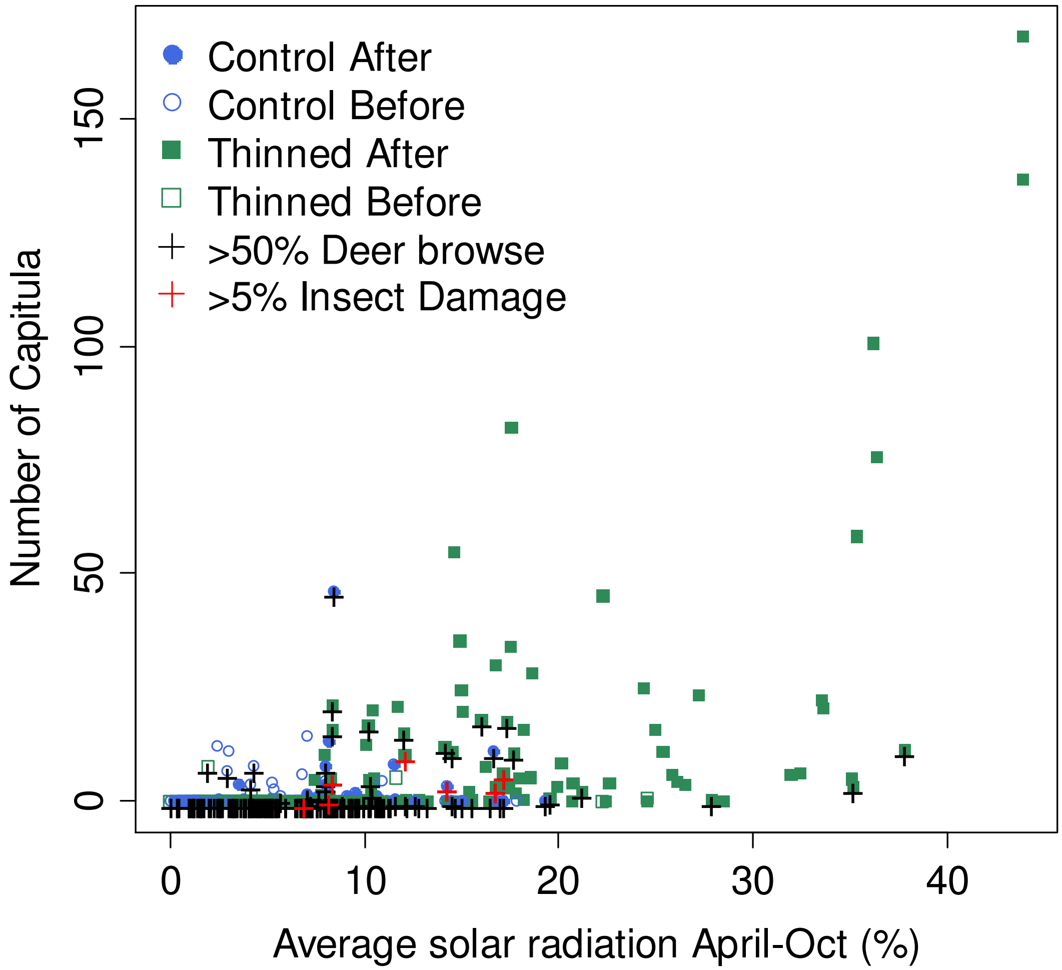

Figure 8. The average number of capitula per plant before and after treatment. Plus marks (+) indicate plants that were damaged by deer or insects. Number of capitula per plant increased with increasing solar radiation (light availability), which was higher in thinned plots after treatment.

Table 5. Analysis results (*p* values) for capitula per plant. A full analysis including treatment, deer browsing, solar radiation, and time had all main factors significant, but there were also complex 3-way interactions. To tease these apart, we analyzed control and thinned plots separately. Non-significant interaction terms were dropped from the analysis (as indicated by "n.s.").

	Control plots	Thinned plots
Time (Before-After thinning)	0.8528	<0.0001
Deer browsing	0.0133	<0.0001
Solar radiation	0.0033	<0.0001
Time * solar	n.s.	0.0008

Changes in community composition with thinning

We used ordination to examine changes in overall species composition with thinning. Ordination is a multivariate technique for showing how similar different sites are in species composition. Specifically, we used non-metric multidimensional scaling (NMDS), which is a particular type of ordination best suited to ecological data. When examining Figure 9, points represent individual plots and the axes are combinations of correlated species. The values of each axis are relatively meaningless; what is important is the distance between points. Points close together indicate plots with very similar species composition. Similarly, this technique can show correlations between environmental factors, species composition, and treatments (as shown in the bottom panel of Figure 9).

Forest canopy thinning led to predictable changes in species composition. The top panel of Figure 9 illustrates the ordination of the plant communities in each plot before and after treatment. Over time, control plots did not undergo substantial changes in species composition, as shown by the short trajectory length in Figure 9 (top panel). Thinned plots changed much more substantially (long trajectory length). The bottom panel of Figure 9 shows the ordination of just the post-thinning data, with significant explanatory variables shown. In this figure, we see that control plots tend to be more associated with higher canopy cover and low growing native shrubs. Thinned plots were more associated with native grasses and vines, tall native shrubs, and exotic annual grasses.

When we examined broad functional groups, the largest change in native species due to thinning was an increase in native grasses (Figure 10). Overall, native shrub cover stayed constant, but there was a shift from shorter growing species, such as *Rubus lasiococcus, R. ursinus,* and *Whipplea modesta,* to taller shrubs, such as *Symphoricarpos albus, S. mollis*, and *Oemleria cerasiformis*, with thinning. While native forbs increased in both control and thinned plots over time, from 2003-2010, native forb cover remained relatively constant in the control plots, but increased from an average of 15% cover in 2003 to 25% in 2010 in the thinned plots.

Total non-native cover remained low throughout the study (typically 1-5% cover). We saw increases in non-native forbs and shrubs with thinning, but the average cover remained very low. Non-native grasses increased with thinning slightly but declined in the control plots. The number of non-native species increased with thinning, particularly at Spores Creek (0 to 13 species) and Weiss Road (6 to 10 species). Control plots typically had 0-3 non-native species present, which did not change over time.

Of special concern was the response of invasive species such as *Cytisus scoparius, Senecio jacobaea, Brachypodium sylvaticum*, *Hypericum perforatum,* and *Rubus armeniacus*. These noxious weeds have the potential to increase in density, especially after disturbances associated with forest stand manipulation. *Hypericum perforatum* did not increase with thinning. *Cytisus scoparius* increased at Spores Creek and Weiss Road (0 to 0.1% cover). *Rubus armeniacus* increased at Lower 79th St. (2% to 3% cover), Spores Creek (0 to 0.1%), and Weiss Road (0.1 to 2%). *Rubus laciniatus* increased at Spores Creek (0 to 0.1%) and Weiss Road (0.1 to 0.5%). *Senecio jacobaea* was found in trace amounts within the plots, but did not increase over time despite being present in large patches along roadsides approaching the plots. *Brachypodium sylvaticum* was identified at Long Hill Northeast, Lower 79th St., Papenfus Lower, Papenfus Upper, RFI #9, Scattered Tracts, and Upper 79th during the study period. However, when observed, we

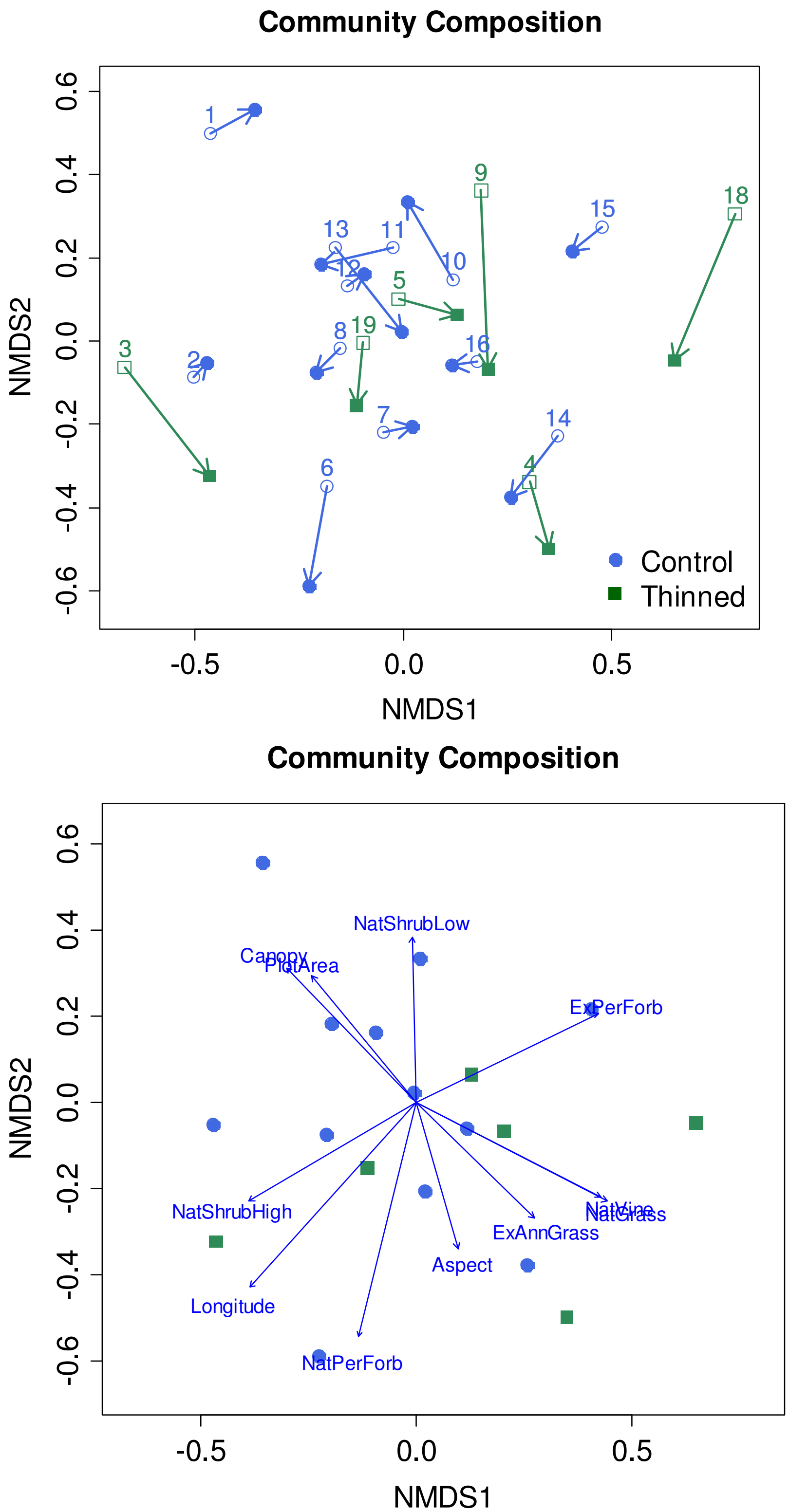

Figure 9. Ordination of plant community composition in forest thinning plots, showing trajectories [before (open symbols) and after (solid symbols) thinning] for each plot (top panel; plot numbers shown) and the composition after thinning with significant explanatory variables (vectors in blue).

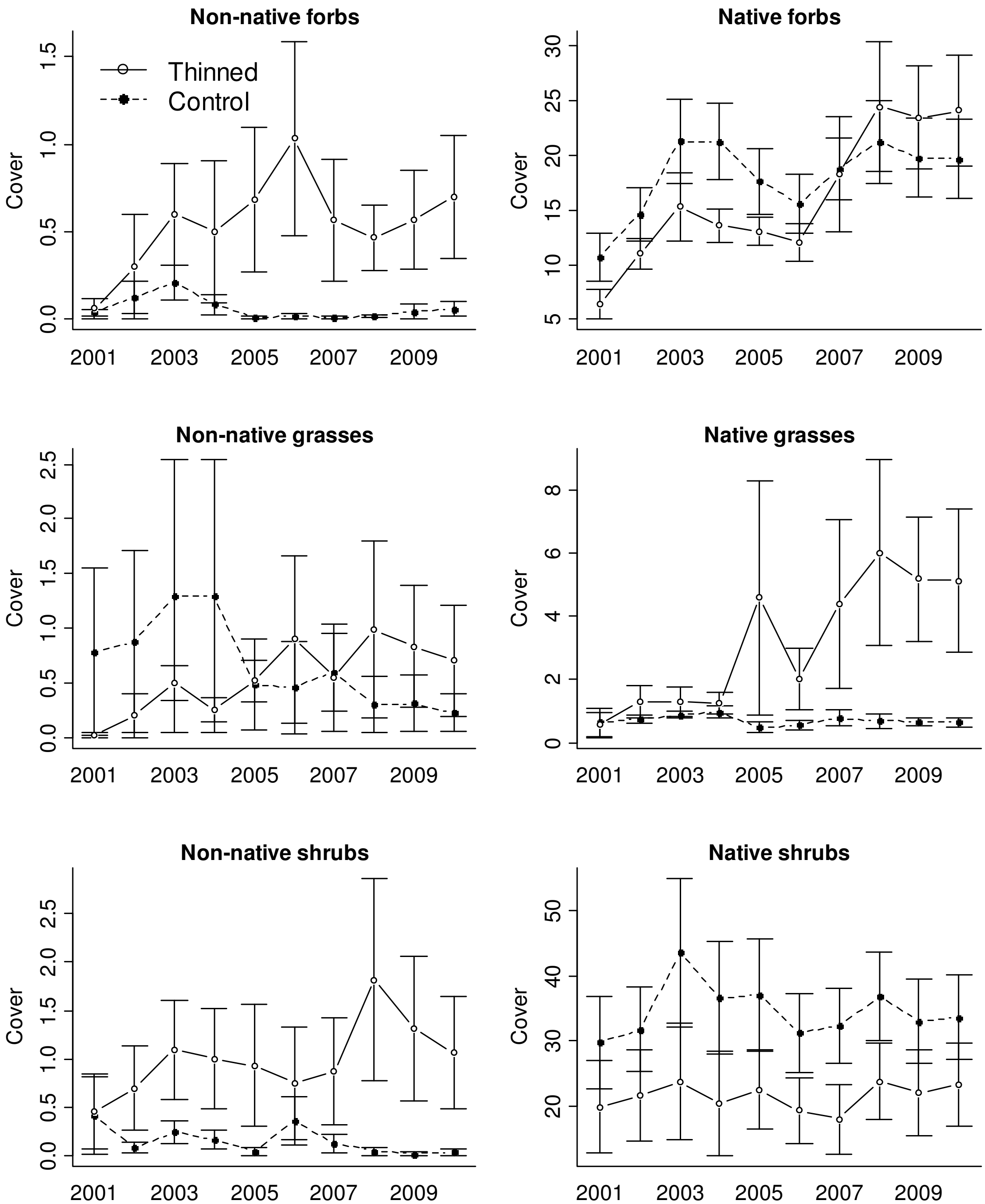

Figure 10. Percentage cover of plant functional groups over time. Data represent plot means ± 1 SE.

hand-pulled these plants and in 2010, *B. sylvaticum* was only observed at Upper 79th. *Cirsium* spp. also appeared in four treated plots after thinning.

Willamette Valley Oak and Pine Habitat Conservation Project Plots

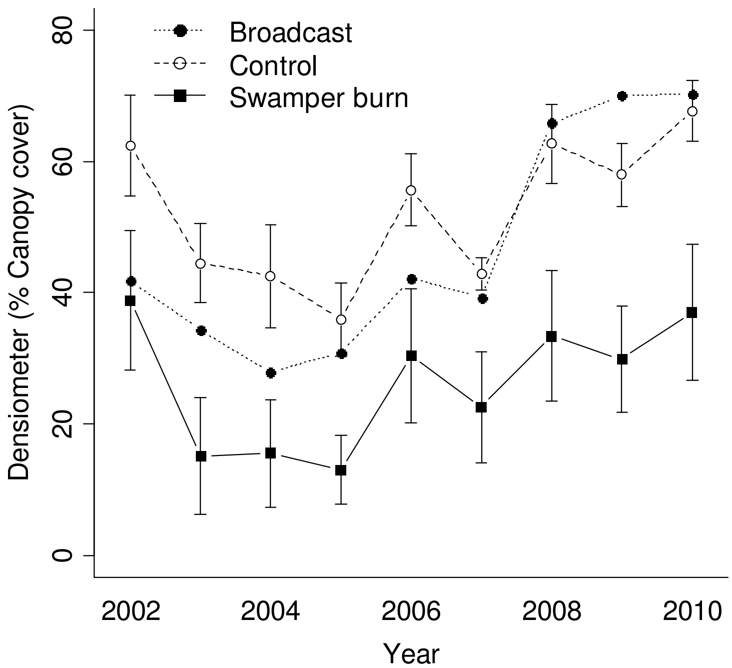

Figure 11. Densiometer readings of % canopy cover at WVOPHCP plots. Treatments were implemented in fall 2002.

We hypothesized burning would reduce canopy cover and increase *E. vialis* plant size and/or rate of flowering. Canopy cover was lower in the broadcast burn plots in 2002 prior to treatment (Figure 11). Canopy cover did decline in the broadcast burn plots in 2003, following treatments in fall of 2002. However, canopy cover declined from 2002-2003 in the control plots as well, indicating that the declines might have been due to changes in canopy cover or sampling time relative to phenology rather than a treatment effect. Reports following treatments suggested that burns were not particularly hot. Additionally, the burned area was small, perhaps insufficient to have a great deal of influence on the light environment.

We did not find any effect of treatments on *E. vialis* plant height (Figure 12), stem number, probability of flowering, or capitula number (Figure 13). Instead, we saw quite a bit of interannual variability in size and capitula number (Figure 12, 13). There were too few individual plants in the study (68 total plants) to test for recruitment or mortality. We also did not find any significant relationship between solar pathfinder or densiometer readings and *E. vialis* performance. This again may be due to the small sample size.

Based on our subsample in the monitoring plots, the population at Weiss Road appears to be relatively stable, with minor fluctuations in size (Table 6). Data collected in 2010 suggests smaller plants with few flowers may result from increased canopy cover; 2010 had the highest cover since this study's inception. Every plant tagged and monitored in 2002 was relocated in 2010 except for two. An additional 14 plants have been tagged and monitored since 2002. The total number of *E. vialis* plants has increased from 53 in 2002 to a peak of 66 plants in 2008 and 2009. Sixty-five plants were counted in 2010. In most years, approximately half of the population was reproductive. However, in 2010, only 19 plants (29%) were found in flower, a possible result of the high canopy cover during this year.

Table 6. Summary of WVOPHCP *E. vialis* plots. Thinning treatments occurred in late 2002.

year	mean # of plants per plot	mean longest stem (cm)	mean total stem length (cm)	mean # of stems	mean # capitula/ reproductive plant	mean basal area (m^2/ha)	mean densiometer canopy cover (%)	mean percent solar radiation[1]
2002	4.6	72.15	164.98	2.77	37.08	5.51	49.86	
2003	5.0	48.87	143.74	4.72	34.04	2.73	29.85	54.69
2004	5.6	54.61	126.37	2.83	30.29	1.93	29.07	56.3
2005	5.8	52.91	120.02	3.36	32.59	4.08	25.83	61.13
2006	5.9	70.71	212.87	4.02	65.55	2.78	42.91	63.15
2007	5.8	47.62	140.6	3.97	22.83	4.63	42.87	50.91
2008	6.0	49.55	159.25	4.22	22.09	5.27	50.24	42.96
2009	6.0	54.61	183.61	4.36	31.03	5.71	46.69	34.95
2010	5.9	37.08	109.17	3.62	3.80	6.60	55.31	38.89

[1] Solar pathfinder readings averaged for months of April – October (not available for 2002).

The burning treatments had little effect on overall species composition (data not shown). Ordination of the vegetative cover of the plots showed no differentiation or significant difference in trajectories with treatment. There was a trend towards increasing non-native cover after treatment in the broadcast burn plots, driven by an increase in non-native grass cover (Figure 14); however, this difference was not significant. Additionally, the increase in grass cover occurred starting in 2006, 4 years after treatment, making it unlikely to be a consequence of burning.

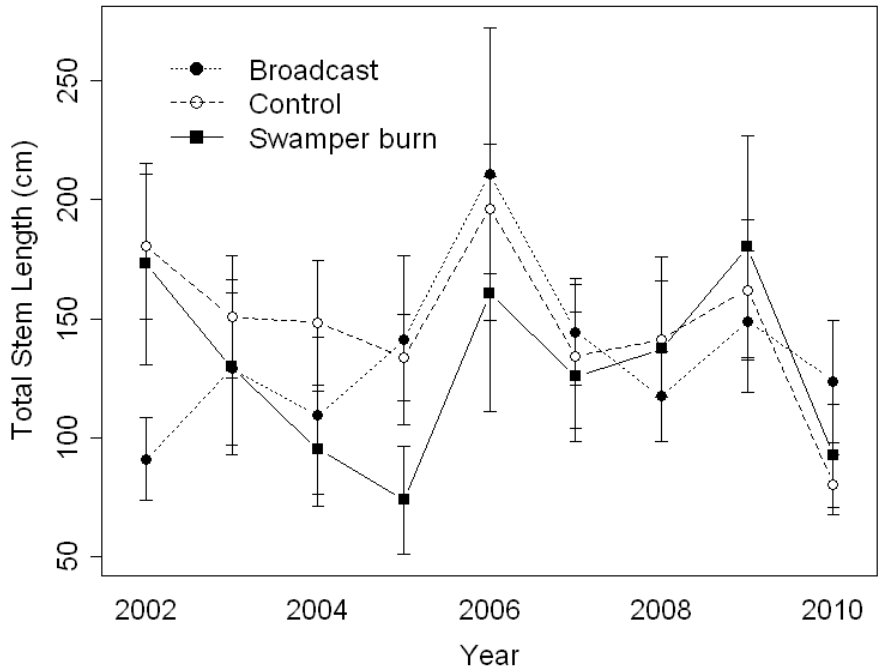

Figure 12. Total stem length by plot type for WVOPHCP plots, 2002-2010.

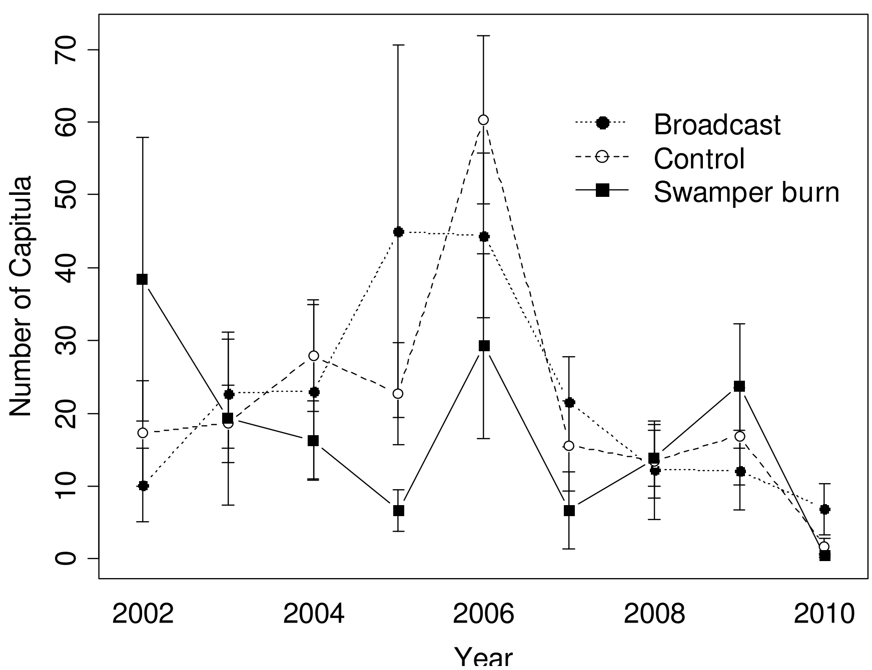

Figure 13. Total number of capitula by plot type for WVOPHCP plots, 2002-2010.

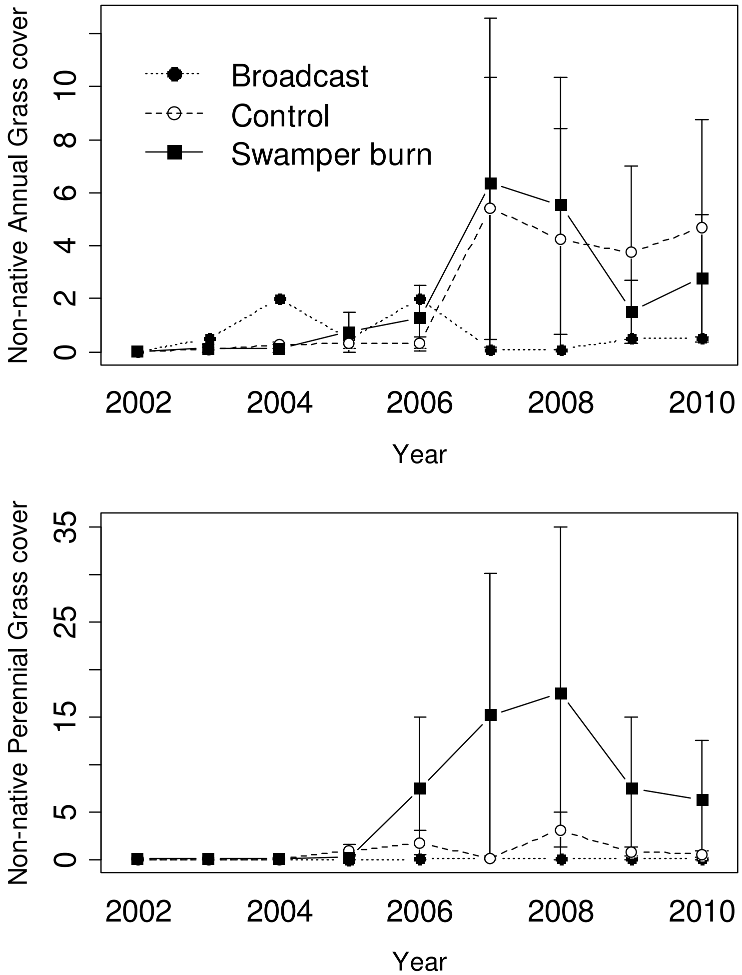

Figure 14. Change in annual (top) and perennial (bottom) non-native grass cover WVOPHCP plots, 2002-2010.

Seeding and planting

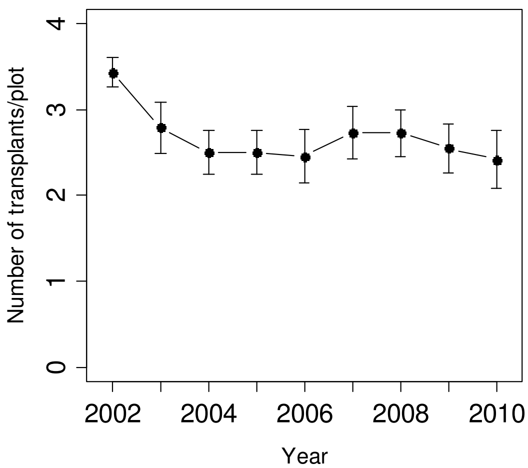

Figure 15. Number of transplants per plot at Long Hill North, 2002-2010.

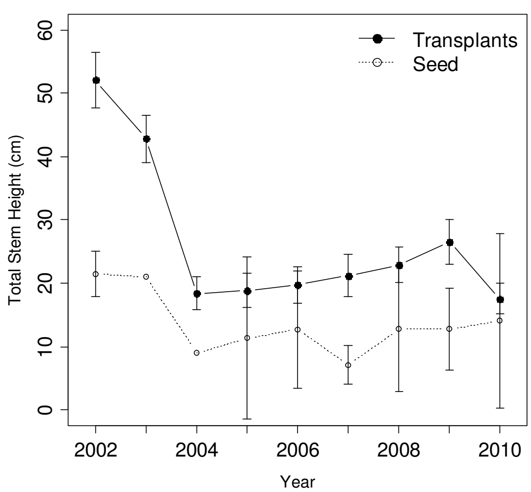

Figure 16. Total stem height for transplants and seedlings at Long Hill North, 2002-2010.

<u>Long Hill seeding and planting</u>

Of 56 transplants planted in December 2001, 32 (57%) survived until 2010. Mortality was highest the first few years after planting, with numbers staying relatively constant after 2004 (Figure 15). Fluctuations in observed plant numbers over time were likely due to severe deer herbivory; plants that had been grazed to the ground could not be relocated. Plants that survived had an average of 1 stem, total stem length of 14.0 cm, and a height of 13.6 cm in 2010. Most transplants did not flower, even after 9 years: one capitulum was produced in 2002, three capitula were produced by one individual in 2006, no capitula were produced in 2007 or 2008, one individual produced ten capitula in 2009, and there were no capitula in 2010.

Average total height (the sum of all plant stems) of transplants decreased over time (Figure 16), again likely due to frequent deer herbivory. This is also a likely reason why few capitula were produced by transplants.

We did not find any correlation between solar pathfinder or densiometer readings and transplant survivorship or size. This may be due in part to small sample sizes, or to significant deer herbivory as the main limiting factor on plant height and survivorship.

We originally hypothesized that both soil disturbance and available light may play a role in seed germination and seedling establishment. After nine years of study, we found no correlation between seedling establishment and solar radiation. Our data suggest that soil disturbance is the primary factor influencing seedling establishment in *E. vialis*. While we didn't track individual germination and establishment of sown seeds, we were able to observe overall seedling establishment from natural and human efforts. For each year of this study, the scraped soil had more plants (including seedlings and adult plants) than unscraped soil (Figure 17). Our measure is the total number of seedlings from sown seeds, natural recruits, and pre-existing plants, due to difficulty in distinguishing among these groups. Very few adult plants were present prior to seeding. *Eucephalus vialis* seeds may not germinate the first season after sowing, as evidenced by seedling peaks in both treatments in 2003. Following this peak, the number of plants per plot

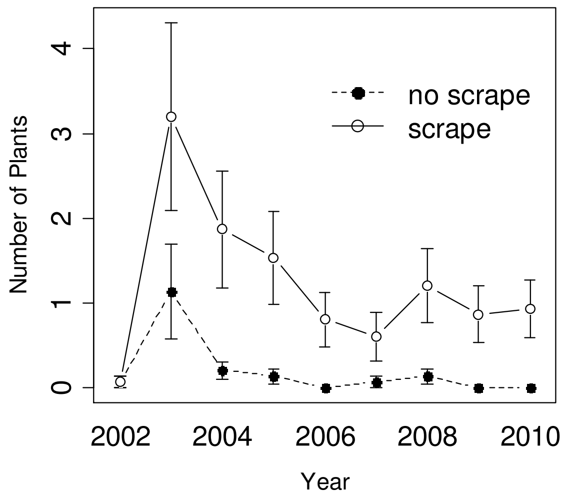

Figure 17. Seedling establishment trends at Long Hill North, 2002-2010.

declined (Figure 17) due to plant mortality or lack of detectability due to deer herbivory. In all years, the number of seedlings in the scraped plots was higher than in the control (no scrape) plots. For seedlings that emerged, the total survivorship was 27%, much lower than the survivorship of transplants. This could be related to their small size (Figure 16, Figure 18); plants from seed remained small throughout the study period. We did not find any relationship between solar pathfinder and densiometer readings and germination, seedling survivorship, or plant size.

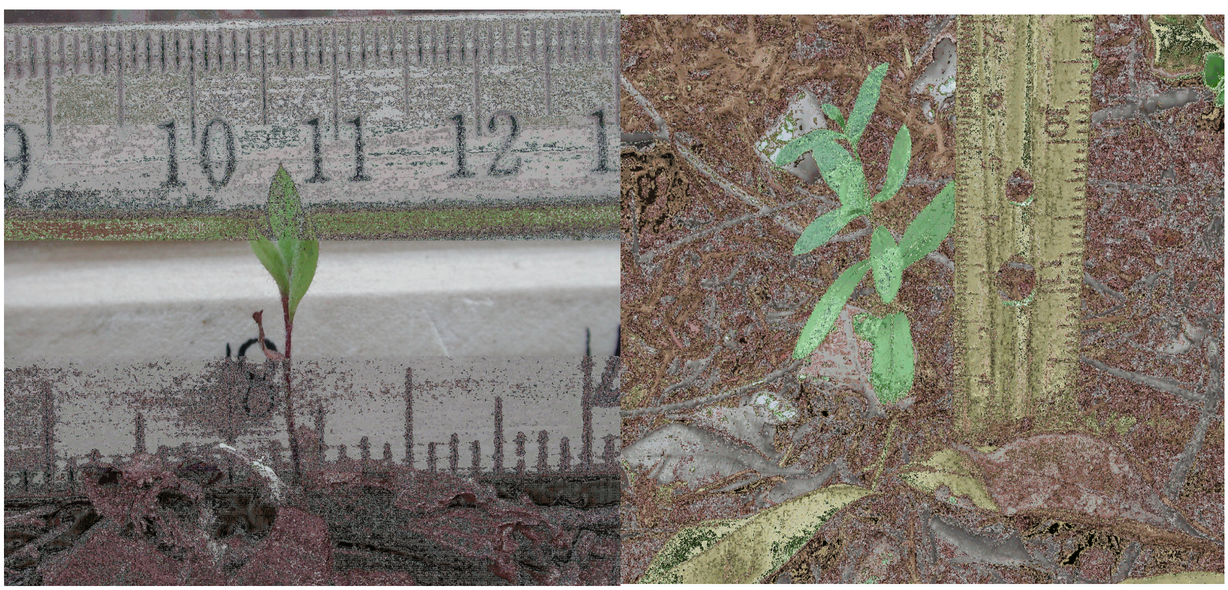

Figure 18. Seedlings of *E. vialis* in the first season of growth after germination (left) and in the second season of growth (right) at the Long Hill site.

<u>Seeding at Weiss Road</u>

At Weiss Road, we tested germination of seeds sown into control, burned, and scraped plots. Of the 1,575 seeds that were sown into 21 plots in February 2003, only two seedlings were located in 2005 in a burn treatment plot. The size of the two plants encountered in 2005 (25 and 20 cm tall) suggest these plants germinated in 2003 or 2004, but escaped detection. One seedling was detected in 2003 on the scraped substrate. This seedling apparently died; no seedlings were found in 2004 or 2005 in the scraped plots. Seeds of this species require up to four months of cold stratification (Kaye 2002); seeds sown in February 2003 had only 1 – 3 months of cold temperatures. We expected higher germination rates in spring 2004 after exposure to a full winter. Due to the low establishment, we did not monitor these plots past 2005.

IMPLICATIONS FOR MANAGEMENT

Detailed measurements of *E. vialis* individuals in heavily shaded habitats revealed that plants were small and infrequently reproductive. Mortality in shaded habitats was higher than in thinned areas. Without habitat modification, these populations are at risk of catastrophic decline or extinction due to the loss of individuals without replacement by seedlings. Forest thinning will likely improve habitat conditions by reducing the abundance of conifers and favoring oaks, chinquapin, madrone, and other hardwoods. This change in forest structure and composition should improve light conditions on the forest floor and allow the plants to grow and flower more frequently.

After ten years of monitoring, the data from this study suggest that canopy reduction by thinning can improve population size and flowering rates of *E. vialis* individuals. The effect of prescribed burning on this species is still unclear; while burning at the WVOPHCP study area had no negative effects on *E. vialis*, it had none of the predicted positive effects either. Because the size of the burned areas was small and may not have effectively reduced canopy cover, we feel the role of fire in regulating *E. vialis* populations remains undecided.

While forest canopy thinning had very positive effects on *E. vialis* flowering and reproduction, we did not observe an increase in recruitment. This may be due to the difficulty of observing small seedlings in a dense understory, as well as a likely time lag between treatment and new recruitment. However, other factors may limit the germination of seeds. From our seed addition study, we found seeds only germinated well on bare mineral soil. This underscores an important difference between thinning and historic disturbance patterns. While moderately intense fires typically burn away litter and expose mineral soil as well as open the canopy, thinning has no effect on litter. Thus thinning may need to be combined with additional management actions, such as clearing away litter around reproductive plants, to increase bare mineral soil for *E. vialis* recruitment. This additional level of disturbance should be evaluated carefully to ensure that it does not open up new opportunities for invasive plants. It is also possible that these relatively small and isolated populations lack sufficient genetic diversity for successful sexual reproduction.

Plot locations for the forest canopy thinning study were carefully chosen for minimal presence of invasive species, so that disturbance from thinning would not lead to large increases in invasive weeds. This strategy worked well; while some non-native species did increase, even after several years their relative abundance remained very low. This argues for either ensuring sites selected for management treatments have low invasive abundance from the outset, or controlling weeds prior to disturbance. However, the number of non-native species did increase at several thinned plots, indicating that post-treatment monitoring and control of invasives may be required.

Both planting and seeding were found to be effective methods for establishing new *E. vialis* populations. Seeding efforts are more likely to be successful if seeds are sown in early winter on a disturbed substrate. Both seeding and transplant efforts would benefit from fencing; deer herbivory was common throughout all plots, and can have deleterious effects on reintroduction efforts.

We recommend monitoring *E. vialis* and plant community composition (particularly of weedy species) at least one year pre- and post-treatment to determine the effect of reduced canopy on plant size and flowering. If possible, continued monitoring will also help detect increases in numbers of plants through seedling recruitment, as well as track encroachment by invasive species.

All plot and plant markers were left intact at the sites we used in this study. Periodic monitoring of these plots (i.e. every three years) would provide valuable information on plant longevity and long-term trends of these populations.

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APPENDIX 1.

PROJECT IMPLEMENTATION SCHEDULE

	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
plot sampling/monitoring	18 plots set up at 11 areas	1 plot dropped at Weiss Road; total of 17 plots at 11 areas	17 plots at 11 sites	1 site added (Rowdy Camp); total of 18 plots at 12 areas	18 plots	18 plots	18 plots	18 plots	18 plots	18 plots
treatment implementation		1 plot treated at Weiss Road after sampling			2 plots treated in spring; 2 treated in fall (after sampling)			Rowdy Camp treated		
Annual report with data summaries	completed	completed	completed	completed	completed	Interim summary (completed)	Interim summary (completed)	Interim summary (completed)	Interim summary (completed)	Final report
complete analysis										complete analysis at end of project

APPENDIX 2.

Eucephalus vialis ecological monitoring equipment list

First Aid Kit
Tecnu
Extra water
4- Meter tapes (2-200ft, 2-300ft)
DBH tape (make sure it records DBH in centimeters!)
4- Corner marking poles—conduit
Wires with numbered tags
Densiometer (2)
Compass (2)
3 –clipboards (tatum)
GPS
loppers
3- Data sheets for each site
Maps to plots
Rulers – 1 per person
Flagging (orange polka dot, green/ white striped, blue polka dots)
Grid strings and data sheets
Solar Pathfinder
Copy of report
Last year's data
Keys
Mechanical Pencils
Latex gloves (for poison oak protection at Weiss Rd.)
Wire Cutters
Plant ID Guide
Floras
Curly Ques
Candy Canes

APPENDIX 3.

Directions to *Eucephalus vialis* ecological monitoring plots

****Watch for School Zones****

BLM contact: Cheshire Mayrsohn, 541.683.6407
Weyerhaeuser key information:
Contact Tally Patten 541.988.7503 *several weeks in advance*. To office: from I-5, head east on Hwy 126 (McKenzie). Take the 42'nd St. exit. At stoplight, turn right. Cross railroad tracks, then *immediately* get in turn lane, and turn into driveway. Park at and enter office building on right, ask for Tally.

McKenzie District

Plot 1- Upper 79th St. T20S R14W Sec 21 UTM: 511873 E, 4876659 N
Special needs? Loppers
126 E to Springfield (turn left on Main St. to follow 126E), turn right on 79th St. Drive 2.2 mi up road until end (road closed), park at berm (large house with fenced yard on left). Walk ~1 mi down ripped road (left fork) and past second berm (take left fork). Take left fork at orange flagging on ATV trail. ~200 m to trail along forest edge, go right, then left at 4-way intersection. Plot ~300m down trail on left. 14 plants.

Plot 2- Lower 79th St. T20S R14W Sec 21 UTM: 509713 E, 4876143 N
Special needs? none
126 E to Springfield (turn left on Main St. to follow 126E), turn right on 79th St. Drive 0.5 mi until pavement ends, park on right across from driveway. Walk ~0.1 mi up road and look for flagline on left ~40 m before yellow gate. Follow orange and white flagging steeply uphill and above an old skid road to plot. 19 plants.

Plot 3- Lower 79th St. Roadside T20S R14W Sec 21 UTM: 509553 E, 4876286 N
Special needs? Bee sting kit
(from parked location for Plot 2) Plot is on the left side of the road just past the driveway. Follow flagging ~5 m, NE 80°. Thinned 11/05. 39 plants.

Plot 4- Papenfus Rd. Upper T19S R2W Sec 15 UTM: 506150 E, 4862019 N
Special needs? Vehicle with high clearance. Weyerhaeuser Key.
Take I-5 to Highway 58 (Exit 188) east to Pleasant Hill. Turn right on Enterprise Rd. (approx. 5 miles from Highway 58 exit). Approximately 2 miles further, veer left onto Papenfus Rd. Follow Papenfus to end of pavement, uphill past house on left fork through locked gate (gate has no BLM lock! Lock needs Weyerhauser N key). At 0.6 mi, take right fork. Follow main gravel road to ridgeline 1.9 mi from gate. Flagline on south side of road at ~1.7 mi from gate. Thinned 3/05. Spot fires in larger treatment area 11/05. 12 plants.

Plot 14- Papenfus Road Lower T19S R2W Sec 15 UTM: 505997 E, 4861959 N
Special needs? Vehicle with high clearance, Weyerhaeuser Key
At 1.9 miles, large ponderosa pine on south side of road. From the pine, walk SE (160°) to forest edge – using compass spot to tree on forest edge. Do NOT follow flagging (including flagging labeled ASVI and IAE). Walk "straight" into forest; plot is located just south of forest/meadow edge and west of intact forest/regrowing-clearcut edge. Approx. 20 plants.

Plot 5- Spores Creek T17S R2W Sec 5 UTM: 504000 E, 4885488 N
Special needs? **BLM key**
Take I-5 to Coburg exit, exit 199. Go west into Coburg and turn south on Coburg road (also called Willamette St.). Follow this road south, after 1.8 m turn left onto McKenzie View, which leads under I-5. At 6 mi, turn left on Hill Rd., and at 3.9 – 4.2, turn left on Donna Rd. At .5 mi, past yellow store, turn left on McGowen Rd. (BLM 16-2-27). Take a left on rd 16-2-28 (marked by Styrofoam zoo sign, 2nd left, past starting range on right) for 2.4 mi (locked gate- need key). Stay on the main fork (left fork). Plot is on the right side of the road, past BRSY blue flagging, just uphill, in a thinned area with yellow veg study sign, white and orange polka-dot flagging. Thinned 10/05. 60 plants.

Plot 6- Bear Creek T19S R2W Sec 21 UTM: 505129 E, 4860114 N
Special needs? Weyerhaeuser N Key, high clearance vehicle (road is full of tall vegetation, avoid this area on a hot, dry day, fire risk!)
Take I-5 to Creswell exit. Go east on main road over I-5. Go right on Bear Creek Rd. (1.6 mi from top of bridge over I-5). Follow around sharp curve to right. Turn left at 2.3 mi and go through green gate (needs Weyerhauser N key). Veer right at 1.1 mi from gate. Park at end of road (0.3 mi farther). Hike up deer trail at end of road, over little knoll. See yellow vegetation study sign, plot is ~ directly downhill ~220 ft. Follow flagging marked P6 (lots of other flagging in area). 28 plants. Bring tecnu!
Old route: On Bear Ck Rd just beyond green gate turnoff is the Bates residence (Phone: 895-2233). Follow driveway around house, through gate, park at the end of the road. Follow map on back of 2001 stand data sheet or aerial photo to plot.

Plot 9- RFI #9 T14S R2W Sec 28 UTM: 505466 E, 4906970 N
Special needs? none
From Brownsville, go East on highway 228. After 5.8 miles, turn right on Courtney Creek Rd (in 2008 the road sign was missing), set odometer to 0. Stay straight (right) on Timber Road. Go 5.5 - 6 miles to Road 14-2-28.2 (closed; 3 miles from junction with Timber Road). Road 14-2-28.2 is on the right and marked by both blue polka dot and orange polka-dot flagging, and blocked off by large boulders. Park at the intersection (also a good pull out just past the turn off) Go up the road and stop just before a meadow and a fork with road 14-2-25.5. Follow bright blue flagline into forest on the right and uphill to plot. Plot is above the second old road bed. Thinned in 3/05. Spot fires 11/05. 46 plants.

Plot 16- Cougar Mountain T20S R2W Sec 6 UTM: 501900 E, 4856781 N
(private site- owner: Betsy Hartzell 541-942-4418, residents Anna and Noah Wemple – Betsy's son - 541-767-3798)
Special needs? High clearance vehicle. Call first.
Take I-5 south to Saginaw exit. Go east over I-5 and turn north on Sears Rd. Stay straight (right-ish) on Meyer Rd (Sears Rd. curves to the left). Left on Witcher Gateway (0.1 mi). After 2.5 – 2.6 mi, large house straight ahead. Go right at 4-way intersection. Stay right and follow main road toward Wemple residence (the 2'nd residence). Go 0.2 mi past residence and park at beginning of second meadow at hill top, plot is on left side of road, just inside forest. Be careful, several new logging roads; as of 2006, follow hand-made signs cautioning to drive slowly. To be thinned winter 05? 22 plants.

Plot 18- Weiss Road T19S R4W Sec 23 UTM: 488780 E, 4860972 N
Special needs? BLM key
I-5 South to Creswell (Exit 182), right off interstate onto Weston Oregon Ave. It will turn into Camas Swale Rd. After 7.1 mi, turn left on Weiss Rd. Go over bridge and turn left on the gravel road, 19-4-22, where there is a locked gate (1.1 mi). Park at turnout (0.4 mi). Take closed road on right, turn left on path. Plot is at edge of forest management area. (See maps for all Weiss Rd plot locations). Thinned Fall 2002. 9 plants.

Plot 19- Rowdy Camp UTM: 513036 E, 4881614 N
Special needs? BLM key and 4WD makes it easier to get up the hills.
I-5 South to Springfield McKenzie exit (126 east). Exit at 42nd St./ Marcola. Turn left toward Marcola, at .4 mi, turn right on Marcola Rd. After 0.6 mi, turn Right on Camp Creek Road. Continue 4.6 miles then turn left on Upper Camp Creek Rd. Go 2.4 miles to Cress Cr. Rd and turn right. Stay straight (left) where the road turns to gravel. After .6 mi (drive past the No Trespassing signs, and drive past the green house with a barbed wire fence around it) , go right at the Y (there is a sign on a tree that says "53/ 1,2,3") go through gate, leave closed behind you. Drive 0.3 miles to the next gate, also leave closed behind you. Drive 0.2 miles from second gate and take a right. Go about .2mi (this distance is estimated) and look for orange dotted flag uphill on your left. If you reach the clearcut, you have gone too far. The plot is about 30m from the road. Proposed treatment fall 2006. 36 plants.

South Valley
Special needs? none
Mosby Creek: **Plot 7** (Inside) 32 plants UTM: 501421 E, 4844852 N
Plot 8 (Outside) 13 plants UTM: 501416 E, 4844850 N
I-5 to Cottage Grove exit. At bottom of off-ramp, turn left onto Row River Rd. At 1.2 mi, turn right onto Row River Conn #1. Take first left onto Mosby Ck Rd. Turn left (after 2.7 mi) on Garroutte Rd (by covered bridge). After 0.9 mi, turn right onto driveway for 34560 and 34582. Stay to the left toward Woodaard, right is private ("Geer"). Veer right before big "Woodaard" sign (0.2 mi up driveway) onto logging road. Stay left at 0.1 mi; this is the 2nd left. Trail to plots is 0.4 mi past sign on right. Trail is on edge of 2003 clearcut; follow flagging.

Old route: From Garroutte Rd., turn right on Stuart Hills Rd (after 0.4 mi; gravel road). Veer left onto pavement, take center driveway to blue house and park on right. Back down driveway ~50 m is old horse trail with flagging. Follow to plot.

Plot 10- Scattered Tracts North T20S R4W Sec 7 UTM: 483386 E, 4854586 N
Special needs? none.
I-5 south to Cottage Grove exit. Go right off the exit ramp. Turn right onto Main St. in Cottage Grove. Main St. turns into Cottage Grove-Lorane Rd.. Turn right on Hawley Ck Rd (19-4-33; ~10.5 mi; *to this point, same as PAG)* and immediately right again on Hill Rd. W. Park on shoulder just past 0.1 mi (before masses of blackberries). Follow flagging uphill to plot (~40 m). 28 plants. Beware wasp nest past plot's lower right corner

Plot 15- PAG site UTM: 486096 E, 4858025 N
Special needs? Vehicle with high clearance.
I-5 south to Cottage Grove exit. Go right off the exit ramp. Turn right onto Main St. in Cottage Grove. Main St. turns into Cottage Grove-Lorane Rd. Turn right on Hawley Ck Rd. (19-4-33; ~10.5 mi; to this point, same as Scattered Tracks). Set mileage at turn onto Hawley Creek. Continue on Hawley Creek, which becomes gravel. First fork at approx. 1.5 miles -- stay to right. Second fork at 2.2 miles – stay to right. At 2.6 miles, “pitchfork” intersection, take left fork (this road needs a vehicle with clearance). Continue on this road for 0.4 mi. Park at skid road on right with double flag. Follow skid road to double flag on young cedar on the right. Follow boxer short flagging through forest to plot. 32 plants.

Plot 11- Long Hill North T20S R4W Sec 23 UTM: 488235 E, 4851575 N
Special needs? BLM key
From Cottage Grove, go west on Main Street (Cottage Grove-Lorane Rd.) Turn left on Overholser Rd (#2675). After .9 mi turn left onto road 20-4-23 to locked gate. Plot is on west side of road 20-4-23.2 (the left fork after gate). 25 plants.

Plot 12 -Long Hill Northeast T20S R4W Sec 23 UTM: 488584 E, 4851591 N
Special needs? BLM key, bring mallet for corner post
(from Long Hill North directions) Just past junction of road 20-4-23.2, follow the first encountered orange and white polka-dot flagline on east side of road. The plot is a long way (10-15 minute walk) downhill. 17 plants.

Plot 13- Long Hill Middle T20S R4W Sec 23 UTM: 488596 E, 4851152 N
Special needs? BLM key
(from Long Hill North directions) ~.25 mi past junction of road 20-4-23.2, follow (second encountered) flagline on east side of road. (can also follow fenceline along clearcut south from Northeast plot). 17 plants.

APPENDIX 4. SUMMARY OF *E. VIALIS* MEASUREMENTS IN FOREST CANOPY THINNING PLOTS, 2001- 2010.

Summary of *E. vialis* measurements in forest canopy thinning plots, 2001.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed[2]
1	12	45.8	88.4	2.3	0	0.0	0.1	0	
2	15	31.2	47.3	2.0	0	0.0	0.3	0	
3	40	43.1	66.7	1.6	0	0.0	0.0	0	
4	11	41.6	64.1	2.1	0	0.0	0.5	0	
5	48	29.8	42.0	1.4	0	0.0	0.3	0	
6	21	46.2	57.6	1.3	0	0.0	0.5	0	
7	28	56.6	89.9	1.8	0	0.0	0.0	0	
8	13	43.4	67.2	1.8	0	0.0	1.1	0	
9	37	16.4	22.2	1.6	0	0.0	0.8	0	
10	26	30.6	71.5	2.3	0	0.0	0.2	0	
11	16	45.6	60.9	1.4	1	4.0	0.2	0	
12	17	33.1	38.3	1.2	0	0.0	0.5	0	
13	16	36.8	47.8	1.4	0	0.0	0.2	0	
14	19	35.6	44.8	1.4	0	0.0	0.0	0	
15	26	42.3	89.7	3.0	1	7.0	1.7	0	
16	19	23.7	30.5	1.3	0	0.0	0.1	0	
18	8	45.9	80.8	2.1	0	0.0	0.1	0	
Average	21.9	38.1	59.4	1.8	0.1	5.5	0.4	0	

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.
[2]Data not collected during this year.

Summary of *E. vialis* measurements in forest canopy thinning plots, 2002.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed[2]	mean # of stems insect browsed[2]
1	12	39.5	83.6	2.3	0	0.0	0.0		
2	19	29.1	31.9	1.2	0	0.0	0.0		
3	39	47.7	87.2	1.8	0	0.0	0.0		
4	12	43.3	71.3	1.8	0	0.0	1.1		
5	52	26.1	33.7	1.3	0	0.0	0.2		
6	23	39.9	44.3	1.1	0	0.0	0.0		
7	34	60.8	97.4	1.7	0	0.0	0.5		
8	12	42.2	57.6	1.7	0	0.0	1.5		
9	42	20.0	25.9	1.3	0	0.0	1.0		
10	27	32.7	75.2	2.4	0	0.0	0.4		
11	15	47.5	58.1	1.3	1	13.0	0.2		
12	13	31.0	35.6	1.3	0	0.0	1.1		
13	16	36.7	53.6	1.7	0	0.0	0.9		
14	19	35.3	75.4	3.3	1	5.0	2.2		
15	21	42.1	90.7	3.2	0	0.0	0.1		
16	20	20.3	24.8	1.3	0	0.0	0.0		
18	8	44.3	73.6	2.0	1	1.0	0.0		
Average	22.6	37.6	60.0	1.8	0.2	6.3	0.5		

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.
[2]Data not collected during this year.

Summary of *E. vialis* measurements in forest canopy thinning plots, 2003.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed
1	14	36.1	65.3	1.9	0	0.0	0.0	0.0	1.5
2	19	29.3	31.4	1.2	0	0.0	0.2	0.0	0.6
3	38	51.1	97.6	2.0	1	22.0	0.0	0.0	0.9
4	12	41.7	59.9	1.6	0	0.0	0.7	0.0	1.6
5	52	23.0	31.5	1.3	0	0.0	0.2	0.0	0.1
6	25	36.5	45.8	1.3	0	0.0	0.0	0.0	0.5
7	32	39.7	64.7	1.8	0	0.0	1.2	0.0	1.1
8	11	27.1	44.7	1.8	0	0.0	1.7	0.0	1.6
9	39	13.1	16.6	1.3	0	0.0	0.8	0.0	no data
10	27	33.3	76.9	2.4	0	0.0	0.6	0.0	no data
11	21	46.3	60.0	1.3	3	20.0	0.2	0.0	1.0
12	15	21.1	23.0	1.1	0	0.0	0.8	0.0	0.3
13	17	27.3	34.2	1.4	0	0.0	1.0	0.0	0.7
14	19	39.0	62.0	2.1	0	0.0	1.1	0.0	1.8
15	28	35.7	66.9	2.7	2	17.5	1.7	0.0	2.5
16	23	17.2	21.9	1.4	0	0.0	0.1	0.0	0.9
18*	8	27.1	48.6	2.0	2	3.0	0.9	0.0	1.0
Average	23.5	32.0	50.1	1.7	0.5	15.6	0.7	0	1.1

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.
* treated prior to 2003 monitoring

Summary of *E. vialis* measurements in forest canopy thinning plots, 2004.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed
1	14	31.9	60.8	1.9	0	0.0	0.0	0.0	1.8
2	17	29.9	31.7	1.2	0	0.0	0.2	0.0	0.9
3	39	49.9	82.2	1.7	1	1.0	0.0	0.0	0.2
4	12	40.5	62.4	1.7	0	0.0	0.7	0.0	1.2
5	43	27.3	37.4	1.4	0	0.0	0.1	0.0	0.5
6	24	35.8	43.2	1.3	13	0.0	0.1	0.0	0.4
7	32	49.5	74.4	1.6	1	19.0	0.6	0.0	1.0
8	10	26.9	35.9	1.4	0	0.0	1.3	0.0	0.6
9	35	11.2	14.1	1.3	0	0.0	0.7	0.0	0.6
10	28	21.9	49.4	2.4	0	0.0	1.4	0.0	0.5
11	23	40.7	58.3	1.4	1	15.0	0.3	0.0	1.1
12	15	20.0	22.7	1.2	0	0.0	0.6	0.0	0.8
13	17	26.5	34.8	1.5	0	0.0	0.9	0.0	0.5
14	18	46.6	67.9	1.7	2	3.0	1.1	0.0	1.5
15	28	36.5	74.3	2.8	3	18.3	0.4	0.0	1.6
16	25	19.9	23.4	1.2	0	0.0	0.3	0.0	1.0
18	7	37.4	55.4	1.6	1	26.0	1.4	0.0	0.3
19	35	19.2	20.3	1.1	0	0.0	0.7	0.0	0.3
Average	23.4	31.7	47.1	1.6	1.2	13.7	0.6	0.0	0.8

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.

Summary of *E. vialis* measurements in forest canopy thinning plots, 2005.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed
1	14	32.5	59.1	1.9	0	0.0	0.1	0.0	0.8
2	17	37.2	39.2	1.1	0	0.0	0.2	0.0	1.1
3	34	70.4	132.9	2.0	3	2.7	0.1	0.0	0.9
4*	11	51.2	80.0	1.6	1	38.0	1.4	0.0	0.7
5	44	32.5	41.4	1.3	0	0.0	0.2	0.0	0.3
6	23	49.9	56.0	1.1	0	0.0	0.0	0.0	0.6
7	31	46.7	87.8	2.1	0	0.0	1.7	0.0	0.3
8	12	25.2	34.1	1.5	0	0.0	1.4	0.0	0.1
9*	27	11.7	12.9	1.2	0	0.0	0.4	0.0	0.6
10	28	23.0	49.2	2.5	0	0.0	1.3	0.0	0.2
11	24	50.3	66.5	1.3	3	9.7	0.0	0.0	1.0
12	16	20.4	21.4	1.1	0	0.0	0.6	0.0	0.2
13	17	26.6	33.8	1.4	0	0.0	0.5	0.0	0.5
14	16	69.4	119.4	1.9	5	19.8	0.3	0.0	0.9
15	30	39.9	66.1	2.0	2	15.5	0.1	0.0	1.8
16	23	20.4	24.6	1.3	0	0.0	0.1	0.0	0.9
18	7	45.0	64.6	1.7	3	6.7	1.4	14.3	1.0
19	37	26.5	28.1	1.1	0	0.0	0.4	0.0	0.9
Average	22.8	37.7	56.5	1.6	0.9	15.4	0.6	0.8	0.7

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.
*treated prior to 2005 monitoring

Summary of *E. vialis* measurements in forest canopy thinning plots, 2006.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed
1	14	32.5	59.1	1.9	0	0.0	0.1	0.0	0.8
2	17	37.2	39.2	1.1	0	0.0	0.2	0.0	1.1
3*	35	70.4	132.9	2.0	3	47.3	0.1	0.0	0.9
4	12	51.2	80.0	1.6	1	30.5	1.4	18.2	0.7
5*	42	32.5	41.4	1.3	0	11.9	0.2	0.6	0.3
6	22	49.9	43.2	1.3	0	0.0	0.0	0.0	0.6
7	28	46.7	87.8	2.1	0	0.0	1.7	0.0	0.3
8	11	25.2	34.1	1.5	0	0.0	1.4	0.0	0.1
9	14	11.7	12.9	1.2	0	0.0	0.4	0.0	0.6
10	11	23.0	49.2	2.5	0	0.0	1.3	0.0	0.2
11	4	50.3	66.5	1.3	3	13.5	0.0	0.0	1.0
12	12	20.4	21.4	1.1	0	1.0	0.6	0.0	0.2
13	3	26.6	33.8	1.4	0	0.0	0.5	0.0	0.5
14	9	20.4	24.6	1.3	5	18.2	0.3	15.9	0.9
15	8	39.9	66.1	2.0	2	11.5	0.1	0.0	1.8
16	17	20.4	24.6	1.3	0	0.0	0.1	0.0	0.9
18	8	45.0	64.6	1.7	3	14.0	1.4	0.0	1.7
19	36	26.5	28.1	1.1	0	0.0	0.4	0.0	0.9
Average	16.8	35.0	50.5	1.5	0.9	18.5	0.6	1.9	0.8

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.
*treated prior to 2006 monitoring.

Summary of *E. vialis* measurements in forest canopy thinning plots, 2007.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed
1	15	25.1	42.4	1.7	0	0.0	0.1	0.0	1.4
2	16	31.4	36.5	1.3	0	0.0	0.3	6.3	1.1
3	35	75.7	211.5	3.1	21	44.6	0.6	22.1	1.7
4	12	71.6	132.6	2.1	5	25.4	1.2	55.8	2.1
5	39	40.9	51.0	1.4	11	22.6	0.1	0.0	0.8
6	19	41.7	44.9	1.1	0	0.0	0.2	10.5	0.5
7	29	32.0	46.4	1.5	0	0.0	1.3	0.0	1.3
8	11	21.3	37.1	1.9	0	0.0	1.6	0.0	1.2
9	30	10.8	14.3	1.4	0	0.0	0.8	3.3	0.4
10	24	17.3	39.6	2.9	0	0.0	2.0	39.1	1.3
11	21	49.5	71.9	1.6	5	2.2	0.2	0.0	1.4
12	12	19.1	14.0	1.0	2	0.0	0.4	25.0	1.0
13	15	16.9	20.6	1.3	1	1.0	0.6	0.0	0.7
14	18	39.1	82.4	2.3	1	10.0	1.8	27.2	2.2
15	28	32.9	70.9	2.8	0	0.0	0.7	16.1	2.3
16	23	20.9	25.6	1.3	0	0.0	0.0	0.0	1.1
18	8	40.3	67.6	2.0	3	10.3	1.1	0.0	1.8
19	35	29.0	37.1	1.4	0	0.0	0.6	5.7	0.9
Average	21.7	34.2	58.1	1.8	2.7	16.6	0.8	11.7	1.3

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.

Summary of *E. vialis* measurements in forest canopy thinning plots, 2008.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed
1	13	25.6	39.9	1.6	0	0.0	0.0	0.0	1.3
2	15	32.8	35.3	1.1	0	0.0	0.0	0.0	0.7
3	35	90.3	255.8	3.5	23	55.7	0.1	0.7	1.0
4	12	74.8	141.8	2.0	2	17.0	2.0	94.2	2.0
5	39	51.9	74.1	1.6	12	23.8	0.1	8.2	0.9
6	19	35.0	39.1	1.2	0	0.0	1.1	0.0	0.4
7	30	34.9	50.6	1.5	0	0.0	0.9	0.0	1.3
8	11	26.2	47.5	2.0	0	0.0	1.5	0.0	0.7
9	21	15.9	18.5	1.3	1	1.0	1.0	4.7	0.4
10	22	19.5	47.6	3.1	0	0.0	1.7	0.0	0.8
11	21	41.1	60.5	1.6	2	7.0	0.7	7.1	1.1
12	12	13.8	14.4	1.1	2	0.0	0.8	0.0	0.6
13	12	12.3	14.3	1.3	0	0.0	1.1	0.0	0.6
14	16	63.4	110.9	2.1	2	26.0	1.6	0.0	1.0
15	23	37.7	77.5	3.2	0	0.0	0.7	0.0	2.2
16	16	26.8	31.9	1.3	1	9.0	0.0	0.0	0.9
18	7	87.3	143.1	2.0	3	14.7	1.0	10.6	1.7
19*	36	33.3	41.7	1.4	1	4.0	0.4	0.0	0.6
Average	20.0	40.0	69.1	1.8	2.7	17.6	0.8	7.0	1.0

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.
*treated prior to 2008 monitoring.

Summary of *E. vialis* measurements in forest canopy thinning plots, 2009.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed
1	14	23.4	36.8	1.5	0	0.0	0.1	0.0	1.3
2	15	34.4	37.7	1.1	0	0.0	0.2	6.7	1.1
3	35	86.4	291.2	3.8	24	40.5	0.1	6.7	3.5
4	11	53.3	139.8	3.1	1	10.0	2.5	3.6	3.1
5	38	58.1	85.6	1.5	15	18.5	0.1	2.6	1.3
6	21	39.4	47.1	1.2	0	0.0	0.1	0.0	0.6
7	30	29.6	42.4	1.5	0	0.0	1.0	0.0	1.2
8	11	21.4	36.8	1.8	0	0.0	0.7	0.0	1.7
9	19	18.2	23.2	1.4	0	0.0	1.2	0.0	1.2
10	24	17.4	43.7	3.1	0	0.0	0.9	0.0	1.7
11	20	50.2	66.3	1.5	4	19.3	0.5	17.3	1.5
12	14	14.0	14.0	1.0	2	0.0	0.2	0.0	0.7
13	9	11.6	17.2	1.4	0	0.0	0.8	0.0	0.7
14	16	61.7	126.5	2.4	3	16.0	0.4	6.3	2.2
15	25	35.0	63.4	2.5	0	0.0	0.2	0.0	2.2
16	17	23.8	27.0	1.2	0	0.0	0.2	0.0	1.1
18	8	30.3	57.1	1.9	2	10.0	1.5	8.1	1.9
19	36	37.5	45.6	1.3	1	2.0	0.4	0.0	1.0
Average	20.2	35.9	66.8	1.9	2.9	16.6	0.6	2.8	1.6

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.

Summary of *E. vialis* measurements in forest canopy thinning plots, 2010.

Plot[1]	# plants	mean length of longest stem (cm)	mean total stem length (cm)	mean # stems	# reproductive plants	mean # capitula/ reproductive plant	mean # of stems deer browsed	mean % of capitula deer browsed	mean # of stems insect browsed
1	13	22.0	35.8	1.7	0	0.0	0.2	0.0	1.2
2	15	30.7	35.3	1.2	0	0.0	0.7	0.0	1.2
3	37	86.2	307.8	4.5	21	33.4	0.4	5.8	4.2
4	11	89.8	223.5	2.6	7	25.7	0.9	28.7	2.6
5	41	59.9	83.2	1.5	23	18.2	0.5	19.2	1.4
6	19	46.2	48.5	1.2	0	0.0	0.3	0.0	0.7
7	24	23.5	32.7	1.5	0	0.0	1.5	0.0	1.4
8	11	13.4	19.8	1.5	0	0.0	1.4	0.0	1.3
9	20	10.7	13.0	1.3	0	0.0	1.1	0.0	0.3
10	22	15.0	33.2	2.7	0	0.0	1.6	0.0	2.5
11	20	36.1	43.8	1.4	1	1.0	1.0	19.0	1.3
12	10	11.3	11.3	1.0	0	0.0	0.3	0.0	0.7
13	6	13.8	16.8	1.3	0	0.0	0.5	0.0	1.3
14	16	73.2	175.8	2.5	5	35.4	0.7	31.9	2.2
15	23	34.6	60.4	2.7	0	0.0	0.2	0.0	1.7
16	17	25.5	31.6	1.3	0	0.0	0.1	0.0	1.0
18	7	32.1	60.9	2.1	2	1.5	1.6	25.7	2.1
19	37	36.5	50.5	1.6	2	5.5	0.7	5.3	1.6
Average	19.0	36.7	71.3	1.9	3.4	17.3	0.8	7.5	1.6

[1]Plot 17 eliminated due to Weiss Road #3 forest manipulations.