AN ABSTRACT OF THE THESIS OF

Alyssa M. Doolittle for the degree of Master of Science in Forest Science, presented on May 5, 2000. Title: Arthropod Communities on Understory Plants in Thinned and Unthinned Douglas-fir Forests in the Oregon Coast Range.

Abstract approved: Signature redacted for privacy.

Timothy D. Schowalter

This study assessed the effects of thinning on arthropod communities on understory plants in the Central Oregon Coast Range. Arthropods were sampled from five understory plants in five pairs of thinned and unthinned, young (50-80 yrs), managed Douglas-fir stands, from late May to mid-July of 1998. Vine maple (*Acer circinatum*), salal (*Gaultheria shallon*), understory hemlock (*Tsuga heterophylla*), bracken fern (*Pteridium aquilinum*), and sword fern (*Polystichum munitum*) were sampled for arthropods using beating sheet and aspirators. Arthropod taxa were sorted and identified to family, species where possible. Intensities and diversity indices were calculated both for all arthropods (including spider taxa) and for spiders separately. Arthropods were placed into functional groups based on trophic level/feeding habits. Spiders were placed in guilds based on prey capture strategies.

Collembolans, psocopterans, aphids and linyphiid spiders together made up 50% of total arthropod abundance. Spiders made up 23% of the total arthropod abundance. Functional groups overall were not found in different intensities between thinned and unthinned stands. Relative representation of spider guilds was

different between thinned and unthinned stands. Cobweb weavers and nocturnal hunters had higher intensities in thinned stands. Sheetweb weavers, orbweb weavers and agile hunters had higher intensities in unthinned stands. Sap-suckers on vine maple were more abundant in unthinned stands. Parasitoids on vine maple were more abundant in thinned stands. Agile hunters on salal were more abundant in unthinned stands. Salal, especially in unthinned stands, provided important structure for spider communities. Salal supported high spider diversity. Hemlock had the highest species richness, for both arthropod and spider communities. Communities on vine maple were diverse, despite low overall arthropod abundance.

The arthropod communities showed significant segregation by plant species and treatment condition. Shrub cover, shrub diversity, patch size, light levels, tree density and stand age explained arthropod community differences. Each one of the understory plants I studied supported a unique portion of the overall understory arthropod community and should be maintained in managed forests to support this important element of diversity. Differences in species distribution and structure of understory vegetation between treatments, resulting in arthropod community differences, suggests that maintenance of both treatment conditions across a landscape is important for maintaining diversity of understory arthropod communities.

Arthropod Communities on Understory Plants in Thinned and Unthinned Douglas-fir Forests in the Oregon Coast Range

By

Alyssa M. Doolittle

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Alyssa M. Doolittle, Author

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INTRODUCTION

A history of extensive timber removal from forests of western Oregon has left a landscape dominated by dense, young, even-aged Douglas-fir stands. Studies suggest that forests managed intensively for wood production are different from natural forests in structure and species composition (Hansen et al. 1991). Federal, state and regional forest management plans have changed in the past decade to include the maintenance of biodiversity and wildlife populations along with timber extraction and recreation objectives. Managers today are using new combinations of silvicultural manipulations to achieve these multiple objectives. Commercial thinning has become an important silvicultural tool for creating and/or maintaining old growth features within young, managed landscapes (Bailey 1996, Tappeiner 1992, Cole 1996, Hayes 1997). There are gaps in our understanding of the effects of these new approaches to forest management on wildlife populations. A major gap is in information about the effects of silvicultural practices on arthropods.

Arthropods have many links throughout forest ecosystems, making it important to understand the effects of stand level silvicultural manipulations on arthropod communitites (Schowalter et al. 1995, Schowalter 1986). Arthropods in all trophic levels are valuable food sources for many species of forest vertebrates, including birds, reptiles and mammals. Each arthropod trophic level carries out specific ecological roles that affect the entire forest system. Predators and parasitoids are recognized as important natural enemies of common forest insect pests (Strong et al. 1984, Hassel 1985). Phytophagous arthropods are recognized as regulators of forest ecosytems through control of primary production and enhancement of nutrient cycling (Mattson and Addy 1975). Detritivores are recognized as a vital part of the cycle of decomposition and regeneration (Seastedt 1984).

Arthropods respond to changes in environmental conditions at microhabitat scales (Klein 1989). When assessing the effect of thinning on arthropod communities in the understory, it is important to understand how thinning affects the structure and the microclimate of the understory. Bailey (1996) studied understory composition in thinned and unthinned Douglas-fir stands and found that shrub cover, density and frequency were greater in thinned stands than in unthinned stands, reflecting an increase in resource availability. Heavier thinnings are likely to create more resources for the understory (Bailey 1996). In a study of *Picea-Tsuga* forests on the central Oregon coast, plant community structure responded differently to different thinning intensities (Alaback and Herman 1988). Understory plant response to thinning is dependent upon thinning intensities, site indices and site histories, as well as geographical location, aspect and elevation. For example, Alaback and Herman (1988) found that species diversity of bryophytes and vascular plants was lower where trees were thinned to 330 trees/ha, a heavy thin. Thinning can improve the ability of certain shrub species to regenerate. Specifically salal, vine maple, bigleaf maple and salmonberry show a positive response to thinning in the coastal forests of Oregon (Tappeiner and Zasada 1993). Rhizomatous species have been found to be particularly promoted by thinning, while low-disturbance, shade-tolerant plants and plants with little mechanical support may be retarded by thinning (Bailey 1996).

Thinning increases light levels and/or reduces competition with trees for other resources possibly affecting energy and nutrient allocation to defensive chemicals that affect their palatability for herbivores (Coley et al. 1985). Host plant condition can be a determining factor for arthropod communities on plants (Schowalter and Ganio 1998, Barbosa and Wagner 1989). Coley et al. (1985) found plant chemical and structural defenses to be the major determinants of leaf and twig palatability. Plants experimentally fertilized to increase nutrient availability may support more herbivores due to plants ability to shift from manufacture of phenolic carbon-based defenses to nitrogen-based compounds and growth (Waring and Cobb 1992). This lends evidence for the theory that resource availability and plant growth are strongly correlated with palatability for herbivores (Coley et al. 1985). Dudt and Shure (1994), in a study of leaf phenolic chemistry and insect herbivory on saplings of yellow-poplar (*Liriodendron tulipifera*) and dogwood (*Cornus florida*) found no effect of fertilization on leaf phenolics or insect herbivory; however, sunlight had a significant positive effect on levels of phenolics in both dogwood and tulip poplar. Lange (1998) did not find stand-level differences in nutrient and tannin concentrations of understory shrub leaves in thinned, unthinned and old growth forest stands in the Oregon Coast Range. Leaf lifetime is also an important determinant of palatability for herbivores. Leaf nitrogen concentration (Mattson 1980) and overall nutritional quality (Lange 1998) decrease with leaf age.

The most extensive arthropod community diversity survey in Oregon has been in the H.J. Andrews experimental forest (Parsons et al. 1991). This type of extensive assessment has not been conducted for arthropods in the Oregon Coast Range. Spiders in the Oregon Coast Range have been assessed by Halaj et al. (1996, 1998).

Fewer studies have been conducted to assess the specific effects of silvicultural thinning practices on arthropod communities (Schowalter 1995, Madson 1998, Jokimäki et al. 1998). Because arthropods have many trophic links throughout forest ecosystems, it is impossible to ignore their presence. Väisänen and Heliövaara (1994) suggested that stand dynamics and the poulation dynamics of forest insects are highly interrelated. Monitoring the response of individual arthropod species and arthropod functional groups has been suggested as an efficient way to detect environmental changes (Schowalter 1989, Kremen et al. 1993, Okland 1994, McIver 1992, Clausen 1986). VanHorne and Bader (1990) suggested that understanding availability of arthropods as a prey source, may lend insight into understanding patterns of habitat occupancy by birds. Concern over arthropod pests in monoculture forest systems, as well as the contributions of arthropods to forest stability and recovery from disturbance, are additional reasons why ecologists and forest managers should understand the effects of forest practices on arthropod communities (Schowalter 1986, Schowalter 1994).

OBJECTIVES

The objective of this study was to assess the effects of thinning on arthropod communities on plants common to the understory of Douglas-fir forests in the Central Oregon Coast Range. I compared the arthropod communities found on understory plants in thinned and unthinned stands. Specifically, I tested for differences in diversity and abundance between thinned and unthinned stands, as well as for differences in functional group and spider guild structure between these two types of forest stands. To provide better understanding of factors affecting the understory shrub arthropod community, I used measurable understory stand conditions, including, stand light levels, understory shrub cover, patch size of sampled shrub and overall understory shrub diversity to test for correlations with arthropod community attributes. This study was also intended to provide baseline data for future analysis of arthropod differences within the understories of thinned and unthinned stands, with possible implications for the management of vertebrate species that prey on these arthropods.

MATERIALS AND METHODS

Site Description

This study was conducted during 1998 in the central Oregon Coast Range, in the western hemlock (*Tsuga heterophylla*) forest zone (Franklin and Dyrness 1988) at elevations of 250-500 ft. Sites were selected between 45° and 44° North Latitude, in Lincoln, Benton and Polk counties. The climate in this region is characterized by wet, mild maritime climate. Average annual precipitation is 150-300 cm (Franklin and Dyrness 1988). I used a randomized complete block study design with two treatments. I chose five pairs of commercially thinned and unthinned Douglas-fir stands, each pair representing a block. Thinned and unthinned stands from each pair were within a kilometer of each other .

Table 1. Site Characteristics for five pairs of thinned and unthinned stands used to study arthropod communities in the Central Oregon Coast Range during early summer 1998. Site Index = height in feet of Dominant and Co-dominant trees at 50 yrs (King 1966). Relative Density = TPA/antilog(10.03-1.65*ln) (in inches)(Curtis 1982).

Site	Stand	Age	Ha Thinned	Site Index	Years since thin	Trees/Ha	%Volume Removed	Relative Density
D-line	Thinned	60	34	121	23	173	12	0.44
	Unthinned	60	40	121	---	267	---	0.63
Mary's Peak	Thinned	50	NA	NA	15	112	21	NA
	Unthinned	50	NA	NA	---	533	---	NA
Adam's Siding	Thinned	78	28	136	24	191	NA	0.52
	Unthinned	78	63	124	---	459	---	0.71
Black Rock	Thinned	73	22	114	24	236	NA	0.56
	Unthinned	73	73	112	---	442	---	0.53
Gnome	Thinned	64	10	120	14	265	43	0.41
	Unthinned	64	40	120	---	591	---	0.65

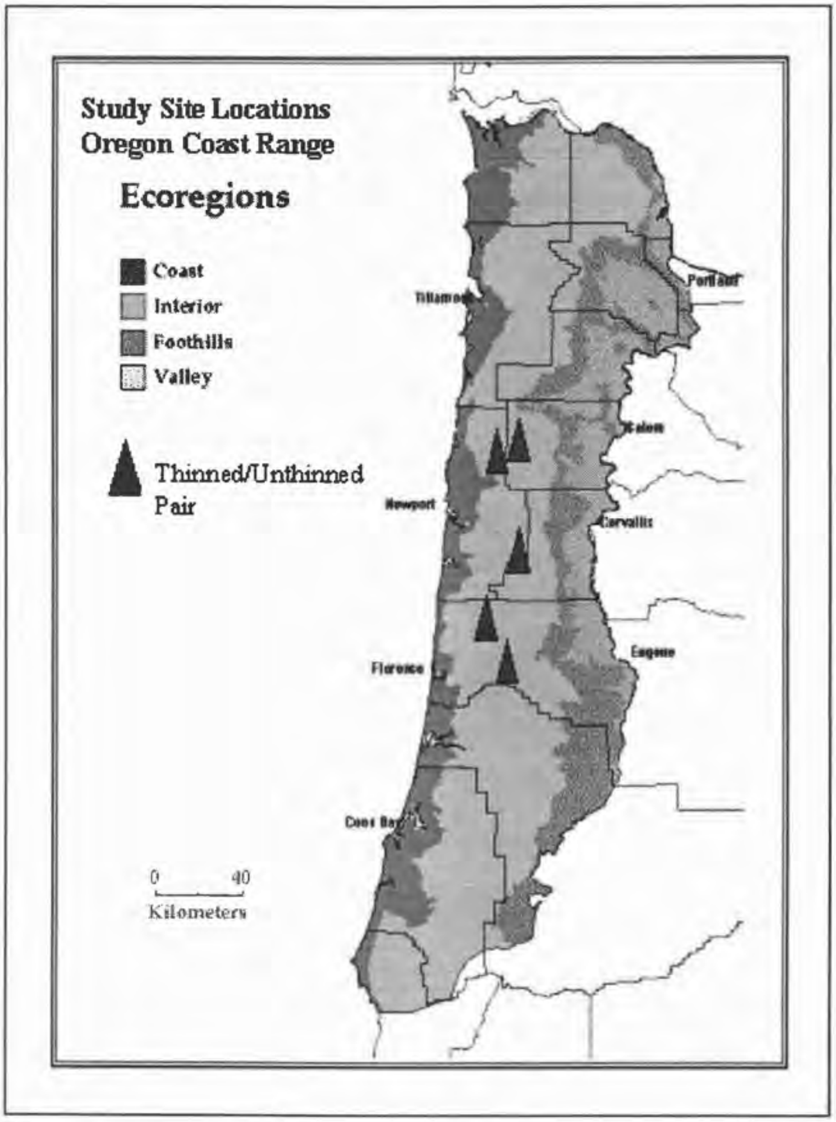


Figure 1. Study site locations in the Central Oregon Coast Range (CLAMS 2000).

Sites were selected using criteria of availability of pair (e.g. similar slope, aspect), time since thin (10-24 yrs), tree age (50-80 yrs), vegetation (at least presence of salal and vine maple or hemlock and ferns), and stand size (minimum 10 ha) (Table 1). Use of study sites for previous studies (e.g. thinning effects on neotropical migrant song bird communities and diet (Hagar 1999)) was also an important criterion. Gnome and D-line were described by Bailey (1996). Adams Siding and Black Rock were described by Humes and Suzuki (Humes 1997; N. Suzuki, unpublished). Mary's Peak and D-line were also used for a bird diet study in 1996 and 1997 (Hagar, 1999). (Table 1).

Shrub Selection

I selected shrub species based on their dominance (high abundance in the stand) and importance for bird forage. Vine maple (*Acer circinatum,* ACCI), salal (*Gaultheria shallon,* GASH), understory hemlock (*Tsuga heterophylla,* TSHE), bracken fern (*Pteridium aquilinum,* PTAQ), and sword fern (*Polystichum munitum,* POMU) met these criteria. Birds have been observed foraging on vine maple, understory hemlock, and bracken fern (Hagar, pers. comm.). Representing selected shrub species in all replicate stands was difficult due to variability of understory shrub composition. Vine maple and salal were abundant and therefore sampled in nearly all stands (Table 2). Sword fern was sufficiently abundant for sampling only in unthinned stands, and bracken fern was sufficiently abundant for sampling only in thinned stands. Hemlock was sampled where it was a significant understory component (Table 2). Amount of vegetation selected for sampling (i.e. leaf

/frond/branch count) was refined from sampling in 1996 and 1997 (Hagar 1999), and each amount provided an adequate arthropod sample (Table 2).

Arthropod Sampling

I sampled arthropods during three periods: May 27-June 5, June 22-30, July 13-18, 1998. Sampling dates represented the period during which birds rely heavily on arthropods for food, i.e. bird breeding season. I used plots evenly spaced along transects to ensure random sampling throughout the stands. For each sampling period, I established a new transect in a randomly selected direction; N-S, E-W, and NE-SW or NW-SE. Over the three sampling periods, I ran one transect in each direction. When stands were elongate,

I broke the transect into two parallel transects, spaced at least 20m apart. I established four, 5m radius plots along each transect at roughly 50-60 m intervals (depending on size of stand).

Table 2. Plant species sampled in each pair of thinned and unthinned stands in the Central Oregon Coast Range, 1998.

Site	Treatment	Plant Sampled	Acronym	Sample Amount
Adam's Siding	Thinned	salal	GASH	50 leaves
		hemlock	TSHE	3 branches
		bracken fern	PTAQ	3 fronds
	Unthinned	vine maple	ACCI	100 leaves
		salal	GASH	50 leaves
		hemlock	TSHE	3 branches
Black Rock	Thinned	vine maple	ACCI	100 leaves
		salal	GASH	50 leaves
		hemlock	TSHE	3 branches
	Unthinned	vine maple	ACCI	100 leaves
		hemlock	TSHE	3 branches
		sword fern	POMU	8 fronds
D-line	Thinned	vine maple	ACCI	100 leaves
		salal	GASH	50 leaves
		bracken fern	PTAQ	3 fronds
	Unthinned	vine maple	ACCI	100 leaves
		salal	GASH	50 leaves
		sword fern	POMU	8 fronds
Gnome	Thinned	vine maple	ACCI	100 leaves
		salal	GASH	50 leaves
		hemlock	TSHE	3 branches
	Unthinned	vine maple	ACCI	100 leaves
		hemlock	TSHE	3 branches
Mary's Peak	Thinned	vine maple	ACCI	100 leaves
		salal	GASH	50 leaves
		bracken fern	PTAQ	3 fronds
	Unthinned	vine maple	ACCI	100 leaves
		salal	GASH	50 leaves
		sword fern	POMU	8 fronds

One of each of the three selected shrub species was sampled in each plot. I sampled the shrubs of each species closest to plot center, a total of three per plot. This resulted in a total of 12 arthropod samples (3 species x 4 plots) from each of 10 stands per sampling cycle (except for the unthinned Gnome stand where the understory was so depauperate that I was only able to find enough of two shrub species per plot to sample).

Branches were selected closest to the plot center, moving away as necessary to obtain sufficient sample (Table 2). Each branch to be sampled was first selected visually, and scanned for quick flying insects (which were aspirated into vial). A 1m x 1m canvas beating sheet was placed under the branch to be clipped. The branch was clipped and vigorously shaken over the beating sheet to dislodge any arthropods onto the canvas. Arthropods were then quickly aspirated into a vial. Arthropods were killed and stored in 70% ethyl alcohol. After being clipped and beaten, branches were bagged, labeled, and kiln dried. I dried each plant sample at 60-65° C until consistent dry weight was obtained, usually after approximately 3 days. Arthropods were sampled only on dry days, because heavy rain or excessively wet vegetation made removal of arthropods from the beating sheet and vegetation difficult, resulting in reduced samples.

I identified arthropods to the taxonomic level of family and lower where possible. Arthropod samples are stored in the Oregon State University Arthropod Collection.

Understory Condition Sampling

I estimated cover of understory vegetation on the same days that I collected arthropods and from the same 5m radius plots as described above. Percent cover was visually estimated for all plant species in each plot (excluding overstory trees). Vegetation information for Black Rock and Adam's Siding was collected in 1996 by Nobuya Suzuki (N. Suzuki, unpublished) which included percent cover estimates in 5m radius plots similarly placed throughout the stands. Therefore, I did not collect cover estimates from these sites. For each stand, I also used cover estimates for each shrub used in arthropod sampling, vine maple, salal, hemlock, bracken fern, and sword fern, to calculate 'patch size' estimates for these sampled species. This estimate was used to see if patch size was correlated with arthropod community attributes found on that particular shrub.

To quantify the canopy cover, I took photographs of the overstory canopy using a hemispheric (fisheye) lens. A Canon AE-1 with a fisheye lens, Canon 7.5mm, F5.6, was used with TMAX 100 b&w film. I took ten canopy photographs per stand, in each of the 10 stands, for a total of 100 photographs. I used a transect placed at randomly selected cardinal direction through the center of each stand and established five new, 5m plots at 50-60 pace intervals along the transect. In the event that the stands were oblong, transects were run lengthwise through the stand to get the best representation of the stand. Two photos were taken per plot, one at plot center and one at a randomly selected cardinal direction 5m from plot center. The camera was oriented north and leveled at one meter off the ground. (Rich 1990, S. Chan, pers. comm.). I digitized negatives from fisheye photographs using Framegrabber on a PC for analysis. CANOPY (Rich 1990), a DOS-based program, was used to calculate light estimates (diffuse and direct) from canopy cover and sunpath for each stand.

DATA ANALYSIS

Understory Condition Analysis

Understory conditions were evaluated by analyzing, for each stand, stand level light levels, shrub diversity, shrub cover and patch size (cover of vine maple, hemlock, salal and ferns), as well as making comparisons within each site of light, shrub cover and shrub diversity. Percentages for all shrub species within individual plots were summed, and plot sums were averaged to obtain a stand level shrub cover estimate. Plot sums were used in t-test analysis to test for difference in shrub cover between treatment *within* sites. Patch size was also determined in each stand for vine maple, salal, hemlock, sword fern and bracken fern. Shannon's diversity index was used to calculate shrub diversity per plot. Plot level diversity estimates were used with simple t-test analysis to test for difference between treatment within sites. These diversity estimates were averaged for each stand. To estimate stand light levels, Direct Site Factor (DSF, measure of direct light) and Indirect Site Factor (ISF, measure of diffuse light) values were obtained from CANOPY and used to compute total light levels, Global Site Factor (GSF=ISF x DSF). These GSF values for each plot were also used in t-test analysis to test for treatment differences by site to evaluate representation of this method as well as compare the treatment effects on light levels. Stand level GSF values were obtained by averaging plot GSF values. The stand level averages of GSF values, shrub cover and diversity were tested for differences between thinned and unthinned stands using one-way ANOVA (SAS Inc., 1996).

Correlation analysis was run on stand level averages, as well as on other stand measurements used in multivariate analysis, such as trees per acre and stand age. I computed Pearson correlation coefficients and p-values for the correlation between light, total shrub cover, shrub diversity, and patch size, trees per hectare and stand age. These variables were expected to be positively correlated because shrub development in thinned and unthinned stands is related to the change in trees per hectare and increase in light created by tree removal. Degree of correlation is important for understanding the relationship between these stand characteristics.

Arthropod Data Organization

Arthropods were placed in functional groups according to their trophic interactions: sapsuckers, folivores, other herbivores, predators, parasitoids, detritivores, omnivores, 'tourists' and unknowns (Appendix A has taxa list). Total herbivores were also analyzed (including sap-suckers, folivores and other herbivores). Spiders were separated into guilds according to their prey capture strategies and target prey. Web weavers included: Sheetweb weavers (Linyphiidae and Dictynidae), Cobweb weavers (Theridiidae), and Orbweb weavers (Araneidae, Tetragnathidae, and Uloboridae). Hunting Spiders included: Nocturnal hunters (Anyphaenidae and Clubionidae), Agile hunters (Salticidae), and Surface Hunters (Philodromidae and Thomisidae). All other spiders, mostly immatures were lumped into an 'Other' category.

For ANOVA and linear regression analysis, samples were pooled by site, treatment, plant species, and sampling period (n=87). For multivariate analysis, samples were pooled by site, treatment, and plant species (n=29). Arthropod intensity (abundance) was calculated for each pooled sample by dividing the number of pooled individuals by pooled plant sample dry weight (kg). The same method was used to calculate arthropod intensity for each functional group and spider guild. The natural logarithmic transfomation was used where necessary to correct for non-normal distribution and unequal variance within analysis with the spider guild and functional group data. A data subset was created with the spiders only, and pooled samples of spider individuals were used to obtain spider intensity, as above. Matrices were created using both 'all arthropod' data (including spiders) and 'spiders only' data for use in Indicator Taxa Analysis and Ordination analysis. Shannon's diversity index was used to measure diversity of arthropods and spiders by pooled sample.

For both Indicator Taxa Analysis and Non-metric Multi-dimensional Scaling ordinations, arthropods and spider data sets were analyzed both with and without fern data. Fern species were not sampled in both treatments, as mentioned above. Therefore, I could not use the ferns to look at treatment differences by plant species. Ferns had many strong indicator taxa; they supported a distinct community, and high abundances of arthropods, which overshadowed analysis of arthropod community attributes on other plants sampled. Arthropod community attributes on vine maple, hemlock and salal were more visible when sword fern and bracken fern were removed from the analysis.

ANOVA and Linear Regression Analysis

ANOVA was performed using PROC MIXED (SAS, Inc. 1996) to test for effects of treatment on arthropod and spider intensity and diversity for each plant species. ANOVA tests were also used to test for treatment effects for each functional group and spider guild for each plant sample species. Regression analysis was performed using PROC GLM (SAS, Inc. 1996) to evaluate significance of relationships between stand light levels, total understory shrub cover, patch size, and shrub diversity on arthropod and spider intensity and diversity by plant species, as well as on functional group and spider guild by plant species. Sword fern and bracken fern were not used in this part of the analysis because each fern could not be sampled in both thinned and unthinned stands. Site was used as a blocking factor in all of the regression analysis and ANOVAs.

Indicator Taxa Analysis

I used Dufrene and Legendre's (1997) method with PC-ORD software (McCune and Mefford 1997) to analyze indicator values for arthropod taxa by plant species and treatment. This method combines (by multiplication) the relative abundance of a taxon in a particular group with its relative frequency of occurrence to produce an indicator value. The indicator value is then used with a Monte Carlo technique to test for statistical significance. Alpha of 0.05 was used to determine significance; p- values ≤ 0.10 but > 0.05, were considered suggestive of significance. Arthropod data were separated into two matrices: all arthropods (including spiders) and spiders only. Indicator taxa analysis was run with matrices of taxon by sample to test for association with plant species. Each matrix was further reduced by dropping fern samples (sword fern and bracken fern) to test for indicators of salal, hemlock and vine maple. I also tested for indicators of treatment within each plant species for all arthropods and spiders only, functional group and spider guild.

Multiple-response Permutation Procedure

I used Multiple-response permutation procedure (MRPP) to determine the significance of differences among sample groups clustered by plant sample, site and treatment. Four data matrices (all arthropods, spiders only, fuctional groups and spider guilds) were used to test for significance of grouping by site and plant. The same four matrices were reduced by pooling data by individual plant species, and used to test for grouping by treatment, thinned vs. unthinned. MRPP is used to test the hypothesis of no difference between two or more groups (McCune 1998). MRPP does not have the requirement of equal variance , as do ANOVA or 2-sample t-tests, and therefore is appropriate to use with multivariate data which often do not meet this assumption. MRPP derives a test statistic, T, from a permutation (Zimmerman 1985). The probability value is expressed as the probability of getting a within group distribution as extreme or more extreme than the observed average within group distance, given the possible distribution of groups (McCune 1998). MRPP tests were performed using PCORD (McCune and Mefford 1995).

Non-metric Multidimensional Scaling

I used Non-metric Multidimensional Scaling (NMS) in PCORD to perform ordinations of arthropod communities along gradients described by stand conditions (stand age, trees per hectare, shrub cover, cover of sampled shrubs, shrub diversity, light levels) and by plant type and treatment (McCune and Mefford 1995). Sample units used in ordination were the same as used in Indicator Analysis, with matrices of arthropod taxon by pooled sample (samples pooled by site treatment and plant species, sample n= 29). NMS is an ordination method based on ranked differences (Mather 1976 and Kruskal 1964). NMS works well with data sets that are non-normal, discontinuous or on "otherwise questionable scales" (McCune 1998), all of which apply to my data. Starting configurations were determined in NMS , as suggested in PCORD, to determine appropriate dimensionality, statistical significance and to avoid local minima (McCune and Mefford 1995). I used Sorenson's distance measure and a three-axis configuration. I examined NMS ordinations for grouping or patterns in arthropod and spider community composition along environmental gradients. Overlays were used to illustrate associations of arthropod and spider communities with thinning treatment or plant species.

RESULTS

Understory Conditions

ANOVA analysis indicated that the overall difference between average light levels in thinned vs. unthinned stands was significant ($F_{1,4}$=11.99, p=0.0257) (Figure 2). GSF (Global site factor) values obtained from fish-eye photo analysis were used in pair-wise comparisons (Table 3). All of the paired stands had significantly different light levels with the exception of Mary's Peak, that approached significance (T = 2.64, p = 0.057), and D-line (T = -0.69, p = 0.53). Shrub cover was different between thinned and unthinned stands ($F_{1,4}$=57.82, p =0.0016)(Figure 3). Shrub diversity, measured as the Shannon Index diversity, was not significantly different between thinned and unthinned stands ($F_{1,4}$= 5.33, p = 0.0821)(Figure 4).

Figure 2. GSF light levels with standard error for thinned and unthinned stands. Fisheye photographs taken in five pairs of thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range, August, 1998.

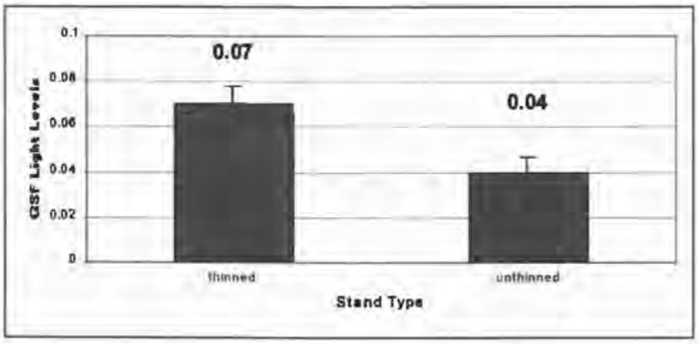


Figure 3. Shrub Cover Indices with standard error for thinned and unthinned stands. Cover estimates taken from ten plots in each of ten paired thinned and unthinned stands in the Central Oregon Coast Range, May-July, 1998.

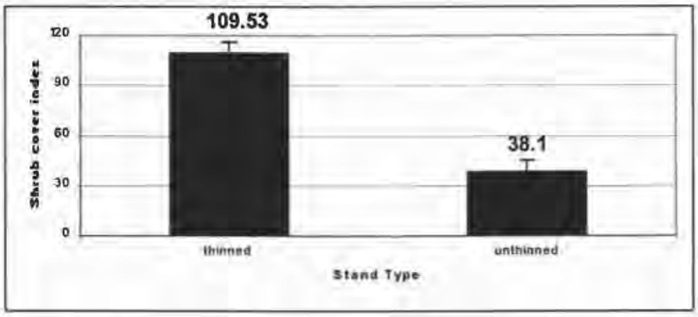
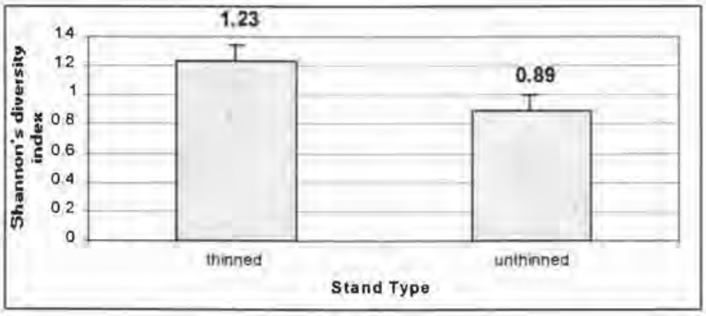


Figure 4. Shrub diversity with standard error for paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range, May-July 1998. Shrub diversity estimates were derived from ten plots in each of ten paired stands.



T-test analysis show that despite relatively small differences in light levels between treatments, shrub cover is consistently greater in thinned when compared to unthinned stands (Tables 3, 4). Global site factor (GSF) values obtained from fish-eye photograph analysis were used to compare light levels between each thinned and unthinned pair (Table 3). All the paired stands had significantly different light levels (α=0.05) with the exception of D-Line (T =-0.69, p-value=0.53). Overall light level differences between treatments were relatively small, averaging a 2.5% - 7 %. Adam's Siding thinned stand had average light level only 0.4% greater than Mary's Peak unthinned stand average light level. However these small differences in light levels actually affected the understory of these stands accordingly. In each pair, the thinned stand had significantly greater shrub cover than the unthinned stand.

Table 3. Values for difference of mean Global Site Factor values for each site from SAS paired t-test analysis. Photgraphs of Canopy taken using hemispheric lens in paired thinned and unthinned stands in the Central Oregon Coast Range.

	MEAN GSF Thinned	MEAN GSF Unthinned	Mean Diff.	Std Error for the difference	T-stat for the difference	p-value for the difference
ADAM'S SIDING	0.059	0.033	0.025	0.006	4.09	0.015
BLACK ROCK	0.058	0.030	0.028	0.008	3.54	0.024
D-LINE	0.073	0.063	0.01	0.015	0.69	0.529
GNOME	0.102	0.031	0.071	0.012	5.77	0.005
MARY'S PEAK	0.097	0.054	0.043	0.016	2.64	0.057

Table 4. Results for t-test for difference of understory shrub cover between thinned and unthinned stands by study site. Cover estimates taken from ten plots in each of ten paired thinned and unthinned stands in the Central Oregon coast Range, May-July 1998.

	Mean shrub cover Thinned	stderr for mean thinned	Mean Shrub cover Unthinned	stderr for mean unthinned	T-stat for the difference	p-value for the difference
ADAM'S SIDING	110.25	4.80	37.25	3.79	11.83	0.0001
BLACK ROCK	97.08	3.15	50.18	5.37	7.52	0.0001
D-LINE	95.33	7.34	55.53	6.98	3.92	0.0003
GNOME	126.60	9.72	14.35	3.99	9.65	0.0001
MARY'S PEAK	118.40	7.29	33.2	8.04	17.68	0.0001

Table 5. Results for t-test for difference of understory shrub diversity between thinned and unthinned stands by study site. Diversity estimates taken from ten plots in each of ten paired thinned and unthinned stands in the Central Oregon coast Range, May-July 1998.

	Mean shrub diversity Thinned	stderr for mean thinned	Mean Srub diversity Unthinned	stderr for mean unthinned	T-stat for the difference	p-value for the difference
ADAM'S SIDING	1.19	0.08	1.38	0.01	-2.16	0.037
BLACK ROCK	1.35	0.03	1.00	0.11	3.94	0.000
D-LINE	1.20	0.11	0.89	0.15	2.34	0.026
GNOME	1.32	0.07	0.77	0.29	3.02	0.010
MARY'S PEAK	1.13	0.00	0.45	0.08	4.50	0.000

Both Adam's Siding and D-line had attributes that made the pair-wise differences (thinned vs. unthinned) less distinct than in other sites. The average shrub diversity in Adam's siding unthinned was greater than that in Adam's siding thinned.

These differences were responsible for shrub diversity not being significantly different overall between thinned and unthinned stands. D-line and Adam's Siding were important parts of this study and were not dropped form the analysis despite these differences.

Many stand conditions were highly correlated (Table 6). The details of these correlations will be referred to in further discussion of these stand conditions. I used stand conditions to assess arthropod community differences and to see if any of these stand level conditions could help explain arthropod community conditions. It made sense that shrub cover, light levels, shrub diversity, and patch size were all negatively correlated with trees per hectare. However, shrub diversity and light were not correlated. Patch size was not correlated with shrub diversity. Stand age was negatively correlated with light levels and positively correlated with shrub diversity. Stand age was not correlated with shrub cover, individual shrub cover and trees per hectare.

Table 6. Pearson's correlation coefficients and corresponding p-values for correlations between stand conditions. Stand conditions collected for paired thinned and unthinned stands in the Central Oregon Coast Range.

		Light levels	Shrub diversity	Patch Size	Trees per Hectare	Stand age
Shrub cover	PCC	**0.819**	**0.604**	**0.522**	**-0.888**	-0.026
	p-value	**0.000**	**0.001**	**0.004**	**0.000**	0.892
Light levels	PCC	***	0.245	**0.485**	**-0.731**	**-0.527**
	p-value	***	0.201	**0.005**	**0.000**	**0.003**
Shrub diversity	PCC	***	***	0.248	**-0.552**	**0.588**
	p-value	***	***	0.195	**0.002**	**0.001**
Patch Size	PCC	***	***	***	**-0.524**	-0.135
	p-value	***	***	***	**0.004**	0.486
Trees per hectare	PCC	***	***	***	***	0.084
	p-value	***	***	***	***	0.665

Arthropod Taxa

A total of 9935 individual arthropods were sorted from 347 samples. Overall arthropod intensity was 15,600 arthropods per kg dry foliage (Table 7). Overall spider intensity was more than 3600 spiders per kg (Table 7). This breakdown was consistent by plant and treatment. Entomobryidae (springtails), Psocoptera (plant lice), Aphididae (aphids), Sminthuridae (globular springtails) and Linyphiidae (sheetweb weaving spiders) were most abundant groups, together making up 50% of the total arthropod intensity. Spiders made up 23% of the total arthropod intensity.

Table 7. Arthropod and Spider Intensity Results from arthropod sampling conducted in 1998 on five understory plants in five paired thinned and unthinned forest stands in the Central Oregon Coast Range. Intensity = #individuals per kg dry plant weight. Intensities calculated using pooled samples. n = number of samples, % represents percent of total intensity.

Data Subset	n	Arthropod Intensity	%	Spider Intensity	%
All Data	**347**	**15573**	**100**	**3594**	**100**
Vine maple	95	2641	17	611	17
Salal	96	4504	29	1148	32
Hemlock	84	2099	13	601	17
Bracken Fern	36	2666	17	487	14
Sword Fern	36	3658	23	747	21
Thinned Stands	**180**	**7623**	**48**	**1688**	**47**
Unthinned Stands	**167**	**7950**	**52**	**1906**	**53**

Treatment Differences in Arthropod Community

Functional group distribution overall was not different between thinned and unthinned stands (Figure 5). Detritivores were the most abundant functional group and were found at greater intensity in unthinned stands. However this difference is not significant. Spider guilds showed more differences between thinned and unthinned stands than did arthropod functional groups (Figure 6). The most abundant spider guild, Sheetweb Weavers, was found at greater intensity in unthinned stands ($F_{1,19} = 6.40$, $p = 0.0204$). The second most abundant spider guild, Cobweb Weavers, was found in greater intensity in thinned stands ($F_{1,19} = 69.75$, $p = 0.0001$).

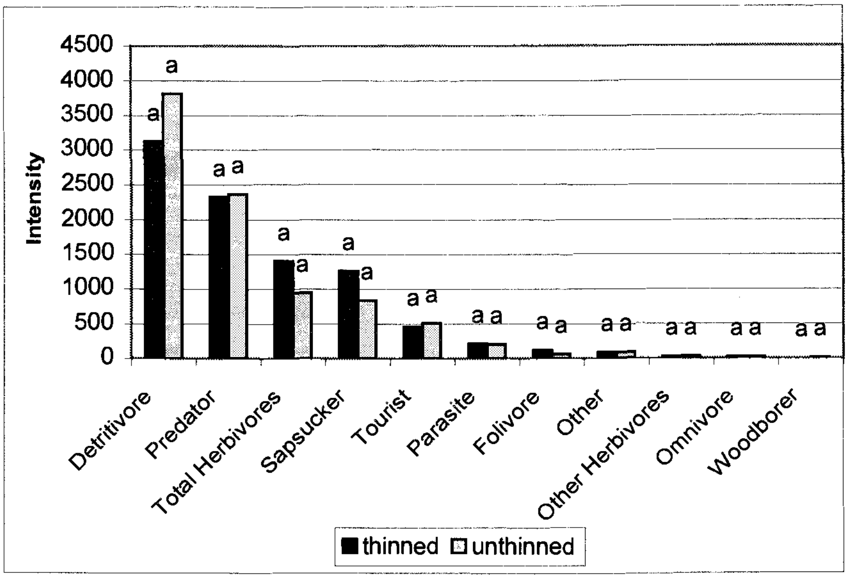


Figure 5. Functional Group Distribution of arthropods collected from 5 understory plants in 5 paired thinned and unthinned stands in the Central Oregon Coast Range. Different letters indicate significant differences between thinned and unthinned stands.

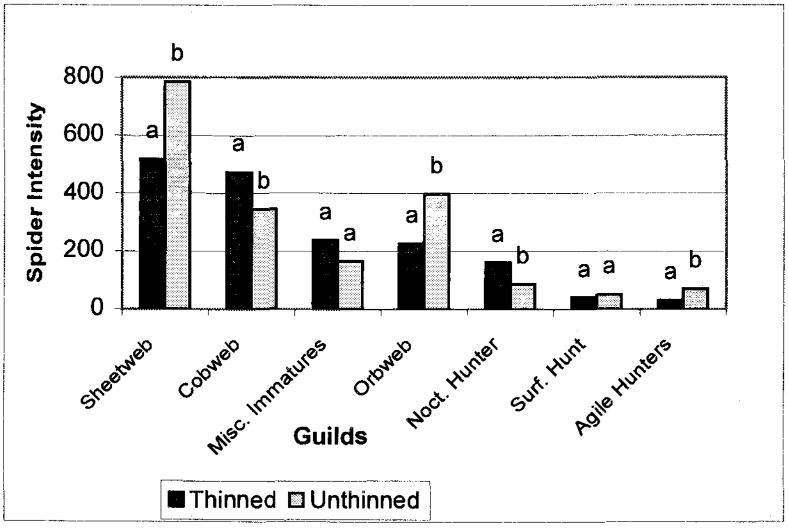


Figure 6. Spider Guild Distribution of arthropods between thinned and unthinned stands collected during 1998 from 5 understory plants in 5 paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range. Different letters indicate significant differences between thinned and unthinned stands.

Indicator Analysis of arthropod taxa on individual plant species showed few taxa to be indicators of treatment for a given plant species (Table 8). Arthropods on hemlock were evenly distributed between thinned and unthinned stands; no taxa indicative of treatment were found on hemlock. However, Misc. Araneidae found on hemlock were indicators of hemlock in the understory of thinned stands. *Pitohyphantes rubrifasciata* had highest indicator value for understory hemlock in unthinned stands. Clubionidae (Nocturnal Hunting Spiders) and Scelionidae (Parasitic Hymenoptera) were indicators of vine maple in thinned stands. All Lepidopterans other than Geometrids and Noctuids found on vine maple were found in only thinned stands, and were perfect indicators of vine maple in thinned stands. *Clubonia canadensis* and *Theridion canadensis* on vine maple were indicators of thinned stands (Table 9). Curculionidae, Phoridae, miscellaneous Theridiidae and Salticidae were indicators of salal in unthinned stands.

Table 8. Indicator taxa Analysis with arthropod taxa (including spiders) by plant species to test for treatment indicators. Arthropods sampled from understory plants in five paired thinned and unthinned stands in the Central Oregon Coast Range. Indicator values given are % of perfect indication, based on combination of relative frequency and relative abundance. Only those taxon with significant indication are shown below. Bold indicates which indicator values were significant

	acci		**gash**		**Tshe**	
Arthropod Taxa	**thin**	unthin	**thin**	unthin	**Thin**	unthin
Araneidae (Orbweb weaver)	56	44	35	**65**	50	50
Clubionidae (Nocturnal Hunter)	**86**	3	45	29	61	26
Curculionidae (Coleoptera)	24	40	24	**70**	25	0
Misc Lepidoptera	**100**	0	33	59	52	10
Phoridae (Diptera)	37	27	8	**79**	8	23
Salticidae (Agile Hunter)	30	44	9	**77**	29	62
Scelionidae (Para. Hymenoptera)	**85**	3	11	15	22	37

Table 9. Indicator taxa analysis with spider taxa only, for each plant species, to test for treatment indicators. Spiders were sampled from five paired thinned and unthinned stands in the Central Oregon Coast Range. Indicator values given are % of perfect indication, based on combination of relative frequency and relative abundance. Bold indicates significance, $p < 0.05$.

	acci		**gash**		**tshe**	
Spider taxa	**thin**	**unthin**	**thin**	**unthin**	**thin**	**unthin**
Misc Araneida	0	60	14	44	**72**	9
Clubiona canadensis	**88**	2	55	10	42	29
Pityohyphantes rubrofasciata	14	23	14	44	14	**71**
Prolinyphia spp	8	60	14	43	0	**67**
Salticidae	9	58	10	**74**	17	66
Misc Theridiidae	0	80	9	**78**	27	15
Theridion califomicum	**67**	0	34	58	25	0

Arthropod Community by Plant Species

Arthropods were most abundant on sword fern, followed by bracken fern and salal (Figure 7). Average arthropod diversity was greatest on vine maple, while hemlock had the greatest average arthropod richness (Figures 8 and 9). Spiders were most abundant on sword fern, followed by bracken fern and salal (Figure 10). Salal, closely followed by the ferns, had the greatest average spider diversity, while hemlock had the highest average spider richness (Figures 11 and 12).

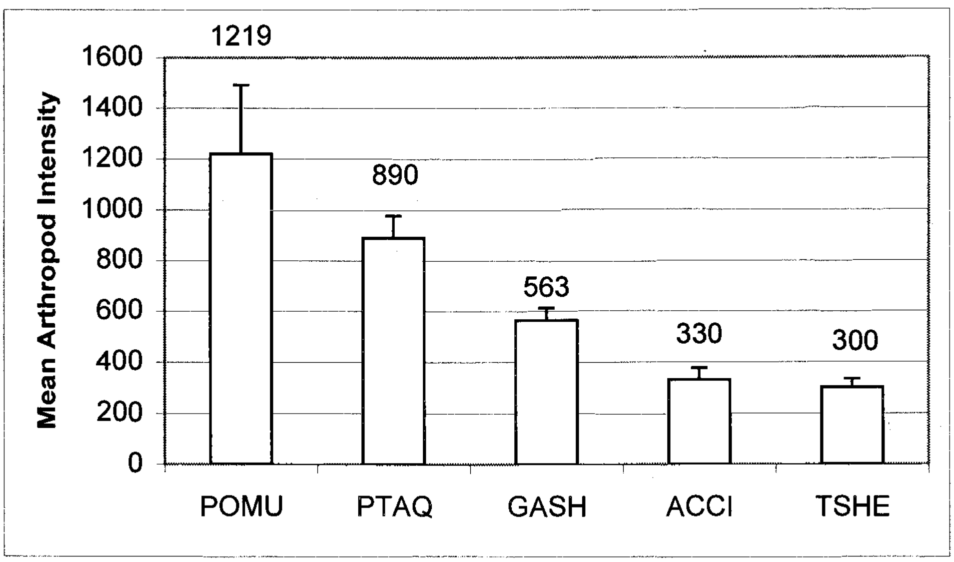


Figure 7. Mean intensity of arthropods by plant species with standard error bars. Samples taken from paired thinned and unthinned stands in the Central Oregon Coast Range during early summer, 1998.

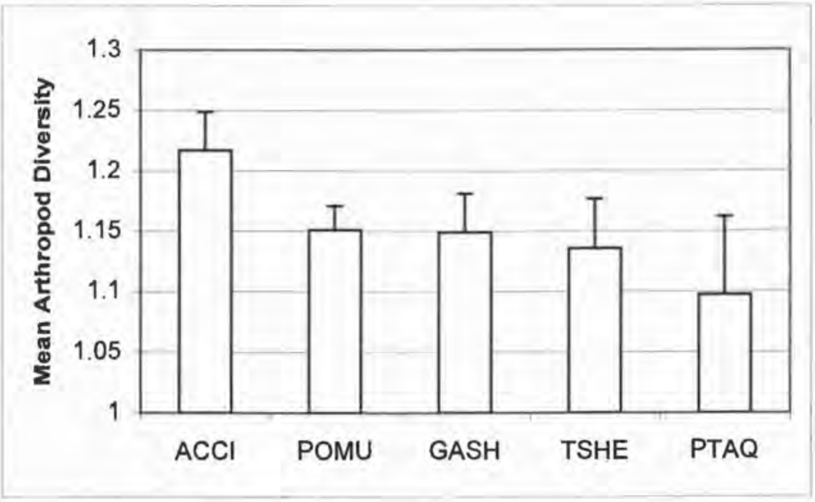


Figure 8. Mean arthropod diversity by plant species with standard error bars. Shannon's diversity index used to calculate diversity. Samples taken from paired thinned and unthinned stands in the Central Oregon Coast Range during early summer, 1998.

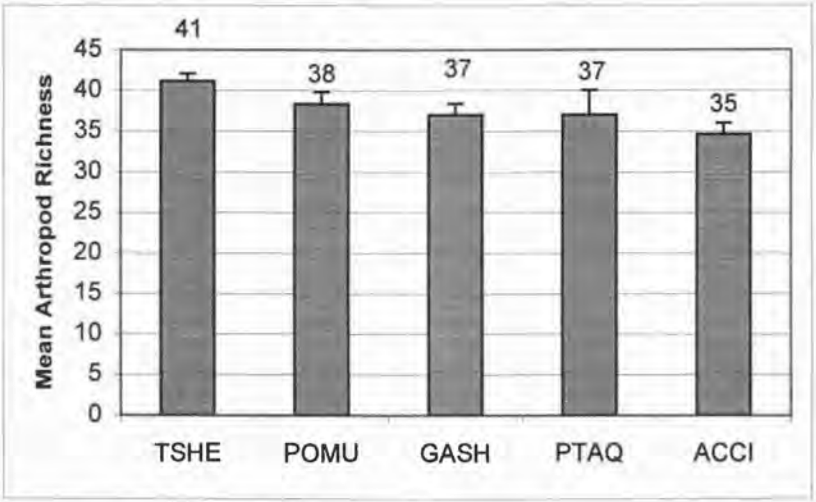


Figure 9. Mean arthropod richness by plant species with standard error bars. Samples taken from paired thinned and unthinned stands in the Central Oregon Coast Range during early summer, 1998.

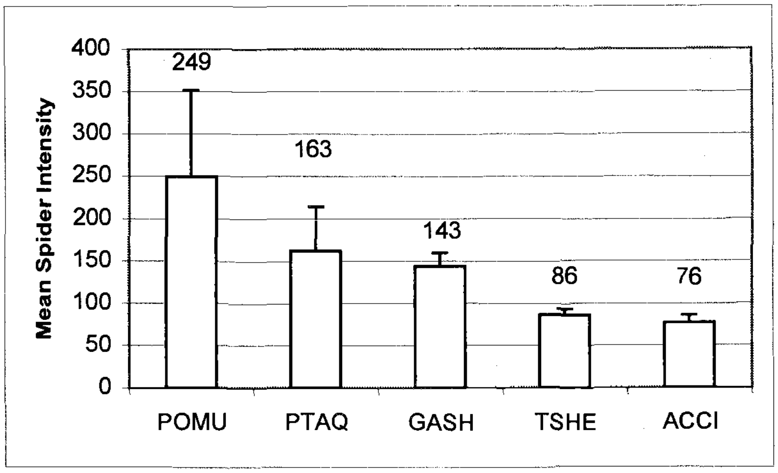


Figure 10. Mean intensity of spiders for each plant species with standard error bars. Samples taken from paired thinned and unthinned stands in the Central Oregon Coast Range during early summer, 1998.

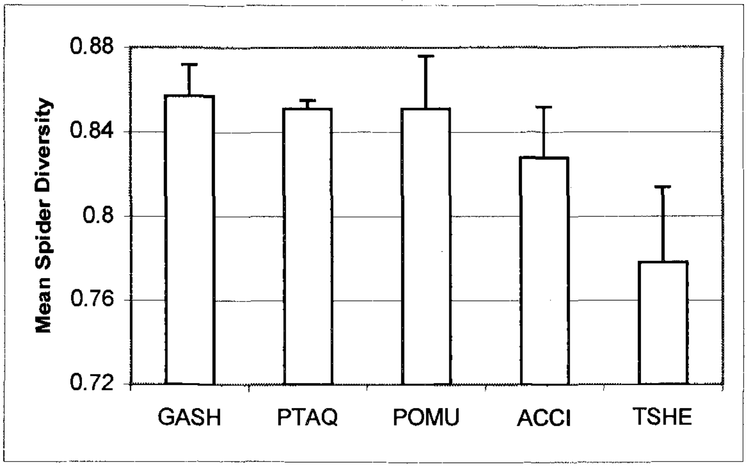


Figure 11. Mean spider diversity by plant species with standard error bars. Samples taken from paired thinned and unthinned stands in the Central Oregon Coast Range during early summer, 1998.

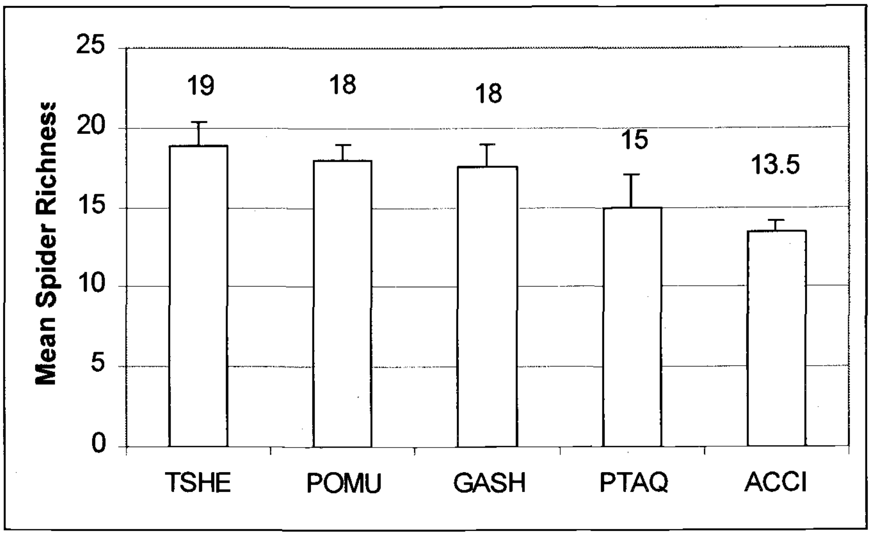


Figure 12. Mean spider richness by plant species with standard error bars. Samples taken from paired thinned and unthinned stands in the Central Oregon Coast Range during early summer, 1998.

Arthropod and spider communities were grouped significantly by plant species (Table 10). Sword fern was characterized by abundant detrivores (p= 0.0001). Bracken fern was characterized by sapsuckers, mainly aphididae, (p=0.0001). Detritivores were found at greatest intensity on salal (2398 per kg), followed by sword fern (1986 per kg). Predator abundance followed this trend with greatest intensity on salal (1330 per kg) and then sword fern (1016 per kg) (Figure 13). Total herbivore abundance was driven mostly by sap-sucker abundance. Sap-suckers were most abundant on bracken fern (917 per kg), followed by vine maple (482 per kg). Folivores were also most abundant on bracken fern and vine maple (53 and 52 per kg, respectively), although overall folivore abundance was low (Appendix A). Parasitoids were at least twice as abundant on vine maple (166 per kg) as on all other plants sampled. Cobweb weavers were found in greatest intensity on salal

(Figure 15). Sheetweb weavers were found in greatest intensity on sword fern and salal, and Orbweb weavers on hemlock.

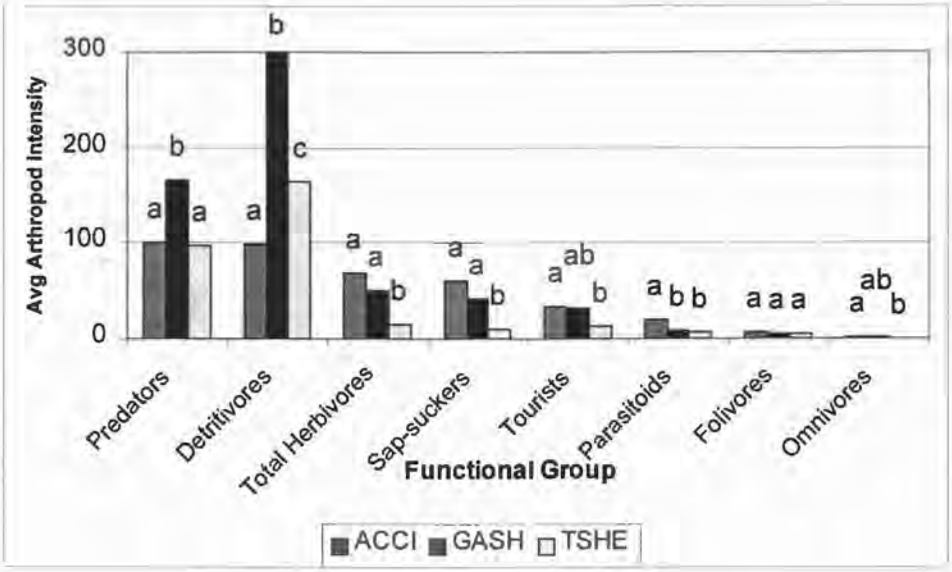


Figure 13. Intensity of arthropod functional groups on vine maple (ACCI), hemlock (TSHE), and salal (GASH), in paired thinned and unthinned Douglas-fir stands, Central Oregon Coast Range. Data labels represent statistical significance of difference (α = 0.05) within each functional group only.

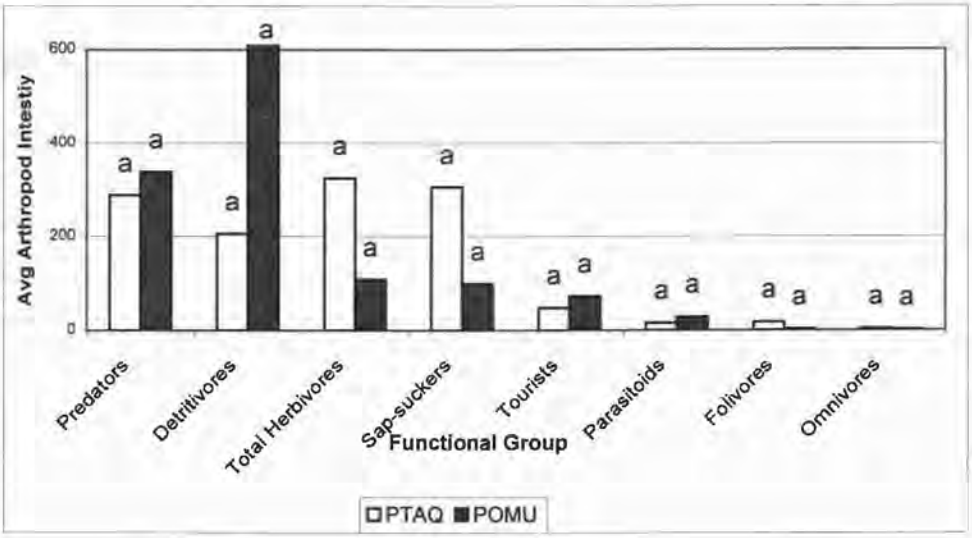


Figure 14. Intensity of arthropod functional groups on bracken fern (PTAQ) and sword fern (POMU) from understory of paired thinned and unthinned Douglas-fir stands, Central Oregon Coast Range, 1998. Data labels represent statistical significance of difference ($\alpha = 0.05$) within each functional group only.

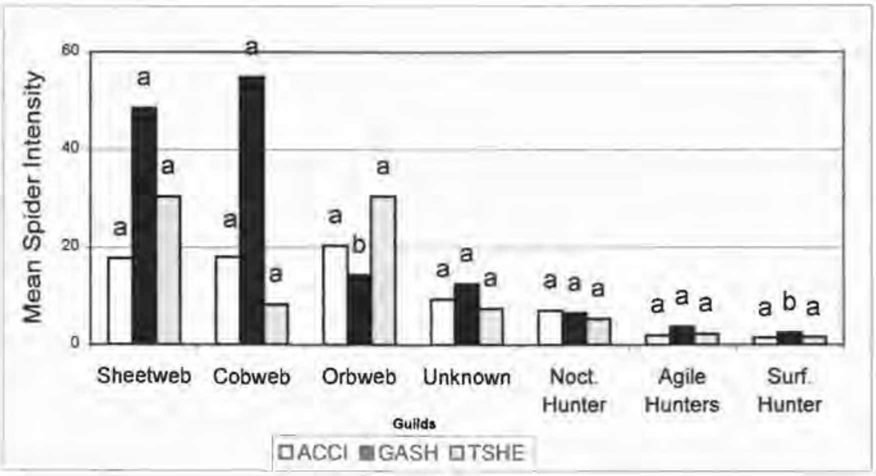


Figure 15. Intensity of spider guilds on vine maple (ACCI), salal (GASH), and hemlock (TSHE) from understory of paired thinned and unthinned Douglas-fir stands, Central Oregon Coast Range, 1998. Data labels represent statistical significance of difference ($\alpha = 0.05$) within each spider guild only.

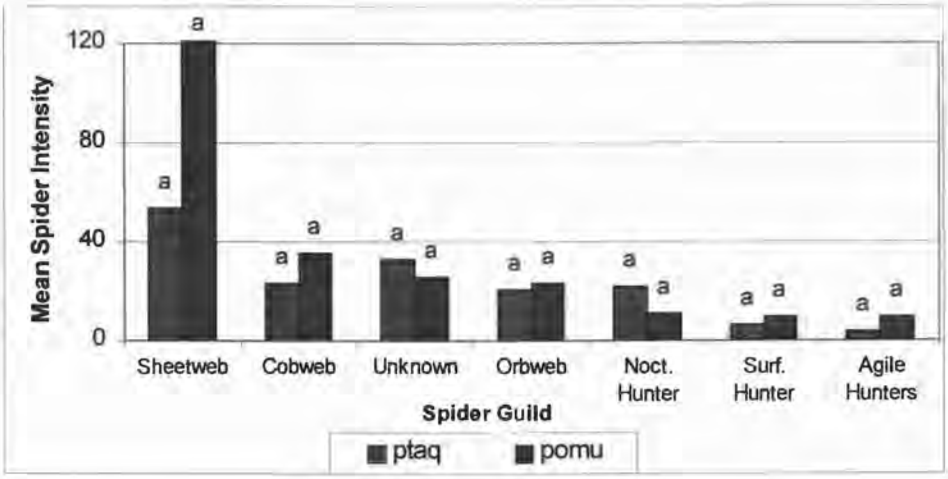


Figure 16. Intensity of spider guilds on bracken fern (PTAQ) and sword fern (POMU) from understory of paired thinned and unthinned Douglas-fir stands, Central Oregon Coast Range, 1998. Data labels represent statistical significance of difference (α = 0.05) within each spider guild only.

Analysis of all the arthropods from all samples grouped by plant species (Table 8) showed that the ferns had the greatest number of significant indicator family groups. Bracken fern was significantly indicated by Aphididae, Cercopidae, Chrysopidae, Coccinellidae, Encyrtidae, Formicidae, Hemerobiidae, Mordellidae, Tenthredinidae, and Clubionid spiders. Sword fern was significantly indicated by Acarina, Diapriidae, Entomobryidae, Melyridae, Orabatida, Philodromidae, Salticidae, and *Polyxenus spp*. Cantharids approached significant indication on sword fern. However, cantharids, mostly *Malthodes spp*, were well distributed on other plants as well. With the fern samples included, there were no significant indicator taxa suggested for vine maple.

Indicator taxa analysis showed a total of 21 taxonomic groups to be significant indicators of these three plant species ($p < 0.10$) (Table 11). Vine maple was significantly indicated by coccinellids, pteromalids, and other Chalcidoidea. Aphididae approached significant indication of vine maple. Salal was indicated by cercopids, entomobryids, formicids, lepidopterans other than geometrids and noctuids, mordellids, *Polyxenus*, theridiids, linyphiids, and sminthurids. Sciaridae is suggestive of being an indicator for salal ($p < 0.08$). Hemlock is indicated by psocopterans, psychodids, and staphylinids. Uloboridae and Araneidae spider families were suggestive ($p < 0.10$) of being indicators for hemlock.

Indicator Taxa Analysis of spider taxa showed that 12 spider taxa were suggestive of indication with p-values less than 0.10 (Table 12). Sword fern and salal had the most significant indicator taxa. Spider analysis were run a without the ferns which allowed possible indicators on salal and hemlock to stand out. Salal had six indicator taxa (Table 12); *Neriene spp, Theridion californicum, Theridion differens, Theridion sexpunctatum*, other *Theridion spp* and Micryphantinae. Hemlock had five indicator taxa (Table 12); *Pityohyphantes brachygynus,* other *Pityohyphantes spp, Theridion lawrencii, Hyptiotes gertschi,* and *Nuctenea patagiata*..

Table 10. INDICATOR TAXA ANALYSIS with arthropod taxa. Arthropods sampled from shrubs in the understory of five paired thinned and unthinned stands in the Central Oregon Coast Range, 1998. Significant results from two analysis shown below: Indicator taxa analysis with all five plants to show fern indicators,and without ferns to show indicators for vine maple, salal, and hemlock only. Indicator values given are % of perfect indication, based on combination of relative abundance and relative frequency. **Bold indicates p-value < 0.05.** For complete taxa list see appendix.

TAXON	ANALYSIS WITHOUT FERNS				ANALYSIS WITH FERNS (all 5 plant		
INSECTS	**acci**	**gash**	**tshe**	p-value	**ptaq**	**pomu**	**p-value**
Aphididae	61	34	5	0.066	**32**	23	**0.009**
Cantharidae	58	29	12	0.116	26	31	0.073
Cercopidae	1	**55**	16	**0.029**	**41**	3	**0.036**
Chalcidoidea	**56**	10	24	**0.051**	9	29	0.175
Chrysopidae	-	-	-	0.373	**42**	7	**0.056**
Curculionidae	15	46	17	0.135	0	17	0.229
Coccinellidae	**59**	24	9	**0.008**	**32**	12	**0.047**
Coniopterygidae	0	0	29	0.068	0	0	0.081
Diapriidae	-	-	-	0.676	5	**61**	**0.003**
Elateridae	-	-	-	0.311	5	43	**0.024**
Encyrtidae	-	-	-	0.371	**43**	0	**0.050**
Entomobryiidae	12	**70**	17	**0.001**	20	28	**0.005**
Formicidae	28	**54**	6	**0.024**	**39**	13	**0.002**
Hemerobiidae	-	-	-	0.810	39	26	0.073
Unkn Lepidoptera	8	**54**	10	**0.022**	0	0	**0.003**
Melyridae	-	-	-	0.960	0	**49**	**0.010**
Mordellidae	-	-	-	0.693	**33**	0	0.088
Phoridae	-	-	-	0.365	**39**	6	0.067
Psocoptera	15	30	**54**	**0.014**	18	19	**0.055**
Psychodidae	0	0	**57**	**0.003**	0	0	**0.002**
Pteromalidae	**67**	6	12	**0.054**	4	31	0.284
Scelionidae	-	-	-	0.825	6	26	0.351
Sciaridae	37	50	13	0.086	24	27	0.138
Sminthuridae	11	**58**	27	**0.045**	24	23	0.702
Staphylinidae	0	3	**43**	**0.039**	0	14	0.246
Tenthredinidae	-	-	-	0.912	**53**	0	**0.010**
SPIDERS, MITES, and OTHERS							
Acarina	-	-	-	0.844	23	30	0.011
Orabatida	3	**88**	2	**0.001**	7	**53**	**0.003**
Araneidae	31	22	46	0.098	22	21	0.693
Clubionidae	-	-	-	0.974	**35**	24	**0.046**
Dictynidae	7	2	36	0.129	0	10	0.178
Linyphiidae	18	**51**	31	**0.009**	22	**25**	**0.039**
Palpatores	8	45	34	0.142	22	31	0.073
Philodromidae	-	-	-	0.976	16	**38**	**0.050**
Polyxenidae	2	**81**	1	**0.004**	6	50	**0.007**
Salticidae	21	28	23	0.912	12	**37**	**0.017**
Theridiidae	22	**68**	10	**0.001**	18	24	**0.037**
Uloboridae	2	5	38	0.095	12	0	0.370

Table 11. Spider indicator taxa for plant species. Spiders sampled from understory of five paired thinned and unthinned stands in the Central Oregon Coast Range, 1998. Significant results from two analysis shown below: Indicator taxa anlaysis with all five plants, to show fern indicators, and without ferns to show vine maple, salal and hemlock indicators. Indicator values given are % of perfect indication, based on comination of relative abundance and relative frequency. **Bold indicates p-values < 0.05.** For complete taxa list, see Appendix A.

	Analysis without ferns				Analysis with ferns		
Spider taxa	**acci**	**gash**	**tshe**	**p-value**	**ptaq**	**pomu**	**p-value**
Araneidae							
Araneilla displicata	35	1	22	0.232	7	0	0.255
Misc Araneids	-	-	-	-	5	20	0.609
Ceraticilus atriceps	-	-	-	-	0	33	0.185
Cyclosa conica	9	5	19	0.635	5	**46**	**0.030**
Nuctenea patagiata	5	**81**	2	0.09	20	21	0.674
Clubionidae							
Agroeca spp	-	-	-	-	0	33	0.185
Clubiona canadensis	21	19	21	0.996	**34**	12	**0.030**
Dictynidae							
Dictyna spp	7	2	36	0.132	0	9	0.090
Hyptiotes gertschi	1	5	38	0.093	10	0	0.395
Linyphiidae							
Micryphantinae	8	**73**	17	**0.012**	24	24	0.371
Neriene spp	30	19	**49**	**0.001**	12	**32**	0.140
Pityohyphantes brachygynus	2	1	**58**	**0.014**	0	0	**0.011**
Pityohyphantes rubrofasciata	-	-	-	0.772	6	5	0.751
Pityohyphantes spp	6	10	**68**	**0.001**	4	4	**0.003**
Prolinyphia spp	35	16	3	0.213	5	**40**	**0.030**
Philodromidae							
Philodromus spectabilis	-	-	-	0.722	0	**38**	**0.045**
Salticidae							
Misc Salticids	15	30	20	0.675	4	**35**	**0.015**
Metaphidippus watonus	-	-	-	-	0	33	0.212
Theridiidae							
Misc Therids	16	32	7	0.434	0	7	0.447
Theridion californicum	7	**60**	0	**0.007**	19	5	0.177
Theridion differens	0	**54**	12	**0.020**	0	0	**0.020**
Theridion lawrencei	25	0	57	0.103	0	11	0.326
Theridion murarium	0	25	0	0.320	0	0	0.204
Theridion sexpunctatum	6	**84**	2	**0.001**	5	17	**0.011**
Theridion spp	27	**69**	2	**0.002**	23	12	**0.020**

Hemlock Arthropod Community: Treatment and Understory Condition Comparisons

Arthropod diversity on hemlock was greater in thinned stands than unthinned stands ($F_{1,2}$=21.30, p-value=0.0439). Arthropod intensity and spider intensity and diversity did not differ between thinned and unthinned stands (Table 12). ANOVA results suggest that parasitoids on hemlock were found in slightly greater intensity in unthinned stands than thinned stands ($F_{1,2}$= 13.73, p=0.0657), but these results are misleading. Parasitoids were found in greater intensities on hemlock in only one of three paired sites. Consistently more Nocturnal hunting spiders were found on hemlock in thinned stands ($F_{1,2}$= 73.83, p=0.0133) than on hemlock in unthinned stands (Figure 17). Sap-sucker intensity on hemlock was slightly greater in thinned stands ($F_{1,2}$= 8.99, p=0.0956) (Figure 18).

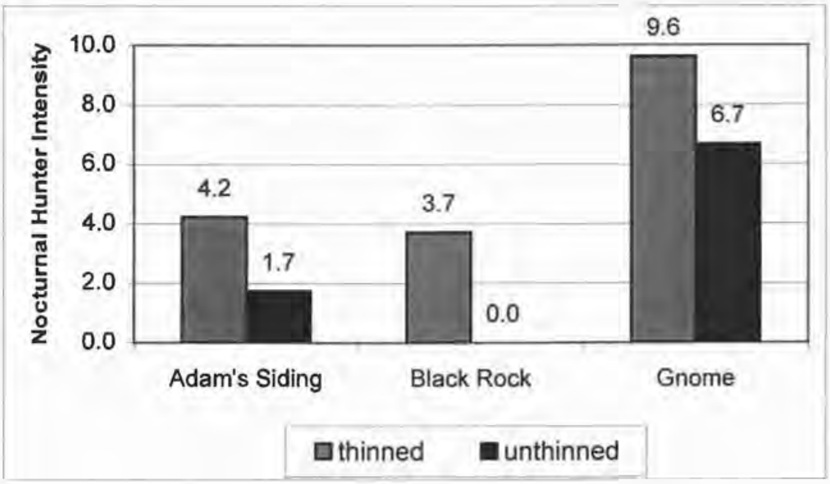


Figure 17. Comparison of **Nocturnal Hunter Intensity** (#/kg dried plant wt) found on hemlock in thinned vs. unthinned stands. Arthropods sampled in paired thinned and unthinned Douglas-fir understories in the Central Oregon Coast Range during the summer, 1998.

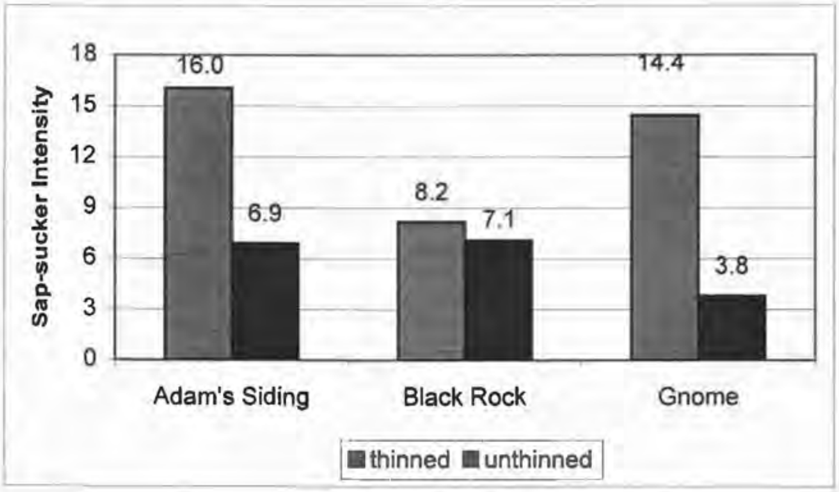


Figure 18. Comparison of **Sap-sucker Intensity** (#/kg dried plant wt) found on hemlock on thinned vs. unthinned stands. Arthropods sampled in paired thinned and unthinned Douglas-fir understories in the Central Oregon Coast Range during the summer, 1998.

Table 12. ANOVA results for treatment effects on arthropod and spider groups sampled from vine maple, salal and hemlock in five paired thinned and unthinned stands in the Central Oregon Coast Range.

	Vine Maple		**Salal**		**Hemlock**	
Response	$F_{1,2}$	p-value	$F_{1,2}$	p-value	$F_{1,2}$	p-value
Arthropod Intensity	1.79	0.3128	1.31	0.3702	0.01	0.9442
Arthropod Diversity	2.00	0.2931	0.95	0.4328	**21.31**	**0.0439**
Spider Intensity	1.42	0.3559	5.05	0.1536	2.44	0.2590
Spider Diversity	0.54	0.5397	1.17	0.392	2.55	0.2514
Agile Hunters	4.48	0.1685	**249.33**	**0.0040**	0.00	0.9635
Cobweb weavers	**15.28**	**0.0596***	**8.12**	**0.1042***	0.67	0.4982
Nocturnal Hunters	3.72	0.1935	0.75	0.4781	**73.83**	**0.0133**
Orbweb weavers	**7.07**	**0.1171***	**5.47**	**0.1443***	3.60	0.1980
Surface hunter	1.85	0.3069*	0.46	0.5677	0.18	0.7145
Sheetweb weaver	0.11	0.7693	2.9	0.2307	0.14	0.7428
Unknown	0.04	0.8613	3.69	0.1948	0.51	0.5496
Detritivores	**6.69**	**0.1225***	0.00	0.9689*	0.00	0.9887
Total Herbivores	**24.06**	**0.0391***	0.36	0.6079*	**4.02**	**0.1827***
Sapsuckers	**55.84**	**0.0174***	0.45	0.5697*	**8.99**	**0.0956***
Folivores	1.73	0.3186*	3.82	0.1900*	0.16	0.7282*
Predators	1.65	0.3278*	**7.29**	**0.1141***	0.05	0.8382*
Parasitoids	**12.42**	**0.0719***	0.51	0.5487*	**13.73**	**0.0657**
Omnivores	0.12	0.7645*	**16.51**	**0.0556***	1.22	0.3848
Tourists	**8.23**	**0.1030***	**11.59**	**0.0765***	1.60	0.3332

*** denotes natural log transformation used on response variable in analysis**

Arthropod diversity on hemlock showed a response to both shrub cover and light levels ($F_{1,2}$= 28.16, p= 0.033; $F_{1,2}$=39.66, p=0.024, respectively)(Figure 19).

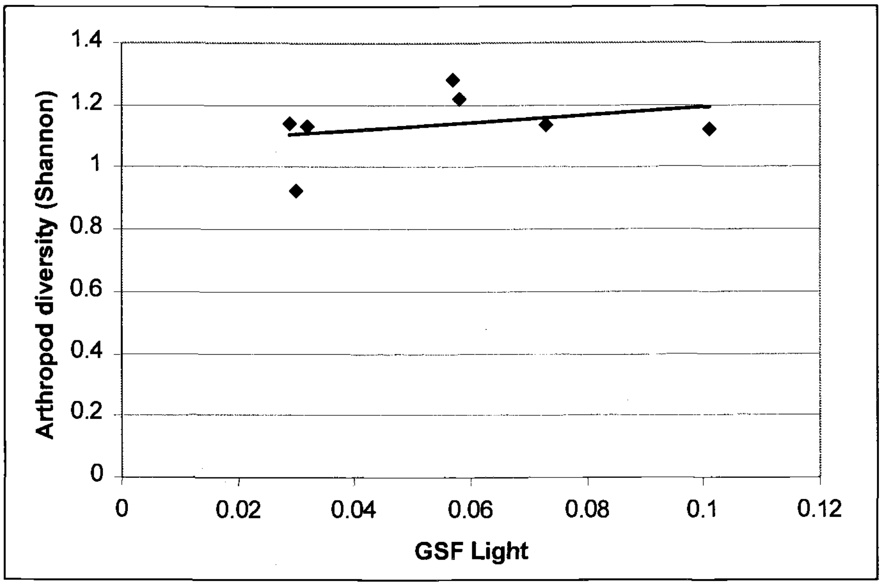


Figure 19. **Arthropod Diversity** on Hemlock with Stand **Light** Levels. Samples taken from understory hemlock in paired thinned and unthinned stands in the Central Oregon Coast Range, 1998.

Arthropod intensity, spider intensity and diversity on hemlock showed no response to shrub cover ($F_{1,2}$= 0.15, p= 0.738; $F_{1,2}$= 0.82, p=0.460, $F_{1,2}$= 3.73, p=0.193, respectively, Table 13). Arthropod intensity and diversity, and spider intensity and diversity on hemlock showed no response to shrub diversity ($F_{1,2}$= 0.04, p= 0.866; $F_{1,2}$= 3.62, p= 0.197; $F_{1,2}$= 0.35, p= 0.616; $F_{1,2}$= 0.10, p= 0.783, respectively). Arthropod intensity, spider intensity and spider diversity found on hemlock showed no response to stand light levels ($F_{1,2}$= 0.11, p= 0.773; $F_{1,2}$= 0.60, p= 0.520; $F_{1,2}$= 2.20, p=0.276, respectively). Total herbivores show a postitive relationship with amount of hemlock cover present in the stand ($F_{1,2}$= 15.65, p=0.058) (Figure 20).

Sap-sucker intensity on was positively correlated to light and, slightly more so, with shrub cover ($F_{1,2}$=16.64, p=0.055; $F_{1,2}$=31.92, p=0.029). Orbweb weaver intensity was negatively correlated with stand light level and shrub cover ($F_{1,2}$=6.52, p=0.125; $F_{1,2}$=8.53, p=0.100)(Figure 21).

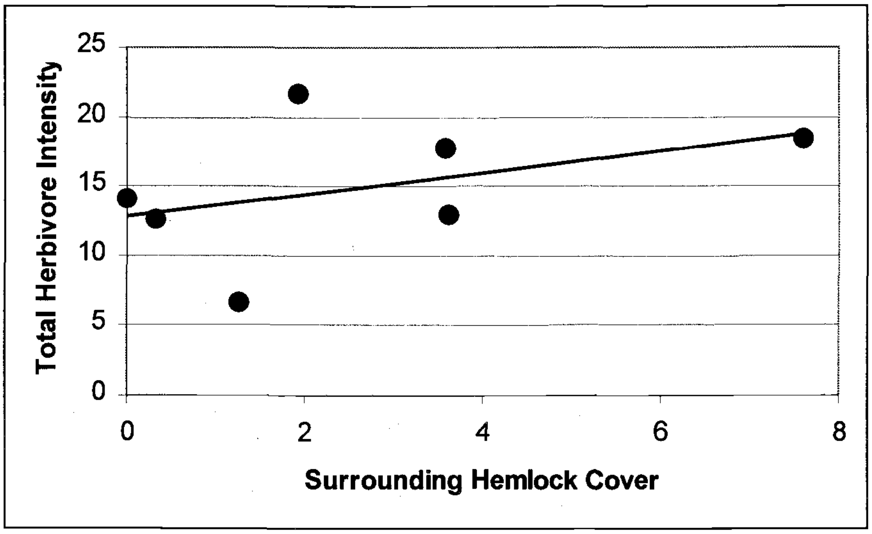


Figure 20. Positive correlation of **Total Herbivore Intensity** with amount of surrounding hemlock cover. Samples taken from understory hemlock in paired thinned and unthinned stands in the Central Oregon Coast Range during 1998.

Table 13. Linear Regression Results for tests of Light levels, Shrub cover, Shrub diversity and Hemlock patch size on Arthropod Community groups found on Hemlock in the Understory of ten thinned and unthinned Douglas-fir stands in Coast Range. Regression Coefficients, standard error for coefficient, F statistic, and p- value. **Bold and Enlarged indicates p-value < 0.05;** **Bold indicates p-value < 0.15.**

Hemlock	Light Index				Shrub Cover				Shrub Diversity				Patch Size			
Response	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value
Arthropod Intensity	285.54	868.82	0.11	0.773	0.187	0.489	0.15	0.738	-20.05	105.21	0.04	0.866	6.66	10.32	0.42	0.584
Arthropod Diversity	**3.10**	**0.49**	**39.7**	**0.024**	**0.001**	**0.000**	**28.2**	**0.033**	**0.304**	**0.159**	3.62	0.197	0.03	3.36	3.36	0.208
Spider Intensity	-152.96	197.84	0.60	0.520	-0.097	0.107	0.82	0.460	-14.57	24.78	0.35	0.616	-0.32	2.85	0.01	0.920
Spider Diversity	2.58	1.73	2.20	0.276	0.001	0.000	3.73	0.193	0.092	0.292	0.10	0.783	0.028	0.024	1.36	0.363
Agile Hunters	18.17	32.53	0.31	0.632	0.005	0.019	0.07	0.821	4.02	3.03	1.76	0.316	0.45	0.30	2.21	0.275
Cobweb weavers	213.29	114.97	3.44	0.204	0.116	0.069	2.76	0.238	17.55	18.85	0.87	0.45	**3.11**	**0.98**	**9.88**	**0.088**
Nocturnal Hunters	**58.33**	**22.70**	**6.6**	**0.124**	**0.034**	**0.011**	**8.98**	**0.095**	5.37	4.12	1.7	0.322	0.49	0.48	1.03	0.416
Orbweb weavers	**-452.31**	**177.20**	**6.52**	**0.125**	**-0.264**	**0.090**	**8.53**	**0.100**	-30.41	37.83	0.65	0.505	-5.50	2.54	4.69	0.162
Surface Hunters	0.10	26.55	0.00	0.997	0.001	0.015	0.00	0.952	-1.47	2.98	0.25	0.669	0.10	0.32	0.10	0.785
Sheetweb weaver	9.99	174.51	0.00	0.959	0.012	0.098	0.02	0.909	-9.19	19.74	0.22	0.687	0.74	2.15	0.12	0.762
Unknown	-0.55	41.54	0.00	0.990	-0.002	0.023	0.01	0.930	-0.43	4.93	0.01	0.937	0.27	0.49	0.31	0.632
Ln Total Herbivores	**11.88**	**4.19**	**8.04**	**0.105**	**0.006**	**0.002**	**6.09**	**0.132**	1.01	0.85	1.41	0.357	**0.159**	**0.04**	**15.7**	**0.058**
Ln Sapsuckers	**18.54**	**4.54**	**16.6**	**0.055**	**0.010**	**0.001**	**31.9**	**0.029**	1.37	1.33	1.07	0.410	0.210	0.095	4.85	0.158
Ln Folivores	3.86	11.50	0.11	0.769	0.000	0.006	0.00	0.979	1.38	1.01	1.88	0.304	0.119	0.124	0.91	0.439
Ln Predators	-0.67	3.33	0.04	0.859	0.000	0.000	0.04	0.868	-0.19	0.37	0.27	0.653	0.009	0.042	0.05	0.846
Parasitoids	-44.15	35.80	1.52	0.342	-0.028	0.017	2.61	0.247	-2.93	5.25	0.31	0.633	-0.216	0.584	0.14	0.746
Tourist	77.30	63.86	1.47	0.349	0.039	0.038	1.07	0.408	11.34	5.98	3.59	0.198	0.665	0.960	0.48	0.559
Detritivores	138.62	681.05	0.04	0.857	0.122	0.381	0.10	0.779	-34.41	78.19	0.19	0.702	3.248	8.445	0.15	0.737
Ln Other Herbivores	-6.14	13.03	0.22	0.684	-0.003	0.007	0.17	0.718	-1.23	1.38	0.8	0.466	-0.012	0.174	0.01	0.947

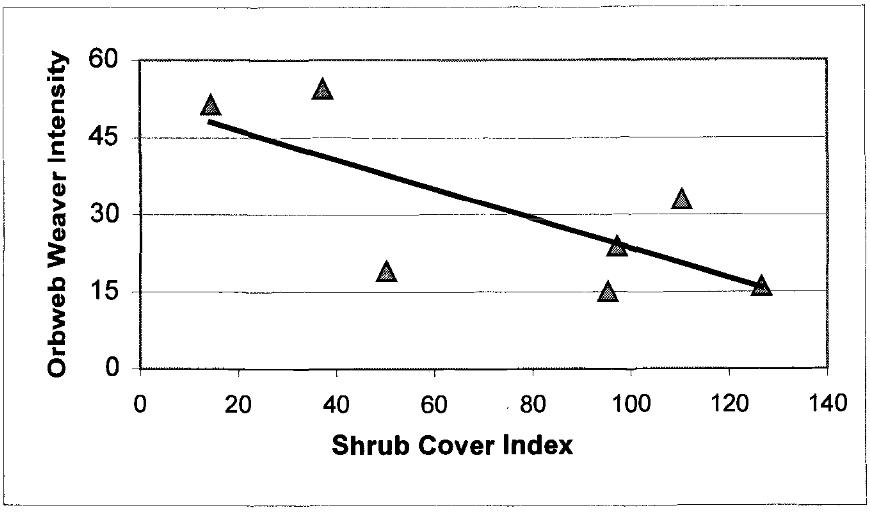


Figure 21. Relationship of **Orbweb Weavers** on Hemlock with **shrub cover**. Samples taken from understory hemlock in paired thinned and unthinned stands in the Central Oregon Coast Range during 1998.

Salal Arthropod Community: Treatment and Understory Condition Comparisons

Spider intensity and diversity, and arthropod intensity and diversity did not differ between thinned and unthinned stands on salal (Table 10). I found more phorids (Omnivores) on salal in unthinned stands ($F_{1,2}$= 16.51, p=0.055). There were more Agile hunters on Salal in unthinned stands than in thinned stands ($F_{1,2}$= 249.33, p=0.004)(Figure 22).

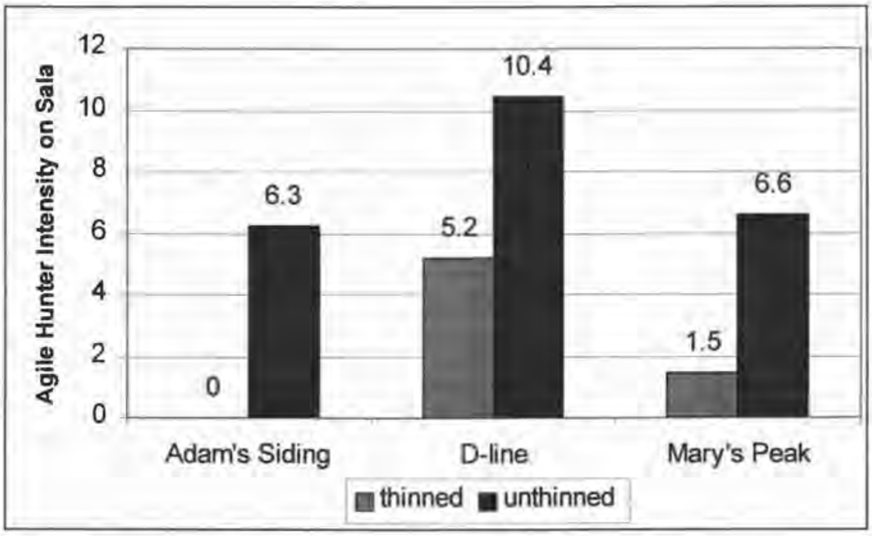


Figure 22. Comparison of **Agile Hunter** Intensity (#/kg dried plant wt) found on **salal** in thinned vs. unthinned stands. Arthropods sampled from salal in paired thinned and unthinned Douglas-fir understories in the Central Oregon Coast Range during the summer, 1998.

Arthropod intensity on salal was negatively correlated with surrounding shrub diversity ($F_{1,2}$= 16.65, p= 0.055)(Figure 23). Spider intensity and orbweb weaver intensity had a negative correlation with stand light levels ($F_{1,2}$= 9.95, p= 0.087; $F_{1,2}$=21.75, p=0.043)(Figure 24). Agile hunters showed a negative correlation with shrub cover ($F_{1,2}$= 24.34, p=0.03) (Figure 25). Anova results suggest that predators and tourists on salal responded negatively to increasing stand light levels ($F_{1,2}$= 16.24, p= 0.056; $F_{1,2}$=14.04, p= 0.064, Table 12). However, these results were misleading, due to one pooled sample outlier (Figure 26).

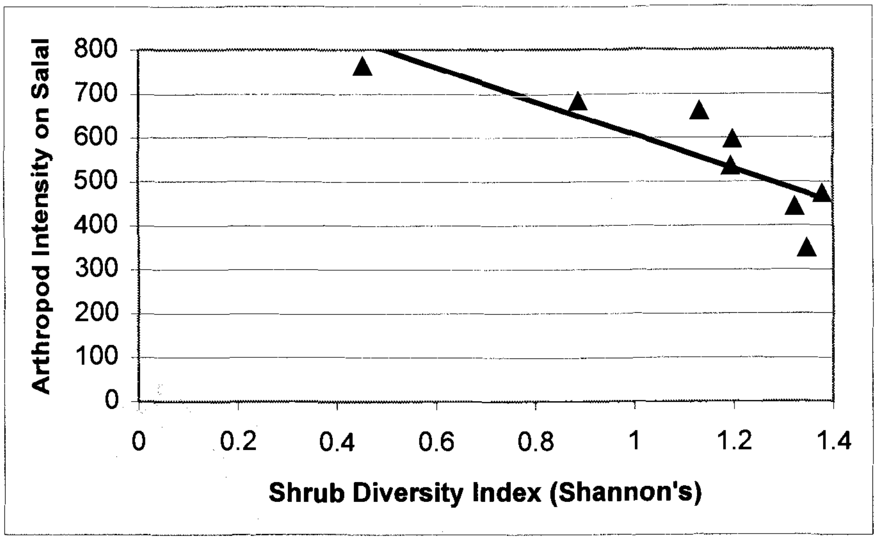


Figure 23. Relationship of arthropod intensity and stand level shrub diversity. Spiders sampled from salal in paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range during 1998.

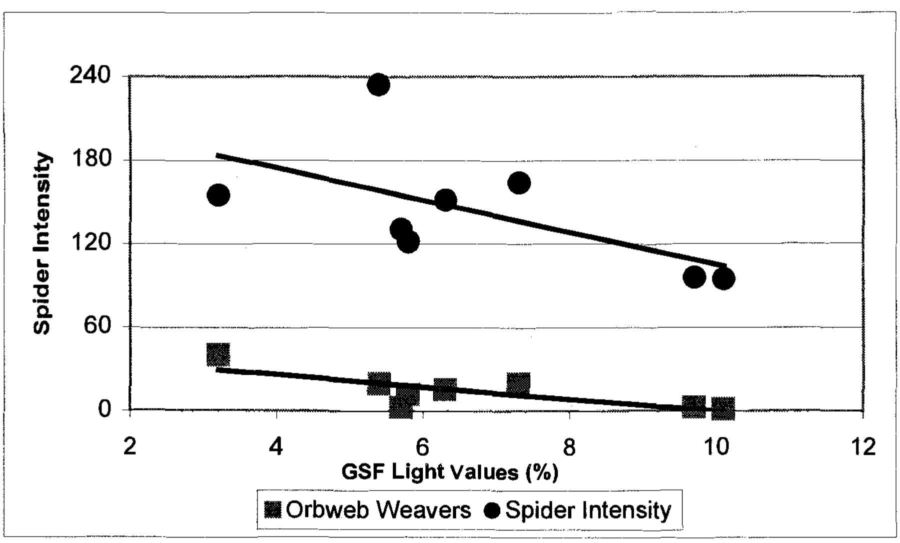


Figure 24. Relationship of Spider Intensity and Orbweb Intensity on Salal with Light levels. Spiders sampled from salal in paired thinned and unthinned stands in the Central Oregon Coast Range.

Table 14. Linear Regression Results for tests of Light levels, Shrub cover, Shrub diversity and Salal patch size on Arthropod Community groups found on Salal in the Understory of ten thinned and unthinned Douglas-fir stands in Coast Range. Regression Coefficients, standard error for coefficient, F statistic, and p- value. **Bold and Enlarged indicates p-value < 0.05;** **Bold indicates p-value < 0.15.**

Salal	Light Index				Shrub cover				Shrub diversity				Patch size			
Response	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value
Arthropod Intensity	-1383.4	1822.8	0.58	0.527	-0.54	0.805	0.44	0.574	**-184.26**	**45.15**	**16.7**	**0.055**	**-0.66**	**1.66**	0.16	0.729
Arthropod Diversity	-0.44	2.37	0.04	0.868	0.000	0.001	0.13	0.755	0.137	0.126	1.18	0.391	-0	0.001	0.30	0.640
Spider Intensity	**-2543.4**	**806.17**	**9.95**	**0.087**	-0.97	0.503	3.67	0.195	-142.04	84.68	2.81	0.235	-1.93	0.915	4.45	0.169
Spider Diversity	0.194	1.095	0.03	0.875	-0.000	0.000	0.02	0.911	0.043	0.066	0.42	0.582	-0.000	0.000	0.00	0.978
Agile Hunters	**-166.16**	**62.37**	**7.10**	**0.116**	**-0.08**	**0.015**	**24.34**	**0.038**	-6.71	7.49	0.80	0.464	**-0.14**	**0.047**	**8.97**	**0.095**
Ln Cobweb weavers	-6.837	7.05	0.94	0.435	-0	0.003	0.33	0.621	-0.57	0.40	2.03	0.289	-0	0.006	0.42	0.581
Nocturnal Hunters	11.56	159.77	0.01	0.948	-0.01	0.068	0.03	0.878	9.90	8.04	1.52	0.343	-0.03	0.131	0.06	0.829
Ln Orbweb weavers	**-42.61**	**9.13**	**21.75**	**0.043**	**-0.02**	**0.006**	**8.13**	**0.104**	-1.70	1.71	0.99	0.424	**-0.04**	**0.008**	**18.20**	**0.050**
Surface hunter	41.10	114.89	0.13	0.754	0.004	0.050	0.01	0.940	1.19	7.85	0.02	0.892	0.03	0.096	0.10	0.781
Sheetweb weaver	-1687.89	825.11	4.13	0.177	-0.16	0.449	1.86	0.305	**-120.97**	**45.14**	**7.18**	**0.115**	-1.17	0.882	1.76	0.315
Unknown	133.33	137.71	0.68	0.497	0.058	0.054	1.13	0.399	9.85	8.01	1.51	0.344	0.079	0.120	0.44	0.577
Ln Total Herbivores	9.66	21.73	0.20	0.700	0.006	0.008	0.62	0.514	-0.540	1.499	0.14	0.748	0.012	0.016	0.57	0.530
Ln Sapsuckers	15.41	30.37	0.26	0.662	0.010	0.011	0.72	0.484	-0.771	2.080	0.14	0.746	0.019	0.023	0.71	0.486
Ln Folivores	-19.97	18.63	1.15	0.396	-0.100	0.006	2.54	0.252	-0.030	1.558	0.00	0.986	-0.020	0.013	2.45	0.258
Ln Predators	**-14.95**	**3.71**	**16.24**	**0.056**	**-0.01**	**0.002**	**5.55**	**0.142**	-0.880	0.412	4.56	0.166	**-0.01**	**0.004**	**5.29**	**0.148**
Ln Parasitoids	2.36	0.924	0.01	0.924	-0	0.009	0.02	0.911	-0.302	1.466	0.04	0.855	0.002	0.018	0.02	0.904
Ln Omnivores	-24.83	12.31	4.06	0.181	-0.010	0.005	4.17	0.177	**-1.840**	**0.592**	**9.65**	**0.089**	-0.02	0.012	1.93	0.299
Ln Tourists	**-23.26**	**6.20**	**14**	**0.064**	**-0.010**	**0.001**	**38.30**	**0.025**	-0.719	1.055	0.46	0.566	**-0.020**	**0.002**	**78.7**	**0.012**
Ln Detritivores	9.59	4.84	3.93	0.186	0.003	0.002	1.79	0.312	0.417	0.470	0.79	0.468	0.007	0.004	3.08	0.221
Ln Other Herbivores	22.58	30.24	0.56	0.533	0.008	0.013	0.39	0.595	**3.070**	**0.694**	**19.58**	**0.047**	**0.010**	**0.027**	0.14	0.742

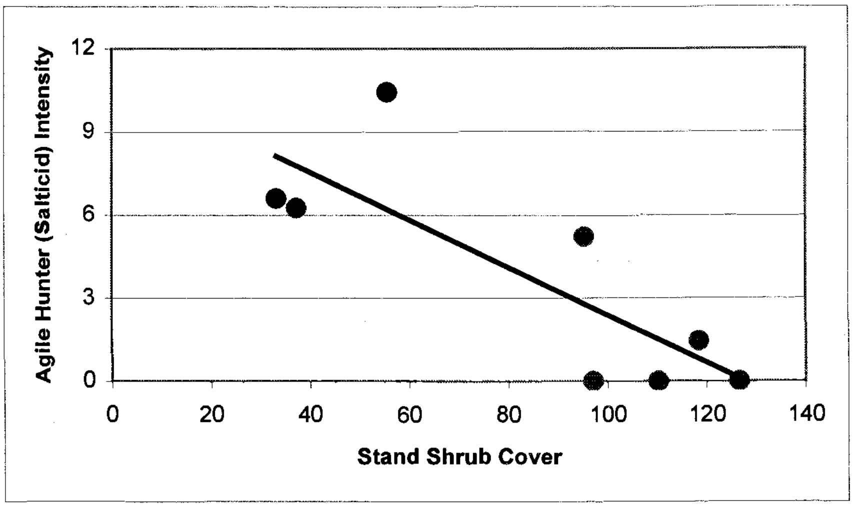


Figure 25. Relationship of Agile Hunters (Salticids) on Salal with stand Shrub Cover. Samples from paired thinned and unthinned stands in the Central Oregon Coast Range, 1998.

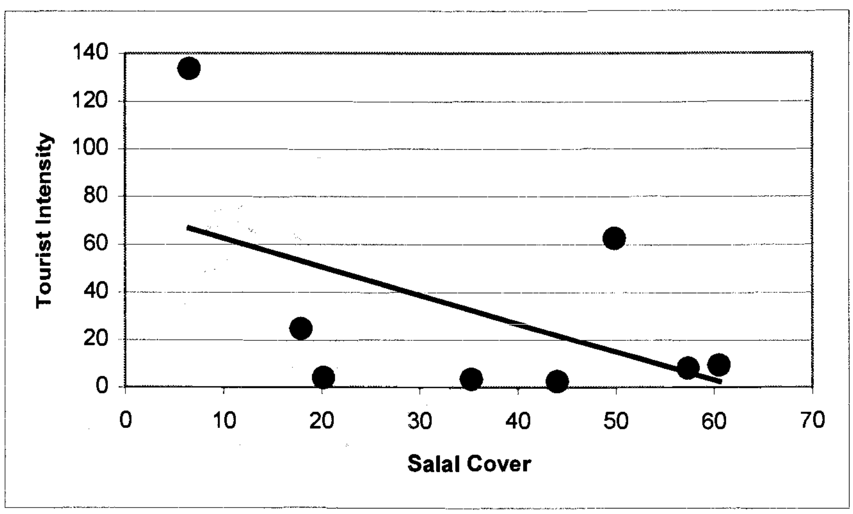


Figure 26. Relationship of Tourist Intensity (#s per kg dried salal) on Salal with amount of surrounding salal cover. Samples from thinned and unthinned stands in the Central Oregon Coast Range, 1998.

Vine Maple Arthropod Community: Treatment and Understory Condition Comparisons

Arthropod intensity and diversity and spider intensity and diversity on vine maple was not different between thinned and unthinned stands (Table 10). I found more total herbivores on vine maple in unthinned stands ($F_{1,2}$= 24.06, p=0.03). This is mostly due to the greater abundance of sapsuckers that were found on vine maple in unthinned stands ($F_{1,2}$= 55.84, p=0.01)(Figure 27). Parasitoids, however, were found in greater abundance on vine maple in thinned stands ($F_{1,2}$= 12.42, p=0.07)(Figure 29).

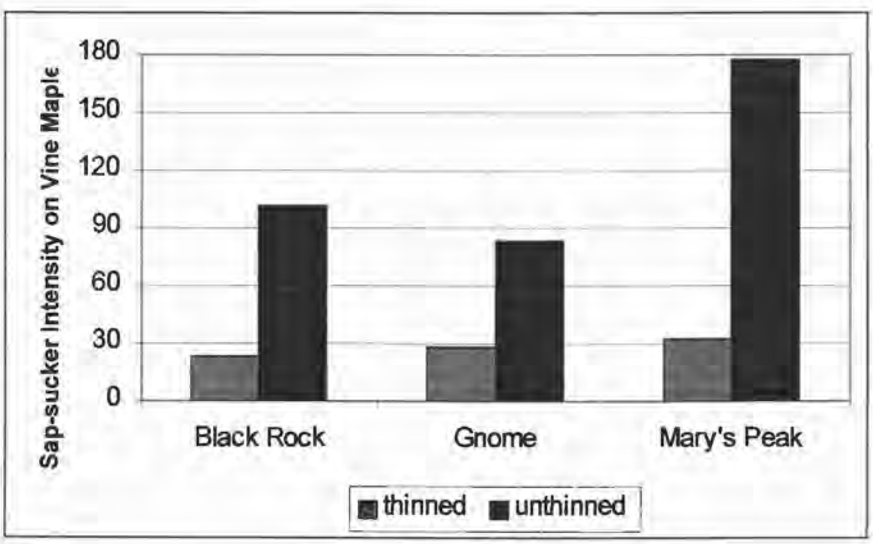


Figure 27. Comparison of **Sap-sucker** Intensity (#/kg dried plant wt) found on **vine maple** in thinned vs. unthinned stands. Arthropods sampled in paired thinned and unthinned Douglas-fir understories in the Central Oregon Coast Range during the summer, 1998.

Table 15. Linear Regression Results for tests of Light levels, Shrub cover, Shrub diversity and vine maple patch size on Arthropod Community groups found on vine Maple in the Understory of ten thinned and unthinned Douglas-fir stands in the Coast Range. Regression Coefficients, standard error for coefficient, F statistic, and p- value. **Bold and Enlarged indicates p-value < 0.05; Bold indicates p-value < 0.15.**

Vine Maple	Light Index				Shrub cover				Shrub				Patch size			
Response	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value	Reg. Coeff.	Coeff. Std Err	$F_{1,2}$	p-value
Arthropod Intensity	1257.2	566.9	4.92	0.156	0.739	0.337	4.81	0.159	105.8	63.5	2.78	0.237	0.630	3.644	0.03	0.878
Arthropod Diversity	**2.92**	**1.15**	**6.39**	**0.127**	0.001	0.000	4.96	0.155	0.244	0.137	3.16	0.217	0.007	0.006	1.52	0.342
Spider Intensity	**498.53**	**196.1**	**6.46**	**0.126**	**0.294**	**0.115**	**6.45**	**0.126**	42.7	22.32	3.66	0.195	0.372	1.379	0.07	0.812
Spider Diversity	0.897	0.921	0.95	0.432	0.000	0.061	0.61	0.517	0.041	0.099	0.17	0.719	0.000	0.003	0.02	0.911
Agile Hunters	-12.41	11.79	1.11	0.402	-0.01	0.006	1.43	0.354	-1.49	0.87	2.94	0.228	**-0.07**	**0.003**	**414.71**	**0.002**
Ln Cobweb Weavers	**34.47**	**12.42**	**7.69**	**0.109**	**0.019**	**0.008**	**6.12**	**0.131**	2.72	1.67	2.65	0.245	0.018	0.094	0.04	0.865
Nocturnal Hunters	167.84	122.29	1.88	0.303	0.108	0.064	2.80	0.236	**19.63**	**7.67**	**6.55**	**0.124**	0.571	0.434	1.73	0.318
Ln Orbweb Weavers	**-11.75**	**4.05**	**8.41**	**0.101**	**-0.01**	**0.002**	**8.10**	**0.104**	**-1.08**	**0.395**	**7.48**	**0.111**	-0.04	0.019	3.71	0.193
Ln Surface hunter	-1.16	8.58	0.02	0.904	-0	0.005	0.06	0.833	-0.417	0.746	0.31	0.632	**-0.04**	**0.015**	**5.77**	**0.138**
Sheetweb weaver	15.86	29.28	0.29	0.642	0.006	0.017	0.15	0.735	0.266	2.912	0.01	0.935	-0.02	0.108	0.04	0.863
Unknown (mostly imm.)	24.12	81.32	0.09	0.794	0.007	0.048	0.02	0.892	-1.16	7.69	0.02	0.893	-0.13	0.273	0.24	0.673
Ln Total Herbivores	**-20.67**	**8.53**	**5.88**	**0.136**	**-0.01**	**0.004**	**8.80**	**0.097**	**-2.16**	**0.36**	**35.30**	**0.027**	**-0.07**	**0.029**	**6.07**	**0.132**
Ln Sapsuckers	**-24.69**	**9.81**	**6.33**	**0.128**	**-0.01**	**0.005**	**8.77**	**0.097**	**-2.53**	**0.51**	**24.2**	**0.038**	**-0.09**	**0.031**	**7.59**	**0.110**
Ln Folivores	10.78	7.83	1.9	0.302	0.006	0.004	1.66	0.326	0.93	0.77	1.45	0.351	0.04	0.025	2.61	0.247
Ln Predators	**7.99**	**3.34**	**5.71**	**0.139**	**0.004**	**0.001**	**6.15**	**0.131**	0.70	0.35	3.99	0.183	0.006	0.022	0.10	0.787
Ln Parasitoids	14.54	9.55	2.32	0.267	0.008	0.005	2.44	0.258	1.44	0.81	3.20	0.215	**0.063**	**0.018**	**11.45**	**0.077**
Ln Omnivores	4.04	11.41	0.13	0.757	0.001	0.006	0.04	0.854	-0.12	1.09	0.01	0.922	-0.02	0.037	0.38	0.601
Ln Tourists	**22.77**	**1.80**	**159.5**	**0.006**	**0.013**	**0.001**	50.9	**0.019**	**1.94**	**0.62**	**9.73**	**0.089**	0.011	0.015	0.57	0.530
Ln Detritivores	**7.03**	**0.73**	**91.61**	**0.010**	**0.004**	**0.000**	49.7	**0.019**	**0.60**	**0.18**	**10.2**	**0.085**	-0.03	0.023	0.49	0.555

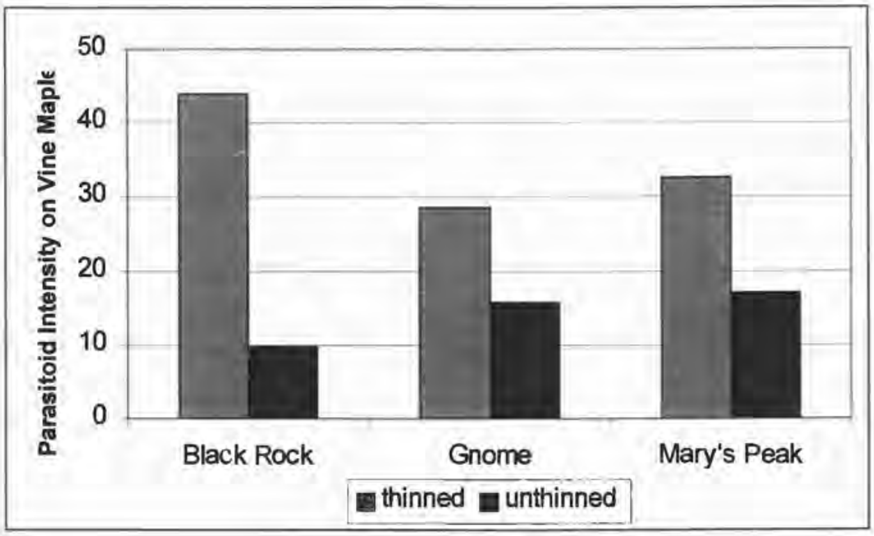


Figure 28. Comparison of **Parasitoid** Intensity (#/kg dried plant wt) found on **vine maple** in thinned vs. unthinned stands. Arthropods sampled in paired thinned and unthinned Douglas-fir understories in the Central Oregon Coast Range during the summer, 1998.

Increase in stand light levels on vine maple had a slight, but not significant positive affect on arthropod intensity, diversity and spider intensity ($F_{1,2}$= 4.92, p=0.15; $F_{1,2}$= 6.39, p=0.12; $F_{1,2}$= 6.46, p=0.12). Spider diversity on vine maple did not show a response to amount of shrub cover or light. Spider intensity on vine maple showed evidence of increase with increase in understory shrub diversity. Arthopod intensity, diversity and spider diversity on vine maple did not show a response to stand level understory diversity. Stand shrub cover seemed to have a slight, but not significant positive affect on arthropod intensity, diversity and spider intensity on ($F_{1,2}$= 4.81, p=0.15; $F_{1,2}$= 4.96, p=0.15, $F_{1,2}$= 6.45, p=0.12). There was no evidence of shrub cover affecting spider diversity on vine maple. Cobweb weaver was positively correlated with stand light; while orbweb weaver intensities showed evidence of a negative correlation with stand light levels (Regression Coeff. = 34.47, $F_{1,2}$= 7.69, p=0.109; Regression Coeff. = -11.75, $F_{1,2}$= 8.41, p=0.101; Figure 29). Orbweb weavers also showed a slightly greater negative correlation to shrub cover ($F_{1,2}$= 8.10 , p=0.104).

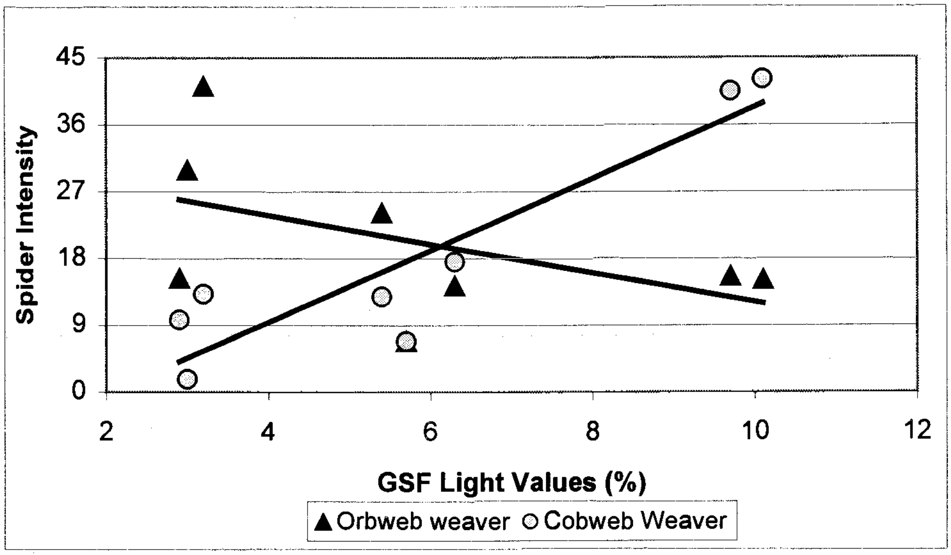


Figure 29. **Orbweb and Cobweb weavers** on vine maple with Stand **Light** Levels. Spiders sampled from vine maple in paired thinned and unthinned stands in the Central Oregon Coast Range.

MRPP

Multi-response permutation procedures results suggests that arthropods form statistically different groups when grouped by plant type (p-value=0.00, A=0.12, T = –8.06). All arthropods also form statistically different groups when separated by site (p-value=0.00, A=0.09, T = –6.09). Similar results were found when using data matrix of functional groups by plant (p-value= 0.00, a=0.12, T = –5.065) and by site (p-value=0.00, A=0.12, T =–2.38). When using a matrix of spider guilds, grouping by site and plant was significant (p-value= 0.00, A= 0.09, T =-3.20; p-value= 0.01, A= 0.07, T =-2.38, respectively). To evaluate effects of treatment, arthropods were also analyzed in data subsets by plant type. The only evidence of grouping by treatment was found with spider guilds on salal and with spider taxa on vine maple (p-value=0.06, a=0.112, T-stat= -1.64; p= 0.060, A= 0.050, T-stat= -1.67).

Table 16. MRPP results for tests of grouping by **plant species, site and treatment**. Used data pooled from all five plants sampled.

Data Set Used	GroupingVar	p-value	A-value*	T-stat
Arthropods (>5%)	Plant Spp	-0.00000	0.08969	-6.49073
Spiders Only	Plant Spp	0.00012	0.07609	-4.39600
Functional Groups	Plant Spp	0.00004	0.12191	-5.06500
Spider Guilds	Plant Spp	0.01820	0.07352	-2.38400
Arthropods	Site	0.00000	0.07854	-5.91038
Spiders Only	Site	0.00238	0.05414	-3.25000
Functional Groups	Site	0.00004	0.12191	-5.21100
Spider Guilds	Site	0.00417	0.09501	-3.20000
Arthropods	Treatment	-0.02077	0.01559	-2.49073
Spiders Only	Treatment	0.00131	0.03235	-4.12000

Table 17. MRPP results for tests for grouping by **Treatment** on each plant species.

Data Set Used	Plant Spp	p-value	A-value*	T-stat
All Arthropods	ACCI	0.153667	0.018517	-1.02
	GASH	0.166985	0.019888	-0.95
	TSHE	0.931454	-0.04286	1.40
Spiders Only	**ACCI**	**0.060800**	**0.05037**	**-1.67**
	GASH	0.454200	-0.00018	0.58
	TSHE	0.878390	-0.03000	1.17
Functional groups	ACCI	0.115141	0.052562	-0.14
	GASH	0.422927	0.005677	-1.22
	TSHE	0.903907	-0.05677	1.02
Spider Guilds	ACCI	0.294618	0.01941	-0.45
	GASH	**0.065994**	**0.11202**	**-1.64**
	TSHE	0.659548	-0.02738	0.45

NMS

Ordinations of arthropod communities (with >5% occurrence) from all five plants, showed evidence of segregation of arthropods by treatment. The three dimensional ordination represented 77% of the variation in the arthropod community, with 12% on Axis 1, 24% on Axis 2 and 41% on Axis 3. Axis one appeared to be important for the grouping of arthropod communities by **treatment** (Figure 30).

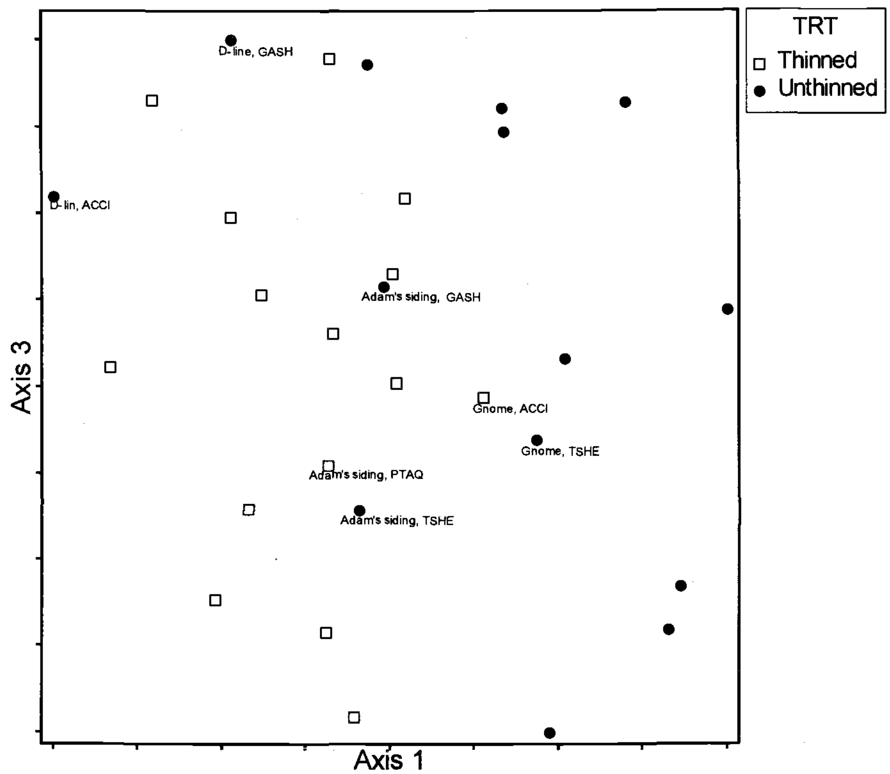


Figure 30. NMS Ordination graph of arthropod communities from paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range with treatment condition overlay. Vectors indicate the direction and amount of correlation between axis scores and stand conditions.

Tree density had the greatest correlation with Axis 1 (r = 0.708, p=0.0001; Figure 26, Table 18). Shrub cover also was correlated with Axis 1 (r = -0.530, p= 0.0031). Three athropod taxa were positively correlated with Axis 1; one taxon was negatively correlated with Axis 1 (Table 18). Stand age was correlated with Axis 3 (r = -0.644, p = 0.0002). Eight arthropod taxa were positively correlated with Axis 3; one taxon was negatively correlated with Axis 1 (Table 18).

Table 18. Pearson correlation coefficients, p-values and associated stand condition associated with arthropods significantly correlated with Axis one and three. Values from ordination of arthropods with >5% occurrence in samples of all five plants. Samples taken from paired thinned and unthinned Douglas-fir stands, Central Oregon Coast Range.

TAXON	AXIS	R	P-VALUE	Correlated Stand Conditions
Elateridae	1	0.528	0.0032	Shrub Cover (-), Trees per Hectare
Pteromalidae	1	0.576	0.0010	Shrub Cover (-), Trees per Hectare
Uloboridae	1	-0.616	0.0004	Shrub Cover (-), Trees per Hectare
Anyphaenidae	3	0.584	0.0009	Stand age, Shrub Diversity
Cantharidae	3	0.623	0.0003	Stand age, Shrub Diversity
Geometridae	3	-0.750	0.0001	Stand age, Shrub Diversity
Linyphiidae	3	0.550	0.0020	Stand age, Shrub Diversity
Polyxenidae	3	0.823	0.0001	Stand age, Shrub Diversity
Salticidae	3	0.751	0.0010	Stand age, Shrub Diversity
Sciaridae	3	0.837	0.0001	Stand age, Shrub Diversity
Sminthuridae	3	0.675	0.0001	Stand age, Shrub Diversity
Theridiidae	3	0.543	0.0023	Stand age, Shrub Diversity

When ferns were excluded from analysis, arthropod communities were still separated by plant and treatment. Viewing data without ferns was important because each fern was only sampled in one treatment group, and both ferns had many taxa in high abundance, which often clouded community differences on vine maple, hemlock and salal. The three dimensional ordination represented 79% of variation in the community matrix, with 5% on Axis 1, 45% on Axis 2, and 28% on Axis 3. Axis 2 and 3 was the best representation of arthropod samples from vine maple, hemlock and salal, showing separation by plant species and treatment. Arthropod communities on salal and hemlock were separated in ordination space, however communities on vine maple were not strongly clustered (Figure 32). There is good separation between treatment groups (Figure 33). The overlapping samples evident when viewing ordination with treatment overlay, are from Adam's Siding unthinned and thinned (Figure 33).

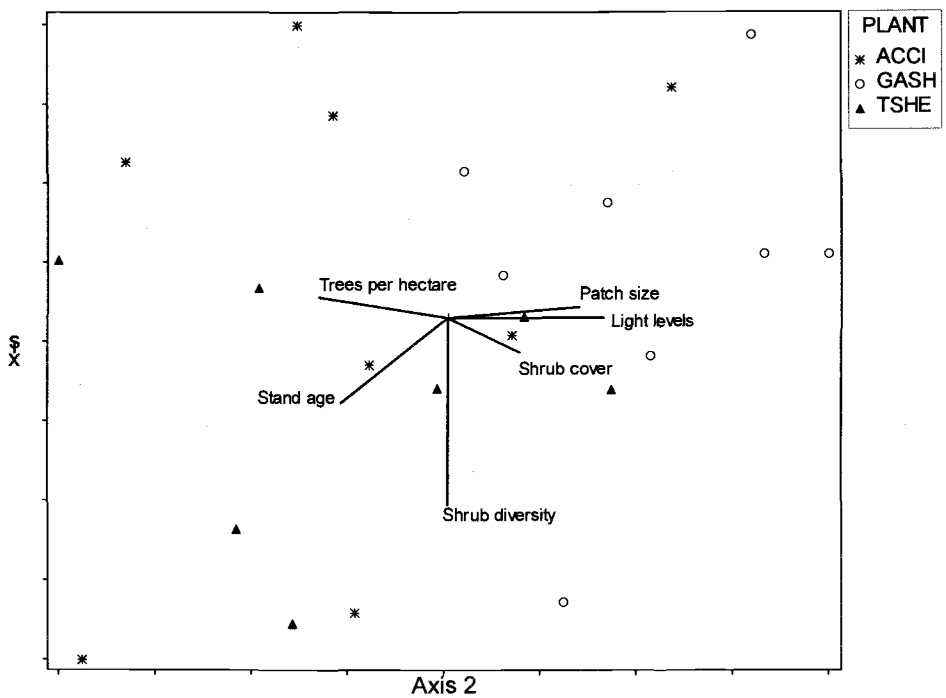


Figure 32. NMS Ordination graph of arthropod taxa samples from vine maple, hemlock and salal, (ferns excluded) from paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range with plant species overlay. Vectors indicate the direction and amount of correlation between axis scores and stand conditions.

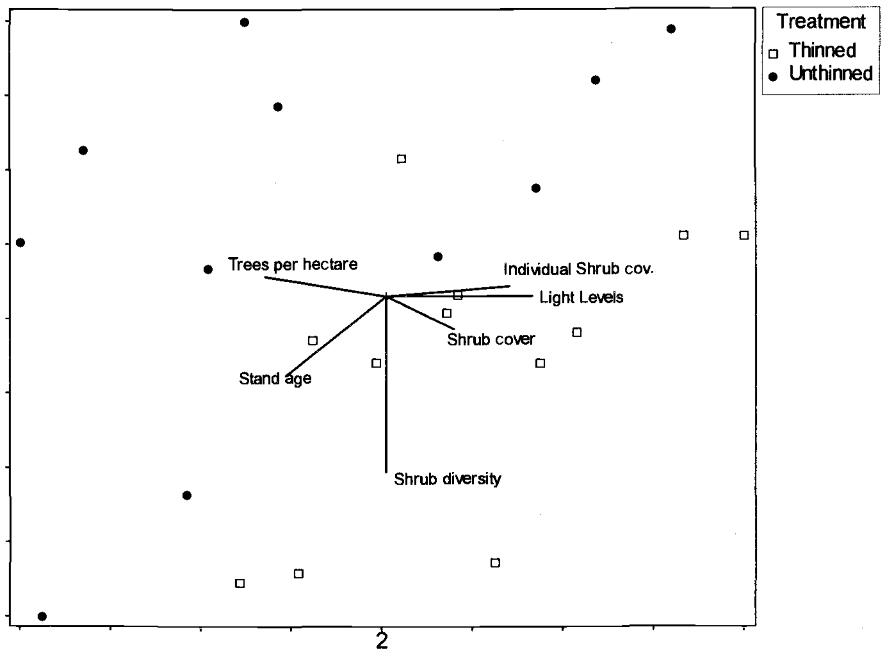


Figure 33. NMS Ordination graph of arthropod assemblages from vine maple, hemlock and salal, (ferns excluded) from paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range with treatment overlay. Vectors indicate the direction and amount of correlation between axis scores and stand conditions.

The understory condition most strongly correlated with Axis 3 was shrub diversity ($r = -0.697$, $p = 0.002$). Six arthropod taxa were positively correlated with Axis 3 (Table 19). Individual shrub cover and light levels were positively correlated with Axis 1 ($r = 0.583$, $p = 0.0035$; $r = 0.635$, $p = 0.001$). Trees per hectare was negatively correlated with Axis 1 ($r = -0.578$, $p = 0.0038$). Two arthropod taxa were negatively correlated with Axis 2; nine taxa were positively correlated with Axis 2 (Table 19).

Table 19. Pearson correlation coefficients, p-values and associated stand condition associated with arthropods significantly correlated with Axis 2 and 3. Ordination vlaues for arthropods with >5% occurrence in samples of vine maple, hemlock, and salal. Samples taken from paired thinned and unthinned Douglas-fir stands, Central Oregon Coast Range.

TAXON	AXIS	R	P-VALUE	Correlated Stand Conditions
Misc. Spider	2	-0.514	0.0226	Patch size, Light, Trees/Hectare
Araneidae	2	0.550	0.0074	Patch size, Light, Trees/Hectare
Cercopidae	2	0.690	0.0001	Patch size, Light, Trees/Hectare
Curculionidae	2	0.500	0.0080	Patch size, Light, Trees/Hectare
Entomobryidae	2	0.760	0.0001	Patch size, Light, Trees/Hectare
Formicidae	2	0.650	0.0077	Patch size, Light, Trees/Hectare and Shrub Cov.
Misc. Lepidopts	2	0.507	0.0101	Patch size, Light, Trees/Hectare
Linyphiidae	2	0.501	0.0183	Patch size, Light, Trees/Hectare
Palpatores	2	0.511	0.0077	Patch size, Light, Trees/Hectare
Polyxenidae	2	0.736	0.0010	Patch size, Light, Trees/Hectare and Shrub Cov..
Pteromalidae	2	-0.625	0.0019	Patch size, Light, Trees/Hectare
Sminthuridae	2	0.560	0.0009	Patch size, Light, Trees/Hectare
Theridiidae	2	0.614	0.0035	Patch size, Light, Trees/Hectare
Anyphaenidae	3	0.581	0.0034	Shrub diversity
Coccinellidae	3	0.625	0.0034	Shrub diversity
Salticidae	3	0.635	0.0004	Shrub diversity
Sciaridae	3	0.682	0.0006	Shrub diversity

Ordinations performed with data set of spiders sampled (with >5% occurrence) from all five plants, showed evidence of segregation of arthropods by treatment and plant. Axis 1 and 2 showed treatment and plant segregation between spider taxa (Figures 34 and 35). Similar to arthropod ordinations, salal and hemlock were separated, with vine maple and ferns throughout ordination. The three dimensional ordination represented 84% of variation in the taxa matrix, with 21% on Axis 1, 8% on Axis 2, and 55% on Axis 3.

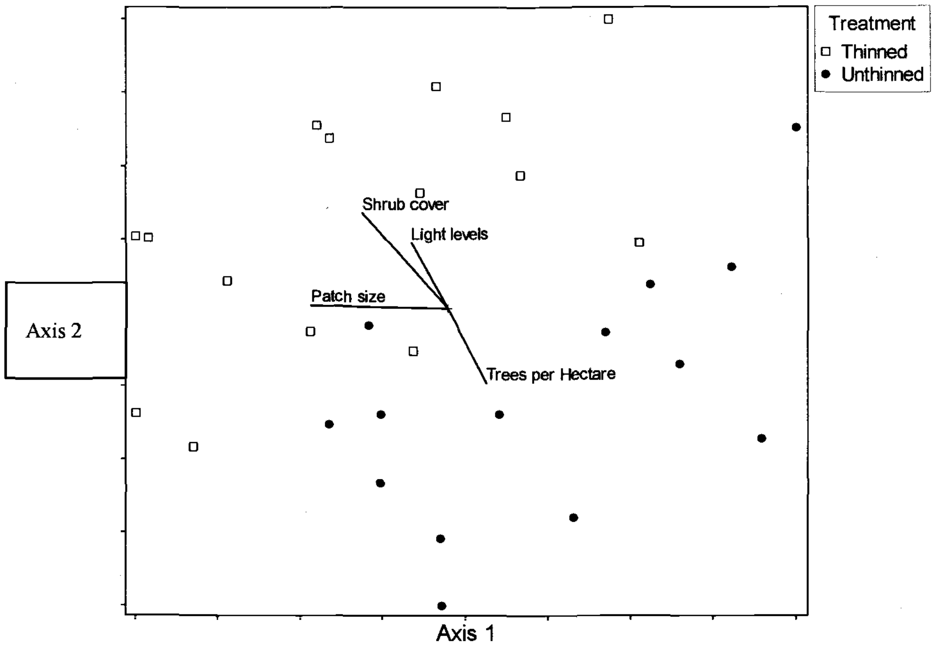


Figure 34. NMS Ordination graph of spider assemblages sampled from five shrubs in paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range with treatment overlay. Vectors indicate the direction and amount of correlation between axis scores and stand conditions.

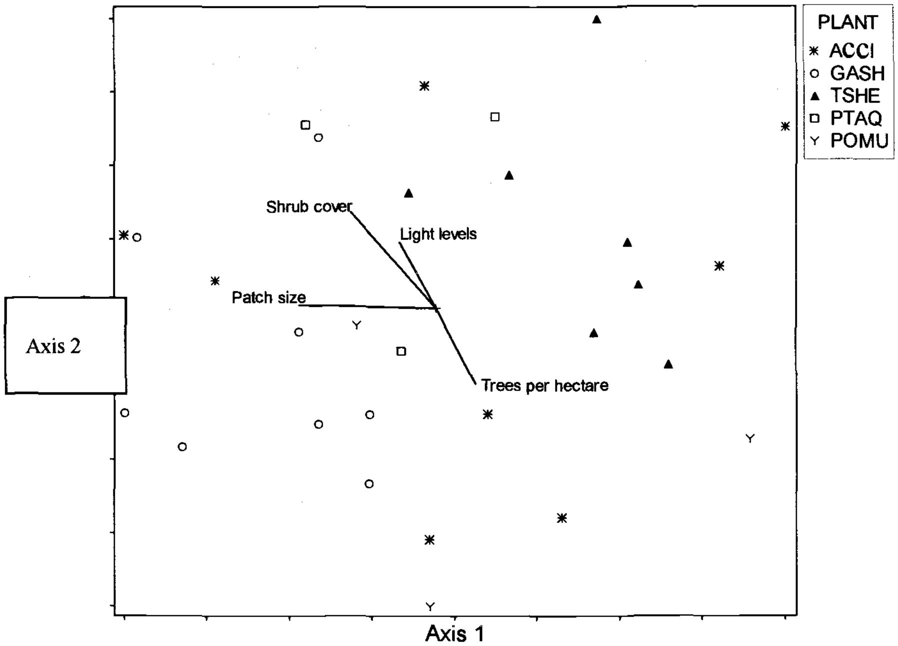


Figure 35. NMS Ordination graph of spider assemblages from five shrubs sampled from paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range with plant species overlay. Vectors indicate the direction and amount of correlation between axis scores and stand conditions.

The understory condition most strongly correlated with Axis 1 was cover of sampled shrub species ($r = -0.629$, $p = 0.0003$). One spider taxon is positively correlated with Axis 1; one spider taxon is negatively correlated with Axis 1 (Table 20). Axis 2 is positively correlated with shrub cover ($r = 0.539$, $p = 0.0025$) and negatively correlated with trees per hectare ($r = -0.478$, $p=0.0086$). Two spider taxa are negatively correlated with Axis 2 (Table 20). Axis 3 is correlated with light levels ($r = 0.514$, $p = 0.0043$) and stand age ($r = -0.580$, $p = 0.0010$). Two spider taxa are positively correlated with Axis 3; two spider taxa are negatively correlated with Axis 3 (Table 20).

Table 20. Pearson correlation coefficients, p-values and associated stand condition associated with spiders significantly correlated with Axis 1, 2, and 3. Taken from ordination of spiders with >5% occurrence in samples of all five plants. Samples taken from paired thinned and unthinned Douglas-fir stands, Central Oregon Coast Range.

TAXON	AXIS	R	P-VALUE	Correlated Stand Conditions
Nuctenea patagiata	1	0.525	0.0035	Patch size, shrub cover, trees/hectare
Theridion californicum	1	-0.635	0.0002	Patch size
Other *Theridion spp*	1	-0.700	0.0001	Patch size., Light, Stand age
Nuctenea patagiata	2	-0.622	0.0003	Patch size, shrub cover, trees/hectare
Salticidae	2	-0.509	0.0048	Shrub cover and trees per hectare
Other Linyphiidae	3	0.628	0.0003	Light levels and Stand age
Pityohyphantes brachygynous	3	-0.650	0.0001	Light levels and Stand age
Other *Pityohyphantes spp*	3	-0.619	0.0003	Light levels and Stand age

Ordinations performed with spider data (with >5% occurrence) without fern samples, showed some segregation of samples by plant (Figure 36), but no segreation by treatment. There was no grouping visible by treatment when the ferns are removed. The three dimensional ordination represented 89% of variation in the taxa matrix, with 14% on Axis 1, 15% on Axis 2, and 60% on Axis 3.

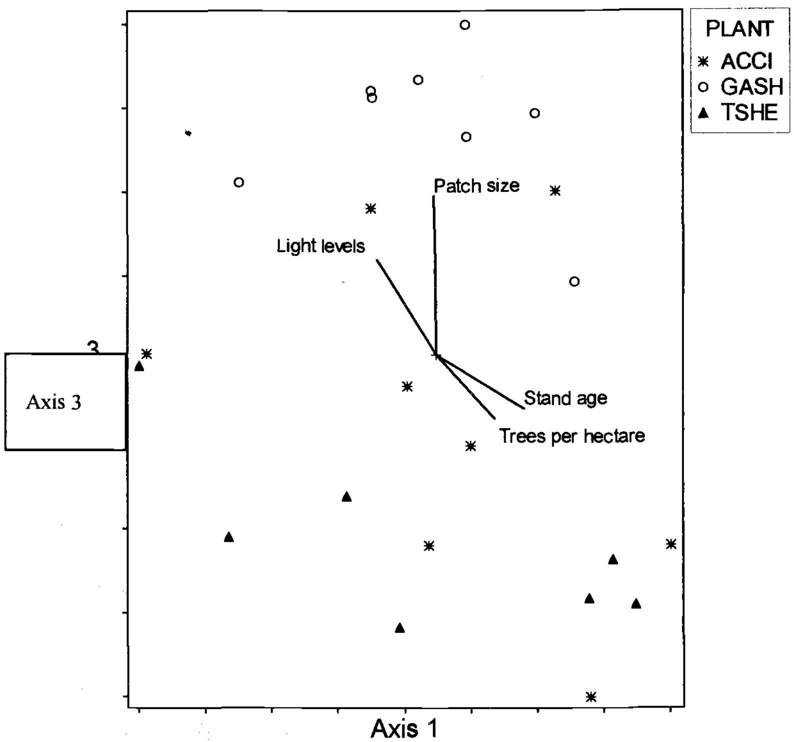


Figure 36. NMS Ordination of spider taxa samples from vine maple, hemlock and salal only with treatment overlay. Vectors indicate the direction and amount of correlation between axis scores and stand conditions. Arthropod samples were taken from paired thinned and unthinned Douglas-fir stands in the Central Oregon Coast Range during 1998.

The understory condition most strongly correlated with Axis 1 was stand age ($r = 0.509$, $p=0.0103$). Three taxa were negatively correlated with Axis 1 (Table 21). One taxon was positively correlated with Axis 1. Axis 3 is positively correlated with light levels ($r = 0.533$, $p = 0.0087$) and individual shrub cover ($r = 0.687$, $p= 0.0003$). Two taxa were negatively correlated with Axis 3. Four taxa were positively correlated with Axis 3 (Table 21).

Table 21. Pearson correlation coefficients, p-values and associated stand condition associated with spiders significantly correlated with Axis 1 and 3. Taken from ordination of spiders with >5% occurrence in samples vinemaple, hemlock and salal only. Samples taken from paired thinned and unthinned Douglas-fir stands, Central Oregon Coast Range.

TAXON	AXIS	R	P-VALUE	Correlated Stand Conditions
Hyptiotes gertschi	1	-0.600	0.0023	Stand age
Other Linyphiidae	1	-0.742	0.0001	Stand age
Nuctenea patagiata	1	0.665	0.0012	Stand age, light and patch size
Unknown Spider (mostly imm)	1	-0.610	0.0027	Stand age
Neriene spp	3	0.727	0.0001	Light levels and Patch size
Nuctenea patagiata	3	-0.569	0.0027	Stand age, light and patch size.
Pityohyphantes brachygynous	3	-0.519	0.0066	Light levels and Patch size
Theridion califomicum	3	0.594	0.0021	Light levels and Patch size
Theridion sexpunctatum	3	0.887	0.0001	Light levels and Patch size

DISCUSSION

This study indicates that arthropod communities on understory shrubs differ by both plant species and thinning treatment. Many studies have established that some arthropods are associated with plant species characteristics (Schowalter and Ganio 1998, Lawton and Schroder 1977), while some are associated with landscape variables (Jokimäki et al. 1998, Väisänen and Heliövaara 1994). Oboyski (1995) assessed arthropod communities on riparian hardwoods in the west central Coast Range, and found that the host association of dominant herbivores was the strongest factor affecting total arthropod community composition.

Plant Species Responses

The ferns I sampled had the most distinctive and abundant arthropod community. Bracken fern was sampled only in thinned stands, where it often forms large patches. The community on bracken fern appeared to be largely herbivore driven. Aphids were found in greatest numbers on bracken fern. Well-known aphid predators, such as ants, coccinellids, chrysopids, hemerobiids and some parasitic hymenopterans were all found at indicator levels on bracken fern. Tenthredinidae larvae and Cercopidae adults and immatures were the other dominant herbivores making use of bracken fern. These findings are consistent with other studies of arthropod community on bracken fern (Lawton 1976, Rigby and Lawton 1981). Analysis of the chemical defenses of bracken suggests that concentrations of condensed tannins and flavenols are higher in bracken found in open vs. shaded areas (Jones 1983). The community of arthropods associated with bracken appears to have found ways to cope with these phenols, and bracken does not have a reduced richness or abundance of herbivores or predators associated with it (Lawton 1976). Bracken is found consistently in understory of thinned Douglas-fir stands, but only scarcely in unthinned stands. Bracken found in unthinned stands is generally reduced in size, when compared to bracken found in areas of fuller sun. Bracken fern is probably an important food source for insectivorous birds in thinned stands because of the abundance of herbivores it supports. Aphid and tenthredinid larvae, both indicator taxa on bracken, are found in the diet of Wilson's warblers conducted at these same sites (Hagar 1999).

Sword fern is found commonly in the understory of unthinned Douglas-fir stands, and although it is present in many thinned Douglas-fir stand understories, it is usually a less dominant understory component. The sword fern arthropod community is strongly defined by detritivores. Mites, collembolans, polyxenids and millipedes, were all found consistently in the detritus that accumulates on sword fern. The many detritivores found on sword fern seemed to be able to support many predators, as predator abundance was highest on sword fern. Halaj (1996), Olive (1982) and others have found that higher spider densities were associated with increased prey abundance. Surface hunters (Philodromids and Salticidae), Sheetweb weavers (mostly micryphantinae and subadult linyphiids), and a small (~3mm) orbweb weaver (*Cyclosa conica*) were abundant predators on sword fern. Another small (~2mm) Linyphiid spider, *Ceraticelus atriceps*, was only found on sword fern.

Salal is also low to the ground, and because it is evergreen, old leaves often carry accumulated detritus, similar to sword fern. Salal supported the second highest (higher than vine maple or hemlock) level of detritivores and fungivores; including particularly sminthurids, polyxenids, oribatid mites, and entomobryids. Cercopids in the immature stages frequently used salal for their host. Theridiidae spiders were common to salal.

Understory hemlock supports a distinctive arthropod community. Hemlock had the highest average species richness. Hemlock had the greatest spider richness, 42 of the 53 taxa used in the Indicator Taxa Analysis of spiders were found on hemlock. Psychodid flies and other rarely encountered taxa in the Tourist group, such as coniopterygids and tricopterans, were also found only on hemlock. Small psocopteran fungus feeders were most abundant on hemlock. Schowalter and Ganio (1998) and Halaj (1996) also found Psocoptera to be abundant on hemlock. Small staphylinid beetles are also indicators of hemlock over vine maple and salal. Hemlock in the understory provides an important food base for resident bird species as well as being an important host for arthropod species not found on other common understory plant species.

The arthropod community on vine maple was less distinct than that found on salal or hemlock. Arthropod abundance on vine maple was low compared to the ferns and salal, while average arthropod diversity was highest on vine maple. Oboyski (1995) also found low arthropod abundance on vine maple, however, he found low diversity on vine maple. However, in my study, vine maple had the greatest abundance of parasitoids and the lowest abundance of predators. Tourists, herbivores (mostly sap-suckers), and parasitoids were more abundant on vine maple than on salal and hemlock. The dominant herbivore on vine maple was aphids.

Treatment Responses

My results also suggest that abundance of some arthropod community components are correlated with stand conditions associated with thinning treatment, such as light levels, shrub cover, shrub diversity and patch size. Greatorex-Davies et al. (1994) found species richness and abundance of true bugs and chrysomelid and curculionid beetles are negatively affected by increasing levels of shade. Jokimäki et al. (1998) found that differences in abundances of many arthropod taxa found in pine-dominated forests in northern Finland, were explained by vegetation that was characteristic of higher light conditions, i.e. numbers of saplings, deciduous shrubs and spruces. I found higher overall diversity and sap-sucker abundances on hemlock in stands with higher light levels. Orbweb weavers and all predators on hemlock were more abundant in low light. Strong and Lawton (1984) suggested that herbivores are also affected by host plant patch size and density and degree of plant diversity surrounding host plant. I found both herbivores on hemlock and parasitoids on vine maple to be positively correlated with hemlock patch size. Herbivores on vine maple were negatively correlated with surrounding shrub diversity.

Salticids hunt by sight, and Oboyski (1995) found salticids tended more towards open and more sunlit habitats. I found salticid abundance and frequency to be higher on salal in unthinned stands. Salticids were also found in highest abundance and frequency on sword fern, which I sampled only in unthinned stands. This is a good example of a situation where it is necessary to examine causation at a microhabitat level. Actual light levels at the microhabitat level on salal could actually be higher or equivalent on solitary salal plants in unthinned stands compared to salal plants forming continual cover in thinned stands, even though average stand light levels were significantly lower in unthinned stands. High prey abundance on sword fern and salal could also explain differences in salticid abundance. Halaj (1996) found that salticids (agile hunters) were significantly correlated with prey abundance.

Thinning changed the understory conditions of the stands, affecting shrub cover, shrub species composition, and stand light levels. Light levels dictate not only what shrubs will persist, but also the growth form they will take (McKenzie 1999, Bailey 1996). I hypothesize that the within plant structure of the shrub species explains many arthropod community differences and is as important as light, shrub cover, diversity, etc, in determining the composition of the arthropod community, especially for spiders. Lawton (1983) in a paper exploring the correlation between architecture and insect species diversity, noted that "...insect diversity and richness fall when structural diversity of the vegetation is reduced, even though the number of plant species remains more or less unchanged". Many studies have indicated that species diversity of web spiders is positively correlated with the structural diversity of vegetation (Robinson 1981, Greenstone 1984, Halaj et al. 1996). Halaj et al. (1998) studied the arboreal spider community on Douglas-fir (*Pseudotsuga menziesii*), red alder (*Alnus rubra*), western redceder (*Thuja plicata*), western hemlock (*Tsuga heterophylla*) and noble fir (*Abies procera*) and found that habitat structure and prey availability best explained patterns of hunting and web-building spider abundance on individual tree species.

Theridiidae, cobweb building spiders, spiders take advantage of the three dimensional space available between leaves of salal to build webs, feeding on crawling insects upon the leaves and stems (Moldenke, pers.comm.). Adults and immatures of three *Theridion spp.* were found with high frequency and abundance on salal. Orbweb weavers also take advantage of 3-D space available on salal. They were more abundant on salal in shadier stands, as were predators in general. Orbweb weavers were also more abundant where salal patch size was smaller. The structure of salal differs between thinned and unthinned stands. Dense overstories and SDI >360 can hinder salal reproduction, both clonal and rhizome (Huffman 1994). Therefore, salal in thinned stands is able to form large, dense, continuous patches, whereas, salal in unthinned stands generally exists in smaller patches with fewer leaves and more exposed woody stems, often with solitary salal plants. I suggest these structural differences explain the reduction in predators on salal as light levels increase, as sparser salal plants in lower light conditions often had fewer leaves with more exposed woody stems. Halaj (1996) found 70% of variation in spider density across individual host trees can be explained by amount of wooden twigs provided by their branches. Although he did not sample salal, Oboyski (1995) found more webspinners in shaded low-order stream sites.

Structure on vine maple did not differ as obviously as that of salal between thinned and unthinned stands. Commercial thinning favors the establishment of vine maple, and O'Dea (1992) found thinning encourages the layering of vine maple. This change in structure could account for differences in arthropod communities on vine maple between thinned and unthinned stands. Increased light levels and increased growth rates should make vine maple in thinned sites far more palatable to sap-suckers. However, the opposite was true: three times as many aphids were found on vine maple in unthinned stands as found on vine maple in thinned stands. This could be explained by the greater abundance of parasitoids found on vine maple in thinned stands. Lower sap-sucker abundance on vine maple in thinned stands could also be due to bird predation, as Wilson's warblers, known aphid consumers, are abundant in thinned stands but not unthinned stands.

The only spiders that utilize vine maple in any numbers are branch-to-branch web builders, *Araniella displicata*, and *Prolinyphia spp.* *Prolinyphia* were found in greatest numbers on sword fern, but overall appeared to be a prominent predator in unthinned stands. *Prolinyphia* need large space to build their webs, between 3-10" (Moldenke, pers. comm.). *Prolinyphia* on vine maple in unthinned stands utilized structure provided by vine maple to set up a web to catch air borne arthropods; they are not strictly targeting vine maple residents. Tourists, such as some dipterans, aquatic adults and others, found on vine maple suggest that it is a good place to sit, sun etc. Often vine maple is the only structure found in the unoccupied understory space between lower shrubs and the overstory canopy.

The stand conditions, light, cover, hemlock cover and shrub diversity did not explain very many arthropod community components on hemlock. Treatment differences also did not affect the arthropods on hemlock to the extent apparent on other shrubs. This suggests that the arthropod community on hemlock is influenced by factors not measured in this study. Hemlock provides two dimensional space for web weavers to build webs between branches, such as *Pityohyphantes brachygynus* and other *Pityohyphantes spp.* Hemlock also provides microspace between needles and fine branching, important for smaller web weavers such as *Dictyna spp.*, *Hyptiotes gertschi*, and immature *Nuctenea patagiata.*

Management practices can affect arthropod communities by changing microclimate conditions. Managers often approach conservation of biodiversity from the stand level, while arthropods on understory shrubs are responding to microhabitat conditions that cannot necessarily be predicted by stand level conditions. However, understanding the effects of silvicultural manipulations on understory shrubs can translate to an understanding of effects on arthropod communities.

CONCLUSIONS

The arthropod communities on shrubs in the central Oregon Coast Range showed segregation primarily among plant species. Each of the understory plants I studied supported a unique portion of the overall understory arthropod community. In addition, shrub cover, shrub diversity, patch size, light levels, tree density and stand age were correlated with some arthropod community components. I found that thinning indirectly affected 1) stand level arthropod communities by altering plant species composition and 2) plant level arthropod communities by changing the structure of plant species present.

Birds are important insectivores in forest ecosystems (Marquis 1994). Food availability is a major factor in habitat selection by breeding birds, therefore insight into arthropod community responses to forest structures aids in the understanding of vegetation characteristics that affect habitat quality for birds. Related studies in the same stands have found that the abundance of some species of birds differ between thinned and unthinned stands (Hagar 1999, Hagar 1996). The presense of well-developed understory was positively correlated with the abundance of several insectivorous bird species (Hagar 1999). My results suggest that bracken fern, salal, sword fern and hemlock in particular may be important in supporting insects that may be food for birds.

Vine maple, hemlock, salal, bracken fern and sword fern support distinct arthropod communities. Treatment differences between shrub species distribution and structure, and within arthropod communities found on these shrubs, suggest that both treatment conditions maybe important for maintaining diversity of understory arthropod communities.

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APPENDICES

Appendix A. Taxa List (>5% Occurrence, Taxa used in analysis)

Functional group/Taxon	Order	Individuals	Intensity	Occurrences
HERBIVORES		**1326**	**2217**	**488**
SAP-SUCKERS		**1150**	**2096**	**327**
Achilidae	(HOMOPTERA)	14	19	14
Aphidiidae	(HOMOPTERA)	988	1857	180
Cercopidae	(HOMOPTERA)	71	101	63
Cicadellidae	(HOMOPTERA)	20	35	20
Miridae	(HEMIPTERA)	53	76	50
Misc Sap-suckers		4	7	4
FOLIVORES		**134**	**56**	**122**
Chrysomellidae	(COLEOPTERA)	11	15	11
Curculionidae	(COLEOPTERA)	35	48	33
Geometridae	(LEPIDOPTERA)	46	55	45
Other Lepidoptera larvae	(LEPIDOPTERA)	10	103	10
Tenthredinidae	(HYMENOPTERA)	32	56	23
MISC HERBIVORES		**42**	**65**	**39**
Mordellidae	(COLEOPTERA)	14	18	13
Snail		17	29	15
Misc Wood-feeders	(COLEOPTERA)	7	13	7
Misc Herbivores		4	6	4
DETRITIVORES		**4551**	**6932**	**1393**
Acarina		151	239	119
Cecidomyiidae	(DIPTERA)	300	442	128
Coccinellidae	(COLEOPTERA)	51	80	44
Elateridae	(COLEOPTERA)	42	66	39
Entomobryidae	(COLLEMBOLA)	1211	2012	308
Lathridiidae	(COLEOPTERA)	8	12	8
Machillidae	(ARCHEOGNATHA)	6	9	6
Orabatida		146	295	46
Polyxenidae	(POLYXENIDA)	482	956	74
Psocoptera		1259	1460	246
Sciaridae	(DIPTERA)	277	483	180
Sminthuridae	(COLLEMBOLA)	579	824	157
Tenebrionidae	(HYMENOPTERA)	5	6	5
Thysanoptera		7	8	6
Tipulidae	(DIPTERA)	5	6	5
Other Detritivores		22	34	22
OMNIVORES	**Phoridae**	**25**	**42**	**23**

Functional group/Taxon	Order	Individuals	Intensity	Occurrences
PARASITOIDS		**273**	**420**	**214**
Braconidae	(HYMENOPTERA)	25	39	25
Unkn. Chalcidoidea	(HYMENOPTERA)	61	84	53
Cynipidae	(HYMENOPTERA)	7	11	6
Diapriidae	(HYMENOPTERA)	14	29	11
Encyrtidae	(HYMENOPTERA)	7	11	6
Eulophidae	(HYMENOPTERA)	10	14	10
Ichneumonidae	(HYMENOPTERA)	17	26	17
Pteromalidea	(HYMENOPTERA)	94	145	49
Scelionidae	(HYMENOPTERA)	19	30	18
Misc Parasitoids	(Diptera and Hymenopt.)	19	30	19
TOURISTS		**582**	**932**	**204**
Chironomidae	(DIPTERA)	560	908	183
Plecoptera		3	4	3
Psychodidae	(DIPTERA)	12	10	11
Misc Tourists		7	10	7
OMNIVORES	Phoridae	**25**	**42**	**23**
MISCELLANEOUS		**93**	**128**	**84**
Misc Coleoptera		13	17	13
Misc Diptera		79	110	70
Staphylinidae		1	1	1
PREDATORS		**2991**	**4694**	**2412**
SPIDERS		**2386**	**3594**	**2028**
Anyphaenidae	*Anyphaena spp*	**61**	**89**	**58**
Araneidae		**469**	**606**	**454**
	Araneus spp	5	9	5
	Araneilla displicata	22	27	29
	Araneus gemmoides	17	20	27
	Cyclosa conica	16	24	15
	Nuctenea patagiata	386	491	315
	Tetrgnatha versicolor	1	1	1
	Misc Araneids	22	34	62
Unkn Spider		**249**	**396**	**134**
Clubionidae		**99**	**159**	**118**
	Misc. Clubionids	15	25	15
	Agroeca spp	2	5	2
	Clubiona canadensis	82	128	101
Dictynidae	*Dictyna spp*	**14**	**17**	**14**
Linyphiidae		**831**	**1304**	**600**
	Ceraticelus atriceps	2	5	2
	Micryphantinae	231	409	158

Functional group/Taxon	Order	Individuals	Intensity	Occurrences
	Neriene spp	89	145	84
	Pityohyphantes brachygy	25	24	23
	Pityohyphantes rubrofasc	20	27	20
	Pityohyphantes spp	60	64	56
	Prolinyphia spp	32	58	32
	Spirembolus mundus	2	4	2
	Misc. Linyphiids	370	567	223
Philodromidae		**46**	**79**	**46**
	Philodromus spp	6	10	6
	Philodromus gertschi	4	7	4
	Philodromus rufus	22	37	22
	Philodromus spectabilis	9	17	9
	Philodromus speciosus	2	2	2
	Misc. Philodromids	3	7	3
Salticidae		**51**	**84**	**34**
Tetragnathidae		**5**	**6**	**5**
Theridiidae		**535**	**817**	**523**
	ACHSP	11	17	36
	Dipoena malkani	3	5	3
	Theridion spp	328	515	307
	Theridion aurantium	1	1	1
	Theridion californicum	22	35	22
	Theridion differens	29	35	26
	Theridion lawrencei	12	13	12
	Theridion murarium	2	3	2
	Theridion sexpunctatum	91	142	83
	Misc. Theridiids	36	51	31
Thomisidae		**13**	**22**	**13**
	Xysticus spp	1	2	1
	Xysticus gosiutus	6	10	6
	Misumena spp	1	2	1
	Misumena vatia	5	9	5
Uloboridae	*Hyptiotes gertschi*	**13**	**15**	**12**
INSECT PREDATORS		**605**	**1100**	**384**
Empidiidae	(DIPTERA)	10	15	10
Formicidae	(HYMENOPTERA)	179	344	112
Hemerobiidae	(NEUROPTERA)	16	29	16
Cantharidae	(COLEOPTERA)	278	523	129
Chrysopidae	(NEUROPTERA)	17	29	17
Coccinellidae	(COLEOPTERA)	14	27	14
Coniopterygidae	(NEUROPTERA)	2	2	2
Melyridae	(COLEOPTERA)	5	9	5
Palpatores	(OPILIONES)	68	100	64
Raphidiidae	(RAPHIIDIOPTERA)	5	8	4
Spirobolida	(SPIROBOLIDA)	4	6	4
Staphylinidae	(COLEOPTERA)	7	8	7

Appendix B. Spider Guild Breakdown, Annotated

Total Spiders Collected= 2395 = 24% of arthropods collected

Sheeweb Weavers 837. 35%

Linyphiidae and Dictynidae (Heckled band weavers)

both catch flyers with a web

- Micryphantinae and *Dictyna* build webs leaf to leaf
- Linyphiids build webs branch to branch.

Cobweb Weavers 541 23%

Theridiidae catch walkers with leaf to leaf web

Orbweb Weavers 488 20%

Araneidae, Tetragnathidae, Uloboridae

All catch flyers with web, mostly branch to branch, however immatures could have smaller webs

Unkn 243 10%

Mostly immatures and few mangled, or otherwise undescribable

Nocturnal Hunters 160 7%

Anyphaenidae, Clubionidae

Catch walkers by disturbing them nocturnally

Agile Hunters 63 3%

Salticidae

Catch walkers and fliers visual hunters

Surface Hunters 53 2%

Philodromids (typically Runners) and Thomisids (Ambushers)

- Both catch walkers on plant surfaces, but by slightly different methods,
- Lumped together in to Surface Hunters group