AN ABSTRACT OF THE DISSERTATION OF

Kenric J. Walburger for the degree of Doctor of Philosophy in Animal Science presented on October 28, 2005.
Title: The Effects of Timber Harvest and Herbivory on Understory Vegetation and Composition of Beef Cattle Diets on Forested Rangelands.

Abstract Approved:

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Timothy DelCurto

The objectives of the experiment were to: 1) determine the relationship between overstory canopy cover and ungulate herbivory on understory production, composition and diversity and 2) determine the effects of timber harvest, ungulate herbivory and season of use on botanical composition and nutritional quality of beef cattle diets. Three randomly selected grand fir (*Abies grandis*) and ponderosa pine (*Pinus ponderosa*) sites were established in 1986. Timber harvest and herbivory treatments were arranged in a split-plot design.

Results from grand fir forests indicated that timber harvest had a greater magnitude effect on understory species and shrub responses than herbivory treatments. Understory production was significantly greater in treatments that allowed domestic and wild ungulate herbivory compared to total removal of ungulate herbivory. Production of understory vegetation increased with decreasing canopy cover. Plant communities were affected by timber harvest and

herbivory. There appeared to be differences among all timber harvest treatments, whereas, among herbivory treatments, total removal of ungulate herbivory appeared to be different than other herbivory treatments.

Results from ponderosa pine treatments indicated that there were no directional responses attributed to either timber harvest or herbivory on understory plant species frequency. Understory production was significantly greater in treatments with no ungulate herbivory compared to treatments with domestic and wild ungulate herbivory. Production was significantly greater in commercially thinned stands compared to non- harvested stands with greater canopy cover. Plant communities were affected by timber harvest but not by herbivory.

Nutritional quality of diets was significantly greater in June than in August for both grand fir and ponderosa pine sites. Timber harvest treatments only affected ADF content in grand fir sites, whereas, herbivory treatments had no affect on nutritional quality of diets. Graminoids were the major constituent in the diet, forbs were intermediate and shrubs were the least. Season of use did not influence the botanical composition of diets.

This research indicates that the effects of timber harvest may have a greater effect on understory vegetation composition, structure and production than herbivory. In addition, timing of grazing had a greater influence on diet quality than did herbivory and(or) timber harvest.

The Effects of Timber Harvest and Herbivory on Understory Vegetation and Composition of Beef Cattle Diets on Forested Rangelands

by

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I understand that my dissertation will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my dissertation to any reader upon request.

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Kenric J. Walburger, Author

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degree is as much hers as mine. My kids, Justin and Mackenzie, I am finally going to be done and have a real job.

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CONTRIBUTION OF AUTHORS

Dr. Timothy DelCurto assisted in planning data collection, data analysis and manuscript preparation. Dr. Martin Vavra assisted in manuscript preparation and initiated and maintaining the experiment over the years.

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CHAPTER 1

INTRODUCTION

Forested rangelands comprise a significant portion of the public land in the western US. Within the northwestern U.S. (Idaho, Montana, Oregon, and Washington) forested rangelands comprise approximately 35 percent of the total land area, and public ownership comprises 59 percent of these forested rangelands (Smith et al. 2002). Forests of the interior Northwest, on average, receive greater precipitation, have deeper soil profiles, and have greater soil moisture holding capacity than adjacent grasslands (Riggs et al. 2004). Ponderosa pine (*Pinus ponderosa*) and grand fir (*Abies grandis*) are two of the forest types that are commonly found within the region. These productive forests provide valuable habitat for many wildlife species and summer grazing allotments for beef cattle.

However, over the last 100 years, many of these forests have developed into relative homogeneous stands in composition and structure of fire-sensitive and disease-susceptible species (Belsky and Blumenthal 1997; Hessburg et al. 2005), thereby reducing the overall understory productivity of the area. Many areas with high potential for timber harvest and forage production have the lowest output due to dense canopy cover (Hedrick et al. 1969).

To restore productivity to these dense stands, in terms of forage and timber production, it may be necessary to open the canopy. Forage production response to overstory canopy cover is well documented (McConnell and Smith 1965 and 1970; Jameson 1967; Young et al. 1967; Thompson and Gartner 1971; Miller et al. 1986) and results suggest that as overstory canopy cover decreases understory production (kg/ha) increases. Clary et al. (1975) also documented this relationship between canopy cover and forage production, but noted there was an economic optimum between increasing forage production for cattle grazing and increased timber growth for harvest. However, this optimum may not be ecologically sustainable. Understory plant species responses/trajectories must be considered if grazing and logging are to be sustainable.

Timber harvest on forested rangelands sets back succession, and generally the overstory development proceeds with the following pattern: herb and shrub to tall shrub to juvenile tree stage development and, finally, replacement of shade-intolerant for shade-tolerant species (Bainbridge and Strong 2005). However, understory vegetation successional development can be influenced by the level of disturbance (Griffis et al. 2001; Gibbs et al. 2004), residual species (Halpern 1988; Selmants and Knight 2003), understory species composition of adjacent undisturbed stands (Selmants and Knight 2003), and possibly by soils (Bennett et al. 1987). Schoonmaker and McKee (1988) reported that species richness increased to peak at 15 to 20 years after logging and burning in a coniferous forest in western Oregon. They also documented that species diversity is greatest up to 20 years following disturbance.

Following disturbances, such as timber harvest, forested rangelands often become focal points of ungulate herbivory for 2 reasons: 1) vegetation within disturbed sites is often more palatable than undisturbed areas and 2) surrounding undisturbed forest communities contain limited understory forage (Vavra et al. 2004). As a result, grazing or herbivory may influence plant community structure and diversity within these environments. Hobbs (1996), Augustine and

McNaughton (1998), Riggs et al. (2000), and Kie and Lehmkuhl (2001) all documented that ungulate herbivory can influence plant community structure and composition. Ungulate herbivory directly affects vegetation through selective feeding and the ability of a plant to recover from herbivory (Augustine and McNaughton 1998). However, plant species diversity is not consistently affected by grazing (Stohlgren et al. 1999; Riggs et al. 2000; Brockway and Lewis 2003), but individual species, at the local level, are affected by herbivory and logging and their interaction. Herbivory has the greatest effect in altering plant community structure within clearcuts (Riggs et al. 2000). Stohlgren et al. (1999) also documents that grazing effects local species; however few plant species showed consistent directional responses to grazing.

Timber harvest increases the opportunity for cattle/wildlife to forage and obtain a higher quality diet and subsequently increase productivity. Several researchers (Harris 1954; Young et al. 1967; Roath and Krueger 1982; Gillen et al. 1984) have documented that cattle use increased in areas with greater forage production. Young et al. (1967) also noted that it was more difficult to get moderate to heavy utilization under dense overstory canopy covers than more open canopy covers. The understory vegetation under open canopies is typically grass dominated with greater forage production than under more closed canopies (McConnell and Smith 1965 and 1970). As a result, cattle grazing on forested rangelands typically selected diets that were high in grass, moderate in forbs and minimal in shrubs (Holeckek et al. 1982; Quinton 1984; Mitchell and Rodgers 1985; Uresk and Paintner 1985). However, cattle diets can vary as a grazing season progresses, increasing proportionally in forbs and shrubs, while decreasing in grasses (Holechek et al. 1982; Mitchell and Rodgers 1985; Uresk and Paintner 1985). Although cattle diets change with progression of the grazing season, nutritional quality of cattle diets continues to decline as well (Walker et al. 1989).

Holechek et al. (1981), Kirby and Parman (1986), and Griggs et al. (1995, 2001) documented that nutritional quality of cattle diets declined with progression of the grazing season. Holechek et al. (1981) further noted, in a mixed-conifer forest, that CP content was not affected by season of use but IVOMD declined with progression of the grazing season. However, Kirby and Parman (1986) and Griggs et al. (1995, 2001) documented, on grassland sites, that CP and IVOMD declined with progression of the grazing season. Therefore, the nutritional quality of cattle diets may be affected by previous ungulate herbivory, canopy cover and/or plant community changes.

Although, much is known about how quantity of vegetation responds to canopy cover changes, less is known about how herbivory can affect plant community structure. Even less is known about how plant community responds to the combined effects of herbivory and overstory canopy within forested environments. Therefore the objectives of this study are:

1. Determine the relationship between overstory canopy cover and ungulate herbivory on understory production, understory species composition and diversity.

2. Determine the effects of timber harvest, ungulate herbivory and season of use on botanical composition and nutritional quality of beef cattle diets.

The following chapters will present the data collected to answer the two objectives. Chapter 2 contains the results of the changes in plant community structure, production and composition of the ponderosa pine sites. Chapter 3 contains the plant community structure, production, and compositional changes of the grand fir sites. Finally, Chapter 4 contains the botanical composition and nutritional quality of steer diets grazing both the grand fir and ponderosa pine sites.

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CHAPTER 2

The Effects of Herbivory and Timber Harvest on Understory Vegetation in a Ponderosa Pine (*Pinus ponderosa*) Habitat in Northeastern Oregon.

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ABSTRACT

The objectives of this study were to document the effects of logging and herbivory, cattle and native ungulates, on understory vegetation within a ponderosa pine (*Pinus ponderosa*) habitat. Three randomly selected sites were established in 1986. Ponderosa pine sites were arranged as a split-plot design and timber harvest treatments [1) commercial thinning (TH), 2) control (CON)] were whole plots and herbivory treatments [1) cattle and native ungulate grazing (GR), 2) native ungulate grazing (BG), and 3) exclusion of cattle and native ungulates grazing (EX)] were the sub-plots. Understory production was affected by timber harvest and herbivory. Total production was greater in ($P < 0.05$) TH than in CON for all years sampled and production was greater in the BG and EX when compared to GR. A total of 149 species were identified on these sites, but only 35 species occurred in every treatment combination which were used for analysis. In general, there were no directional responses attributed to either timber harvest or herbivory on understory plant species frequency. Herbivory and timber harvest did not affect ($P > 0.10$) understory plant species richness, Shannon diversity, or evenness. Differences occurred among timber harvest and herbivory treatments on individual shrub species density and cover. Non-metric multidimensional scaling (NMS) ordination and multi-response permutation procedures (MMRP) analyses revealed that plant communities were different in 1985 prior to study initiation and these differences were maintained through 2003. Plant communities in TH were different than in CON, however, herbivory did not appear to affect plant community structure. This research indicates that the effects of timber harvest may have a greater effect on understory vegetation composition, structure, and diversity than herbivory.

Keywords: Beef cattle, Native ungulates, Mule deer, Elk, Succession

INTRODUCTION

Forested rangelands comprise a significant portion of the public land in the western US. Ponderosa pine (*Pinus ponderosa* P.& C. Lawson) forests provide the most extensive and important forested grazing lands in North America (Skovlin 1976). These forests also provide valuable habitat for many wildlife species. However, over the last 100 years, many of these forests have developed into relative homogeneous stands in composition and structure of fire-sensitive and disease-susceptible species (Belsky and Blumenthal 1997; Hessburg et al. 2005), thereby reducing the overall productivity of the area. Traditionally, many of these areas with high potential for timber harvest and forage production have the lowest output due to dense canopy cover (Hedrick et al. 1969).

Two uses common to western ponderosa pine forests are timber and forage production. To enhance these, thinning of overstory canopy maybe a useful tool, but the effects of this manipulation on forage production, and understory community structure and diversity is not well known. Timber harvest on forested rangelands sets back succession and, in most cases, increases understory forage production. Forage production response to overstory canopy cover is well documented (McConnell and Smith 1965 and 1970; Jameson 1967; Young et al. 1967; Thompson and Gartner 1971) in that as overstory canopy cover decreases understory production (kg/ha) increases.

Herbivory may also influence plant community structure, diversity, and production within forested environments. Hobbs (1996), Augustine and

McNaughton (1998), and Riggs et al. (2000), Kie and Lehmkuhl (2001) all documented that herbivory can influence plant community structure and composition. Ungulate herbivory directly affects vegetation through selective feeding and the ability of a plant to recover from herbivory (Augustine and McNaughton 1998). However, plant species diversity was not consistently affected by ungulate herbivory (Stohlgren et al. 1999, Riggs et al. 2000 and Brockway and Lewis 2003), but individual species, at the local level, were affected by herbivory and timber harvest. Herbivory had the greatest effect in altering plant community structure within clearcuts (Riggs et al. 2000). Stohlgren et al. (1999) also documented grazing effects on local species, however few plant species showed consistent directional responses to grazing.

As stated earlier, much is known about how quantity of vegetation responds to canopy cover. However, little is known about how plant community structure and composition responds when combining the effects of herbivory and overstory canopy within a ponderosa pine forest. Therefore the objective of this study was to document the effects of timber harvest and herbivory on understory vegetation composition, structure and diversity.

MATERIALS AND METHODS

The study area is located at the Eastern Oregon Agriculture Research Center's Hall Ranch that is approximately 16 km east of the city of Union in the Wallowa Mountains of northeastern Oregon with an elevation range from 1050 to 1250 m.

Summers tend to be dry and warm with temperatures rarely exceeding 38°C, though freezing or near-freezing temperatures are possible all year. Winters are cold and wet, with the majority of the precipitation coming in the form of snow between November and May. Average annual precipitation for the Hall Ranch was 56 cm (Table 1). Elk (*Cervus elaphus* L.) and mule deer (*Odocoileus hemionus* Raf.) are indigenous to the area and can be found throughout the year; however, heaviest use occurs in the spring and the fall.

Table 1. Precipitation data (cm), for vegetation sampling years, from weather station located at Eastern Oregon Agriculture Research Center's Hall Ranch.

Year	Precipitation (cm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1985	1.3	4.3	3.8	4.1	5.8	3.3	1.0	2.5	5.3	5.6	8.9	2.5	48.5
1988	6.1	4.1	6.4	4.3	5.6	8.1	0.0	1.0	0.8	0.5	11.9	7.4	56.1
1989	8.9	4.1	9.7	5.1	6.1	3.6	0.5	9.1	2.5	3.8	4.3	2.0	59.7
1991	4.6	3.0	6.6	6.1	13.0	7.9	0.5	0.3	0.0	3.8	11.4	2.0	59.2
1992	2.0	4.6	1.3	4.6	1.5	9.1	2.8	0.5	3.0	4.3	6.4	8.1	48.3
1994	6.1	7.6	2.3	7.4	7.4	3.3	1.0	0.0	0.8	3.6	10.4	3.6	53.3
1995	9.7	3.0	9.1	9.7	6.9	7.6	2.0	4.1	1.3	4.1	12.4	9.1	79.0
1997	5.8	5.3	1.5	10.4	4.3	3.6	5.3	1.3	3.3	3.8	4.1	7.6	56.4
2003	6.1	6.4	9.9	7.4	7.1	1.0	0.0	3.6	2.5	2.0	3.6	8.9	58.4
Avg.	5.9	4.9	5.5	6.1	6.6	4.7	1.6	1.8	2.3	3.6	6.6	5.9	55.6

Three replicated sites of a *Pinus ponderosa* P.& C. Lawson / *Symphoricarpos albus* (L.) Blake (ponderosa pine) habitat type, 15 ha in size, were selected to analyze the effects of herbivory and timber harvest on understory plant communities. Potential areas, with relatively homogeneous stand structure and of the necessary size, were initially identified and then research sites were selected from these areas. The ponderosa pine community had two timber harvest treatments applied to them (Figure 1): 1) commercial thinning (thinned) and 2) uncut (Control). Commercial thinning was done by removing merchantable timber to achieve homogeneous reduction in stands to a basal area of less than 24 m^2/ha (tree spacing of approx. 8 m). Timber harvest began in 1985 and was completed by 1986. In order to protect herbaceous vegetation and minimize soil disturbance from the impact of skidding, spacing between skid trails were at least 36.5 m if soils were not frozen and with adequate snow cover. Understory vegetation is highly variable and composed of many graminoid, forb, and shrub species. Common graminoids include elk sedge (*Carex geyeri* Boott), pinegrass (*Calamagrostis rubescens* Buckl.), and Kentucky bluegrass (*Poa pratensis* L.). Common forbs include western yarrow (*Achillea millefolium* L. var. *occidentalis* DC.), strawberries (*Fragaria* spp.), bedstraws (*Galium* spp.), lupines (*Lupinus* spp.), and heart leafed arnica (*Arnica cordifolia* Hook.). Common shrubs are

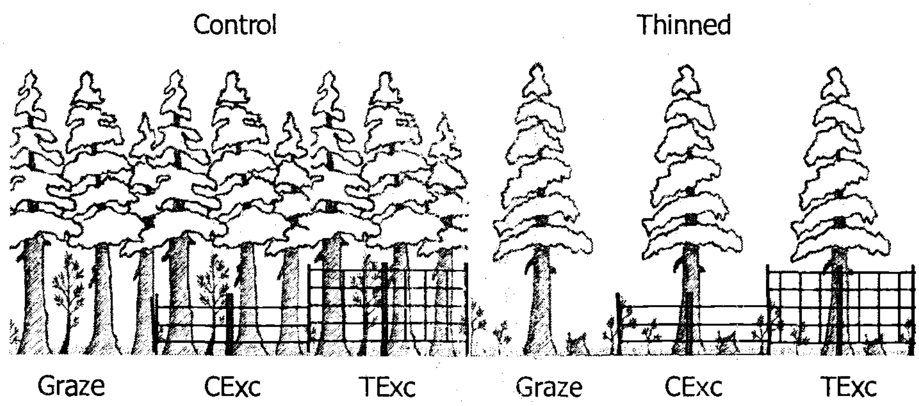

Figure 1. Layout of timber harvest (control and thinned) and herbivory (Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing) treatments for each ponderosa pine site.

snowberry and Oregon grape (*Mahonia repens* (Lindley) G. Don). Although ponderosa pine is the dominant overstory species, western larch (*Larix occidentalis* Nutt.) can often be found.

The following herbivory treatments were applied to each timber harvest treatment: 1) grazing by cattle and native ungulates to achieve 60 percent utilization (grazed), 2) native ungulate grazing only (cattle exclosure), and 3) exclusion of cattle and native ungulates (total exclosure). Sixty percent utilization is considered heavy relative to current recommendations (Holechek 1995), but was used because it was considered a typical utilization level for industrial forests. Grazing treatment fencing was completed in 1986, and cattle were then grazed in a deferred rotation grazing system. Cattle grazed these sites from mid-June to mid-July in even years and mid-July to mid-August in odd years. Grazing by cattle was removed from 2001 through 2003.

Vegetation Sampling

Vegetation was monitored using the same procedures for all collection periods. Three permanent transect lines, 30 m in length, were established in all treatment combinations to monitor vegetation changes. These permanent transects were used to determine overstory cover, understory species frequency, and shrub cover and density. A spherical densiometer (Strickler 1959) was used to determine percent overstory canopy at 0, 15 and 30 m along each 30 m transect. Canopy cover was determined prior to timber harvest in 1985 and again in 2003.

Herbaceous production was measured in 1989, 1992, 1995 and 2003 by clipping 20, 0.5-m^2 rectangular plots placed randomly within each experimental unit. Plots were clipped to a 2 cm stubble height and 10 plots were grouped into 8 classes: elk sedge, pinegrass, Kentucky bluegrass, snowberry, other perennial grasses, perennial forbs, annuals/biennials and shrubs. An additional 10 plots were clipped for total production. Production clips were completely dried in a forced air oven at 55°C, and weighted to the nearest tenth gram.

Species composition of herbaceous species spiraea (*Spiraea betulifolia* Pallas), Oregon grape, and snowberry was determined by frequency counts using 30 cm x 30 cm and 30 cm x 60 cm plot sizes at three-meter intervals along each transect; thus providing 10 plots per transect and 30 plots for each experimental unit. Frequency was calculated as the number of plots a given species was present divided by the total number of plots sampled per treatment. Species composition was collected prior to timber harvest in 1985 and then again in 1988, 1991, 1994, 1997, and in 2003. Changes in plant species composition from 1985 were used to determine differences among treatments and years. Several plant community indices were calculated: species richness, general diversity using Shannon diversity index (Shannon and Weaver 1963), and evenness (evenness = Shannon diversity / ln (richness); Pielou 1969). Richness was determined by count of unique plant taxa in the monitoring data.

Shrub cover was measured using the line-intercept method. Shrub canopy measurements were visually rounded and the intercept recorded to the nearest 10 cm with a minimum hole size of 10 cm. Percentage of cover was calculated as the length of the total intercept by each species divided by the transect length. Shrub density, by species, was calculated using a 30 m x 2 m plot; 1 m on each side of the 30 m transect. Since many shrubs sprout from their base, an individual was counted as one stem protruding from the soil surface. Shrub canopy and density were determined prior to timber harvest in 1985 and subsequently in 1988, 1991, 1994, and 2003. Changes in shrub cover and density from 1985 were used to determine differences among treatments and years.

Statistical Analysis

All data were analyzed using the MIXED procedures in SAS (SAS Inst. Inc., Cary, NC) with the block (site replication) effect considered random. The experimental design was a replicated split-plot design within a randomized complete block design with repeated measures, using year as the repeated variable. Timber harvest treatment was analyzed as the whole plot with grazing treatment analyzed as the sub-plot. Treatment means were separated using LSmeans procedures of SAS (SAS Inst. Inc., Cary, NC) and were considered significant at the ($P < 0.05$) level. Only plant species that occurred in all treatment combinations were included in the analysis. However, in order to capture some possible effects on rare species the species richness, Shannon diversity index, evenness and species turnover rates were calculated using all unique plant taxa.

PC-ORD (Version 4, MjM Software Design, Gleneden Beach, OR) was used to analyze the changes in plant community data. Non-metric multidimensional scaling (NMS) ordination was used to compare the differences in plant communities, among timber harvest and herbivory treatments, between 1988, 1991, 1994, 1997 and 2003 with 1985. Results are presented in a series of diagrams where distances between points indicate the degree of similarity. Multi-response permutation procedures (MRPP), for determination of year effects, and blocked MRPP, for determination of timber harvest and herbivory treatment effects which were blocked by site, were also used to compare the differences in plant communities between 1988, 1991, 1994, 1997 and 2003 with 1985. Non-metric multidimensional scaling and MMRP used Sorensen (Bray-Curtis) metric as a measure of dissimilarity. Prior to analysis, a constant of 100 was added to the differences in species composition from 1985 in order to remove the negative values associated with declining species occurrence since 1985. PC-ORD (Version 4) was not capable of conducting a blocked MRPP using the Sorensen (Bray-Curtis) metric; therefore, Euclidean (Pythagorean) metric was used instead. Due to the complex experimental design of this study, PC-ORD required simplification of the data prior to analysis. As a result, year effects were analyzed first, and similar years were grouped together and subsequently analyzed for timber harvest and herbivory main effects. If there were timber harvest main effects, the effects due to herbivory were then analyzed within each timber harvest treatment. Differences, for all analyses, were deemed significant at the level of $P \leq 0.05$.

RESULTS

Canopy Cover

In 2003, canopy cover in the thinned treatments was 18% lower than it was in controlled treatments, and controlled treatments were not different than overstory canopy in 1985. There was no effect ($P > 0.10$) of herbivory on overstory canopy cover.

Understory Production

There was no timber harvest x herbivory x year interaction ($P \geq 0.37$) among any of the production classes. Total production was greater ($P \leq 0.01$) in the thinned treatments than the controls for all years (Table 2). However, total production was greatest ($P \leq 0.01$) in 1989 and then declined by 580 kg • ha^{-1} in 1992 and 1995. Total production increased again in 2003 but it was still less ($P = 0.03$) than was measured in 1989. Total production was also affected by herbivory (Fig. 2) with grazed treatments having 100 kg • ha^{-1} less ($P \leq 0.001$) production than either the cattle or total exclosures.

Production of Kentucky bluegrass was greatest ($P \leq 0.01$) in the thinned treatments in 1989; however, production then declined by 1992 and has remained similar ($P \geq 0.90$) through 2003 (Table 2). In 1989, the thinned treatments were also greater in production than the controls, but this was the only year that this occurred even though the thinned treatments had numerically greater production than control treatments.

Table 2. The effects of timber harvest on the understory production (kg/ha) within a ponderosa pine forest in eastern Oregon.

	Year	Timber Harvest Treatments		
		Thinned	Control	SE
Total Production	1989	1408^{a1}	719^{b12}	168.4
	1992	826^{a2}	578^{b1}	168.4
	1995	875^{a2}	667^{b1}	168.4
	2003	1111^{a3}	873^{b2}	168.4
Kentucky bluegrass	1989	230^{a1}	31^{b}	50.6
	1992	100^{2}	38	50.6
	1995	102^{2}	36	50.6
	2003	105^{2}	48	50.6
Other perennial grasses	1989	269^{a1}	70^{b}	48.2
	1992	144^{2}	79	48.2
	1995	94^{2}	72	48.2
	2003	116^{2}	121	48.2
Perennial forbs*		263^{a}	147^{b}	23.4

* there was no timber harvest x year effect ($P > 0.05$), therefore only main effects for timber harvest are presented.
[a,b] row values with differing superscripts are different at ($P < 0.05$).
[1,2,3] column values with differing superscripts within production groups are different at ($P < 0.05$).

Production of other perennial grasses followed a similar trend as Kentucky bluegrass, with greatest ($P < 0.01$) production occurring in thinned treatments in 1989. However, in 1992 the production of these other grasses tended ($P = 0.06$) to be greater in the thinned treatments when compared to the control pastures. By 1995 and continuing through 2003, there were no differences in production between timber harvest treatments. Perennial forbs were only affected by timber harvest with greater ($P < 0.001$) production occurring in the thinned treatments.

Production of elk sedge was affected by both year and herbivory treatments (Fig. 2, 3). Production was greater ($P \leq 0.01$) in 2003 as compared to 1989 and 1992, with 1995 being intermediate, indicating that production of elk

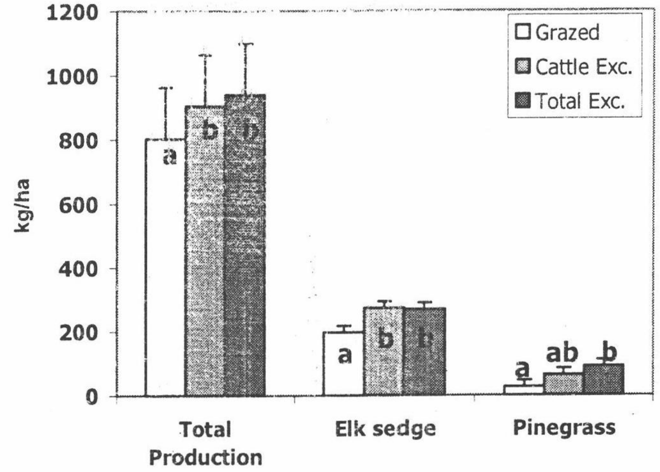

Figure 2. The effects of herbivory treatments on the understory production (kg/ha) within a ponderosa pine forest in eastern Oregon. Herbivory treatments were: Grazed – cattle and big game grazing; Cattle Exc. – cattle exclosure, big game grazing only; Total Exc. -- total exclosure, exclusion of cattle and big game grazing.
(columns with different letters are different at $P < 0.05$.)

sedge was increasing across all treatments. However, grazed treatments had less production of elk sedge than either the cattle or total exclosures. Pinegrass was also affected by herbivory with lower production occurring in the grazed treatments when compared to the total exclosures (Fig. 2).

Snowberry production was affected, but the effect varied by an herbivory year interaction ($P = 0.05$). In 1989, shortly after thinning, production was similar ($P \geq 0.20$) among all herbivory treatments (Fig. 4). However, by 2003 production

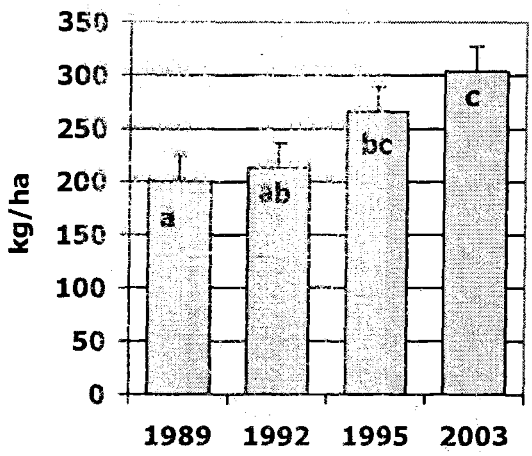

Figure 3. Changes in the production of elk sedge over time within a ponderosa pine forest in northeastern Oregon. (a,b,c bars with different letters are different ($P \leq 0.05$))

was greater ($P \leq 0.01$) in the total exclosures when compared to both the grazed and cattle exclosures.

Species Composition

These sites supported a relatively rich plant community, with a total of 149 plant species documented during the period of study (listed in Appendix A). Of the 100 forbs identified, only 25 species occurred in every treatment combination during the period of study. Prior to the initiation of the study, in 1985 (Table 3), occurrence of plant species showed considerable variation and, as a result, the effects of timber harvest and herbivory treatments were varied and documented

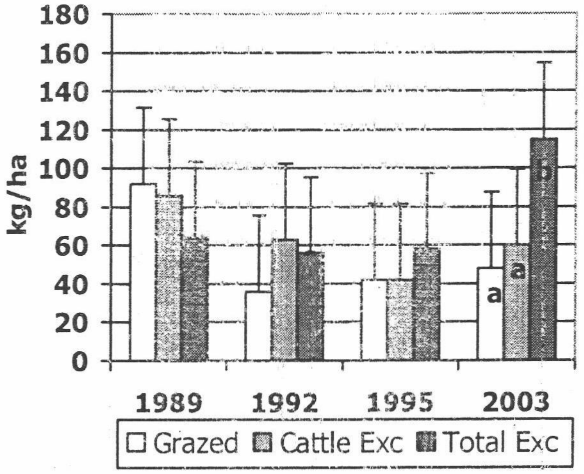

Figure 4. The effects of herbivory treatments on snowberry production (kg/ha) within a ponderosa pine forest in eastern Oregon. Herbivory treatments were: Grazed – cattle and big game grazing; Cattle Exc. – cattle exclosure, big game grazing only; Total Exc. – total exclosure, exclusion of cattle and big game grazing. (a,b columns with different letters, within year, were different at $P < 0.05$.)

limited directional responses (Tables 4, 5, 6; tables only show significant results for affected species).

Although species richness was unaffected by timber harvest and herbivory treatments, species richness was greatest ($P < 0.01$) in 1991 as compared to all other years (Table 7). Species richness in the understory increased from 1985 to 1991 by 28%, from 42 to 54 species, while it decreased from 1991 to 2003 by 42%, from 54 to 31 species on average. Most of the species gained by 1991 and subsequently lost by 2003 were forbs. Plant species diversity showed a similar trend, with diversity being greatest ($P \leq 0.01$) in 1991 and subsequently declining

Table 3. Frequency means for the 35 commonly occurring species in 1985, prior to experiment initiation, in a ponderosa pine forest in northeastern Oregon.

	Mean	SD	Min	Max
Bromus carinatus Hook. & Arn.	0	0	0	0
Carex concinnoides Mackenzie	0	0	0	0
Carex geyeri Boott	72.0	22.0	16.7	96.7
Calamagrostis rubescens Buckl.	18.7	11.3	3.3	40.0
Elymus glaucus Buckl.	10.2	12.0	0	43.3
Melica bulbosa Geyer ex Porter & Coult.	7.6	11.5	0	33.3
Poa pratensis L.	30.9	23.6	3.3	73.3
Trisetum canescens Buckl.	28.0	14.2	6.7	50.0
Achillea millefolium L.	21.7	9.7	10.0	40.0
Anemone piperi Britt. ex Rydb.	0	0	0	0
Antennaria rosea Greene	0	0	0	0
Arnica cordifolia Hook.	47.8	35.1	0	96.7
Claytonia perfoliata Donn ex Willd.	0	0	0	0
Eurybia conspicua (Lindl.) Nesom	0	0	0	0
Fragaria spp.	30.0	16.5	6.7	80.0
Galium spp	19.4	18.3	0	56.7
Hieracium albiflorum Hook.	11.3	11.4	0	50.0
Iris missouriensis Nutt.	0.4	1.1	0	3.3
Lathyrus spp.	42.6	22.1	10.0	86.7
Lupinus spp.	7.8	8.0	0	30.0
Moehringia macrophylla (Hook.) Fenzl	16.3	19.4	0	76.7
Osmorhiza berteroi DC.	20.0	20.48	0	70.0
Potentilla gracilis Dougl. ex Hook.	5.2	7.0	0	23.3
Prunella vulgaris L.	1.3	2.6	0	10.0
Ranunculus spp.	0.6	1.3	0	3.3
Stellaria longipes Goldie	0.4	1.6	0	6.7
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.7	2.15	0	6.7
Taraxacum officinale G.H. Weber ex Wiggers	10.4	12.9	0	50.0
Thalictrum fendleri Engelm. ex Gray	0.6	1.3	0	3.3
Trifolium repens L.	1.5	2.3	0	6.7
Viola adunca Sm.	7.4	9.4	0	30.0
Vicia americana Muhl. ex Willd.	6.5	10.4	0	33.3
Mahonia repens (Lindl.) G. Don	15.7	11.9	0	46.7
Spiraea betulifolia Pallas	3.5	11.9	0	50.0
Symphoricarpos albus (L.) Blake	43.3	16.6	20.0	76.7

Table 4. The effects of timber harvest and year on the difference in species frequency from 1985 in a ponderosa pine forest in northeastern Oregon.

	Timber Harvest	Year					
		1988	1991	1994	1997	2003	SE
Bromus carinatus Hook. & Arn.†	Thin	0^{a}	10.0^{b1}	6.7^{b1}	0^{a}	2.6^{a}	2.1
	Cont	0	0.4^{2}	0^{2}	2.6	0.4	2.1
Carex geyeri Boott†	Thin	-7.0^{ac}	-15.9^{ab1}	-12.2^{ab}	-25.2^{b1}	7.4^{c}	10.7
	Cont	4.4	-1.5^{2}	0.4	5.2^{2}	3.7	10.7
Ranunculus spp.†	Thin	4.1^{ac1}	0^{b}	-1.1^{b}	-1.1^{b}	4.4^{c}	1.2
	Cont	1.1^{2}	0.7	0	0	2.2	1.2
Stellaria longipes Goldie†	Thin	5.6^{a}	7.8^{a1}	0^{bc}	5.9^{a}	-0.7^{c}	1.8
	Cont	1.5	0.7^{2}	0.7	3.0	0	1.8
Calamagrostis rubescens Buckl.		0.9^{a}	0.9^{a}	1.1^{a}	0^{a}	-16.3^{b}	3.2
Trisetum canescens Buckl.		-28.0^{a}	-12.4^{b}	-17.6^{b}	-19.3^{b}	-18.9^{b}	6.0
Eurybia conspicua (Lindl.) Nesom		0^{a}	0^{a}	8.5^{b}	0.7^{a}	0^{a}	1.4
Fragaria spp.		-0.9^{a}	-10.6^{b}	-9.3^{b}	-14.0^{b}	-11.1^{b}	6.0
Prunella vulgaris L.		2.0^{a}	-0.7^{bc}	1.5^{ab}	-0.9^{c}	-1.3^{c}	0.8
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*		-0.5^{a}	4.6^{ab}	10.9^{b}	13.9^{c}	17.8^{c}	2.8
Vicia americana Muhl. ex Willd.		2.0^{ab}	6.9^{a}	-0.6^{bc}	1.9^{abc}	-3.7^{c}	2.3
Mahonia repens (Lindl.) G. Don		0.6^{a}	2.2^{a}	4.1^{ab}	0^{a}	8.5^{b}	3.0

* Timber harvest treatment: Thin – commercial thinning; Cont - control.
† Species with a timber harvest x year interaction ($P \leq 0.05$).
[a,b,c] row values with differing superscripts are different ($P \leq 0.05$).
[1,2] column values with differing superscripts within species are different at ($P < 0.05$).

to its lowest ($P < 0.001$) levels by 2003. Values for the Shannon diversity index increased from 3.13 to 3.36 for 1985 to 1991 and then declined to 2.85 by 2003. Values for species evenness represented good equity in the distribution of plant species across the sites. There was a decrease ($P \leq 0.05$) in equity over time; this decline may be due to the changes in species turnover.

Table 5. The effects of timber harvest and herbivory on the change in species frequency from 1985 in a ponderosa pine forest in northeastern Oregon.

	Timber Harvest*			Herbivory†			
	Thin	Cont	SE	Graze	CExc	TExc	SE
Elymus glaucus Buckl.	12.4	9.6	6.4	12.8[a]	15.2[a]	4.9[b]	2.5
Trisetum canescens Buckl.	-22.1[a]	-16.1[b]	5.6	-10.2[a]	-25.8[b]	-21.6[b]	5.7
Arnica cordifolia Hook.	-7.7	-1.6	6.2	2.0[a]	-9.2[b]	-5.7[b]	5.5
Achillea millefolium L.	7.8[a]	-8.3[b]	2.3	5.7	-1.3	-5.1	2.6
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	12.4[a]	6.3[b]	2.1	11.2	10.6	6.2	2.3
Claytonia perfoliata Donn ex Willd.	1.4	2.2	1.3	3.3[a]	1.6[b]	0.6[b]	1.1
Lathyrus spp.	-19.5[a]	-2.2[b]	4.0	-5.3[a]	-21.8[b]	-5.4[a]	4.6
Potentilla gracilis Dougl. ex Hook.	-3.4[a]	-0.4[b]	1.9	-1.1	-0.8	-3.9	2.0
Viola adunca Sm.	0.3	0	4.2	3.4[a]	0[ab]	-3.8[b]	5.5
Vicia americana Muhl. ex Willd.	4.5[a]	-2.4[b]	1.9	3.1	-0.2	3.1	1.9

* Timber harvest treatment: Thin – commercial thinning; Cont - control.

† Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.

a,b values with differing superscripts are different at ($P < 0.05$).

Species turnover rates (Table 8) indicated that until 2003, species lost were similar to colonization by new species. But, in 2003 there was an increase in species lost from the sites and a reduction in colonization by new species.

Shrub Density and Cover

Shrubs were not a major component of these sites in 1985 (Table 9) and were highly variable across locations. There was no year x timber harvest x herbivory

Table 6. The effects of timber harvest and herbivory on the change in understory species frequency from 1985 in a ponderosa pine forest in northeastern Oregon.

	Timber Harvest*	Herbivory[†]			
		Graze	CExc	TExc	SE
Calamagrostis rubescens Buckl.	Thin	-7.3[a]	-0.2[ab1]	-4.4[a1]	2.7
	Cont	-1.1[a]	-8.2[b2]	5.3[a2]	2.7
Poa pratensis L	Thin	21.8[a1]	12.7[ab]	8.7[b1]	5.4
	Cont	-2.2[a2]	10.9[b]	-12.2[a2]	5.4
Antennaria rosea Greene	Thin	0.4[a]	5.6[b1]	2.0[a]	1.1
	Cont	1.6	1.8[2]	0.4	1.1
Fragaria spp.	Thin	-13.1[a]	2.4[b1]	-14.9[a]	6.2
	Cont	-5.6[a]	-15.3[b2]	-8.7[ab]	6.2
Hieracium albiflorum Hook.	Thin	3.8[ab1]	-2.4[a]	4.9[b1]	3.5
	Cont	-10.7[2]	-3.6	-10.2[2]	3.5
Iris missouriensis Nutt.	Thin	-0.9[a]	1.1[b1]	0.7[b]	0.5
	Cont	0.2[ab]	-0.9[a2]	1.3[b]	0.5
Lupinus spp.	Thin	5.8[1]	10.2	5.8[1]	4.0
	Cont	-8.9[a2]	7.3[b]	-17.6[a2]	4.0
Osmorhiza berteroi DC.	Thin	-16.4	-14.9	-10.9	13.2
	Cont	-5.8[a]	-18.4[b]	-5.8[a]	13.2
Prunella vulgaris L.	Thin	2.4[1]	0.2	0.2	0.9
	Cont	-3.1[a2]	-0.2[b]	1.1[b]	0.9
Ranunculus spp.	Thin	0[a]	-0.4[a]	4.2[b1]	0.8
	Cont	0.9	1.3	0.2[2]	0.8
Taraxacum officinale G.H. Weber ex Wiggers	Thin	-0.7[a]	-16.7[b1]	-5.6[a]	5.5
	Cont	-2.7	-2.0[2]	-6.7	5.5
Symphoricarpos albus (L.) Blake	Thin	-2.0[a]	7.1[ab]	9.1[b]	6.0
	Cont	4.0[a]	-10.4[b]	2.9[a]	6.0

*Timber harvest treatment: Thin – commercial thinning; Cont - control.
[†] Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.
[a,b] row values with differing superscripts are different at ($P < 0.05$).
[1,2] column values with differing superscripts within species are different at ($P < 0.05$).

interactions with any species density or cover. The changes in wax current (*Ribes cereum* Dougl.) density (Table 9) was affected by a timber harvest x herbivory interaction ($P = 0.02$). Number of wax current shrubs only increased ($P \leq 0.05$) in the control treatments where all large ungulate herbivory was excluded.

Table 7. Plant species richness, diversity, and evenness responses to timber harvest and herbivory in a ponderosa pine forest in northeastern Oregon.

	Thinned Overstory			Control Overstory		
	Grazed	Cattle Exc.	Total Exc.	Grazed	Cattle Exc.	Total Exc.
No. of species						
1985[a]	38	42	40	42	41	51
1988[a]	43	48	42	42	43	43
1991[b]	54	56	52	49	58	55
1994[a]	46	40	39	44	42	42
1997[a]	41	42	44	46	43	43
2003[c]	34	33	32	30	30	29
Shannon diversity						
1985[ac]	2.98	3.11	3.05	3.25	3.02	3.36
1988[ab]	3.16	3.22	3.18	3.17	3.14	3.18
1991[b]	3.34	3.38	3.34	3.33	3.41	3.37
1994[a]	3.29	3.09	3.20	3.22	3.07	3.08
1997[c]	3.05	3.10	3.18	3.21	3.12	3.04
2003[d]	2.86	2.86	2.90	2.86	2.76	2.87
Evenness						
1985[a]	0.82	0.83	0.83	0.87	0.81	0.86
1988[a]	0.84	0.83	0.85	0.85	0.83	0.85
1991[a]	0.84	0.84	0.85	0.86	0.84	0.84
1994[a]	0.86	0.84	0.87	0.85	0.82	0.82
1997[b]	0.82	0.83	0.84	0.84	0.83	0.81
2003[b]	0.83	0.81	0.83	0.84	0.81	0.85

[a,b,c,d] Years with differing superscripts are different ($P < 0.05$).

Herbivory treatments also affected ($P \leq 0.01$) the changes in wild rose (*Rosa gymnocarpa* Nutt.) density (Table 10, Fig. 5), with total exclosures changing more than either the grazed or cattle exclosures. Rose density increased by 17 plants • ha^{-1} in the total exclosures from 1985 to 2003, but the grazed and cattle exclosures density of wild rose was not different ($P \geq 0.10$) than it was in 1985. Wild rose density also changed ($P < 0.01$) over time, with an increase ($P = 0.001$) of 20 plants • ha^{-1} by 2003.

Table 8. Understory species turnover rates from 1985 to 1988, 1991, 1994, 1997 and 2003 in a ponderosa pine forest in northeastern Oregon.

	# of new species since 1985	# of species lost since 1985
1988	10.8[1]	9.7[1]
1991	14.8[2]	9.6[1]
1994	10.7[1]	11.0[1]
1997	10.5[1]	10.8[1]
2003	6.8[3]	14.1[3]
SE	0.9	1.3

[1,2,3] values within columns with different superscripts are different ($P < 0.05$)

Table 9. Shrub species density (#/ha) and cover in 1985, prior to experiment initiation, in a ponderosa pine forest in northeastern Oregon.

		Mean	SD	Min	Max
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	Density	1.7	1.7	0	6.3
	Cover	0.7	2.0	0	8.3
Crataegus douglasii Lindl.	Density	1.9	2.4	0	9.3
	Cover	0.8	1.7	0	5.6
Holodiscus discolor (Pursh) Maxim.	Density	0.1	0.3	0	1.3
	Cover	0.2	0.5	0	1.9
Physocarpus malvaceus (Greene) Kuntze	Density	0.1	0.4	0	1.7
	Cover	0.1	0.4	0	1.4
Prunus virginiana L.	Density	0.2	0.8	0	3.7
	Cover	0	0	0	0
Ribes cereum Dougl.	Density	1.9	4.0	0	13.0
	Cover	1.1	2.5	0	8.8
Rosa gymnocarpa Nutt.	Density	6.5	7.0	0	27.3
	Cover	0.6	1.0	0	3.3

Changes in serviceberry (*Amelanchier alnifolia* (Nutt.) Nutt. ex M. Roemer) cover (Table 10) of the total exclosures was different ($P \leq 0.05$) than either the grazed or cattle exclosures. Cover within total exclosures increased ($P = 0.001$) while cover in both grazed and cattle exclosures has not changed ($P \geq 0.25$) since 1985. Changes in wild rose cover were also detected ($P = 0.01$) among the herbivory treatments; however, they were not different ($P \geq 0.35$) than the cover measured in 1985.

Table 10. The effects of timber harvest and herbivory on the changes from 1985 of understory shrub density (#/ha) and cover in a ponderosa pine forest in northeastern Oregon.

	Timber	Density				Cover			
		Herbivory Treatments†				Herbivory Treatments			
	Harv.*	Gr	CExc	TExc	SE	Gr	CExc	TExc	SE
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer		0.6	-0.4	2.0	0.5	0.6[a]	-0.4[a]	2.0[b]	0.5
Rosa gymnocarpa Nutt.		6.8[a]	5.2[a]	17.8[b]	3.7	-0.3[a]	0[ab]	0.3[b]	0.3
Ribes cereum Dougl.[Y]	Thin	0.8	0.2	0[1]	2.3	0.1	-0.1	-0.2	0.9
	Cont	1.0[a]	-0.8[a]	7.8[b2]	2.3	-1.3	-1.0	-1.6	0.9

*Timber harvest treatment: Thin – commercial thinning; Cont - control.
† Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.
[Y] Species with a timber harvest x herbivory interaction ($P \leq 0.05$).
[a,b] row values with differing superscripts are different at ($P < 0.05$).
[1,2] column values with differing superscripts within species are different at ($P < 0.05$).

Plant Community Responses

Initial NMS ordination and MRPP analysis of pretreatment data, 1985, indicated that there were differences ($P < 0.001$, A = 0.24) among replicate sites, therefore all subsequent analyses were blocked by site. There was an affect ($P = 0.003$, A = 0.07) of year on plant community structure, with 1991, 1994 and 1997 being similar to each other and different from both 1988 and 2003. Analysis of 1988 plant community data revealed that there were no timber harvest effects or

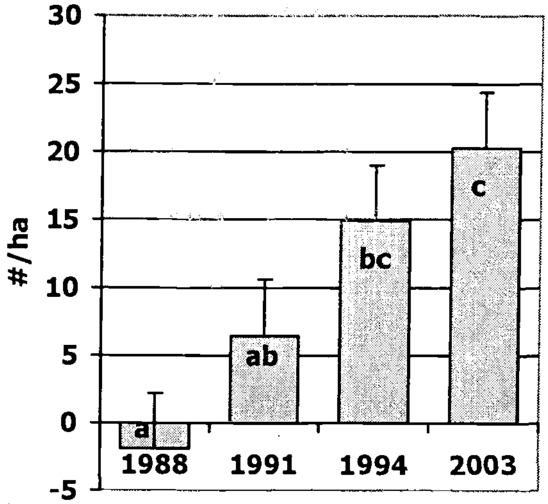

Figure 5. The changes in rose (*Rosa gymnocarpa* Nutt.) density over time between 1988, 1991, 1994 and 2003 with 1985. (a,b,c bars with different letters are different ($P \leq 0.05$))

herbivory effects. However, NMS analysis of plant community data for 1991 through 1997 revealed that timber harvest may be changing plant communities. Subsequent blocked MMRP analysis determined that there was a tendency ($P =$ 0.08, A = 0.15) for timber harvest to affect the plant community. However, by 2003 (Fig. 6) the NMS ordination revealed that there was continued separation among sites since 1985 and there was a continued divergence of plant communities due to timber harvest treatments, therefore only 2003 data are presented. Blocked MMRP analysis subsequently determined that there was a tendency for a timber harvest ($P =$ 0.07, A = 0.20) effect on plant community structure.

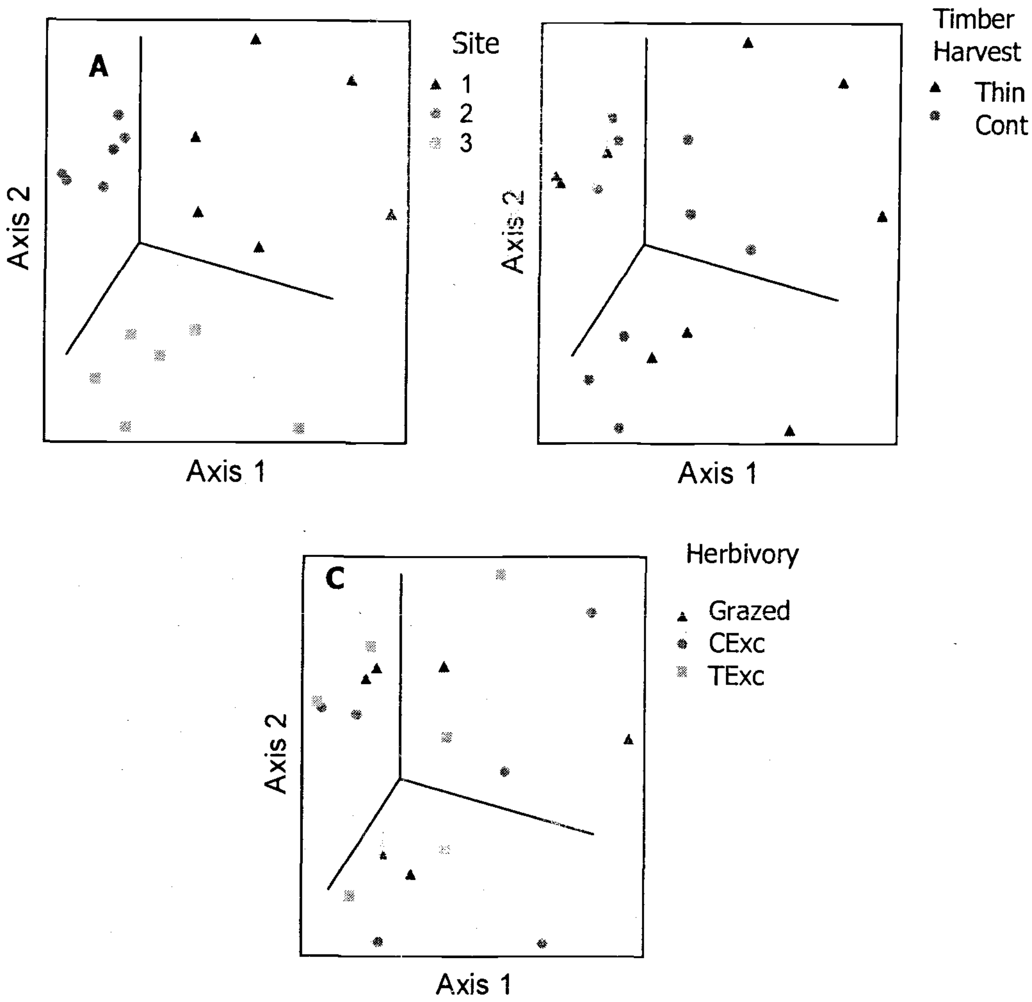

Figure 6. NMS Ordination of understory species composition in 2003 of (A) site differences, (B) timber harvest effects, (C) herbivory effects in a ponderosa pine forest in northeastern Oregon. Lines in charts demonstrate separation of sites. (Timber harvest treatment: Thin – commercial thinning; Cont - control.Herbivory treatments: Grazed – cattle and big game grazing; Cattle Exc – cattle exclosure, big game grazing only; Total Exc – total exclosure, exclusion of cattle and big game grazing.)

DISCUSSION

The understory vegetation increased with the reduction of overstory canopy cover. Total understory production was greatest following experiment initiation and was influenced by timber harvest and herbivory. Many researchers (McConnell and Smith 1965, 1970; Young et al. 1967; Thompson and Gartner 1971; Long and Turner 1975; Vora 1993) have also documented that understory production increased with reduction in canopy cover. McConnell and Smith (1965, 1970) indicated that understory response to thinning was greater at 8 years compared to 3 years. However, in our study, understory production was greatest 3 years following thinning. Riegel et al. (1992) determined that increased understory vegetation production to timber harvest was a result of reduced competition for resources, mainly nitrogen and water. Therefore, a reason for the early peak in understory production was likely due to expansion of roots systems from remaining ponderosa pine trees, again causing increased competition for the available resources. As a result, differences in understory production in thinned and control treatments have remained steady at approximately 230 kg • ha^{-1} from 1992 through 2003.

Understory production responses to timber harvest were not proportional among graminoids, forbs and shrubs. Graminoid species were primarily responsible for the increased production measured in thinned treatments. Production of forbs moderately increased within thinned treatments, whereas shrub production was not different in any period following timber harvest. Pase

(1958) and McConnell and Smith (1965, 1970) also documented that the responses from grasses were greater than either forbs or shrubs to reduction in canopy cover.

Cattle and native ungulates should benefit from reduction in overstory canopy, with increased production of graminoids and forbs. Cattle tend to avoid areas of lower production (Harris 1954; Roath and Krueger 1982; Gillen et al. 1984) and cattle diets are dominated by graminoids with minimal amounts of forbs and shrubs (Holechek et al. 1982; Mitchell and Rodgers 1985; Walburger 2005). Whereas, the composition of mule deer and elk diets, during the summer months, have greater amounts of forbs and shrubs with lower amounts of graminoids (Findholt et al. 2004; Beck and Peek 2005), but graminoid consumption by elk varies depending on time of year (Gibbs et al. 2004). Gibbs et al. (2004) reported that elk diets were high in graminoids in May and June, 80% of diet, and then consumption dropped dramatically in July and August, to < 50% of diet.

Herbivory can also influence the production of understory species. The effects of cattle grazing on total production were primarily due to the reduction in the production of elk sedge. Elk sedge has been noted as the most prominent forage species in the diets of cattle during the summer in northeastern Oregon (Skovlin et al. 1976). Holechek et al. (1982) determined that elk sedge in cattle diets was as high as 23% in late summer and 24% in fall. As documented by this study, elk sedge may not be able to maintain production following 60% utilization on ponderosa pine sites.

Herbivory by large ungulates also affected the production of snowberry within thinned treatments. Krueger and Winward (1974) reported that cattle and big game also reduced snowberry in a Douglas-fir\ponderosa pine\Kentucky bluegrass community in northeastern Oregon. The exclusion of cattle, mule deer, and elk in the Blue Mountains of Oregon has resulted in a 2.7 times greater production of shrub species inside exclosures than outside (Riggs et al. 2000).

Few plant species in this study demonstrated a significant directional change to timber harvest or herbivory treatments. This could be due to several factors: first, plant communities at the beginning of the study, in 1985, were different in all of the replicates even though they were classified as the same habitat type. The continuation of the differences in plant communities by 2003 among the replicates was still evident (Fig. 6). A closer examination of the NMS ordination analysis reveals that the plant communities, within each replicate, are responding differently to timber harvest. Therefore, any directional plant species responses within this study may be confounded by another replicate.

Secondly, by utilizing a timber harvest technique that minimizes soil disturbance, such as in this study, secondary succession may not have been initiated. As a result, residual species were able to dominate these sites. It has been documented that predisturbance plant species (Halpern 1989; Selmants and Knight 2003) and level of disturbance (Halpern 1989; Griffis et al. 2001) contribute to the observed successional responses and resultant plant species following disturbance. Furthermore, Halpern (1989) documented that understory plant communities with minimal disturbances were dominated by predisturbance plant species. Stohlgren et al. (1999) also determined that few plant species showed consistent directional responses to grazing or the removal of grazing.

Finally, three major soil series occur across these sites (Riegel et al. 1992). Bennett et al. (1987) reported that soil types as well as canopy cover influenced understory production. Further, they commented that differences in soils may have the ability to influence understory vegetation. In addition, Stohlgren et al. (1999) concluded that soil characteristics, climate, and disturbances may have a greater effect on plant species than grazing.

We found no influences of timber harvest or herbivory on community richness, Shannon diversity, evenness or species turnover rates. However, species richness and diversity were greatest 6 years following experiment initiation, whereas, evenness began to decline 11 years following experiment initiation, possibly indicating increasing dominance of the site by a few species. Schoonmaker and Mckee (1988) reported that diversity increased weakly and peaked at 15 years post-harvest while species richness was greatest 20 years post-harvest in coniferous forests of the western Cascade Mountains of Oregon. Griffis et al. (2001) concluded that the increase in species richness following a disturbance was primarily due to exotic species in a northern Arizona ponderosa pine forest. They also concluded that exotic species invasion increased with intensity of disturbance. However, in this study increased species richness was not due to exotic species. The possible reason for the lack of responses to timber harvest was that these ponderosa pine forests were only thinned and intensity of disturbance was minimized. Stohlgren et al. (1999) and Riggs et al. (2000) also found no differences in richness, diversity, or evenness attributable to herbivory.

IMPLICATIONS

Timber harvest and herbivory have the potential to change plant community structure and composition as well as understory production. Timber harvest had the greatest effect on understory production and plant community structure. Consequently, by minimizing disturbances on a site the effects on the resultant species and plant communities are minimal and will probably be determined by the plant community structure prior to the disturbance and the physical and microclimatic characteristics of that location.

Utilization rates approaching 60% are not recommended by current grazing plans; therefore, the effects of cattle upon forested rangelands should not be as dramatic. Deer and elk herbivory influenced the production and occurrence of several species, but mainly shrubs. As a result, the impacts of large herds of deer and elk may be as influential on potential successional pathways of understory vegetation as cattle grazing.

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CHAPTER 3

The Effects of Herbivory and Timber Harvest on Understory Vegetation in a Grand Fir (*Abies grandis*) Habitat in Northeastern Oregon.

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ABSTRACT

The objectives of this study were to document the effects of logging and herbivory, cattle and native ungulates, on understory vegetation within a grand fir (*Abies grandis*) habitat. Three replicated sites were established in 1986. Grand fir sites were arranged as a split-plot design; timber harvest treatments [1) no harvest (CON), 2) thinning (TH), 3) clearcut (CL)] were whole plots and herbivory treatments [1) cattle and native ungulate grazing (GR), 2) native ungulate grazing (BG), and 3) exclusion of cattle and native ungulate grazing (EX)] were the sub-plots. Understory production was affected by timber harvest and herbivory. Total production in CL was 350 kg · ha^{-1} greater ($P < 0.05$) than TH, and TH was 275 kg · ha^{-1} greater ($P < 0.05$) than CON. Total production in GR was 102 kg · ha^{-1} greater than EX. A total of 141 species were identified on these sites, however, only 29 of these species occurred in all treatment combinations and were used for analysis. Timber harvest treatment had a greater magnitude of effect than did herbivory on understory plant species. Differences were observed among timber harvest and herbivory treatments on individual shrub species density and cover. The NMS ordination and MMRP analysis revealed that plant communities were different in 1985 prior to study initiation and these differences were maintained through 2003. Plant communities were affected by timber harvest and herbivory treatments. There appeared to be differences among all timber harvest treatments, whereas, among herbivory treatments, EX appeared to be different than GR and BG. This research indicates that the effects of timber

harvest may have a greater effect on understory vegetation composition, structure, and diversity than herbivory.

KEYWORDS: Beef cattle, Native ungulates, Mule deer, Elk, Mixed conifer

INTRODUCTION

Forests of the interior Northwest on average, receive greater precipitation, have deeper soil profiles, and have greater soil moisture holding capacity than adjacent grasslands (Riggs et al. 2004). These forests provide valuable habitat for many wildlife species and summer grazing allotments for beef cattle. However, over the last 100 years, many of these forests have developed into relative homogeneous stands in composition and structure of fire-sensitive and disease-susceptible species (Belsky and Blumenthal 1997; Hessburg et al. 2005), thereby reducing the overall understory productivity of the area. Many areas with high potential for timber harvest and forage production have the lowest output due to dense canopy cover (Hedrick et al. 1969).

In order to enhance forage production and create a diversity of habitats it may be necessary to open the canopy. Timber harvest on forested rangelands sets back succession and, in most cases, increases understory forage production. Forage production response to overstory canopy cover is well documented (McConnell and Smith 1965 and 1970; Jameson 1967; Young et al. 1967; Thompson and Gartner 1971) and documents that as overstory canopy cover decreases understory production (kg/ha) increases.

Large herbivores are attracted to areas of higher forage production and palatable food resources, and as a result of timber harvest, it can be expected that they will focus their foraging within these areas (Vavra et al. 2004). Hobbs (1996), Augustine and McNaughton (1998), Riggs et al. (2000), and Kie and

Lehmkuhl (2001) all documented that herbivory can influence plant community structure, composition and production. Ungulate herbivory directly affects vegetation through selective feeding and the ability of a plant to recover from herbivory (Augustine and McNaughton 1998). However, plant species diversity is not consistently affected by grazing (Stohlgren et al. 1999, Riggs et al. 2000, and Brockway and Lewis 2003), but individual species, at the local level, are affected by herbivory and timber harvest. Herbivory has the greatest effect in altering plant community structure within clearcuts (Riggs et al. 2000). Stohlgren et al. (1999) also documented grazing effects on local species, however few plant species showed consistent directional responses to grazing.

Little is known about how plant community structure responds when combining the effects of herbivory and reduction of overstory canopy within a grand fir forest. Therefore the objective of this study was to document the effects of timber harvest and herbivory on understory vegetation composition, structure, diversity and production.

MATERIALS AND METHODS

The study area is located at the Eastern Oregon Agricultural Research Center's Hall Ranch that is approximately 16 km east of the city of Union in the Wallowa Mountains of northeastern Oregon. Elevation ranges from 1050 to 1250 m. Summers tend to be dry and warm with temperatures rarely exceeding 38°C, though freezing or near-freezing temperatures are possible all year. Winters are cold and wet, with the majority of the precipitation (66 cm average) coming in the form of snow between November and May (Table 1). Elk (*Cervus elaphus* L.) and mule deer (*Odocoileus hemionus* Raf.) are indigenous to the area and can be found throughout the year; however, heaviest use occurs in spring and fall.

Table 1. Precipitation data (cm), for vegetation sampling years, from weather station located at Eastern Oregon Agriculture Research Center's Hall Ranch.

Year	Precipitation (cm)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1985	1.3	4.3	3.8	4.1	5.8	3.3	1.0	2.5	5.3	5.6	8.9	2.5	48.5
1991	4.6	3.0	6.6	6.1	13.0	7.9	0.5	0.3	0.0	3.8	11.4	2.0	59.2
1994	6.1	7.6	2.3	7.4	7.4	3.3	1.0	0.0	0.8	3.6	10.4	3.6	53.3
1995	9.7	3.0	9.1	9.7	6.9	7.6	2.0	4.1	1.3	4.1	12.4	9.1	79.0
1997	5.8	5.3	1.5	10.4	4.3	3.6	5.3	1.3	3.3	3.8	4.1	7.6	56.4
2003	6.1	6.4	9.9	7.4	7.1	1.0	0.0	3.6	2.5	2.0	3.6	8.9	58.4
Avg.	5.9	4.9	5.5	6.1	6.6	4.7	1.6	1.8	2.3	3.6	6.6	5.9	55.6

Three replicated sites, of an *Abies grandis* (Dougl. ex D. Don) Lindl. / *Pachistima myrsinites* (Pursh) Raf. (grand fir) habitat type, were selected to analyze the effects of herbivory and logging on understory plant communities. Areas of relatively homogeneous stand structure were initially selected and experimental sites were subsequently chosen from these areas. The grand fir sites had three timber harvest treatments applied to them (Figure 1): 1) clear cut, 2) crown thinning (thinned) and 3) uncut (Control). Crown thinning consisted of removing co-dominant and some dominant trees. Timber harvest began in 1985 and was completed by 1986. To protect herbaceous vegetation and minimize soil disturbance from the impact of skidding, spacing between skid trails was at least 36.5 m if soils were not frozen and with adequate snow cover. The grand fir

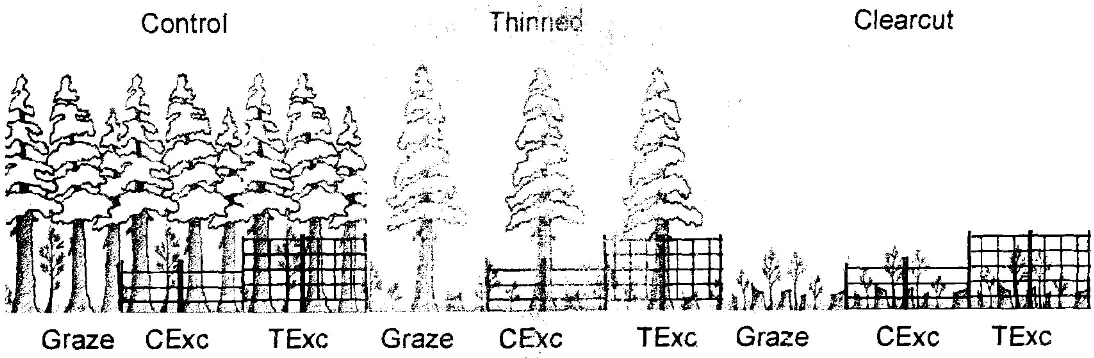

Figure 1. Layout of the timber harvest (control, thinned and clearcut) and herbivory (Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing) treatments for each grand fir site.

clearcuts were replanted in the spring of 1988 with Ponderosa pine (*Pinus ponderosa* P. & C. Lawson), Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco) and western larch (*Larix occidentalis* Nutt.). Understory vegetation was highly variable and composed of many graminoid, forb, and shrub species. Common graminoids included elk sedge (*Carex geyeri* Boott), pinegrass (*Calamagrostis rubescens* Buckl.), Kentucky bluegrass (*Poa pratensis* L.) and blue wildrye (*Elymus glaucus* Buckl.). Common forbs include western yarrow (*Achillea millefolium* L. var. *occidentalis* DC.), strawberries (*Fragaria* spp.), bedstraws (*Galium* spp.), lupines (*Lupinus* spp.), and heart leafed arnica (*Arnica cordifolia* Hook.). Common shrubs were snowberry (*Symphoricarpos albus* (L.) Blake), Oregon grape (*Mahonia repens* (Lindley) G. Don), and ninebark (*Physocarpus malvaceus* (Greene) Kuntze). Although grand fir was the dominant overstory species, in thinned and control treatments, Douglas fir, western larch and Ponderosa pine were still found.

The following grazing treatments were applied to each timber harvest treatment: 1) grazing by cattle and native ungulates (to achieve 60 percent utilization), 2) native ungulate grazing only, and 3) exclusion of cattle and native ungulates. Grand fir grazing exclosure fencing was completed in 1986, but perimeter fencing was not completed until 1994; therefore pastures were grazed in common by allotment cattle, from September to November. Following completion of perimeter fencing in 1994, pastures were grazed in a deferred rotation system with pastures grazed from mid-July to mid-August in odd years and mid-August to the beginning of October in even years. Grazing by cattle was removed during 2001, but in 2002 and 2003 pastures were grazed from mid-August to mid-October by allotment cattle.

Vegetation Sampling

Vegetation was monitored using the same procedures for all collection periods. Three permanent transect lines, 30 m in length, were established in all treatment combinations to monitor vegetation changes. These permanent transects were used to determine overstory cover, understory species frequency, shrub cover and shrub density. A spherical densiometer (Strickler 1959) was used to determine percent overstory canopy at 0, 15 and 30 m along each 30 m transect. Canopy cover was determined prior to timer harvest and again in 2003.

Species composition of each herbaceous species and low growing shrubs (spiraea (*Spiraea betulifolia* Pallas), Oregon grape, and snowberry) was determined by frequency counts using 30 cm x 30 cm and 30 cm x 60 cm plot sizes at three-meter intervals along each transect; thus providing 10 plots per transect and 30 plots for each experimental unit. Frequency was calculated as the number of plots containing a given species divided by the total number of plots sampled per treatment. Species composition was collected prior to timber harvest in 1985 and then again in 1994, 1997, and in 2003. Changes in plant species composition from 1985 were used to determine differences among treatments and years. Several plant community indices were calculated: species richness, general diversity using Shannon diversity index (Shannon and Weaver 1963), and evenness (evenness = Shannon diversity / ln (richness); Pielou 1969). Richness was determined by count of unique plant taxa in the monitoring data.

Shrub cover was measured using the line-intercept method. Shrub canopy measurements were visually rounded and the intercept recorded to the nearest 10 cm with a minimum hole size of 10 cm. Percent cover was calculated as the length of the total intercept by each species divided by the transect length. Shrub density, by species, was calculated using a 30 m x 2 m plot; 1 m on each side of the 30 m transect. Since many shrubs sprout from their base, an individual was counted as one stem protruding from the soil surface. Shrub canopy and density were determined prior to timber harvest in 1985, 1991, 1994 and 2003. Changes in shrub canopy cover and density from 1985 (Table 2) were used to determine differences among treatments and years.

Herbaceous production was measured in 2003 by clipping 0.5 m x 1.0 m rectangular plots placed randomly within each experimental unit. Plots were clipped to a 2 cm stubble height and grouped into 7 classes: elk sedge, pinegrass, Kentucky bluegrass, other perennial grasses, perennial forbs, annuals/biennials and shrubs. Production clips were completely dried, in a forced air oven at 55 degrees Celsius, and weighted to the nearest tenth gram. Production was also measured in 1995, but only data for total production was available.

Statistical Analysis

All data were analyzed using the MIXED procedures in SAS (SAS Inst. Inc., Cary, NC) with the block (site replication) effect considered random. The experimental design was a split-plot within a randomized complete block design with repeated measures, using year as the repeated variable, and three replications. Logging treatment was treated as the whole plot with grazing treatment analyzed as the sub-plot. Treatment means were separated using LSmeans procedures of SAS (SAS Inst. Inc., Cary, NC) and were considered significant at the ($P < 0.05$) level. Only plant species that occurred in all treatment combinations were included in the analysis. However, in order to capture some possible effects on rare species the species richness, Shannon diversity index, evenness and species turnover rates were calculated using all unique plant taxa.

PC-ORD (Version 4, MjM Software Design, Gleneden Beach, OR) was used to analyze all of the plant community data. Non-metric multidimensional scaling (NMS) ordination was used to compare the differences in plant communities, among logging and grazing treatments, between 1988, 1991, 1994, 1997 and 2003 with 1985. Results are presented in a series of diagrams where distances between points indicate the degree of similarity. Multi-response permutation procedures (MRPP), for determination of year effects, and blocked MRPP, for determination of timber harvest and herbivory treatment effects which were blocked by site, were also used to compare the differences in plant communities between 1988, 1991, 1994, 1997 and 2003 with 1985. Non-metric multidimensional scaling and MMRP used Sorensen (Bray-Curtis) metric as a measure of dissimilarity. Prior to analysis, a constant of 100 was added to the differences in species composition from 1985 in order to remove the negative values associated with declining species occurrence since 1985. PC-ORD was not capable of conducting a blocked MRPP using the Sorensen (Bray-Curtis) metric; therefore, Euclidean (Pythagorean) metric was used instead. Due to the complex experimental design of this study, PC-ORD required simplification of the data prior to analysis. As a result, year effects were analyzed first, and similar years were grouped together and subsequently analyzed for timber harvest main effects. If there were timber harvest main effects, the effects due to herbivory were analyzed within each timber harvest treatment. The data was simplified in this manner because of the original split-plot design. Differences, for all analyses, were deemed significant at the level of $P \leq 0.05$.

RESULTS

Canopy Cover

Timber harvest in 1986 affected ($P < 0.001$) the overstory canopy in 2003 (Fig. 2). Overstory canopy cover was greatest in the controls, intermediate in the thinned and least in the clearcuts, 81, 50, and 30% respectively. The overstory canopy in the clearcuts was comprised predominantly of ponderosa pine, but grand fir seedlings were present throughout the treatment.

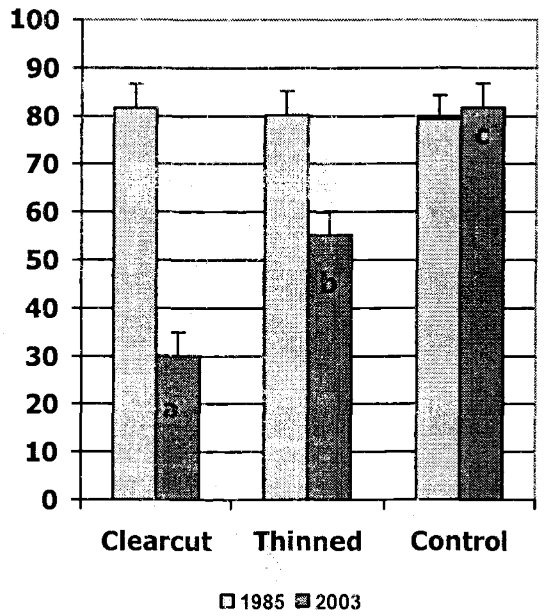

Figure 2. Overstory canopy cover (%) of grand fir sites in 1985, prior to timber harvest, and subsequently in 2003. Columns are means + SE bars. (a,b,c bars, within year, with different letters were different at $P < 0.05$)

Species Composition

Species composition in 1985 was extremely variable (Table 2 and 3), but, there were differences ($P \leq 0.05$) in the species composition among sites, timber harvest and herbivory treatments. Therefore, changes in species composition from 1985 were analyzed for 1994, 1997 and 2003.

Table 2. Species frequency means in 1985, prior to experiment initiation, in a grand fir forest in northeastern Oregon.

	Mean	SD	Min	Max
Bromus carinatus Hook. & Arn.	0.3	1.3	0	6.7
Bromus inermis Leyss.	0	0	0	0
Carex concinnoides Mackenzie	6.5	6.9	0	26.7
Carex geyeri Boott	53.9	21.4	6.7	86.7
Calamagrostis rubescens Buckl.	15.2	9.0	2.2	41.1
Elymus glaucus Buckl.	3.9	5.6	0	16.7
Festuca occidentalis Hook.	23.5	12.0	6.7	53.3
Luzula campestris (L.) DC.	3.9	3.8	0	13.3
Melica bulbosa Geyer ex Porter & Coult.	24.4	13.1	0	53.3
Poa pratensis L.	7.6	12.7	0	44.4
Trisetum canescens Buckl.	28.0	13.0	6.7	50.0
Achillea millefolium L.	8.3	7.6	0	26.7
Anemone piperi Britt. ex Rydb.	22.0	16.4	0	66.7
Arnica cordifolia Hook.	41.9	16.2	16.7	72.2
Eurybia conspicua (Lindl.) Nesom	5.2	11.6	0	50.0
Fragaria spp.	48.8	14.8	26.7	80.0
Galium spp	7.9	15.5	0	63.3
Hieracium albiflorum Hook.	10.1	5.9	0	23.3
Lathyrus spp.	44.4	11.3	20.0	70.0
Lupinus spp.	4.5	7.0	0	26.7
Moehringia macrophylla (Hook.) Fenzl	44.5	17.1	10.0	80.0
Senecio integerrimus Nutt.	0	0	0	0
Stellaria longipes Goldie	0.1	0.6	0	3.3
Taraxacum officinale G.H. Weber ex Wiggers	4.1	4.4	0	15.6
Thalictrum fendleri Engelm. ex Gray	26.6	19.0	0	76.7
Viola adunca Sm.	14.6	7.0	3.3	30.0
Mahonia repens (Lindl.) G. Don	3.4	3.5	0	13.3
Spiraea betulifolia Pallas	29.2	9.9	10.0	53.3
Symphoricarpos albus (L.) Blake	13.9	10.5	0	36.7

Table 3. The average shrub species density (#/ha) and cover (%) in 1985, prior to experiment initiation, in a grand fir forest in northeastern Oregon.

		Mean	SD	Min	Max
Acer glabrum Torr. var. *glabrum*	Density	0.02	0.09	0	0.44
	Cover	0	0.02	0	0.08
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	Density	1.1	1.1	0	3.7
	Cover	0.2	0.3	0	1.5
Crataegus douglasii Lindl.	Density	0.2	0.5	0	2.3
	Cover	0.04	0.2	0	0.8
Holodiscus discolor (Pursh) Maxim.	Density	3.5	2.8	0	10.7
	Cover	3.4	3.0	0	10.9
Philadelphus lewisii Pursh	Density	0.01	0.06	0	0.33
	Cover	0.02	0.08	0	0.43
Physocarpus malvaceus (Greene) Kuntze	Density	35.5	27.4	2.3	121.3
	Cover	10.5	8.6	0.6	30.8
Prunus virginiana L.	Density	0.04	0.14	0	0.67
	Cover	0.01	0.03	0	0.14
Ribes cereum Dougl.	Density	0.02	0.08	0	0.33
	Cover	0	0.01	0	0.08
Rosa gymnocarpa Nutt.	Density	13.1	14.2	0.3	66.0
	Cover	1.1	0.9	0	3.7

These sites supported a relatively rich plant community, with a total of 141 species (for complete species listing, see Appendix A); however, only 29 species occurred in all treatment combinations across all years. Of the 29 species, the occurrence of 24 species was affected by time, timber harvest and/or herbivory treatments (Tables 4, 5, 6, 7; tables only show significant results for affected species). Timber harvest had the greater effect on the magnitude of change in species composition than did herbivory. In general, the disturbance caused by timber harvest increased the occurrence of graminoid species. However, forb species were variable in their response to timber harvest. Western yarrow increased with timber harvest and lupines increased in timber harvested and

Table 4. The effects of timber harvest and herbivory treatments on the changes in understory species composition in a grand fir forest in northeastern Oregon.

	Timber Harvest Treatments				Herbivory Treatments			
	Clear	Thin	Contr	SE	Graze	CExc	TExc	SE
Bromus carinatus Hook. & Arn.	13.0[a]	6.9[b]	3.0[b]	2.6	8.9	7.5	6.5	2.6
Bromus inermis Leyss.	7.9[a]	3.5[ab]	1.4[a]	2.9	5.1	2.0	5.1	2.9
Carex geyeri Boott	-13.5	2.5	3.0	6.0	-14.1[a]	-1.5[b]	0.1[b]	5.8
Elymus glaucus Buckl.	32.1[a]	42.9[b]	15.7[c]	3.6	24.9	22.7	29.2	3.6
Luzula campestris (L.) DC.	-3.3	2.3	-3.1	2.4	-2.1[a]	2.1[b]	-4.1[a]	1.7
Achillea millefolium L.	36.8[a]	21.4[a]	-4.6[b]	7.3	18.8	15.4	12.7	3.7
Arnica cordifolia Hook.	-37.4[a]	-6.8[ab]	12.1[b]	15.5	-11.0	-9.6	-12.7	6.6
Hieracium albiflorum Hook.	-8.2	-3.7	-4.3	2.5	-3.4[a]	-10.1[b]	-13.1[b]	2.8
Moehringia macrophylla (Hook.) Fenzl	-33.8	-20.6	-16.8	10.2	-24.6[a]	-14.8[b]	-31.8[a]	9.9
Thalictrum fendleri Engelm. ex Gray	-26.5[a]	-7.3[b]	-1.2[b]	6.2	-11.2	-10.2	-13.5	4.9
Spiraea betulifolia Pallas	-23.4[a]	1.9[b]	-3.0[b]	4.1	-9.0	-9.9	-5.6	3.5
Symphoricarpos albus (L.) Blake	23.2[a]	15.3[b]	5.7[c]	4.1	10.9	12.8	13.8	2.3

[a,b] row values with differing superscripts are different at ($P < 0.05$).

herbivory treatments, however, peas (*Lathyrus* spp.) and heartleaf arnica were negatively affected by timber harvest. Shrubs were also affected by timber harvest treatments, with snowberry increasing in clearcuts and thinned treatments, whereas spiraea (*Spiraea betulifolia*) decreased in clearcuts and was not affected in thinned or controls.

Species richness and Shannon diversity were affected ($P \leq 0.05$) by timber harvest and herbivory (Table 8). However, since there were no interactions with years, it was concluded that changes seen in species richness and Shannon diversity index were evident prior to study initiation and may not be attributed to

Table 5. Changes in species composition, since 1985, in a grand fir forest in northeastern Oregon.

	1994	1997	2003	SE
Carex geyeri Boott	-8.7^{a}	-19.7^{b}	12.9^{c}	5.8
Elymus glaucus Buckl.	45.2^{a}	17.5^{b}	28.0^{b}	4.7
Anemone piperi Britt. ex Rydb.	-16.9^{a}	-12.0^{a}	14.7^{b}	10.9
Arnica cordifolia Hook.	-18.9^{a}	-8.7^{b}	-4.6^{b}	6.9
Fragaria spp.	-17.7^{a}	-17.9^{a}	-5.7^{b}	8.0
Lathyrus spp.	-23.4^{a}	-19.3^{a}	-10.9^{b}	3.9
Symphoricarpos albus (L.) Blake	9.1^{a}	10.9^{a}	24.2^{b}	4.0

^{a,b} row values with differing superscripts are different at ($P < 0.05$).

Table 6. Changes in species composition, from 1985, as affected by time and timber harvest treatments in a grand fir forest in northeastern Oregon.

	Timber Harvest	Year 1994	1997	2003	SE
Moehringia macrophylla (Hook.) Fenzl	Clearcut	-43.4^{a}	-40.1^{a1}	-17.9^{b1}	11.5
	Thinned	-41.9^{a}	-25.6^{a1}	5.6^{b2}	11.5
	Control	-47.8^{a}	-4.1^{b2}	1.5^{b2}	11.5
Stellaria longipes Goldie	Clearcut	13.3	15.5	11.4	7.1
	Thinned	1.1^{a}	9.3^{ab}	10.4^{b}	7.1
	Control	0.7^{a}	4.1^{a}	22.6^{b}	7.1
Viola adunca Sm.	Clearcut	5.5^{a}	7.3^{a}	33.6^{b1}	8.2
	Thinned	2.3^{a}	-0.6^{a}	19.8^{b1}	8.2
	Control	-4.7	-11.0	-8.8^{2}	8.2

^{a,b} row values with differing superscripts are different at ($P < 0.05$).
^{1,2,3} column values with differing superscripts within species are different at ($P < 0.05$).

application of timber harvest or herbivory treatments. Values for species evenness represented good equity in the distribution of plant species across treatments. Species turnover rates, comparing 2003 to 1985 (Table 9), indicated that number of new species entering these site was only affected by timber harvest ($P = 0.02$) whereas the number of species disappearing from these sites was affected by a timber harvest by herbivory interaction ($P = 0.006$). Thinned harvest treatments

Table 7. Changes in species composition, from 1985 to 2003, as affected by timber harvest and herbivory treatments in a grand fir forest in northeastern Oregon.

	Herbivory	Timber Harvest Treatments			
	Treatment*	Clearcut	Thinned	Control	SE
Calamagrostis rubescens Buckl.	Graze	10.4	26.3^{1}	7.4^{1}	9.2
	CExc	1.5^{a}	23.7^{b12}	23.7^{b2}	9.2
	TExc	7.2	12.2^{2}	25.6^{2}	9.2
Festuca occidentalis Hook.	Graze	-8.9	-14.4^{1}	-8.9^{1}	7.1
	CExc	-14.8^{a}	8.1^{b2}	-13.3^{a12}	7.1
	TExc	-11.9^{ab}	3.0^{a2}	-25.2^{b2}	7.1
Trisetum canescens Buckl.	Graze	-31.5^{1}	-16.1^{1}	-9.9	9.5
	CExc	-10.4^{2}	-1.0^{2}	-23.0	9.5
	TExc	-19.8^{12}	-7.4^{12}	-15.7	9.5
Lathyrus spp.	Graze	-44.4^{a1}	-27.4^{a1}	-3.7^{b}	6.8
	CExc	-23.7^{a2}	0.7^{b2}	-9.7^{ab}	6.8
	TExc	-35.2^{a1}	-19.3^{ab1}	1.5^{b}	6.8
Lupinus spp.	Graze	10.7^{ab1}	20.4^{a1}	4.1^{b1}	6.0
	CExc	13.7^{a1}	2.6^{ab2}	-7.0^{b2}	6.0
	TExc	1.2^{2}	-1.9^{2}	0.4	6.0
Taraxacum officinale G.H. Weber ex Wiggers	Graze	-5.6^{a}	-2.6^{a}	3.3^{b1}	2.0
	CExc	-2.6	-1.5	-0.7^{12}	2.0
	TExc	-3.6	-5.2	-4.4^{2}	2.0
Mahonia repens (Lindl.) G. Don	Graze	-0.4	1.9^{1}	-3.0	3.3
	CExc	-0.7	-7.8^{a2}	2.2^{b}	3.3
	TExc	-1.2^{a}	8.5^{b1}	2.6	3.3

* Herbivory treatments: Grazed – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.
^{a,b} row values with differing superscripts are different at ($P < 0.05$).
$^{1.2.3}$ column values with differing superscripts within species are different at ($P < 0.05$).

had a greater ($P = 0.008$) number of new species entering the sites than controls, with clearcuts being intermediate. However, the number of species disappearing from these sites was greatest ($P < 0.05$) in the total exclosures of clearcuts. Other than total exclosures from clearcuts, it appears that the number of new species were similar to the number of species lost from these sites.

Table 8. Plant species richness, diversity, and evenness responses to timber harvest and herbivory in a grand fir forest in northeastern Oregon.

	Clearcut Overstory			Thinned Overstory			Control Overstory		
	Gr*	CExc	TExc	Gr	CExc	TExc	Gr	CExc	TExc
Species Richness [ab]									
1985	49	41	61	47	31	45	46	36	31
1994	46	45	43	43	40	43	40	29	31
1997	44	40	41	39	41	40	32	29	29
2003	44	39	39	43	49	38	36	33	30
Average	46	41	46	43	40	42	39	32	30
Shannon Diversity [ab]									
1985	3.16	3.20	3.20	3.09	2.98	3.19	3.04	2.99	3.09
1994	3.24	3.28	3.24	3.24	3.21	3.29	3.15	2.81	2.91
1997	3.14	3.13	3.14	3.25	3.23	3.25	2.96	2.80	2.96
2003	3.21	3.09	3.12	3.22	3.30	3.13	3.04	2.89	2.92
Average	3.19	3.18	3.18	3.20	3.18	3.22	3.05	2.87	2.97
Evenness									
1985	0.81	0.86	0.78	0.80	0.87	0.84	0.79	0.83	0.90
1994	0.85	0.86	0.86	0.86	0.87	0.87	0.85	0.83	0.85
1997	0.83	0.85	0.84	0.89	0.87	0.88	0.85	0.83	0.88
2003	0.85	0.84	0.85	0.86	0.85	0.86	0.85	0.83	0.86
Average	0.84	0.85	0.83	0.85	0.87	0.86	0.84	0.83	0.87

* Herbivory treatments: Gr – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.
[a] Herbivory effect ($P < 0.05$)
[b] Timber Harvest effect ($P < 0.05$)

Shrub Density and Cover

Shrub cover and density was minimal for most species in 1985 (Table 3), except for ninebark which had a density of 35.5 plants • ha^{-1} and 10.5% cover in 1985. Changes in serviceberry cover and density were affected by year, timber harvest, or herbivory treatments. Cover increased 1.4% by 2003 in thinned treatments whereas clearcuts and controls had no cover increases when compared to 1985. Changes in density were observed, however, these changes were on the order of 1 plant • ha^{-1}.

Table 9. The effects of timber harvest and herbivory on understory species turnover rates from 1985 to 2003 in a grand fir forest in northeastern Oregon.

	Clearcut	Thinned	Control	SE
# of new species since 1985*				
	9.4[ab]	12.1[a]	7.6[b]	1.7

	Clearcut	Thinned	Control	SE
# of species lost since 1985†				
Grazed	12.7[1]	14.3[1]	14.7[1]	2.1
Cattle Exclosure	11.7[1]	6.7[2]	9.3[12]	2.1
Total Exclosure	23.3[a2]	12.3[1]	8.7[b2]	2.1

* Nonsignificant timber harvest x herbivory effect ($P = 0.82$). Significant timber harvest treatment effect ($P = 0.02$).

† Significant timber harvest x herbivory effect ($P = 0.006$).

[a,b,c] values within rows with different superscripts are different ($P < 0.05$).

[1,2] values within columns with different superscripts are different ($P < 0.05$).

Wild rose density was affected by year and herbivory treatments. Wild rose density was 16 plants • ha^{-1} greater ($P = 0.03$) in 1994 when compared to1985 and has remained the same through 2003. The density of wild rose has increased ($P = 0.03$) in the total exclosures by 16 plants • ha^{-1} but only tended to increase ($P = 0.06$) in the cattle exclosures by 12 plants • ha^{-1} since 1985. However, the density of rose in the grazed pastures has not changed ($P = 0.26$) since 1985.

Understory Production

There were no interactions ($P > 0.08$) between timber harvest and herbivory for production measures, except for production of Kentucky bluegrass, therefore only main effects were reported. Total understory production increased ($P = 0.02$) from 760 kg • ha^{-1} in 1995 to 1108 kg • ha^{-1} in 2003. Total understory production was also affected ($P < 0.01$) by timber harvest treatments (Table 10). Understory production in clearcuts was 350 kg • ha^{-1} greater ($P = 0.02$) than thinned treatments and thinned treatments were 275 kg • ha^{-1} greater ($P = 0.04$) than controls. Total understory production was also affected ($P = 0.04$) by herbivory treatments. Grazed treatments averaged 102 kg • ha^{-1} greater ($P = 0.01$) understory production than the total exclosures. Cattle exclosures were intermediate but not different ($P \geq 0.13$) than the grazed or total exclosures.

Timber harvest had a greater impact on the understory production than did herbivory. Only Kentucky bluegrass was affected by herbivory (Table 10), and it exhibited a timber harvest x herbivory interaction ($P = 0.01$). Kentucky bluegrass production was greatest ($P < 0.01$) in the cattle and total exclosures of clearcuts

Table 10. The effects of timber harvest and herbivory on understory production in a grand fir forest in northeastern Oregon.

	Timber Harvest Treatments				Herbivory Treatments*			
	Clear	Thin	Cont	SE	Gr	CExc	TExc	SE
Total Production	1259^{a}	909^{b}	634^{c}	75.2	982^{a}	940^{ab}	880^{b}	52.7
Carex geyeri Boott	312	172	211	38.3	219	216	261	33.8
Calamagrostis rubescens Buckl.	213^{ab}	302^{a}	127^{b}	78.7	293	167	181	78.7
Other perennial grasses	142^{a}	197^{a}	53^{b}	29.7	142	166	85	29.7
Perennial forbs	221	170	176	57.9	195	218	154	50.0
Annuals / biennials	61	13	3	22.7	25	23	30	17.6
Shrubs	242	205	224	39.3	213	225	234	34.3
Poa pratensis L.†								
Grazed	155^{1}	55	6	63.6				
CEXC	280^{a2}	56^{b}	27^{b}	63.6				
TExc	294^{a2}	52^{b}	10^{b}	63.6				

* Herbivory treatments: Gr – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.
† Timber harvest x herbivory interaction ($P = 0.01$).
a,b row values with differing superscripts are different at ($P < 0.05$).
1,2,3 column values with differing superscripts within species are different at ($P < 0.05$).

compared to all other treatment combinations. Elk sedge production tended ($P = 0.09$) to be greater in the clearcuts compared to the thinned and control treatments. Production of pinegrass was 60% greater in the thinned treatments compared to the controls, with clearcuts intermediate and not different than either thinned or control treatments. Production of pinegrass within grazed treatments tended ($P = 0.08$) to be greater than either cattle or total exclosures. Other perennial grasses also responded to reduction in canopy cover with greater ($P < 0.05$) production in the clearcuts and thinned treatments when compared to controls.

Plant Community Responses

Initial NMS and MRPP analysis of pretreatment data, 1985, indicated that there were differences ($P < 0.001$, A = 0.16) among replicate sites, therefore all subsequent analyses were blocked by site. Upon further investigation, all years exhibited similar trends; therefore only 2003 data were reported (Fig. 3). The NMS ordination analysis revealed an apparent difference among sites, with one of the sites being different than the other two (Fig. 3A). Timber harvest (Fig. 3B) appeared to affect the changes in plant community composition and subsequent MMRP analysis determined that plant communities changes were different ($P < 0.01$, A = 0.09).

Changes in plant communities were also affected by herbivory treatments ($P = 0.01$, A = 0.19). However, there were no herbivory effects ($P \geq 0.33$, A ≤ 0.01) when it was analyzed within timber harvest treatment. Closer examination

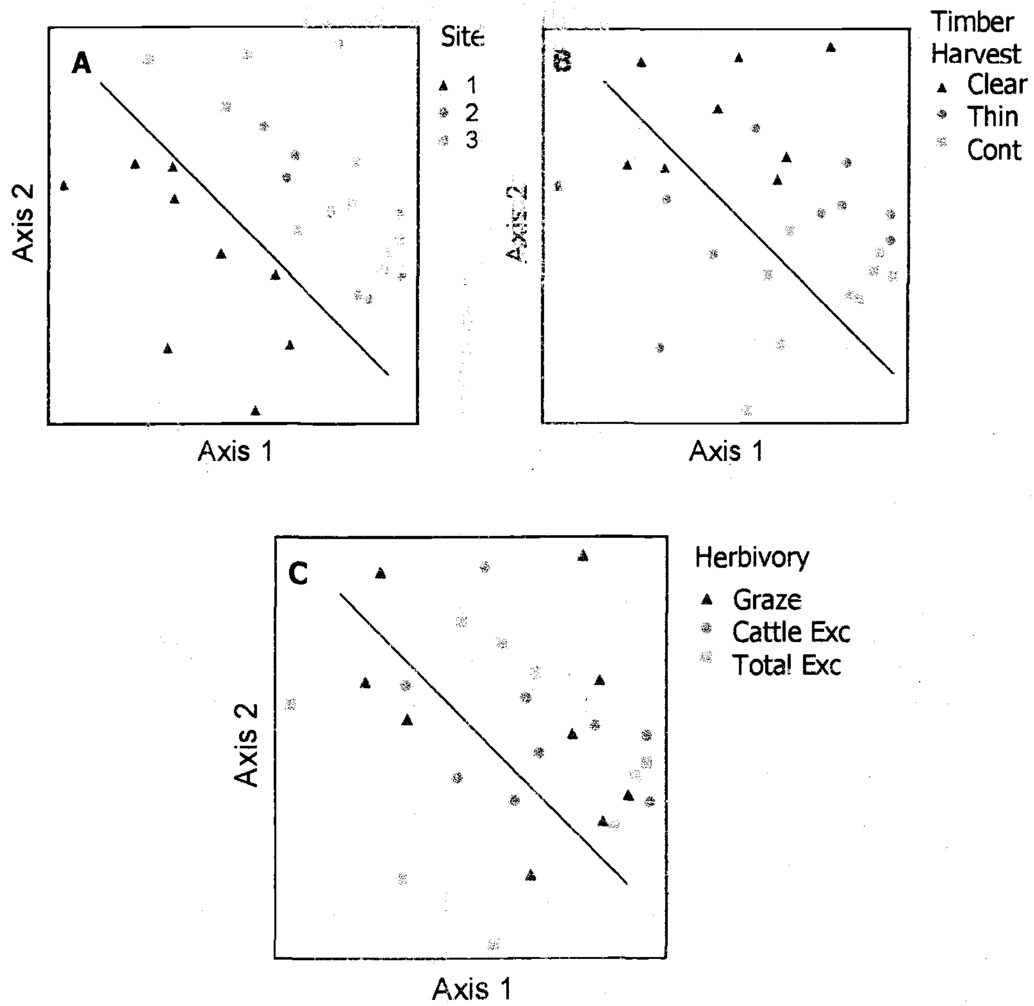

Figure 3. NMS Ordination of the changes in understory species composition from 1985 to 2003 of (A) site differences, (B) timber harvest effects, and (C) herbivory effects in a grand fir forest in northeastern Oregon. Line in charts demonstrates separation of the differences among sites. (Timber harvest treatment: Clear – clearcut , Thin -- crown thinning; Cont – control; Herbivory treatments: Grazed – cattle and big game grazing; Cattle Exc – cattle exclosure, big game grazing only; Total Exc – total exclosure, exclusion of cattle and big game grazing.)

of the changes in plant community attributed to herbivory (Fig. 3C) revealed that only within Site 1 was there an observable difference. Changes observed in cattle exclosures and grazed treatments were more similar than total exclosures. Whereas in Sites 2 and 3, it appeared that there were no differences in changes of plant community composition attributable to herbivory.

DISCUSSION

Understory vegetation composition was affected by timber harvest and herbivory. Species richness, diversity and evenness were affected by either timber harvest or herbivory. But, these differences occurred prior to initiation of the study; therefore, differences observed in subsequent years were probably carry over effects from this time. Species turnover was also affected by timber harvest and herbivory, but the number of new species was similar to the number of species lost, except for total exclosures in clearcuts which had greater number of species lost that new species. The greater number of lost species from total exclosures in clearcuts was probably the result of this treatment having considerably greater number of species present than the other clearcut herbivory treatments in 1985 (Table 8). However, by 2003, the differences in species richness in clearcut herbivory treatments were no longer present.

Many other researchers (Schoonmaker and McKee 1988; Halpern 1989; Thomas et al. 1999; Selmants et al. 2003) have documented that species richness and diversity increase following disturbance. Schoonmaker and McKee (1988) reported that species richness increased to peak at 15 to 20 years after logging and burning in a Douglas fir forest in western Oregon. They also documented that diversity is greatest up to 20 years following disturbance.

The lack of changes in species richness and diversity observed in our study could be related to disturbance intensity and initial plant community composition. Griffis et al. (2001) documented that low intensity disturbances did not increase diversity or species richness. Timber harvest is a significant disturbance for overstory succession, but if disturbance to soil and vegetation was minimized, such as in this study, successional trajectories may ultimately be determined by initial species and site history (Halpern 1989; Selmants et al. 2003). Tilman and Downing (1994) suggested that communities with high species richness were more resilient because they probably contain disturbance resistant species. Halpern (1989) commented further that early succession was characterized by a shift in abundance of generally persistent species, rather than replacement species. Riggs et al. (2000) observed that richness and diversity appeared to be more dynamic in clearcuts than in selective-cut of uncut areas and varied over locations.

We observed no differences in plant species richness, diversity, or evenness that was due to herbivory. Stohlgren et al. (1999) and Riggs et al. (2000) also found no differences in richness, diversity or eveness as a result of herbivory. However, we observed that 11 of the 29 species, that occurred in all treatment combinations over the duration of the study, were affected by herbivory. Plant community responses (Figure 3) also indicated that herbivory had minimal effects on plant community structure as compared to timber harvest. These observed herbivory effects over time were not as great in magnitude when compared to the timber harvest treatments but still indicate that ungulates have the ability to modify plant species composition. However, Riggs et al. (2000) commented that herbivory effects were often equal or even greater in magnitude than episodic agents, especially in clearcuts. Irwin et al. (1994) also commented that herbivory from large ungulates caused moderate to severe reductions in shrubs and that elk/deer can have important effects in the absence of livestock. They also noted observed differences in plant communities as a result of native ungulate herbivory. Many other researchers (Krueger and Winward 1974; Laycock and Conrad 1981; Milchunas and Lauenroth 1993; Hobbs 1996; Augustine and McNaughton 1998; Weisberg and Bugmann 2003) have also reported that ungulate herbivory has the ability to change plant species composition.

Understory production was 98 and 30% greater in the clearcuts and thinned treatments, respectively, than in the control treatment. Many other researchers (Pase 1958; McConnell and Smith 1965, 1970; Young et al. 1967; Thompson and Gartner 1971; Long and Turner 1975; Pyke and Zamora 1982) have documented similar results. These observed changes in understory production are primarily due to differences in shading (Naumburg et al. 2001) and changes in the competition between overstory and understory for available resources (Riegel et al. 1995).

In this study, increased production of understory vegetation was the result of changes in the production of graminoids; consequently forbs, shrubs and annual/biennials were unaffected by timber harvest treatments. Pase (1958), and McConnell and Smith (1965, 1970) reported that graminoid production increased at a greater rate than either forbs or shrubs. However, Thompson and Gartner (1971) reported that all vegetation types increased in forage production with neither groups taking a particular advantage when trees were removed. On multiple sites across northeastern Oregon, Riggs et al. (2000) reported that production of forbs was greater than graminoids irrespective of canopy cover.

Timber harvest appears to favor increased livestock and native ungulate production because of increased understory production. Cattle are attracted to areas of greater production (Harris 1954; Roath and Krueger 1982; Gillen et al. 1984) and tend to select a diet that is high in grasses (Holechek et al. 1982; Mitchell and Rodgers 1985, Walburger 2005). Whereas, deer and elk diets are composed of greater amounts of forbs and shrub species than cattle diets (Findholt et al. 2004; Beck and Peek 2005), but graminoid consumption by elk varies depending on time of year (Gibbs et al. 2004). Gibbs et al. (2004) reported that elk diets were high in graminoids in May and June, 80% of diet, and then consumption dropped dramatically in July and August, to < 50% of diet.

By only documenting the observed effects on graminoids, forbs, and shrubs we omitted a significant amount of above ground production. Long and Turner (1975) reported that 22 years post-harvest mosses comprised <1% of understory production, but by 30 years post-harvest mosses comprised 11% of understory production. They also determined that total community production was greatest 70 years post-harvest. Therefore, maintaining a mosaic of overstory age classes may allow for increased number of habitats from which herbivores and other wildlife species may occupy and allow for multiple uses across the landscape.

Herbivory affected total understory production and Kentucky bluegrass production. Production was greatest in the grazed treatments compared to the total exclosures. It appeared that grazing, within this study, stimulated greater forage production. Other researchers in other environments have documented similar results (McNaughton 1979; Turner et al. 1993; Frank and McNaughton 1993; Fahnestock and Delting 1999; Frank et al. 2002; Loeser et al. 2004). The reason for the increased production of understory vegetation in the grazed pastures was probably due to timing of grazing. Pastures were not grazed until plants were senesced and life cycles were potentially completed in the late summer. Following grazing, production of the young plant material in the fall and following spring would have higher photosynthetic rates than the older senesced plant material (Painter and Detling 1981; Wallace 1990). Grazing would increase light penetration through the foliage canopy (Monsi et al. 1973) thereby increasing the amount of light reaching the younger plant material, and subsequently, resulting in increased plant production. However, Holechek et al. (1995) concluded that 30% utilization rates by cattle on forested rangelands were recommended for sustainable grazing. Consequently, extreme care must be taken when exceeding this recommended utilization rate.

IMPLICATIONS

Timber harvest and herbivory are capable of influencing plant community structure and understory production. Although, timber harvest had the greatest effect on understory production and species composition, herbivory had modifying effects. If soil disturbances are minimized, understory species occupying the site prior to harvest will largely determine resultant plant community structure. Grasses and grass-likes appear to have a greater advantage under these circumstances.

However, herbivory had modifying effects within timber harvest treatments on species composition. Production of understory vegetation can be maintained, and possibly increased, with appropriate timing of herbivory upon forested rangelands. Utilization rates approaching 60% is not recommended because of distribution problems with cattle on diverse forested rangelands. Plant community responses to herbivory and timber were variable and demonstrate the importance of recognizing that site effects, e.g. aspect, soil depth, soil type, initial plant community, may have the ability to modify successional trajectories.

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CHAPTER 4

Effects of Timber Harvest and Previous Herbivory on Subsequent Diets of Cattle Grazing Forested Rangelands.

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ABSTRACT

The objectives of this study were to document the effects of timber harvest and herbivory on nutritional quality and botanical composition of steer diets in grand fir (*Abies grandis*) and ponderosa pine (*Pinus ponderosa*) forests. Three grand fir and ponderosa pine sites were established in 1986. Grand fir sites were arranged as a split-plot design and timber harvest treatments: [1) no harvest (CON), 2) thinning (TH), 3) clearcut (CL)] were whole plots and herbivory treatments [1) cattle and big game grazing (GR), 2) big game grazing (BG), and 3) exclusion of cattle and big game grazing (EX)] were the sub-plots. Ponderosa pine sites were arranged as a split-plot design and timber harvest [1) CON, 2) TH] were whole plots and herbivory treatments [1) GR, 2) BG, and 3) EX] were sub-plots. Diet samples were collected using four ruminally cannulated steers in June and August of 2001 and 2002. Within each pasture, steers were allowed to graze for 20 min. Results from the grand fir habitat revealed that nutritional quality was better in June than August. The CP and IVOMD were greater ($P < 0.05$) in June than in August and ADF and NDF had lower values ($P < 0.05$) in June compared to August. The ADF content in the diet was greater ($P < 0.05$) in the CONT as compared to CC and TH. Previous herbivory did not ($P > 0.10$) influence diet quality. Microhistological analysis of ruminal masticate was used to determine the botanical composition of diets. Graminoids were the major constituent in the diet ranging from 65 to 91%, forbs were intermediate ranging from 8 to 31%, and shrubs were least ranging from 0.2 to 3.5%. Season of use did not affect ($P >$

0.10) the composition of diets. Results from the ponderosa pine sites revealed that CP, IVOMD, ADF, and NDF of the diets were only affected by season of use. June diets were of higher ($P < 0.05$) quality than in August. Graminoids were the major constituent in the diet ranging from 83 to 88%, forbs were intermediate ranging from 10 to 14%, and shrubs were least ranging from 2 to 3%. Again, season of use did not affect ($P > 0.10$) the composition of diets. This study suggests that timing of grazing had a greater influence on diet quality than did previous herbivory and(or) timber harvest, however, previous herbivory and(or) timber harvest had a greater influence on composition of diets than did timing of grazing.

Key Words: *Abies grandis,* botanical composition, microhistological analysis, *Pinus ponderosa*

INTRODUCTION

Grazing cattle and timber harvest are common practices associated with forested rangelands in North America. These areas comprise a significant portion of the public lands in the west and are productive in producing habitat and forage for livestock and wildlife, as well as wood products for human use. However, over the past 100 years many areas with the potential for high forage production have low outputs due to dense canopy cover (Hedrick et al 1969). Therefore, it may be necessary to open the canopy to return the understory productivity of these lands.

Timber harvest on forested rangelands sets back succession and, in most cases, increases understory forage production (McConnell and Smith 1965 and 1970; Jameson 1967; Young et al. 1967; Thompson and Gartner 1971). This results in an increased opportunity for cattle/wildlife to forage and obtain a higher quality diet and subsequently increase productivity. Typically, cattle select a diet that is predominantly grass with limited forbs and shrubs (Holechek et al. 1982; Mitchell and Rodgers 1985). However, cattle diets vary throughout the grazing season, with woody vegetation becoming a greater part of the diet as the grazing season progress (Holechek et al. 1982; Mitchell and Rodgers 1985; Darambazar 2003).

Few studies have evaluated diet quality on forested rangelands over the grazing season, whereas more is known about changing body condition and weight change over this same period. Holechek et al. (1981, 1987), Vavra (1984), and Walburger (2000) have all documented that cattle gain less in the late summer and fall when compared to late spring and early summer.

The combined effects of timber harvest and previous herbivory (wild and/or domestic ungulates) on diet quality have not been documented. Therefore, the objectives of this study were to determine how timber harvest, previous herbivory and season of use affect the quality of diets obtained from forested rangelands.

MATERIALS AND METHODS

The study area is located at the Eastern Oregon Agriculture Research Center's Hall Ranch, which is approximately 16 km east of the city of Union in the Wallowa Mountains of northeastern Oregon. Elevation ranges from 1050 to 1250 m and annual precipitation averages 56 cm with about 65% coming in the winter; whereas summers are usually dry (Figure 1). Cattle have been grazing the area since mid-1880. Elk (*Cervus elaphus* L.) and mule deer (*Odocoileus hemionus* Raf.) are indigenous to the area and can be found throughout the year; however, heaviest use occurs in spring and fall.

The study was conducted as a replicated split-plot design. Three *Abies grandis* (Dougl. ex D. Don) Lindl. / *Pachistima myrsintes* (Pursh) Raf. (grand fir), 22.5 ha each in size, and three *Pinus ponderosa* P.& C. Lawson / *Symphoricarpos albus* (L.) Blake (Ponderosa pine), 15 ha each in size, sites were selected to analyze the effects of herbivory and overstory canopy cover on botanical composition of diets and diet quality. Sites were selected within areas of relatively homogeneous stand

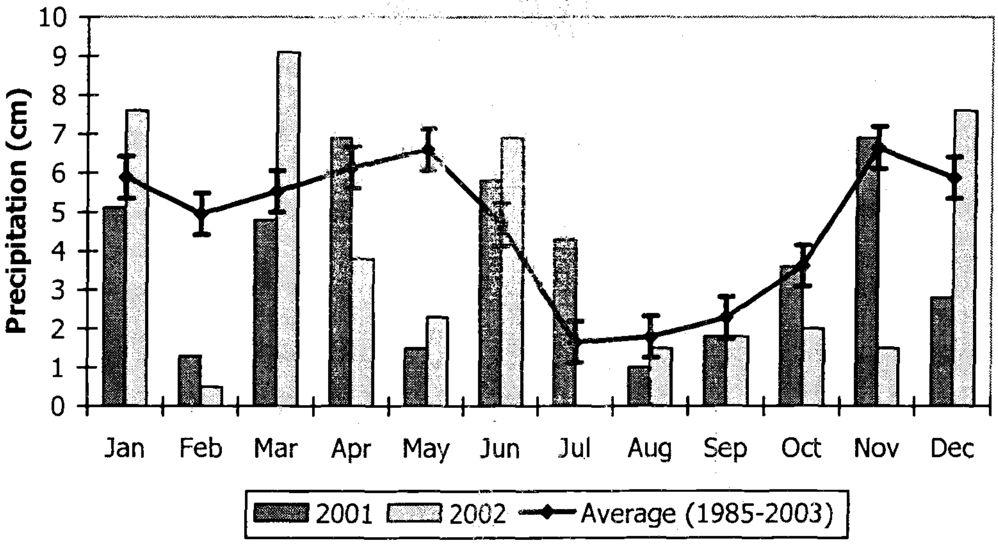

Figure 1. Precipitation data (cm) from weather station located at Eastern Oregon Agriculture Research Center's Hall Ranch.

structure. The grand fir sites had three timber harvest treatments applied: 1) clear cut, 2) crown thinning and 3) uncut (Control; Figure 2). Crown thinning consisted of removing co-dominant and some dominant trees. Timber harvest began in 1985 and was completed in 1986. The grand fir clearcuts were replanted in the spring of 1988 with Ponderosa pine, Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco var. *glauca* (Beissn.) Franco), and western larch (*Larix occidentalis* Nutt.). Whereas, the ponderosa pine sites had two timber harvest treatments applied: 1) commercial thinning and 2) uncut (Control; Figure 3). Thinning within the Ponderosa pine sites was done to achieve a tree basal area of 24 m^2/ha (tree spacing of approx. 8 m). Timber harvest began in 1985 and was completed in 1986.

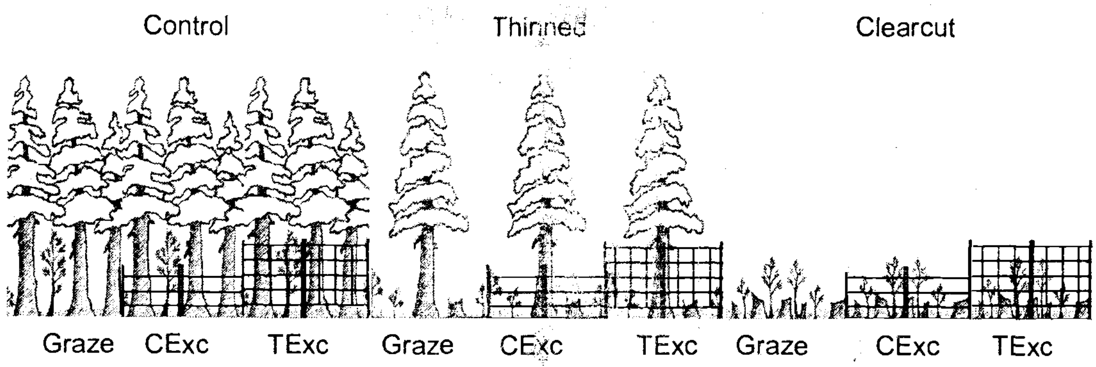

Figure 2. Layout of the timber harvest (control, thinned and clearcut) and herbivory (Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing) treatments for each grand fir site.

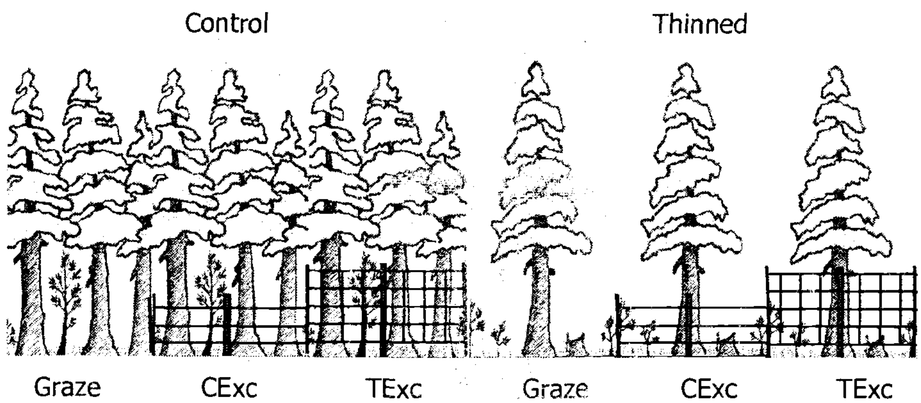

Figure 3. Layout of timber harvest (control and thinned) and herbivory (Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing) treatments for each ponderosa pine site.

The following herbivory treatments were applied within all timber harvest treatments for both grand fir and ponderosa pine sites: 1) grazing by cattle and big game (to achieve 60 percent utilization), 2) big game grazing only (Cattle exclosure), and 3) exclusion of cattle and big game grazing (Total Exclosure). Sixty percent utilization is considered heavy relative to current recommendations (Holechek 1995), but was used because it was considered a typical utilization level for industrial forests. Cattle and total exclosures were approximately 0.5 ha in size. Grazing by cattle was done in conjunction with allotment grazing from mid-August through October for the grand fir sites. Whereas, ponderosa pine sites were grazed in a deferred rotation grazing system. Even years were grazed from mid-June to mid-July and odd years were grazed from beginning of July to mid-August. Grazing by cattle in ponderosa pine sites was removed from 2001 and 2002 to allow for diet collections in mid-August.

Vegetation on these sites was varied but the dominant grasses were elk sedge (*Carex geyeri* Boott), pinegrass (*Calamagrostis rubescens* Buckl.), and Kentucky bluegrass (*Poa pratensis* L.). Numerous forbs were also found which include heartleaf arnica (*Arnica cordifolia* Hook.), western yarrow (*Achillea millefolium* L. var. *occidentalis* DC.), cinquefoil species (*Potentilla* spp.), and lupine species (*Lupinus* spp.). Several shrub species were typically found which include mallow ninebark (*Physocarpus malvaceus* (Greene) Kuntze), common snowberry, Oregon grape (*Berberis repens* Lindl.), and spirea (*Spiraea betulifolia* Pallas). Overstory of the grand fir sites within the controls and thinned timber harvest treatments were dominated by grand fir, whereas, dominant overstory species within clearcuts was ponderosa pine, Douglas-fir, and Western larch, however, grand fir saplings were numerous. Overstory of the ponderosa pine sites was dominated by ponderosa pine and interspersed with western larch.

Four ruminally cannulated steers were used to determine diets in June and August of 2001 and 2002. Prior to the grazing bout, steers were transported to site and ruminally evacuated as described by Lesperance et al. (1960), except rumen walls were rinsed with a sponge to remove as much material as possible. Steers were allowed to graze for 20 min. and grazed masticate samples were removed immediately following the grazing bout. Multiple collections were made by each steer within a day, both morning and evening collections. Launchbaugh et al. (1990) reported no differences in cattle diets between morning and evening collections, therefore only considerations for possible effects from an empty rumen were considered. To minimize possible effects of an empty rumen on forage selectivity by steers, we randomized the order that sites were grazed within each block. Following collection of masticate samples, original rumen contents were replaced. Masticate samples were completely dried at 55° C in a forced air oven and were ground through a Wiley Mill (Thomas Scientific, Sweedesboro, NJ) using a 1 mm screen. Composite samples were created for each experimental unit by combining 50 g sub-sample of each steers masticate sample. Samples were then analyzed for CP (AOAC, 1990), ADF, NDF (Ankom^{200} fiber analyzer, ANKOM Technology Corporation, Fairport, NY), and IVOMD (Daisy^{II}, ANKOM Technology Corporation, Fairport, NY). Livestock were handled according to the protocol approved by the Institutional Animal Care and Use Committee at Oregon State University.

Botanical composition of steer diets was determined using microhistological analysis. Composite samples were soaked in sodium hydroxide and mounted using techniques described by Holechek (1982). Three slides for each sample collected from grand fir sites and four slides for each sample collected from ponderosa pine sites were prepared and then dried at 55°C in a forced air oven, for a minimum of 48 hours, prior to analysis. Twenty fields per slide were systematically observed at 100x magnification. Plant fragments were identified by comparing epidermal characteristics with plant species reference slides and recorded as frequency counts. Dry weight composition of each sample was determined by dividing the frequency of each species by the total number of frequencies for all species (Holechek and Gross 1982).

Herbaceous production was collected in 2003 by clipping 0.5 m x 1.0 m rectangular plots placed randomly within each experimental unit. Plots were clipped by species to a 2 cm stubble height. Production clips were completely dried in a forced air oven at 55 degrees Celsius and weighted to the nearest tenth gram. Using the production data, a relative preference index (RPI) was calculated to determine the relationship between botanical composition and forage availability. This index was used to account for the differences (data not provided) in understory forage production among the herbivory and timber harvest treatments. Relative preference index was calculated as: % diet composition / % forage composition (Krueger 1972).

All data were analyzed as a split-plot design within a randomized complete block design with three replications using MIXED procedures in SAS (SAS Inst. Inc., Cary, NC) with the block (site replication) effect considered random. The whole-plot experimental unit was timber harvest treatment and the sub-plot experimental unit was herbivory within timber harvest treatments. Treatment means were separated using LSmeans procedures of SAS (SAS Inst. Inc., Cary, NC) and were considered significant at $P < 0.05$.

RESULTS

Grand Fir Sites

There were no interactions ($P > 0.40$) among season of use, timber harvest and herbivory treatments for any measures of diet quality determined; therefore, only treatment means are reported. Crude protein, IVOMD, NDF and ADF were all affected by season of use (Table 1). Crude protein and IVOMD of steer diets were 4.5 and 6.1 percentage points, respectively, higher ($P < 0.001$) in June than in August. Only minor differences ($P \leq 0.02$) in NDF and ADF content occurred between June and August (2.4% and 1.4%; respectively). Even though August diets were of lower quality, the nutritional requirements for a lactating cow were met (NRC 1996).

Timber harvest and herbivory treatments had little effect on the quality of steer diets; except for ADF. The clearcuts and thinned treatments had lower ($P \leq 0.03$) ADF values than control treatments. This increase of ADF in the control

Table 1. The effect of season of use and timber harvest on the subsequent quality of steer diets in a grand fir forested habitat.

	Season of Use			Timber Harvest Treatment			
	June	August	SE	Clearcut	Thinned	Control	SE
CP, % OM	14.9[a]	10.3[b]	0.3	12.6	12.5	12.6	0.3
IVOMD (%)	78.5[a]	72.4[b]	0.5	76.6	75.4	74.5	0.9
NDF, % OM	55.6[a]	58.0[b]	0.7	57.3	55.8	57.4	0.6
ADF, % OM	39.7[a]	41.1[b]	0.5	38.4[a]	40.0[a]	42.9[b]	0.8

[a,b] values with differing superscripts are different at ($P < 0.05$)

treatments could be due to greater amount of forbs consumed by steers and/or the effects of increased canopy cover on structural characteristics of consumed forages.

Botanical composition of steer diets did not exhibit season of use x timber harvest x herbivory treatment interactions ($P \geq 0.70$). However, graminoids and forbs exhibited a timber harvest x herbivory treatment interaction ($P = 0.04$). Graminoids were also affected by season of use, with June diets having greater amount of graminoids than August diets (83.5% and 80.4%, respectively). Amount of shrubs consumed was not affected ($P \geq 0.11$) by either season of use, timber harvest or herbivory treatments.

Consumption of graminoids was least ($P \leq 0.02$) in controls, across all herbivory treatments, compared to clearcuts and thinned treatments (Table 2). In addition, total exclosures within the controls, had the lowest amount of graminoids in steer diets compared to grazed and cattle exclosures. Conversely, consumption of forbs was greatest ($P \leq 0.04$) in controls, across all herbivory treatments, compared to clearcuts and thinned treatments.

Table 2. The effects of timber harvest and herbivory treatments on the botanical composition (%) of steer diets in a grand fir forested habitat.

	Herbivory Treatments†	Timber Harvest Treatments			SEM
		Clearcut	Thinned	Control	
Graminoids	Grazed	88.3^{1}	82.7^{ab12}	76.1^{a2}	3.17
	Cattle Exc	91.5^{1}	88.0^{a1}	75.8^{a2}	
	Total Exc	90.3^{1}	79.4^{b2}	65.4^{b3}	
Forbs	Grazed	10.7^{1}	15.6^{ab1}	22.5^{a2}	3.10
	Cattle Exc	8.3^{1}	10.7^{a1}	21.1^{a2}	
	Total Exc	9.3^{1}	19.6^{b2}	31.1^{b3}	
Shrubs	Grazed	0.9	1.7	1.3	0.96
	Cattle Exc	0.2	1.3	3.1	
	Total Exc	0.4	0.9	3.5	

† Herbivory treatments: Grazed – cattle and big game grazing; Cattle Exc – cattle exclosure, big game grazing only; Total Exc – total exclosure, exclusion of cattle and big game grazing

[a,b] column values with differing superscripts within forage type are different at ($P < 0.05$)

[1,2,3] row values with differing superscripts are different at ($P < 0.05$)

Also, RPI did not exhibit a season of use x timber harvest x herbivory treatment interaction ($P \geq 0.75$). However, the RPI of graminoids and forbs within steer diets was affected ($P \leq 0.04$) by a timber harvest x herbivory treatment interaction. Steers showed a strong preference for graminoids in all timber harvest and herbivory treatments (Table 3). However, preference did vary within timber harvest treatments. Within clearcuts, preference for graminoids was greatest ($P \leq 0.04$) in cattle exclosures. Within controls, graminoids were preferred and not different among all grazing treatments. In clearcuts, steers selected forbs in proportion to availability, but in the thinned treatment, steers preference for forbs was greatest ($P = 0.01$) in the total exclosure compared to either the grazed or cattle exclosures. Steers also showed a preference for forbs in the cattle and total exclosures of control (no timber harvest) treatments (1.53

Table 3. The effects of timber harvest and herbivory treatments on the relative preference index (RPI)* of graminoids, forbs, and shrubs for steer diets in a grand fir forested habitat.

	Herbivory Treatments[†]	Timber Harvest Treatments			SEM
		Clearcut	Thinned	Control	
Graminoids	Grazed	1.39[a]	1.30[ab]	1.50	0.12
	Cattle Exc	1.57[c]	1.39[a]	1.42	
	Total Exc	1.32[a]	1.18[b]	1.51	
Forbs	Grazed	0.90	1.14[a]	1.08[a]	0.34
	Cattle Exc	0.55	0.84[a]	1.53[b]	
	Total Exc	0.70[1]	1.94[b2]	2.00[c2]	
Shrubs	Grazed	0.03	0.09	0.05	0.04
	Cattle Exc	0.02	0.08	0.11	
	Total Exc	0.03	0.05	0.10	

* RPI = % diet composition / % forage composition (Krueger 1972)

[†] Herbivory treatments: Grazed – cattle and big game grazing; Cattle Exc – cattle exclosure, big game grazing only; Total Exc – total exclosure, exclusion of cattle and big game grazing

[a,b] column values with differing superscripts within forage type are different at ($P < 0.05$)

[1,2,3] row values with differing superscripts are different at ($P < 0.05$)

and 2.00, respectively). Shrubs, on the other hand, were not preferred ($P \geq 0.23$) in the timber harvest or herbivory treatments.

Total understory production and graminoid production in 2003, 18 years post-harvest, was only affected ($P \leq 0.05$) by timber harvest treatments (Table 4). Total understory production was greater in the clearcuts compared to both thinned and controls, 353 and 591 kg • ha^{-1} greater respectively. Graminoid production was 540 kg • ha^{-1} greater ($P = 0.02$) in clearcuts compared to controls. Thinned treatments tended ($P = 0.09$) to be greater than controls but were not different ($P = 0.22$) from clearcuts. Production of forbs and shrubs were not affected ($P \geq 0.61$) by either timber harvest or herbivory.

Table 4. The effects of timber harvest on understory production (kg • ha^{-1}), 18 years post-harvest, in a grand fir forest in northeastern Oregon.

	Clearcut	Thinned	Control	SE
Total Production	1423^{a}	1070^{b}	832^{b}	94
Graminoids	947^{a}	736^{ab}	407^{b}	118
Forbs	246	175	178	64
Shrubs	242	205	224	39

^{a,b} values with differing superscripts are different at ($P < 0.05$)

Ponderosa Pine Sites

There were no interactions ($P > 0.11$) among season of use, timber harvest and herbivory treatments for any measures of diet quality determined; therefore, only treatment means are reported. Neither timber harvest nor herbivory treatments influenced ($P > 0.10$) diet quality. Crude protein, IVOMD, NDF and ADF were only affected by season of use (Table 5), with the higher quality diets occurring in June compared to August. Crude protein and IVOMD were 3.9 and 5.7 percentage points, respectively, higher ($P < 0.001$) in June than in August. In contrast, ADF and NDF content were 3.6 and 5.7 percentage points, respectively, lower ($P \leq 0.01$) in June than in August.

Table 5. The effects of season of use on the diet quality of steers grazing a ponderosa pine forested habitat.

	Season of Use		
	June	August	SE
Crude protein	13.7^{a}	9.8^{b}	0.28
IVOMD	80.2^{a}	74.5^{b}	0.45
NDF	53.5^{a}	59.2^{b}	0.65
ADF	35.2^{a}	38.8^{b}	0.50

^{a,b} values with differing superscripts are different at ($P<0.05$)

There were no interactions ($P \geq 0.21$) among season of use, timber harvest and herbivory treatments on the botanical composition of diets; therefore, only treatment means are reported. Neither season of use nor timber harvest treatments affected ($P \geq 0.28$) the botanical composition of steer diets, but the amount of graminoids and forbs in the steer diets was affected ($P \leq 0.04$) by herbivory treatments. Greater than 80% of the steer diets (Table 6) was graminoids, however, the diets from cattle exclosures contained 5.2% and 4.3% more ($P \leq 0.04$) graminoids than the grazed and total exclosures, respectively. Composition of forbs in the diets was greater ($P = 0.01$) in the grazed pasture than in the cattle exclosure, and the total exclosure tended to be greater ($P = 0.08$) than the cattle exclosure.

There were no interactions ($P \geq 0.11$) among season of use, timber harvest and herbivory treatments on the RPI for graminoids, forbs and shrubs of steer

Table 6. The effects of herbivory on the botanical composition (%) and relative preference index (RPI)* of steer diets within a ponderosa pine forest type.

		Herbivory Treatments†			
		Grazed	Cattle Exc	Total Exc	SE
Botanical Composition					
	Graminoids	83.2^{a}	88.4^{b}	84.1^{a}	2.75
	Forbs	14.3^{a}	9.9^{b}	13.1^{ab}	2.64
	Shrubs	2.5	1.7	2.9	0.40
RPI					
	Graminoids	1.28^{a}	1.28^{a}	1.50^{b}	0.15
	Forbs	0.54^{a}	0.51^{a}	0.81^{b}	0.15
	Shrubs	0.38^{a}	0.27^{ab}	0.15^{b}	0.10

* RPI = % diet composition / % forage composition (Krueger 1972)

† Grazing treatments: Grazed – cattle and big game grazing; Cattle Exc – cattle exclosure, big game grazing only; Total Exc – total exclosure, exclusion of cattle and big game grazing

a,b values with differing superscripts are different at ($P<0.05$)

diets; therefore, only treatment means are reported. Neither season of use nor timber harvest treatments affected ($P \geq 0.13$) the RPI for graminoids, forbs or shrubs in steer diets, but the RPI for graminoids and forbs in steer diets were affected ($P \leq 0.02$) by herbivory treatments. Steers preferred a diet that was dominated by graminoids (Table 6); however, preference was greater ($P < 0.001$) in the total exclosure than in either the grazed or cattle exclosures. Overall, steer diets were proportionally lower in forbs or shrubs than available in the pastures. However, steer diets in the total exclosures had greater ($P \leq 0.03$) RPI for forbs than either the grazed or cattle exclosures. In contrast, cattle grazing the total exclosures had lower ($P \leq 0.02$) RPI for shrubs than the grazed treatments and tended to have lower RPI ($P = 0.07$) than the cattle exclosures.

Total understory production tended ($P = 0.08$) to be greater in thinned treatments compared to controls (Table 7). Also, production of forbs was 144 kg • ha^{-1} greater ($P = 0.001$) in thinned treatments compared to controls. Herbivory treatments only influenced the production of shrubs. Shrub production of total exclosures was greater than grazed and cattle exclosures, 128 and 105 kg • ha^{-1} respectively. Graminoid production was not affected ($P \geq 0.18$) by either timber harvest or herbivory treatments.

DISCUSSION

Quality of diets collected from grand fir and ponderosa pine sites declined in late-June to mid-August irrespective of timber harvest and herbivory treatments. Even

Table 7. The effects of timber harvest on understory production (kg • ha^{-1}), 18 years post-harvest, in a ponderosa pine forest in northeastern Oregon.

	Timber Harvest Treatments			Herbivory Treatments*			
	Thin	Control	SE	Graze	Cattle Exc	Total Exc	SE
Total Production	1111	873	237	974	1016	988	237
Graminoids	634	535	115	568	652	535	120
Forbs	275[a]	131[b]	50	206	187	216	52
Shrubs	160	125	85	92[a]	115[a]	220[b]	84

* Grazing treatments: Grazed – cattle and big game grazing; Cattle Exc – cattle exclosure, big game grazing only; Total Exc – total exclosure, exclusion of cattle and big game grazing

[a,b] values with differing superscripts are different at (P<0.05)

though nutritional quality of these diets was declining, the quality of diets obtained in August was of sufficient quality to meet the requirements for lactating cattle during this period (NRC 1996). Declining quality of cattle diets is a result of declining forage quality and(or) declining quantity of desirable forages. Cook and Harris (1968), Skovlin (1967), and Clark (2003) have reported that plant quality declines with increasing plant phenology and as the grazing season progresses, with grass quality declining the greatest. However, shrubs and forbs typically remain higher in quality and were able to maintain that quality throughout the summer.

Walburger et al. (2000) reported that aspect, north vs. south, with its accompanying differences in overstory, soils and moisture availability can influence the quality of plants throughout grazing season, with north aspects having higher quality later in the grazing season than south aspects. Svejcar and Vavra (1985) speculated that decreasing canopy cover increases the amount of sunlight reaching the soil surface, thereby increasing the soil temperature and reducing the available soil moisture later in the summer; as a result, accelerating plant phenology and reducing forage quality. However, McEwen and Dietz (1965), Dealy (1966), and Severson and Uresk (1988) were unable to detect differences in CP due to changes in overstory canopy cover in ponderosa pine forests. As well, Regelin et al. (1974) found no differences in CP content in various understory species within a mixed-conifer forest. Our results indicate that the change in overstory canopy cover did not affect the quality of diets because there were no interactions with season of use and timber harvest treatment, nor were there any interactions with season of use and timber harvest treatment in the botanical composition of diets. Therefore, cattle in this study were selecting compositionally similar diets in June and August and quality of diets was not changing due to timber harvest treatment in August. We speculate that decreased canopy cover may slow plant phenology of consumed forage species thereby allowing them to maintain higher forage qualities later in the year.

Within this study, steer diets, for grand fir and ponderosa pine sites, were dominated by grasses, 65-90% of the diet, forb composition was intermediate, 8-31% of the diets, and shrub consumption was minimal, ≤3.5% of diets. The changes in composition within these diets, especially for grand fir sites, were likely due to changes in understory production. The ability of steers to obtain a diet high in grasses, a preferred constituent, in control treatments of grand fir sites would be more difficult than in clearcuts because graminoid production was 591 kg • ha^{-1} less compared to thinned and clearcut treatments. Therefore, composition of diets, to a great extent, reflected the steer's ability to obtain desired forage components.

Unexpectedly, season of use was not an influencing factor on botanical composition. Beck and Peek (2005), in northeastern Nevada, also reported that cattle diets are dominated by grasses and forbs with minimal inputs from shrubs. However, Mitchell and Rodgers (1985), in a Douglas-fir/ninebark habitat type in northern Idaho, reported cattle had similar composition of diets from mid-June through August, but the diets were dominated by grasses and browse. Other researchers (Holechek 1982; Uresk and Painter 1985) have reported changes in diet composition during this time period of mid-June through August. Holechek et al. (1982), in eastern Oregon, reported that cattle diets were composed primarily of grass but it varied among seasons with consumption of browse increasing with progression of the grazing season. They also reported that consumption of forbs declined through the grazing period and were minor constituents in the diet. Uresk and Painter (1985), in the Black Hills, reported that consumption of grasses and shrubs were similar throughout the grazing period and constituted approximately 54% and 28% of the diet, respectively, whereas consumption of forbs declined throughout the grazing period and only averaged 17% over the grazing season. The probable reason for the differences in diets was that the other studies (Holechek 1982; Mitchell and Rodgers 1985; Uresk and Painter 1985) allowed grazing to continue throughout the duration of the seasonal collection periods which, in turn, may reflect changes in forage availability. In fact, Launchbaugh et al. (1990) reported that cattle diets differed depending on when during the grazing period they were sampled. Whereas this study only allowed grazing after collections were completed, therefore, these diets represent what cattle could select if forage availability was not limited.

Even though the composition of diets was changing, cattle still showed a preference towards grasses. Forbs were of similar proportions in the diet as was available in the pasture and shrubs were not preferred. Beck and Peek (2005) found similar preferences for grasses, forbs and shrubs. However, site did influence their results with cattle using grasses and forbs in proportion to their availability in aspen habitats, but cattle preferred grass in a sagebrush habitat. Holechek at al. (1982) provided percent cover data which allowed for comparison to percent within diets, however, this may not be a surrogate for production. They reported that during mid-June cattle preferred a grass dominated diet with forbs in similar proportion of diet composition to percent cover, and shrubs not preferred. But by mid-August, forbs were not preferred and shrubs composition within diets was of similar proportion to percent cover. However, these differences may be the result of continued grazing of the plant communities and representconfounded by changes in forage availability.

MANAGEMENT IMPLICATIONS

Cattle grazing on forested rangelands have the ability to select a diet that has sufficient quality to meet their nutritional requirements. In this study, timber harvest and previous herbivory had no effects on the quality of diets that cattle were able to select. Season of use was the only influence on diet quality; even though diet quality was declining it was sufficient to prevent weight loss in a lactating cow. Cattle grazing forested rangelands in northeastern Oregon preferred a diet that was dominated by graminoids. However, as graminoid production decreases, such as in heavily timbered areas, cattle will increase consumption of forbs. Shrubs occurred considerably less in the diets and forbs occurred of similar proportion as available on the rangeland. These results were determined when forage availability was not limited. As a result, managers may want to monitor cattle use and determine rotational schedules based on when cattle start consuming shrubs in order to meet management goals.

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CHAPTER 5

CONCLUSION

The overall objectives of this research were to evaluate the relationship between overstory canopy cover and ungulate herbivory on understory production, understory species composition, and diversity in a ponderosa pine and grand fir forest in northeastern Oregon. The primary factors evaluated were species frequency, shrub cover and density, and understory production.

Changes in species frequency was affected by both herbivory and timber harvest. The magnitude of species changes was greater with timber harvest than herbivory, thereby indicating that timber harvest had a greater affect on influencing successional trajectories of understory vegetation. However, due to large variations in species occurrence across ponderosa pine treatments, we were unable to detect consistent directional responses attributed to either timber harvest or herbivory treatments. These non-directional responses by the understory vegetation were probably due to initial composition of plant communities and subsequent differences in plant community changes among the ponderosa pine sites. Timber harvest and herbivory had little effect on shrub cover and density.

Grand fir sites were not as variable in plant community composition compared to the ponderosa pine sites. As a result, we were able to document consistent responses by the understory vegetation. Graminoid species increased with increased levels of overstory removal, whereas, forbs responses were determined by life history traits. Again, timber harvest and herbivory had little effect on shrub cover and density.

Total production of understory vegetation increased with decreasing overstory canopy cover. Treatments grazed by cattle, elk and mule deer reduced understory production in ponderosa pine sites but increased understory production in the grand fir sites. These differences were most likely attributed to soil characteristics.

Understory vegetation dynamics following timber harvest is of major concern, because herbivores are attracted to these areas and they have the potential for altering successional pathways. However, this research demonstrated that herbivory following timber harvest had minor effects on the resulting plant communities. Specifically, the plant communities among the ponderosa pine sites all responded differently. Across a landscape this could be very important in maintaining biological diversity and, in some cases, in mitigating effects of animal congregation areas. Ponderosa pine sites were also grazed by cattle during the time when many of native perennial grasses are most susceptible to damage from grazing (Stout and Quinton 1986) which could have influenced community responses.

Irwin et al. (1994) and Riggs et al. (2000) documented that herbivores reduced production and cover of shrubs compared to exclosures. However, in our study, there was not a response of either shrub density or cover to removal of herbivores. This unexpected result could be the result of lack of disturbance (in the case of the ponderosa pine sites), herbivory by cattle, elk and deer over the past 40 years has suppressed shrubs to the point that they are now removed from this system and(or) fire needs to be put back into these systems to simulate shrub regrowth.

The lack of strong directional changes in understory vegetation may also relate to our design structure. By having the experiment structured this way, limits our analytical abilities. Rare plants and plants that occupy a single treatment were removed from all analyses. As a result, we could be underestimating the effects of herbivory and timber harvest treatments. However, the plants used for analyses typically represented the dominant species in frequency and production. By reducing the rare species; the ability to detect differences in plant communities is increased because of the reduction in noise (McCune and Grace 2002).

Further studies need to be determined on the levels of disturbance, specifically, understory vegetation responses to fire, timber harvest and herbivory. Also, studying the effects of different stocking rates and season of use would provide valuable insight into establishing grazing systems on forested rangelands.

The second objective of this research was to determine the effects of timber harvest, ungulate herbivory, and season of use on the nutritional quality and botanical composition of cattle diets. The primary factors evaluated for nutritional quality of diets were CP, IVOMD, ADF, and NDF. The primary factors evaluated for botanical composition of diets was the microhistological determination of the proportions of graminoids, forbs and shrubs from the diets.

Season of use was the primary factor in determining nutritional quality of steer diets in ponderosa pine and grand fir sites. Higher quality diets were measured in June compared to August. Timber harvest and herbivory had very limited effect on the nutritional quality of steer diets. Graminoid species dominated the diets of steers across all sites. But, consumption of forbs increased with increased overstory canopy cover in grand fir sites. Shrubs were not an important component of steer diets.

Cattle grazing on forested rangelands are constantly faced with changes in species availability, changing plant communities across the rangeland, variation in production from feeding site to feeding site, and seasonal changes in moisture content and forage quality. Even with all these changes and variability in potential forage species, cattle typically selected a diet that is high in graminoids when given the opportunity.

Rotational grazing systems are regularly used to better distribute cattle across rangelands and to provide vegetation recovery periods. Therefore, further study is needed in determining the effects of limited forage availability on cattle diet selection for various time periods throughout the grazing season. Also, documenting the effects of timber harvest, herbivory and progression through the grazing season on the available forage quality.

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APPENDICES

Appendix A

List of Species Identified in Grand Fir and Ponderosa Pine Sites

Table 1. List of all species identified by frequency counts for ponderosa pine sites.

CODE	PLANT SPECIES	COMMON NAME
(grasslike)		
CACO	*Carex concinnoides*	NW sedge
CAGE	*Carex gereyii*	Elk sedge
CARO	*Carex rossii*	Ross sedge
LUCA	*Luzula campestris*	Woodrush
(shrubs)		
MARE	*Mahonia repens*	Oregon grape
SPBE	*Spirea betulifolia*	Spirea
SYAL	*Symphocarpos albus*	Snowberry
(grasses)		
AGCA	*Agropyron canium*	Bearded wheatgrass
AGID	*Agrostis idahoensis*	Bentgrass
AREL	*Arrhenatherum elatius*	Tall oatgrass
BRBR	*Bromus briziformis*	Rattle brome
BRCA	*Bromus carinatuis*	Mtn. brome
BRHO	*Bromus hordeaceus*	Soft brome
BRIN	*Bromus inermus*	Smooth brome
BRRI	*Bromus rigidus*	ripgut brome
BRTE	*Bromus tectorum*	Cheatgrass
BRVU	*Bromus vulgaris*	Columbia
CARU	*Calamagrostris rubescens*	Pinegrass
DAIN	*Danthonia intermedia*	timber oatgrass
DAGL	*Dactylis glomerata*	Orchard grass
DECA	*Deschampsia caespitosa*	tufted hairgrass
ELGL	*Elymus glaucus*	Blue wildrye
FEID	*Festuca idahoensis*	Idaho fescue
FEOC	*Festuca occidentalis*	Western fescue
FEOV	*Festuca ovina*	fescue
FERU	*Festuca rubra*	red fescue
FESU	*Festuca sublata*	Bearded fescue
KOCR	*Koeleria cristata*	Prairie Junegrass
MEBU	*Melica bulbosa*	Onion grass
PHPR	*Phleum pratense*	Timothy
POCO	*Poa compressa*	Canadian bluegrass
POPR	*Poa pretense*	Kentucky bluegrass
POSA	*Poa secunda*	Sandberg's bluegrass
PSSP	*Pseudoroegneria spicata*	Bluebunch wheatgrass
STOC	*Stipa occidentalis*	W. needlegrass
TRCA	*Trisetum canescens*	Tall trisetum
VUMI	*Vulpia microstachys*	Small fescue
(forbs)		
ACMI	*Achillea millefolium*	Yarrow
ADBI	*Adenocaulon bicolor*	Pathfinder

Table 1. continued.

CODE	**PLANT SPECIES**	**COMMON NAME**
AGGL	*Agoseris glauca*	pale agoseris
ANPA	*Anemone parviflora*	smallflowered anemone
ANMA	*Anaphalis margaritacea*	pearly everlasting
ANPI	*Anemone piperi*	Piper's anemone
ANRO	*Antennaria rosea*	Rosy pussytoes
APAN	*Apocynum androsaemifolium*	spreading dogbane
AQFO	*Aquilegia Formosa*	Western columbine
ARCO	*Arnica cordifolia*	Heartleaf arnica
ARSE	*Arenaria serpyllofolia*	Thymeleaf sandwort
ASCA	*Astragalous canadensis*	Canadian milkvetch
BLSC	*Blepharpappus scaber*	Rough eyelashweed
CAAP	*Castilleja applegatei*	Indian paintbrush
CAQU	*Camassia quamash*	small camas
CEGL	*Cerastium glomeratum*	Sticky chickweed
CHAN	*Chamerion angustifolium*	Fireplant
CHUM	*Chimaphila umbellate*	Pipsissewa
CIAR	*Cirsium arvense*	Thistle
CIVU	*Cirsium vulgare*	Bull thistle
CLDO	*Clinopodium douglasii*	yerba buena
CLHI	*Clematis hirsutissima*	clematis
CLPE	*Claytonia perfoliata*	Miner's lettuce
CLRH	*Clarkia rhomboidea*	diamond clarkia
COGR	*Collomia grandiflora*	grand collomia
COLI	*Collomia linearis*	tiny trumpet
COPA	*Collinsia parviflora*	Bluelips
CROC	*Crepis occidentalis*	Largeflower hawksbeard
DITR	*Disporum trachycarpum*	fairybells
EPBR	*Epilobium brachycarpum*	tall annual willowherb
ERSU	*Erigeron subtrinervis*	Fleabane
EUCO	*Eurybia conspicua*	Showy aster
	Fragaria spp.	Strawberries
	Galium spp.	Bedstraw
GAHU	*Gayophytum humile*	dwarf groundsmoke
GETR	*Geum triflorum*	Prairiesmoke avens
GEVI	*Geranium viscosissium*	Sticky geranium
HEUN	*Helianthella uniflora*	oneflower helianthella
HIAL	*Hieracium spp.*	Hawkweed
HICY	*Hieracium cynoglossoides*	houndstongue hawkweed
IRMI	*Iris missouriensis*	Rocky Mountain iris
LASE	*Lactuca serriola*	Pricly lettuce
	Lathyrus spp.	Peavine
LASE	*Lactuca serriola*	prickly lettuce
LIBO	*Linnaea borealis*	Twinflower
LINU	*Linanthus nuttallii*	linanthus
LIRU	*Lithospermum ruberale*	Stoneseed
LOTR	*Lomatium triternatum*	nineleaf biscuitroot

Table 1. continued.

CODE	**PLANT SPECIES**	**COMMON NAME**
	Lupinus spp.	Lupine
MAMI	*Madia spp.*	tarweed
MARA	*Maianthemum racemosum*	Western False Solomon's Seal
MAST	*Maianthemum stellatum*	Starry False Solomon's Seal
MELU	*Medicago lupulina*	black medick
MINU	*Microseris nutans*	Nodding microceris
MODI	*Montia dichotoma*	dwarf minerslettuce
MOMA	*Moehringia macrophylla*	Large leaf sandwort
MYVE	*Myosotis verna*	spring forget-me-not
OSBE	*Osmorhiza berteroi*	sweetcicely
PACA	*Packera cana*	woolly groundsel
PAPS	*Packera pseudaurea*	falsegold groundsel
PAST	*Packera streptanthifolia*	Rocky Mountain groundsel
	Pedicularis spp.	lousewort
PEGA	*Perideridia gairdneri*	Gardner's yampah
PHGR	*Phlox gracilis*	slender phlox
PHHO	*Phlox hoodii*	spiny phlox
PHLO	*Phlox longifolia*	longleaf phlox
PIEL	*Piperia elegans*	elegant piperia
PODO	*Polygonum douglasii*	Knotweed
POGL	*Potentilla glandulosa*	Gland cinqufoil
POGR	*Potentilla grazilis*	NW cinquefoil
PRVU	*Prunella vulagaris*	Common self-heal
RAAC	*Ranunculus acriformis*	sharpleaf buttercup
RAUN	*Ranunculus uncinatus*	Woodland buttercup
RUAC	*Rumex acetosella*	Sheep's sorrel
SELA	*Sedum lanceolatum*	spearleaf stonecrop
SEIN	*Senicio inergerrimus*	Western groundsel
SESE	*Senecio serra*	Tall ragwort
SIDO	*Silene dougiasii*	Catchfly
SIME	*Silene menziesii*	Menzies' campion
SIOR	*Sidalcea oregana*	Oregon checkerbloom
SOMI	*Solidago missouriensii*	Missouri goldenrod
STAM	*Streptopus amplexfolius*	claspleaf twistedstalk
STLO	*Stellaria longipes*	longstalk starwort
SYSP	*Symphyotrichum spathulatum*	Western Mountain aster
TAOF	*Taraxacum officinale*	Dandelion
THFE	*Thalictrum fenderi*	Meadow rue
TRDU	*Tragopodon dublus*	Yellow salsify
TRRE	*Trifolium repens*	White clover
VESE	*Veronica serpyllifolia*	Thyme-lf sandwort
VAED	*Valeriana edulis*	tobacco root
VESE	*Veronica serpyllifolia*	thymeleaf speedwell
VIAD	*Viola abunca*	Violet
VIAM	*Vicia americana*	American vetch
ZIPA	*Zigadenus paniculatus*	foothill deathcamas

Table 2. List of all species identified by frequency counts in grand fir sites.

CODE	PLANT SPECIES	COMMON NAME
(grasslike)		
CACO	*Carex concinnoides*	NW sedge
CAGE	*Carex gereyii*	Elk sedge
CARO	*Carex rossii*	Ross sedge
LUCA	*Luzula campestris*	Woodrush
(shrubs)		
MARE	*Mahonia repens*	Oregon grape
SPBE	*Spirea betulifolia*	Spirea
SYAL	*Symphocarpos albus*	Snowberry
(grasses)		
AGCA	*Agropyron canium*	Bearded wheatgrass
AGGI	*Agrostis gigantea*	redtop
AGID	*Agrostis idahoensis*	Bentgrass
AREL	*Arrhenatherum elatius*	Tall oatgrass
BRBR	*Bromus briziformis*	Rattle brome
BRCA	*Bromus carinatuis*	Mtn. brome
BRHO	*Bromus hordeaceus*	Soft brome
BRIN	*Bromus inermus*	Smooth brome
BRRI	*Bromus rigidus*	ripgut brome
BRTE	*Bromus tectorum*	Cheatgrass
BRVU	*Bromus vulgaris*	Columbia
CARU	*Calamagrostris rubescens*	Pinegrass
DAGL	*Dactylis glomerata*	Orchard grass
DAUN	*Danthonia unispicata*	Onespike danthonia
DEEL	*Deschampsia elongate*	Slender hairgrass
ELGL	*Elymus glaucus*	Blue wildrye
ELRE	*Elymus repens*	Quackgrass
FEID	*Festuca idahoensis*	Idaho fescue
FEOC	*Festuca occidentalis*	Western fescue
FEOV	*Festuca ovina*	fescue
FESU	*Festuca sublata*	Bearded fescue
KOCR	*Koeleria cristata*	Prairie Junegrass
MEBU	*Melica bulbosa*	Onion grass
PHPR	*Phleum pratense*	Timothy
POCO	*Poa compressa*	Canadian bluegrass
POPR	*Poa pretense*	Kentucky bluegrass
POSA	*Poa secunda*	Sandberg's bluegrass
PSSP	*Pseudoroegneria spicata*	Bluebunch wheatgrass
SIHY	*Sitanion hystrix*	Bottlebrush squirreltail
STOC	*Stipa occidentalis*	W. needlegrass
THIN	*Thinopyrum intermedium*	Intermediate wheatgrass
TRCA	*Trisetum canescens*	Tall trisetum
VUMI	*Vulpia microstachys*	Small fescue

Table 2. continued.

CODE	PLANT SPECIES	COMMON NAME
(forbs)		
ACMI	*Achillea millefolium*	Yarrow
ADBI	*Adenocaulon bicolor*	Pathfinder
AGCL	*Agoseris glauca*	pale agoseris
ANNE	*Antennaria neglecta*	field pussytoes
ANPA	*Anemone parviflora*	smallflowered anemone
ANPI	*Anemone piperi*	Piper's anemone
ANRO	*Antennaria rosea*	Rosy pussytoes
ANST	*Antennaria stenophylla*	Narrowleaf pussytoes
AQFO	*Aquilegia Formosa*	Western columbine
ARCO	*Arnica cordifolia*	Heartleaf arnica
ARSE	*Arenaria serpyllofolia*	Thymeleaf sandwort
ASCA	*Astragalous canadensis*	Canadian milkvetch
BLSC	*Blepharpappus scaber*	Rough eyelashweed
CAAP	*Castilleja applegatei*	Indian paintbrush
CEGL	*Cerastium glomeratum*	Sticky chickweed
CHAN	*Chamerion angustifolium*	Fireplant
CHUM	*Chimaphila umbellate*	Pipsissewa
CIAR	*Cirsium arvense*	Thistle
CIVU	*Cirsium vulgare*	Bull thistle
CLPE	*Claytonia perfoliata*	Miner's lettuce
CLRH	*Clarkia rhomboidea*	diamond clarkia
COGR	*Collomia grandiflora*	grand collomia
COLI	*Collomia linearis*	tiny trumpet
COPA	*Collinsia parviflora*	Bluelips
CROC	*Crepis occidentalis*	Largeflower hawksbeard
CYOF	*Cynoglossum officinale*	Houndstongue
EPBR	*Epilobium brachycarpum*	tall annual willowherb
ERHE	*Eriogonum heracleoides*	Creamy buckwheat
EPLA	*Epilobium lactiflorum*	willowherb
ERSU	*Erigeron subtrinervis*	Fleabane
EUCO	*Eurybia conspicua*	Showy aster
	Fragaria spp.	Strawberries
	Galium spp.	Bedstraw
GETR	*Geum triflorum*	Prairiesmoke avens
GEVI	*Geranium viscosissium*	Sticky geranium
GOOB	*Goodyera oblongifolia*	Rattlesnake plantain
HIAL	*Hieracium spp.*	Hawkweed
IRMI	*Iris missouriensis*	Rocky Mountain iris
LASE	*Lactuca serriola*	Pricly lettuce
	Lathyrus spp.	Peavine
LIBO	*Linnaea borealis*	Twinflower
LIRU	*Lithospermum ruberale*	Stoneseed
	Lupinus spp.	Lupine
MAMI	*Madia spp.*	tarweed
MARA	*Maianthemum racemosum*	Western False Solomon's Seal

Table 2. continued.

CODE	**PLANT SPECIES**	**COMMON NAME**
MAST	*Maianthemum stellatum*	Starry False Solomon's Seal
MINU	*Microseris nutans*	Nodding microceris
MOMA	*Moehringia macrophylla*	Large leaf sandwort
ORSE	*Orthilia secunda*	Sidebells wintergreen
OSBE	*Osmorhiza berteroi*	sweetcicely
PAPS	*Packera pseudaurea*	falsegold groundsel
PEGA	*Perideridia gairdneri*	Gardner's yampah
PHGR	*Phlox gracilis*	slender phlox
PODO	*Polygonum douglasii*	Knotweed
POGL	*Potentilla glandulosa*	Gland cinqufoil
POGR	*Potentilla grazilis*	NW cinquefoil
PRVU	*Prunella vulagaris*	Common self-heal
PTAQ	*Pteridium aquilinum*	Bracken fern
RAUN	*Ranunculus uncinatus*	Woodland buttercup
RUAC	*Rumex acetosella*	Sheep's sorrel
SEIN	*Senicio inergerrimus*	Western groundsel
SESE	*Senecio serra*	Tall ragwort
SIDO	*Silene douglasii*	Catchfly
SIME	*Silene menziesii*	Menzies' campion
SOMI	*Solidago missouriensii*	Missouri goldenrod
SPRO	*Spiranthes romanzoffiana*	Whirled Orchid
STAM	*Streptopus amplexfolius*	claspleaf twistedstalk
STLO	*Stellaria longipes*	longstalk starwort
STME	*Stellaria media*	Common chickweed
SYSP	*Symphyotrichum spathulatum*	Western Mountain aster
TAOF	*Taraxacum officinale*	Dandelion
THFE	*Thalictrum fenderi*	Meadow rue
TRDU	*Tragopodon dublus*	Yellow salsify
TRGR	*Triteleia grandiflora*	Largeflower triteleia
TRRE	*Trifolium repens*	White clover
VESE	*Veronica serpyllifolia*	Thyme-lf sandwort
VETH	*Verbascum thapsus*	Mullein
VIAD	*Viola abunca*	Violet
VIAM	*Vicia americana*	American vetch
VIGL	*Viola glabella*	pioneer violet

Appendix B

Ponderosa Pine Understory Vegetation Changes

Table 1. The changes in species composition in a ponderosa pine forest from 1985 to 1988 using a 30 cm x 30 cm plot frame.

	Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	0.0	0.0	3.3	0.0	0.0	0.0
Carex geyeri Boott	-20.0	26.7	13.3	13.3	-26.7	-20.0
Calamagrostis rubescens Buckl.	0.0	3.3	6.7	-3.3	6.7	-26.7
Elymus glaucus Buckl.	20.0	3.3	26.7	56.7	23.3	33.3
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	-13.3	-10.0	-13.3
Poa pratensis L.	33.3	-33.3	10.0	-10.0	3.3	43.3
Trisetum canescens Buckl.	-23.3	-23.3	-10.0	-36.7	-36.7	-13.3
Achillea millefolium L.	20.0	-26.7	3.3	13.3	0.0	6.7
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	0.0	0.0	0.0	0.0	0.0	0.0
Arnica cordifolia Hook.	-10.0	10.0	0.0	0.0	6.7	0.0
Claytonia perfoliata Donn ex Willd.	0.0	6.7	16.7	0.0	0.0	3.3
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	0.0	-20.0	-3.3	30.0	-30.0	6.7
Galium spp	23.3	-40.0	3.3	-20.0	-6.7	13.3
Hieracium albiflorum Hook.	0.0	-10.0	0.0	3.3	-6.7	0.0
Iris missouriensis Nutt.	0.0	0.0	3.3	6.7	3.3	-3.3
Lathyrus spp.	-36.7	30.0	0.0	-10.0	13.3	-40.0
Lupinus spp.	0.0	-10.0	-3.3	10.0	-10.0	0.0
Moehringia macrophylla (Hook.) Fenzl	-23.3	-6.7	-16.7	0.0	-6.7	-40.0
Osmorhiza berteroi DC.	-36.7	-6.7	-10.0	-40.0	-23.3	-60.0
Potentilla gracilis Dougl. ex Hook.	-3.3	-13.3	3.3	6.7	-3.3	0.0
Prunella vulgaris L.	-3.3	0.0	0.0	0.0	-3.3	10.0
Ranunculus spp.	0.0	0.0	0.0	6.7	13.3	3.3
Stellaria longipes Goldie	3.3	0.0	3.3	-3.3	6.7	3.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-20.0	3.3	-26.7	-6.7	3.3
Thalictrum fendleri Engelm. ex Gray	-3.3	3.3	0.0	0.0	0.0	0.0
Trifolium repens L.	20.0	10.0	3.3	33.3	3.3	3.3
Viola adunca Sm.	-20.0	-23.3	-10.0	-10.0	-30.0	0.0
Vicia americana Muhl. ex Willd.	26.7	-33.3	6.7	10.0	10.0	6.7
Mahonia repens (Lindl.) G. Don	-10.0	20.0	0.0	-3.3	6.7	0.0
Spiraea betulifolia Pallas	3.3	0.0	0.0	3.3	0.0	0.0
Symphoricarpos albus (L.) Blake	-10.0	3.3	26.7	3.3	-20.0	23.3

Table 1. continued.

	Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	20.0	20.0	26.7	23.3	20.0	20.0
Carex geyeri Boott	10.0	26.7	13.3	0.0	3.3	3.3
Calamagrostis rubescens Buckl.	-6.7	13.3	3.3	-3.3	0.0	13.3
Elymus glaucus Buckl.	0.0	0.0	0.0	3.3	0.0	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	10.0	0.0	0.0
Poa pratensis L.	26.7	-30.0	6.7	20.0	10.0	3.3
Trisetum canescens Buckl.	-20.0	-10.0	-10.0	-50.0	-26.7	-6.7
Achillea millefolium L.	-16.7	6.7	-6.7	0.0	0.0	6.7
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	3.3	0.0	0.0	13.3	16.7	0.0
Arnica cordifolia Hook.	3.3	-10.0	6.7	-3.3	0.0	13.3
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-6.7	13.3	3.3	13.3	0.0	6.7
Galium spp	0.0	0.0	0.0	3.3	0.0	0.0
Hieracium albiflorum Hook.	-6.7	10.0	-16.7	0.0	13.3	16.7
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-43.3	26.7	3.3	-26.7	-6.7	6.7
Lupinus spp.	0.0	-30.0	-6.7	-6.7	13.3	-6.7
Moehringia macrophylla (Hook.) Fenzl	-6.7	-6.7	-6.7	-3.3	-3.3	-3.3
Osmorhiza berteroi DC.	0.0	0.0	3.3	3.3	0.0	3.3
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-3.3	0.0	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	16.7
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	0.0	0.0	3.3	3.3	0.0	3.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	-3.3	0.0	-3.3	0.0
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	10.0	3.3	16.7	16.7	20.0	3.3
Viola adunca Sm.	0.0	-3.3	0.0	0.0	-3.3	0.0
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0
Mahonia repens (Lindl.) G. Don	-6.7	0.0	-10.0	0.0	3.3	0.0
Spiraea betulifolia Pallas	-3.3	16.7	0.0	3.3	3.3	0.0
Symphoricarpos albus (L.) Blake	-13.3	-6.7	26.7	-3.3	-3.3	13.3

Table 1. continued.

	Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 3						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	20.0	20.0	26.7	20.0	20.0	16.7
Carex geyeri Boott	-10.0	-10.0	-10.0	-10.0	-10.0	-16.7
Calamagrostis rubescens Buckl.	-10.0	10.0	-6.7	13.3	0.0	10.0
Elymus glaucus Buckl.	16.7	23.3	20.0	-3.3	3.3	20.0
Melica bulbosa Geyer ex Porter & Coult.	6.7	-3.3	-3.3	6.7	0.0	-3.3
Poa pratensis L.	13.3	6.7	0.0	10.0	20.0	20.0
Trisetum canescens Buckl.	-30.0	-43.3	-36.7	-33.3	-43.3	-50.0
Achillea millefolium L.	-6.7	6.7	-6.7	-6.7	13.3	3.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	0.0	0.0	3.3	13.3	0.0	3.3
Arnica cordifolia Hook.	3.3	10.0	-3.3	-10.0	0.0	6.7
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	3.3	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-6.7	10.0	3.3	-20.0	-6.7	-10.0
Galium spp	0.0	3.3	-3.3	23.3	16.7	-3.3
Hieracium albiflorum Hook.	0.0	-10.0	10.0	-6.7	10.0	6.7
Iris missouriensis Nutt.	-3.3	3.3	0.0	3.3	0.0	0.0
Lathyrus spp.	-6.7	6.7	0.0	-30.0	3.3	-6.7
Lupinus spp.	3.3	13.3	-20.0	-3.3	3.3	3.3
Moehringia macrophylla (Hook.) Fenzl	0.0	-23.3	-20.0	-76.7	-40.0	-10.0
Osmorhiza berteroi DC.	-6.7	0.0	0.0	36.7	16.7	20.0
Potentilla gracilis Dougl. ex Hook.	3.3	6.7	0.0	-3.3	0.0	6.7
Prunella vulgaris L.	0.0	3.3	-6.7	6.7	0.0	13.3
Ranunculus spp.	6.7	3.3	0.0	3.3	10.0	0.0
Stellaria longipes Goldie	0.0	0.0	3.3	10.0	13.3	13.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	6.7	6.7	0.0	-10.0	3.3	16.7
Thalictrum fendleri Engelm. ex Gray	3.3	0.0	-3.3	0.0	0.0	-3.3
Trifolium repens L.	16.7	10.0	3.3	30.0	23.3	0.0
Viola adunca Sm.	0.0	16.7	-3.3	-10.0	-10.0	0.0
Vicia americana Muhl. ex Willd.	-20.0	-3.3	0.0	20.0	0.0	13.3
Mahonia repens (Lindl.) G. Don	-3.3	-16.7	13.3	3.3	-6.7	-10.0
Spiraea betulifolia Pallas	16.7	16.7	3.3	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-26.7	-20.0	-6.7	-6.7	23.3	-3.3

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 2. The changes in species composition in a ponderosa pine forest from 1985 to 1988 using a 30 cm x 60 cm plot frame.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	0.0	0.0	3.3	0.0	0.0	0.0
Carex geyeri Boott	0.0	3.3	13.3	13.3	-23.3	-16.7
Calamagrostis rubescens Buckl.	-3.3	6.7	6.7	-3.3	3.3	-23.3
Elymus glaucus Buckl.	3.3	23.3	13.3	53.3	36.7	20.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	3.3	-20.0	-6.7	-10.0
Poa pratensis L.	0.0	3.3	6.7	-20.0	6.7	33.3
Trisetum canescens Buckl.	-36.7	-30.0	-23.3	-43.3	-50.0	-13.3
Achillea millefolium L.	-3.3	-6.7	6.7	16.7	3.3	20.0
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	3.3	0.0	0.0	0.0	3.3	0.0
Arnica cordifolia Hook.	3.3	-3.3	-3.3	-3.3	20.0	-3.3
Claytonia perfoliata Donn ex Willd.	6.7	0.0	16.7	3.3	0.0	3.3
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-3.3	3.3	0.0	43.3	-16.7	20.0
Galium spp	-13.3	0.0	20.0	3.3	-6.7	16.7
Hieracium albiflorum Hook.	0.0	-6.7	-10.0	3.3	-3.3	3.3
Iris missouriensis Nutt.	0.0	0.0	3.3	6.7	3.3	-3.3
Lathyrus spp.	3.3	-10.0	3.3	-10.0	10.0	-20.0
Lupinus spp.	0.0	-13.3	-3.3	0.0	6.7	-3.3
Moehringia macrophylla (Hook.) Fenzl	-23.3	-13.3	-16.7	0.0	-6.7	-43.3
Osmorhiza berteroi DC.	-60.0	-10.0	-6.7	-43.3	-20.0	-60.0
Potentilla gracilis Dougl. ex Hook.	3.3	-3.3	-6.7	-3.3	0.0	0.0
Prunella vulgaris L.	-3.3	0.0	0.0	-3.3	-3.3	10.0
Ranunculus spp.	0.0	0.0	0.0	16.7	26.7	10.0
Stellaria longipes Goldie	0.0	3.3	3.3	0.0	6.7	10.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	-3.3	-13.3	3.3	-20.0	6.7	6.7
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	10.0	6.7	6.7	33.3	13.3	10.0
Viola adunca Sm.	-20.0	-36.7	-13.3	-13.3	-36.7	-3.3
Vicia americana Muhl. ex Willd.	0.0	-6.7	10.0	13.3	20.0	16.7
Mahonia repens (Lindl.) G. Don	6.7	-3.3	0.0	-6.7	6.7	6.7
Spiraea betulifolia Pallas	0.0	3.3	0.0	3.3	0.0	0.0
Symphoricarpos albus (L.) Blake	-20.0	-3.3	26.7	-3.3	-16.7	3.3
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	23.3	26.7	36.7	40.0	26.7	26.7
Carex geyeri Boott	10.0	26.7	6.7	0.0	0.0	-3.3

Table 2. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Calamagrostis rubescens Buckl.	-10.0	13.3	0.0	0.0	0.0	3.3
Elymus glaucus Buckl.	0.0	0.0	0.0	3.3	0.0	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	10.0	0.0	0.0
Poa pratensis L.	40.0	-36.7	10.0	30.0	6.7	3.3
Trisetum canescens Buckl.	-26.7	-23.3	-16.7	-50.0	-26.7	-16.7
Achillea millefolium L.	-13.3	-3.3	-6.7	3.3	-6.7	3.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	3.3	0.0	3.3	13.3	16.7	0.0
Arnica cordifolia Hook.	-3.3	-3.3	13.3	0.0	-3.3	6.7
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-6.7	20.0	-3.3	10.0	13.3	6.7
Galium spp	0.0	0.0	0.0	3.3	0.0	0.0
Hieracium albiflorum Hook.	-10.0	3.3	-23.3	13.3	20.0	13.3
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-40.0	36.7	16.7	-23.3	3.3	16.7
Lupinus spp.	20.0	-40.0	-6.7	0.0	6.7	6.7
Moehringia macrophylla (Hook.) Fenzl	-6.7	-10.0	-6.7	-3.3	-6.7	-3.3
Osmorhiza berteroi DC.	3.3	0.0	0.0	0.0	0.0	6.7
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-16.7	0.0	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	23.3
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	3.3	0.0	0.0	3.3	0.0	3.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	-3.3	16.7	-3.3	3.3
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	10.0	16.7	26.7	33.3	26.7	6.7
Viola adunca Sm.	0.0	-6.7	0.0	0.0	-3.3	-6.7
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0
Mahonia repens (Lindl.) G. Don	-3.3	0.0	3.3	0.0	6.7	0.0
Spiraea betulifolia Pallas	-6.7	20.0	0.0	6.7	6.7	0.0
Symphoricarpos albus (L.) Blake	-13.3	6.7	23.3	16.7	3.3	0.0
Site 3						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	23.3	33.3	26.7	26.7	23.3	23.3
Carex geyeri Boott	-6.7	-3.3	-10.0	0.0	-16.7	-13.3
Calamagrostis rubescens Buckl.	-10.0	23.3	0.0	6.7	-3.3	6.7
Elymus glaucus Buckl.	20.0	23.3	23.3	-3.3	13.3	23.3
Melica bulbosa Geyer ex Porter & Coult.	6.7	3.3	-3.3	3.3	-10.0	-3.3
Poa pratensis L.	10.0	10.0	-6.7	-3.3	20.0	16.7
Trisetum canescens Buckl.	-36.7	-53.3	-43.3	-56.7	-46.7	-60.0

Table 2. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	-10.0	6.7	-6.7	-10.0	20.0	3.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	0.0	0.0	6.7	13.3	6.7	3.3
Arnica cordifolia Hook.	3.3	13.3	-3.3	-3.3	3.3	6.7
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	3.3	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	0.0	10.0	-3.3	-23.3	0.0	-10.0
Galium spp	-6.7	3.3	6.7	33.3	13.3	-3.3
Hieracium albiflorum Hook.	6.7	-6.7	6.7	-10.0	10.0	10.0
Iris missouriensis Nutt.	0.0	3.3	0.0	3.3	0.0	0.0
Lathyrus spp.	3.3	6.7	-3.3	-30.0	10.0	6.7
Lupinus spp.	-3.3	3.3	-10.0	-3.3	-3.3	-3.3
Moehringia macrophylla (Hook.) Fenzl	0.0	-33.3	-20.0	-80.0	-43.3	-23.3
Osmorhiza berteroi DC.	-3.3	0.0	-3.3	46.7	33.3	13.3
Potentilla gracilis Dougl. ex Hook.	3.3	6.7	0.0	-3.3	3.3	-3.3
Prunella vulgaris L.	3.3	6.7	-6.7	6.7	0.0	30.0
Ranunculus spp.	6.7	3.3	0.0	10.0	10.0	0.0
Stellaria longipes Goldie	0.0	0.0	3.3	10.0	13.3	13.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	3.3	6.7	0.0	-10.0	10.0	13.3
Thalictrum fendleri Engelm. ex Gray	3.3	0.0	-3.3	0.0	0.0	-3.3
Trifolium repens L.	16.7	10.7	6.7	40.0	33.3	0.0
Viola adunca Sm.	0.0	23.3	-3.3	-16.7	-10.0	0.0
Vicia americana Muhl. ex Willd.	-26.7	-6.7	3.3	16.7	3.3	16.7
Mahonia repens (Lindl.) G. Don	0.0	-20.0	6.7	3.3	0.0	3.3
Spiraea betulifolia Pallas	23.3	16.7	6.7	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-26.7	-6.7	-13.3	-13.3	23.3	-3.3

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 3. The changes in species composition in a ponderosa pine forest from 1985 to 1991 using a 30 cm x 30 cm plot frame.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	0.0	3.3	0.0	3.3	26.7	13.3
Carex concinnoides Mackenzie	0.0	0.0	0.0	0.0	0.0	0.0
Carex geyeri Boott	-3.3	-13.3	36.7	3.3	3.3	-26.7
Calamagrostis rubescens Buckl.	6.7	3.3	3.3	-3.3	0.0	-3.3
Elymus glaucus Buckl.	6.7	-6.7	36.7	53.3	0.0	33.3
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	3.3	-23.3	-30.0	-26.7
Poa pratensis L.	6.7	-13.3	-6.7	20.0	10.0	3.3
Trisetum canescens Buckl.	-3.3	0.0	6.7	-20.0	-16.7	-6.7
Achillea millefolium L.	-3.3	-3.3	16.7	3.3	3.3	23.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	13.3	40.0	0.0
Antennaria rosea Greene	0.0	3.3	0.0	3.3	0.0	0.0
Arnica cordifolia Hook.	3.3	-3.3	10.0	0.0	10.0	3.3
Claytonia perfoliata Donn ex Willd.	6.7	3.3	13.3	0.0	0.0	3.3
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-13.3	-23.3	-10.0	-13.3	-63.3	-23.3
Galium spp	3.3	-13.3	3.3	-10.0	23.3	10.0
Hieracium albiflorum Hook.	0.0	-10.0	0.0	3.3	-6.7	0.0
Iris missouriensis Nutt.	0.0	3.3	0.0	3.3	0.0	-3.3
Lathyrus spp.	-13.3	-6.7	-10.0	-23.3	-10.0	-40.0
Lupinus spp.	10.0	-13.3	13.3	0.0	-3.3	0.0
Moehringia macrophylla (Hook.) Fenzl	-6.7	-6.7	-10.0	0.0	-6.7	-16.7
Osmorhiza berteroi DC.	-40.0	-3.3	-6.7	-53.3	-33.3	-56.7
Potentilla gracilis Dougl. ex Hook.	6.7	-3.3	0.0	-13.3	-16.7	-3.3
Prunella vulgaris L.	-3.3	0.0	0.0	0.0	-3.3	0.0
Ranunculus spp.	6.7	0.0	0.0	-3.3	0.0	-3.3
Stellaria longipes Goldie	3.3	3.3	0.0	3.3	13.3	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	-6.7	-23.3	-6.7	-43.3	-13.3	-3.3
Thalictrum fendleri Engelm. ex Gray	-3.3	3.3	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	0.0	0.0	0.0	0.0	0.0
Viola adunca Sm.	-13.3	-3.3	6.7	3.3	6.7	6.7
Vicia americana Muhl. ex Willd.	0.0	-10.0	20.0	13.3	23.3	6.7
Mahonia repens (Lindl.) G. Don	3.3	3.3	0.0	3.3	0.0	3.3
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	3.3	10.0	33.3	-3.3	13.3	3.3
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	20.0	33.3	40.0	23.3	3.3	0.0
Carex geyeri Boott	-6.7	16.7	6.7	-16.7	-3.3	0.0

Table 3. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Calamagrostis rubescens Buckl.	-10.0	10.0	3.3	0.0	16.7	13.3
Elymus glaucus Buckl.	0.0	0.0	0.0	6.7	0.0	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	3.3	0.0	3.3
Poa pratensis L.	0.0	-36.7	-6.7	20.0	-10.0	13.3
Trisetum canescens Buckl.	-20.0	0.0	-6.7	-30.0	-3.3	10.0
Achillea millefolium L.	-20.0	3.3	-3.3	10.0	-3.3	0.0
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	0.0	0.0	3.3	6.7	0.0	0.0
Arnica cordifolia Hook.	6.7	10.0	10.0	-3.3	-23.3	16.7
Claytonia perfoliata Donn ex Willd.	3.3	0.0	3.3	0.0	0.0	3.3
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-13.3	6.7	0.0	6.7	10.0	-10.0
Galium spp	0.0	0.0	0.0	13.3	0.0	6.7
Hieracium albiflorum Hook.	-10.0	-6.7	-46.7	-6.7	3.3	10.0
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-46.7	33.3	-16.7	-26.7	-40.0	3.3
Lupinus spp.	6.7	-26.7	-10.0	0.0	0.0	0.0
Moehringia macrophylla (Hook.) Fenzl	-6.7	-6.7	-6.7	6.7	-3.3	3.3
Osmorhiza berteroi DC.	0.0	0.0	3.3	0.0	3.3	3.3
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-6.7	3.3	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus spp.	0.0	0.0	0.0	0.0	3.3	0.0
Stellaria longipes Goldie	0.0	0.0	0.0	3.3	3.3	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	23.3	0.0	3.3	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	-3.3	-3.3	-3.3	3.3
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	3.3	-3.3	-3.3	-6.7	0.0	6.7
Viola adunca Sm.	3.3	-3.3	0.0	6.7	0.0	3.3
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	10.0	0.0	0.0
Mahonia repens (Lindl.) G. Don	-10.0	-6.7	-3.3	0.0	10.0	-3.3
Spiraea betulifolia Pallas	3.3	0.0	0.0	0.0	3.3	0.0
Symphoricarpos albus (L.) Blake	-3.3	13.3	0.0	10.0	13.3	13.3
Site 3						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	6.7	10.0	30.0
Carex concinnoides Mackenzie	10.0	16.7	13.3	13.3	3.3	20.0
Carex geyeri Boott	-10.0	-23.3	-16.7	-60.0	-40.0	-30.0
Calamagrostis rubescens Buckl.	-3.3	10.0	6.7	16.7	-3.3	0.0
Elymus glaucus Buckl.	3.3	-3.3	6.7	6.7	13.3	0.0
Melica bulbosa Geyer ex Porter & Coult.	6.7	-6.7	13.3	10.0	0.0	-6.7
Poa pratensis L.	-6.7	0.0	-10.0	10.0	6.7	30.0
Trisetum canescens Buckl.	-20.0	-13.3	-16.7	-20.0	-26.7	-36.7

Table 3. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	-6.7	-3.3	-6.7	6.7	26.7	10.0
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	20.0	0.0	13.3
Antennaria rosea Greene	0.0	3.3	3.3	6.7	3.3	0.0
Arnica cordifolia Hook.	0.0	20.0	0.0	-16.7	0.0	16.7
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	16.7	6.7	6.7
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-10.0	-3.3	-6.7	0.0	-6.7	-16.7
Galium spp	0.0	0.0	0.0	23.3	20.0	-3.3
Hieracium albiflorum Hook.	0.0	-16.7	10.0	-3.3	23.3	6.7
Iris missouriensis Nutt.	0.0	10.0	0.0	0.0	0.0	0.0
Lathyrus spp.	3.3	-10.0	0.0	-26.7	-13.3	-6.7
Lupinus spp.	-3.3	3.3	-20.0	23.3	6.7	16.7
Moehringia macrophylla (Hook.) Fenzl	0.0	-13.3	16.7	-13.3	36.7	6.7
Osmorhiza berteroi DC.	-20.0	-13.3	-3.3	20.0	-6.7	20.0
Potentilla gracilis Dougl. ex Hook.	0.0	3.3	0.0	-3.3	0.0	-6.7
Prunella vulgaris L.	0.0	10.0	-10.0	-3.3	0.0	-3.3
Ranunculus spp.	0.0	0.0	0.0	-3.3	6.7	0.0
Stellaria longipes Goldie	0.0	0.0	0.0	16.7	16.7	13.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	6.7	3.3	3.3	-13.3	0.0	0.0
Thalictrum fendleri Engelm. ex Gray	0.0	13.3	-3.3	3.3	0.0	-3.3
Trifolium repens L.	-3.3	6.7	3.3	-6.7	0.0	0.0
Viola adunca Sm.	3.3	-3.3	6.7	0.0	6.7	3.3
Vicia americana Muhl. ex Willd.	3.3	20.0	0.0	20.0	0.0	16.7
Mahonia repens (Lindl.) G. Don	10.0	-6.7	10.0	-3.3	0.0	3.3
Spiraea betulifolia Pallas	16.7	-10.0	0.0	0.0	3.3	3.3
Symphoricarpos albus (L.) Blake	-26.7	-3.3	-10.0	-3.3	13.3	-6.7

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 4. The changes in species composition in a ponderosa pine forest from 1985 to 1991 using a 30 cm x 60 cm plot frame.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	3.3	3.3	0.0	3.3	26.7	13.3
Carex concinnoides Mackenzie	0.0	0.0	0.0	0.0	0.0	0.0
Carex geyeri Boott	-6.7	-13.3	33.3	-3.3	6.7	-33.3
Calamagrostis rubescens Buckl.	3.3	3.3	3.3	-3.3	0.0	-3.3
Elymus glaucus Buckl.	3.3	-6.7	23.3	53.3	3.3	30.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	3.3	-33.3	-30.0	-30.0
Poa pratensis L.	0.0	-13.3	-10.0	13.3	16.7	10.0
Trisetum canescens Buckl.	-3.3	-6.7	-6.7	-23.3	-20.0	0.0
Achillea millefolium L.	-10.0	-6.7	20.0	10.0	-13.3	33.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	20.0	56.7	0.0
Antennaria rosea Greene	0.0	3.3	0.0	3.3	0.0	0.0
Arnica cordifolia Hook.	10.0	0.0	10.0	-3.3	6.7	0.0
Claytonia perfoliata Donn ex Willd.	6.7	3.3	13.3	0.0	0.0	10.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-3.3	-13.3	-13.3	3.3	-60.0	-23.3
Galium spp	6.7	-16.7	13.3	0.0	16.7	10.0
Hieracium albiflorum Hook.	0.0	-10.0	-6.7	6.7	-3.3	0.0
Iris missouriensis Nutt.	0.0	3.3	0.0	3.3	0.0	-3.3
Lathyrus spp.	-16.7	-6.7	-10.0	-30.0	-3.3	-36.7
Lupinus spp.	6.7	-16.7	13.3	0.0	-3.3	0.0
Moehringia macrophylla (Hook.) Fenzl	0.0	-13.3	-3.3	0.0	-6.7	-20.0
Osmorhiza berteroi DC.	-50.0	-3.3	0.0	-53.3	-33.3	-63.3
Potentilla gracilis Dougl. ex Hook.	3.3	-3.3	-10.0	-23.3	-13.3	0.0
Prunella vulgaris L.	-3.3	0.0	0.0	-3.3	-3.3	0.0
Ranunculus spp.	10.0	0.0	0.0	-3.3	0.0	-3.3
Stellaria longipes Goldie	6.7	3.3	3.3	10.0	13.3	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	-3.3	-26.7	-6.7	-40.0	-16.7	-6.7
Thalictrum fendleri Engelm. ex Gray	3.3	3.3	0.0	0.0	0.0	0.0
Trifolium repens L.	-3.3	-26.7	0.0	0.0	0.0	0.0
Viola adunca Sm.	-6.7	-3.3	3.3	0.0	16.7	6.7
Vicia americana Muhl. ex Willd.	0.0	-6.7	23.3	16.7	30.0	6.7
Mahonia repens (Lindl.) G. Don	0.0	3.3	3.3	3.3	6.7	13.3
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	0.0	-3.3	26.7	-6.7	10.0	3.3
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	26.7	33.3	50.0	26.7	10.0	10.0
Carex geyeri Boott	-10.0	20.0	-3.3	-16.7	-10.0	-6.7

Table 4. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Calamagrostis rubescens Buckl.	-13.3	6.7	0.0	0.0	-13.3	3.3
Elymus glaucus Buckl.	0.0	0.0	0.0	6.7	0.0	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	3.3	3.3	0.0	6.7
Poa pratensis L.	-3.3	-46.7	-6.7	16.7	-16.7	13.3
Trisetum canescens Buckl.	-26.7	-6.7	-6.7	-30.0	-3.3	3.3
Achillea millefolium L.	-20.0	0.0	-13.3	10.0	-3.3	-3.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	3.3	0.0	6.7	10.0	3.3	0.0
Arnica cordifolia Hook.	0.0	10.0	13.3	-3.3	-33.3	13.3
Claytonia perfoliata Donn ex Willd.	3.3	0.0	6.7	0.0	3.3	3.3
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-13.3	3.3	-3.3	-3.3	16.7	-10.0
Galium spp	0.0	0.0	0.0	13.3	0.0	6.7
Hieracium albiflorum Hook.	-10.0	-3.3	-53.3	-3.3	10.0	6.7
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-46.7	40.0	-10.0	-23.3	-30.0	3.3
Lupinus spp.	10.0	-36.7	-16.7	3.3	-6.7	10.0
Moehringia macrophylla (Hook.) Fenzl	-6.7	-10.0	-6.7	6.7	-6.7	3.3
Osmorhiza berteroi DC.	0.0	0.0	3.3	3.3	3.3	6.7
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-13.3	3.3	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus spp.	0.0	0.0	0.0	0.0	3.3	0.0
Stellaria longipes Goldie	0.0	0.0	-3.3	3.3	6.7	6.7
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	30.0	3.3	3.3	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	3.3	-3.3	3.3	6.7	-3.3	3.3
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	3.3	-3.3	-3.3	-3.3	0.0	6.7
Viola adunca Sm.	6.7	-6.7	0.0	6.7	0.0	3.3
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	10.0	0.0	0.0
Mahonia repens (Lindl.) G. Don	-13.3	-3.3	-3.3	3.3	10.0	6.7
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	3.3	0.0
Symphoricarpos albus (L.) Blake	-6.7	20.0	6.7	23.3	16.7	-13.3
Site 3						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	13.3	13.3	30.0
Carex concinnoides Mackenzie	13.3	33.3	13.3	20.0	10.0	20.0
Carex geyeri Boott	-6.7	-20.0	-3.3	-50.0	-40.0	-30.0
Calamagrostis rubescens Buckl.	-3.3	20.0	6.7	6.7	-3.3	3.3
Elymus glaucus Buckl.	10.0	-3.3	6.7	6.7	16.7	0.0
Melica bulbosa Geyer ex Porter & Coult.	3.3	6.7	13.3	10.0	-10.0	-10.0
Poa pratensis L.	-10.0	0.0	-20.0	6.7	6.7	30.0
Trisetum canescens Buckl.	-16.7	-13.3	-20.0	-20.0	-13.3	-40.0

Table 4. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	-13.3	0.0	0.0	3.3	16.7	3.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	23.3	0.0	16.7
Antennaria rosea Greene	0.0	6.7	3.3	10.0	3.3	3.3
Arnica cordifolia Hook.	0.0	13.3	3.3	-6.7	-3.3	13.3
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	20.0	10.0	10.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	6.7	3.3	-10.0	-6.7	-3.3	-16.7
Galium spp	-3.3	0.0	3.3	20.0	20.0	-3.3
Hieracium albiflorum Hook.	0.0	-20.0	3.3	-6.7	20.0	10.0
Iris missouriensis Nutt.	0.0	13.3	0.0	0.0	0.0	0.0
Lathyrus spp.	0.0	-13.3	-13.3	-20.0	-56.7	0.0
Lupinus spp.	-6.7	3.3	-30.0	26.7	6.7	20.0
Moehringia macrophylla (Hook.) Fenzl	0.0	-16.7	20.0	-10.0	40.0	3.3
Osmorhiza berteroi DC.	3.3	-20.0	23.3	33.3	3.3	13.3
Potentilla gracilis Dougl. ex Hook.	0.0	3.3	0.0	-3.3	0.0	-16.7
Prunella vulgaris L.	0.0	13.3	-10.0	3.3	0.0	-3.3
Ranunculus spp.	0.0	0.0	0.0	-3.3	6.7	0.0
Stellaria longipes Goldie	0.0	0.0	3.3	26.7	20.0	13.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	3.3	3.3	0.0	-16.7	-3.3	-6.7
Thalictrum fendleri Engelm. ex Gray	6.7	20.0	-3.3	3.3	0.0	-3.3
Trifolium repens L.	-3.3	6.7	0.0	-6.7	0.0	0.0
Viola adunca Sm.	3.3	3.3	10.0	3.3	10.0	10.0
Vicia americana Muhl. ex Willd.	-10.0	20.0	3.3	20.0	0.0	16.7
Mahonia repens (Lindl.) G. Don	13.3	-3.3	-3.3	-6.7	0.0	10.0
Spiraea betulifolia Pallas	16.7	-16.7	-10.0	0.0	6.7	3.3
Symphoricarpos albus (L.) Blake	-26.7	-6.7	-13.3	-3.3	0.0	-3.3

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 5. The changes in species composition in a ponderosa pine forest from 1985 to 1994 using a 30 cm x 30 cm plot frame.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	3.3	3.3	3.3
Carex concinnoides Mackenzie	0.0	0.0	3.3	0.0	0.0	0.0
Carex geyeri Boott	-13.3	23.3	33.3	0.0	-3.3	-10.0
Calamagrostis rubescens Buckl.	10.0	-3.3	-3.3	0.0	10.0	-26.7
Elymus glaucus Buckl.	30.0	40.0	33.3	50.0	43.3	56.7
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	-23.3	-33.3	-23.3
Poa pratensis L.	6.7	-20.0	3.3	0.0	-10.0	30.0
Trisetum canescens Buckl.	-20.0	-16.7	6.7	-36.7	-26.7	3.3
Achillea millefolium L.	10.0	-10.0	3.3	0.0	13.3	36.7
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	6.7
Antennaria rosea Greene	3.3	0.0	0.0	3.3	0.0	0.0
Arnica cordifolia Hook.	10.0	-6.7	3.3	10.0	3.3	3.3
Claytonia perfoliata Donn ex Willd.	0.0	0.0	10.0	0.0	0.0	6.7
Eurybia conspicua (Lindl.) Nesom	0.0	36.7	0.0	10.0	30.0	0.0
Fragaria spp.	-16.7	-36.7	-6.7	6.7	-40.0	-16.7
Galium spp	-13.3	-6.7	3.3	-13.3	0.0	33.3
Hieracium albiflorum Hook.	0.0	-10.0	6.7	0.0	-6.7	6.7
Iris missouriensis Nutt.	0.0	0.0	0.0	3.3	3.3	-3.3
Lathyrus spp.	-20.0	-10.0	10.0	-26.7	-20.0	-26.7
Lupinus spp.	3.3	-3.3	-3.3	0.0	13.3	3.3
Moehringia macrophylla (Hook.) Fenzl	-23.3	-6.7	-16.7	0.0	-6.7	-40.0
Osmorhiza berteroi DC.	-36.7	-13.3	-6.7	-53.3	-30.0	-56.7
Potentilla gracilis Dougl. ex Hook.	-3.3	-10.0	-3.3	-16.7	-23.3	-6.7
Prunella vulgaris L.	-3.3	0.0	0.0	3.3	6.7	3.3
Ranunculus spp.	0.0	0.0	0.0	-3.3	0.0	-3.3
Stellaria longipes Goldie	0.0	6.7	0.0	-6.7	0.0	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	6.7	0.0	40.0	0.0	0.0	33.3
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-23.3	-6.7	-43.3	-10.0	-13.3
Thalictrum fendleri Engelm. ex Gray	-3.3	6.7	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	0.0	3.3	0.0	-3.3	0.0
Viola adunca Sm.	-20.0	-13.3	6.7	-6.7	-6.7	16.7
Vicia americana Muhl. ex Willd.	0.0	-6.7	0.0	0.0	13.3	3.3
Mahonia repens (Lindl.) G. Don	6.7	0.0	0.0	16.7	16.7	13.3
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-3.3	10.0	20.0	10.0	0.0	-6.7
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	16.7	33.3	0.0	26.7	13.3	0.0
Carex geyeri Boott	-3.3	30.0	6.7	-3.3	-13.3	3.3

Table 5. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Calamagrostis rubescens Buckl.	0.0	23.3	-6.7	6.7	16.7	10.0
Elymus glaucus Buckl.	6.7	10.0	0.0	30.0	23.3	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	0.0	0.0	0.0
Poa pratensis L.	10.0	-36.7	-3.3	30.0	13.3	13.3
Trisetum canescens Buckl.	-20.0	-10.0	6.7	-46.7	-16.7	13.3
Achillea millefolium L.	-10.0	0.0	-3.3	16.7	-3.3	16.7
Anemone piperi Britt. ex Rydb.	0.0	0.0	3.3	0.0	3.3	0.0
Antennaria rosea Greene	10.0	0.0	3.3	10.0	3.3	0.0
Arnica cordifolia Hook.	13.3	-6.7	13.3	-10.0	6.7	13.3
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	0.0	0.0	6.7
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	26.7
Fragaria spp.	-20.0	3.3	3.3	10.0	13.3	-6.7
Galium spp	10.0	0.0	0.0	10.0	0.0	0.0
Hieracium albiflorum Hook.	-3.3	3.3	-10.0	-6.7	16.7	-6.7
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-50.0	36.7	0.0	-43.3	-63.3	16.7
Lupinus spp.	33.3	-26.7	0.0	3.3	6.7	-6.7
Moehringia macrophylla (Hook.) Fenzl	-6.7	-6.7	-6.7	-3.3	-3.3	-3.3
Osmorhiza berteroi DC.	0.0	0.0	0.0	0.0	3.3	6.7
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-6.7	0.0	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	0.0	0.0	0.0	0.0	0.0	3.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	20.0	0.0	0.0	33.3	6.7	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	0.0	13.3	-3.3	6.7
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	-3.3	-3.3	-6.7	0.0	0.0
Viola adunca Sm.	3.3	-3.3	3.3	3.3	0.0	3.3
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	-6.7	10.0	0.0
Mahonia repens (Lindl.) G. Don	-6.7	0.0	-3.3	3.3	10.0	0.0
Spiraea betulifolia Pallas	-3.3	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-16.7	10.0	-6.7	-3.3	16.7	3.3
Site 3						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	10.0	20.0	20.0
Carex concinnoides Mackenzie	3.3	26.7	0.0	6.7	3.3	16.7
Carex geyeri Boott	-16.7	-43.3	-13.3	-46.7	-20.0	-16.7
Calamagrostis rubescens Buckl.	6.7	6.7	6.7	13.3	-16.7	-10.0
Elymus glaucus Buckl.	20.0	3.3	-3.3	26.7	6.7	6.7
Melica bulbosa Geyer ex Porter & Coult.	-23.3	-6.7	-3.3	-6.7	0.0	-10.0
Poa pratensis L.	10.0	3.3	-10.0	0.0	-3.3	10.0
Trisetum canescens Buckl.	-30.0	-40.0	-13.3	-30.0	-36.7	-3.3

Table 5. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	-6.7	-16.7	-33.3	-3.3	20.0	16.7
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	16.7	6.7	0.0
Antennaria rosea Greene	0.0	0.0	0.0	10.0	3.3	3.3
Arnica cordifolia Hook.	-10.0	3.3	-33.3	-56.7	-10.0	0.0
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	3.3	0.0	3.3
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	3.3	13.3	33.3
Fragaria spp.	-16.7	-10.0	-6.7	-3.3	-10.0	-13.3
Galium spp	-10.0	-3.3	-6.7	36.7	13.3	10.0
Hieracium albiflorum Hook.	-3.3	-20.0	0.0	-6.7	-6.7	-3.3
Iris missouriensis Nutt.	-3.3	3.3	0.0	0.0	0.0	0.0
Lathyrus spp.	-10.0	-26.7	13.3	-43.3	-26.7	0.0
Lupinus spp.	-3.3	0.0	-16.7	13.3	23.3	10.0
Moehringia macrophylla (Hook.) Fenzl	0.0	-23.3	-20.0	-76.7	-40.0	-10.0
Osmorhiza berteroi DC.	-6.7	-6.7	0.0	0.0	13.3	40.0
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-3.3	-6.7	-6.7
Prunella vulgaris L.	6.7	3.3	-10.0	3.3	10.0	3.3
Ranunculus spp.	0.0	0.0	0.0	-3.3	0.0	0.0
Stellaria longipes Goldie	0.0	0.0	0.0	0.0	0.0	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	13.3	6.7	0.0	20.0	30.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	3.3	0.0	3.3	-16.7	0.0	-3.3
Thalictrum fendleri Engelm. ex Gray	3.3	3.3	-3.3	3.3	13.3	0.0
Trifolium repens L.	0.0	0.0	3.3	-6.7	0.0	0.0
Viola adunca Sm.	0.0	-6.7	6.7	0.0	3.3	6.7
Vicia americana Muhl. ex Willd.	-26.7	10.0	-6.7	3.3	-3.3	0.0
Mahonia repens (Lindl.) G. Don	-6.7	-13.3	10.0	3.3	-3.3	-16.7
Spiraea betulifolia Pallas	0.0	-50.0	-6.7	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-10.0	0.0	-10.0	-3.3	6.7	-6.7

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 6. The changes in species composition in a ponderosa pine forest from 1985 to 1994 using a 30 cm x 60 cm plot frame.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	0.0	6.7	0.0	3.3	3.3	13.3
Carex concinnoides Mackenzie	0.0	0.0	3.3	0.0	0.0	0.0
Carex geyeri Boott	-16.7	23.3	33.3	-3.3	-3.3	-6.7
Calamagrostis rubescens Buckl.	6.7	0.0	-3.3	0.0	13.3	-26.7
Elymus glaucus Buckl.	33.3	50.0	26.7	60.0	43.3	46.7
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	3.3	-33.3	-33.3	-23.3
Poa pratensis L.	-6.7	-6.7	3.3	-6.7	0.0	26.7
Trisetum canescens Buckl.	-33.3	-20.0	0.0	-43.3	-36.7	3.3
Achillea millefolium L.	3.3	-16.7	3.3	6.7	-3.3	40.0
Anemone piperi Britt. ex Rydb.	0.0	0.0	3.3	0.0	0.0	10.0
Antennaria rosea Greene	6.7	0.0	0.0	3.3	0.0	0.0
Arnica cordifolia Hook.	13.3	-3.3	3.3	6.7	0.0	0.0
Claytonia perfoliata Donn ex Willd.	0.0	0.0	20.0	0.0	0.0	6.7
Eurybia conspicua (Lindl.) Nesom	0.0	50.0	0.0	13.3	33.3	0.0
Fragaria spp.	-16.7	-33.3	-13.3	13.3	-33.3	-23.3
Galium spp	-10.0	6.7	10.0	-3.3	0.0	36.7
Hieracium albiflorum Hook.	0.0	-6.7	0.0	0.0	0.0	6.7
Iris missouriensis Nutt.	0.0	0.0	0.0	6.7	3.3	-3.3
Lathyrus spp.	-20.0	-10.0	13.3	-33.3	-16.7	-23.3
Lupinus spp.	3.3	-10.0	-3.3	0.0	26.7	10.0
Moehringia macrophylla (Hook.) Fenzl	-23.3	-13.3	-16.7	0.0	-6.7	-43.3
Osmorhiza berteroi DC.	-53.3	-20.0	-6.7	-60.0	-26.7	-66.7
Potentilla gracilis Dougl. ex Hook.	-6.7	-10.0	-16.7	-30.0	-23.3	-6.7
Prunella vulgaris L.	-3.3	3.3	0.0	0.0	10.0	10.0
Ranunculus spp.	0.0	0.0	0.0	-3.3	0.0	-3.3
Stellaria longipes Goldie	0.0	10.0	0.0	-6.7	-3.3	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	20.0	0.0	46.7	0.0	0.0	43.3
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-33.3	-10.0	-36.7	-13.3	-20.0
Thalictrum fendleri Engelm. ex Gray	-3.3	6.7	0.0	3.3	3.3	0.0
Trifolium repens L.	-3.3	-26.7	3.3	-3.3	-3.3	0.0
Viola adunca Sm.	-23.3	-23.3	13.3	-10.0	-6.7	20.0
Vicia americana Muhl. ex Willd.	0.0	-10.0	0.0	0.0	10.0	3.3
Mahonia repens (Lindl.) G. Don	3.3	3.3	0.0	13.3	16.7	16.7
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-3.3	-13.3	20.0	3.3	6.7	0.0
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	30.0	36.7	0.0	30.0	16.7	0.0
Carex geyeri Boott	3.3	43.3	6.7	-3.3	-16.7	-3.3

Table 6. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Calamagrostis rubescens Buckl.	3.3	20.0	-6.7	10.0	0.0	3.3
Elymus glaucus Buckl.	6.7	13.3	0.0	46.7	33.3	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	0.0	0.0	0.0
Poa pratensis L.	13.3	-46.7	-3.3	33.3	10.0	13.3
Trisetum canescens Buckl.	-26.7	-20.0	0.0	-46.7	-6.7	10.0
Achillea millefolium L.	-10.0	-6.7	-6.7	13.3	-6.7	10.0
Anemone piperi Britt. ex Rydb.	0.0	0.0	6.7	0.0	3.3	0.0
Antennaria rosea Greene	10.0	0.0	3.3	10.0	3.3	0.0
Arnica cordifolia Hook.	3.3	3.3	20.0	-6.7	-3.3	13.3
Claytonia perfoliata Donn ex Willd.	0.0	0.0	10.0	0.0	0.0	10.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	30.0
Fragaria spp.	-10.0	6.7	-3.3	16.7	13.3	-6.7
Galium spp	10.0	0.0	0.0	10.0	0.0	0.0
Hieracium albiflorum Hook.	-13.3	-3.3	-13.3	-6.7	23.3	-6.7
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-50.0	50.0	6.7	-40.0	-56.7	20.0
Lupinus spp.	40.0	-36.7	0.0	6.7	0.0	-6.7
Moehringia macrophylla (Hook.) Fenzl	-6.7	-10.0	-6.7	-3.3	-6.7	-3.3
Osmorhiza berteroi DC.	0.0	0.0	-3.3	-3.3	3.3	10.0
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-20.0	0.0	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	0.0	0.0	-3.3	0.0	0.0	3.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	20.0	3.3	0.0	43.3	6.7	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	3.3	16.7	-3.3	6.7
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	-3.3	-3.3	-6.7	0.0	0.0
Viola adunca Sm.	3.3	-6.7	6.7	6.7	0.0	-3.3
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	-6.7	13.3	0.0
Mahonia repens (Lindl.) G. Don	-10.0	0.0	0.0	3.3	20.0	3.3
Spiraea betulifolia Pallas	-6.7	0.0	0.0	6.7	0.0	0.0
Symphoricarpos albus (L.) Blake	-3.3	20.0	-6.7	23.3	26.7	-13.3
Site 3						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	10.0	26.7	26.7
Carex concinnoides Mackenzie	3.3	26.7	0.0	6.7	6.7	23.3
Carex geyeri Boott	-13.3	-33.3	-13.3	-43.3	-13.3	-3.3
Calamagrostis rubescens Buckl.	0.0	20.0	3.3	10.0	-20.0	-13.3
Elymus glaucus Buckl.	23.3	10.0	-3.3	30.0	10.0	6.7
Melica bulbosa Geyer ex Porter & Coult.	-26.7	-6.7	-3.3	-13.3	-10.0	-16.7
Poa pratensis L.	6.7	3.3	-16.7	0.0	3.3	13.3
Trisetum canescens Buckl.	-36.7	-50.0	-16.7	-53.3	-40.0	-10.0

Table 6. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	-13.3	-26.7	-33.3	6.7	13.3	13.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	16.7	10.0	0.0
Antennaria rosea Greene	0.0	0.0	0.0	10.0	3.3	3.3
Arnica cordifolia Hook.	-3.3	0.0	-33.3	-46.7	-6.7	0.0
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	3.3	0.0	3.3
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	6.7	20.0	43.3
Fragaria spp.	-16.7	-13.3	-3.3	-3.3	3.3	-20.0
Galium spp	-16.7	-6.7	-6.7	40.0	13.3	3.3
Hieracium albiflorum Hook.	-3.3	-23.3	3.3	-13.3	-6.7	-6.7
Iris missouriensis Nutt.	0.0	6.7	0.0	0.0	0.0	0.0
Lathyrus spp.	-10.0	-23.3	6.7	-40.0	-16.7	6.7
Lupinus spp.	-3.3	-3.3	-26.7	23.3	26.7	13.3
Moehringia macrophylla (Hook.) Fenzl	0.0	-33.3	-20.0	-80.0	-43.3	-23.3
Osmorhiza berteroi DC.	-6.7	-13.3	10.0	6.7	16.7	16.7
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-3.3	-13.3	-20.0
Prunella vulgaris L.	6.7	3.3	-10.0	13.3	16.7	3.3
Ranunculus spp.	0.0	0.0	0.0	-3.3	0.0	0.0
Stellaria longipes Goldie	0.0	0.0	0.0	0.0	0.0	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	16.7	10.0	0.0	26.7	30.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	0.0	3.3	-16.7	0.0	-13.3
Thalictrum fendleri Engelm. ex Gray	3.3	3.3	-3.3	3.3	30.0	0.0
Trifolium repens L.	0.0	0.0	0.0	-6.7	0.0	3.3
Viola adunca Sm.	3.3	-6.7	6.7	-6.7	13.3	6.7
Vicia americana Muhl. ex Willd.	-40.0	3.3	-10.0	0.0	-3.3	0.0
Mahonia repens (Lindl.) G. Don	3.3	0.0	0.0	3.3	0.0	-3.3
Spiraea betulifolia Pallas	0.0	-56.7	-13.3	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	3.3	3.3	-23.3	-3.3	16.7	0.0

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 7. The changes in species composition in a ponderosa pine forest from 1985 to 1997 using a 30 cm x 30 cm plot frame.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	3.3	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	0.0	0.0	0.0	0.0	0.0	0.0
Carex geyeri Boott	-13.3	10.0	6.7	-43.3	-33.3	-30.0
Calamagrostis rubescens Buckl.	-3.3	-13.3	-3.3	-3.3	-3.3	-13.3
Elymus glaucus Buckl.	26.7	6.7	40.0	23.3	-10.0	33.3
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	-23.3	-33.3	-30.0
Poa pratensis L.	13.3	6.7	0.0	23.3	6.7	33.3
Trisetum canescens Buckl.	-16.7	-20.0	0.0	-33.3	-33.3	-13.3
Achillea millefolium L.	-6.7	-6.7	-3.3	6.7	3.3	30.0
Anemone piperi Britt. ex Rydb.	13.3	6.7	16.7	10.0	3.3	0.0
Antennaria rosea Greene	0.0	0.0	0.0	0.0	0.0	0.0
Arnica cordifolia Hook.	0.0	-6.7	0.0	-3.3	0.0	3.3
Claytonia perfoliata Donn ex Willd.	3.3	6.7	20.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	6.7	3.3	0.0	0.0	3.3
Fragaria spp.	-20.0	-40.0	-16.7	3.3	-40.0	-30.0
Galium spp	-3.3	-16.7	-10.0	-50.0	-10.0	0.0
Hieracium albiflorum Hook.	-3.3	-13.3	6.7	0.0	0.0	6.7
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	-3.3
Lathyrus spp.	0.0	-10.0	0.0	-16.7	-10.0	-46.7
Lupinus spp.	0.0	-10.0	-3.3	10.0	-3.3	0.0
Moehringia macrophylla (Hook.) Fenzl	-20.0	-6.7	0.0	0.0	-6.7	-40.0
Osmorhiza berteroi DC.	-43.3	-3.3	-16.7	-56.7	-36.7	-66.7
Potentilla gracilis Dougl. ex Hook.	0.0	-13.3	0.0	-10.0	-13.3	-6.7
Prunella vulgaris L.	-3.3	0.0	0.0	0.0	-3.3	0.0
Ranunculus spp.	0.0	0.0	0.0	-3.3	0.0	-3.3
Stellaria longipes Goldie	10.0	0.0	6.7	-3.3	6.7	3.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	10.0	20.0	13.3	10.0	20.0	36.7
Taraxacum officinale G.H. Weber ex Wiggers	-6.7	-23.3	-10.0	-36.7	-16.7	-13.3
Thalictrum fendleri Engelm. ex Gray	-3.3	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	0.0	0.0	0.0	-3.3	0.0
Viola adunca Sm.	-16.7	-20.0	-10.0	-10.0	-23.3	0.0
Vicia americana Muhl. ex Willd.	0.0	-13.3	10.0	16.7	13.3	0.0
Mahonia repens (Lindl.) G. Don	6.7	-3.3	3.3	10.0	23.3	0.0
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-6.7	36.7	23.3	13.3	13.3	13.3
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	6.7	13.3	40.0	13.3	3.3	13.3
Carex geyeri Boott	6.7	40.0	13.3	-23.3	-6.7	16.7

Table 7. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Calamagrostis rubescens Buckl.	0.0	26.7	3.3	3.3	30.0	23.3
Elymus glaucus Buckl.	0.0	0.0	0.0	-3.3	0.0	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	0.0	0.0	0.0
Poa pratensis L.	10.0	-33.3	0.0	50.0	13.3	13.3
Trisetum canescens Buckl.	-16.7	0.0	3.3	-16.7	-3.3	3.3
Achillea millefolium L.	-3.3	-6.7	-10.0	10.0	0.0	0.0
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	3.3	10.0
Antennaria rosea Greene	6.7	0.0	3.3	6.7	0.0	0.0
Arnica cordifolia Hook.	10.0	0.0	20.0	-20.0	-16.7	13.3
Claytonia perfoliata Donn ex Willd.	3.3	0.0	3.3	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-13.3	-3.3	0.0	13.3	13.3	-13.3
Galium spp	0.0	0.0	0.0	16.7	0.0	0.0
Hieracium albiflorum Hook.	0.0	-3.3	-30.0	-6.7	-6.7	-3.3
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-33.3	63.3	-13.3	-36.7	-33.3	-56.7
Lupinus spp.	16.7	-30.0	0.0	6.7	6.7	-6.7
Moehringia macrophylla (Hook.) Fenzl	0.0	-3.3	3.3	-3.3	-3.3	0.0
Osmorhiza berteroi DC.	0.0	0.0	0.0	0.0	0.0	0.0
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-6.7	0.0	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	3.3	0.0	3.3	3.3	3.3	10.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	16.7	3.3	3.3	33.3	13.3	13.3
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	-3.3	-3.3	0.0	0.0
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	-3.3	-3.3	-6.7	0.0	0.0
Viola adunca Sm.	0.0	-3.3	0.0	3.3	0.0	0.0
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	3.3	0.0	0.0
Mahonia repens (Lindl.) G. Don	-13.3	-16.7	-13.3	-3.3	3.3	-6.7
Spiraea betulifolia Pallas	-3.3	0.0	0.0	0.0	3.3	0.0
Symphoricarpos albus (L.) Blake	-16.7	0.0	6.7	6.7	3.3	16.7
Site 3						
Bromus carinatus Hook. & Arn.	10.0	10.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	0.0	6.7	0.0	3.3	6.7	3.3
Carex geyeri Boott	-26.7	-6.7	16.7	-26.7	-60.0	-20.0
Calamagrostis rubescens Buckl.	-16.7	0.0	-3.3	3.3	6.7	-10.0
Elymus glaucus Buckl.	20.0	-3.3	-3.3	26.7	-3.3	-13.3
Melica bulbosa Geyer ex Porter & Coult.	3.3	3.3	10.0	-6.7	10.0	-6.7
Poa pratensis L.	-13.3	-6.7	3.3	6.7	43.3	50.0
Trisetum canescens Buckl.	-30.0	-36.7	-16.7	-33.3	-33.3	-50.0

Table 7. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	-10.0	-6.7	-10.0	-16.7	23.3	20.0
Anemone piperi Britt. ex Rydb.	10.0	0.0	13.3	23.3	3.3	6.7
Antennaria rosea Greene	0.0	0.0	6.7	3.3	3.3	0.0
Arnica cordifolia Hook.	-6.7	13.3	6.7	-36.7	-13.3	-6.7
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-20.0	-23.3	-10.0	-6.7	-26.7	-20.0
Galium spp	-16.7	-13.3	-6.7	30.0	23.3	-6.7
Hieracium albiflorum Hook.	-6.7	-16.7	-6.7	-13.3	-3.3	-3.3
Iris missouriensis Nutt.	-3.3	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-3.3	-13.3	13.3	-30.0	-23.3	3.3
Lupinus spp.	-3.3	0.0	-13.3	3.3	6.7	10.0
Moehringia macrophylla (Hook.) Fenzl	0.0	-23.3	3.3	-66.7	-30.0	10.0
Osmorhiza berteroi DC.	-16.7	-10.0	-13.3	0.0	-16.7	-10.0
Potentilla gracilis Dougl. ex Hook.	6.7	0.0	0.0	16.7	-3.3	3.3
Prunella vulgaris L.	6.7	0.0	-10.0	-3.3	0.0	-3.3
Ranunculus spp.	0.0	0.0	0.0	-3.3	0.0	0.0
Stellaria longipes Goldie	0.0	0.0	3.3	13.3	13.3	3.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	3.3	26.7	16.7	23.3
Taraxacum officinale G.H. Weber ex Wiggers	0.0	3.3	0.0	-10.0	-3.3	-10.0
Thalictrum fendleri Engelm. ex Gray	3.3	0.0	-3.3	0.0	0.0	-3.3
Trifolium repens L.	-3.3	3.3	0.0	-6.7	0.0	0.0
Viola adunca Sm.	0.0	-6.7	-3.3	-6.7	-6.7	0.0
Vicia americana Muhl. ex Willd.	-26.7	6.7	-6.7	10.0	0.0	20.0
Mahonia repens (Lindl.) G. Don	-3.3	-23.3	10.0	6.7	-20.0	-10.0
Spiraea betulifolia Pallas	23.3	0.0	6.7	3.3	0.0	0.0
Symphoricarpos albus (L.) Blake	-20.0	-10.0	-20.0	10.0	-16.7	3.3

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 8. The changes in species composition in a ponderosa pine forest from 1985 to 1997 using a 30 cm x 60 cm plot frame.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	3.3	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	0.0	0.0	0.0	0.0	0.0	0.0
Carex geyeri Boott	-10.0	3.3	10.0	-43.3	-10.0	-33.3
Calamagrostis rubescens Buckl.	-3.3	-13.3	-3.3	-3.3	-6.7	-10.0
Elymus glaucus Buckl.	23.3	13.3	23.3	40.0	-13.3	23.3
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	-33.3	-26.7	-33.3
Poa pratensis L.	3.3	3.3	3.3	20.0	10.0	23.3
Trisetum canescens Buckl.	-30.0	-23.3	-13.3	-36.7	-46.7	-10.0
Achillea millefolium L.	-10.0	-16.7	6.7	13.3	-6.7	33.3
Anemone piperi Britt. ex Rydb.	13.3	6.7	23.3	13.3	10.0	0.0
Antennaria rosea Greene	0.0	0.0	0.0	0.0	0.0	0.0
Arnica cordifolia Hook.	0.0	-6.7	-3.3	-6.7	-3.3	0.0
Claytonia perfoliata Donn ex Willd.	3.3	10.0	30.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	6.7	3.3	0.0	0.0	6.7
Fragaria spp.	-16.7	-36.7	-16.7	6.7	-33.3	-26.7
Galium spp	-10.0	-13.3	-6.7	-46.7	-13.3	10.0
Hieracium albiflorum Hook.	-3.3	-13.3	-3.3	0.0	3.3	13.3
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	3.3	-3.3
Lathyrus spp.	-3.3	-10.0	6.7	-23.3	-3.3	-50.0
Lupinus spp.	0.0	-20.0	-3.3	10.0	3.3	6.7
Moehringia macrophylla (Hook.) Fenzl	-13.3	-13.3	0.0	0.0	-6.7	-40.0
Osmorhiza berteroi DC.	-63.3	-3.3	-20.0	-63.3	-40.0	-80.0
Potentilla gracilis Dougl. ex Hook.	0.0	-10.0	-6.7	-23.3	-6.7	-6.7
Prunella vulgaris L.	-3.3	0.0	0.0	-3.3	-3.3	0.0
Ranunculus spp.	0.0	0.0	0.0	-3.3	0.0	-3.3
Stellaria longipes Goldie	10.0	0.0	13.3	-3.3	6.7	10.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	13.3	26.7	23.3	30.0	26.7	50.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-33.3	-10.0	-40.0	-16.7	-16.7
Thalictrum fendleri Engelm. ex Gray	-3.3	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	-3.3	-26.7	0.0	0.0	0.0	3.3
Viola adunca Sm.	-16.7	-30.0	-13.3	-10.0	-26.7	0.0
Vicia americana Muhl. ex Willd.	0.0	-10.0	16.7	16.7	30.0	0.0
Mahonia repens (Lindl.) G. Don	0.0	0.0	3.3	3.3	16.7	10.0
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-3.3	6.7	26.7	-3.3	6.7	6.7
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	13.3	26.7	46.7	16.7	6.7	13.3
Carex geyeri Boott	6.7	43.3	6.7	-13.3	-10.0	6.7

Table 8. continued.

	Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Calamagrostis rubescens Buckl.	3.3	26.7	0.0	3.3	13.3	13.3
Elymus glaucus Buckl.	0.0	0.0	0.0	-3.3	0.0	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	3.3	0.0	0.0	0.0
Poa pratensis L.	13.3	-40.0	3.3	56.7	6.7	26.7
Trisetum canescens Buckl.	-16.7	-10.0	-3.3	-6.7	3.3	0.0
Achillea millefolium L.	-3.3	-6.7	-3.3	20.0	-3.3	3.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	6.7	10.0
Antennaria rosea Greene	6.7	0.0	10.0	6.7	0.0	0.0
Arnica cordifolia Hook.	0.0	3.3	26.7	-10.0	-16.7	10.0
Claytonia perfoliata Donn ex Willd.	3.3	0.0	10.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-20.0	0.0	-10.0	10.0	13.3	-6.7
Galium spp	0.0	0.0	0.0	16.7	0.0	0.0
Hieracium albiflorum Hook.	-3.3	-6.7	-30.0	0.0	3.3	0.0
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-30.0	73.3	-10.0	-40.0	-23.3	-40.0
Lupinus spp.	16.7	-40.0	0.0	16.7	-6.7	6.7
Moehringia macrophylla (Hook.) Fenzl	0.0	-6.7	3.3	0.0	-6.7	10.0
Osmorhiza berteroi DC.	0.0	0.0	-3.3	0.0	0.0	0.0
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-16.7	3.3	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	10.0	0.0	6.7	6.7	3.3	20.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	20.0	3.3	3.3	40.0	20.0	26.7
Taraxacum officinale G.H. Weber ex Wiggers	3.3	-3.3	-3.3	0.0	3.3	3.3
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	-3.3	-3.3	-6.7	0.0	0.0
Viola adunca Sm.	3.3	-6.7	0.0	3.3	3.3	-6.7
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	6.7	0.0	0.0
Mahonia repens (Lindl.) G. Don	-6.7	-6.7	-3.3	0.0	16.7	-6.7
Spiraea betulifolia Pallas	-6.7	0.0	0.0	3.3	3.3	0.0
Symphoricarpos albus (L.) Blake	-16.7	16.7	6.7	16.7	16.7	-3.3
Site 3						
Bromus carinatus Hook. & Arn.	10.0	13.3	0.0	0.0	6.7	0.0
Carex concinnoides Mackenzie	0.0	6.7	3.3	6.7	6.7	10.0
Carex geyeri Boott	-10.0	-6.7	13.3	-13.3	-53.3	-16.7
Calamagrostis rubescens Buckl.	-13.3	13.3	-3.3	-3.3	3.3	-16.7
Elymus glaucus Buckl.	23.3	-3.3	0.0	33.3	-3.3	-13.3
Melica bulbosa Geyer ex Porter & Coult.	0.0	6.7	13.3	-13.3	0.0	-13.3
Poa pratensis L.	-3.3	-6.7	-3.3	3.3	46.7	46.7
Trisetum canescens Buckl.	-36.7	-43.3	-20.0	-56.7	-33.3	-56.7

Table 8. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	-16.7	-13.3	-10.0	-20.0	6.7	20.0
Anemone piperi Britt. ex Rydb.	16.7	0.0	20.0	26.7	6.7	10.0
Antennaria rosea Greene	0.0	0.0	10.0	3.3	3.3	3.3
Arnica cordifolia Hook.	0.0	6.7	6.7	-30.0	0.0	0.0
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-10.0	-30.0	-13.3	-13.3	-20.0	-6.7
Galium spp	-16.7	-10.0	-3.3	30.0	36.7	0.0
Hieracium albiflorum Hook.	3.3	-20.0	-13.3	-10.0	-10.0	3.3
Iris missouriensis Nutt.	-3.3	6.7	0.0	0.0	3.3	0.0
Lathyrus spp.	10.0	-13.3	3.3	-23.3	-26.7	10.0
Lupinus spp.	-6.7	3.3	-20.0	16.7	16.7	13.3
Moehringia macrophylla (Hook.) Fenzl	0.0	-33.3	13.3	-60.0	-33.3	3.3
Osmorhiza berteroi DC.	-20.0	-16.7	-20.0	-6.7	-26.7	-30.0
Potentilla gracilis Dougl. ex Hook.	6.7	0.0	0.0	16.7	-10.0	-6.7
Prunella vulgaris L.	10.0	0.0	-10.0	-3.3	0.0	-3.3
Ranunculus spp.	0.0	0.0	0.0	-3.3	0.0	0.0
Stellaria longipes Goldie	0.0	0.0	3.3	20.0	16.7	6.7
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	0.0	0.0	3.3	36.7	26.7	33.3
Taraxacum officinale G.H. Weber ex Wiggers	3.3	3.3	3.3	-10.0	0.0	-20.0
Thalictrum fendleri Engelm. ex Gray	10.0	0.0	-3.3	0.0	0.0	3.3
Trifolium repens L.	-3.3	3.3	-3.3	-6.7	0.0	3.3
Viola adunca Sm.	0.0	-6.7	-3.3	-13.3	-3.3	0.0
Vicia americana Muhl. ex Willd.	-40.0	3.3	-10.0	6.7	3.3	26.7
Mahonia repens (Lindl.) G. Don	3.3	-23.3	3.3	10.0	-20.0	0.0
Spiraea betulifolia Pallas	30.0	0.0	0.0	6.7	0.0	0.0
Symphoricarpos albus (L.) Blake	-23.3	-16.7	-23.3	16.7	-23.3	16.7

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 9. The changes in species composition in a ponderosa pine forest from 1985 to 2005 using a 30 cm x 30 cm plot frame.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	0.0	0.0	3.3	43.3	36.7	26.7
Carex concinnoides Mackenzie	0.0	0.0	0.0	0.0	0.0	0.0
Carex geyeri Boott	16.7	0.0	16.7	36.7	13.3	26.7
Calamagrostis rubescens Buckl.	-23.3	-20.0	-3.3	-3.3	0.0	-26.7
Elymus glaucus Buckl.	36.7	-3.3	23.3	-26.7	-33.3	33.3
Melica bulbosa Geyer ex Porter & Coult.	0.0	3.3	43.3	-23.3	-33.3	-30.0
Poa pratensis L.	60.0	26.7	-10.0	33.3	-3.3	33.3
Trisetum canescens Buckl.	-23.3	-23.3	-10.0	-36.7	-36.7	-13.3
Achillea millefolium L.	0.0	-16.7	-13.3	16.7	-3.3	36.7
Anemone piperi Britt. ex Rydb.	13.3	16.7	0.0	3.3	0.0	0.0
Antennaria rosea Greene	0.0	0.0	0.0	0.0	0.0	0.0
Arnica cordifolia Hook.	-13.3	-6.7	0.0	-3.3	0.0	3.3
Claytonia perfoliata Donn ex Willd.	-10.0	-16.7	-6.7	-36.7	-3.3	40.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-3.3	-6.7	3.3	0.0	-3.3	0.0
Galium spp	0.0	0.0	0.0	0.0	3.3	0.0
Hieracium albiflorum Hook.	-3.3	3.3	6.7	-13.3	10.0	-6.7
Iris missouriensis Nutt.	0.0	-13.3	-3.3	6.7	-10.0	3.3
Lathyrus spp.	-23.3	-6.7	-16.7	0.0	-6.7	-40.0
Lupinus spp.	-46.7	-16.7	-23.3	-56.7	-36.7	-70.0
Moehringia macrophylla (Hook.) Fenzl	0.0	0.0	0.0	0.0	0.0	0.0
Osmorhiza berteroi DC.	3.3	-10.0	0.0	3.3	-10.0	-6.7
Potentilla gracilis Dougl. ex Hook.	-3.3	0.0	0.0	0.0	-3.3	0.0
Prunella vulgaris L.	3.3	0.0	6.7	-3.3	13.3	0.0
Ranunculus spp.	0.0	0.0	0.0	-6.7	0.0	0.0
Stellaria longipes Goldie	16.7	20.0	30.0	33.3	20.0	33.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	-33.3	-16.7	-23.3	6.7	-36.7	-23.3
Taraxacum officinale G.H. Weber ex Wiggers	-13.3	-26.7	-10.0	-46.7	-20.0	-10.0
Thalictrum fendleri Engelm. ex Gray	-3.3	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	0.0	0.0	0.0	-3.3	0.0
Viola adunca Sm.	6.7	0.0	-3.3	3.3	-30.0	6.7
Vicia americana Muhl. ex Willd.	0.0	-23.3	0.0	0.0	-3.3	0.0
Mahonia repens (Lindl.) G. Don	6.7	10.0	3.3	40.0	36.7	16.7
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	3.3	23.3	26.7	16.7	16.7	10.0
Site 2						
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	6.7
Carex concinnoides Mackenzie	3.3	0.0	6.7	0.0	0.0	0.0
Carex geyeri Boott	16.7	53.3	26.7	3.3	10.0	13.3

Table 9. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Calamagrostis rubescens Buckl.	-13.3	-13.3	3.3	-10.0	-23.3	13.3
Elymus glaucus Buckl.	0.0	0.0	0.0	-3.3	0.0	0.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	0.0	0.0	0.0
Poa pratensis L.	-3.3	-36.7	-6.7	-10.0	-13.3	-3.3
Trisetum canescens Buckl.	-20.0	-10.0	-10.0	-40.0	-26.7	-6.7
Achillea millefolium L.	-10.0	3.3	-3.3	13.3	-3.3	3.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	3.3	0.0	0.0	6.7	0.0	0.0
Arnica cordifolia Hook.	-3.3	-10.0	26.7	-23.3	-23.3	10.0
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	20.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-13.3	-3.3	-23.3	-3.3	-3.3	-6.7
Galium spp	0.0	0.0	0.0	0.0	0.0	0.0
Hieracium albiflorum Hook.	-36.7	10.0	-6.7	-66.7	-86.7	-53.3
Iris missouriensis Nutt.	23.3	-23.3	0.0	0.0	13.3	-6.7
Lathyrus spp.	-6.7	-6.7	-6.7	-3.3	-3.3	-3.3
Lupinus spp.	0.0	0.0	0.0	-3.3	0.0	-3.3
Moehringia macrophylla (Hook.) Fenzl	0.0	0.0	0.0	0.0	0.0	0.0
Osmorhiza berteroi DC.	0.0	0.0	0.0	0.0	0.0	0.0
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	0.0	0.0	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	16.7	3.3	0.0	36.7	16.7	20.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	-13.3	3.3	0.0	6.7	6.7	-6.7
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	-6.7	-6.7	-3.3	3.3
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	-3.3	-3.3	-6.7	0.0	0.0
Viola adunca Sm.	0.0	-3.3	0.0	0.0	-3.3	0.0
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	-6.7	0.0	0.0
Mahonia repens (Lindl.) G. Don	-16.7	3.3	-10.0	0.0	0.0	0.0
Spiraea betulifolia Pallas	-3.3	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-16.7	16.7	23.3	23.3	26.7	-3.3
Site 3						
Bromus carinatus Hook. & Arn.	10.0	13.3	0.0	0.0	10.0	30.0
Carex concinnoides Mackenzie	0.0	0.0	0.0	0.0	0.0	0.0
Carex geyeri Boott	-30.0	-43.3	-23.3	-13.3	-3.3	-20.0
Calamagrostis rubescens Buckl.	-33.3	-23.3	-10.0	-6.7	-10.0	-20.0
Elymus glaucus Buckl.	3.3	-6.7	-3.3	36.7	0.0	3.3
Melica bulbosa Geyer ex Porter & Coult.	-10.0	10.0	-3.3	-6.7	0.0	-10.0
Poa pratensis L.	56.7	40.0	36.7	30.0	33.3	43.3
Trisetum canescens Buckl.	-30.0	-43.3	-36.7	-33.3	-43.3	-50.0

Table 9. continued.

	Control Overstory			Thined Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	-13.3	-13.3	0.0	16.7	6.7	16.7
Anemone piperi Britt. ex Rydb.	6.7	3.3	23.3	3.3	16.7	26.7
Antennaria rosea Greene	0.0	0.0	0.0	0.0	0.0	0.0
Arnica cordifolia Hook.	-60.0	-63.3	-33.3	-96.7	-56.7	-53.3
Claytonia perfoliata Donn ex Willd.	-13.3	-3.3	0.0	36.7	16.7	-3.3
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	3.3	-13.3	10.0	-10.0	13.3	0.0
Galium spp	-3.3	0.0	0.0	0.0	0.0	0.0
Hieracium albiflorum Hook.	3.3	-20.0	10.0	-13.3	-10.0	-16.7
Iris missouriensis Nutt.	6.7	6.7	-13.3	26.7	16.7	3.3
Lathyrus spp.	0.0	-23.3	-20.0	-76.7	-40.0	-10.0
Lupinus spp.	-23.3	-13.3	-13.3	-20.0	-16.7	-16.7
Moehringia macrophylla (Hook.) Fenzl	0.0	0.0	0.0	0.0	0.0	0.0
Osmorhiza berteroi DC.	6.7	0.0	0.0	0.0	0.0	-6.7
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	-10.0	-3.3	0.0	-3.3
Prunella vulgaris L.	3.3	0.0	6.7	6.7	16.7	6.7
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	3.3	3.3	6.7	13.3	36.7	23.3
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	-6.7	-10.0	-10.0	-16.7	-6.7	-20.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	0.0	0.0	-3.3	-3.3	10.0
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	-3.3	0.0	0.0	-3.3
Trifolium repens L.	-3.3	0.0	0.0	-6.7	0.0	0.0
Viola adunca Sm.	60.0	46.7	23.3	20.0	16.7	50.0
Vicia americana Muhl. ex Willd.	-20.0	-10.0	-3.3	-10.0	3.3	6.7
Mahonia repens (Lindl.) G. Don	16.7	-10.0	6.7	13.3	-6.7	-13.3
Spiraea betulifolia Pallas	0.0	-3.3	-3.3	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-6.7	-3.3	-20.0	3.3	6.7	10.0

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 10. The changes in species composition in a ponderosa pine forest from 1985 to 2005 using a 30 cm x 60 cm plot frame.

	Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1						
Bromus carinatus Hook. & Arn.	0.0	3.3	3.3	53.3	50.0	33.3
Carex concinnoides Mackenzie	0.0	0.0	0.0	0.0	0.0	0.0
Carex geyeri Boott	6.7	-6.7	16.7	33.3	23.3	23.3
Calamagrostis rubescens Buckl.	-26.7	-20.0	-3.3	-3.3	-3.3	-26.7
Elymus glaucus Buckl.	36.7	-3.3	10.0	-26.7	-40.0	30.0
Melica bulbosa Geyer ex Porter & Coult.	0.0	3.3	50.0	-33.3	-33.3	-33.3
Poa pratensis L.	46.7	0.0	-13.3	23.3	3.3	30.0
Trisetum canescens Buckl.	-36.7	-30.0	-23.3	-43.3	-50.0	-13.3
Achillea millefolium L.	-6.7	-26.7	-16.7	6.7	-20.0	43.3
Anemone piperi Britt. ex Rydb.	13.3	23.3	0.0	3.3	0.0	3.3
Antennaria rosea Greene	0.0	0.0	0.0	0.0	0.0	0.0
Arnica cordifolia Hook.	-13.3	-6.7	-3.3	-6.7	-3.3	0.0
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-36.7	-13.3	-33.3	6.7	-33.3	-26.7
Galium spp	-13.3	-10.0	-3.3	-30.0	-6.7	36.7
Hieracium albiflorum Hook.	-3.3	-6.7	-6.7	0.0	0.0	6.7
Iris missouriensis Nutt.	0.0	0.0	0.0	3.3	6.7	0.0
Lathyrus spp.	0.0	3.3	10.0	-6.7	16.7	-6.7
Lupinus spp.	0.0	-26.7	-3.3	3.3	-10.0	6.7
Moehringia macrophylla (Hook.) Fenzl	-23.3	-13.3	-16.7	0.0	-6.7	-43.3
Osmorhiza berteroi DC.	-70.0	-23.3	-33.3	-63.3	-40.0	-83.3
Potentilla gracilis Dougl. ex Hook.	0.0	-6.7	-13.3	-3.3	-6.7	-6.7
Prunella vulgaris L.	-3.3	0.0	0.0	-3.3	-3.3	0.0
Ranunculus spp.	6.7	0.0	10.0	-3.3	13.3	0.0
Stellaria longipes Goldie	0.0	0.0	0.0	-6.7	-3.3	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	16.7	26.7	40.0	36.7	23.3	43.3
Taraxacum officinale G.H. Weber ex Wiggers	-10.0	-33.3	-10.0	-50.0	-26.7	-13.3
Thalictrum fendleri Engelm. ex Gray	-3.3	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	-3.3	-26.7	0.0	-3.3	-3.3	0.0
Viola adunca Sm.	6.7	-3.3	-6.7	0.0	-36.7	3.3
Vicia americana Muhl. ex Willd.	0.0	-23.3	0.0	0.0	-6.7	0.0
Mahonia repens (Lindl.) G. Don	3.3	6.7	3.3	40.0	33.3	23.3
Spiraea betulifolia Pallas	0.0	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	0.0	3.3	23.3	3.3	10.0	-6.7
Site 2						
Bromus carinatus Hook. & Arn.	3.3	0.0	10.0	0.0	3.3	6.7
Carex concinnoides Mackenzie	3.3	0.0	13.3	0.0	0.0	0.0
Carex geyeri Boott	10.0	46.7	16.7	0.0	3.3	6.7
Calamagrostis rubescens Buckl.	-16.7	-16.7	0.0	-3.3	-36.7	3.3
Elymus glaucus Buckl.	0.0	0.0	0.0	-3.3	0.0	0.0

Table 10. continued.

	Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Melica bulbosa Geyer ex Porter & Coult.	0.0	0.0	0.0	0.0	0.0	0.0
Poa pratensis L.	-6.7	-46.7	-6.7	-10.0	-20.0	-3.3
Trisetum canescens Buckl.	-26.7	-23.3	-16.7	-33.3	-26.7	-16.7
Achillea millefolium L.	-10.0	-6.7	-3.3	20.0	-6.7	-3.3
Anemone piperi Britt. ex Rydb.	0.0	0.0	0.0	0.0	0.0	0.0
Antennaria rosea Greene	6.7	0.0	0.0	10.0	0.0	0.0
Arnica cordifolia Hook.	-3.3	0.0	23.3	-13.3	-23.3	16.7
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-20.0	6.7	-6.7	23.3	6.7	-6.7
Galium spp	0.0	0.0	0.0	20.0	0.0	0.0
Hieracium albiflorum Hook.	-20.0	-13.3	-30.0	-3.3	0.0	-6.7
Iris missouriensis Nutt.	0.0	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	-33.3	10.0	-6.7	-73.3	-86.7	-53.3
Lupinus spp.	30.0	-33.3	-3.3	6.7	6.7	-3.3
Moehringia macrophylla (Hook.) Fenzl	-6.7	-10.0	-6.7	-3.3	-6.7	-3.3
Osmorhiza berteroi DC.	0.0	0.0	-3.3	-6.7	0.0	-3.3
Potentilla gracilis Dougl. ex Hook.	0.0	0.0	0.0	-13.3	0.0	0.0
Prunella vulgaris L.	0.0	0.0	0.0	0.0	0.0	0.0
Ranunculus spp.	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	0.0	0.0	-3.3	0.0	0.0	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	33.3	3.3	0.0	56.7	16.7	26.7
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	-6.7	3.3	0.0	3.3
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	0.0	0.0	0.0	0.0
Trifolium repens L.	0.0	-3.3	-3.3	-6.7	0.0	0.0
Viola adunca Sm.	0.0	-6.7	0.0	3.3	-3.3	-6.7
Vicia americana Muhl. ex Willd.	0.0	0.0	0.0	-3.3	0.0	0.0
Mahonia repens (Lindl.) G. Don	-20.0	16.7	0.0	16.7	10.0	-6.7
Spiraea betulifolia Pallas	-6.7	0.0	0.0	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-13.3	30.0	13.3	36.7	30.0	-20.0
Site 3						
Bromus carinatus Hook. & Arn.	13.3	13.3	3.3	0.0	10.0	33.3
Carex concinnoides Mackenzie	0.0	0.0	0.0	0.0	0.0	0.0
Carex geyeri Boott	-23.3	-36.7	-23.3	-13.3	-10.0	-23.3
Calamagrostis rubescens Buckl.	-40.0	-23.3	-16.7	-20.0	-13.3	-26.7
Elymus glaucus Buckl.	3.3	-6.7	-3.3	36.7	0.0	6.7
Melica bulbosa Geyer ex Porter & Coult.	-13.3	10.0	-3.3	-13.3	-10.0	-16.7
Poa pratensis L.	60.0	40.0	26.7	26.7	30.0	43.3
Trisetum canescens Buckl.	-36.7	-53.3	-43.3	-56.7	-46.7	-60.0
Achillea millefolium L.	-23.3	-23.3	3.3	20.0	10.0	10.0
Anemone piperi Britt. ex Rydb.	10.0	6.7	36.7	10.0	16.7	30.0
Antennaria rosea Greene	0.0	0.0	0.0	0.0	0.0	0.0
Arnica cordifolia Hook.	-56.7	-70.0	-33.3	-96.7	-60.0	-56.7
Claytonia perfoliata Donn ex Willd.	0.0	0.0	0.0	0.0	0.0	0.0

Table 10. continued.

	Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Eurybia conspicua (Lindl.) Nesom	0.0	0.0	0.0	0.0	0.0	0.0
Fragaria spp.	-6.7	-13.3	-13.3	-23.3	-6.7	-23.3
Galium spp	-13.3	-6.7	0.0	36.7	20.0	-3.3
Hieracium albiflorum Hook.	3.3	-16.7	16.7	-6.7	6.7	3.3
Iris missouriensis Nutt.	-3.3	0.0	0.0	0.0	0.0	0.0
Lathyrus spp.	6.7	-16.7	-3.3	-10.0	0.0	-3.3
Lupinus spp.	3.3	3.3	-20.0	43.3	16.7	10.0
Moehringia macrophylla (Hook.) Fenzl	0.0	-33.3	-20.0	-80.0	-43.3	-23.3
Osmorhiza berteroi DC.	-26.7	-20.0	-20.0	-26.7	-26.7	-43.3
Potentilla gracilis Dougl. ex Hook.	6.7	0.0	0.0	0.0	-6.7	-20.0
Prunella vulgaris L.	0.0	0.0	-10.0	-3.3	0.0	-3.3
Ranunculus spp.	3.3	0.0	6.7	10.0	26.7	6.7
Stellaria longipes Goldie	0.0	0.0	0.0	0.0	0.0	0.0
Symphyotrichum spathulatum (Lindl.) Nesom var. *spathulatum*	3.3	3.3	10.0	16.7	40.0	26.7
Taraxacum officinale G.H. Weber ex Wiggers	-3.3	0.0	0.0	-6.7	-3.3	0.0
Thalictrum fendleri Engelm. ex Gray	0.0	0.0	-3.3	0.0	0.0	-3.3
Trifolium repens L.	-3.3	0.0	-3.3	-6.7	0.0	0.0
Viola adunca Sm.	63.3	60.0	30.0	23.3	26.7	50.0
Vicia americana Muhl. ex Willd.	-33.3	-16.7	-3.3	-16.7	10.0	6.7
Mahonia repens (Lindl.) G. Don	23.3	-3.3	-6.7	13.3	6.7	-6.7
Spiraea betulifolia Pallas	0.0	6.7	-13.3	0.0	0.0	0.0
Symphoricarpos albus (L.) Blake	-3.3	-13.3	-33.3	0.0	10.0	3.3

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Appendix C

Ponderosa Pine Shrub Density and Cover Changes

Table 1. Changes in shrub density from 1985 to 1988, 1991, 1994, and 2003.

		Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
1988	**Site 1**						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	-1.0	1.3	-6.3	-3.3	1.0	-1.3
	Crataegus douglasii Lindl.	0.3	0.3	0.0	-2.0	-2.7	-1.0
	Holodiscus discolor (Pursh) Maxim.	-1.3	0.0	0.0	0.0	0.0	0.3
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	-1.7
	Prunus virginiana L.	0.0	0.0	0.0	-2.3	0.0	0.0
	Ribes cereum Dougl.	-5.3	22.7	-6.7	-1.7	-0.3	3.3
	Rosa gymnocarpa Nutt.	1.3	3.0	3.0	-3.0	1.3	-1.0
	Site 2						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	-1.0	0.3	0.3	-0.3	0.3	0.0
	Crataegus douglasii Lindl.	-1.0	-1.3	-1.0	0.0	0.0	0.3
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	-23.7	8.3	-7.0	0.0	2.0	-0.3
	Site 3						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	-0.3	-1.3	-0.3	-2.3	-0.7	-0.3
	Crataegus douglasii Lindl.	-2.7	-5.3	-0.3	-1.3	7.7	-1.7
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	-0.3	-0.3
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	-0.3	0.0	0.0
	Rosa gymnocarpa Nutt.	-5.0	-6.0	-4.0	-0.3	-5.7	2.7
1991	**Site 1**						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	1.3	1.3	2.0	3.0	5.0	2.0
	Crataegus douglasii Lindl.	0.0	1.0	0.0	0.0	-0.7	-0.7
	Holodiscus discolor (Pursh) Maxim.	-0.3	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	-1.7
	Prunus virginiana L.	0.0	0.0	0.0	-3.7	0.0	0.0
	Ribes cereum Dougl.	-2.3	10.7	-0.7	0.0	-0.7	1.7
	Rosa gymnocarpa Nutt.	4.0	3.0	2.3	19.7	8.3	9.7

Table 1. continued.

		Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
	Site 2						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	1.7	0.3	0.7	0.3	0.0
	Crataegus douglasii Lindl.	1.0	0.0	1.0	2.3	1.7	0.7
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.3	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	-15.3	35.3	11.7	0.3	19.3	0.3
	Site 3						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	3.7	45.0	1.0	-0.7	1.3	1.3
	Crataegus douglasii Lindl.	0.3	-5.3	-0.3	1.0	1.3	3.7
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.3	1.3	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	-0.3	-0.3
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	-0.3	0.0	0.0
	Rosa gymnocarpa Nutt.	2.3	-2.3	8.3	4.3	3.3	2.7
1994	**Site 1**						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	4.0	8.3	34.7	24.7	22.3	7.7
	Crataegus douglasii Lindl.	0.3	0.7	0.0	9.3	1.3	-0.3
	Holodiscus discolor (Pursh) Maxim.	9.3	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.3	0.0	0.0	0.0	0.0	-1.7
	Prunus virginiana L.	0.0	0.0	0.0	-3.7	0.0	0.0
	Ribes cereum Dougl.	0.3	35.7	13.3	1.3	0.3	0.7
	Rosa gymnocarpa Nutt.	13.0	5.0	5.0	25.3	53.7	14.3
	Site 2						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	2.7	9.0	1.3	1.7	8.3	0.0
	Crataegus douglasii Lindl.	0.0	-1.3	1.0	-0.3	2.0	0.3
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	-11.7	45.7	30.0	1.0	40.0	4.3

Table 1. continued.

		Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
	Site 3						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	156.3	360.7	-1.3	-0.3	3.0	-0.7
	Crataegus douglasii Lindl.	7.3	1.0	-0.7	3.0	0.0	1.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	-0.3	6.7	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	57.3	0.0	7.3	1.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.3	0.0	0.0
	Rosa gymnocarpa Nutt.	16.3	5.3	5.7	0.0	13.0	1.3
2003	**Site 1**						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	3.7	2.3	5.7	5.7	11.0	16.7
	Crataegus douglasii Lindl.	2.7	0.3	0.3	1.3	0.7	0.0
	Holodiscus discolor (Pursh) Maxim.	7.0	0.0	0.0	0.0	0.0	0.7
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	-1.7
	Prunus virginiana L.	0.0	0.0	0.0	25.3	0.0	6.0
	Ribes cereum Dougl.	-2.0	25.0	5.3	0.7	0.0	3.7
	Rosa gymnocarpa Nutt.	17.3	16.3	3.7	23.0	78.7	17.7
	Site 2						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	1.0	21.3	1.0	7.0	1.0	1.7
	Crataegus douglasii Lindl.	-1.0	0.3	0.3	-0.3	2.3	0.3
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.3	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	-5.3	47.3	31.0	2.7	19.7	0.7
	Site 3						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	4.3	4.0	3.3	1.0	2.0	7.7
	Crataegus douglasii Lindl.	2.3	-4.3	0.7	-0.7	0.7	7.7
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	-0.3	-0.3	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.7	1.0	-0.3
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.3	2.3	0.7	0.3
	Rosa gymnocarpa Nutt.	57.0	22.3	17.3	1.3	9.0	5.0

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 2. Changes in shrub cover from 1995 to 1988, 1991, 1994, and 2003.

		Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
1988	**Site 1**						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.4	0.4	-1.4	-7.1	0.8	-0.3
	Crataegus douglasii Lindl.	0.0	0.0	0.0	-4.1	-0.1	-0.1
	Holodiscus discolor (Pursh) Maxim.	2.8	0.0	0.0	0.0	0.0	0.5
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	-1.4
	Prunus virginiana L.	0.0	0.0	0.0	0.9	0.0	0.0
	Ribes cereum Dougl.	-3.3	-2.2	-2.8	0.1	-0.7	0.6
	Rosa gymnocarpa Nutt.	-0.1	0.0	1.1	-0.1	-1.1	0.0
	Site 2						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.0	0.4	0.0
	Crataegus douglasii Lindl.	0.0	0.0	0.5	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	-0.8	0.0	-2.1	0.0	0.0	0.1
	Site 3						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.1	0.0	0.0	0.3	0.0	0.0
	Crataegus douglasii Lindl.	2.5	-5.3	0.0	-0.2	0.6	-0.2
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.6	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	-0.8	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	-0.2	0.0	0.0
	Rosa gymnocarpa Nutt.	0.1	-0.6	-0.1	-0.1	-0.1	0.0
1991	**Site 1**						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.3	3.5	3.0	-3.6	2.7	-0.8
	Crataegus douglasii Lindl.	0.0	0.0	0.0	-4.2	0.0	-0.1
	Holodiscus discolor (Pursh) Maxim.	2.1	0.0	0.0	0.0	0.0	0.5
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	-1.4
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	-2.7	-5.0	-3.9	0.0	0.0	0.5
	Rosa gymnocarpa Nutt.	-0.2	0.8	0.4	1.7	0.7	0.5

Table 2. continued.

		Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
	Site 2						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	1.3	0.0	0.0	0.4	0.0
	Crataegus douglasii Lindl.	0.0	0.0	-0.2	0.1	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	-1.0	0.5	-2.2	0.0	0.3	0.0
	Site 3						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.2	4.8	0.2	0.0	0.2	0.0
	Crataegus douglasii Lindl.	2.8	-4.9	0.0	-0.1	0.0	0.5
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	-0.9	1.2	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	-0.8	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	-0.2	0.0	0.0
	Rosa gymnocarpa Nutt.	0.2	-0.7	0.1	0.1	0.2	0.1
1994	**Site 1**						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	2.0	6.3	4.1	-4.1	2.8	-1.1
	Crataegus douglasii Lindl.	0.2	1.0	0.0	-4.5	0.1	1.4
	Holodiscus discolor (Pursh) Maxim.	-1.9	0.0	0.0	0.0	0.0	0.1
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	-1.4
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	-3.2	-5.9	-4.1	0.2	-0.7	0.0
	Rosa gymnocarpa Nutt.	0.9	0.4	0.4	1.5	2.2	0.5
	Site 2						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.2	0.0	0.0	0.0	0.2	0.0
	Crataegus douglasii Lindl.	0.0	0.0	-0.1	0.0	0.6	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	-0.8	0.2	-2.0	0.0	0.7	0.0

Table 2. continued.

		Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
	Site 3						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	3.7	10.8	0.0	-0.2	0.0	0.0
	Crataegus douglasii Lindl.	5.5	-5.3	0.0	-0.2	0.0	-1.3
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	-0.9	0.1	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	1.6	0.0	0.7	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	-0.2	0.0	0.0
	Rosa gymnocarpa Nutt.	0.4	-0.6	-0.1	-0.1	0.8	0.0
2003	**Site 1**						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	1.1	3.7	3.8	-2.6	6.8	7.0
	Crataegus douglasii Lindl.	0.2	0.1	0.0	-4.4	4.5	-0.1
	Holodiscus discolor (Pursh) Maxim.	1.5	0.0	0.0	0.0	0.0	-0.4
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	-1.4
	Prunus virginiana L.	0.0	0.0	0.0	1.9	0.0	0.0
	Ribes cereum Dougl.	-3.0	-6.5	-4.9	0.0	-0.7	0.0
	Rosa gymnocarpa Nutt.	-0.6	2.4	0.0	0.7	0.7	-0.2
	Site 2						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.1	0.6	0.0
	Crataegus douglasii Lindl.	0.0	0.0	-0.2	0.0	4.7	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	-1.1	-0.1	-2.8	0.0	0.0	0.0
	Site 3						
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.2	1.2	0.0	-0.2	1.4	0.1
	Crataegus douglasii Lindl.	2.1	-1.0	0.0	-0.6	0.3	0.7
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	-0.9	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	-0.8	0.0
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.0	0.0	-0.2	0.0	0.0
	Rosa gymnocarpa Nutt.	-0.4	1.7	0.0	-0.1	-0.2	0.0

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Appendix D

Grand Fir and Ponderosa Pine Understory Production

Table 1. The effects of year, timber harvest, and herbivory treatments on understory production.

Forest Type	Year	Site	Timber Harvest	Herbivoy	Total Prod.	CAGE	CARU	POPR	SYAL	Pgrass	Pforb	Annual	Shrub
ABGR	2003	1	Clearcut	CExc	1231.8	124.0	54.4	273.2	148.4	227.4	230.2	50.0	320.6
ABGR	2003	1	Clearcut	CGExc	1261.9	289.2	33.0	371.2	132.2	63.4	296.0	216.4	212.6
ABGR	2003	1	Clearcut	Grazed	1399.5	288.4	172.6	158.4	138.2	165.8	466.8	143.8	171.8
ABGR	2003	1	Control	CExc	876.0	336.0	8.8	52.8	63.8	74.4	244.6	6.0	220.4
ABGR	2003	1	Control	CGExc	925.4	178.0	16.6	23.8	109.4	113.8	277.2	4.4	267.2
ABGR	2003	1	Control	Grazed	738.2	198.8	6.8	7.6	25.2	52.4	316.2	2.6	192.2
ABGR	2003	1	Thinned	CExc	1060.8	113.0	135.4	132.2	21.4	496.4	180.8	29.0	95.4
ABGR	2003	1	Thinned	CGExc	967.1	235.8	218.0	123.0	21.8	94.0	105.2	24.8	251.2
ABGR	2003	1	Thinned	Grazed	948.2	193.6	269.6	90.8	25.8	159.8	231.6	13.4	117.2
ABGR	2003	2	Clearcut	CExc	1180.5	171.8	113.8	82.0	53.4	188.0	97.8	12.2	398.2
ABGR	2003	2	Clearcut	CGExc	1329.6	473.8	210.8	71.2	165.4	91.0	103.2	2.6	211.6
ABGR	2003	2	Clearcut	Grazed	1322.7	208.8	320.4	11.4	96.2	128.2	109.2	8.4	432.2
ABGR	2003	2	Control	CExc	754.9	283.0	89.0	1.2	8.6	35.0	47.8	0.6	322.8
ABGR	2003	2	Control	CGExc	665.6	296.4	64.2	5.8	31.0	45.6	29.6	0.6	118
ABGR	2003	2	Control	Grazed	770.2	191.8	249.6	10.0	24.0	43.0	70.6	5.4	120.8
ABGR	2003	2	Thinned	CExc	1354.2	69.6	464.0	0.8	49.0	70.8	490.0	0.6	154.8
ABGR	2003	2	Thinned	CGExc	1175.0	312.2	154.6	27.6	63.0	196.0	82.4	4.8	268.8
ABGR	2003	2	Thinned	Grazed	899.0	90.2	78.2	28.6	60.4	345.6	114.6	2.2	327.6
ABGR	2003	3	Clearcut	CExc	1769.8	296.4	64.4	483.6	50.0	217.4	410.4	62.8	81.8
ABGR	2003	3	Clearcut	CGExc	1449.7	422.0	206.0	439.2	83.4	68.0	117.0	12.0	245.4
ABGR	2003	3	Clearcut	Grazed	1934.2	535.8	740.8	294.0	85.2	132.6	155.8	40.0	107.8
ABGR	2003	3	Control	CExc	1022.5	264.6	212.2	27.2	21.0	63.2	197.0	5.6	209.8
ABGR	2003	3	Control	CGExc	902.0	36.0	200.0	0.0	6.0	24.6	246.4	0.2	358
ABGR	2003	3	Control	Grazed	830.4	116.8	292.4	0.0	21.4	29.2	151.2	3.6	208.6
ABGR	2003	3	Thinned	CExc	1167.8	281.2	364.2	33.6	26.2	121.0	68.4	38.8	216.4
ABGR	2003	3	Thinned	CGExc	934.2	104.4	528.0	4.2	3.2	65.0	123.6	0.4	169.8

Table 1. continued.

Forest Type	Year	Site	Timber Harvest	Herbivoy	Total Prod.	CAGE	CARU	POPR	SYAL	Pgrass	Pforb	Annual	Shrub
ABGR	2003	3	Thinned	Grazed	1119.3	145.8	509.6	46.6	20.6	223.6	136.2	4.8	242.2
PIPO	1989	1	Control	GRAZED	865.6	197.0	45.6	65.2	215.8	130.0	264.6	32.4	11.6
PIPO	1989	1	Control	CEXC	868.7	152.8	60.0	27.2	123.2	91.4	309.0	12.8	30.4
PIPO	1989	1	Control	CGEXC	1047.7	182.0	80.6	118.2	108.8	147.2	277.2	74.4	35.6
PIPO	1989	1	Thinned	GRAZED	1744.7	164.8	13.8	367.8	141.8	342.2	341.0	76.6	37.6
PIPO	1989	1	Thinned	CEXC	1788.9	182.2	0.0	528.6	261.6	472.8	290.2	11.2	84.2
PIPO	1989	1	Thinned	CGEXC	1883.4	182.8	0.0	473.4	152.8	524.6	463.0	68.4	11.2
PIPO	1989	2	Control	GRAZED	494.0	131.2	0.0	1.6	26.6	42.6	198.4	4.6	22.6
PIPO	1989	2	Control	CEXC	467.9	134.2	2.4	0.0	23.6	25.2	253.4	1.0	25.6
PIPO	1989	2	Control	CGEXC	593.5	247.0	49.2	0.0	8.8	9.4	193.6	1.2	19.0
PIPO	1989	2	Thinned	GRAZED	903.2	145.4	63.8	12.6	84.0	121.8	370.8	4.8	20.4
PIPO	1989	2	Thinned	CEXC	1209.6	298.4	25.4	46.0	60.2	109.8	582.0	5.6	15.4
PIPO	1989	2	Thinned	CGEXC	1239.2	251.2	184.2	16.2	51.4	104.6	441.4	5.6	40.4
PIPO	1989	3	Control	GRAZED	690.8	231.6	92.8	57.0	64.4	95.0	236.4	1.0	51.2
PIPO	1989	3	Control	CEXC	699.5	247.2	38.0	8.0	19.8	56.6	268.8	0.0	57.8
PIPO	1989	3	Control	CGEXC	746.0	116.2	75.2	3.8	38.8	36.0	329.6	2.0	107.6
PIPO	1989	3	Thinned	GRAZED	1225.0	260.8	44.8	188.0	17.0	157.6	448.6	5.2	71.0
PIPO	1989	3	Thinned	CEXC	1319.5	216.2	68.6	172.0	29.8	414.6	320.4	3.0	41.4
PIPO	1989	3	Thinned	CGEXC	1355.5	270.0	71.8	266.8	31.4	174.4	403.0	0.0	3.2
PIPO	1992	1	Control	GRAZED	757.5	314.0	0.8	96.8	80.6	127.4	125.6	0.0	0.0
PIPO	1992	1	Control	CEXC	852.2	307.2	0.0	109.2	146.8	107.6	50.6	0.0	43.4
PIPO	1992	1	Control	CGEXC	723.9	117.4	13.0	73.0	64.6	147.0	137.6	0.0	0.0
PIPO	1992	1	Thinned	GRAZED	935.7	259.6	11.0	172.0	63.6	137.8	157.0	0.0	68.8
PIPO	1992	1	Thinned	CEXC	1215.7	131.4	0.0	267.2	143.0	261.2	176.6	0.0	116.0
PIPO	1992	1	Thinned	CGEXC	1102.2	88.4	16.6	141.8	161.8	161.0	176.6	0.0	145.0
PIPO	1992	2	Control	GRAZED	338.4	142.2	13.0	3.2	47.2	57.4	116.6	12.0	27.6
PIPO	1992	2	Control	CEXC	311.9	251.6	45.6	21.0	38.8	38.0	17.0	6.0	0.0
PIPO	1992	2	Control	CGEXC	558.0	153.8	115.2	0.0	24.0	33.2	27.6	9.0	14.0

Table 1. continued.

Forest Type	Year	Site	Timber Harvest	Herbivoy	Total Prod.	CAGE	CARU	POPR	SYAL	Pgrass	Pforb	Annual	Shrub
PIPO	1992	2	Thinned	GRAZED	543.9	261.4	4.0	20.0	0.0	139.8	109.4	0.0	0.0
PIPO	1992	2	Thinned	CEXC	731.1	243.8	83.6	70.4	22.8	170.8	225.4	7.2	3.0
PIPO	1992	2	Thinned	CGEXC	751.7	222.2	170.8	61.0	8.8	39.4	87.0	0.0	35.4
PIPO	1992	3	Control	GRAZED	498.2	210.0	13.6	2.0	7.2	111.4	84.0	1.2	28.8
PIPO	1992	3	Control	CEXC	608.2	253.6	43.6	34.8	12.6	67.6	77.0	1.0	67.4
PIPO	1992	3	Control	CGEXC	558.1	482.0	23.2	0.0	3.8	25.8	42.4	8.6	35.4
PIPO	1992	3	Thinned	GRAZED	623.1	101.0	51.8	31.6	16.4	131.6	117.8	28.8	8.4
PIPO	1992	3	Thinned	CEXC	775.0	123.4	69.4	87.1	14.0	111.8	127.6	19.0	82.4
PIPO	1992	3	Thinned	CGEXC	753.2	173.4	5.0	50.6	71.4	147.0	217.4	4.0	0.0
PIPO	1995	1	Control	GRAZED	906.6	251.4	0.0	153.6	113.4	136.4	211.8	42.6	0.0
PIPO	1995	1	Control	CEXC	1025.7	304.4	267.2	94.2	99.2	145.6	136.2	11.4	41.6
PIPO	1995	1	Control	CGEXC	980.2	173.6	385.0	39.2	161.2	100.8	207.8	59.6	0.6
PIPO	1995	1	Thinned	GRAZED	1048.1	174.2	9.2	145.4	84.8	219.6	260.4	27.6	35.8
PIPO	1995	1	Thinned	CEXC	1067.1	330.2	0.0	103.8	105.2	124.6	300.4	58.0	36.8
PIPO	1995	1	Thinned	CGEXC	1112.9	179.8	80.8	205.2	95.4	176.8	461.2	0.0	38.6
PIPO	1995	2	Control	GRAZED	378.7	122.2	2.2	0.0	7.4	21.2	96.6	7.8	3.0
PIPO	1995	2	Control	CEXC	436.2	271.8	18.4	0.4	10.2	2.0	94.2	6.2	0.0
PIPO	1995	2	Control	CGEXC	689.2	518.6	16.2	8.6	12.4	22.4	93.2	23.2	1.2
PIPO	1995	2	Thinned	GRAZED	494.9	185.4	6.2	46.0	25.6	49.0	77.4	19.6	6.0
PIPO	1995	2	Thinned	CEXC	771.7	321.8	28.0	69.6	15.8	63.4	146.0	23.2	0.0
PIPO	1995	2	Thinned	CGEXC	867.5	389.8	274.0	27.4	2.2	56.2	152.2	23.4	0.0
PIPO	1995	3	Control	GRAZED	380.5	78.4	12.0	1.0	3.6	127.8	131.8	3.2	2.8
PIPO	1995	3	Control	CEXC	600.7	478.4	11.0	9.6	18.2	39.8	62.4	6.2	44.8
PIPO	1995	3	Control	CGEXC	602.8	224.8	3.2	18.4	23.4	52.8	82.8	1.0	147.0
PIPO	1995	3	Thinned	GRAZED	588.0	92.4	48.6	21.8	17.2	29.2	240.6	3.4	0.6
PIPO	1995	3	Thinned	CEXC	874.7	211.4	138.8	200.4	1.2	50.2	154.8	16.0	25.2
PIPO	1995	3	Thinned	CGEXC	1049.2	482.8	10.4	95.4	54.8	76.4	300.4	9.6	4.4
PIPO	2003	1	Control	CGEXC	1287.8	295.2	134.4	106.4	301.4	72.2	239.6	13.2	55.0

Table 1. continued.

Forest Type	Year	Site	Timber Harvest	Herbivoy	Total Prod.	CAGE	CARU	POPR	SYAL	Pgrass	Pforb	Annual	Shrub
PIPO	2003	1	Control	CEXC	1438.1	507.6	269.2	95.6	129.8	127.0	171.6	0.0	92.2
PIPO	2003	1	Control	GRAZED	1260.5	137.2	0.8	106.0	88.6	546.6	200.6	0.2	76.2
PIPO	2003	1	Thinned	CEXC	1532.9	479.6	0.0	168.0	150.4	170.0	300.4	22.0	135.2
PIPO	2003	1	Thinned	GRAZED	1654.7	330.8	53.6	181.0	110.8	323.8	317.6	90.4	145.2
PIPO	2003	1	Thinned	CGEXC	1582.4	281.2	116.8	115.6	198.2	56.6	418.6	118.0	347.4
PIPO	2003	2	Control	GRAZED	570.8	137.0	36.0	0.0	22.2	41.2	131.8	0.4	2.0
PIPO	2003	2	Control	CGEXC	694.9	297.4	40.8	0.0	29.8	52.4	79.0	0.0	24.2
PIPO	2003	2	Control	CEXC	462.5	236.0	65.4	0.6	11.4	26.4	105.4	0.0	8.4
PIPO	2003	2	Thinned	GRAZED	906.5	238.6	61.8	25.8	25.6	76.4	268.6	3.2	14.0
PIPO	2003	2	Thinned	CGEXC	868.6	324.4	151.0	10.2	20.6	21.4	189.4	1.0	63.2
PIPO	2003	2	Thinned	CEXC	994.2	307.4	168.0	46.8	21.0	96.0	244.6	5.8	19.2
PIPO	2003	3	Thinned	GRAZED	713.0	258.0	10.2	120.8	21.4	127.8	181.4	15.0	4.6
PIPO	2003	3	Thinned	CGEXC	903.2	507.6	86.4	125.0	111.2	27.0	184.6	11.6	8.0
PIPO	2003	3	Thinned	CEXC	845.9	184.2	77.8	151.8	38.0	144.0	230.8	19.4	2.2
PIPO	2003	3	Control	CGEXC	576.2	279.8	54.4	3.8	25.8	35.8	50.2	5.0	133.0
PIPO	2003	3	Control	CEXC	824.5	378.2	76.6	35.6	8.4	56.2	60.4	7.2	73.6
PIPO	2003	3	Control	GRAZED	741.1	293.4	56.6	82.0	20.6	131.0	127.4	0.2	20.4

ABGR - *Abies grandis* (Dougl. ex D. Don) Lindl.; PIPO - *Pinus ponderosa* P.& C. Lawson
Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.
Total Prod. – Total Production; CAGE - *Carex geyeri* Boott; CARU - *Calamagrostis rubescens* Buckl.; POPR - *Poa pratensis* L.; SYAL - *Symphoricarpos albus* (L.) Blake; PGrass – other perennial grasses; PForb – perennial forbs; Annuals – annuals and biennials; Shrubs – other shrubs.

Appendix E

Grand Fir Understory Vegetation Changes

Table 1. The changes in species composition in a grand fir forest from 1985 to 1994 using a 30 cm x 30 cm plot frame.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1									
Bromus carinatus Hook. & Arn.	0.0	0.0	-1.1	0.0	0.0	0.0	3.3	-6.7	0.0
Bromus inermis Leyss.	3.3	3.3	3.3	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	3.3	10.0	-2.2	3.3	3.3	3.3	23.3	3.3	0.0
Carex geyeri Boott	-36.7	-33.3	-28.9	-23.3	-16.7	-1.1	6.7	13.3	-38.9
Calamagrostis rubescens Buckl.	3.3	6.7	-12.2	23.3	66.7	-27.8	-3.3	-13.3	4.4
Elymus glaucus Buckl.	46.7	60.0	40.0	20.0	10.0	33.3	40.0	80.0	62.2
Festuca occidentalis Hook.	6.7	6.7	-16.7	-26.7	-43.3	-11.1	30.0	10.0	-21.1
Luzula campestris (L.) DC.	0.0	-13.3	-4.4	-3.3	-10.0	-1.1	20.0	13.3	-5.6
Melica bulbosa Geyer ex Porter & Coult.	-16.7	-46.7	-25.6	-30.0	-43.3	-14.4	-36.7	-16.7	-32.2
Poa pratensis L.	73.3	36.7	48.9	13.3	3.3	26.7	13.3	-10.0	43.3
Trisetum canescens Buckl.	-20.0	-40.0	-36.7	-33.3	-46.7	-22.2	0.0	6.7	-38.9
Achillea millefolium L.	46.7	50.0	17.8	-6.7	-13.3	-2.2	3.3	-6.7	17.8
Anemone piperi Britt. ex Rydb.	-56.7	-63.3	-44.4	-13.3	-20.0	-8.9	-36.7	-10.0	-18.9
Arnica cordifolia Hook.	-26.7	-20.0	-23.3	-13.3	-26.7	18.9	-40.0	-50.0	-58.9
Eurybia conspicua (Lindl.) Nesom	3.3	6.7	-4.4	-13.3	-13.3	-21.1	-16.7	0.0	0.0
Fragaria spp.	-40.0	-56.7	-63.3	-36.7	-26.7	-20.0	-16.7	-16.7	-21.1
Galium spp	-33.3	-36.7	0.0	0.0	-20.0	-12.2	3.3	16.7	-13.3
Hieracium albiflorum Hook.	0.0	-10.0	-3.3	-10.0	-20.0	3.3	16.7	0.0	0.0
Lathyrus spp.	6.7	-36.7	-38.9	-36.7	-30.0	-5.6	-10.0	-23.3	-47.8
Lupinus spp.	10.0	0.0	2.2	0.0	0.0	-1.1	0.0	-13.3	4.4
Moehringia macrophylla (Hook.) Fenzl	-60.0	-70.0	-63.3	-50.0	-80.0	-53.3	-50.0	-56.7	-50.0
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	33.3	53.3	23.3	10.0	0.0	0.0	0.0	3.3	3.3

Table 1. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-3.3	-15.6	-3.3	-10.0	0.0	0.0	-13.3	-6.7
Thalictrum fendleri Engelm. ex Gray	-3.3	-30.0	-11.1	6.7	3.3	-10.0	0.0	3.3	-5.6
Viola adunca Sm.	3.3	-10.0	-10.0	-13.3	0.0	-4.4	3.3	-6.7	-3.3
Mahonia repens (Lindl.) G. Don	3.3	0.0	0.0	6.7	30.0	-4.4	-6.7	23.3	0.0
Spiraea betulifolia Pallas	-36.7	-23.3	-22.2	-23.3	13.3	1.1	10.0	10.0	-26.7
Symphoricarpos albus (L.) Blake	20.0	13.3	36.7	-6.7	-26.7	-15.6	16.7	33.3	-4.4
Site 2									
Bromus carinatus Hook. & Arn.	6.7	10.0	10.0	0.0	10.0	0.0	3.3	13.3	6.7
Bromus inermis Leyss.	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	26.7	18.1	26.7	10.0	-3.3	3.3	16.7	16.7	-8.9
Carex geyeri Boott	0.0	-18.5	-43.3	-6.7	0.0	11.1	-6.7	-3.3	21.1
Calamagrostis rubescens Buckl.	-10.0	-0.1	16.7	26.7	26.7	14.4	10.0	20.0	21.1
Elymus glaucus Buckl.	16.7	58.8	46.7	13.3	30.0	26.7	40.0	46.7	50.0
Festuca occidentalis Hook.	30.0	-10.8	13.3	-3.3	6.7	-6.7	10.0	13.3	-16.7
Luzula campestris (L.) DC.	0.0	-3.3	0.0	0.0	-3.3	-1.1	0.0	-6.7	-2.2
Melica bulbosa Geyer ex Porter & Coult.	-3.3	-26.7	-16.7	-23.3	-26.7	-21.1	-36.7	-53.3	-32.2
Poa pratensis L.	16.7	22.5	16.7	0.0	3.3	8.9	0.0	16.7	1.1
Trisetum canescens Buckl.	3.3	-13.9	-20.0	-23.3	-26.7	-2.2	-23.3	-30.0	-25.6
Achillea millefolium L.	26.7	2.1	20.0	-3.3	-6.7	5.6	3.3	43.3	27.8
Anemone piperi Britt. ex Rydb.	-13.3	-16.7	-16.7	0.0	3.3	15.6	-30.0	-26.7	-8.9
Arnica cordifolia Hook.	-33.3	-38.1	-53.3	3.3	0.0	26.7	-3.3	-53.3	-11.1
Eurybia conspicua (Lindl.) Nesom	0.0	-0.7	3.3	0.0	0.0	-2.2	0.0	0.0	-3.3
Fragaria spp.	-33.3	-18.5	-6.7	-6.7	-16.7	-15.6	13.3	-3.3	-5.6
Galium spp	3.3	1.3	3.3	0.0	0.0	0.0	6.7	-6.7	13.3
Hieracium albiflorum Hook.	-10.0	-8.1	13.3	0.0	-6.7	8.9	-3.3	-3.3	23.3

Table 1. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Lathyrus spp.	-40.0	-42.8	-46.7	-6.7	26.7	-7.8	-3.3	-36.7	-41.1
Lupinus spp.	0.0	-6.9	-3.3	-20.0	3.3	-6.7	-3.3	3.3	11.1
Moehringia macrophylla (Hook.) Fenzl	-33.3	-42.4	-33.3	-26.7	-60.0	-52.2	-20.0	-73.3	-40.0
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	0.0	-0.4	0.0	-3.3	0.0	0.0	0.0	3.3	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-1.0	0.0	0.0	0.0	6.7	0.0	0.0	-1.1
Thalictrum fendleri Engelm. ex Gray	-40.0	-21.9	-3.3	0.0	-6.7	2.2	-16.7	-36.7	8.9
Viola adunca Sm.	-6.7	27.1	56.7	-13.3	-16.7	-3.3	6.7	-6.7	10.0
Mahonia repens (Lindl.) G. Don	-3.3	-1.5	-3.3	0.0	-6.7	-2.2	-13.3	10.0	-3.3
Spiraea betulifolia Pallas	-16.7	-23.9	-46.7	-20.0	-10.0	-1.1	-6.7	-6.7	-6.7
Symphoricarpos albus (L.) Blake	20.0	12.6	3.3	13.3	-3.3	-2.2	-6.7	-3.3	20.0
Site 3									
Bromus carinatus Hook. & Arn.	0.0	6.7	13.3	3.3	0.0	6.7	0.0	0.0	0.0
Bromus inermis Leyss.	6.7	0.0	10.0	0.0	0.0	3.3	0.0	3.3	0.0
Carex concinnoides Mackenzie	-3.3	2.8	-13.3	0.0	0.0	2.2	20.0	3.3	20.0
Carex geyeri Boott	-40.0	12.2	-30.0	6.7	13.3	-11.1	23.3	6.7	2.2
Calamagrostis rubescens Buckl.	-13.3	8.5	20.0	23.3	16.7	15.6	30.0	33.3	22.2
Elymus glaucus Buckl.	30.0	26.3	23.3	16.7	33.3	23.3	46.7	30.0	40.0
Festuca occidentalis Hook.	-36.7	-25.8	-6.7	20.0	-13.3	-13.3	20.0	23.3	0.0
Luzula campestris (L.) DC.	-6.7	3.2	-6.7	16.7	0.0	-3.3	0.0	3.3	-1.1
Melica bulbosa Geyer ex Porter & Coult.	-10.0	-17.2	-33.3	-36.7	-23.3	-14.4	0.0	-10.0	-10.0
Poa pratensis L.	100.0	72.6	80.0	3.3	0.0	27.8	16.7	3.3	6.7
Trisetum canescens Buckl.	30.0	-21.0	-46.7	-16.7	-3.3	-2.2	-10.0	-10.0	-8.9
Achillea millefolium L.	-10.0	35.7	-13.3	6.7	0.0	-1.1	26.7	10.0	30.0

Table 1. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Anemone piperi Britt. ex Rydb.	-10.0	-11.8	-30.0	-13.3	-16.7	8.9	-16.7	3.3	-3.3
Arnica cordifolia Hook.	-40.0	-39.6	-36.7	-20.0	-20.0	5.6	-10.0	23.3	11.1
Eurybia conspicua (Lindl.) Nesom	0.0	-1.3	0.0	0.0	0.0	-2.2	3.3	3.3	5.6
Fragaria spp.	-3.3	-12.2	-53.3	-3.3	6.7	-3.3	0.0	-13.3	-4.4
Galium spp	0.0	-0.3	0.0	0.0	3.3	-2.2	0.0	0.0	3.3
Hieracium albiflorum Hook.	-13.3	-13.5	-13.3	-23.3	3.3	17.8	0.0	-3.3	-2.2
Lathyrus spp.	-36.7	-29.4	-70.0	6.7	10.0	-31.1	-16.7	-3.3	-41.1
Lupinus spp.	33.3	2.8	10.0	0.0	0.0	33.7	0.0	6.7	42.2
Moehringia macrophylla (Hook.) Fenzl	-10.0	-31.8	-46.7	-30.0	-40.0	-37.8	-26.7	-23.3	-36.7
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	6.7	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	-6.7	-4.3	-6.7	0.0	-6.7	20.0	-6.7	0.0	-1.1
Thalictrum fendleri Engelm. ex Gray	-6.7	-39.4	-70.0	-16.7	-30.0	-5.6	-23.3	6.7	-10.0
Viola adunca Sm.	-3.3	-4.6	-3.3	-10.0	-3.3	22.2	3.3	3.3	11.1
Mahonia repens (Lindl.) G. Don	0.0	0.3	3.3	0.0	-3.3	0.0	-6.7	-6.7	5.6
Spiraea betulifolia Pallas	-26.7	-16.7	-20.0	0.0	-6.7	-8.9	3.3	-20.0	15.6
Symphoricarpos albus (L.) Blake	13.3	9.0	30.0	6.7	10.0	-1.1	0.0	10.0	0.0

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 2. The changes in species composition in a grand fir forest from 1985 to 1994 using a 30 cm x 60 cm plot frame.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1									
Bromus carinatus Hook. & Arn.	0.0	0.0	-1.1	3.3	-3.3	-1.1	3.3	-3.3	0.0
Bromus inermis Leyss.	3.3	6.7	3.3	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	3.3	20.0	-4.4	3.3	6.7	3.3	16.7	3.3	0.0
Carex geyeri Boott	-36.7	-30.0	-23.3	-20.0	-20.0	0.0	3.3	6.7	-55.6
Calamagrostis rubescens Buckl.	13.3	10.0	-17.8	20.0	60.0	-27.8	3.3	-6.7	-20.6
Elymus glaucus Buckl.	53.3	60.0	43.3	23.3	13.3	38.9	50.0	80.0	71.7
Festuca occidentalis Hook.	16.7	10.0	-23.3	-26.7	-56.7	-20.0	16.7	6.7	-31.1
Luzula campestris (L.) DC.	0.0	-16.7	-5.6	-3.3	-16.7	1.1	20.0	10.0	-13.3
Melica bulbosa Geyer ex Porter & Coult.	-23.3	-60.0	-30.0	-33.3	-56.7	-21.1	-50.0	-20.0	-40.0
Poa pratensis L.	70.0	40.0	47.8	0.0	0.0	23.3	26.7	-6.7	35.0
Trisetum canescens Buckl.	-23.3	-53.3	-51.1	-43.3	-53.3	-30.0	-16.7	0.0	-42.8
Achillea millefolium L.	50.0	50.0	25.6	-20.0	-23.3	-3.3	13.3	-13.3	32.8
Anemone piperi Britt. ex Rydb.	-60.0	-83.3	-54.4	-46.7	-36.7	-3.3	-40.0	-23.3	-31.7
Arnica cordifolia Hook.	-36.7	-23.3	-24.4	3.3	-26.7	21.1	-13.3	-43.3	-77.8
Eurybia conspicua (Lindl.) Nesom	-3.3	3.3	-5.6	-16.7	-6.7	-12.2	-16.7	-3.3	-2.2
Fragaria spp.	-33.3	-56.7	-58.9	-30.0	-26.7	-22.2	-16.7	-13.3	-22.8
Galium spp	-36.7	-40.0	0.0	0.0	-36.7	-11.1	3.3	10.0	-20.0
Hieracium albiflorum Hook.	0.0	-16.7	-5.6	-10.0	-33.3	0.0	-3.3	0.0	-1.7
Lathyrus spp.	-10.0	-40.0	-48.9	-26.7	-26.7	-1.1	3.3	-30.0	-57.2
Lupinus spp.	10.0	0.0	4.4	-6.7	3.3	-4.4	3.3	-16.7	6.7
Moehringia macrophylla (Hook.) Fenzl	-70.0	-73.3	-67.8	-66.7	-90.0	-63.3	-50.0	-63.3	-62.2
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	43.3	63.3	36.7	10.0	3.3	0.0	6.7	3.3	0.0

Table 2. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-20.0	-22.2	-13.3	-13.3	-1.1	0.0	-23.3	-10.0
Thalictrum fendleri Engelm. ex Gray	-6.7	-33.3	-8.9	6.7	6.7	-13.3	0.0	3.3	-10.0
Viola adunca Sm.	13.3	3.3	-1.1	-6.7	-10.0	-8.9	-3.3	-16.7	13.9
Mahonia repens (Lindl.) G. Don	10.0	0.0	0.0	16.7	30.0	-5.6	-10.0	23.3	-3.3
Spiraea betulifolia Pallas	-36.7	-16.7	-22.2	-30.0	6.7	11.1	-20.0	16.7	-30.6
Symphoricarpos albus (L.) Blake	13.3	20.0	32.2	-6.7	-23.3	-14.4	20.0	46.7	-2.2
Site 2									
Bromus carinatus Hook. & Arn.	6.7	16.7	13.3	0.0	10.0	0.0	3.3	13.3	6.7
Bromus inermis Leyss.	0.0	0.0	10.0	0.0	0.0	0.0	3.3	0.0	0.0
Carex concinnoides Mackenzie	33.3	13.6	33.3	6.7	3.3	6.7	16.7	26.7	-14.4
Carex geyeri Boott	23.3	-30.0	-33.3	-6.7	-10.0	12.2	-20.0	-3.3	21.1
Calamagrostis rubescens Buckl.	-3.3	-5.7	26.7	23.3	33.3	24.4	10.0	40.0	20.0
Elymus glaucus Buckl.	40.0	53.8	56.7	20.0	33.3	30.0	53.3	56.7	63.3
Festuca occidentalis Hook.	33.3	-10.8	20.0	-3.3	-6.7	-8.9	10.0	13.3	-17.8
Luzula campestris (L.) DC.	3.3	-5.8	0.0	-3.3	13.3	2.2	0.0	3.3	-2.2
Melica bulbosa Geyer ex Porter & Coult.	-6.7	-36.0	-26.7	-36.7	-40.0	-28.9	-43.3	-60.0	-42.2
Poa pratensis L.	33.3	22.2	26.7	6.7	10.0	8.9	3.3	26.7	2.2
Trisetum canescens Buckl.	6.7	-15.7	-20.0	-26.7	-33.3	-5.6	-23.3	-40.0	-30.0
Achillea millefolium L.	30.0	16.9	16.7	0.0	-3.3	3.3	3.3	46.7	32.2
Anemone piperi Britt. ex Rydb.	-26.7	-14.3	-16.7	-3.3	-6.7	8.9	-33.3	-30.0	-13.3
Arnica cordifolia Hook.	-40.0	-41.4	-60.0	16.7	0.0	25.6	-3.3	-46.7	-6.7
Eurybia conspicua (Lindl.) Nesom	0.0	-1.0	3.3	0.0	0.0	-4.4	0.0	0.0	-3.3
Fragaria spp.	-30.0	-23.8	-10.0	-3.3	-16.7	-22.2	13.3	-10.0	2.2
Galium spp	6.7	0.6	13.3	0.0	0.0	0.0	6.7	-6.7	24.4
Hieracium albiflorum Hook.	-13.3	-9.7	16.7	-3.3	-10.0	10.0	-6.7	0.0	32.2
Lathyrus spp.	-46.7	-47.1	-53.3	-3.3	23.3	0.0	-10.0	-36.7	-33.3

Table 2. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Lupinus spp.	3.3	-9.7	-6.7	-30.0	6.7	-11.1	-3.3	0.0	13.3
Moehringia macrophylla (Hook.) Fenzl	-43.3	-52.2	-50.0	-36.7	-66.7	-68.9	-23.3	-76.7	-52.2
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	0.0	-0.4	0.0	-3.3	0.0	6.7	0.0	6.7	0.0
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-1.4	0.0	0.0	0.0	6.7	0.0	-3.3	2.2
Thalictrum fendleri Engelm. ex Gray	-43.3	-29.6	3.3	0.0	-10.0	1.1	-16.7	-40.0	5.6
Viola adunca Sm.	-13.3	6.9	63.3	-20.0	-16.7	-16.7	0.0	-36.7	12.2
Mahonia repens (Lindl.) G. Don	-6.7	-0.8	-6.7	0.0	-6.7	-5.6	-20.0	6.7	-4.4
Spiraea betulifolia Pallas	0.0	-35.1	-70.0	-23.3	-6.7	2.2	-10.0	-20.0	-16.7
Symphoricarpos albus (L.) Blake	23.3	26.4	-3.3	26.7	-3.3	-2.2	-6.7	-6.7	20.0
Site 3									
Bromus carinatus Hook. & Arn.	6.7	6.3	16.7	0.0	0.0	6.7	0.0	0.0	0.0
Bromus inermis Leyss.	6.7	0.0	20.0	0.0	0.0	6.7	0.0	3.3	0.0
Carex concinnoides Mackenzie	0.0	1.9	-16.7	-13.3	-3.3	-1.1	20.0	6.7	23.3
Carex geyeri Boott	-36.7	14.2	-50.0	3.3	13.3	-11.1	36.7	10.0	7.8
Calamagrostis rubescens Buckl.	-20.0	14.0	23.3	36.7	26.7	11.1	43.3	40.0	21.1
Elymus glaucus Buckl.	40.0	49.6	33.3	33.3	50.0	23.3	63.3	40.0	46.7
Festuca occidentalis Hook.	-40.0	-33.2	-13.3	23.3	-13.3	-25.6	20.0	30.0	-6.7
Luzula campestris (L.) DC.	-10.0	5.0	-6.7	20.0	-3.3	-5.6	6.7	3.3	5.6
Melica bulbosa Geyer ex Porter & Coult.	-10.0	-22.1	-40.0	-40.0	-33.3	-17.8	-6.7	-13.3	-15.6
Poa pratensis L.	93.3	78.5	83.3	6.7	0.0	27.8	23.3	3.3	16.7
Trisetum canescens Buckl.	33.3	-22.6	-60.0	-26.7	-16.7	-4.4	-10.0	-16.7	-10.0
Achillea millefolium L.	-20.0	48.9	-16.7	10.0	0.0	3.3	30.0	0.0	34.4
Anemone piperi Britt. ex Rydb.	-13.3	-19.7	-46.7	-16.7	-20.0	8.9	-20.0	-10.0	-6.7
Arnica cordifolia Hook.	-50.0	-44.4	-40.0	-16.7	-16.7	0.0	-6.7	33.3	7.8

Table 2. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Eurybia conspicua (Lindl.) Nesom	0.0	-1.4	0.0	0.0	0.0	-2.2	6.7	3.3	4.4
Fragaria spp.	-13.3	-20.7	-40.0	-16.7	10.0	-13.3	-16.7	-13.3	-12.2
Galium spp	0.0	2.2	0.0	-6.7	6.7	1.1	0.0	0.0	3.3
Hieracium albiflorum Hook.	-26.7	-19.2	-23.3	-26.7	0.0	20.0	3.3	-3.3	-3.3
Lathyrus spp.	-33.3	-35.6	-80.0	3.3	6.7	-22.2	-13.3	0.0	-28.9
Lupinus spp.	40.0	4.7	16.7	3.3	0.0	3.3	3.3	13.3	41.1
Moehringia macrophylla (Hook.) Fenzl	-10.0	-39.4	-63.3	-33.3	-50.0	-47.8	-36.7	-30.0	-41.1
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	10.0	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Taraxacum officinale G.H. Weber ex Wiggers	-13.3	-2.4	-10.0	0.0	-6.7	20.0	-6.7	0.0	-2.2
Thalictrum fendleri Engelm. ex Gray	-20.0	-47.9	-80.0	-20.0	-26.7	-13.3	-23.3	6.7	0.0
Viola adunca Sm.	-6.7	-4.9	-3.3	-20.0	-10.0	26.7	10.0	3.3	24.4
Mahonia repens (Lindl.) G. Don	-3.3	-1.7	6.7	0.0	-3.3	-1.1	-10.0	-6.7	4.4
Spiraea betulifolia Pallas	-43.3	-25.3	-26.7	23.3	0.0	-7.8	3.3	-10.0	12.2
Symphoricarpos albus (L.) Blake	13.3	3.8	36.7	6.7	13.3	0.0	3.3	10.0	0.0

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 3. The changes in species composition in a grand fir forest from 1985 to 1997 using a 30 cm x 30 cm plot frame.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1									
Bromus carinatus Hook. & Arn.	3.3	23.3	28.9	0.0	0.0	3.3	3.3	0.0	10.0
Bromus inermis Leyss.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	0.0	0.0	-2.2	0.0	0.0	0.0	3.3	0.0	0.0
Carex geyeri Boott	-56.7	-33.3	-38.9	-20.0	0.0	-14.4	-20.0	-20.0	-55.6
Calamagrostis rubescens Buckl.	0.0	-3.3	-8.9	10.0	23.3	-11.1	-6.7	-23.3	4.4
Elymus glaucus Buckl.	30.0	10.0	3.3	3.3	-3.3	16.7	13.3	23.3	22.2
Festuca occidentalis Hook.	0.0	-6.7	-16.7	-20.0	-46.7	-4.4	16.7	-6.7	-24.4
Luzula campestris (L.) DC.	6.7	-13.3	-1.1	-6.7	-10.0	-1.1	16.7	3.3	-5.6
Melica bulbosa Geyer ex Porter & Coult.	-16.7	-46.7	-25.6	-30.0	-43.3	-14.4	-36.7	-16.7	-32.2
Poa pratensis L.	76.7	53.3	52.2	30.0	-6.7	13.3	30.0	-3.3	33.3
Trisetum canescens Buckl.	-26.7	-46.7	-40.0	-33.3	-43.3	-25.6	-3.3	0.0	-32.2
Achillea millefolium L.	33.3	20.0	37.8	-13.3	-13.3	-12.2	0.0	-13.3	11.1
Anemone piperi Britt. ex Rydb.	-50.0	-60.0	-44.4	-10.0	6.7	-2.2	-30.0	16.7	-22.2
Arnica cordifolia Hook.	-23.3	-23.3	-26.7	3.3	-13.3	18.9	0.0	-16.7	-25.6
Eurybia conspicua (Lindl.) Nesom	-3.3	0.0	-4.4	-10.0	-3.3	-14.4	-13.3	0.0	0.0
Fragaria spp.	-50.0	-76.7	-53.3	-30.0	-26.7	-3.3	-10.0	-23.3	-34.4
Galium spp	-33.3	-56.7	-10.0	26.7	-10.0	27.8	23.3	0.0	-6.7
Hieracium albiflorum Hook.	0.0	-10.0	-6.7	-10.0	-16.7	-6.7	0.0	-6.7	-10.0
Lathyrus spp.	-10.0	-23.3	-18.9	-16.7	-20.0	-8.9	-3.3	-13.3	-7.8
Lupinus spp.	10.0	0.0	12.2	0.0	0.0	-1.1	0.0	-13.3	4.4
Moehringia macrophylla (Hook.) Fenzl	-60.0	-66.7	-60.0	-10.0	-50.0	-6.7	-20.0	-40.0	-43.3
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	20.0	33.3	53.3	20.0	3.3	13.3	23.3	16.7	26.7

Table 3. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Taraxacum officinale G.H. Weber ex Wiggers	0.0	-6.7	-15.6	-3.3	-3.3	0.0	3.3	-13.3	-6.7
Thalictrum fendleri Engelm. ex Gray	-6.7	-30.0	-11.1	0.0	6.7	-10.0	-3.3	0.0	-5.6
Viola adunca Sm.	-20.0	-20.0	-16.7	-16.7	0.0	-11.1	-3.3	-10.0	-3.3
Mahonia repens (Lindl.) G. Don	-3.3	0.0	0.0	6.7	16.7	-4.4	-6.7	3.3	0.0
Spiraea betulifolia Pallas	-36.7	-30.0	-32.2	-13.3	10.0	-2.2	-3.3	30.0	0.0
Symphoricarpos albus (L.) Blake	10.0	10.0	30.0	13.3	-3.3	-2.2	10.0	20.0	-11.1
Site 2									
Bromus carinatus Hook. & Arn.	16.7	10.0	33.3	0.0	0.0	0.0	0.0	6.7	13.3
Bromus inermis Leyss.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	23.3	28.1	30.0	-3.3	-16.7	0.0	-3.3	0.0	-8.9
Carex geyeri Boott	3.3	-21.8	-23.3	-3.3	13.3	-8.9	-26.7	-3.3	-5.6
Calamagrostis rubescens Buckl.	3.3	19.9	16.7	43.3	26.7	24.4	33.3	30.0	27.8
Elymus glaucus Buckl.	13.3	22.1	26.7	0.0	6.7	0.0	26.7	36.7	26.7
Festuca occidentalis Hook.	-3.3	2.5	-6.7	0.0	13.3	30.0	6.7	3.3	-6.7
Luzula campestris (L.) DC.	0.0	-3.3	0.0	-3.3	-6.7	-4.4	0.0	-10.0	-2.2
Melica bulbosa Geyer ex Porter & Coult.	-3.3	-26.7	-16.7	-23.3	-26.7	-21.1	-36.7	-53.3	-32.2
Poa pratensis L.	10.0	29.2	23.3	0.0	0.0	-1.1	0.0	33.3	27.8
Trisetum canescens Buckl.	0.0	22.8	-10.0	-20.0	-3.3	-5.6	0.0	-33.3	-22.2
Achillea millefolium L.	26.7	22.1	26.7	-3.3	-6.7	2.2	6.7	46.7	27.8
Anemone piperi Britt. ex Rydb.	-13.3	-16.7	-13.3	0.0	3.3	-4.4	-13.3	-23.3	-12.2
Arnica cordifolia Hook.	-16.7	-38.1	-60.0	33.3	36.7	26.7	-10.0	-60.0	-21.1
Eurybia conspicua (Lindl.) Nesom	3.3	-0.7	0.0	0.0	0.0	1.1	6.7	0.0	-3.3
Fragaria spp.	-16.7	4.9	-3.3	10.0	-6.7	-12.2	-16.7	-10.0	-5.6
Galium spp	-3.3	-2.1	6.7	0.0	0.0	0.0	0.0	-3.3	0.0
Hieracium albiflorum Hook.	-13.3	-8.1	0.0	0.0	0.0	2.2	-3.3	-10.0	-10.0

Table 3. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Lathyrus spp.	-43.3	-42.8	-40.0	-16.7	3.3	-4.4	3.3	-33.3	-34.4
Lupinus spp.	0.0	-6.9	-3.3	-26.7	0.0	0.0	0.0	6.7	17.8
Moehringia macrophylla (Hook.) Fenzl	-20.0	-42.4	-26.7	26.7	6.7	7.8	-10.0	-70.0	-26.7
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	0.0	-0.4	0.0	-3.3	3.3	0.0	0.0	6.7	6.7
Taraxacum officinale G.H. Weber ex Wiggers	-3.3	-1.0	0.0	0.0	0.0	0.0	0.0	0.0	-1.1
Thalictrum fendleri Engelm. ex Gray	-46.7	-25.3	-13.3	3.3	-3.3	8.9	-13.3	-30.0	-17.8
Viola adunca Sm.	20.0	40.4	53.3	-13.3	-20.0	-13.3	6.7	6.7	-13.3
Mahonia repens (Lindl.) G. Don	-3.3	-4.9	0.0	0.0	-10.0	-2.2	-10.0	3.3	-3.3
Spiraea betulifolia Pallas	0.0	-17.2	-40.0	-23.3	-6.7	2.2	-3.3	-16.7	-16.7
Symphoricarpos albus (L.) Blake	30.0	12.6	30.0	10.0	0.0	-5.6	-10.0	0.0	26.7
Site 3									
Bromus carinatus Hook. & Arn.	10.0	13.3	0.0	3.3	0.0	0.0	3.3	0.0	0.0
Bromus inermis Leyss.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	-16.7	-7.2	-13.3	-3.3	6.7	-11.1	0.0	-3.3	23.3
Carex geyeri Boott	-23.3	2.2	-43.3	3.3	0.0	-17.8	10.0	-23.3	-11.1
Calamagrostis rubescens Buckl.	-3.3	5.1	10.0	23.3	33.3	8.9	50.0	16.7	38.9
Elymus glaucus Buckl.	13.3	32.9	23.3	0.0	0.0	0.0	36.7	16.7	6.7
Festuca occidentalis Hook.	-53.3	-25.8	-3.3	-16.7	-26.7	-10.0	-10.0	20.0	-13.3
Luzula campestris (L.) DC.	-3.3	-3.5	-6.7	-3.3	-6.7	0.0	0.0	10.0	-1.1
Melica bulbosa Geyer ex Porter & Coult.	-10.0	-17.2	-33.3	-36.7	-23.3	-14.4	0.0	-10.0	-10.0
Poa pratensis L.	100.0	99.3	93.3	3.3	0.0	-2.2	0.0	0.0	26.7
Trisetum canescens Buckl.	-16.7	-21.0	-40.0	-10.0	0.0	-2.2	23.3	3.3	21.1
Achillea millefolium L.	36.7	25.7	30.0	10.0	3.3	-4.4	20.0	3.3	20.0

Table 3. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Anemone piperi Britt. ex Rydb.	-3.3	-15.1	-30.0	0.0	0.0	15.6	-10.0	10.0	-3.3
Arnica cordifolia Hook.	-43.3	-39.6	-53.3	-6.7	26.7	31.9	6.7	46.7	7.8
Eurybia conspicua (Lindl.) Nesom	-3.3	2.1	0.0	0.0	0.0	-2.2	3.3	0.0	2.2
Fragaria spp.	3.3	-18.9	-50.0	-13.3	13.3	-13.3	-6.7	-23.3	-11.1
Galium spp	0.0	-0.3	0.0	0.0	0.0	-2.2	0.0	0.0	0.0
Hieracium albiflorum Hook.	-13.3	-10.1	-20.0	-20.0	-3.3	1.1	-3.3	-16.7	-8.9
Lathyrus spp.	-33.3	-46.1	-60.0	-10.0	13.3	-1.1	-6.7	-20.0	-27.8
Lupinus spp.	13.3	19.4	16.7	0.0	0.0	0.0	0.0	-3.3	42.2
Moehringia macrophylla (Hook.) Fenzl	-10.0	-31.8	-43.3	-13.3	-6.7	8.9	-16.7	13.3	-16.7
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	6.7	6.7	20.0	0.0	0.0	0.0	0.0	0.0	3.3
Taraxacum officinale G.H. Weber ex Wiggers	-10.0	-4.3	-6.7	0.0	-6.7	0.0	-6.7	-3.3	-1.1
Thalictrum fendleri Engelm. ex Gray	-13.3	-42.8	-73.3	-16.7	-6.7	11.1	-16.7	-6.7	0.0
Viola adunca Sm.	10.0	-4.6	3.3	-13.3	-3.3	-7.8	10.0	-3.3	4.4
Mahonia repens (Lindl.) G. Don	0.0	0.3	0.0	0.0	3.3	-3.3	-6.7	-6.7	12.2
Spiraea betulifolia Pallas	-26.7	-20.0	-23.3	-3.3	-20.0	-12.2	0.0	-23.3	15.6
Symphoricarpos albus (L.) Blake	10.0	25.7	16.7	16.7	3.3	-1.1	3.3	10.0	6.7

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 4. The changes in species composition in a grand fir forest from 1985 to 1997 using a 30 cm x 60 cm plot frame.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1									
Bromus carinatus Hook. & Arn.	10.0	33.3	38.9	3.3	-3.3	2.2	3.3	0.0	13.3
Bromus inermis Leyss.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	0.0	0.0	-4.4	0.0	0.0	0.0	3.3	3.3	0.0
Carex geyeri Boott	-53.3	-40.0	-50.0	-20.0	-6.7	-16.7	-10.0	-23.3	-62.2
Calamagrostis rubescens Buckl.	0.0	-3.3	-14.4	20.0	20.0	2.2	-6.7	-23.3	1.1
Elymus glaucus Buckl.	30.0	10.0	0.0	6.7	0.0	22.2	20.0	20.0	23.3
Festuca occidentalis Hook.	0.0	-6.7	-23.3	-13.3	-56.7	-13.3	23.3	-6.7	-31.1
Luzula campestris (L.) DC.	6.7	-16.7	-2.2	-6.7	-16.7	1.1	20.0	0.0	-6.7
Melica bulbosa Geyer ex Porter & Coult.	-23.3	-60.0	-30.0	-33.3	-56.7	-21.1	-50.0	-20.0	-40.0
Poa pratensis L.	80.0	50.0	44.4	10.0	-16.7	10.0	30.0	-3.3	33.3
Trisetum canescens Buckl.	-30.0	-63.3	-54.4	-26.7	-53.3	-33.3	-16.7	-3.3	-31.1
Achillea millefolium L.	43.3	23.3	42.2	-23.3	-20.0	-10.0	10.0	-13.3	21.1
Anemone piperi Britt. ex Rydb.	-56.7	-83.3	-57.8	-33.3	0.0	0.0	-30.0	13.3	-26.7
Arnica cordifolia Hook.	-23.3	-30.0	-27.8	10.0	-6.7	14.4	6.7	-13.3	-17.8
Eurybia conspicua (Lindl.) Nesom	-10.0	-3.3	-5.6	-13.3	-3.3	-12.2	-13.3	-3.3	-2.2
Fragaria spp.	-56.7	-76.7	-52.2	-33.3	-13.3	-5.6	-6.7	-16.7	-34.4
Galium spp	-40.0	-56.7	-6.7	36.7	-13.3	28.9	26.7	3.3	-3.3
Hieracium albiflorum Hook.	3.3	-16.7	-8.9	-10.0	-30.0	-3.3	-13.3	-10.0	-16.7
Lathyrus spp.	-23.3	-20.0	-28.9	-10.0	-13.3	-14.4	10.0	-23.3	-18.9
Lupinus spp.	10.0	0.0	21.1	-3.3	0.0	-4.4	10.0	-16.7	3.3
Moehringia macrophylla (Hook.) Fenzl	-66.7	-66.7	-64.4	-6.7	-50.0	0.0	-10.0	-46.7	-45.6
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	30.0	46.7	66.7	20.0	6.7	33.3	36.7	23.3	30.0

Table 4. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Taraxacum officinale G.H. Weber ex Wiggers	6.7	-20.0	-22.2	-13.3	-3.3	5.6	3.3	-23.3	-3.3
Thalictrum fendleri Engelm. ex Gray	-13.3	-33.3	-12.2	0.0	6.7	-10.0	-3.3	-3.3	-10.0
Viola adunca Sm.	-20.0	-20.0	-14.4	-16.7	-6.7	-15.6	-3.3	-13.3	-4.4
Mahonia repens (Lindl.) G. Don	-3.3	0.0	0.0	10.0	20.0	-5.6	-10.0	6.7	-6.7
Spiraea betulifolia Pallas	-33.3	-33.3	-35.6	-33.3	23.3	-5.6	-10.0	33.3	-8.9
Symphoricarpos albus (L.) Blake	-6.7	0.0	28.9	16.7	0.0	-1.1	16.7	33.3	-8.9
Site 2									
Bromus carinatus Hook. & Arn.	16.7	10.0	36.7	0.0	0.0	0.0	3.3	10.0	13.3
Bromus inermis Leyss.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	23.3	36.9	33.3	-10.0	-20.0	0.0	-3.3	-6.7	-7.8
Carex geyeri Boott	3.3	-23.3	-16.7	-3.3	3.3	-17.8	-36.7	-20.0	-5.6
Calamagrostis rubescens Buckl.	-10.0	17.6	16.7	33.3	33.3	31.1	26.7	30.0	33.3
Elymus glaucus Buckl.	10.0	23.8	33.3	0.0	6.7	3.3	33.3	40.0	33.3
Festuca occidentalis Hook.	-6.7	-4.2	-6.7	10.0	10.0	24.4	6.7	-6.7	-14.4
Luzula campestris (L.) DC.	3.3	-5.8	0.0	-13.3	-6.7	-7.8	0.0	-16.7	-2.2
Melica bulbosa Geyer ex Porter & Coult.	-6.7	-36.0	-26.7	-36.7	-40.0	-28.9	-46.7	-60.0	-42.2
Poa pratensis L.	10.0	28.9	23.3	0.0	0.0	-1.1	0.0	40.0	25.6
Trisetum canescens Buckl.	3.3	24.3	-13.3	-26.7	-3.3	-12.2	-3.3	-43.3	-30.0
Achillea millefolium L.	46.7	33.6	26.7	-3.3	-6.7	0.0	10.0	50.0	35.6
Anemone piperi Britt. ex Rydb.	-20.0	-24.3	-20.0	-3.3	-3.3	-7.8	-16.7	-26.7	-3.3
Arnica cordifolia Hook.	-23.3	-44.7	-70.0	36.7	36.7	32.2	-13.3	-56.7	-3.3
Eurybia conspicua (Lindl.) Nesom	3.3	-1.0	0.0	0.0	0.0	-4.4	10.0	0.0	-3.3
Fragaria spp.	-6.7	6.2	3.3	0.0	-6.7	-15.6	-16.7	-3.3	-7.8
Galium spp	-3.3	-2.8	6.7	0.0	3.3	0.0	3.3	0.0	7.8

Table 4. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Hieracium albiflorum Hook.	-20.0	-13.1	-3.3	-3.3	3.3	3.3	-3.3	-20.0	-7.8
Lathyrus spp.	-53.3	-50.4	-46.7	-10.0	10.0	3.3	3.3	-43.3	-33.3
Lupinus spp.	0.0	-9.7	-6.7	-36.7	0.0	-4.4	6.7	13.3	20.0
Moehringia macrophylla (Hook.) Fenzl	-26.7	-48.9	-43.3	26.7	13.3	4.4	-6.7	-66.7	-18.9
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	0.0	-0.4	0.0	-3.3	3.3	0.0	0.0	6.7	6.7
Taraxacum officinale G.H. Weber ex Wiggers	-3.3	-1.4	0.0	0.0	0.0	6.7	0.0	-3.3	2.2
Thalictrum fendleri Engelm. ex Gray	-60.0	-32.9	-13.3	20.0	-3.3	11.1	-13.3	-26.7	-27.8
Viola adunca Sm.	13.3	43.6	70.0	-20.0	-16.7	-26.7	6.7	-16.7	-11.1
Mahonia repens (Lindl.) G. Don	-6.7	-7.5	-3.3	0.0	-10.0	-5.6	-13.3	3.3	-4.4
Spiraea betulifolia Pallas	-6.7	-21.8	-53.3	-23.3	-10.0	2.2	0.0	-23.3	-23.3
Symphoricarpos albus (L.) Blake	23.3	9.7	16.7	16.7	0.0	1.1	-6.7	3.3	30.0
Site 3									
Bromus carinatus Hook. & Arn.	13.3	12.9	3.3	0.0	0.0	0.0	6.7	0.0	0.0
Bromus inermis Leyss.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	-33.3	-14.7	-16.7	-16.7	3.3	-17.8	0.0	-3.3	20.0
Carex geyeri Boott	-23.3	-2.5	-60.0	-10.0	0.0	-24.4	16.7	-16.7	-12.2
Calamagrostis rubescens Buckl.	-13.3	4.0	13.3	23.3	33.3	11.1	46.7	23.3	34.4
Elymus glaucus Buckl.	20.0	32.9	26.7	3.3	0.0	3.3	43.3	16.7	10.0
Festuca occidentalis Hook.	-56.7	-33.2	-6.7	-16.7	-20.0	-15.6	-16.7	20.0	-23.3
Luzula campestris (L.) DC.	-10.0	-5.0	-6.7	-3.3	-10.0	-2.2	0.0	10.0	-1.1
Melica bulbosa Geyer ex Porter & Coult.	-10.0	-22.1	-40.0	-40.0	-33.3	-17.8	-6.7	-13.3	-15.6
Poa pratensis L.	93.3	98.5	96.7	3.3	0.0	-2.2	0.0	0.0	30.0
Trisetum canescens Buckl.	-23.3	-29.3	-46.7	-16.7	-6.7	-7.8	30.0	0.0	20.0

Table 4. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Achillea millefolium L.	50.0	35.6	33.3	10.0	10.0	-6.7	36.7	0.0	31.1
Anemone piperi Britt. ex Rydb.	-6.7	-23.1	-46.7	0.0	10.0	15.6	-13.3	3.3	-6.7
Arnica cordifolia Hook.	-50.0	-41.1	-63.3	-6.7	20.0	30.0	10.0	50.0	11.1
Eurybia conspicua (Lindl.) Nesom	-3.3	1.9	0.0	0.0	0.0	-2.2	6.7	0.0	1.1
Fragaria spp.	-6.7	-17.4	-43.3	-16.7	6.7	-26.7	-20.0	-26.7	-12.2
Galium spp	0.0	2.2	0.0	-6.7	0.0	-2.2	0.0	0.0	0.0
Hieracium albiflorum Hook.	-26.7	-15.8	-30.0	-23.3	-6.7	3.3	-3.3	-20.0	-10.0
Lathyrus spp.	-30.0	-52.2	-70.0	-16.7	20.0	-2.2	-6.7	-23.3	-18.9
Lupinus spp.	13.3	21.4	23.3	0.0	0.0	0.0	3.3	6.7	41.1
Moehringia macrophylla (Hook.) Fenzl	-10.0	-39.4	-60.0	-6.7	-16.7	-1.1	-13.3	20.0	-21.1
Senecio integerrimus Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Stellaria longipes Goldie	13.3	13.3	33.3	0.0	0.0	3.3	3.3	0.0	6.7
Taraxacum officinale G.H. Weber ex Wiggers	-16.7	-5.7	-10.0	0.0	-6.7	0.0	-6.7	-3.3	-2.2
Thalictrum fendleri Engelm. ex Gray	-26.7	-54.6	-80.0	-6.7	-3.3	6.7	-23.3	-13.3	3.3
Viola adunca Sm.	16.7	-8.2	6.7	-23.3	-3.3	-6.7	10.0	-13.3	21.1
Mahonia repens (Lindl.) G. Don	0.0	-1.7	0.0	0.0	0.0	-4.4	-10.0	-6.7	14.4
Spiraea betulifolia Pallas	-43.3	-28.6	-33.3	0.0	-13.3	-11.1	10.0	-23.3	15.6
Symphoricarpos albus (L.) Blake	20.0	27.1	26.7	10.0	6.7	-3.3	13.3	10.0	10.0

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 5. The changes in species composition in a grand fir forest from 1985 to 2003 using a 30 cm x 30 cm plot frame.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1									
Bromus carinatus Hook. & Arn.	33.3	36.7	28.9	23.3	3.3	0.0	33.3	10.0	38.6
Bromus inermis Leyss.	3.3	70.0	36.7	10.0	16.7	6.7	26.7	40.0	23.3
Carex concinnoides Mackenzie	6.7	10.0	1.1	0.0	0.0	0.0	13.3	16.7	0.0
Carex geyeri Boott	3.3	0.0	-2.2	13.3	16.7	5.6	0.0	23.3	-8.9
Calamagrostis rubescens Buckl.	10.0	-3.3	-8.9	6.7	-20.0	-7.8	0.0	-20.0	24.4
Elymus glaucus Buckl.	30.0	40.0	20.0	23.3	3.3	40.0	36.7	73.3	52.2
Festuca occidentalis Hook.	-6.7	-6.7	-16.7	-26.7	-46.7	-4.4	23.3	3.3	5.6
Luzula campestris (L.) DC.	3.3	-13.3	-4.4	-6.7	-10.0	5.6	36.7	0.0	7.8
Melica bulbosa Geyer ex Porter & Coult.	-13.3	-46.7	-25.6	10.0	26.7	45.6	-6.7	-16.7	-32.2
Poa pratensis L.	76.7	53.3	48.9	13.3	-6.7	13.3	40.0	40.0	53.3
Trisetum canescens Buckl.	-26.7	-46.7	-40.0	-43.3	-50.0	-12.2	-6.7	-33.3	-47.5
Achillea millefolium L.	60.0	36.7	61.1	-3.3	-13.3	-8.9	0.0	6.7	34.4
Anemone piperi Britt. ex Rydb.	-33.3	-50.0	-27.8	10.0	33.3	21.1	-6.7	46.7	-8.9
Arnica cordifolia Hook.	3.3	-10.0	-26.7	6.7	-6.7	18.9	-20.0	-26.7	-52.2
Eurybia conspicua (Lindl.) Nesom	-3.3	0.0	-4.4	-13.3	-50.0	-34.4	-16.7	0.0	0.0
Fragaria spp.	-36.7	-63.3	-36.7	-13.3	6.7	-6.7	-26.7	6.7	-7.8
Galium spp	-33.3	-33.3	10.0	3.3	-20.0	-2.2	10.0	10.0	-10.0
Hieracium albiflorum Hook.	0.0	-10.0	-6.7	-6.7	-20.0	6.7	3.3	0.0	-6.7
Lathyrus spp.	0.0	-23.3	-25.6	-16.7	-16.7	1.1	0.0	-16.7	-4.4
Lupinus spp.	13.3	0.0	18.9	6.7	0.0	-1.1	16.7	-10.0	4.4
Moehringia macrophylla (Hook.) Fenzl	-43.3	-53.3	-46.7	-20.0	-56.7	-20.0	-6.7	0.0	-33.3
Senecio integerrimus Nutt.	3.3	30.0	33.3	0.0	53.3	40.0	6.7	6.7	3.3
Stellaria longipes Goldie	6.7	26.7	46.7	36.7	40.0	43.3	36.7	10.0	0.0

Table 5. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Taraxacum officinale G.H. Weber ex Wiggers	3.3	-6.7	-5.6	-3.3	-6.7	3.3	0.0	-13.3	-3.3
Thalictrum fendleri Engelm. ex Gray	3.3	-26.7	-7.8	0.0	10.0	0.0	10.0	0.0	-5.6
Viola adunca Sm.	26.7	20.0	23.3	-16.7	0.0	-1.1	-3.3	-6.7	3.3
Mahonia repens (Lindl.) G. Don	-3.3	0.0	0.0	6.7	6.7	-4.4	-6.7	46.7	6.7
Spiraea betulifolia Pallas	-6.7	0.0	-25.6	10.0	20.0	21.1	-3.3	66.7	10.0
Symphoricarpos albus (L.) Blake	20.0	26.7	40.0	13.3	16.7	1.1	20.0	53.3	-7.8
Site 2									
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	24.0	0.0	0.0	0.0
Bromus inermis Leyss.	0.0	3.3	60.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	20.0	31.4	20.0	-3.3	-23.3	0.0	-6.7	-6.7	-5.6
Carex geyeri Boott	33.3	11.5	-13.3	26.7	26.7	31.1	16.7	50.0	37.8
Calamagrostis rubescens Buckl.	13.3	29.9	23.3	36.7	20.0	17.8	46.7	23.3	27.8
Elymus glaucus Buckl.	16.7	55.4	-3.3	0.0	10.0	6.7	43.3	50.0	30.0
Festuca occidentalis Hook.	-16.7	-14.2	-20.0	-30.0	-30.0	-30.0	-10.0	-23.3	-33.3
Luzula campestris (L.) DC.	0.0	-3.3	0.0	0.0	-6.7	-4.4	0.0	-10.0	-2.2
Melica bulbosa Geyer ex Porter & Coult.	-3.3	-13.3	-3.3	-6.7	13.3	22.2	-36.7	-53.3	-32.2
Poa pratensis L.	16.7	25.8	16.7	10.0	33.3	45.6	10.0	43.3	11.1
Trisetum canescens Buckl.	-3.3	9.4	-3.3	-13.3	16.7	-6.2	20.0	6.7	11.1
Achillea millefolium L.	23.3	15.4	46.7	3.3	-3.3	-1.1	0.0	50.0	27.8
Anemone piperi Britt. ex Rydb.	-3.3	26.7	23.3	53.3	46.7	45.6	33.3	-6.7	17.8
Arnica cordifolia Hook.	-16.7	-28.1	-60.0	43.3	43.3	40.0	6.7	-30.0	-1.1
Eurybia conspicua (Lindl.) Nesom	0.0	-0.7	0.0	0.0	0.0	-2.2	0.0	0.0	-3.3
Fragaria spp.	-43.3	-5.1	20.0	6.7	-3.3	14.4	-3.3	23.3	1.1
Galium spp	-3.3	-2.1	0.0	0.0	3.3	0.0	0.0	0.0	3.3
Hieracium albiflorum Hook.	-13.3	-8.1	0.0	0.0	-3.3	-1.1	-6.7	-13.3	-6.7

Table 5. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Lathyrus spp.	-36.7	-32.8	-40.0	-6.7	16.7	5.6	36.7	-6.7	-7.8
Lupinus spp.	0.0	-6.9	-3.3	-23.3	0.0	10.0	0.0	10.0	14.4
Moehringia macrophylla (Hook.) Fenzl	16.7	-22.4	10.0	33.3	3.3	14.4	40.0	-20.0	20.0
Senecio integerrimus Nutt.	0.0	0.0	0.0	6.7	6.7	0.0	3.3	6.7	10.0
Stellaria longipes Goldie	0.0	-0.4	0.0	10.0	36.7	16.7	3.3	23.3	6.7
Taraxacum officinale G.H. Weber ex Wiggers	-3.3	-1.0	6.7	0.0	0.0	0.0	3.3	0.0	-1.1
Thalictrum fendleri Engelm. ex Gray	-46.7	-21.9	-6.7	20.0	0.0	12.2	3.3	-23.3	2.2
Viola adunca Sm.	26.7	47.1	73.3	-10.0	-16.7	-13.3	26.7	46.7	23.3
Mahonia repens (Lindl.) G. Don	-3.3	-1.5	-3.3	0.0	-10.0	-2.2	-13.3	10.0	-3.3
Spiraea betulifolia Pallas	-6.7	-27.2	-23.3	0.0	3.3	8.9	-10.0	0.0	20.0
Symphoricarpos albus (L.) Blake	40.0	26.0	43.3	3.3	13.3	4.4	13.3	13.3	20.0
Site 3									
Bromus carinatus Hook. & Arn.	10.0	36.7	20.0	0.0	1.1	1.4	45.5	0.0	2.6
Bromus inermis Leyss.	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	-16.7	-7.2	-13.3	-6.7	-16.7	-11.1	3.3	-10.0	6.7
Carex geyeri Boott	-3.3	48.9	10.0	30.0	23.3	-17.8	50.0	23.3	5.6
Calamagrostis rubescens Buckl.	10.0	1.8	36.7	20.0	36.7	32.2	53.3	43.3	65.6
Elymus glaucus Buckl.	10.0	19.6	40.0	13.3	0.0	0.0	33.3	16.7	16.7
Festuca occidentalis Hook.	-53.3	-25.8	-6.7	-16.7	-40.0	-30.0	-13.3	-16.7	-20.0
Luzula campestris (L.) DC.	-6.7	-3.5	-6.7	-3.3	-6.7	-3.3	0.0	0.0	-1.1
Melica bulbosa Geyer ex Porter & Coult.	-10.0	-17.2	-33.3	-33.3	-23.3	-14.4	0.0	-10.0	-10.0
Poa pratensis L.	80.0	86.0	73.3	16.7	3.3	1.1	10.0	3.3	10.0
Trisetum canescens Buckl.	-33.3	-21.0	-46.7	-13.3	15.6	-10.3	-8.8	23.3	-1.5
Achillea millefolium L.	83.3	42.4	63.3	3.3	0.0	-4.4	36.7	6.7	46.7

Table 5. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Anemone piperi Britt. ex Rydb.	16.7	-1.8	-20.0	16.7	33.3	18.9	30.0	56.7	26.7
Arnica cordifolia Hook.	-40.0	-36.3	-43.3	-20.0	13.3	38.9	16.7	43.3	11.1
Eurybia conspicua (Lindl.) Nesom	-3.3	-1.3	0.0	-3.3	0.0	-2.2	0.0	0.0	-1.1
Fragaria spp.	13.3	11.1	-20.0	0.0	13.3	-13.3	3.3	-3.3	8.9
Galium spp	0.0	-0.3	0.0	0.0	0.0	-2.2	0.0	0.0	10.0
Hieracium albiflorum Hook.	-10.0	-13.5	-20.0	-23.3	6.7	4.4	-3.3	-16.7	-8.9
Lathyrus spp.	-20.0	-39.4	-60.0	16.7	10.0	18.9	6.7	-20.0	-34.4
Lupinus spp.	43.3	9.4	46.7	0.0	0.0	3.3	10.0	-3.3	42.2
Moehringia macrophylla (Hook.) Fenzl	0.0	1.5	-23.3	0.0	30.0	28.9	20.0	23.3	6.7
Senecio integerrimus Nutt.	6.7	0.0	0.0	3.3	0.0	0.0	16.7	3.3	3.3
Stellaria longipes Goldie	10.0	0.0	13.3	10.0	3.3	6.7	0.0	13.3	0.0
Taraxacum officinale G.H. Weber ex Wiggers	-3.3	-4.3	-6.7	3.3	-6.7	0.0	-6.7	-3.3	-1.1
Thalictrum fendleri Engelm. ex Gray	-13.3	-32.8	-73.3	-30.0	16.7	1.1	-10.0	3.3	-10.0
Viola adunca Sm.	50.0	22.1	13.3	-10.0	-3.3	-7.8	36.7	10.0	41.1
Mahonia repens (Lindl.) G. Don	6.7	-3.1	0.0	0.0	-3.3	-3.3	0.0	-6.7	2.2
Spiraea betulifolia Pallas	-26.7	-26.7	-30.0	-3.3	6.7	-22.2	6.7	-16.7	22.2
Symphoricarpos albus (L.) Blake	26.7	49.0	13.3	26.7	3.3	15.6	13.3	36.7	6.7

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Table 6. The changes in species composition in a grand fir forest from 1985 to 2003 using a 30 cm x 60 cm plot frame.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Site 1									
Bromus carinatus Hook. & Arn.	50.0	40.0	28.9	23.3	0.0	-1.1	40.0	16.7	45.1
Bromus inermis Leyss.	13.3	83.3	40.0	13.3	23.3	10.0	33.3	53.3	36.7
Carex concinnoides Mackenzie	6.7	20.0	5.6	0.0	0.0	0.0	23.3	23.3	0.0
Carex geyeri Boott	10.0	6.7	-10.0	10.0	13.3	0.0	0.0	16.7	-2.2
Calamagrostis rubescens Buckl.	13.3	-3.3	-14.4	10.0	-26.7	-7.8	0.0	-20.0	24.4
Elymus glaucus Buckl.	36.7	40.0	20.0	23.3	3.3	45.6	53.3	66.7	53.3
Festuca occidentalis Hook.	-6.7	-10.0	-23.3	-26.7	-60.0	-13.3	30.0	-3.3	-1.1
Luzula campestris (L.) DC.	3.3	-16.7	-5.6	-6.7	-16.7	7.8	40.0	-3.3	16.7
Melica bulbosa Geyer ex Porter & Coult.	-20.0	-60.0	-30.0	13.3	26.7	55.6	-16.7	-20.0	-40.0
Poa pratensis L.	73.3	50.0	41.1	0.0	-10.0	16.7	53.3	36.7	53.3
Trisetum canescens Buckl.	-30.0	-63.3	-54.4	-53.3	-60.0	-20.0	-23.3	-43.3	-56.2
Achillea millefolium L.	50.0	46.7	62.2	-13.3	-23.3	-6.7	3.3	3.3	37.8
Anemone piperi Britt. ex Rydb.	-36.7	-66.7	-41.1	-16.7	33.3	23.3	3.3	43.3	-6.7
Arnica cordifolia Hook.	10.0	-13.3	-27.8	13.3	0.0	-25.6	-20.0	-10.0	-47.8
Eurybia conspicua (Lindl.) Nesom	-10.0	-3.3	-5.6	-16.7	-60.0	-42.2	-16.7	-3.3	-2.2
Fragaria spp.	-36.7	-70.0	-38.9	-13.3	16.7	-5.6	-30.0	3.3	-21.1
Galium spp	-43.3	-43.3	20.0	3.3	-30.0	2.2	6.7	3.3	-13.3
Hieracium albiflorum Hook.	3.3	-16.7	-5.6	-3.3	-33.3	3.3	-6.7	0.0	-13.3
Lathyrus spp.	-3.3	-6.7	-32.2	-13.3	-10.0	-1.1	13.3	-26.7	-2.2
Lupinus spp.	13.3	0.0	24.4	-3.3	0.0	-4.4	16.7	-16.7	23.3
Moehringia macrophylla (Hook.) Fenzl	-46.7	-53.3	-51.1	-30.0	-60.0	-16.7	0.0	3.3	-38.9
Senecio integerrimus Nutt.	6.7	30.0	36.7	3.3	56.7	50.0	10.0	6.7	3.3
Stellaria longipes Goldie	16.7	30.0	56.7	46.7	46.7	46.7	50.0	16.7	3.3

Table 6. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Taraxacum officinale G.H. Weber ex Wiggers	6.7	-23.3	-8.9	-13.3	-10.0	5.6	3.3	-23.3	-3.3
Thalictrum fendleri Engelm. ex Gray	-3.3	-26.7	-2.2	0.0	13.3	0.0	20.0	-3.3	-10.0
Viola adunca Sm.	23.3	20.0	38.9	-13.3	-6.7	-5.6	-3.3	0.0	8.9
Mahonia repens (Lindl.) G. Don	-6.7	0.0	0.0	16.7	10.0	-5.6	-10.0	50.0	0.0
Spiraea betulifolia Pallas	3.3	-6.7	-28.9	-3.3	33.3	17.8	-16.7	70.0	14.4
Symphoricarpos albus (L.) Blake	13.3	23.3	35.6	20.0	20.0	2.2	26.7	60.0	4.4
Site 2									
Bromus carinatus Hook. & Arn.	0.0	0.0	0.0	0.0	0.0	26.0	0.0	0.0	0.0
Bromus inermis Leyss.	0.0	10.0	66.7	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	26.7	30.3	26.7	-13.3	-20.0	3.3	-10.0	-6.7	-4.4
Carex geyeri Boott	43.3	3.3	-6.7	16.7	20.0	25.6	0.0	30.0	34.4
Calamagrostis rubescens Buckl.	3.3	24.3	20.0	30.0	26.7	17.8	43.3	33.3	26.7
Elymus glaucus Buckl.	26.7	57.1	-6.7	3.3	10.0	6.7	50.0	56.7	36.7
Festuca occidentalis Hook.	-26.7	-17.5	-23.3	-36.7	-50.0	-42.2	-13.3	-40.0	-41.1
Luzula campestris (L.) DC.	0.0	-5.8	0.0	-10.0	-3.3	-7.8	0.0	-16.7	-2.2
Melica bulbosa Geyer ex Porter & Coult.	-6.7	-19.3	-10.0	-13.3	10.0	24.4	-46.7	-60.0	-42.2
Poa pratensis L.	20.0	35.6	20.0	16.7	43.3	58.9	20.0	50.0	22.2
Trisetum canescens Buckl.	0.0	31.0	-3.3	6.7	20.0	-11.6	26.7	3.3	23.3
Achillea millefolium L.	33.3	23.6	46.7	3.3	-3.3	0.0	3.3	56.7	28.9
Anemone piperi Britt. ex Rydb.	6.7	29.0	40.0	63.3	50.0	35.6	36.7	-10.0	30.0
Arnica cordifolia Hook.	-23.3	-31.4	-60.0	43.3	40.0	42.2	6.7	-30.0	10.0
Eurybia conspicua (Lindl.) Nesom	0.0	-1.0	0.0	0.0	0.0	-4.4	0.0	0.0	-3.3
Fragaria spp.	-33.3	-7.1	26.7	3.3	-3.3	11.1	20.0	20.0	8.9
Galium spp	-3.3	-2.8	0.0	0.0	6.7	0.0	0.0	3.3	1.1
Hieracium albiflorum Hook.	-20.0	-13.1	-3.3	-3.3	-3.3	-3.3	-3.3	-26.7	-7.8

Table 6. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Lathyrus spp.	-43.3	-40.4	-43.3	-6.7	16.7	6.7	36.7	-3.3	3.3
Lupinus spp.	0.0	-9.7	-6.7	-36.7	0.0	-11.1	0.0	-16.7	-3.3
Moehringia macrophylla (Hook.) Fenzl	10.0	-32.2	3.3	33.3	0.0	11.1	40.0	-10.0	21.1
Senecio integerrimus Nutt.	0.0	0.0	0.0	6.7	6.7	0.0	6.7	6.7	10.0
Stellaria longipes Goldie	6.7	6.3	3.3	16.7	40.0	23.3	6.7	26.7	10.0
Taraxacum officinale G.H. Weber ex Wiggers	-3.3	-1.4	10.0	0.0	0.0	6.7	3.3	-3.3	-1.1
Thalictrum fendleri Engelm. ex Gray	-60.0	-26.3	0.0	26.7	-3.3	17.8	3.3	-23.3	-1.1
Viola adunca Sm.	30.0	53.6	80.0	-16.7	-10.0	-20.0	30.0	23.3	25.6
Mahonia repens (Lindl.) G. Don	-3.3	-4.2	-3.3	0.0	-10.0	-5.6	-16.7	6.7	-1.1
Spiraea betulifolia Pallas	3.3	-38.5	-40.0	-3.3	0.0	8.9	0.0	-3.3	6.7
Symphoricarpos albus (L.) Blake	56.7	29.7	33.3	0.0	10.0	4.4	26.7	16.7	23.3
Site 3									
Bromus carinatus Hook. & Arn.	13.3	39.6	36.7	-3.3	1.4	2.1	55.2	0.0	4.6
Bromus inermis Leyss.	3.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Carex concinnoides Mackenzie	-33.3	-11.4	-16.7	-20.0	-26.7	-17.8	10.0	-10.0	0.0
Carex geyeri Boott	0.0	40.8	-6.7	20.0	26.7	-17.8	50.0	23.3	1.1
Calamagrostis rubescens Buckl.	3.3	-2.6	36.7	23.3	43.3	27.8	53.3	46.7	57.8
Elymus glaucus Buckl.	13.3	19.6	43.3	20.0	0.0	0.0	36.7	20.0	20.0
Festuca occidentalis Hook.	-56.7	-33.2	-13.3	-23.3	-46.7	-42.2	-20.0	-20.0	-30.0
Luzula campestris (L.) DC.	-13.3	-5.0	-6.7	-3.3	-10.0	-5.6	0.0	0.0	-1.1
Melica bulbosa Geyer ex Porter & Coult.	-10.0	-22.1	-40.0	-36.7	-33.3	-17.8	-6.7	-13.3	-15.6
Poa pratensis L.	76.7	85.1	76.7	16.7	3.3	1.1	10.0	3.3	13.3
Trisetum canescens Buckl.	-43.3	-29.3	-60.0	-20.0	8.6	-13.2	-8.6	33.3	2.1
Achillea millefolium L.	80.0	48.9	66.7	6.7	0.0	-3.3	36.7	0.0	47.8

Table 6. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED	CEXC	TEXC	GRAZED
Anemone piperi Britt. ex Rydb.	16.7	-3.1	-30.0	30.0	40.0	25.6	36.7	53.3	30.0
Arnica cordifolia Hook.	-46.7	-27.8	-56.7	-3.3	13.3	30.0	33.3	50.0	7.8
Eurybia conspicua (Lindl.) Nesom	-3.3	-1.4	0.0	-3.3	0.0	-2.2	0.0	0.0	-2.2
Fragaria spp.	3.3	9.3	-20.0	-6.7	13.3	-20.0	-10.0	-3.3	1.1
Galium spp	0.0	-1.1	0.0	-6.7	0.0	-2.2	3.3	0.0	10.0
Hieracium albiflorum Hook.	-23.3	-19.2	-30.0	-26.7	0.0	6.7	-3.3	-20.0	-10.0
Lathyrus spp.	-20.0	-42.2	-66.7	10.0	20.0	24.4	3.3	-10.0	-32.2
Lupinus spp.	50.0	-1.9	30.0	0.0	0.0	6.7	10.0	3.3	47.8
Moehringia macrophylla (Hook.) Fenzl	3.3	0.6	-36.7	23.3	33.3	28.9	26.7	23.3	12.2
Senecio integerrimus Nutt.	6.7	3.3	0.0	3.3	0.0	0.0	16.7	3.3	6.7
Stellaria longipes Goldie	13.3	0.0	13.3	16.7	10.0	6.7	6.7	13.3	0.0
Taraxacum officinale G.H. Weber ex Wiggers	-6.7	-5.7	-10.0	3.3	-6.7	0.0	-6.7	-3.3	-2.2
Thalictrum fendleri Engelm. ex Gray	-20.0	-44.6	-76.7	-20.0	13.3	-3.3	-13.3	6.7	-6.7
Viola adunca Sm.	46.7	31.8	13.3	-16.7	-3.3	-10.0	46.7	3.3	47.8
Mahonia repens (Lindl.) G. Don	6.7	-5.0	0.0	0.0	-6.7	-4.4	-3.3	-6.7	4.4
Spiraea betulifolia Pallas	-43.3	-35.3	-43.3	6.7	3.3	-31.1	23.3	-10.0	32.2
Symphoricarpos albus (L.) Blake	63.3	50.4	10.0	33.3	6.7	13.3	16.7	36.7	16.7

Herbivory treatments: Graze – cattle and big game grazing; CEXC – cattle exclosure, big game grazing only; TEXC – total exclosure, exclusion of cattle and big game grazing.

Appendix F

Grand Fir Shrub Density and Cover Change

Table 1. The changes in shrub density from 1995 to 1991, 1994, and 2003.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
1991 **Site 1**									
Acer glabrum Torr. var. *glabrum*	0.4	-0.1	-0.6	-0.1	0.9	-1.0	-1.1	-0.8	-2.7
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	2.1	0.0	0.0
Philadelphus lewisii Pursh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Physocarpus malvaceus (Greene) Kuntze	0.0	17.0	0.0	0.7	5.3	0.6	0.0	5.0	4.0
Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ribes cereum Dougl.	-0.3	-0.7	-2.3	0.0	0.3	-0.3	0.0	0.0	1.0
Rosa gymnocarpa Nutt.	-4.0	-0.3	-2.7	3.7	0.0	-0.3	-0.7	-0.3	-1.1
Site 2									
Acer glabrum Torr. var. *glabrum*	-0.6	-0.1	0.6	0.3	-0.1	0.4	-0.1	0.0	0.3
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Holodiscus discolor (Pursh) Maxim.	0.0	0.3	0.0	0.2	0.2	0.0	0.0	0.0	0.4
Philadelphus lewisii Pursh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Physocarpus malvaceus (Greene) Kuntze	7.0	23.4	7.7	1.3	1.7	3.1	18.7	-0.7	9.8
Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ribes cereum Dougl.	0.0	1.0	-0.3	0.0	0.0	0.0	0.0	0.0	0.0
Rosa gymnocarpa Nutt.	-1.0	65.8	-4.7	1.3	2.0	3.4	3.3	3.7	-2.6
Site 3									
Acer glabrum Torr. var. *glabrum*	0.0	-1.1	-0.1	-0.4	0.9	-0.4	-0.8	-1.7	-0.2
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 1. continued.

		Clearcut Overstory			Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	3.2	0.5	0.5	2.1
	Philadelphus lewisii Pursh	0.0	-0.1	0.0	0.0	0.0	-0.4	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	-1.3	3.6	-0.7	3.7	3.0	-0.8	5.3	0.0	2.4
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	0.9	0.0	0.0	0.0	0.0	-0.3	0.0	0.0
	Rosa gymnocarpa Nutt.	-2.0	-4.0	-3.0	-0.7	16.3	2.8	16.0	1.7	9.3
1994	**Site 1**									
	Acer glabrum Torr. var. *glabrum*	5.6	-0.3	3.2	-0.4	2.7	-0.5	-1.1	4.5	1.8
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0
	Philadelphus lewisii Pursh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	16.0	8.7	8.3	7.7	19.3	9.9	10.3	38.7	45.7
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	-0.3	1.7	4.3	-0.3	0.3	-0.3	0.0	2.7	1.0
	Rosa gymnocarpa Nutt.	19.3	5.0	2.0	12.3	0.3	-0.3	1.3	-0.3	-1.1
	Site 2									
	Acer glabrum Torr. var. *glabrum*	0.2	-0.3	1.3	0.3	1.0	0.9	0.1	-0.5	-0.4
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	2.5
	Philadelphus lewisii Pursh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	8.0	14.1	35.7	4.0	5.3	5.8	23.0	9.3	19.8
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 1. continued.

		Clearcut Overstory			Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
	Ribes cereum Dougl.	0.0	0.0	-0.3	0.0	0.0	0.0	0.3	0.0	0.0
	Rosa gymnocarpa Nutt.	23.3	15.4	10.3	22.3	18.7	29.4	22.7	43.7	33.1
	Site 3									
	Acer glabrum Torr. var. *glabrum*	0.2	-0.5	0.4	-0.5	2.0	1.5	-2.0	-1.7	-0.3
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.6	0.0	0.6	1.1	4.3	0.3	1.3	1.2
	Philadelphus lewisii Pursh	0.0	-0.1	0.0	0.0	0.0	-0.4	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	5.0	4.0	-0.3	10.7	7.3	23.6	13.0	13.0	-0.6
	Prunus virginiana L.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ribes cereum Dougl.	0.0	-0.1	1.3	0.0	0.0	0.0	-0.3	0.0	0.0
	Rosa gymnocarpa Nutt.	13.0	26.0	2.3	25.3	27.7	4.4	17.0	68.7	-7.7
2003	**Site 1**									
	Acer glabrum Torr. var. *glabrum*	0.2	0.9	0.6	-0.8	-0.2	-1.0	-0.9	0.7	-0.7
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.6	0.0	0.1	1.4	1.8	1.8	2.0	2.9	1.3
	Crataegus douglasii Lindl.	5.9	12.8	9.0	3.6	8.9	2.2	2.3	9.6	1.6
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.3	0.0
	Philadelphus lewisii Pursh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Physocarpus malvaceus (Greene) Kuntze	19.0	24.3	30.7	20.3	18.3	10.2	23.7	34.7	36.0
	Prunus virginiana L.	8.7	1.7	0.0	140.0	80.3	0.0	2.3	50.7	38.0
	Ribes cereum Dougl.	7.0	1.3	5.3	-0.7	0.3	0.3	0.3	3.0	0.7
	Rosa gymnocarpa Nutt.	-0.7	3.3	26.3	44.0	0.0	-0.3	1.3	-0.3	-1.1
	Site 2									

Table 1. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
Acer glabrum Torr. var. *glabrum*	-0.5	0.1	0.1	0.6	-0.3	-0.2	0.2	0.3	-0.6
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.3	0.3	1.8	1.3	0.0	0.9	0.1
Crataegus douglasii Lindl.	7.3	11.8	3.7	2.6	0.8	0.7	5.1	5.3	2.2
Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Philadelphus lewisii Pursh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Physocarpus malvaceus (Greene) Kuntze	2.0	8.7	29.3	2.3	4.7	5.4	30.3	19.3	15.1
Prunus virginiana L.	0.0	38.7	4.3	4.0	20.7	11.0	19.7	38.7	20.0
Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosa gymnocarpa Nutt.	9.0	23.4	-9.3	14.0	10.3	15.8	38.0	31.3	32.8
Site 3									
Acer glabrum Torr. var. *glabrum*	1.1	0.0	0.0	-0.5	0.8	0.0	-2.0	-1.7	-0.4
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.8	0.2	3.2	1.2	0.4	0.1	1.2	0.0
Crataegus douglasii Lindl.	4.9	12.1	4.8	4.1	0.3	4.1	1.6	3.2	2.2
Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.1	0.2	0.3	0.3	0.9	0.1
Philadelphus lewisii Pursh	0.0	-0.1	0.0	0.0	0.0	-0.4	0.0	0.0	0.0
Physocarpus malvaceus (Greene) Kuntze	7.7	2.6	-0.3	1.3	3.0	2.6	12.3	4.7	4.8
Prunus virginiana L.	4.7	32.7	0.0	0.0	30.7	0.0	18.3	0.0	4.0
Ribes cereum Dougl.	1.3	-0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosa gymnocarpa Nutt.	10.7	15.0	20.3	4.0	12.0	1.1	31.3	53.3	1.7

Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.

Table 2. The changes in shrub density from 1995 to 1991, 1994, and 2003.

		Clearcut Overstory			Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
1991	**Site 1**									
	Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.0	0.0	1.2	-0.1	0.0	4.4	1.3
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	-0.8	-0.2	0.0	0.0	0.0	0.0	0.0
	Philadelphus lewisii Pursh	-5.2	-1.1	-1.3	-7.8	0.0	0.0	0.0	-0.4	-0.2
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	-10.9	-30.8	-6.5	-8.9	-8.8	-4.2	-8.8	-0.6	-1.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
	Site 2									
	Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	-0.2	-0.7	0.0	0.0	0.2	1.2	-0.3	-0.4
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Philadelphus lewisii Pursh	0.0	-2.8	-0.3	-3.0	-5.0	1.5	-3.2	-3.0	-0.6
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	-8.9	-7.0	-2.0	9.8	1.0	-0.1	3.6	6.6	-5.5
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Site 3									
	Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	-0.2	-0.1	0.2	0.0	-1.5	0.0	0.0	0.1

Table 2. continued.

		Clearcut Overstory			Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.6	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
	Philadelphus lewisii Pursh	-3.4	-3.7	-5.2	0.7	2.2	-1.8	-2.4	0.0	-4.1
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	-1.8	-6.7	-1.6	3.0	1.9	-6.3	-5.2	1.6	3.3
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1994	**Site 1**									
	Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.0	0.4	0.5	1.8	0.1	0.2	2.1	1.9
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	-0.8	-0.2	0.0	0.0	0.0	0.0	0.0
	Philadelphus lewisii Pursh	-3.3	-0.2	-0.4	-8.0	0.0	0.0	0.0	-0.4	-0.2
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	-0.4	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	-12.7	-30.8	-1.0	-9.1	5.2	-23.6	1.8	5.5	-1.0
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	0.6	0.5	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
	Site 2									
	Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	0.5	-0.1	0.2	0.0	0.5	1.2	-0.3	0.9
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Philadelphus lewisii Pursh	1.5	-3.0	0.1	1.9	-6.4	-0.1	0.3	1.2	1.5
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 2. continued.

		Clearcut Overstory			Control Overstory			Thinned Overstory		
		CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
	Prunus virginiana L.	6.3	-4.3	3.7	9.7	-1.2	2.0	-6.5	-2.7	6.5
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Site 3									
	Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.8	-0.2	0.1	0.5	0.3	-1.2	1.0	0.5	-0.1
	Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
	Philadelphus lewisii Pursh	-3.4	2.2	-5.2	0.4	0.4	-3.3	-1.1	10.2	-6.6
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	-1.7	-6.3	-1.6	1.6	5.3	-11.3	15.1	0.6	-1.3
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2003	**Site 1**									
	Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.7	3.6	0.8	0.1	3.0	0.1	0.9	11.1	1.3
	Crataegus douglasii Lindl.	0.0	0.1	0.0	1.0	0.1	0.0	0.0	0.1	0.0
	Holodiscus discolor (Pursh) Maxim.	0.0	1.3	1.2	-0.2	0.6	0.0	0.0	0.0	0.0
	Philadelphus lewisii Pursh	-5.2	-0.9	-0.1	-1.0	0.0	0.0	0.3	-0.4	-0.2
	Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	-0.4	0.0	0.0	0.0	0.0	0.0
	Prunus virginiana L.	-9.0	-24.3	-6.1	-9.1	2.7	3.6	-2.7	-0.6	-0.5
	Ribes cereum Dougl.	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
	Rosa gymnocarpa Nutt.	0.2	2.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0
	Site 2									

Table 2. continued.

	Clearcut Overstory			Control Overstory			Thinned Overstory		
	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE	CEXC	TEXC	GRAZE
Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.0	-0.1	0.2	1.2	0.1	0.3	1.3	2.7	1.0
Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Philadelphus lewisii Pursh	0.7	0.6	-0.3	-0.3	-10.3	-1.2	0.2	1.0	-0.6
Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prunus virginiana L.	15.0	6.3	5.1	-5.3	0.5	0.6	-1.7	2.8	-4.5
Ribes cereum Dougl.	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Rosa gymnocarpa Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Site 3									
Acer glabrum Torr. var. *glabrum*	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
Amelanchier alnifolia (Nutt.) Nutt. ex M. Roemer	0.7	0.3	-0.1	-0.1	0.9	-1.5	0.2	2.0	2.9
Crataegus douglasii Lindl.	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.1
Holodiscus discolor (Pursh) Maxim.	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0
Philadelphus lewisii Pursh	-1.7	0.9	-5.1	0.7	2.4	-1.0	1.6	11.0	-5.9
Physocarpus malvaceus (Greene) Kuntze	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Prunus virginiana L.	-2.1	-6.7	-1.6	1.6	4.6	-7.5	11.8	4.7	1.5
Ribes cereum Dougl.	0.0	2.6	0.0	0.0	0.0	0.0	0.0	1.3	1.1
Rosa gymnocarpa Nutt.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.

Appendix G

Nutritional Quality of Steer Diets

Table 1. Nutritional quality of diets collected in June and August of 2001 and 2002 for ponderosa pine sites.

YEAR	TIME	Site	Timber Harvest	Herbivory	IVOMD	ADF	NDF	CP
2001	JUNE	1	Thin	Graze	0.80	0.32	0.56	12.61
2001	JUNE	1	Thin	CExc	0.77	0.33	0.57	12.48
2001	JUNE	1	Thin	TExc	0.77	0.35	0.51	14.49
2001	JUNE	1	Cont	Graze	0.82	0.35	0.58	14.95
2001	JUNE	1	Cont	CExc	0.79	0.34	0.58	13.45
2001	JUNE	1	Cont	TExc	0.82	0.29	0.47	13.16
2001	JUNE	2	Thin	Graze	0.82	0.36	0.48	12.33
2001	JUNE	2	Thin	CExc	0.80	0.36	0.54	13.39
2001	JUNE	2	Thin	TExc	0.82	0.34	0.52	12.68
2001	JUNE	2	Cont	Graze	0.74	0.38	0.54	12.71
2001	JUNE	2	Cont	CExc	0.77	0.39	0.59	12.64
2001	JUNE	2	Cont	TExc	0.79	0.38	0.59	12.68
2001	JUNE	3	Thin	Graze	0.80	0.30	0.48	11.40
2001	JUNE	3	Thin	CExc	0.76	0.36	0.54	16.09
2001	JUNE	3	Thin	TExc	0.79	0.31	0.51	13.61
2001	JUNE	3	Cont	Graze	0.76	0.36	0.57	14.50
2001	JUNE	3	Cont	CExc	0.74	0.38	0.60	13.63
2001	JUNE	3	Cont	TExc	0.77	0.35	0.56	13.21
2001	AUG	1	Thin	Graze	0.73	0.37	0.61	9.78
2001	AUG	1	Thin	CExc	0.73	0.35	0.61	8.97
2001	AUG	1	Thin	TExc	0.72	0.37	0.60	8.62
2001	AUG	1	Cont	Graze	0.75	0.35	0.60	8.69
2001	AUG	1	Cont	CExc	0.73	0.36	0.58	10.36
2001	AUG	1	Cont	TExc	0.76	0.38	0.63	9.78
2001	AUG	2	Thin	Graze	0.73	0.37	0.59	7.07
2001	AUG	2	Thin	CExc	0.72	0.39	0.58	11.50
2001	AUG	2	Thin	TExc	0.76	0.37	0.57	9.14
2001	AUG	2	Cont	Graze	0.72	0.43	0.59	11.20
2001	AUG	2	Cont	CExc	0.74	0.38	0.60	9.09
2001	AUG	2	Cont	TExc	0.72	0.40	0.64	8.52
2001	AUG	3	Thin	Graze	0.75	0.37	0.60	9.00
2001	AUG	3	Thin	CExc	0.74	0.36	0.58	10.79
2001	AUG	3	Thin	TExc	0.74	0.36	0.59	10.05
2001	AUG	3	Cont	Graze	0.72	0.39	0.62	10.32
2001	AUG	3	Cont	CExc	0.73	0.36	0.61	7.65
2001	AUG	3	Cont	TExc	0.73	0.37	0.55	8.86
2002	JUNE	1	Thin	Graze	0.87	0.37	0.54	14.22
2002	JUNE	1	Thin	CExc	0.84	0.36	0.52	13.19
2002	JUNE	1	Thin	TExc	0.79	0.31	0.42	12.44
2002	JUNE	1	Cont	Graze	0.84	0.33	0.45	14.15
2002	JUNE	1	Cont	CExc	0.78	0.37	0.57	14.47
2002	JUNE	1	Cont	TExc	0.83	0.37	0.61	16.77
2002	JUNE	2	Thin	Graze	0.86	0.32	0.44	13.98

Table 1. continued.

YEAR	TIME	Site	Timber Harvest	Herbivory	IVOMD	ADF	NDF	CP
2002	JUNE	2	Thin	CExc	0.81	0.33	0.51	14.43
2002	JUNE	2	Thin	TExc	0.80	0.32	0.52	13.75
2002	JUNE	2	Cont	Graze	0.80	0.34	0.48	14.33
2002	JUNE	2	Cont	CExc	0.78	0.35	0.53	14.12
2002	JUNE	2	Cont	TExc	0.85	0.41	0.59	12.10
2002	JUNE	3	Thin	Graze	0.86	0.37	0.54	15.87
2002	JUNE	3	Thin	CExc	0.82	0.38	0.55	14.25
2002	JUNE	3	Thin	TExc	0.79	0.37	0.60	15.11
2002	JUNE	3	Cont	Graze	0.77	0.37	0.50	12.99
2002	JUNE	3	Cont	CExc	0.84	0.39	0.58	15.22
2002	JUNE	3	Cont	TExc	0.82	0.38	0.52	13.49
2002	AUG	1	Thin	Graze	0.73	0.43	0.57	12.10
2002	AUG	1	Thin	CExc	0.79	0.39	0.61	10.78
2002	AUG	1	Thin	TExc	0.75	0.43	0.60	10.57
2002	AUG	1	Cont	Graze	0.74	0.39	0.59	9.35
2002	AUG	1	Cont	CExc	0.73	0.40	0.63	9.35
2002	AUG	1	Cont	TExc	0.74	0.39	0.60	13.62
2002	AUG	2	Thin	Graze	0.75	0.40	0.53	10.50
2002	AUG	2	Thin	CExc	0.74	0.40	0.59	9.36
2002	AUG	2	Thin	TExc	0.76	0.41	0.58	9.72
2002	AUG	2	Cont	Graze	0.77	0.39	0.58	9.32
2002	AUG	2	Cont	CExc	0.74	0.39	0.55	7.69
2002	AUG	2	Cont	TExc	0.77	0.40	0.63	9.20
2002	AUG	3	Thin	Graze	0.77	0.40	0.58	10.07
2002	AUG	3	Thin	CExc	0.72	0.38	0.60	10.88
2002	AUG	3	Thin	TExc	0.77	0.39	0.64	9.94
2002	AUG	3	Cont	Graze	0.77	0.43	0.59	10.92
2002	AUG	3	Cont	CExc	0.78	0.41	0.61	11.21
2002	AUG	3	Cont	TExc	0.79	0.39	0.51	8.97

Timber harvest treatments: Thin – commercial thinning; Cont – control.
Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.

Table 2. Botanical composition and relative preference index for steer diets collected in June and August of 2001 and 2002 for the ponderosa pine sites.

YEAR	TIME	Site	Timber Harvest	Herb. Trt.	Botanical Composition Grass	Forbs	Shrubs	Relative Pref. Index Grass	Forbs	Shrubs
2001	JUNE	1	Cont	CExc	92.39	5.67	1.95	1.29	0.46	0.12
2001	JUNE	1	Cont	TExc	88.34	8.55	3.11	1.76	0.42	0.11
2001	JUNE	1	Cont	Graze	94.63	4.38	1.00	1.38	0.25	0.07
2001	JUNE	1	Thin	CExc	86.42	9.94	3.64	1.47	0.47	0.18
2001	JUNE	1	Thin	TExc	73.93	18.11	7.96	2.11	0.57	0.24
2001	JUNE	1	Thin	Graze	96.77	3.23	0.00	1.59	0.15	0.00
2001	JUNE	2	Cont	CExc	87.82	10.41	1.77	1.21	0.45	0.41
2001	JUNE	2	Cont	TExc	85.21	13.27	1.52	1.14	0.88	0.15
2001	JUNE	2	Cont	Graze	72.26	23.50	4.24	1.25	0.66	0.65
2001	JUNE	2	Thin	CExc	85.04	12.83	2.14	1.25	0.47	0.48
2001	JUNE	2	Thin	TExc	82.69	16.64	0.67	1.27	0.69	0.06
2001	JUNE	2	Thin	Graze	67.57	31.41	1.02	1.20	0.83	0.18
2001	JUNE	3	Cont	CExc	91.86	7.22	0.93	1.16	0.81	0.08
2001	JUNE	3	Cont	TExc	89.15	6.96	3.90	1.40	0.74	0.14
2001	JUNE	3	Cont	Graze	85.51	9.29	5.20	1.11	0.53	0.93
2001	JUNE	3	Thin	CExc	80.10	15.54	4.36	1.18	0.57	0.92
2001	JUNE	3	Thin	TExc	74.38	18.31	7.30	1.06	1.00	0.65
2001	JUNE	3	Thin	Graze	79.59	16.69	3.72	1.11	0.68	1.06
2001	AUG	1	Cont	CExc	94.08	3.50	2.42	1.31	0.28	0.15
2001	AUG	1	Cont	TExc	88.12	7.97	3.91	1.75	0.39	0.13
2001	AUG	1	Cont	Graze	88.12	7.52	4.36	1.29	0.43	0.31
2001	AUG	1	Thin	CExc	94.37	3.39	2.24	1.61	0.16	0.11
2001	AUG	1	Thin	TExc	87.44	7.89	4.68	2.50	0.25	0.14
2001	AUG	1	Thin	Graze	88.20	8.57	3.22	1.45	0.39	0.19
2001	AUG	2	Cont	CExc	76.63	18.39	4.98	1.06	0.79	1.14
2001	AUG	2	Cont	TExc	86.64	11.10	2.26	1.16	0.74	0.22
2001	AUG	2	Cont	Graze	77.98	16.97	5.05	1.35	0.48	0.77
2001	AUG	2	Thin	CExc	77.97	19.51	2.52	1.15	0.71	0.57
2001	AUG	2	Thin	TExc	85.14	13.60	1.26	1.31	0.56	0.12
2001	AUG	2	Thin	Graze	82.00	14.70	3.30	1.45	0.39	0.60
2001	AUG	3	Cont	CExc	96.09	1.90	2.01	1.21	0.21	0.17
2001	AUG	3	Cont	TExc	68.34	24.64	7.02	1.07	2.62	0.26
2001	AUG	3	Cont	Graze	88.85	9.39	1.76	1.15	0.54	0.31
2001	AUG	3	Thin	CExc	85.67	12.42	1.91	1.26	0.46	0.40
2001	AUG	3	Thin	TExc	92.84	5.98	1.18	1.32	0.33	0.11
2001	AUG	3	Thin	Graze	88.94	10.64	0.42	1.24	0.43	0.12
2002	JUNE	1	Cont	CExc	94.48	4.82	0.70	1.32	0.39	0.04
2002	JUNE	1	Cont	TExc	92.19	6.75	1.06	1.83	0.33	0.04
2002	JUNE	1	Cont	Graze	77.21	19.75	3.03	1.13	1.14	0.21
2002	JUNE	1	Thin	CExc	95.22	4.78	0.00	1.62	0.22	0.00
2002	JUNE	1	Thin	TExc	90.12	9.48	0.39	2.58	0.30	0.01
2002	JUNE	1	Thin	Graze	98.45	1.55	0.00	1.61	0.07	0.00

Table 2. continued.

YEAR	TIME	Site	Timber Harvest	Herb. Trt.	Botanical Composition Grass	Forbs	Shrubs	Relative Pref. Index Grass	Forbs	Shrubs
2002	JUNE	2	Cont	CExc	83.65	15.60	0.76	1.16	0.67	0.17
2002	JUNE	2	Cont	TExc	87.08	12.04	0.88	1.17	0.80	0.09
2002	JUNE	2	Cont	Graze	67.95	28.02	4.03	1.18	0.79	0.62
2002	JUNE	2	Thin	CExc	95.33	4.30	0.37	1.40	0.16	0.08
2002	JUNE	2	Thin	TExc	95.25	4.35	0.40	1.46	0.18	0.04
2002	JUNE	2	Thin	Graze	75.31	19.35	5.34	1.33	0.51	0.96
2002	JUNE	3	Cont	CExc	92.52	6.50	0.98	1.17	0.73	0.08
2002	JUNE	3	Cont	TExc	88.72	9.53	1.76	1.40	1.01	0.07
2002	JUNE	3	Cont	Graze	94.86	4.77	0.37	1.23	0.27	0.07
2002	JUNE	3	Thin	CExc	85.79	13.15	1.06	1.26	0.48	0.22
2002	JUNE	3	Thin	TExc	91.26	7.19	1.54	1.30	0.39	0.14
2002	JUNE	3	Thin	Graze	81.12	17.63	1.24	1.13	0.72	0.35
2002	AUG	1	Cont	CExc	92.73	6.56	0.71	1.29	0.53	0.04
2002	AUG	1	Cont	TExc	88.84	8.67	2.50	1.77	0.42	0.09
2002	AUG	1	Cont	Graze	93.17	6.45	0.37	1.36	0.37	0.03
2002	AUG	1	Thin	CExc	94.66	4.95	0.38	1.61	0.23	0.02
2002	AUG	1	Thin	TExc	80.23	17.43	2.35	2.29	0.54	0.07
2002	AUG	1	Thin	Graze	80.62	15.42	3.95	1.32	0.71	0.23
2002	AUG	2	Cont	CExc	80.91	17.08	2.00	1.12	0.74	0.46
2002	AUG	2	Cont	TExc	79.67	18.91	1.41	1.07	1.25	0.14
2002	AUG	2	Cont	Graze	76.14	19.03	4.84	1.32	0.53	0.74
2002	AUG	2	Thin	CExc	85.98	11.22	2.80	1.26	0.41	0.63
2002	AUG	2	Thin	TExc	78.81	17.54	3.65	1.21	0.72	0.34
2002	AUG	2	Thin	Graze	72.12	26.02	1.86	1.28	0.69	0.33
2002	AUG	3	Cont	CExc	88.23	11.17	0.60	1.11	1.25	0.05
2002	AUG	3	Cont	TExc	59.33	33.48	7.19	0.93	3.56	0.27
2002	AUG	3	Cont	Graze	88.39	11.27	0.34	1.15	0.65	0.06
2002	AUG	3	Thin	CExc	82.96	17.04	0.00	1.22	0.63	0.00
2002	AUG	3	Thin	TExc	83.91	15.24	0.85	1.19	0.83	0.08
2002	AUG	3	Thin	Graze	79.83	18.66	1.51	1.11	0.76	0.43

Timber harvest treatments: Thin – commercial thinning; Cont – control.
Herbivory treatments: Graze – cattle and big game grazing; CExc -- cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.

Table 3. Nutritional quality of diets collected in June and August of 2001 and 2002 for grand fir sites.

YEAR	TIME	Site	LOGTRT	GRAZTRT	NDF	ADF	IVOMD	CP
2001	JUNE	1	Clear	Graze	0.55	0.33	0.82	14.32
2001	JUNE	1	Clear	CExc	0.55	0.34	0.78	16.08
2001	JUNE	1	Clear	TExc	0.50	0.34	0.74	18.44
2001	JUNE	1	Thin	Graze	0.56	0.37	0.77	16.43
2001	JUNE	1	Thin	CExc	0.55	0.35	0.78	15.62
2001	JUNE	1	Thin	TExc	0.53	0.35	0.70	20.13
2001	JUNE	1	Cont	Graze	0.58	0.41	0.75	16.87
2001	JUNE	1	Cont	CExc	0.58	0.37	0.74	16.49
2001	JUNE	1	Cont	TExc	0.55	0.40	0.75	17.42
2001	JUNE	2	Clear	Graze	0.57	0.34	0.76	12.19
2001	JUNE	2	Clear	CExc	0.57	0.41	0.75	14.46
2001	JUNE	2	Clear	TExc	0.56	0.35	0.77	14.77
2001	JUNE	2	Thin	Graze	0.57	0.37	0.76	14.12
2001	JUNE	2	Thin	CExc	0.56	0.39	0.76	15.55
2001	JUNE	2	Thin	TExc	0.55	0.39	0.72	13.12
2001	JUNE	2	Cont	Graze	0.55	0.40	0.74	15.64
2001	JUNE	2	Cont	CExc	0.60	0.42	0.77	13.98
2001	JUNE	2	Cont	TExc	0.58	0.39	0.75	12.74
2001	JUNE	3	Clear	Graze	0.52	0.35	0.77	14.67
2001	JUNE	3	Clear	CExc	0.53	0.34	0.76	14.21
2001	JUNE	3	Clear	TExc	0.53	0.32	0.73	14.25
2001	JUNE	3	Thin	Graze	0.59	0.39	0.76	13.97
2001	JUNE	3	Thin	CExc	0.55	0.36	0.76	13.10
2001	JUNE	3	Thin	TExc	0.57	0.40	0.72	14.37
2001	JUNE	3	Cont	Graze	0.56	0.43	0.75	16.50
2001	JUNE	3	Cont	CExc	0.55	0.38	0.74	14.97
2001	JUNE	3	Cont	TExc	0.58	0.43	0.72	15.14
2001	AUG	1	Clear	Graze	0.60	0.38	0.74	10.09
2001	AUG	1	Clear	CExc	0.62	0.39	0.75	10.39
2001	AUG	1	Clear	TExc	0.60	0.37	0.78	9.91
2001	AUG	1	Thin	Graze	0.59	0.40	0.69	9.08
2001	AUG	1	Thin	CExc	0.57	0.37	0.76	8.93
2001	AUG	1	Thin	TExc	0.60	0.44	0.61	8.87
2001	AUG	1	Cont	Graze	0.56	0.45	0.75	10.70
2001	AUG	1	Cont	CExc	0.66	0.42	0.74	9.17
2001	AUG	1	Cont	TExc	0.65	0.44	0.72	9.83
2001	AUG	2	Clear	Graze	0.59	0.37	0.75	8.46
2001	AUG	2	Clear	CExc	0.66	0.42	0.70	9.85
2001	AUG	2	Clear	TExc	0.60	0.39	0.70	9.06
2001	AUG	2	Thin	Graze	0.59	0.42	0.70	8.72
2001	AUG	2	Thin	CExc	0.60	0.41	0.72	9.49
2001	AUG	2	Thin	TExc	0.52	0.41	0.70	9.47
2001	AUG	2	Cont	Graze	0.61	0.44	0.72	9.67
2001	AUG	2	Cont	CExc	0.65	0.43	0.71	8.52

Table 3. continued.

YEAR	TIME	Site	LOGTRT	GRAZTRT	NDF	ADF	IVOMD	CP
2001	AUG	2	Cont	TExc	0.64	0.43	0.68	8.52
2001	AUG	3	Clear	Graze	0.57	0.34	0.76	9.13
2001	AUG	3	Clear	CExc	0.58	0.35	0.77	10.32
2001	AUG	3	Clear	TExc	0.59	0.34	0.74	9.42
2001	AUG	3	Thin	Graze	0.56	0.37	0.75	9.34
2001	AUG	3	Thin	CExc	0.61	0.39	0.68	10.00
2001	AUG	3	Thin	TExc	0.58	0.39	0.69	8.62
2001	AUG	3	Cont	Graze	0.61	0.46	0.69	9.37
2001	AUG	3	Cont	CExc	0.64	0.43	0.63	9.40
2001	AUG	3	Cont	TExc	0.58	0.46	0.67	9.07
2002	JUNE	1	Clear	Graze	0.56	0.42	0.84	14.92
2002	JUNE	1	Clear	CExc	0.59	0.44	0.81	12.97
2002	JUNE	1	Clear	TExc	0.59	0.42	0.81	14.95
2002	JUNE	1	Thin	Graze	0.53	0.43	0.80	14.34
2002	JUNE	1	Thin	CExc	0.60	0.44	0.82	14.51
2002	JUNE	1	Thin	TExc	0.48	0.37	0.85	14.75
2002	JUNE	1	Cont	Graze	0.51	0.44	0.79	14.48
2002	JUNE	1	Cont	CExc	0.57	0.45	0.79	14.57
2002	JUNE	1	Cont	TExc	0.57	0.45	0.86	14.49
2002	JUNE	2	Clear	Graze	0.58	0.41	0.79	14.88
2002	JUNE	2	Clear	CExc	0.59	0.41	0.81	14.02
2002	JUNE	2	Clear	TExc	0.58	0.41	0.79	14.29
2002	JUNE	2	Thin	Graze	0.53	0.41	0.84	14.52
2002	JUNE	2	Thin	CExc	0.55	0.40	0.83	16.37
2002	JUNE	2	Thin	TExc	0.57	0.45	0.81	13.98
2002	JUNE	2	Cont	Graze	0.52	0.43	0.79	15.79
2002	JUNE	2	Cont	CExc	0.52	0.42	0.86	13.80
2002	JUNE	2	Cont	TExc	0.60	0.48	0.82	12.68
2002	JUNE	3	Clear	Graze	0.56	0.38	0.83	14.29
2002	JUNE	3	Clear	CExc	0.55	0.37	0.85	15.76
2002	JUNE	3	Clear	TExc	0.58	0.37	0.83	15.20
2002	JUNE	3	Thin	Graze	0.48	0.39	0.84	14.16
2002	JUNE	3	Thin	CExc	0.60	0.43	0.84	14.26
2002	JUNE	3	Thin	TExc	0.57	0.44	0.83	14.48
2002	JUNE	3	Cont	Graze	0.57	0.44	0.79	15.38
2002	JUNE	3	Cont	CExc	0.58	0.44	0.80	14.50
2002	JUNE	3	Cont	TExc	0.45	0.40	0.79	14.31
2002	AUG	1	Clear	Graze	0.59	0.44	0.75	10.81
2002	AUG	1	Clear	CExc	0.59	0.42	0.70	10.37
2002	AUG	1	Clear	TExc	0.58	0.40	0.75	11.67
2002	AUG	1	Thin	Graze	0.54	0.41	0.71	10.80
2002	AUG	1	Thin	CExc	0.57	0.40	0.76	9.16
2002	AUG	1	Thin	TExc	0.59	0.44	0.71	9.92
2002	AUG	1	Cont	Graze	0.53	0.45	0.72	10.17
2002	AUG	1	Cont	CExc	0.56	0.41	0.76	10.80
2002	AUG	1	Cont	TExc	0.55	0.46	0.74	11.16

Table 3. continued.

YEAR	TIME	Site	LOGTRT	GRAZTRT	NDF	ADF	IVOMD	CP
2002	AUG	2	Clear	Graze	0.57	0.46	0.71	9.96
2002	AUG	2	Clear	CExc	0.58	0.40	0.73	9.80
2002	AUG	2	Clear	TExc	0.60	0.45	0.72	12.20
2002	AUG	2	Thin	Graze	0.54	0.38	0.75	11.02
2002	AUG	2	Thin	CExc	0.50	0.37	0.78	11.76
2002	AUG	2	Thin	TExc	0.59	0.43	0.72	10.62
2002	AUG	2	Cont	Graze	0.55	0.37	0.76	11.05
2002	AUG	2	Cont	CExc	0.53	0.43	0.71	11.52
2002	AUG	2	Cont	TExc	0.62	0.46	0.77	10.61
2002	AUG	3	Clear	Graze	0.56	0.38	0.77	11.87
2002	AUG	3	Clear	CExc	0.54	0.41	0.76	12.09
2002	AUG	3	Clear	TExc	0.56	0.37	0.75	13.44
2002	AUG	3	Thin	Graze	0.54	0.40	0.72	12.97
2002	AUG	3	Thin	CExc	0.53	0.42	0.72	11.60
2002	AUG	3	Thin	TExc	0.54	0.41	0.73	12.53
2002	AUG	3	Cont	Graze	0.59	0.44	0.74	10.37
2002	AUG	3	Cont	CExc	0.58	0.44	0.68	10.96
2002	AUG	3	Cont	TExc	0.53	0.44	0.63	12.01

Timber harvest treatments: Clear – clearcut, Thin – crownthinning; Cont – control.
Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.

Table 4. Botanical composition and relative preference index for steer diets collected in June and August of 2001 and 2002 for the grand fir sites.

					Botanical Composition			Relative Pref. Index		
YEAR	TIME	Site	Timber Harvest	Herb. Trt.	Grass	Forbs	Shrubs	Grass	Forbs	Shrubs
2001	JUNE	1	Clear	CExc	87.92	12.08	0.00	1.55	0.66	0.00
2001	JUNE	1	Clear	TExc	83.04	16.96	0.00	1.44	0.61	0.00
2001	JUNE	1	Clear	Graze	83.05	16.95	0.00	1.47	0.52	0.00
2001	JUNE	1	Cont	CExc	77.94	22.06	0.00	1.55	0.84	0.00
2001	JUNE	1	Cont	TExc	59.46	38.65	1.89	1.57	1.21	0.06
2001	JUNE	1	Cont	Graze	72.01	27.52	0.48	2.11	0.67	0.02
2001	JUNE	1	Thin	CExc	81.71	18.29	0.00	1.08	1.14	0.00
2001	JUNE	1	Thin	TExc	81.82	18.18	0.00	1.24	1.79	0.00
2001	JUNE	1	Thin	Graze	82.56	17.44	0.00	1.23	0.80	0.00
2001	JUNE	2	Clear	CExc	86.43	13.57	0.00	1.64	1.39	0.00
2001	JUNE	2	Clear	TExc	88.25	11.12	0.63	1.21	1.22	0.03
2001	JUNE	2	Clear	Graze	89.61	10.39	0.00	1.63	1.08	0.00
2001	JUNE	2	Cont	CExc	77.88	22.12	0.00	1.49	3.56	0.00
2001	JUNE	2	Cont	TExc	73.75	23.52	2.73	1.00	4.36	0.13
2001	JUNE	2	Cont	Graze	80.35	19.65	0.00	1.11	1.89	0.00
2001	JUNE	2	Thin	CExc	92.72	7.28	0.00	1.92	0.19	0.00
2001	JUNE	2	Thin	TExc	69.55	30.01	0.44	1.05	3.60	0.02
2001	JUNE	2	Thin	Graze	82.91	15.01	2.08	1.51	1.27	0.06
2001	JUNE	3	Clear	CExc	90.05	9.95	0.00	1.33	0.37	0.00
2001	JUNE	3	Clear	TExc	93.81	6.19	0.00	1.24	0.79	0.00
2001	JUNE	3	Clear	Graze	88.04	11.96	0.00	1.02	1.45	0.00
2001	JUNE	3	Cont	CExc	77.54	21.15	1.31	1.34	1.03	0.06
2001	JUNE	3	Cont	TExc	64.89	31.73	3.37	2.15	1.11	0.08
2001	JUNE	3	Cont	Graze	71.82	28.18	0.00	1.31	1.47	0.00
2001	JUNE	3	Thin	CExc	87.00	11.83	1.17	1.17	1.93	0.06
2001	JUNE	3	Thin	TExc	89.85	9.43	0.72	1.27	0.76	0.04
2001	JUNE	3	Thin	Graze	75.31	19.18	5.51	1.06	1.81	0.30
2001	AUG	1	Clear	CExc	92.71	7.29	0.00	1.64	0.40	0.00
2001	AUG	1	Clear	TExc	91.02	8.98	0.00	1.58	0.32	0.00
2001	AUG	1	Clear	Graze	93.07	6.93	0.00	1.65	0.21	0.00
2001	AUG	1	Cont	CExc	84.62	14.13	1.26	1.68	0.54	0.05
2001	AUG	1	Cont	TExc	63.57	35.90	0.53	1.68	1.13	0.02
2001	AUG	1	Cont	Graze	54.50	45.50	0.00	1.59	1.11	0.00
2001	AUG	1	Thin	CExc	88.13	11.87	0.00	1.16	0.74	0.00
2001	AUG	1	Thin	TExc	76.17	22.56	1.26	1.15	2.22	0.05
2001	AUG	1	Thin	Graze	84.26	15.74	0.00	1.25	0.72	0.00
2001	AUG	2	Clear	CExc	92.49	7.51	0.00	1.75	0.77	0.00
2001	AUG	2	Clear	TExc	89.75	10.25	0.00	1.23	1.13	0.00
2001	AUG	2	Clear	Graze	82.95	16.31	0.74	1.51	1.69	0.02
2001	AUG	2	Cont	CExc	84.59	14.75	0.67	1.62	2.37	0.02
2001	AUG	2	Cont	TExc	80.67	17.54	1.79	1.10	3.25	0.08
2001	AUG	2	Cont	Graze	80.60	18.30	1.09	1.12	1.76	0.06

Table 4. continued.

YEAR	TIME	Site	Timber Harvest	Herb. Trt.	Botanical Composition			Relative Pref. Index		
					Grass	Forbs	Shrubs	Grass	Forbs	Shrubs
2001	AUG	2	Thin	CExc	85.54	12.84	1.61	1.77	0.33	0.13
2001	AUG	2	Thin	TExc	82.86	16.50	0.64	1.26	1.98	0.02
2001	AUG	2	Thin	Graze	81.97	17.47	0.56	1.49	1.48	0.02
2001	AUG	3	Clear	CExc	95.57	4.43	0.00	1.41	0.16	0.00
2001	AUG	3	Clear	TExc	95.08	4.92	0.00	1.25	0.63	0.00
2001	AUG	3	Clear	Graze	93.09	6.91	0.00	1.08	0.84	0.00
2001	AUG	3	Cont	CExc	77.36	20.37	2.27	1.33	0.99	0.11
2001	AUG	3	Cont	TExc	57.60	33.20	9.19	1.91	1.17	0.22
2001	AUG	3	Cont	Graze	79.78	17.69	2.53	1.45	0.93	0.10
2001	AUG	3	Thin	CExc	95.67	3.88	0.46	1.28	0.63	0.02
2001	AUG	3	Thin	TExc	73.64	23.94	2.41	1.04	1.92	0.14
2001	AUG	3	Thin	Graze	93.59	6.41	0.00	1.32	0.60	0.00
2002	JUNE	1	Clear	CExc	95.50	4.50	0.00	1.69	0.25	0.00
2002	JUNE	1	Clear	TExc	87.13	12.87	0.00	1.51	0.46	0.00
2002	JUNE	1	Clear	Graze	94.20	5.80	0.00	1.67	0.18	0.00
2002	JUNE	1	Cont	CExc	76.76	21.94	1.31	1.53	0.83	0.06
2002	JUNE	1	Cont	TExc	75.81	24.19	0.00	2.00	0.76	0.00
2002	JUNE	1	Cont	Graze	68.83	30.23	0.94	2.01	0.74	0.04
2002	JUNE	1	Thin	CExc	87.91	12.09	0.00	1.16	0.75	0.00
2002	JUNE	1	Thin	TExc	83.43	16.09	0.48	1.26	1.59	0.02
2002	JUNE	1	Thin	Graze	81.62	18.38	0.00	1.21	0.85	0.00
2002	JUNE	2	Clear	CExc	95.70	4.30	0.00	1.81	0.44	0.00
2002	JUNE	2	Clear	TExc	94.17	4.29	1.54	1.29	0.47	0.08
2002	JUNE	2	Clear	Graze	95.93	2.90	1.17	1.75	0.30	0.03
2002	JUNE	2	Cont	CExc	82.48	17.52	0.00	1.57	2.82	0.00
2002	JUNE	2	Cont	TExc	84.32	15.68	0.00	1.15	2.91	0.00
2002	JUNE	2	Cont	Graze	88.73	11.27	0.00	1.23	1.08	0.00
2002	JUNE	2	Thin	CExc	94.14	5.86	0.00	1.95	0.15	0.00
2002	JUNE	2	Thin	TExc	89.19	10.32	0.49	1.35	1.24	0.02
2002	JUNE	2	Thin	Graze	90.29	9.71	0.00	1.64	0.82	0.00
2002	JUNE	3	Clear	CExc	95.27	4.73	0.00	1.41	0.17	0.00
2002	JUNE	3	Clear	TExc	97.53	2.47	0.00	1.28	0.32	0.00
2002	JUNE	3	Clear	Graze	89.68	10.32	0.00	1.04	1.25	0.00
2002	JUNE	3	Cont	CExc	74.40	24.08	1.52	1.28	1.17	0.07
2002	JUNE	3	Cont	TExc	56.44	38.05	5.52	1.87	1.34	0.13
2002	JUNE	3	Cont	Graze	90.04	9.96	0.00	1.64	0.52	0.00
2002	JUNE	3	Thin	CExc	93.59	6.41	0.00	1.25	1.04	0.00
2002	JUNE	3	Thin	TExc	74.62	24.80	0.58	1.06	1.99	0.03
2002	JUNE	3	Thin	Graze	83.33	14.75	1.92	1.18	1.39	0.10
2002	AUG	1	Clear	CExc	91.58	8.42	0.00	1.62	0.46	0.00
2002	AUG	1	Clear	TExc	82.02	17.98	0.00	1.42	0.64	0.00
2002	AUG	1	Clear	Graze	87.49	12.51	0.00	1.55	0.39	0.00
2002	AUG	1	Cont	CExc	59.66	39.54	0.79	1.19	1.50	0.03
2002	AUG	1	Cont	TExc	44.28	48.55	7.18	1.17	1.52	0.24

Table 4. continued.

YEAR	TIME	Site	Timber Harvest	Herb. Trt.	Botanical Composition Grass	Forbs	Shrubs	Relative Pref. Index Grass	Forbs	Shrubs
2002	AUG	1	Cont	Graze	62.07	37.02	0.90	1.81	0.90	0.04
2002	AUG	1	Thin	CExc	88.48	11.52	0.00	1.17	0.72	0.00
2002	AUG	1	Thin	TExc	76.69	23.31	0.00	1.16	2.30	0.00
2002	AUG	1	Thin	Graze	79.60	18.79	1.61	1.18	0.87	0.15
2002	AUG	2	Clear	CExc	88.53	9.79	1.68	1.68	1.00	0.04
2002	AUG	2	Clear	TExc	83.54	13.82	2.64	1.15	1.52	0.15
2002	AUG	2	Clear	Graze	65.35	25.85	8.80	1.19	2.68	0.25
2002	AUG	2	Cont	CExc	70.08	9.36	20.57	1.34	1.51	0.50
2002	AUG	2	Cont	TExc	80.52	19.48	0.00	1.09	3.61	0.00
2002	AUG	2	Cont	Graze	84.63	14.35	1.03	1.17	1.38	0.06
2002	AUG	2	Thin	CExc	83.32	14.29	2.38	1.72	0.36	0.19
2002	AUG	2	Thin	TExc	84.30	15.70	0.00	1.28	1.88	0.00
2002	AUG	2	Thin	Graze	78.75	19.22	2.03	1.43	1.62	0.06
2002	AUG	3	Clear	CExc	85.82	13.33	0.85	1.27	0.49	0.17
2002	AUG	3	Clear	TExc	98.13	1.87	0.00	1.29	0.24	0.00
2002	AUG	3	Clear	Graze	98.03	1.49	0.48	1.13	0.18	0.09
2002	AUG	3	Cont	CExc	66.13	25.82	8.06	1.14	1.26	0.38
2002	AUG	3	Cont	TExc	43.99	46.76	9.25	1.46	1.64	0.22
2002	AUG	3	Cont	Graze	80.24	10.83	8.93	1.46	0.57	0.34
2002	AUG	3	Thin	CExc	77.32	12.63	10.05	1.04	2.06	0.52
2002	AUG	3	Thin	TExc	70.64	24.76	4.60	1.00	1.99	0.27
2002	AUG	3	Thin	Graze	78.57	15.00	6.43	1.11	1.41	0.35

Timber harvest treatments: Clear – clearcut, Thin – crownthinning; Cont – control. Herbivory treatments: Graze – cattle and big game grazing; CExc – cattle exclosure, big game grazing only; TExc – total exclosure, exclusion of cattle and big game grazing.