Understory Plant Succession Following Cutting of Western Juniper (*Juniperus occidentalis*) Woodland on Steens Mountain, Oregon

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This report discusses understory plant succession following cutting of a western juniper (*Juniperus occidentalis*) woodland on Steens Mountain in southeastern Oregon. Measurement of the understory response has been part of a larger overall study comparing nitrogen cycling, soil water availability, and litter decomposition between cut and uncut western juniper woodland.

Recent Juniper Expansion

Historically western juniper was largely confined to rockier ridges and rocky low sagebrush flats where fires did not carry due to lack of fine fuels (Miller et al 1993). Most old growth western juniper (> 140 yrs.) will be found on these sites. In the last 100 hundred years western juniper woodlands have been rapidly expanding in range and density particularly in mountain big-sagebrush communities and along drainages (Miller and Rose 1994; Eddleman 1987). This expansion has been a result of several interacting factors which include reduced fire frequencies, improper grazing practices particularly in the late 1800s and early 1900s, and possibly changes in climate (Eddleman 1987; Burkhardt and Tisdale 1969; Kauffman and Sapsis 1989). Once juniper woodlands develop (60-80 yr. woodland) reduced production of understory species may limit fine fuel levels thereby reducing the potential for these areas to burn. Now, fire is being lost as a cost effective tool for managing juniper woodlands.

Fire frequency has declined for a number of reasons. American Indians set many of the fires in the Northwest to improve forage conditions for game animals and promote growth of desired food plants (Miller et al. 1993; Miller and Wigand 1994). The reduction of these peoples population as a result of war and/or disease in the 1800's and eventual confinement to reservations reduced the number of fires set purposefully. More recently, the suppression of wildfires has resulted in reduced numbers and size of fires. Long-term continuous grazing can also reduce the amount of fine fuels which are necessary to carry fires.

An indication that fire frequencies have declined is the condition of many of Oregon's aspen woodlands. Aspen woodlands generally require fires about every 80-100 years to maintain site dominance. Fires kill the older aspen trees but more importantly remove later successional conifers which eventually replace the aspen. After fire, aspen sprouts from roots and reoccupies the site. Without fires (or cutting) that remove or kill the above ground vegetation, aspen stands can be overtopped and shaded out by longer lived trees such as western juniper. At present, many aspen woodlands throughout western North America are being replaced by coniferous forest, a clear indication of reduced fire frequency. On Steens Mountain many of the lower elevation aspen stands are on the way out as a result of succession to western juniper woodland.

Improper grazing may also indirectly contribute to western juniper expansion by setting up conditions essential for its establishment and dispersal. Grazing can shift plant competitive interactions. Heavy season-long grazing of herbaceous plants releases water and nutrients for use by woody plants such as sagebrush and rabbitbrush. Reduced competition from grazed plants can increase the dominance of these shrubs in shrub-steppe plant communities. How does this benefit western juniper? Many juniper seedlings are found beneath sagebrush "nurse" plants which maintain an environment conducive to western juniper seedling establishment (Eddleman 1987). The combination of reduced fire frequency and increased number and longevity of sagebrush safe sites for juniper seedlings may enhance development of juniper woodlands.

The reduction or loss of understory ground cover is also hypothesized to increase dispersal distances of juniper seeds by gravity and overland flow (Burkhardt and Tisdale, 1969). Lack of vegetation to keep juniper seeds from traveling downslope may increase the rate of woodland spread and may also lead to high concentrations of trees at the base of slopes.

The effects of increased density and distribution of western juniper appear to be similar to those documented for pinyon-juniper woodlands throughout the western United States (West 1984). Studies indicate that as these woodlands develop there are reductions in understory plant productivity (Eddleman 1984), changes in nutrient and energy flows through the system (Tiedemann 1987), increased rates of soil erosion (Buckhouse and Mattison 1980; West 1984), and possible losses in plant community and species diversity . Restoration of these sites by fire or mechanical treatments often result in dramatic increases in understory plant productivity (Vaitkus and Eddleman 1987), increased ground cover and reduced soil erosion. Although these changes are often observationally evident there is a lack of quantitative evidence that adequately documents the ecological impacts of western juniper succession into other plant communities and the ecological responses of woodland sites to restoration or wildfires. With regard to understory restoration, quantitative studies in western juniper woodland have been limited to those done in Central Oregon (Vaitkus and Eddleman 1987) and northeastern California (Evans and Young 1985). There is also a general lack of knowledge of how woodland development and restoration of these sites may affect: 1) community level functions and processes such as biological diversity or nutrient cycling, and 2) landscape level processes such as watersheds. There is concern that the lack of a good ecological data base will hamper or misdirect decisions relating to the restoration and use of these lands.

Steens Mountain Juniper Study

We initiated the Steens juniper study to improve our understanding of some ecological processes that maybe influenced by western juniper woodland. The main objectives of this study were to gain and understanding of understory plant succession, nitrogen cycling, soil water availability, and plant litter decomposition after cutting down a western juniper woodland. This paper will focus on measurements regarding understory plant response, comparing cut and uncut juniper woodland.

The study was set up on Steens Mountain 50 miles south of Burns in Harney County, Oregon. The juniper belt on the mountain runs from about 3,800 to 6,800 ft. Much of this area is dominated or rapidly being dominated by western juniper. Of the junipers on the mountain the majority are less than 100 years old (Miller and Rose 1994).

The site selected for our study is dominated by a mature juniper woodland. The site is situated at about 5,000 ft. elevation on a west facing slope. Soils are about 18-20 inches deep, clayey, and fairly rocky beneath the surface. Underlying the soil is an old ash layer that is relatively impenetrable to root growth. This particular site is a worst case scenario. Juniper canopy cover is approximately 20-25 percent and the density of trees about 95 trees/acre. Almost all of the mountain big sagebrush originally present on the site is dead. Understory herbaceous basal cover prior to cutting was less than 3 percent with much of the interspace zones between trees being exposed soil. Plant species composition on the site is primarily made up of native perennial and annual species. Bare ground accounted for nearly 75 percent of the area. Rill erosion was evident throughout the site. Except for unusual conditions (high winds and temperatures, and low humidity) this site will not burn. The only effective treatments would be cutting, other mechanical removal, or herbicides. Cutting is probably the cheapest and most ecologically sound method. Cost sharing would entail an expense of $20-25/acre.

Eight 2-acre blocks were selected in July 1991. Half of each block was cut in August 1991. Cut trees were left on site. Understory measurements were carried out in 1992 and 1993. Measurements included understory plant yield, basal and areal cover, plant density, and species compositions and diversity. Although all species have been measured separately, in this report plants have been grouped into five categories; sandberg's bluegrass, deep-rooted perennial grasses (e.g. Bluebunch wheatgrass, Junegrass etc.), perennial forbs, annual grasses, and annual forbs. Plant measurements were also separated into interspace and tree canopy zones.

The underlying hypothesis of this segment of the study was that understory plant yield, cover, density, and diversity would all significantly increase after cutting down juniper trees. This would be a result of decreased competition for water and soil nutrients.

Results

Study results will mainly focus on information gathered in 1993. As a general rule, all vegetation components measured showed significant increases following cutting of woodland plots in both 1992 and 1993. Climate conditions in 1992 and 1993 were substantially different and are reflected in some of the results. The year 1992 was a drought year and temperatures tended to be higher than normal. Growing season (April - July) precipitation on our site in 1992 was about 4.5 inches (mostly received in June and July) and this was reflected by fairly dry soil conditions especially in woodland plots. In 1993 much of eastern Oregon received record levels of precipitation and temperatures tended to be cooler. Growing season precipitation on the site was about 10 inches.

Yield: In 1992 average total understory yield on the cut plots (40 lbs/acre) was about 2.2 times greater than yield on woodland plots (18 lbs/acre) (Figure 1). In 1993 total understory yield on cut plots averaged 293 lbs/acre and was nearly 9 times greater than yield on the woodland plots (34 lbs/acre) (Figure 2). Perennial plant yield (grasses and forbs) accounted for 97-98 percent of the total yield. Annual plant yields made up a relatively small amount of the total, about 2-3 percent. Soil water availability is the most limiting factor affecting the growth of plants in semi-arid and arid ecosystems. Other studies have demonstrated that by increasing water available for understory plant uptake, understory yields and survival will increase. In this study, measurements of soil water content and plant water stress indicated that soil water was more available over the course of the growing season in the cut plots compared to the woodland plots. This was due to the elimination of juniper competing for soil water on cut plots.

The year effect on understory yield is evident from the results. Woodland understory yield went from 18 lbs/acre in 1992 to only 34 lbs/acre in 1993, about a 90 percent increase but still extremely low given the capabilities of the site. In the woodland plots juniper competition limits the potential response of the understory in a high precipitation year. On the cut plots understory yield went from 41 lbs/acre in 1992 to 293 lbs/acre in 1993, a 700 percent increase, although the increase was not due to the year effect alone. Without competition from juniper, the understory was able to respond in the higher moisture year.

Besides a significant increase in understory yields following cutting there was a shift in the seasonality of understory production. We attribute this shift to both an increase in available soil water later into the growing season and changes in plant species composition from shallow rooted perennial grasses (Sandberg's bluegrass) to deep rooted perennial grasses and forbs. In the woodland plots earlier growing and less productive species, especially sandberg's bluegrass, represented a larger proportion of the total yield than later developing plants (e.g. deeper rooted perennial grasses and forbs). In 1993 sandberg's represented 55 percent and later growing perennials about 44 percent of the total yield (Figure 3). In contrast, on cut plots later growing perennials represented 55 percent of understory yield and sandberg's bluegrass 42 percent.

The resulting increases in understory yield after removing western juniper competition in this study are analogous to results found in studies done in western juniper woodlands of Central Oregon and by others in pinyon-juniper woodlands in the western United States.

Density: Plant density increased significantly following cutting. For example, deep rooted perennial grass density was about .38 plants/ft^2 in both the interspace and old tree canopy zones of cut plots, almost 3 times higher than in the woodland plots (Figure 4). Perennial forb density in the cut plots in the interspace and canopy zones was .28 and .27

plants/ft^2, respectively. In the woodland plots perennial forb density was .15 and .28 plants/ft^2 for interspace and canopy zones respectively. Although perennial forb density in the canopy location is identical between the two treatments, plants on cut plots were much larger and had greater reproductive effort. In general, all plants on the cut plots where larger and produced much greater numbers of reproductive shoots. Because of larger plant size on the cut plots plant cover was also greater.

Cover: Both basal and canopy cover were significantly greater in the cut plots. In 1993 total average basal cover of herbaceous plants on the cut plots was about 5 percent , nearly 3.5 times greater than in the woodland plot (1.4 percent) (Figure 5). Canopy cover of understory plants in cut plots was about 14.5 percent and in woodland plots only about 2.2 percent. Herbaceous cover on the cut plots should continue to increase as open areas are filled in by new plants and the size of existing plants and levels of plant litter increases. Additional protection to the soil surface of cut plots was provided by downed junipers. Canopy cover of downed junipers on cut plots averaged nearly 40 percent. The combined cover of downed trees and understory canopy on cut plots was about 55 percent and would be expected to significantly reduce soil erosion.This was observed following a heavy thunderstorm in July 1992. Downed juniper trees in cut plots tended to trap sediment moving down from adjacent upslope juniper woodland. In the woodlands, overland flow of water and sediment tended to sweep around juniper trees and continue downslope into a sagebrush community. Eddleman (pers. communication) has also observed similar results on larger juniper cuts in the Crooked River area of Oregon.

Species Diversity: Plant species diversity was greater on cut plots both in the interspace and canopy zones as measured by total species numbers. In 1992 the average number of species observed on cut plots (34 species) was over 100 percent greater than the number on woodland plots (16). In 1993 the average number of species found in cut plots was 45 compared to just 27 in the woodland plots (about a 67 percent difference). The differences in the number of species found between 1992 and 1993 also reflect differences between drought (1992) and wet (1993) years. In both years it is evident that plant diversity is significantly greater in the cut plots.

Summary

Cutting western juniper woodland resulted in significantly increasing understory plant yield, density, cover, and total species numbers. Understory response the first year (1992) following treatment didn't appear to be very large. For example, in 1992 understory yield only increased from 18 to 41 lbs/acre. This was partially due to relatively dry conditions in 1992 but it also may take several years before full site potential is reached. By 1993 recovery of the understory was accelerating; the recovery being helped along by the greater than average amount of precipitation received. There is still much unoccupied space in the cut plots and it is expected that the trend of increasing understory yield, cover, and density will continue until most available space is filled. We estimate that plant yield on these sites should average between 400 and 700 lbs/acre depending on the year. Given present vegetation composition, native perennial plants should continue to make up the major component of the system.

Several other points to reiterate or emphasize are: (1) as understory cover improves, soil stability should increase and soil erosion should decrease; (2) cut trees provide several benefits including: a) a source of nutrients to be released into the soil during litter decomposition; b) a source of organic matter which is important in formation of good soil structure; c) protection and establishment sites for plant seedlings; and d) greater ground cover which should also contribute to reducing soil erosion; (3) plant diversity was increased after western juniper was cut, particularly as a result of more perennial and annual forb species. Monitoring of this study and other projects in western juniper woodlands is continuing.

Acknowledgements

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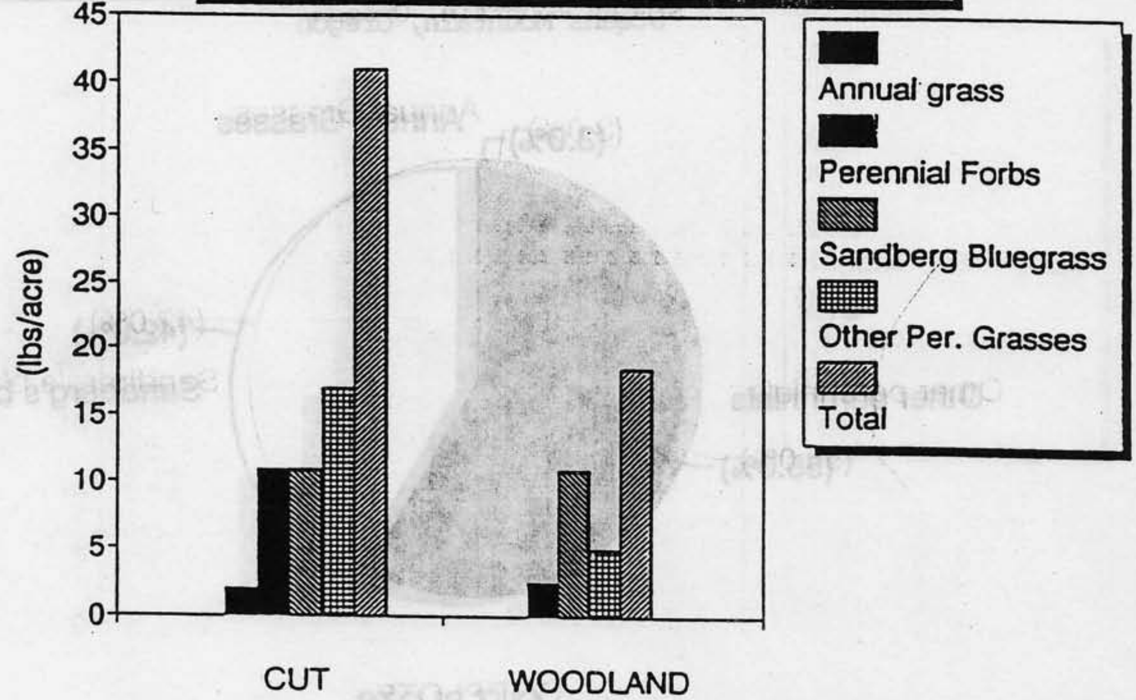
Table 1. Species numbers in cut and uncut western juniper woodland. Steens Mountain, Oregon.

	1992		1993	
Plant Category	Cut	Woodland	Cut	Woodland
perennial grass	8	7	8	7
annual grass	2	1	2	2
perennial forb	9	3	16	7
Annual forb				
- native	10	4	11	7
- non-native	5	1	8	4
TOTAL	34	16	45	27

Steens Mountain, Oregon.

Figure 1: Understory Yield
1992



Steens Mountain, Oregon.

Figure 2: Understory Yield
1993

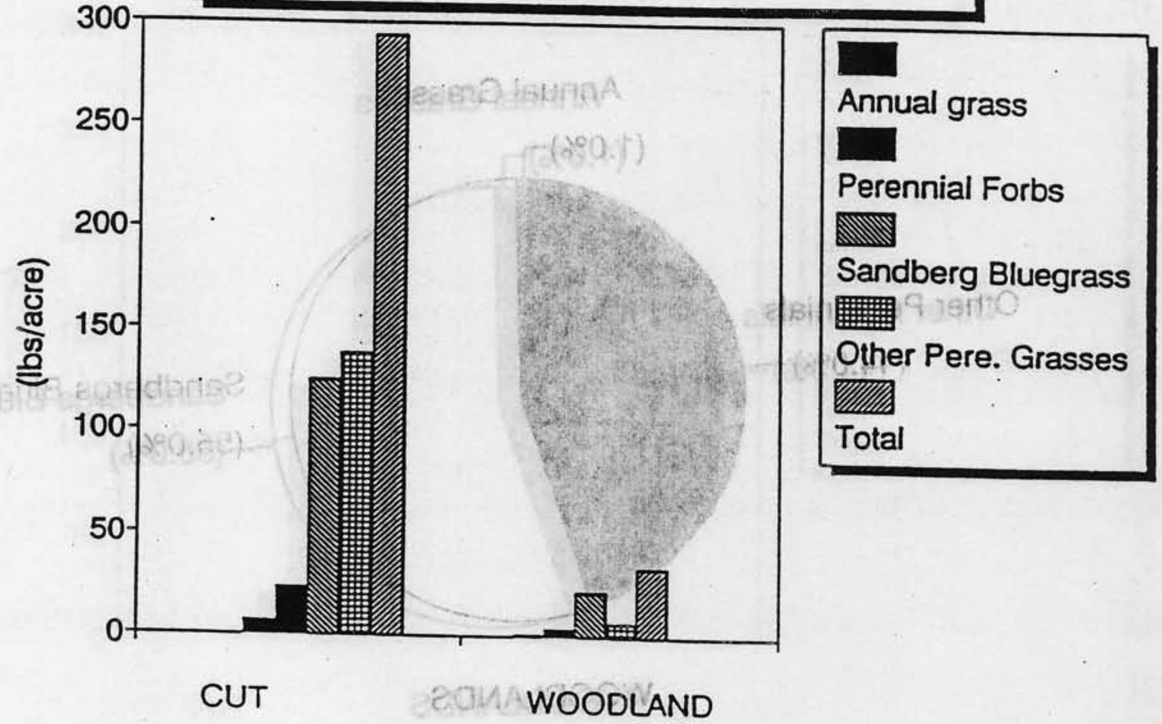
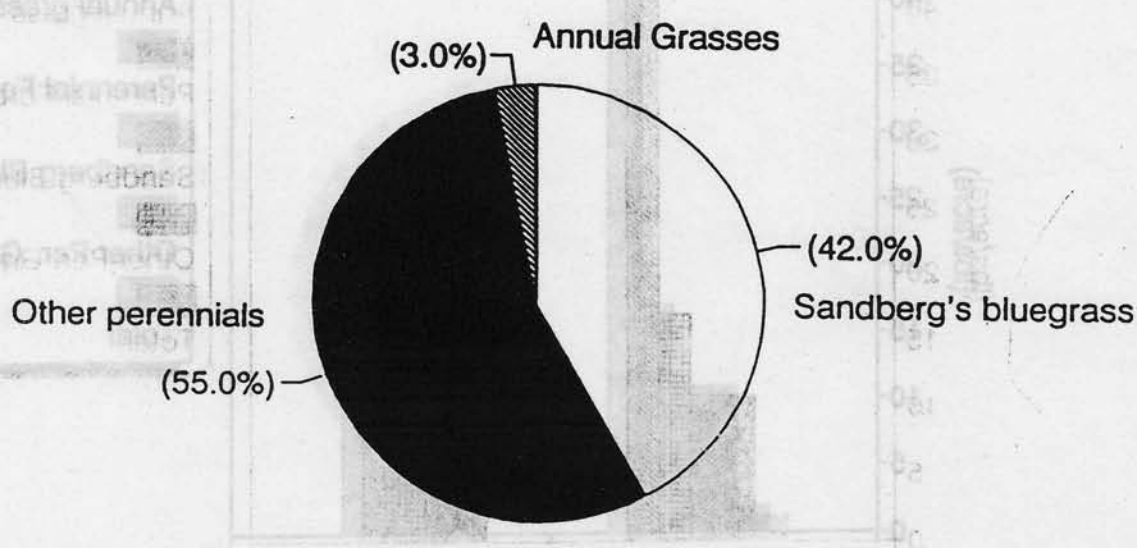
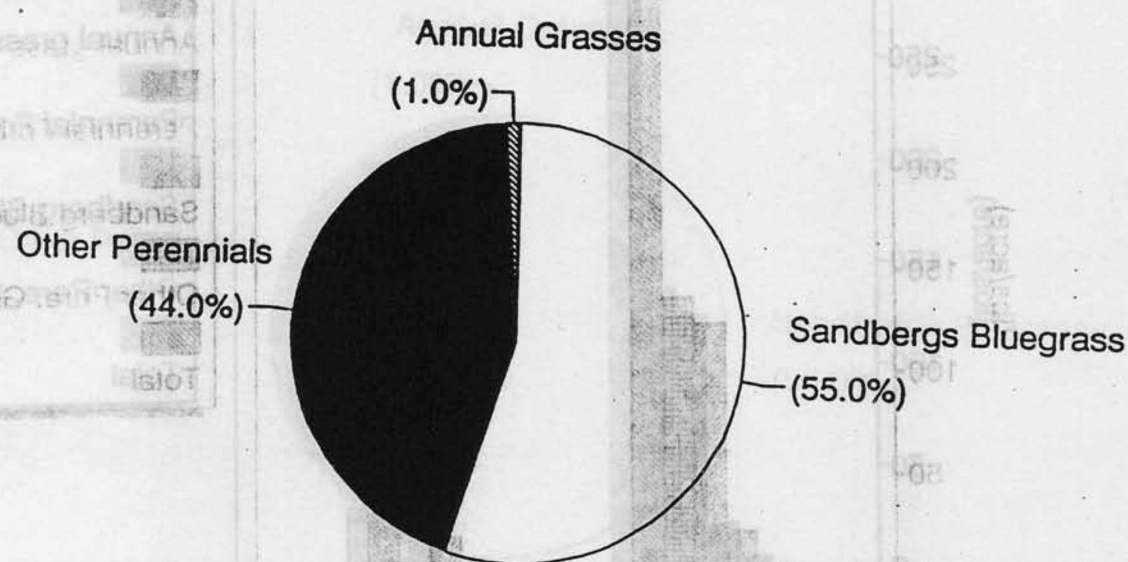


Figure 3: Understory Yield Composition
1993

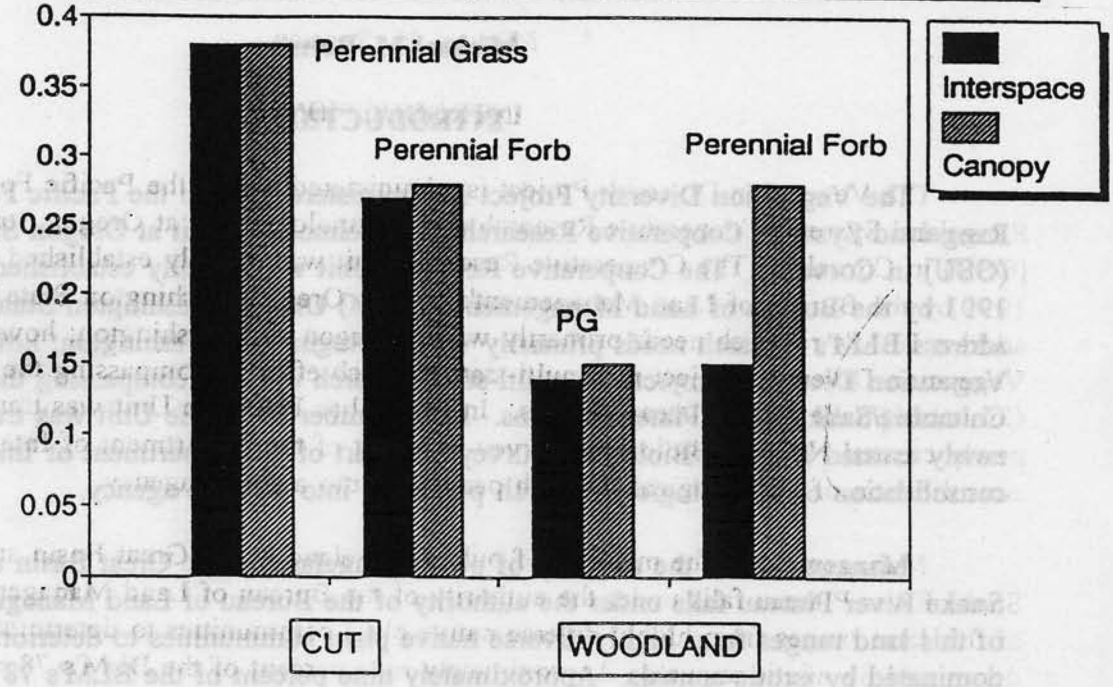
Steens Mountain, Oregon



CUT PLOTS



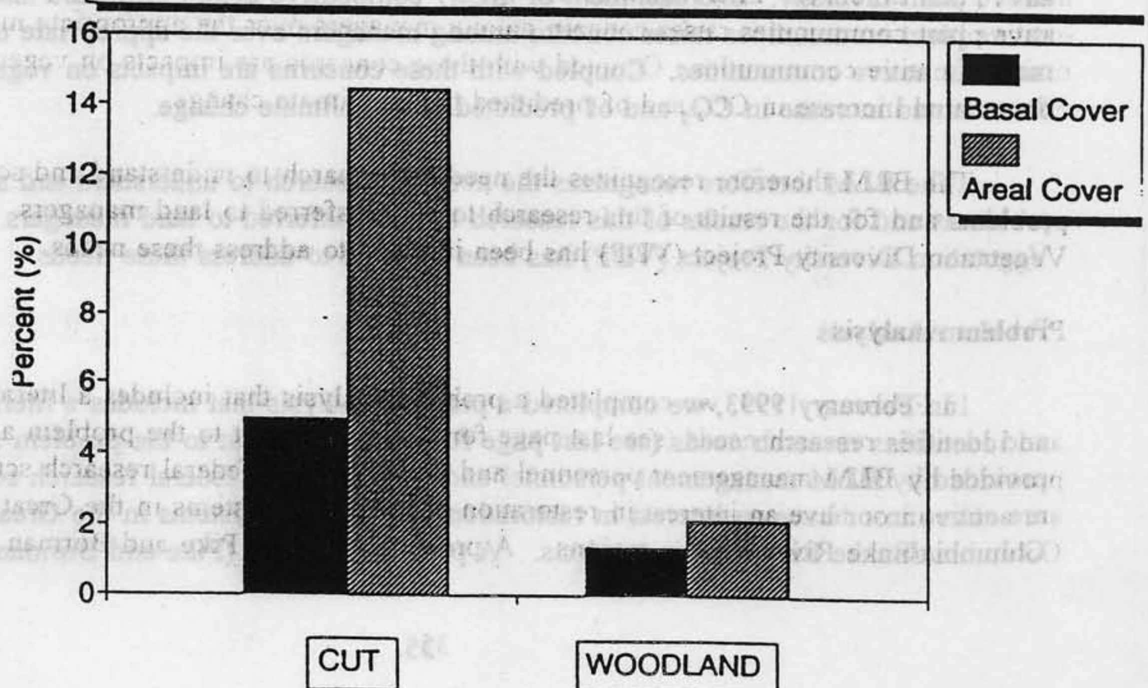
WOODLANDS



Steens Mountain, Oregon

Figure 4: Understory Plant Density

1993



Steens Mountain, Oregon

Figure 5: Total Understory Plant Cover

1993