ECOLOGICAL CONSTRAINTS TO MANAGEMENT OF CENTRAL OREGON RANGELANDS: ENJOYING ITS PRODUCTS AND VALUES

Tim Deboodt

OSU Crook County Extension Agent

Central Oregon rangelands are expansive and diverse. Residents and visitors alike can find spectacular views and places of solitude. Central Oregon rangelands provide habitats for wildlife, places to graze livestock, water for fish, recreation, and irrigation. While the environment may seem harsh, central Oregon rangelands are vital to the cultures, economies, and communities of the area. Central Oregon rangelands are the product of the combination of environmental factors that determine the products and values that can be expected with and without active management. It is important to understand these environmental factors since they form constraints on what can be found in the area.

WHAT ARE THE ECOLOGICAL CONSTRAINTS TO MANAGEMENT OF CENTRAL OREGON RANGELANDS?

The ecological constraints to management of central Oregon rangelands are made up of the climate, soils, vegetation, and history of the area. Central Oregon rangelands are a result of the combination of these factors in time and space. As any one factor changes over time, the landscape changes accordingly.

The discussion of this paper is given in the context of "The Ecological Provinces of Oregon: A Treatise on the Basic Ecological Geography of the State" by E. William Anderson, M. Borman and W. Krueger, May 1998. Central Oregon is composed of primarily three ecological provinces, Mazama, John Day and High Desert. Within each of these three provinces, one or more of these factors are different.

CLIMATE

Climate is the make up of weather patterns over time. Primarily precipitation and temperature are the parts that create an area's climate. Precipitation in the area varies from 7 to 40 inches on an annual basis. Within the region, winter precipitation makes up 50 to 60 percent of the annual total, spring moisture accounts for 20 to 30 percent with little or no rain occurring during the summer months. Vegetative growth is dependent on stored soil moisture and limited to spring when growing conditions (i.e. temperature) are favorable and moisture is available.

Precipitation is highly variable from year to year. In a review of annual rainfall records for Prineville, Oregon, average annual rainfall is 10 inches. Variation around that average is significant. In a review of precipitation records of the last 81 years, 1991 was the driest with 3.5 inches of annual rainfall and the mid-1950's had the wettest year with 16.3 inches of precipitation. Within these 81 years, 41 years were dryer than the average, 34 years were wetter than the average, and only 6 years produced an "average" rainfall amount.

Temperature is highly variable, both during the year and within season. Temperature ranges in the region from a minus 20 to 100 plus degrees F. A farmer from Prineville is quoted as saying "Central Oregon is blessed with 88 days of growing season, the problem however is that they are not consecutive". A review of the weather records would indicate that this statement is true. Freezing temperatures that would affect plant growth, 25 – 28 degrees F or lower, have been recorded for every night of the summer.

SOILS

The soils of the Mazama, John Day, and High Desert ecological provinces are uniquely different from each other. This difference expresses itself in the composition of plant communities, available soil moisture for plant growth, and site fertility.

<u>Mazama Soils</u>

Pumice sands and volcanic ash characterize Mazama soils, large soil particles whose origins stem from Mt. Mazama when it erupted approximately 6500 years ago. Soil depths range from 8 inches to 15 feet. Because of the large soil particle size, there is a corresponding large pore size between soil particles. This characteristic benefits water infiltration (well-drained soils) and limits soil water evaporation. Even areas of low precipitation within this province have relatively high water availability for plant growth.

Because of this water-soil relationship, we find plant species growing in dryer areas than we would normally find them. An example of this is Idaho fescue growing in a 10-inch precipitation zone. Typically we would not find this species in these dryer sites; instead we would find bluebunch wheatgrass or Thurber's needlegrass dominating this site in any other soil type.

Soil fertility is relatively high in the upper weathered pumice soil profile but less or non-existent deeper in the unweathered pumice profile. Very little plant root development can be found in these deeper profiles. In this province, vegetative communities are more a reflection of the differences in climatic factors than with differences in soil factors. Because of the pumice layer, soils are relatively uniform across the Central Oregon portion of the province.

Because of this soil uniformity, it is believed that juniper is a climax species within this province in the area from about Redmond to around Bend, east to about Hampton. Juniper stands within this province have of trees of very old age and have all age classes represented within the stands.

John Day Soils

The John Day Province is marked by a landscape of highly dissected, steep hillsides with extensive plateaus and valleys. While at first glance the soils of the John Day province would appear to have been formed from basalt bedrock, the soils of this province are made up primarily of sedimentary or tuffaceous materials. Basalt flows provide a cap to the nonstony sedimentary materials. Weatherization of these flows provides the rock found on many hillsides.

Soils are generally high in clay content. Red and green clays mark the John Day province. Because of the fine-textured soils in this province, they are highly susceptible to water erosion. Due to the high clay content, soils experience frost heaving in the winter and cracking in the summer.

The clayey sediments of the John Day province are usually calcareous. Western juniper has an affinity for calcium. This soil characteristic is part of the explanation for the expansive spread of western juniper within this ecological province.

High Desert Soils

Anderson, et.al., describe the soils of the High Desert ecological province as being formed from parent materials mainly through water action. The landscape is made of large and small internally drained basins, surrounded by extension terraces formed from ancient lakes.

Soils are highly variable in this province, ranging from deep loam to shallow clays. These soils may be highly alkaline, calcareous, or neutral. Vegetative production in this province is primarily limited by low precipitation and cold temperatures during the spring growing season when there is most likely to be favorable moisture conditions.

VEGETATION

E.R. Jackman wrote in "The Oregon Desert" that plants in the desert areas of Oregon have developed under rules of survival. In his book, Jackman indicates that these rules of survival include that the plant be predominately gray in color, that they are unattractive to animals, and that they have developed moisture saving devices.

In looking at the landscapes of central Oregon's rangelands, they are predominately gray in color, gray-green, gray-blue, or mostly gray. Sagebrush is dusty gray, juniper is gray-blue, green rabbitbrush is gray-green, and gray rabbitbrush is gray.

Plants have developed defensive mechanisms for protection against herbivory. These protective mechanisms include chemical based devices (being astringent, bitter, or poisonous), or have physical characteristics that affect the eating quality (woolly leaves or resins), or cause physical harm to the animal (thorns or awns).

Finally, plants have developed some form of moisture saving device. Leaves may be rolled like Idaho fescue, or modified (scale-like) to protect stomates (small openings in the leaf tissue). An example of a plant with a modified leaf is juniper. Other moisture saving strategies include buried crowns, small leaves or leaves with smooth margins as apposed to serrated or highly dissected margins, large stem to leaf ratio, hard seeds, or completion of a life cycle as an annual. Plants that have developed the ability to live in low precipitation areas are generally small, have reduced leaf surface area, and have short growing periods.

TIME

Time is an important factor in the development of rangelands. Time allows vegetation to express itself. Time allows for the variation of season. Some plants are growing when others are dormant.

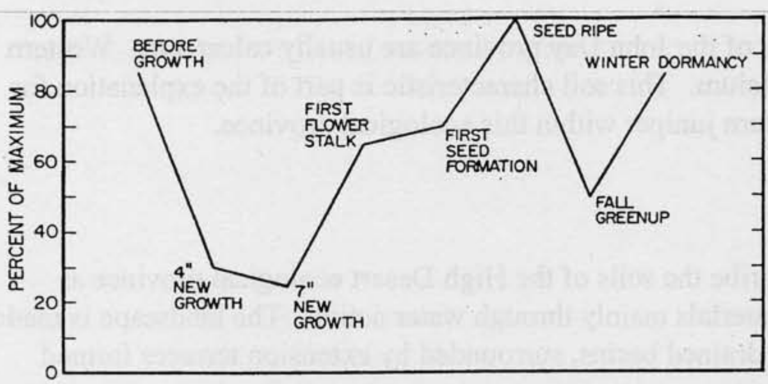

Figure 1. Available energy in roots of bluebunch wheatgrass at varying stages of maturity.

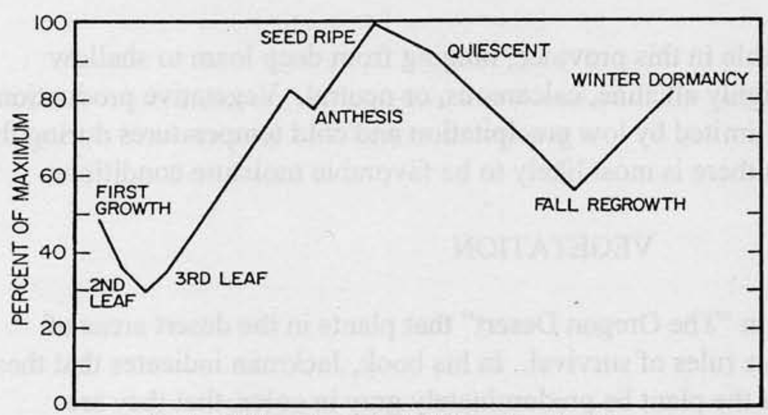

Figure 2. Available energy in roots of squirreltail at several stages of maturity.

Figure 1,2: General phenology and energy flow of bluebunch wheatgrass and bottlebrush squirreltail.

Some plants are flowering while others are already replenishing their root reserves. Figure 1 is a generalized phenology and energy flow of two grasses, bluebunch wheatgrass (top) and bottlebrush squirreltail (bottom) and how they compare throughout the year for initiation of growth, flowering, seed development, and dormancy. Seasonality changes a plant's palatability and therefore its likelihood to be grazed. As a plant becomes more mature, it becomes less palatable, less nutritious, and, therefore, less likely to be grazed.

Time accounts for the annual fluctuations that a site experiences. Earlier in this paper, we discussed the annual variation in precipitation for Prineville. Vegetative expression will be different depending on whether spring is cool or warm and wet or dry.

Time is also geological in nature. As mentioned earlier, much of the parent material in the John Day province is sedimentary. It has been a long time since we had enough moisture in central Oregon to allow that type of soil formation to occur.

Time also allows for vegetation to respond to the history of the site. Fire, drought, grazing, and/ or some other event(s) has had some impact on the landscape. Soils, vegetation, and microclimates are impacted by these events. Frequency of the event(s) and the duration of time between events have a significant impact on the make-up of the plant community and its productivity.

SO WHAT ARE THE ECOLOGICAL CONSTRAINTS TO MANAGEMENT OF CENTRAL OREGON RANGELANDS?

The ecological constraints to management of central Oregon rangelands are made up of the climate, soils, vegetation, and history of the area. Central Oregon rangelands are represented by diverse ecological provinces that in turn contain a variety of landscapes and vegetative communities. These combinations of vegetation, soils, climate, and time determine the products and values the land can produce. That knowledge provides us with the opportunity to enjoy its products and values.

LITERATURE CITED:

Anderson, E. William, Michael M. Borman and William C. Krueger. 1998. The Ecological Provinces of Oregon: A treatise on the basic ecological geography on the state. Oregon Agricultural Experiment Station, SR 990. 138 pgs.

Jackman, E.R. and R.A. Long. 1977. The Oregon Desert. The Caxton Printers, Ltd. Caldwell, Idaho.

PRE AND POSTSETTLEMENT FIRE REGIMES IN MOUNTAIN BIG SAGEBRUSH COMMUNITIES: THE NORTHERN INTERMOUNTAIN REGION

[1]Rick Miller, [2]Chris Baisan, [3]Jeff Rose, and [4]Dave Pacioretty

[1]Professor of Range Ecology, Oregon State University, [2]Research Associate, Tree Ring Laboratory, University of Arizona, [3]Fire Ecologist, Burns District BLM, Oregon and [4]Area Manager, BLM Butte Montana

SUMMARY

This paper summarizes, in three parts, past and current fire history work being conducted. We present results of fire return intervals across 10 sites in mountain big sagebrush/Idaho fescue plant communities. We also have included two tables of proposed fire regimes for a number of sagebrush plant associations based on ongoing work in eastern Oregon and northeastern California.

INTRODUCTION

Fire is a primary disturbance process in sagebrush steppe communities, influencing plant dynamics, composition, and structure. The balance between woody and herbaceous vegetation is highly influenced by the length of fire return intervals. Prior to settlement, fire regimes (Table 1) were spatially complex, changing across the landscape with fuels, topography, and ignition sources. In Oregon, mean fire return intervals varied across different mountain big sagebrush communities from 15 to several hundred years. Fire regimes have changed since Eurasian settlement in the late 1800s (Gruel 1999, Miller and Rose 1999, Miller and Tausch 2001, Swetnam et al. 1999, Tausch 1999). As a result pinyon and juniper woodlands and shrub density and cover in the more mesic sagebrush steppe communities have significantly increased. Pinyon and juniper woodlands have expanded as much as 5 to 10 times in area and 2 to 20 times in density within occupied areas (Cottam and Stewart 1940, Burkhardt and Tisdale 1976, Tausch et al. 1981, Miller and Rose 1995, 1999, Miller and Tausch 2001). The majority of this expansion has occurred in the more productive mountain big sagebrush cover type. However, western juniper has also invaded aspen, mountain mahogany, and riparian communities below 7,000 ft in the northwestern portion of the Great Basin (Miller and Rose 1995, Wall et al. 2001). Many private landowners and public land management agencies have been attempting to reintroduce fire to restore range health, improve livestock grazing conditions, and enhance wildlife habitat. However, knowledge and documentation describing presettlement fire regimes across different cover types throughout this region are limited.

OBJECTIVES

The overall purpose of this paper is to describe several proposed fire regimes, which characterize different mountain big sagebrush plant associations in the northwestern portion of the Intermountain shrub region. Specific objectives are to:

1. Report fire return intervals documented for the mountain big sagebrush/Idaho fescue plant association based on research results.
2. Propose several tentative fire regimes for plant associations based on ongoing work using tree age structure and charred material.

Table 1. Characteristics of fire regimes.

Fire Regimes are defined by the following characteristics: *1. temporal* - seasonality, fire return interval (variability); *2. spatial* - size/extent, spatial complexity; *3. magnitude* - fire intensity, fire severity.
Fire regimes are a function of physical and biotic factors
Physical factors - Climate and weather patterns - Topography - Ignition sources Biotic factors- Plant life history characteristics and fire adaptations - Spatial and temporal patterns of fuel quantity, structure and flammability

Part I: *Fire Regimes in mountain big sagebrush/Idaho fescue association*

STUDY AREA

The study area was located in the High Desert and Klamath Ecological Provinces, which encompass portions of southeast and south central Oregon and northeastern California (Fig. 1). Soils across the study sites are Argixerolls and Haploxerolls derived from igneous materials. Fire scar samples were collected across 10 stands representing the mountain big sagebrush (*Artemisia tridentata* spp *vaseyana*)/Idaho fescue (*Festuca idahoensis*) plant association. Bitterbrush (*Purshia tridentata*) was a co-dominant in several of the communities and curlleaf mountain mahogany (*Cercocarpus ledifolius*) in one community. The presence of presettlement ponderosa pine (*Pinus ponderosa*) adjacent to or growing within these communities was the primary determining factor for documenting pre and post-settlement fire regimes for these communities.

METHODS

Sample sites were selected opportunistically. We reconnaissanced a large region for presettlement ponderosa pine trees associated with mountain big sagebrush steppe communities. Presettlement fire-scarred trees are scarce in these areas due to low tree densities and past harvest. Several of the sites were small islands surrounded by shrub steppe and currently being encroached by western juniper. Other sites, such as Pine Mountain and Dead Indian, were located at the edge of a forest shrub steppe ecotone (Fig. 2). We sampled trees that were growing at the edge of the forest community, single trees growing in the adjacent shrub steppe community, and forest edges fingering out into the shrub steppe community. Our assumption was that fire did not stop at the forest edge or in some cases the micro-community edge. Fuels were contiguous and in most cases ground fuels were heavier in the shrub steppe due to a greater abundance of shrubs and grasses than in the ponderosa pine understory. Similar age structures of post-settlement pine and juniper trees and their synchrony of establishment following the last fire also supports our assumption that fire did not stop at the ecotone between the two communities.

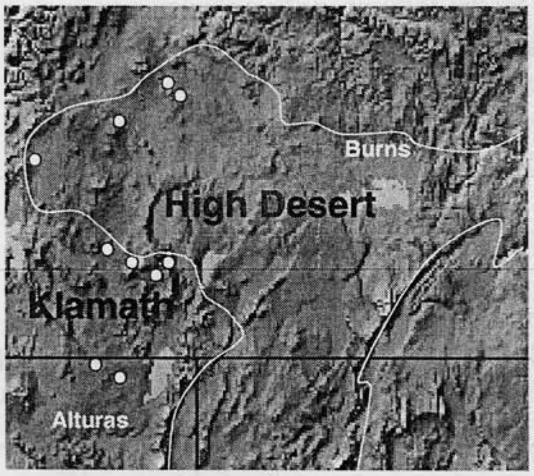

Figure 1. Mountain big sagebrush (Ë%) study site locations in the High Desert and Klamath Ecological Provinces.

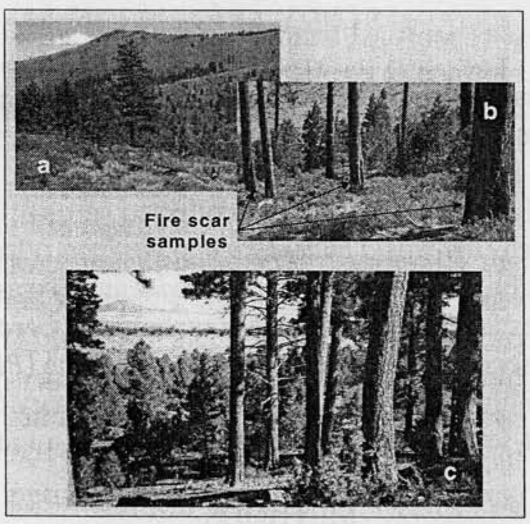

Figure 2. Pine Mountain (a&b) and Dead Indian (c) sample stands, with fire scarred trees in photo b.

FIRE HISTORY

Mountain big sagebrush steppe and juniper woodlands - Fire scar samples were collected in clusters of 3 to 5 trees (< 2.5 ac.) where available (Fig. 2 & 3). Sampling in clusters provided a more complete record than individual trees due to the variability of fire scarring among trees (Kilgore and Taylor 1979). Tree samples were prepared and measured as described by Arno and Sneck (1977) at the University of Arizona Tree Ring Laboratory. All samples were cross-dated with core samples collected from each site to identify the exact year of each fire event (Stokes and Smiley 1968, Fritts 1976). Fire frequency, fire interval variability, and season were determined for each cluster across the region. Season of burn was determined by the position of the scar in the ring (Fritts 1976).

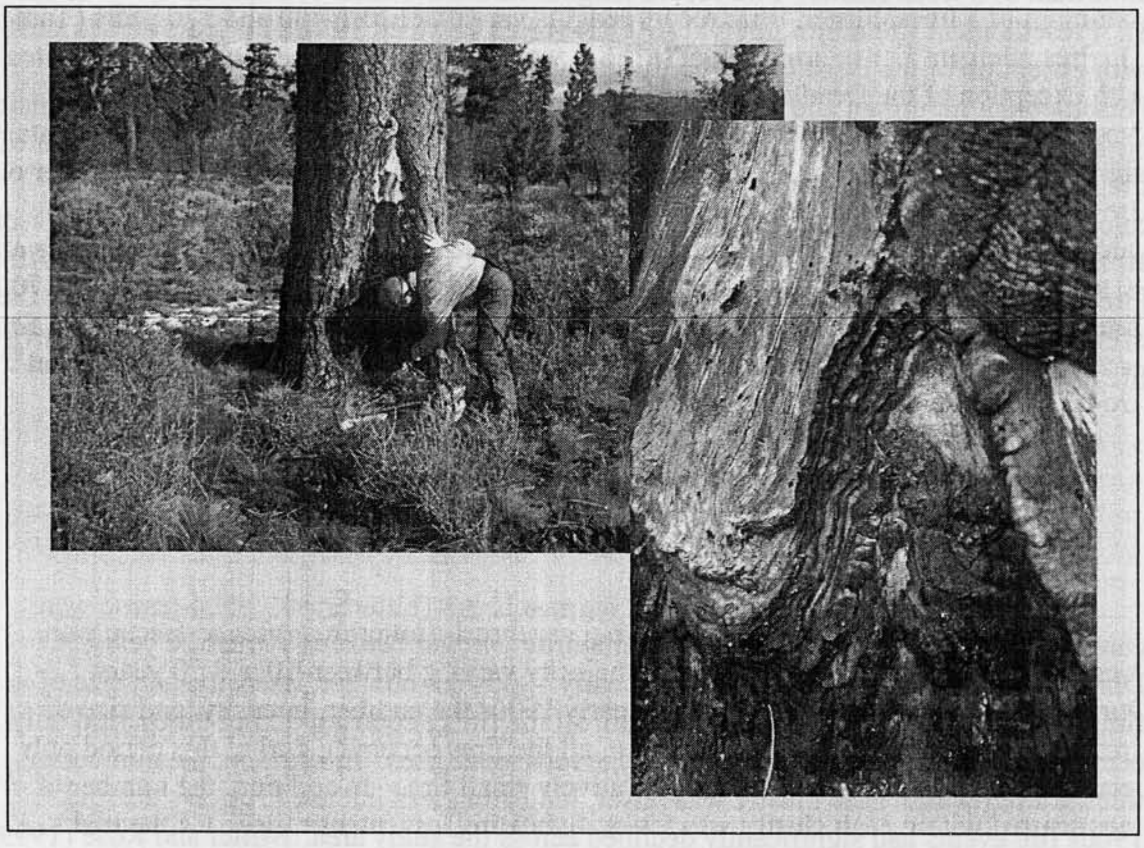

Figure 3: Fire scar trees on the Squaw Mountain study

DATA ANALYSES

The statistics module in the FHX2 fire history program (Grissino-Mayer 1995) was used to summarize and evaluate fire intervals and seasonality. Fire histories for all sites were split as presettlement, scars occurring prior to 1870, and postsettlement, fire scars occurring after 1899. The split was based on historical records documenting the arrival of livestock across this region (Oliphant 1968, Miller et al. 1994) and their impact on fire regimes through the reduction of fine fuels (Burkhart and Tisdale 1976, Miller

Rose 1999). We considered the time interval between 1871 and 1899 as an adjustment period. Miller and Rose (1999) reported that fire occurrence and size began decreasing during this time period.

RESULTS

Approximately 200 fire scars were collected across eastern Oregon and northeastern California. The earliest fire scars collected were 1467 on Pine Mountain and 1517 in the upper Chewaucan River basin (Table 2). However, due to limited sampling depth and incomplete records (caused by burn-out of old fire scars by more recent fires) we calculated MFRI across the 10 sites beginning between 1600 and 1830 with a minimum of 3 trees/cluster. Fire record lengths varied between 400 and 170 years (Table 3). Presettlement fire return interval (MFRI) varied between 10 and 20 years across sites, with exception of the Dead Indian study site where the MFRI was less than 10 years. Presettlement minimum and maximum intervals (years between fires) across the mountain big sagebrush/Idaho fescue cover type were 3 and 32 years. Due to the limited number of fire events occurring between 1900 and 2001 across all sites, MFRI could not be calculated for this time period (Figure 4). Fire occurrence was significantly less across all 10 sites between 1900-2001 compared to the frequency of events occurring prior to 1870. Fire has not occurred across 6 of the 10 sites during the past 100 years and only 1 or 2 fire events have occurred on the remaining 4 sites during this time period. The most recent fire event recorded occurred 50 years ago.

DISCUSSION

Mean Fire Return Intervals

Presettlement MFRI in mountain big sagebrush-(bitterbrush)/Idaho fescue were consistently less than 20 years, with the majority varying between 10 and 20 years. During the period between 1870 and the early 1900s the number, intensity, and size of fires began to decline. On the Chewaucan, all the fires occurring during this period only occurred within one cluster indicating relatively small fires. In addition, the number of trees scarred within each cluster was fewer, indicating less intense fires. By the mid 1900s fire events had significantly declined across the study area. Miller and Rose (1999) concluded that the introduction of livestock in the Chewaucan River basin in the late 1860s significantly affected fire return intervals through the reduction of fine fuels. Fire suppression in the National Forests began in the early 1900s; however, intensive suppression on rangelands did not begin until after World War II. Fire events become noticeably absent after 1950 across all sites (Fig. 4).

The results suggest that the presettlement fire regime across much of this plant association was low intensity and highly frequent (Table 4). We propose that under the presettlement fire regime the majority of the mountain big sagebrush-(bitterbrush)/Idaho fescue plant association was dominated by a herb layer with a widely scattered and patchy shrub layer.

Table 2. Mean fire return intervals (MFRI) and number of fire events across 10 mountain big sagebrush (bitterbrush) / Idaho fescue sites in central and southeastern Oregon and northeastern California.

Parameters	Site									
	Pine Mountain 1	**Pine Mountain 2**	**Chewaucan Lower**	**Chewaucan Mid**	**Chewaucan Upper**	**Picture Rock Pass**	**Squaw Mt**	**Devils Garden**	**Dead Indian**	**Cinder Butte**
	Presettlement									
Period	1740-1870	1626-1870	1780-1870	1650-1870	1600-1870	1751-1870	1820-1870	1800-1870	1830-1870	1750-1870
# Events	10	17	6	19	20	8	10	4	7	7
MFRI	12.6	14.8	17.2	11.7	14.1	16	12.2	17.3	6.2	16.5
Min Interval	7	4	12	3	3	5	7	11	3	-
Max Interval	23	32	26	28	25	32	25	25	10	-
	Postsettlement									
Period	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001	1900-2001
# Events	1	2	0	0	0	0	3	0	2	0
MFRI	-	-					>34		>37.5	
Min Interval	84	36					15		8	
Max Interval		>50					>63		>67	
Last Event	1914	1950	1869	1897	1869	1863	1938	1871	1934	1860s
Sample Size	4	5	3	3	4	2	4	3	4	2

Table 3. Fire scar dates across sites.

Pine Mountain 1	Pine Mountain 2	Chewaucan Lower	Chewaucan Mid	Chewaucan Upper	Picture Rock Pass	Squaw Mt	Devils Garden	Dead Indian
	1467			1517	1751	1820	1802	1830
	1626			1527	1756	1828	1813	1835
	1661			1565	1771	1838	1829	1842
	1668			1592	1800	1845	1855	1845
	1710			1601	1810	1869	1871	1855
	1727			1610	1823	1883		1862
	1740			1632	1855	1890		1867
1742		1657	1657	1863	1900			1871
1755		1678	1678		1915			1875
	1759		1688	1688		1938		1893
1778	1778		1693	1693				1926
1785	1785		1703					1934
1793			1706					
	1796		1717	1717				
1807	1807		1723	1723				
1819	1819		1736					
1829	1829		1740					
1845			1743					
1855	1855			1757				
1886	1886		1768	1768				
1914	1914		1771	1771				
	1950	1783	1783					
			1792					
			1806					
	1809	1809						
		1814						
	1829	1829	1829					
			1839					
	1841	1841						
			1849					
	1855	1855	1855					
	1869	1869	1869					
	1879							
		1880						
	1889							
	1897							

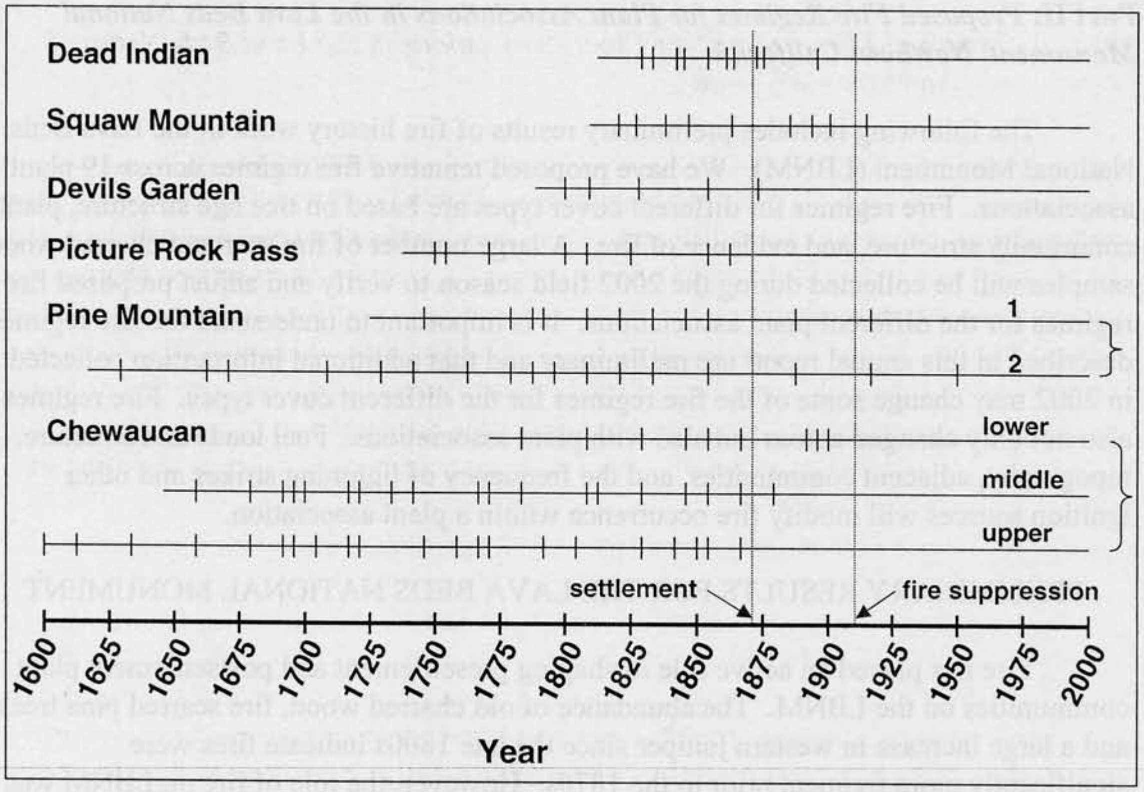

Figure 4. Chronology of fire occurrences among the different stands sampled in mountain big sagebrush / Idaho fescue plant association.

Table 4. Presettlement fire regime characteristics in the mountain big sagebrush bitterbrush) / Idaho fescue cover type for the High Desert and Klamath Ecological Provinces.

Frequency	High (MFRI = 10-20 years)
Season	Mid summer through fall
Primary Ignition	Lightning
Size	Varied
Complexity	Varied
Severity	Low
Intensity	Low

Part II: ***Proposed Fire Regimes for Plant Associations in the Lava Beds National Monument, Northern California***

The following includes preliminary results of fire history work in the Lava Beds National Monument (LBNM). We have proposed tentative fire regimes across 19 plant associations. Fire regimes for different cover types are based on tree age structure, plant community structure, and evidence of fire. A large number of fire scar and charred wood samples will be collected during the 2002 field season to verify and adjust proposed fire regimes for the different plant associations. It is important to understand the fire regimes described in this annual report are preliminary and that additional information collected in 2002 may change some of the fire regimes for the different cover types. Fire regimes also not only changed across but also with plant associations. Fuel loads and structure, topography, adjacent communities, and the frequency of lightning strikes and other ignition sources will modify fire occurrence within a plant association.

PRELIMINARY RESULTS FOR THE LAVA BEDS NATIONAL MONUMENT

Fire has played an active role in shaping presettlement and postsettlement plant communities on the LBNM. The abundance of old charred wood, fire scarred pine trees, and a large increase in western juniper since the late 1800s indicate fires were significantly more frequent prior to the 1870s. However, the role of fire on LBNM was spatially diverse across the monument (Table 5). For example, presettlement mean fire return intervals (MFRI) varied from 10-20 years in some plant communities to greater than 150 years in other communities. The complexity of fire regimes in the LBNM is largely determined by varying fuel loads, topography, and terrain dissected by rock outcrops (mostly recent lava flows).

Evidence supports that fire has played an active but complex role in plant communities across the LBNM. The more arid plant communities, dominated by Thurber and western needlegrass, were probably characterized by relatively long MFRI of 60 to 100 years, which supported a shrub steppe community with few juniper. However, in the more arid western needlegrass communities, fire return intervals were considerably longer, allowing the development of old growth juniper woodlands. On some of the recent lava flows and rock outcrops, fires were rare or absent allowing juniper trees to exceed ages of 500 (very possibly >1000) years. In contrast, fire return intervals were relatively short (10 to 20 years) in the wetter more productive communities dominated by bluebunch wheatgrass and Idaho fescue. Under the presettlement fire regime the herbaceous layer with an open scattered stand of shrubs would have dominated these communities. Western juniper has expanded and/or increased in density into many of these sites since the 1870s, suggesting a change in fire regimes. The 2002 field season will allow us to significantly expand and verify the fire history story on the LBNM proposed in this annual report.

Table 5. Proposed Mean Fire Return Intervals and last fire event for plant communities measured in the LBNM.

Community	Cover Type	Last Fire(s)	Estimated MFRI	Juniper Status
JUOC/ARTRV/STOC	JUOC/ARTRV-PUTR-CELE/STOC	1730s*	150+	Old Growth
JUOC/ARTRV/STOC	JUOC/ARTRV-PUTR-CELE/STOC	1840s*	150+	early
ARTRV-(Ribes)/STTH-STOC	ARTRV-PUTR/AGSP-STTH-STOC	1941/1860s*	50-100	early
JUOC/ARTRV/STOC	CELE-ARTRV-PUTR/AGSP-STOC	1860s*	70+	mid
ARTRV-CHMI/AGSP-STTH-STOC				
ARTRV/AGSP-STTH-STOC	PUTR-ARTRV/AGSP-STOC	1941/1880s*	<60	early
ARTRV/STOC	ARTRV-PUTR/STOC-STTH-AGSP	1941	50-100	early
AGSP-STTH-STOC	ARTRV/AGSP-STTH-STOC	1973	50-100	early
ARTRV/AGSP-STTH	ARTRV/AGSP-STTH	1986	30-70	early
AGSP-STTH-STOC				
ARTRV-CELE/FEID-AGSP	ARTRV/AGSP-STTH-STOC	1996	30-70	early
ARTRV/AGSP-STTH	ARTRV/AGSP-STTH	1994	30-70	early
PIPO/FEID	PIPO/FEID	1870s*	10-20	mid
JUOC/CELE/FEID	PIPO/FEID	1870s*	10-20	mid
ARTRV/FEID-AGSP	ARTRV/FEID-AGSP	1941	10-20	early
ARTRV/FEID-AGSP	ARTRV-PUTR/FEID-AGSP	1890s*	10-20	mid
ARTRV/FEID-AGSP	ARTRV-PUTR/FEID-AGSP	1941/1860s*	10-20	Post-mixed
ARTRV/FEID-AGSP	ARTRV-PUTR/FEID-AGSP	1986/1941	10-20	early
CELE-ARTRV/AGSP-STOC-STTH	CELE-ARTRV/AGSP-STOC-STTH	Late 1800s*	50-100[1]	mid-late
ARTRV-CHMI/ AGSP-STOC-STTH	ARTRV-CHMI/ AGSP-STOC-STTH	Late 1800s*	50-100[1]	mid
CELE	PIPO/CELE?/FEID	Late 1800s*	10-20	early

Last Fire: estimated from tree age structure and/or LBNM fire map; fire dates with * are estimates which will be verified with charred wood samples in 2002.

MFRI: tentative proposed mean fire return interval based on fuel type, tree age structure, and evidence of fire, to be reevaluated in 2002

Juniper Status: Successional status of juniper woodland on the site

JUOC = western juniper, PIPO=ponderosa pine, ARTRV = mt big sagebrush, CELE=curlleaf mt. mahogany, CHMI=Chamaebatiaria millifolium, PUTR=bitterbrush, AGSP=bluebunch wheatgrass, FEID=Idaho fescue, STOC=western needlegrass, STTH= Thurber needlegrass

Part III: Proposed Fire Regimes for Plant Associations in Eastern Oregon and Northern California:

Presettlement fire regimes were highly variable among mountain big sagebrush associations ranging from high-frequency low-intensity fires to low-frequency high-intensity fires (Table 6). In several of the more productive mountain big sagebrush plant associations, fires were frequent (MFRI = 10-20 yrs) and low intensity (Miller and Rose 1999, Miller and Tausch 2001, EOARC data). At the other end of the spectrum, infrequent (MFRI > 100 years) high-intensity fires characterized some of the less productive plant associations on pumice soils (EOARC data). Plant associations with relatively short fire regimes were probably grass dominated with a low density of shrubs. As MFRI increased, the physiognomy shifted from grassland to shrub steppe. Sparse stands of western juniper probably became established as MFRI > 50 years. Since the late 1800s, fire events have generally decreased across the mountain big sagebrush series, especially those where presettlement MFRI were < 100 years. The result has been an increase in shrub cover and density and decline in the herb layer, and often a shift from shrub steppe to western juniper woodlands.

Table 6. Proposed presettlement fire regimes and community physiognomy for different sagebrush plant associations in northeastern California.

Association	MFRI (yrs)	Intensity	Community Structure
ARTRV-SYOR/BRMA	10-20	light	Open shrub - Grassland
ARTRV/STCO	10-20	light	Open shrub - Grassland
ARTRV/FEID	10-20	light	Open shrub - Grassland
ARTRV/AGSP-FEID	15-25	light	Open shrub - Grassland
ARTRV/AGSP	15-35	light-moderate	Open shrub - Grassland
ARTRV/AGSP-STTH	30-70	moderate-high	Shrub steppe
ARTRV/STTH	50-100	high	Shrub steppe
ARTRV/STOC	50-100+ >200	moderate-high	Shrubsteppe Open juniper shrub steppe Juniper woodland
ARTRW/FEID	20-30	moderate	Grassland
ARTRW/AGSP	30-50	moderate-high	Open shrub grassland
ARTRW/STTH	35-100+	high	Shrub steppe
ARTRW/STOC	>100	high	Shrub steppe
ARTRW/ORHY	>100	high	Shrub steppe
ARTRT/ELCI	<50	low-moderate	Grassland to shrub steppe
ARTRT/AGSP	30-100	moderate-high	Shrub steppe
ARAR/FEID	10-20	light	Grassland
ARAR/AGSP	20-50	light-moderate	Open shrub grassland
ARAR/POSA	100-200	moderate	Shrub steppeTree shrub sav
ARAR=low sagebrush, ARTRW=Wyoming big sagebrush, ARTRV = mt. big sagebrush, SYOR=Symphoricarpus oreophilus, AGSP=bluebunch wheatgrass, BRMA=mountain brome ELCI=basin wildryegrass, FEID=Idaho fescue, ORHY=Indian ricegrass, OSA=Sandberg bluegrass, STCO=Columbia needlegrass, STOC=western needlegrass, STTH= Thurber's needlegrass			

LITERATURE CITED

Arno, S.F., and K.M. Sneck. 1977. A method of determining fire history in coniferous forests in the mountain West. USDA For. Ser. Gen. Tech. Rep. INT-42. Washington D.C.

Burkhart, J.W., and E.W. Tisdale. 1976. Causes of juniper invasion in southwestern Idaho. Ecology 57:472-484.

Cottam, W.P., and G. Stewart. 1940. Plant succession as a result of grazing and of meadow desiccation by erosion since settlement in 1862. J. For. 38:613-626.

Fritts, H.G. 1976. Tree rings and climate. Academic Press, New York, NY.

Grissino-Mayer, H.D. 1995. User's Manual FHX2: Software for the analysis of fire history from tree rings. Lab. of Tree-Ring Res., Univ. of Arizona, Tucson, AZ.

Gruell, G.E. 1999. Historical and modern roles of fire in pinyon-juniper, p. 24-28. *In*: Stephen B. Monsen and Richard Stevens (comps)., Proc.: Ecology and management of pinyon-juniper communities within the interior West; 1997 Sept. 15-18; Provo, Ut. USDA For. Ser. Proc. RMRS-P-9.

Kilgore, B.M., and D. Taylor. 1979. Fire history of a sequoia-mixed conifer forest. Ecology 60:129-142.

Miller, R.F., T.J. Svejcar, and N.E. West. 1994. Implications of livestock grazing in the Intermountain sagebrush region: plant composition, p. 101-146. *In:* M. Vavra, W. A. Laycock, and R. D. Pieper, (eds.), Ecological Implications of Livestock Herbivory in the West. Soc. Range Manage., Denver, CO

Miller, R.F., and J.A. Rose. 1995. Historic expansion of *Juniperus occidentalis* (western juniper) in southeastern Oregon. Great Basin Nat. 55:37-45.

Miller, R. F., and J. A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. Journal of Range Management 52: 550-559.

Miller, R.F., T.J. Svejcar, and J.F. Rose. 2000. Impacts of western juniper on plant community composition and structure. J. Range Manage. 53:574-585.

Miller, R.F., and J.A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. J. Range Manage. 52:550-559.

Miller, R.F. and R.J. Tausch. 2001. The role of fire in pinyon and juniper woodlands: a descriptive analysis. pages 15-29. *in:* K. Galley and T. Wilson (Eds.), The Role of Fire In The Control and Spread Of Invasive Species. Tallahassee: Tall Timbers Research Station.

Oliphant, J.O. 1968. On the cattle ranges of the Oregon country. University of Washington Press, Seattle, Washington.

Stokes, M.A. and T.L. Smiley. 1968. An introduction to tree ring dating. Univ. Chicago Press. Chicago, IL.

Swetnam, T.W., C.D. Allen, and J.L. Betancourt. 1999. Applied historical ecology: Using the past to manage the future. Ecol. Mono. 9:1189-1206.

Tausch, R.J. 1999. Historic woodland development, p. 12-19. *In:* Monsend S.B., R. Stevens, R.J. Tausch, R. Miller, S. Goodrich. 1999. Proceedings: ecology and management of pinyon-juniper communities within the interior west. USDA For. Ser. RMRS-P-9

Tausch, R.J. N.E. West, and A.A. Nabi. 1981. Tree age and dominance patterns in Great Basin pinyon-juniper woodlands. J. Range Manage. 34:259-264.

Wall, T.G., R.F. Miller, and T.J. Svejcar. 2001. Juniper encroachment into aspen in the Northwest Great Basin. J. Range Manage. 54:691-698.

LIVESTOCK GRAZING IN CUT JUNIPER WOODLANDS

Jon Bates

Rangeland Scientist, USDA-ARS, Eastern Oregon Agricultural Research Center, Burns, OR

INTRODUCTION

Cutting to remove tree competition is commonly used in areas invaded by western juniper and has resulted in increased understory biomass, forage quality, ground cover, and diversity. These results are based on resting sites two or more years after cutting. Reintroduction of livestock after treating juniper has not received adequate study. Juniper treatments occupy relatively small areas (a few acres to several hundred acres) in large pastures (thousands of acres) used by livestock. Resting entire pastures until these areas recover may be warranted biologically, but may not be practical from a management perspective. At the same time, introducing livestock too soon after juniper treatments may inhibit understory recovery, particularly on sites with a diminished perennial bunchgrasses component, and/or permit dominance by weedy annuals. Understory dynamics in western juniper woodlands were assessed under grazed and ungrazed conditions in years immediately following tree cutting. The grazing prescription was intensive and of short duration (5 days or less). Cover, density, and seed production of understory species were monitored over a 3-year period after cutting in 1991.

MATERIALS AND METHODS

Study Site

The study site was located on Steens Mountain, southeast Oregon. Elevation at the site is 1550 m (5000 ft) and aspect is west facing with a 22% slope. The pasture used is 300 acres in size. Livestock since 1999 have access to about 160 acres of the pasture. Juniper has fully occupied about 40% of the site. The other 60% of the pasture is open woodland with a sagebrush/bunchgrass understory. Juniper dominated areas are where the experimental treatments were applied. On the juniper-dominated sites, big sagebrush has been largely eliminated with only a scattering of old, decadent shrubs remaining. On ungrazed plots, juniper canopy cover averaged 27% and tree density averaged 112 trees/ac. On grazed plots, juniper cover averaged 25% and tree density was 97 trees/ac. Bare ground was 95% in intercanopy zones and rill erosion was evident throughout the site. Sandberg's bluegrass is the dominant understory species comprising about 75% of total understory perennial plant cover. Other species found on site are bottlebrush squirreltail, bluebunch wheatgrass, Thurber's needlegrass, basalt milkvetch, and pale alyssum. Water year (Oct. 1 - Sept. 30) precipitation at Malheur National Wildlife Refuge weather stations located 16 miles southwest (elev. 4265 ft) and 18 miles northwest (4100 ft) have averaged 11.2" and 9.7" over the past 34 years. Soils on the site are 16 to 20 inches deep, rocky, and are clay loam in texture. Soils are underlain by a welded ash tuff of rhyolite/rhyodacite composition which blocks root penetration.

Experimental Design

The experimental design includes for 2-acre sized blocks. Vegetation was characterized prior to tree cutting. Trees in half of each block were cut with chainsaws in Sept.-Oct. 1998. All cut juniper trees were left in place. A 4-strand barbed wire fence was built through the center of each plot in August 1999. Half of each woodland and cut treatment replicate was grazed in 1999 and 2000 with the other half protected from domestic livestock. Post-treatment measurements of understory characteristics were made in June 1999, 2000, and 2001. Plots were short duration grazed in early May 1999 and 2000. Livestock were in this pasture 4-5 days. Plots were not grazed in 2001.

Understory Sampling

Understory measurements were canopy cover, density, and seed production. Understory plants were measured by species, but for this article are condensed into five functional groups. Functional groups are Sandberg's bluegrass, perennial bunchgrasses (e.g. Thurber's needlegrass, bluebunch wheatgrass, squirreltail), perennial forbs, annual grasses, and annual forbs. Understory plant density and canopy/ground cover was measured using 0.2-m^2 (2-ft^2) frames along three 45-m (150-ft) transects in both grazed and ungrazed portions of the cut and uncut woodlands. Seed was collected in five 100 ft^2 plots for each treatment replicate. Seed was collected by hand for all perennial grass species by hand twice per week from late June into early August in 2000 and 2001. Seed was not collected in 1999 the first year after cutting as there was little reproductive development.

RESULTS

Understory Response
Pre-cutting

Measurements in 1998 did not show any major differences in plant cover (Tables 1 and 2) or density (Table 2) among plots that were left as woodlands and plots that were selected to be cut. Densities of perennial grass were greater in plots selected to be cut than those left as woodland.

Grazing

The grazing application was intensive and of short duration (5 days or less), and occurred in early May 1999 and 2000. In 1999, plots were grazed by 140 cow/calf pairs for 5 days and by 50-75 cow/calf pairs for 4 days in 2000. Utilization in cut-grazed plots averaged 75% in 1999 and 2000. Utilization in grazed/woodland plots averaged 67% in 1999 and 15% in 2000. Regrowth (data not compiled) occurred in cut-grazed plots but not in the woodland. Most regrowth in the cut-grazed treatment was vegetative.

Post-Cutting

Sandberg's bluegrass - There were no differences in cover, density, and seed production between cut and woodland plots - grazed and ungrazed treatments (Table 2 and 3).

Table 1: Ground covers, bare ground, rock, and juniper cover for grazed and ungrazed cut and woodland treatments.

Year	Treatment	Herbaceous Cover	Litter	Moss/crust	Bare ground	Rock	Juniper Cover
1998	Grazed - Cut	5.3	3.9	0.9	54.6	10.3	25.5
	Ungrazed - Cut	4.5	2.8	0.9	55.4	12.1	25.1
	Grazed-Woodland	4.6	2.1	0.8	60.2	8.2	29.0
	Ungrazed-Wood.	4.6	2.5	0.7	60.4	10.2	27.4
2000	Grazed-Cut	7.3	41.2	0.1	47.9	7.9	---
	Ungrazed-Cut	8.6	33.0	0.1	47.8	7.8	---
	Grazed-Woodland	4.2	1.8	0.6	63.8	8.1	28.7
	Ungrazed-Wood	4.0	2.1	0.5	62.5	9.2	27.4
2001	Grazed - Cut	16.4	32.5	0.1	47.9	4.0	---
	Ungrazed - Cut	15.7	31.2	0.1	47.3	6.4	---
	Grazed-Woodland	3.7	1.0	0.4	59.7	7.4	28.4
	Ungrazed-Wood	3.6	2.4	0.5	61.2	10.0	26.5

Table 2: Functional group covers and densities for grazed and ungrazed cut and woodland treatments.

Year	Treatment	Sandberg Bluegrass		Perennial Grass		Annual Grass		Perennial Forb		Annual Forb	
		Cover	Density	Cover	Density	Cover	Density	Cover	Density	Cover	Density
1998	Grazed	2.3	8.6	1.0	2.2	0.2	22	0.6	2.1	1.2	409
	Ungrazed	1.9	7.1	0.7	2.8	0.4	28	0.3	1.2	1.2	444
	Graze-Wood	1.4	5.9	0.7	1.8	0.2	21	0.2	1.0	0.8	387
	Ungraze-Wood	1.5	5.5	0.6	1.7	0.4	19	0.1	1.4	0.8	389
2000	Grazed	1.1	3.1	1.3	2.0	1.5	24	0.4	3.0	3.0	33
	Ungrazed	1.7	3.7	1.6	2.4	0.7	13	1.7	4.4	2.9	33
	Graze-Wood	1.5	5.6	0.7	1.8	0.5	20	0.3	0.8	0.8	45
	Ungraze-Wood	1.5	5.7	0.6	1.6	0.4	12	0.3	1.1	0.6	47
2001	Grazed	2.1	6.2	2.2	3.3	9.4	282	0.5	1.5	2.1	346
	Ungrazed	1.6	4.8	2.9	2.6	7.1	233	1.3	2.4	2.3	429
	Graze-Wood	1.4	6.1	0.5	2.1	0.8	11	0.2	0.5	0.9	344
	Ungraze-Wood	1.6	5.9	0.6	1.7	0.3	11	0.4	1.5	0.7	254

Table 3: Seed Production (lb/ac) for grazed and ungrazed cut and woodland treatments.

Year	Treatment	Native Bluegrass	Bluebunch Wheatgrass	Basin Wildrye	Junegrass	Indian Ricegrass	Squirrel-tail	Thurber's Needlegrass	Total
2000	Grazed/Cut	0.1	0.04	0.03	0.0	1.6	0.4	0.5	2.7
	Ungrazed/Cut	0.6	1.8	0.3	0.5	3.8	2.1	5.3	14.4
	Grazed/Wood	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
	Ungrazed/Wood	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
2001	Grazed/Cut	4.8	6.3	0.3	0.3	11.2[1]	6.1	4.7	32.4
	Ungrazed/Cut	5.0	8.3	0.9	2.0	10.8[1]	5.2	11.4	42.2
	Grazed/Wood	4.5	0.0	0.0	0.0	0.1	0.0	0.1	4.7
	Ungrazed/Wood	4.1	0.0	0.0	0.0	0.0	0.0	0.2	4.4

[1] Ricegrass seed heads were clipped so weight includes all material in the upper seed stock. Thus the values shown here overestimate actual seed production of ricegrass.*Perennial Bunchgrasses* - Cover in cut plots increased between 1998 and 2001 and was greater than in the woodlands by 2001 (Table 2). Densities of perennial grass remained greater in cut plots versus the woodlands. No differences were found between grazed and ungrazed portions of the cut/woodland treatments in cover or density (Table 2). Seed production differed significantly among the treatments (Table 3). Seed production was greatest in the ungrazed-cut treatment. Woodland grazed and ungrazed treatments had little seed production in both collection years (and was primarily composed of Sandberg's bluegrass). Cut plots had greater seed production in 2001 versus 2000. Thurber's needlegrass seed production was sensitive to the grazing treatment. Thurber's needlegrass seed production was significantly less in the grazed compared to the ungrazed treatment in both years.

Annual Grasses - Annual grass response trend has been similar in ungrazed and grazed-cut plots (Table 2). Cover and densities of annual grasses did not differ between the two treatments in all years. Annual grass density and cover were greater in the cut versus woodland treatments. The increase in annual grass density and cover has largely been under cut trees and around old litter zones. Annual grass presence is limited in intercanopy zones.

Perennial Forbs - Perennial forb cover and density has tended to be greatest in the cut-ungrazed versus the other treatments (Table 2)

Annual Forbs - Annual forb density did not differ among treatments (Table 2). Annual forb cover was greater in cut treatments (grazed and ungrazed) in all years after cutting compared to the woodlands.

Total ground cover - Ground cover (herbaceous, litter, moss, and juniper cover) was nearly 50% greater in the cut treatment (grazed and ungrazed) than in the woodland treatments by 2001 (Table 1). Intercanopy herbaceous cover was 2 times greater in cut versus woodland plots in 2001.

DISCUSSION AND IMPLICATIONS

Grazing following the cutting of juniper had no impact on site recovery in terms of plant cover and density. Increases in herbaceous cover and density were similar in cut-grazed and ungrazed treatments. However, it is difficult to draw any firm conclusions from these results. These trials were conducted across three relatively dry years with little precipitation falling in the spring at this site. Soils on this site are shallow and dry relatively quickly. Regrowth on the cut grazed plots was adequate following May grazing in 1999 and 2000 but this growth was primarily vegetative with little seed produced. The dry conditions were probably a major factor for the lack of perennial grass recruitment in the grazed and ungrazed-cut treatments. Average or higher precipitation years would likely produce differing responses. The relatively short grazing prescriptions imposed were detrimental to seed production on the cut-grazed versus the ungrazed cut treatment. Thurber's needlegrass seed production was negatively impacted by the grazing prescription. Other perennial grass species seed crops were less affected by grazing. How this may affect further site recovery will be determined by continued monitoring of these treatments.

Grazing management, particularly on drier type-sites such as the one described here, will require thorough consideration. The site used in this study probably requires rest or deferment during the first few growing seasons to provide plants the opportunity to produce maximum seed crops and permit seedling establishment. Juniper cutting on these type of areas should attempt to coincide with regular pasture rotations so cut areas are rested or deferred in years immediately following juniper treatment. Grazing in late summer and fall may be permissible as plants are largely dormant during this time. Unplanned grazing on parts of 4 cut plots (cut in 1991) from an earlier study done on the same locale during late summer and early fall in 1992 and 1993 did not retard understory recovery on these plots (Bates et al. 1998 and 1999). However, these results should be considered anecdotal and require further investigation for research verification.

Older cut treatments (1991) that were rested 2 years following cutting have seen significant increases in perennial grass density and cover with or without grazing (Bates et al. 1998 and 1999). In cut-grazed plots (spring grazed 1994-1997), perennial grass density increased by 333% and cover by 300% between 1991 and 1998. In ungrazed-cut plots, perennial grass density increased by 575% between 1991and 1997 with similar increases in cover.

Finally, increases in annual grass density and cover occurred under both grazed and ungrazed conditions. Removal of grazing did not prevent annual grass from increasing in the cut treatment.

LITERATURE

Bates, J., R.F. Miller, and T.J. Svejcar. 1998. Understory patterns in cut western juniper (*Juniperus occidentalis* spp. *occidentalis* Hook.) Woodlands. Great Basin Nat. 58(4):363-375.

Bates J., R.F. Miller, and T.S. Svejcar. 1998. Understory dynamics in a cut juniper woodlands (1991-1997). Eastern Oregon Agricultural Research Center Annual Report. Special Report 991, June 1998. Agri. Exp. Sta. Oregon State Univ. & USDA-Agric. Res. Ser. p. 24-33.

Bates J., R.F. Miller, and T.S. Svejcar. 1999. Plant succession in cut juniper woodlands: 1991-1998. Eastern Oregon Agricultural Research Center Annual Report. Special Report 991, June 1998. Agri. Exp. Sta. Oregon State Univ. & USDA-Agric. Res. Ser. p. 24-33.

Bates, J.D., R.F. Miller, and T.J. Svejcar. 2000. Understory vegetation response following cutting of western juniper. J. Range Manage. 53(1): 119-126.

Burkhardt, J.W. and E.W. Tisdale. 1969. Nature and successional status of western juniper vegetation in Idaho. J. Range Manage. 22:264-270.

Burkhardt, J.W. and E.W. Tisdale. 1976. Causes of juniper invasion in Southwestern Idaho. Ecology 57:472-484.

Driscoll, R.S. 1964. Vegetation-soil units in the central Oregon juniper zone. Res. Pap. PNW-19. USDA - Forest Service, Pacific Northwest Forest and Range Experiment Station. Portland, Ore.

Eddleman L.E. 1987. Establishment and stand development of western juniper in central Oregon. pp. 255-259. In: R.L. Everett, ed., Proceedings, Pinyon-Juniper Conference. Inter. For. Range Res. Sta., USDA-For. Ser., Gen Tech. Rep. INT-215. Ogden, Utah.

Everett, R.L. 1987. Plant response to fire in the pinyon-juniper zone. p. 152-157. In: Proc. Pinyon-Juniper Conference, R.L. Everett (ed), Inter. For. Range Res. Sta., USDA-For. Ser. Gen. Tech. Rep. INT-215. Ogden, Utah.

Everett, R.L. and K.O. Ward. 1984. Early plant succession in pinyon-juniper controlled burns. Northwest Science 58:57-68.

Miller, R.F. and J. D. Bates. 2001. History, Ecology, and Management of Western Juniper Woodlands and Associated Shrublands: 2000 Annual Report. Eastern Oregon Agric. Research Center, Burns Oregon. 80 pp.

Miller, R.F. and J.R. Rose. 1995. Historic expansion of *Juniperus occidentalis* southeastern Oregon. Great Basin Nat. 55:37-45.

Miller, R.F. and P.E Wigand. 1994. Holocene changes in semiarid pinyon-juniper woodlands; responses to climate, fire, and human activities in the U.S. Great Basin. BioSci. 44:465-474.

Rose, J.R. and L.E. Eddleman. 1994. Ponderosa pine and understory growth following western juniper removal. Northwest Sci. 68:79-85.

Vaitkus, M.R., and L.E. Eddleman. 1987. Composition and productivity of a western juniper understory and its response to canopy removal. pp. 456-460. In: Proceedings-Pinyon-juniper Conference, R.L. Everett, ed. Inter. For. Range Res. Sta., USDA-For. Ser. Gen Tech. Rep. INT-215. Ogden, Utah.

DYNAMICS IN CENTRAL OREGON'S WESTERN JUNIPER WOODLANDS

Lee Eddleman

Professor, Range Ecology
Department of Rangeland Resources, Oregon State University

Studies in the western juniper[1] woodlands of Central Oregon began in 1982. At that time, there were concerns with the rapid expansion of western juniper onto other types of rangeland, mostly sagebrush steppe. Of particular concern was the decline in forage resources in the woodlands for livestock. Also of concern were the potential changes in watershed function. Studies since 1982 have focused on a variety of topics including understory response to non-livestock use, cutting, slash manipulation, seeding, water use and fire.

The various projects conducted in Central Oregon would not have taken place were it not for the encouragement, direction and aid of a number of individuals. The initiation of these studies was largely at the instigation of Tom Bunch, former OSU Crook County Extension Agent. He provided not only encouragement but in many cases the resources and the necessary cooperators to get the treatments applied. The same high level of support was continued by the current OSU Crook County Extension Agent, Tim Deboodt. Early on, Clint Jacks, OSU Jefferson County Extension Agent, became actively involved in supporting and promoting efforts in Jefferson County. Tom Bedell, former OSU State Range Extension Specialist, provided encouragement and actively promoted efforts to better understand management of these woodlands.

The willing cooperation of several landowners in the area is also gratefully acknowledged. They allowed use of their land for a variety of activities. In the Prineville area, cooperators included Richard Breese, Doug Breese, John & Lynne Breese, J. B. Cox, and Denny Denton of L S Ranches. In the Brothers area Billy McCormack of McCormack and Sons Ranch and in the Willowdale area Ron Ochs were cooperators.

Byron Cheney, then Ranger on the Crooked River National Grasslands (USFS), became interested in these projects and supported studies in the Cyrus Butte area. Through the efforts of Clint Jacks and the interest of the Warm Springs Tribe, studies were also carried out on the Warm Springs Indian Reservation.

There were several cooperators who supplied seed for the seeding projects. They included the Round Butte Seed Co. of Culver OR, and the USDA, NRCS Plant Materials Centers of Pullman WA, Aberdeen ID and Bridger MT.

Only four of the studies are included in this report. These four have a long-term component.

---

[1] Botanical names of plant species are listed in Appendix I.

I. LONG TERM VEGETATION CHANGES WITH AND WITHOUT JUNIPER CONTROL.

First impressions suggest that one of the characteristics of western juniper is that it is a strong competitor acquiring scarce resources, and that this competition continues to strengthen as trees become larger and denser within an area. As a result of the presence of western juniper there appears to be a decline in both abundance and vigor of several herbaceous and woody plant species, and a loss in understory plant species richness. An additional contributing factor to this process involves grazing, in which larger herbivores are faced not only with less area to graze but also a reduced plant abundance and vigor. Taken together these two factors may well cause considerable decline in understory productivity.

Concerns, for loss of site productivity and for loss of plant species, have been raised by many managers in both the private and public sector in central Oregon. As a result significant questions arise as to the potential for recovery of productivity. Although recovery is essentially ecological in nature, it has major economic implications. Treatments cost money. For example can those sites that appear to be strongly impoverished recover on their own, or is site intervention, in the form of partial or wholesale tree removal, needed? If competition from trees is removed, how does the remnant vegetation respond?

In 1982 a study was begun looking initially into the short-term, the first two years, response of understory vegetation to the removal of western juniper trees. Areas selected for this study were those in which the trees were representative of young western juniper woodlands, oldest tree layer less than 100 years of age. Additionally the understory was to be representative of low productivity conditions with low species vigor and richness in the interspace areas. Following the initial treatment study it was decided that longer term measurements of change over time were needed.

AREA AND METHODS

These study areas were located in the John Day Ecological Province (Anderson et al. 1998) of central Oregon southeast of Prineville on a western juniper covered plateau area locally known as Combs Flat. Study areas were selected along a gentle NNW facing slope ranging in elevation from 3640 to 3980 ft (Table 1). Lower plots were about 3% slope and ranged up to 13% at the upper plots.

Soils were progressively deeper with elevation (Table 1). All had loamy surface soils and were underlain by a cobbly clay layer beginning at about 10 inches deep and varying in thickness from 5 to 15 inches. Beneath the clay was either fractured or weathered basalt.

The nearest weather recording station at Prineville, Oregon is at 2850 ft in elevation where the average annual precipitation was 11.1 for the years of 1975 through 2000. Based on the long-term precipitation records at Prineville, running averages of annual precipitation show a general increase in annual precipitation into the 1970s and then somewhat of a leveling off. For this reason the 1975 through 2000 period was chosen to best represent more accurately the effective moisture inputs during the study period. Peak inputs of moisture for the Prineville area occur in mid-winter followed by a second smaller peak in May (Figure 1).

Table 1. Parameters of the long term study site.

Slope Position	Elevation ft	Slope %	Soils	Precip.[1] in.	Probable vegetation at early settlement
Lower	3,640 ft (1110 m)	3	Depth- 13"-15" 9"-10" silt loam 10"-15" cobbly clay +15" Fractured Basalt w/indurate pan between	13.2 (335 mm)	Basin big sagebrush /Bluebunch wheatgrass -Idaho fescue
Mid-slope	3740 (1140m)	5	Depth 20"-25" 0-8" (10) loam 10"-25" cobbly clay 20"-25" Fractured Basalt	14.2 361 mm	Low sagebrush /Bluebunch wheatgrass -Idaho fescue
Upper	3970 (1210 m)	13	Depth 24"-30" 0"-10"(12) gravelly loam 10"-24" (29) v. cobbly clay 24" weathered Basalt	14.6 (371 mm)	Mountain big sagebrush /Idaho fescue Bluebunch wheatgrass

1/ Precipitation determined from a correction factor developed from 24 duplicate monthly measurements made on each site and regressed on Prineville weather station monthly data.

Storms, particularly spring and early summer rainstorms, are frequently local and therefore precipitation input can be highly variable across the general area represented by the Prineville station and thus only generally related to that of Prineville. The winters are not particularly cold, with December and January means near freezing. Frost may occur any month of the year however low temperatures lethal to plant reproductive structures occur in May in over 1/3 of the years.

Climatic diagrams are useful tools that can be used to predict the long-term potential productivity and growth forms of vegetation. The ratio of temperature (° C) to precipitation (mm), in use and judged most informative, is 1:2 (Walter 1973). The point at which the precipitation line descends across the temperature line indicates the point at which growth rates begin to decline for those plants dependent on moisture in the surface 12-16 inches, in this case it crosses in June (Table 1).

Growth of native vegetation in this area is possible in all those months with monthly means temperatures of 50° F (10 °C) or greater since the monthly minimum temperature rises above freezing (0° C) at about the same time. In the majority of years rapid growth should occur in May, begin a decline in June and end in July. Temperatures are warm enough for water to be used by western juniper in all months, although December and January may be too cold in some years. Never-the-less transpiration is contingent on plant available soil moisture being present.

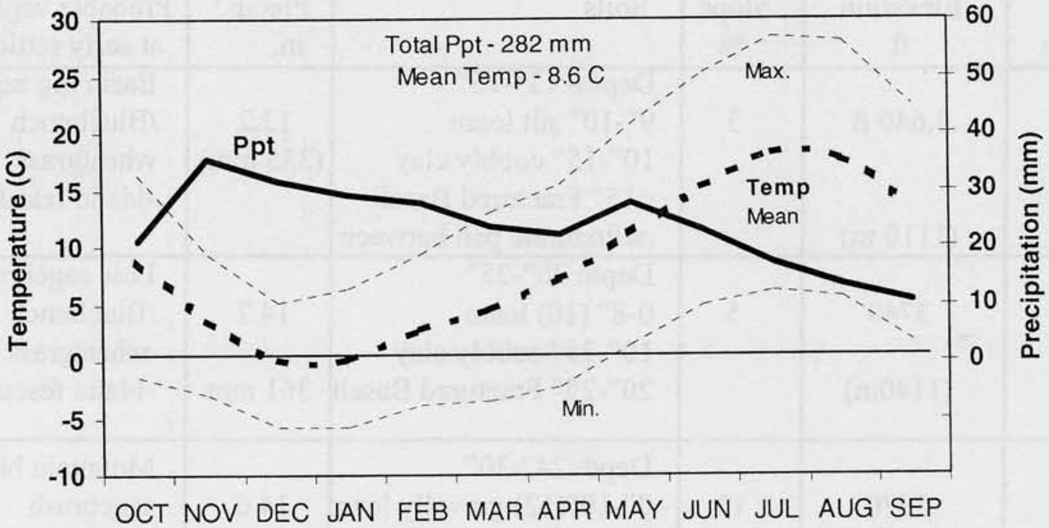

Figure 1. Water year Climatic Diagram for Prineville, Oregon (1975 through 2000). NOTE: Precipitation at 25.4 mm = 1 inch; Temperature 10 °C = 50 °F.

Three study sites were selected in 1982 along the NNW trending slope. Each site was selected for uniformity of tree cover, soils, and understory vegetation. As elevation increased, slope, precipitation, and soil depth increased (Table 1). These three areas were fenced in 1983 and were largely ungrazed by domestic livestock through 2000. At each study site four study plots were located, each 0.49 ac. (2000 m^2) in size. In 1982 all western juniper trees under 1-m height were measured for height and those over 1 m height were measured as to canopy diameter, bole diameter at 1 ft (30 cm), and height.

In the fall of 1982, two plots at each site were selected (paired plots), based on greatest observed similarity. One of these plots was randomly selected for cutting and the other to left uncut. Trees of the treated plot were then cut in the fall 1982, and all slash removed from the plot area. In the fall of 1987 one of the two remaining uncut plots was cut, trees were partially limbed, and the resulting slash scattered over the plot.

Beginning the summer of 1983 and again in 1984, herbaceous production was measured on each of the paired plots. These results were presented by Vaitkus (1986) and Vaitkus and Eddleman (1987, 1991). Herbaceous production was measured in some plots again in 1985 and in 1987. In these measurements the beneath-canopy position was measured separately from the interspace position, the data were then weighted by percent of plot area in each position, and overall plot production determined. In 1989 and thereafter (1992, 1993, 1995, 1996, and 2000), estimates of species cover and density were made using five or more random transects with random sub-sample plot placement along these transects. A minimum of 20, 15.7"x 19.7" (40 cm x 50 cm), sub-sample plots were placed along each transect. For each species, foliar cover was estimated and numbers of individuals rooted within the plot were counted. Transect means were considered the samples. Not all plots were measured in every sample year.

For the 2000 measurements, regressions were run for production based on cover percentages by species and in some cases species groups. A sample size of 30 per plant species or group for each plot was used with exceptions for those plots with very few individuals. In the latter case sample size was lower.

RESULTS

The lower, mid, and upper slope precipitation presented in Figure 2 are estimates from a series of on-site rain gage measurements correlated to Prineville precipitation. The first two year's measurements were associated with above average precipitation and the next two with below average precipitation. 1989 measurements were made during an average year preceded by a drought year. Measurements made in 1992 were in a near average year but again preceded by a dry year and a severe drought year. The 1993 measurement year was wet while 1995 was an above average water year preceded by the severe drought year of 1994. The following year, 1996, was also above average.

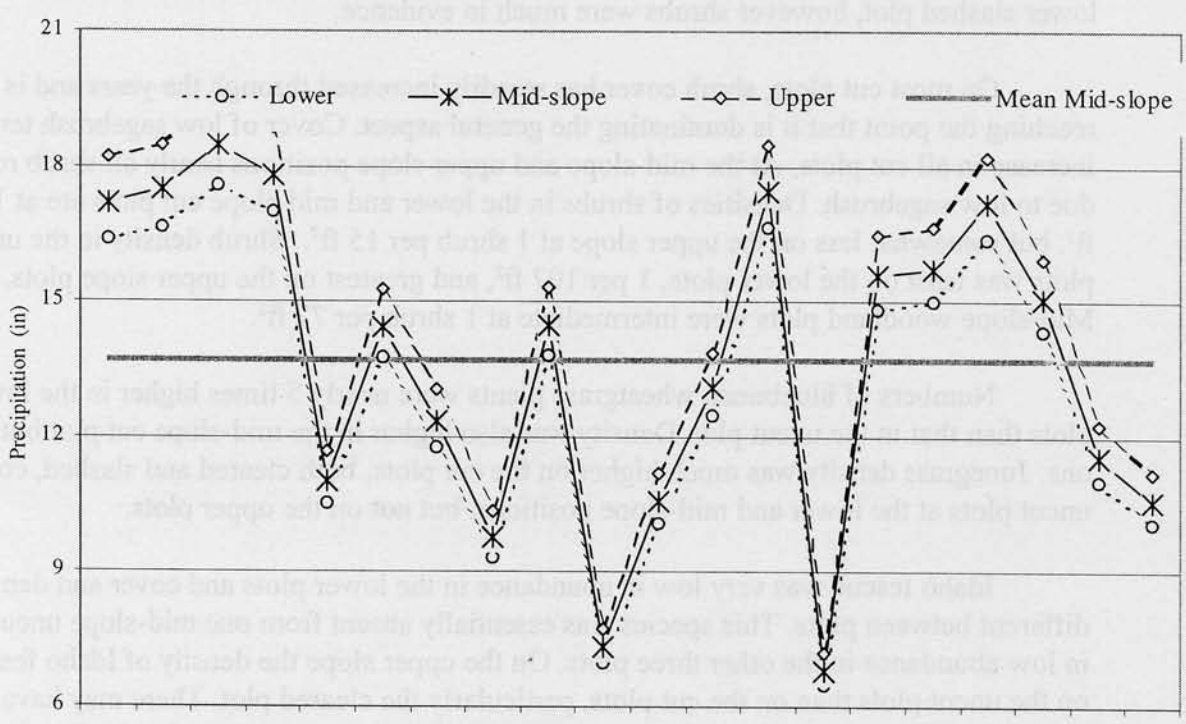

Figure 2. Growth year precipitation ending in the year noted, beginning in 1981 and ending in 2000.

Although the year 2000 and the year preceding were rather dry, these two were preceded by a series of above average water years, 1995 through 1998. Vegetation parameters appear to have been influenced by precipitation within-year and that of the preceding year.

Since the study plots were fenced at the beginning of the study, measured production and cover values were little influenced by domestic livestock grazing over the 18 years. Native herbivores, in particular mule deer and elk, at times focused their grazing on the cut plots. Their impact on measured density and cover values is unknown. The increased grazing on their part took place primarily in the first several years but declined as the standing dead material began to build up in the bunchgrass plants. A notable exception was that there was continued use of junegrass, which was heavily grazed in the spring in all sample years.

Measurements made in 2000 (Table 2 and Table 3) show perennial grass cover to be higher in the older cleared plots of lower and mid-slope position but not on the upper plots. Bluebunch wheatgrass and junegrass were the primary contributors to grass cover on the lower plots while bluebunch wheatgrass alone was the primary contributor on the mid-slope plot. Perennial forb cover was higher on the cleared plots at the lower and mid-slope position. Yarrow was the largest contributor to perennial forb cover.

Shrub cover constituted the biggest difference between uncut and cleared plots for 18 years, at all slope positions. Younger slashed plots responded variably as to shrub cover. On-ground observation indicates that random transects almost entirely missed the shrub component in the lower slashed plot, however shrubs were much in evidence.

On most cut plots, shrub cover has steadily increased through the years and is rapidly reaching the point that it is dominating the general aspect. Cover of low sagebrush tended to increase in all cut plots. At the mid-slope and upper slope positions nearly all shrub response was due to low sagebrush. Densities of shrubs in the lower and mid-slope cut plots are at 1 shrub per 12 ft^2, but somewhat less on the upper slope at 1 shrub per 15 ft^2. Shrub density in the uncut woodland plots was least on the lower plots, 1 per 107 ft^2, and greatest on the upper slope plots, 1 per 28 ft^2. Mid-slope woodland plots were intermediate at 1 shrub per 77 ft^2.

Numbers of bluebunch wheatgrass plants were nearly 5 times higher in the lower slope cut plots than that in the uncut plot. Density was also higher in the mid-slope cut plot but not the upper one. Junegrass density was much higher on the cut plots, both cleared and slashed, compared to the uncut plots at the lower and mid-slope positions, but not on the upper plots.

Idaho fescue was very low in abundance in the lower plots and cover and density were not different between plots. This species was essentially absent from one mid-slope uncut plot and was in low abundance in the other three plots. On the upper slope the density of Idaho fescue was higher on the uncut plots than on the cut plots, particularly the cleared plot. There may have been a negative response to shade removal exacerbated by the very dry year of 1985. Death of this plant was observed in the cut-cleared plot in the first few years after removing the tree overstory. Densities of this species in this older cut and cleared plot appeared to reach bottom in the drought year of 1994 at 1 per 36 ft^2 and has since increased steadily to 1 per 5 ft^2 in 2000. On each of the other three upper plots, Idaho fescue has been increasing in density since measurements began.

Table 2. LOWER PLOT - density, cover and aboveground biomass by species and groups in 2000.

	DENSITY (/10 FT^w)				**COVER (%)**				**ABOVE GROUND BIOMASS (Lbs/Ac)**			
		Paired Plots				Paired Plots			Green	Green +Dead	Green	Green +Dead
Treatment	Uncut	Uncut	Cleared	Slashed	Uncut	Uncut	Cleared	Slashed	Uncut		Cleared	
Years post treatment			**18**	**13**			**18**	**13**			**18**	**18**
PERENNIAL GRASS	32.6	61.0	21.8	18.0	4.7	4.6	14.0	8.9	54	58	152	347
Sandberg bluegrass	30.1	54.7	14.2	10.8	3.4	2.8	1.9	2.3	11	11	1	0
Bluebunch wheatgrass	0.5	0.4	2.6	2.6	0.8	0.4	6.7	4.8	35	35	135	267
Squirreltail	1.1	2.7	1.1	2.6	0.4	0.1	0.5	1.2	4	4	4	27
Idaho fescue	0.0	0.2	0.1	0.1	0.0	0.5	0.1	0.0	5	0	5	36
Junegrass	0.9	0.0	3.8	1.7	0.2	0.0	4.7	0.6	0	20	7	9
Misc.												
ANNUAL FORBS	138	124	158	165	0.7	0.0	0.1	0.1	1	2	6	6
ANNUAL GRASS	12	41	80	78	0.1	0.9	0.1	0.3	1	6	6	6
Cheatgrass	11.7	40.4	41.6	61.9	0.1	0.9	0.1	0.3	1	6	6	6
PERENNIAL & BIENNIAL FORBS	1.1	6.8	6.3	4.3	0.9	0.9	1.9	1.5	7	8	6	14
SHRUBS	0.0	0.1	0.9	0.1	0.9	0.4	9.4	0.3				
Bare					53	42	30	29				
itter					25	27	35	31				
Tree	0.1	0.4	0.0	0.0	25	27						

Table 3. Status of plant cover in 2000 for all plots.

	LOWER PLOTS				MIDDLE PIOTS				UPPER PLOTS			
		Paired Plots				Paired Plots				Paired Plots		
Treatment	Uncut	Uncut	Cleared	Slashed	Uncut	Uncut	Cleared	Slashed	Uncut	Uncut	Cleared	Slashed
Years post treatment			**18**	**13**				**18**	**13**		**18**	**13**
PERENNIAL GRASS	4.7	4.6	14.0	8.9	6.6	4.8	13.0	5.5	10.6	14.1	13.3	12
Sandberg bluegrass	3.4	2.8	1.9	2.3	4.0	2.3	3.1	2.2	3.3	2.6	2.4	1.8
Bluebunch wheatgrass	0.8	0.4	6.7	4.8	1.7	2.0	8.0	1.4	1.9	4.4	4.5	3.6
Squirreltail	0.4	0.1	0.5	1.2	0.9	0.3	1.6	1.2	0.6	0.9	1.8	2.3
Idaho fescue	0.0	0.5	0.1	0.0	0.0	0.1	0.3	0.1	4.8	6.3	4.1	4.2
Junegrass	0.2	0.0	4.7	0.6	0.0	0.1	0.0	0.5	0.0	0.0	0.3	0.1
Misc.									0.0	0.0	0.2	0.0
ANNUAL FORBS	0.7	0.0	0.1	0.1	0.2	0.1	0.2	0.4	0.1	0.3	0.1	0.0
ANNUAL GRASS	0.1	0.9	0.1	0.3	2.2	0.2	0.2	1.0	0.0	0.0	0.4	0.2
Cheatgrass	0.1	0.9	0.1	0.3	0.0	0.2	0.0	0.2	0.0	0.0	0.4	0.2
PERENNIAL FORBS	0.9	0.9	1.9	1.5	0.2	0.8	1.0	0.4	1.6	2.2	1.9	1.2
SHRUBS	0.9	0.4	9.4	0.3	1.7	2.1	9.1	9.7	3.2	3.0	14.6	5.2
Bare	53	42	30	29	27	50	27	21	30	22	18	10
Litter	25	27	35	31	38	21	34	43	28	36	46	30
Tree	25	27			25	19			37	37		

In 2000, bare ground was greater on the uncut paired plot than the paired cleared plot for the lower and mid-slope position but not for the upper slope. However in 1995, the first year after a drought year, the uncut plot on the upper slope had considerably more bare ground (60%) compared to the cut plot (45%). For the paired plots, litter cover was higher on the cleared plot than the uncut plot. Differences on the lower slope plots were less due to a trade-off between juniper litter on uncut plots and a combination of shrub and herbaceous plant litter on the cut plots.

Some conclusions can be made concerning vegetation changes since the initiation of the project on Combs Flat.

Woodland plots have changed little in composition over the study period. Sandberg bluegrass has remained as a constant in the herbaceous understory. Mid- and lower slope woodland plots have continued to show a decline in shrub density and cover. Woodland plots have shown little change in perennial forb cover or cheatgrass cover with the exception of the upper plots during the wet year of 1993.

Cut plots have shown a major increase in shrub density and cover. Cut plots have steadily increased in large long-lived perennial grass cover. Squirreltail was the first plant to respond to cutting juniper and its response was greater in the slashed plots than the cleared plots. Cut plots have fluctuated widely from year to year in cheatgrass cover but not in perennial forb cover.

II. ESTABLISHMENT AND DEVELOPMENT OF BROADCAST SEEDED GRASSES UNDER WESTERN JUNIPER SLASH

Recommendations as to cultural practices needed to establish populations of new plants in otherwise depleted western juniper understory are frequently based on intensive site preparation. The degree to which competition for establishment is dependent on populations of cheatgrass and sandberg bluegrass should always raise concern for establishment success. Removal of both overstory and understory competition and the preparation of the ideal seedbed for seeding purposes are both expensive and problematic. The latter is partially due to the presence of slash, stumps, and a thick needle mat that usually develops beneath the juniper canopy and partially due to the common presence of a stony soil surface. Alternatives to intensive whole site preparation could be those that confine establishment efforts to the area between tree canopies followed by various approaches to manipulation of the overstory trees ranging from complete removal to leaving live standing trees.

If the trees are to be cut, there may be justifiable reasons for leaving the slash on the area to provide a mulch favorable for germination. Also, slash left on the area may provide shade and protection for seedling growth, conserve on-site the nutrients stored in the green foliage and branches, and perhaps to slow down nutrient turnover rates. Rapid nutrient turnover appears to favor early seral species such as cheatgrass.

In 1987, a study was begun to evaluate the establishment of seeded grasses using no site preparation other than western juniper slash as the covering for broadcast seed. A second part of the study was designed to answer questions about vegetation recovery without seeding and with and without slash cover. In the latter case, interest was in plant species composition shift and rates of change, if any.

AREA AND METHODS

The project area was selected in 1987 with the characteristics of uniformity of tree cover, understory vegetation cover and composition, and soils. Western juniper trees were less than 100 years old and there was an unproductive understory present. The area was a lower toe slope (3 % slope) with a NNW trending aspect at an elevation of 3130 feet. Soils of the site are fairly deep, as much as 40 inches, with a deep sandy loam surface, grading with depth to loams and then to a cobbly or stony clay loam over fractured basalt. Mean water year (October through September) precipitation is just over 13 inches, with peaks in winter and spring. In addition to big sagebrush, mostly basin big sagebrush, the former understory grasses for this area were probably, in order of dominance; Thurber's needlegrass, junegrass, bluebunch wheatgrass, Idaho fescue, sandberg bluegrass, and squirreltail. Remnants of these species were found scattered through the area.

Two adjacent sites, each approximately 1.2 acres (60 m by 80 m) in size were delineated, one each to be treated in each of 2 consecutive years. Treatment plots were marked out in each area, these plots being approximately 16 ft by 49 ft (3 m by 15 m) in size. Each plot was either seeded and covered with slash or not seeded and either covered with slash or cleared of slash.

In late January of 1988 five replicate plots were randomly selected for seeding to a grass variety (Table 1) and broadcast seeded. Additionally 10 randomly located plots were selected for a no seeding treatment, 5 to be covered with slash and 5 to be left clear. Following seeding, the trees were cut and the slash scattered as evenly as convenient over the seeded plots and the non-seeded slash-covered plots. This procedure was repeated on the second area in January of 1989. Seeding rates were in most cases rather high to compensate for lack of sites adequate for germination and establishment.

Table 1. Grass varieties broadcast seeded and covered with slash. .

Variety	Common Name	PLS[1]/sq ft	lbs/ac
Goldar	Bluebunch wheatgrass	46	21
	Rush wheatgrass	6	8
Critana	Thickspike wheatgrass	37	14
Rosana	Western wheatgrass	34	16
Ephraim	Crested wheatgrass	56	19
Nordan	Crested wheatgrass	59	20
Secar	Snake River wheatgrass	36	14
Sherman	Big bluegrass	271	14
	Mammoth wildrye	10	14
Tegmar	Intermediate wheatgrass	9	9

[1/] PLS/ft^2 is Pure Live Seed per square foot.

Of those grass species and varieties planted, Rush wheatgrass, Critana thickspike wheatgrass, Rosana western wheatgrass, and Tegmar intermediate wheatgrass are all strongly rhizomatous. The other species are bunch grasses or in some cases may be very weakly rhizomatous in coarse-textured soils.

RESULTS

Canopy cover of western Juniper on the 1988 plots was just under 20 percent, but was just over 20 percent on the 1989 plots. The understory at the beginning of the study was dominated by sandberg bluegrass and an annual chick lupine. The latter plant was abundant in some years and nearly absent in others (Table 2).

Table 2. Understory cover prior to the seeding treatment.

Plant Group	Cover %
Shrub	< 1 %
Herbaceous Plants	< 12%
Perennial Herbaceous	6% - 7%
Grass	5% - 6%
Forbs	< 0.5%
Annual Herbaceous	5% - 6%
Grass	< 1%
Forbs	5% - 6%

Over 70% of the perennial grass cover was sandberg bluegrass. The annual chick lupine, an early spring ephemeral, contributed over 95% of the annual forb cover. Cheatgrass was scattered throughout the area and was infrequently abundant in very small patches. Overall this species contributed about 0.5 % cover and was therefore sufficiently abundant to be of concern. Most perennial grasses expected to be on the site were present but scarce. Densities in sq ft per individual plant were: squirreltail –1 per 3 ft^2, junegrass – 1 per 13 ft^2, bluebunch wheatgrass – 1 per 17 ft^2, Thurber's needlegrass – 1 per 33 ft^2, and Idaho fescue – 1 per 100 ft^2. Most of the squirreltail was beneath existing canopies of juniper or sagebrush while most of the Thurber's needlegrass was in the interspace areas. Shrub cover was mostly basin big sagebrush with partially dead canopies.

Perennial forbs were scarce and only two mat formers were encountered frequently throughout the area. These were yarrow and low pussytoes, the latter being primarily in the interspace areas.

Water year precipitation (October through September) for the project area based on regression of Prineville records and 30 monthly on-site measurements are given below.

1987 – 11.8"	1992 – 12.5"	1997 – 16.4"
1988 - 9.3"	1993 – 16.6"	1998 – 14.4"
1989 - 13.8"	1994 - 6.5"	1999 – 11.0"
1990 - 7.0"	1995 – 14.8"	2000 – 10.1"
1991 – 10.1"	1996 - 15.0"	

The estimated average water year precipitation for the area, 1981 through 2000, is 13.1 inches. In the year preceding the first planting, the water year precipitation was near average, while 1988 was dry and 1989 was an average moisture year. The moisture available in the year planted as well as moisture inputs in subsequent years after emergence have a significant impact on germination, survival and growth of seeded species. Recovery of plant species already on the site is also dependent on precipitation events. 1990 was very dry, 7.0 inches, and was followed by a steady increase in precipitation to a peak in 1993 of over 16 inches. A drought year occurred in 1994, but was followed by four consecutive years of average or better precipitation. Precipitation then declined below average for 1999 and 2000.

A few measurements were made in 1993, a very wet year, that showed a significant increase in perennial grass cover. This gain was apparently lost during the drought year of 1994 but apparently regained during the period of above average precipitation years, 1995 through 1998. Woodland plots showed significant gains in cover of perennial herbaceous plants in 2000 but this was nearly all due to an increase in cover of sandberg bluegrass (Table 3). This species appears to respond rapidly to wetness or dryness of the early spring months. Open plots showed and increase in Thurber's needlegrass, for both the 1988 and 1989 plots while junegrass increased only in the 1988 plots. Slash covered plots showed an increase in squirreltail and junegrass cover in both the 1988 and 1989 plots, but Thurber's needlegrass had increased its cover only in the 1988 plots.

Table 3. Changes in vegetation cover over time in woodland and unseeded plots.

		Treated	1990	1995	2000
Woodland		no			
	Perennial Grass		5.4	5.3	**11.0**[1]
Perennial Forb			0.2	0.2	0.8
	Cheatgrass		0.1	1.6	**3.4**
	Shrub		1.3	1.1	1.9
Open Plots					
	Perennial Grass	1988	6.0	5.9	**10.2**
		1989	5.5	7.0	7.0
	Perennial Forb	1988	0.6	1.4	3.0
		1989	1.3	0.7	2.0
	Cheatgrass	1988	1.8	0.9	8.5
		1989	1.4	2.4	**15.9**
	Shrub	1988	0.8	1.5	**7.6**
		1989	1.7	1.9	4.4
Slash Covered Plots					
	Perennial Grass	1988	5.3	6.7	**11.8**
		1989	3.8	**8.8**	**7.7**[2]
	Perennial Forb	1988	0.6	0.9	1.6
		1989	0.5	2.2	1.4
	Cheatgrass	1988	1.1	1.7	**5.7**
		1989	0.3	1.3	**7.4**
	Shrub	1988	0.5	0.8	2.4
		1989	0.3	**2.2**	**11.7**

[1] Bold numbers indicate a significant increase in cover for the treatment year over the ten year period.

[2] Underline indicates no difference in years for bold numbers.

Cheatgrass showed an expected pattern of response in that it was higher in wet years than in dry years and generally had a higher cover in 2000 than in preceding years. Shrubs had not increased in the woodland area but increased in almost all treated plots and included both big sagebrush and green rabbitbrush.

Seeded grass plots had developed greater cover by 2000 than the unseeded plots (Table 3). Initial establishment for the 1988 plots, as measured in 1990, was significantly less than for the 1989 plots for all varieties except Rosana western wheatgrass. By 2000 plant cover in general was less for the 1988 plots than for the 1989 plots with the exception of Tegmar intermediate wheatgrass and Rush wheatgrass. These two varieties produce abundant short rhizomes and rapidly formed dense stands. They also had invaded adjacent plots. Both the higher moisture input in 1989 and the greater slash provided for the 1989 plots may have contributed to the higher establishment for that year compared to 1988. Mammoth wildrye did not establish.

Table 3. Seeded grass establishment and cover development with western juniper slush.

Species	Treatment & Seeding (yr)	Initial slash cover (%)	Herbaceous ground	Number of seedlings established 1990	Cover % 1993	Cover % 1995	Cover % 2000	Cheatgrass cover %
Goldar	1988	19	7	7	-	4.0	9.0	**6.0**[1]
	1989	44	4	22	5.2	4.3	**17.3**	1.4
Tegmar	1988	18	6	3	-	3.8	**18.0**	1.8
	1989	32	6	14	2.6	7.3	12.6	0.8
Critana	1988	28	6	7	-	1.6	3.2	5.0
	1989	32	6	24	3.4	2.6	**7.1**	8.7
Rosana	1988	38	5	5	-	2.4	5.8	2.8
	1989	36	6	6	1.1	2.5	**9.9**	3.2
Rush	1988	21	5	5	-	3.0	**15.1**	4.7
	1989	29	5	17	4.0	7.7	10.3	1.4
Ephraim	1988	29	8	5	-	0.9	1.7	6.8
	1989	34	5	16	3.9	4.7	**3.4**	7.8
Nordan	1988	18	5	6	-	2.5	2.4	4.5
	1989	25	5	17	2.0	4.3	4.7	**9.9**
Secar	1988	38	7	1	-	0.3	0.5	6.0
	1989	42	6	10	1.4	1.9	**2.2**	**13.0**
Sherman	1988	28	7	7	-	1.6	2.4	4.8
	1989	41	5	20	6.5	5.4	7.2	2.8

[1] Bold numbers indicate a significant difference between treatment years.

Perennial grass cover in those plots seeded to Goldar bluebunch wheatgrass, Tegmar intermediate wheatgrass, and Rush wheatgrass tended to be strongly dominated by the seeded variety rather than species previously present on the plot. This was not the case for the other varieties, particularly when they failed to achieve greater than a 5% cover early on. In this latter group, major contributors to perennial grass cover in 2000 were Thurber's needlegrass, squirreltail and junegrass all of which had increased signifancantly following treatment. Sandberg bluegrass provided less ground cover than initially in nearly all plots.

Plots seeded to Tegmar intermediate wheatgrass and Rush wheatgrass had significantly less shrub cover than those seeded to other varieties. Plots of Tegmar intermediate wheatgrass had the least cheatgrass while plots of Secar, Nordan crested wheatgrass, Ephraim crested wheatgrass and Critana thickspike wheatgrass and the 1988 plots of Goldar bluebunch wheatgrass had considerable cheatgrass present in 2000. Sherman big bluegrass plots initially had very little cheatgrass present but over time Sherman big bluegrass declined in density and cover, possibly caused in part by the drought in 1994. An additional factor in its decline could have been early spring grazing by mule deer, antelope and stray cattle since they focused their foraging activities on this variety as well as on junegrass. With the decline in Sherman big bluegrass, cheatgrass cover increased.

In summary, it appears the slash may function alone fairly well as a cover for seed. In this project, high seeding rates were used and therefore the practice may not be economical. The dry year appears to have overridden some of the positive effects of slash, resulting in low establishment. Never-the-less seedlings did establish even in the dry year, and for Tegmar intermediate wheatgrass and Rush wheatgrass in sufficient numbers to dominate the plot.

As we have found in seeding projects in the Ashwood area there is little reason to expect any establishment from seed broadcast on the surface without slash cover, except in very wet years.

In general the expected establishment for good grass seed with a mid-range seed size, such as crested wheatgrass, and with good site preparation is about 5%, or 1 in 20 seeds planted. Rush wheatgrass exceeded this rate even in the dry year, although it is a large seeded species. Goldar bluebunch wheatgrass and Critana thickspike wheatgrass approached this rate in the near average moisture year, 1989, but not for the preceding dry year seeding. For the dry year planting Goldar bluebunch wheatgrass, Tegmar intermediate wheatgrass, and Rush wheatgrass evidenced a strong increase in cover from 1995 to 2000.

Several of the seeded grass varieties may hold promise for reseeding in central Oregon's juniper woodlands when accompanied by release from western juniper competition. On the site studied, Rush wheatgrass was particularly aggressive. Goldar bluebunch wheatgrass, when established, tended to be very competitive for resources.

Use of juniper slash as a seed covering is promising but may not overcome the negative effects of a droughty year. Additionally, since scattering slash is a hand operation, the cost per unit area may be too high to justify its use.

III. ESTABLISHMENT RESPONSE OF BROADCAST SEEDED GRASSES TO AMOUNT OF WESTERN JUNIPER SLASH COVER

Various seeding trials in cut-over western juniper woodlands suggest that a positive relationship may exist between juniper slash cover and plant establishment. However the observations made on those areas directly beneath whole tree canopies lying on the soil surface indicate that too much cover may have a strong negative effect on understory plants. This project was initiated to examine the effects of slash cover amounts on seeded grass establishment.

This study site is in the John Day Physiographic Province, roughly 8 miles WNW of Ashwood at an elevation of about 2360 feet. The slope was about 5 to 8% and had a SSE aspect. Soils of this study site were cobbly silty clay loams and were less than 30 inches deep. Clay content increases with depth but a strong clayey layer is inconsistent across the area. Aspect, elevation, soils, as well as live and dead plant remnants suggest the area to have at one time been a mountain big sagebrush/bluebunch wheatgrass - Thurber's needlegrass community. It likely contained considerable Idaho fescue, big bluegrass, squirreltail, bitterbrush, and green rabbitbrush. Large erect perennial forbs; such as the balsamroots, lupines, and some milkvetches were surely present as well.

The area at the time of the study initiation had a western juniper canopy cover averaging of 20%. Trees were less than 100 years of age. Understory herbaceous plant cover never exceeded 5% and was dominated by sandberg bluegrass (Table 1). Bare-ground, that area unoccupied by higher plants, was the dominant surface feature, followed by juniper litter and cobble plus gravel in about equal amounts. Widely scattered small perennial forbs were present. Large perennial bunchgrasses were not present. Woody plants were essentially absent. Snakeweed was not abundant, but was well scattered over the area.

Climate of the area is one of cool winters and warm summers. Climate records at Ashwood show that over the last 30 years, November, December, and January have been the most dependable precipitation months and that each month has averaged 1.7 inches of moisture. A smaller secondary moisture peak occurs in May, averaging 1.4 inches. Conversely July, August and September have been consistently dry and have received an averaged of 0.6 inches of moisture or less each month.

METHODS

In 1991 and again in 1992 a series of small plots (25 in each year) were located, numbered and randomly assigned for treatment. Each treatment plot was 9.8 x 32.8 ft (3 x 10 m). Only the central 6.5 x 28 ft (2 x 8.5 m) portion of the plot was sampled for density and cover. Ten small sub-sample plots each 15.7 in. x 19.7 in. (40 x 50 cm) were randomly located in each plot for the baseline samples and these same sub-sample plot locations were repeated in successive sample years for that plot. Baseline samples were completed in the summer prior to treatment.

Western juniper trees were cut in late winter and removed from the plots. Plots to be scarified were roller punched. The roller punch was a 6 ft long, 18-20 inch diameter juniper trunk pulled on an A-Frame behind an ATV. Limb stubs 8-10" long were left on the trunk. These were angle cut to dig into the soil. Holes were at average density of 1.5 per 2 ft^2. The holes created were 2 to 3 inches in depth and width. Greater overall soil surface disturbance occurred during the treatment in late winter of 1993, as the soils were much wetter.

All plots were then broadcast seeded. Grass varieties seeded were seeded as a mixture of the following species at the rates in pounds per acre (lbs/ac) and number of pure live seed per square foot indicated below.

'SHERMAN' big bluegrass	0.5 lb/ac	10.0 seed/ft^2
'ROSANA' western wheatgrass	2.6lb/ac	7.5 seed/ft^2
'CRITANA' thichspike wheatgrass	2.4 lb/ac	7.5 seed/ft^2
'GOLDAR' bluebunch wheatgrass	7.2 lb/ac	16.0 seed/ft^2

Following seeding, slash from the cut trees was used to cover the site with slash as uniformly as possible to the treatment percentages listed below (Table 1). There were 5 treatments each of 5 replicates in each of 2 successive years, 1992 and 1993.

Table 1. Soil surface treatment, seeding method and slash cover of seeded plots.

Scarification	Seeded by	Slash cover
None	Broadcast seeding	0%
Roller punch	Broadcast seeding	0%
Roller punch	Broadcast seeding	25%
Roller punch	Broadcast seeding	50%
Roller punch	Broadcast seeding	75%

All plots were sampled in 1994 and in 2000. From 1995 on, periodic livestock grazing occurred, usually focusing on the treated plots. A rather hot wildfire fire burned across the area in 1996 and consumed the vegetation and slash on the treated plots.

RESULTS

Baseline sampling of ground-surface-cover took place in the year before seeding. Understory cover was dominated by sandberg bluegrass, frequently contributing over 60% of the herbaceous cover (Table 2). Bare soil, that area unoccupied by higher plants, was the dominant surface feature, followed by juniper litter and cobble plus gravel in about equal amounts. Annual grasses, annual forbs, perennial forbs, and snakeweed contributed very little to the ground cover. Shrub cover was under 1%.

Table 2. Baseline ground cover percentages for the slash cover-seeding trial near Ashwood.

Year Seeded	1992	1993
Baseline Sample	**1991** (%)	**1992** (%)
Category		
LITTER [1]	40	24
BARE [2]	55	71
PERENNIAL GRASS	3.0	2.7
Sandberg bluegrass	**3.0**	**2.7**
ANNUAL GRASS	0.2	0.3
PERENNIAL FORB	0.2	0.1
ANNUAL FORB	0.4	0.4
SHRUB	0.8	0.8
Snakeweed	0.3	0.5

[1] LITTER – almost entirely western juniper litter
[2] BARE – includes moss and lichens (~ 6% cover) and Gravel and Rock (~ 15% cover)

Seed germination and establishment is largely dependent on adequate moisture being available at the right time of the year. Water year precipitation (October through September) at Ashwood averaged 13.9 inches for the years of 1972 through 2000. The Ashwood station is at an elevation of 2,480 feet, 120 feet higher than the study site and is approximately 8 miles ESE of the study area. Precipitation in the water years relative to this study as given below are for the Ashwood station except where noted as on-site. On-site measurements were made using at least two standard rain gages to make the measurements each month of the year.

Water Year Precipitation (inches)

1990–91	— 11.0 inches	1996-97	— 23.6 inches
1991-92	— 10.3 on-site	1997-98	— 17.2
1992-93	— 14.6 on-site	1998-99	— 11.8
1993-94	— 6.4	1999-00	— 12.4
1994-95	— 15.9	2000-01	— 11.4
1995-96	— 17.7		

Precipitation in the water year preceding the first planting was below average. The first year planting, establishing in water year 1991-92, was a year in which precipitation was even farther below average. Precipitation events were also widely separated. The second planting, 1993, water year was above average with precipitation distributed well during the establishment period.

Establishment measurements in numbers of individual plants were made the second growth year for each planting. Both Critana thickspike wheatgrass and Rosana western wheatgrass are rhizomatous. For these two varieties, individuals were considered to be the individual clumps of tillers present aboveground. Given the nearly 4-inch difference in precipitation the establishment of seeded grasses was, as should be expected, less for the dry year planting than for the wet year planting (Table 3).

Table 3. Establishment success in the second growth year and in 2000 (post-fire) as influenced by slash cover. Data in numbers of plants per 10 square feet.

			Treatment and Seeding Year			
		Seeded in	1992		1993	
Surface treatment	Slash cover	Seeded variety	1993	2000	1994	2000
Roller Punch	75%	GOLDAR	4.6	0.4	6.6	0.2
		CRITANA	0.3	0.4	3.0	0.6
		ROSANA	0.8	2.9	0.7	5.5
		SHERMAN	1.5	1.3	7.3	0.2
		Total	**7.1**	**5.0**	**17.6**	**6.5**
Roller Punch	50%	GOLDAR	6.2	0.2	10.0	0.9
		CRITANA	0.3	0.7	5.3	3.5
		ROSANA	0.3	0.8	3.3	2.5
		SHERMAN	0.3	0.0	11.8	0.1
		Total	**7.1**	**1.7**	**30.4**	**7.0**
Roller Punch	25%	GOLDAR	3.2	0.6	11.1	2.1
		CRITANA	0.1	0.0	4.8	7.5
		ROSANA	0.1	0.0	4.1	3.1
		SHERMAN	0.0	0.0	6.1	1.1
		Total	**3.4**	**0.6**	**26.1**	**13.8**
Roller Punch	0%	GOLDAR	3.1	1.2	10.0	9.8
		CRITANA	0.1	0.0	4.6	1.8
		ROSANA	0.1	0.0	3.4	1.4
		SHERMAN	0.1	0.2	7.6	0.1
		Total	**3.4**	**1.4**	**25.6**	**6.4**
None	0%	GOLDAR	1.2	0.0	4.4	3.2
		CRITANA	0.1	1.4	2.3	0.0
		ROSANA	0.0	1.7	2.0	1.1
		SHERMAN	0.0	0.0	2.6	0.1
		Total	**1.3**	**3.1**	**1.3**	**4.3**

After two years of growth, Goldar bluebunch wheatgrass had establish more plants than the other varieties in all treatments and years. For the wet year planting the establishment of Goldar bluebunch wheatgrass, Critana thickspike wheatgrass, and Rosana western wheatgrass was approximately proportional to the seeding rate per square foot. Goldar bluebunch wheatgrass establishing about two times as many individuals as the other two varieties. However for the dry year, Goldar bluebunch wheatgrass established a disproportionately higher number of individuals compared to Critana thickspike wheatgrass and Rosana western wheatgrass. Sherman big bluegrass did established a few plants in the dry year in the 75% slash cover plots but otherwise was hard to find. For the wet year this variety established high numbers of individual plants in all plots except those not scarified or without slash cover.

Density measurements made in the summer of 2000 were undoubtedly influenced by 1993-94 drought, grazing, and the 1996 fire. Field observations made in the years prior to and after the fire indicate that the loss of Goldar bluebunch wheatgrass plants found on the 2000 sample date was largely attributable to the fire. Fire nearly wiped out Goldar populations in the 50% and 75% slash covered plots. Considerable slash was still present on these plots in 1996 and they burned hot and clean. For the 1993 planting, mortality for this variety was low on those plots with no slash cover.

Critana thickspike wheatgrass and Rosana western wheatgrass produced a mixed response. Death may have occurred in the 1994 drought and again in the 1996 fire. These two varieties along with Sherman big bluegrass were also selected for by the grazers. With the exception of the dry year 25% slash covered plots, Rosana western wheatgrass responded well in all slash cover treatments and to the no scarification-no slash cover treatment. Critana thickspike wheatgrass survived potential mortality factors in the wet year planting on plots with 25% and 50% slash cover.

Sherman big bluegrass established viable populations in the wet year planting, but observations indicate some plants died in late summer of 1994. Also all plots with heavy fuels loading experienced high mortality of individuals from the fire. Most notable in this regard are the slash covered plots. Again observations suggest that most mortality in the non-slash covered plots had occurred prior to the fire either from drought, grazing, or a combination of the two.

CONCLUSIONS

In arriving at possible conclusions from this project, an arbitrary value of 1 plant per square foot was assumed to represent success in establishment. These conclusions may not be applicable to areas that have stronger herbaceous understories to begin with.

1- Successful establishment of broadcast seeded grasses appears to be possible in dry years with good soil surface scarification and 50% or more slash cover provided after seeding.

2- Successful establishment of broadcast seeded grasses was strongly favored by above average precipitation.

3- Establishment of broadcast seeded grasses from the wet year planting was successful even in the non-scarified and no-slash-cover plots.

4- Second year establishment from the wet year planting was highest in those plots that were scarified and had 0 to 50% slash cover.

5- Heavy slash and fine fuels accumulation, hot fire, and either Goldar bluebunch wheatgrass or Sherman big bluegrass appear to not be compatible combinations.

IV. BROADCAST SEEDING AND SITE PREPARATION IN WESTERN JUNIPER WOODLANDS

At the urging of several land managers and OSU Extension Service personnel, plots were established in a young western juniper woodland in the Ashwood area to demonstrate the possibility, or lack of it, of establishing viable populations of seeded grasses in areas that were unproductive. Since economics play a major role in restoration activities, a new approach was taken to reduce the percentage of area treated by confining surface treatment to the interspaces between tree canopies. Another approach to reducing cost was to limit mechanical preparation of the seedbed to a minimum and use juniper canopies or slash to replace intensive site preparation.

STUDY AREA

In western juniper woodlands the presence of a closed canopy, and/or a dominance of sandberg bluegrass are generally considered major deterrents to the successful introduction of additional plant species. An area presenting both conditions was selected for study in the John Day Physiographic Province, roughly 8 miles WNW of Ashwood at an elevation of about 2360 feet. The slopes range from 5 to 15% and have aspects ranging from SSE to ESE. Soils of the demonstration area are cobbly silty clay loams and are less than 30 inches deep. Clay content increases with depth but a strong clay layer is inconsistent across the area. Aspect, elevation, soils, as well as live and dead plant remnants suggest the area to have at one time had been a mountain big sagebrush/Thurber's needlegrass community. It likely contained considerable bitterbrush, bluebunch wheatgrass, idaho fescue, big bluegrass, and squirreltail. Large erect perennial forbs, such as the balsamroots, lupines, and some milkvetches were surely present as well.

At the time of study initiation, the area had a western juniper canopy cover averaging about 20% over the area but ranged from 11 to 34%. Trees were less than 100 years of age. The understory cover was dominated by sandberg bluegrass, frequently contributing over 90% of the perennial herbaceous cover. Understory herbaceous plant cover never exceeded 4%. Bare soil, that area unoccupied by higher plants, was the dominant surface feature, followed by juniper litter and cobble plus gravel in about equal amounts. Widely scattered small perennial forbs were present. Large perennial bunchgrasses were difficult to find although a few Thurber's needlegrass plants were found at the upper end of some plots. Squirreltail was not present. Woody plants were essentially absent, however they were present as scattered individuals and occasional patches of a few plants. Snakeweed was not abundant, but was well scattered over the area.

Climate of the area is one of cool winters and warm summers. Climate records at Ashwood show that over the last 30 years, November, December, and January have been the most dependable precipitation months and that each month has averaged 1.7 inches of moisture. A smaller secondary moisture peak occurred in May, averaging 1.4 inches. Conversely July, August and September have been consistently dry and have received an average of 0.6 inches or less of moisture.

METHODS

Plots were established to demonstrate seeded plant response to various treatments that had potential to alter community structure. In 1991 eight plots, each 0.49 ac (40 x 50 m) in size, were selected in an area that contained sandberg bluegrass as the only herbaceous constant in the understory with a western juniper overstory. Three additional plots were added in 1992.

Each plot was sampled for plant density and cover by species in the year prior to treatment. Each plot was sampled using a twenty 15.7 x 19.7 inch (40 x 50 cm) subplot in which individual plants were counted and cover was estimated. These subplots were randomly located along each of five randomly located transects on each demonstration plot. This same procedure was employed after treatment to assess changes on density and cover by species and species groups.

The first eight plots were treated in late winter 1992 and the three added plots were treated in late winter of 1993. Treatments were applied when the soil was moist in late January and early February. Since the area was established as a demonstration area, only one plot for each treatment was selected although two of the treatments were repeated in successive years.

Treatments were as follows:

1992 Seeding	Surface Scarification	Trees	Slash
1. No seeding	None	Uncut	None
2. Seeded	Roller punched	Trees cut	Slash scattered
3. Seeded	Roller punched	Trees cut	Whole trees left
4. Seeded	Tree drag	Trees cut	Slash scattered
5. Seeded	Tree drag	Trees cut	Whole trees left
6. Seeded	None	Trees cut	Slash scattered
7. Seeded	None	Trees cut	Whole trees left
8. None	None	Trees cut	Slash scattered
1993			
9. Seeded	Roller punched	Uncut	None
10. Seeded	Roller punched	Trees cut	Slash scattered
11. Seeded	Roller punched	Trees cut	Whole trees left

Four grass species were broadcast seeded on the site using a whirlwind seeder in late winter but prior to any treatment of the site. Since all seeding was done while the trees were still standing seeding rates were less beneath the canopy and were higher in the interspace areas relative to the average rate for the whole plot. Surface scarification treatments were applied after seeding and prior to tree cutting.

Grass varieties were seeded as a mixture of the following species at the rates in pounds per acre (lbs/ac) and number of pure live seed per square foot indicated below.

'SHERMAN' big bluegrass	0.5 lb/ac	10.0 seed/ft^2
'ROSANA' western wheatgrass	2.6 lb/ac	7.5 seed/ft^2
'CRITANA' thichspike wheatgrass	2.4 lb/ac	7.5 seed/ft^2
'GOLDAR' bluebunch wheatgrass	7.2 lb/ac	16.0 seed/ft^2

The roller punch treatment was applied using a partially limbed six-foot length of juniper trunk with a bole diameter of 14 to 18 inches and limb stubs left at 8 to 10 inches long. These stubs were sharpened by cutting at an angle. This contraption was mounted on an A–frame and pulled behind an ATV. Since the surface soil scarification treatments were applied prior to tree cutting, punch holes were only in the interspace position and beneath the outer edges of the tree canopy. Average density of holes was 1 per 2 ft^2, and the holes had a width and depth of 2 to 3 inches. The roller punch created larger holes and overall greater surface disturbance in the three plots treated in late winter of 1993. This was due to the loose soils resulting from good winter moisture input.

The tree drag was a cut tree with the foliage removed an only long stiff branches remaining. This contraption was attached to an ATV as a drag. The drag left irregular furrows of 1 to 2 inches deep when pulled across moist soil, however furrows were somewhat shallower when the drag was pulled across dry soil.

For the slash and scatter treatment, all trees were partially limbed, then the bole was cut and limbed and the limbs were then scattered across the plot. Boles were left where they fell and were in most cases in contact with the soil. For the whole tree treatment, trees were dropped and left. The only limbs removed were those necessary to get to the base of the tree to cut it down.

Each plot was measured for establishment response as well as response of other plant species in terms of density and cover using the method of sampling described above. Slash cover, litter cover, and bare soil area were also determined each time the plot was sampled. In the case of Rosana western wheatgrass and Critana thickspike wheatgrass that are rhizomatous, individual clusters of tillers where counted as individuals for density calculations.

RESULTS

Baseline vegetation analysis showed that all plots varied only as to western juniper canopy cover, ranging from 11 to 30%. No significant differences were found in understory cover or density of species or species groups. This lack of difference was due to, in the case of sandberg bluegrass, its uniform cover across the area. All other understory species and species groups occurred at very low frequencies and therefore no differences could be detected at the sampling intensity employed.

Table 1. Baseline, 1991, cover (%) values for plant groups and species on the Ashwood Demonstration Plots.

Species & Groups	Cover (%)
Western Juniper	**20.0**
Herbaceous Plants	**3.7**
Perennial Grasses	2.9
Sandberg bluegrass	2.8
Annual Grasses	0.2
Perennial Forbs	0.4
Annual Forbs	0.2
Shrubs	**1.0**

That portion of the soil surface not occupied by higher plants was made up of bare soil, moss and lichen, cobble plus gravel. Moss and lichen cover averaged under 10%. There was some overlap of juniper canopy cover and herbaceous cover since some herbaceous plants, sandberg bluegrass in particular, grew beneath tree canopies. Bluebunch wheatgrass, Thurber's needlegrass, and Idaho fescue occurred as scattered individuals in some plots. Yarrow, low pussytoes, and blue mountain buckwheat were common perennial forbs. These latter plus snakeweed were usually encountered on each transect.

From 1995 on the area was grazed periodically by cattle. In 1996 a wildfire went through the area and either all or a major portion of each plot was burned. The fire appeared to have been rather hot and driven by a good wind since juniper trees in woodland areas with little understory fuel were rather uniformly killed, including those trees in the untreated plot.

Seed germination and establishment are largely dependent on adequate moisture being available at the right time of the year. Water year precipitation (October through September) at Ashwood averaged 13.9 inches for the years of 1972 through 2000. The Ashwood station is at an elevation 2,480 feet, 120 feet higher than the study site and is approximately 8 miles ESE of the study area. Precipitation in the water years relative to this study, given below, are for the Ashwood station except where noted as on-site. On-site measurements were made using at least two standard rain gages to make the measurements each month of the year.

Water Year Precipitation (inches)

1990–91 — 11.0 inches	1996-97 — 23.6 inches
1991-92 — 10.3 on-site	1997-98 — 17.2
1992-93 — 14.6 on-site	1998-99 — 11.8
1993-94 — 6.4	1999-00 — 12.4
1994-95 — 15.9	2000-01 — 11.4
1995-96 — 17.7	

The first planting, water year ending in September 1992, took place in a dry year, more than 3 inches below average. Moisture inputs were near average in November, February, April, and June. Droughty months were December, January, March, May, and July. May moisture input was only 0.2 inches. The dryness of the year and the length of time between precipitation events suggest that adequate moisture for both germination and seedling survival was largely absent.

Seed planted the second year, water year ending in September 1993, had much better soil moisture conditions. Total precipitation was slightly above average. Precipitation was adequate in all months except April, which was dry. Even July precipitation was slightly above average.

Measurement of seeded grass establishment was made in 1993 and 1994. Only 1994 data is included in this report (Table 2). This year was droughty from beginning to end. October through January precipitation totaled about 1.6 inches, or 4.4 inches below average. Only April precipitation was near average. During the summer only a trace of precipitation occurred in August. Precipitation steadily increased through the 1997 water year then declined steadily through 2001. In the latter case three months of the growing season months were droughty. The area burned in 1996 and plots were again measured in 2000.

Table 2: Density of seeded grasses in numbers per 10 square feet in 1994 (pre-fire) and 2000, (post fire).

Plot	Treatment	Sample Year	Goldar	Critana	Rosana	Sherman
seeded 1992						
1	none	1994	-	-	-	-
		2000	-	-	-	-
2	seed, punch, slash	1994	0.7	0	0	0
		2000	0.1	0.6	0.3	0
3	seed, punch, whole	1994	0.7	0	0	0
		2000	0.1	0.8	2.0	0
4	seed, drag, slash	1994	7.8	0.2	0	0
		2000	trace	0.7	2.5	0
5	seed, drag, whole	1994	6.1	0.7	0	0
		2000	0.1	0.8	3.5	0
6	seed, none, slash	1994	0	0	0	0
		2000	0	trace	0.3	0
7	seed, none, whole	1994	0	0	0	0
		2000	0	0	trace	0
8	none, none, slash	1994	-	-	-	-
		2000	-	-	-	-
seeded 1993						
9	seed, punch, uncut	1994	6.2	0	0	0
		2000	1.8	0.1	0	0
10	seed, punch, slash	1994	30.7	1.3	0	0
		2000	7.2	2.9	0.9	0
11	seed, punch, whole	1994	7.6	1.5	0.5	0.4
		2000	0.3	4.6	0	0

Grasses seeded the first year did not establish in those plots that did not receive a surface scarification. In this dry-year planting, those plots that received a tree-drag treatment, established greater numbers of plants and retained them through the dry year of 1994 in higher numbers than those that were roller punched. This may be due to the greater overall surface disturbance associated with the drag. Slash-scatter plots tended to establish greater numbers of plant than the whole-tree plots. In the dry year planting, Rosana western wheatgrass was the most consistent in establishment on plots receiving some surface scarification.

Establishment of grasses seeded in the second year was much higher than that of the first year. This might be expected since precipitation was higher, particularly for the winter months, and more dependable across all months. This wetter year showed good establishment for 'Goldar bluebunch wheatgrass' and 'Critana thickspike wheatgrass', generally proportional to their seeding rate. Rosana western wheatgrass established well only in the slash-scatter plot. 'Sherman big bluegrass' did not establish in significant numbers. This variety was absent from the 2000 samples, presumably killed by the wildfire since it was present in pre-fire samples. Of particular interest was the establishment of seeded grass at 6 per 10 ft^2 in the woodland plot. These plants were slow to develop under the juniper canopy and remained at 2-3 tillers per plant and were 4-6 inches tall through 1994.

Measurements made three years post-burn for the woodland and cut-slash scatter plots of the 1993 planting showed a 50% to 70% loss in numbers of individuals of the seeded grasses but at the same time there was an increase in their cover. The whole tree plot, showed both a loss of individuals and of cover. For this plot 'Rosana western wheatgrass became the main seeded species in 2000 while Goldar bluebunch wheatgrass dropped from 1 plant per 1.3 ft^2 to 1 plant per 36 ft^2.

No doubt, differences between 1994 and 2000 data were heavily influenced by the drought year data of 1994, the fire of 1996, and the three wet years prior to the 2000 data collection. As noted above, 1994 was a drought year and although 2000, along with the preceding two years, were slightly below normal, these three years were preceded by three well above average years (1996 – 1998).

There was a large increase in cover and numbers of large resident perennial bunchgrasses on the untreated and unseeded plot. Both idaho fescue and thurber needlegrass increased. Total herbaceous cover and perennial forb cover had increased, however the largest increase in numbers and cover and density took place in cheatgrass and snakeweed. Cheatgrass that had less than 0.1% cover in 1994 had reached over 8% cover in 2000. Sandberg bluegrass had declined to about 6% of the herbaceous cover in 2000.

Changes from 1994 to 2000 in the non-seeded vegetation were similar across all plots with a few notable exceptions. Several of the plots showed strong increases in medusahead and ornate prairie clover. Snakeweed was rather scarce on those plots that had a lot of fuel, mostly residual slash from the cut-and-scatter treatment, on the ground when the fire went through. Plots with whole trees present tended to have more snakeweed in 2000 compared to 1994.

CONCLUSIONS

Conclusions are certainly tentative, but some observations may warrant further examination.

Seeded grass establishment from the 1992 dry year planting appears much lower than from the 1993 planting. In the latter case, the cut-and-scatter plot appeared to be a successful planting since it had at least one seeded plant per square foot with approximately a 20% canopy cover in 2000.

There is good reason to classify the dry year planting a failure or at best marginal. However scheduling the season of treatment may offer a way to bypass dry years. Winter precipitation is likely crucial to germination and seedling establishment. Examination of the last 30 years of records from Ashwood show that wet winters have occurred in 26% of the years. These were years in which the sum of the three peak month's (November, December, and January) precipitation exceeds the average and no one winter month is below average. In only one year was a wet winter followed by a dry spring, the others were average or above.

Conversely 20% of the winters were dry or droughty. These years were characterized by two or in some cases all three of the winter months being very dry and in only one of these years did spring moisture appear to partially compensate for winter drought.

The other 46% of the years have slightly below average winter precipitation and are rather average on all counts. However, in all cases they far exceed the 1992 planting year in terms of precipitation amounts. About half of these years have turned out to be above average in total precipitation and the majority appear to have had a regularity of precipitation input that suggest a fair level of seeded plant establishment might have been possible.

Planting in February allows an evaluation of available winter moisture resources. Recommendation may best be made for seeding in those years where the total precipitation for November-January exceeds 5.0 inches and in which none of the three individually are below 1.7 inches. It is also likely that better odds for establishment could be established by adding in October precipitation, it should be 1.0 inch or more. If two or more of those four months are dry planting activities might best be avoided. In addition the elimination of the major water using plant, western juniper, will need to be done. This would best be accomplished prior to the time it begins to consume stored soil moisture. For this area active water use is likely to begin in February or in colder years in March.

Juniper slash scattered on the soil surface to cover seed increase shading and cooling of the soil surface during seedling establishment may be needed in average years but may not be of significant value in wet year. The increased cost in going from cut-and-leave to cut-and-slash scatter is significant. However whole tree canopies have their detractions. Areas beneath and around the margin of whole trees lying on the soil surface appear to be the epicenters for cheatgrass and medusahead establishment and when burned provide a major source of seed for movement into the rest of the area.

Fire appeared to be detrimental to younger establishing plants when high heat loads were experienced. Fire severity may be increased when large amounts of slash are present near the soil surface. Although snakeweed appeared to be largely killed out by hot fires, annual grasses such as cheatgrass and medusahead mushroomed in numbers and cover. On the other hand, fire killed most of the newly establishing trees in the seeded plots. Fire also killed the larger trees in the uncut plot resulting in a significant increase in the resident understory grasses.

APPENDIX I. References used in parts I through IV.

REFERENCES

Anderson, E. W., M. M. Borman and W. C. Krueger. 1998. The Ecological Provinces of Oregon: A treatise on the basic ecological geography on the state. Oregon Agricultural Experiment Station. SR 990. 138 p.

Bates J., R.F. Miller, and T.S. Svejcar. 1998. Understory dynamics in a cut juniper woodlands (1991-1997). Eastern Oregon Agricultural Research Center Annual Report. Special Report 991, June 1998. Agri. Exp. Sta. Oregon State Univ. & USDA-Agric. Res. Ser. p. 24-33.

Bates J., R.F. Miller, and T.S. Svejcar. 1999. Plant succession in cut juniper woodlands: 1991-1998. Eastern Oregon Agricultural Research Center Annual Report. Special Report 991, June 1998. Agri. Exp. Sta. Oregon State Univ. & USDA-Agric. Res. Ser. p. 24-33.

Bates, J., R.F. Miller, and T.J. Svejcar. 1998. Understory patterns in cut western juniper (*Juniperus occidentalis* spp. *occidentalis* Hook.) Woodlands. Great Basin Nat. 58(4):363-375.

Bates, J.D., R.F. Miller, and T.J. Svejcar. 2000. Understory vegetation response following cutting of western juniper. J. Range Manage. 53(1): 119-126.

Bedell, T.E., L.E. Eddleman, T. Deboodt, and C. Jacks.1993. Western Juniper: Its impact and management in Oregon Rangelands. Oregon State University Extension Service. EC 1417

Doescher, P.S., L.E. Eddleman and M.R. Vaitkus. 1987. Evaluation of soil nutrients, pH, and organic matter in rangelands dominated by western juniper. Northwest Science 61: 97-102.

Eddleman L.E. 1987. Establishment and stand development of western juniper in central Oregon. pp. 255-259. In: R.L. Everett, (comp.) Proceedings, Pinyon-Juniper Conference. Inter. For. Range Res. Sta., USDA-For. Ser., Gen Tech. Rep. INT-215. Ogden, Utah.

Eddleman, L.E. 1994. Broadcast seeding as a means of restoring depleted western juniper woodlands. Annual Rep. 1994. Oregon State University, Agric. Exp. Sta. Spec. Rpt 935.

Miller, P.M., L.E. Eddleman and J.M. Miller. 1992. The seasonal course of physiological processes in Juniperus occidentalis. Forest Ecology and Management. 48:185-215.

Miller, R.F., L.E. Eddleman and R.F. Angell. 1987. Relationships of western juniper stem conducting tissue and basal circumference to leaf area and biomass. The Great Basin Naturalist. 47:349-354.

Rose, J. A. and L.E. Eddleman. 1994. Ponderosa pine and understory growth following western juniper removal. Northwest Science 68:79-85.

Vaitkus, M. R. 1986. Effect of western juniper on understory herbage production in Central Oregon. A Thesis. Oregon State University.101 p.

Vaitkus, M.R. and L.E. Eddleman. 1987. Juniper understory and it's response to canopy removal. pp 456-460 In: Everett, R.L. (Comp.) Proceedings—pinyon juniper conference; 1986 January 13-16; Reno, NV. Gen. Tec. Rep. INT-215. Ogden, UT: USDA, For. Ser., Intermountain Research Station; 1987.

Vaitkus, M. R. and L.E. Eddleman. 1991. Tree size and understory phytomass production in western juniper woodland. Great Basin Naturalist. 51: 236-243.

Walter, H. 1973. The Vegetation of the Earth, In Relation to Climate and Eco-physiological Conditions. New York, Springer-Verlag.

APPENDIX II: Plant common names used in parts I through IV with their botanical names.

COMMON NAME	BOTANICAL NAME
Basin big sagebrush	Artemisia tridentata spp. tridentata
Big bluegrass	Poa ampla
Bitterbrush (antelope bitterbrush)	Purshia tridentata
Bluebunch Wheatgrass	Pseudoroegneria spicata
Cheatgrass	Bromus tectorum
Chick lupine	Lupinus subvexus (syn. L. microcarpus)
Crested wheatgrass	Agropyron desertorum
Greeen rabbitbrush	Chrysothamnus viscidiflorus
Idaho fescue	Festuca idahoensis
Intermediate wheatgrass	Thinopyrum intermedium
Junegrass (prairie junegrass)	Koeleria macrantha (syn. K. pyramidata)
Low pussytoes	Antennaria dimorpha
Low sagebrush	Artemisia arbuscula
Mammoth wildrye	Leymus racemosus
Medusahead	Taeniatherum caput-medusae
Mountain big sagebrush	Artemisia tridentata ssp. vasyana
Ornate prairie clover (blue mtn. p.c.)	Dalea ornata (syn .Petalostemon ornatus)
Rush wheatgrass	Thinopyrum ponticum
Sandberg bluegrass	Poa secunda (syn. P. sandbergii)
Snake River wheatgrass	Elymus wawawaensis
Snakeweed (Broom snakeweed)	Gutierrezia sarothrae
Squirreltail (bottlebrush squirreltail)	Elymus hystrix
Thickspike wheatgrass	Elymus macrourus
Thurber's needlegrass	Achnatherum thurberianum
Western Juniper	Juniperus occidentalis
Western wheatgrass	Pascopyrum smithii
Yarrow (western yarrow)	Achillea millifolium