Western Juniper Woodland Program

Rick Miller, Tony Svejcar, Lee Eddleman, Jon Bates, Kara Paintner and Jeff Rose

Throughout the west, juniper woodlands have greatly increased in density and distribution. Western juniper (*Juniperus occidentalis*), the northwest equivalent of the pinyon-juniper zone in the Intermountian region, has increased rather dramatically during the past 100 years. Western juniper currently occupies nearly 4 million acres in eastern Oregon, northeastern California, southwestern Idaho, and northern Nevada. It is estimated that nearly 2.3 million acres are located in Oregon. Presettlement juniper woodlands were usually open, savannah-like, or confined to rocky surfaces or ridges. Western juniper began increasing in density and distribution in the late 1800s, primarily invading mountain big sagebrush, low sagebrush, quaking aspen, and riparian communities.

The juniper woodland program at Eastern Oregon Agricultural Research Center (EOARC) has several long-term objectives relating to the ecology, biology, and management of western juniper. Current objectives are:

(1) Identify changes in plant composition and structure and soil characteristics during transition of sagebrush-grassland and aspen communities to juniper woodlands across different soils, climate, aspects, and elevations.

(2) Evaluate the effects of juniper removal on plant community composition, structure, productivity, biodiversity, soil water availability, and soil nutrients across different soils, aspects, and elevations.

(3) Describe juniper age structure, site characteristics, and plant composition of old-growth stands and correlate establishment of old-growth trees with climate.

(4) Develop a classification system for juniper woodlands, using sites in varying states of transition towards juniper woodlands and sites with the potential for invasion.

Currently our study sites are located in Harney and Grant counties in eastern Oregon and Modoc County in northeastern California. However, we hope to expand the juniper woodland program in the future to encompass the majority of this species' range.

SUCCESSION IN WESTERN JUNIPER WOODLANDS:
Soils, woodland structure, and understory response

INTRODUCTION

The overall goals of this study are: (1) to determine what effects increasing juniper has on understory vegetation and ground cover; and (2) evaluate how these changes are modified by such site factors as climate, soils, aspect, elevation, and geology. In addition, we hope to predict the structure and composition of fully developed woodlands on a variety of sagebrush-grassland and aspen sites. We also hope to define the points during transition that thresholds occur (e.g., inability to burn, soil erosion, understory recovery).

Little information exists that correlates soils with western juniper woodlands. Published soil surveys for central and eastern Oregon indicate only the general occurrence of juniper, and only occasional reference is made to the presence of old-growth trees. Western juniper occurs across a wide variety of soils, from shallow heavy clays to deep loams, suggesting that management, site potential, sustainable productivity, growth rates, old growth, and watershed integrity will change across different community types. We also have little information relating such site factors as soils to successional changes that occur during the development of a juniper woodland in shrub bunchgrass or aspen communities. Changes in plant composition and structure will influence such processes as water cycles, nutrient cycles, energy flow; and such site characteristics as productivity, and use by various wildlife species. This study addresses objective number 1: Identify changes in plant composition and structure, and soil characteristics during transition of sagebrush-grassland and aspen communities to juniper woodlands across different climates, soils, aspects, and elevations.

METHODS

Plots were established on Steens Mountain during the summer of 1994. During 1995, work will continue on the Steens and be expanded to northeastern California. Plant community types being studied are mountain big sagebrush, low sagebrush, and aspen with varying levels of juniper density and cover on soils common to these types. Sites are being selected to encompass gradients of elevation, aspect, soil depth, and soil texture. Vegetation and site parameters measured will be juniper, shrub, and herbaceous cover and density, cover of bare-ground, rock, litter, and cryptogams, and soil carbon and nitrogen, as well as elevation, aspect, and slope. Meteorological models will be used to integrate climatic factors with other parameters being measured. Multivariate Analysis will be used to evaluate the influence of site variables and juniper dominance on plant community composition, and total soil carbon and nitrogen.

Plant cover, density, and biomass were measured in permanently marked 60-x-46 meter macroplots. Soil carbon and nitrogen samples will be collected in the A horizon in the shrub and tree interspace on each site. Ten juniper trees (sapling size or greater), that are not competing with neighboring trees, will be cored to estimate growth potential for each site. Samples will be analyzed with a CHN analyzer. A complete soils description will be reported for each site.

RESULTS

We wish to stress these results are based on only one field season and a limited number of sites (29) measured across a variety of site factors. Based on measurements and observations during the 1994 field season, and past work by Miller and Rose (1995), the majority of juniper stands on Steens Mountain are young developing woodlands still in a state of transition. Juniper woodlands on Steens Mountain, generally occur in an elevation belt between 4,700 and 7,000 feet, and can be divided into four zones: (1) mature juniper woodlands, usually found on rocky ridges and low sagebrush tablelands; (2) young woodlands that have recently invaded the sagebrush zone, including mountain mahogany communities; (3) young woodlands that have recently invaded quaking aspen groves; and (4) young woodlands that are invading riparian areas. During the summer of 1994, 29 permanent plots were located within the first three zones to describe community characteristics across different sites and levels of juniper succession. Ten permanent plots were located and described on sites to be cut during the fall of 1994.

Within the three zones, we have tentatively grouped plots into seven community types based on plant species composition, soils, and other site factors (Table 1). We expect woodland structure, plant species composition, response to management, and change of important processes, such as hydrology, to differ across these community types during juniper woodland succession. The greatest loss of understory vegetation occurred on sites where a cemented ash layer (duripan) restricted plant rooting depth to 18 inches. The least impact to understory occurred on the shallow heavy soils on fractured bedrock occupied by very old juniper trees, low sagebrush, and Sandberg bluegrass. A general pattern that occurred across all community types (with the exception for the western juniper/low sagebrush/Sandberg bluegrass type) was the decline in the shrub component as juniper trees increased in density. Across the dry mountain big sagebrush/Idaho fescue type, where juniper canopy cover ranged from 26 to 44 percent, 67 percent of the bitterbrush and sagebrush canopies were dead. On the wetter mountain big sagebrush/Idaho fescue type shrub cover was < 3 percent on sites with > 45 percent juniper cover, compared to sites with > 20 percent shrub cover where juniper cover was < 25 percent. As site potential increased (primarily due to aspect and soil texture and depth), the occurrence of old trees declined and maximum cover and density of young trees increased. Maximum potential tree cover ranged from nearly 20 percent on the shallow heavy soils, to nearly 100 percent on deep loams located on north facing slopes. As our sample size increases across these sites we hope to define thresholds within these communities.

PLANT SUCCESSION FOLLOWING JUNIPER CONTROL

There are few quantitative data on public or private lands documenting changes in plant cover and composition following western juniper removal by cutting or burning. The lack of data limits our ability to plan, predict potential outcomes, determine if objectives were met, and to evaluate the degree of success or failure in juniper removal projects. This information will be critical for effective planning of future juniper management. This study addresses objective number 2: To evaluate the effects of juniper removal on plant community composition, productivity, biodiversity and structure across different soils, aspects, and elevation. Three separate studies have been set up in Grant and Harney counties to measure plant succession following juniper removal. Study sites are located northwest of Mount Vernon and Steens Mountain.

Mount Vernon

The Mount Vernon study is designed to evaluate the effect of juniper cutting on understory plant species composition, cover, and density. Cut trees are left in place. We are also measuring the response of small mammals. The study area is located in a mountain big sagebrush - bitterbrush / Idaho fescue - bluebunch wheatgrass site just below the ponderosa pine forest zone. Two years of plant data have been collected, the year prior and the year following treatment, 1992 and 1993 respectively. A large seed crop was produced in 1993, but 1994 was very dry. Plant species composition will again be measured in 1995. Results have not yet been summarized.

Steens Mountain I

Ten permanent plots were established during the summer of 1994 on Steens Mountain on sites where juniper will be cut. Juniper removal plots range across community types from the western juniper/low sagebrush/Sandberg bluegrass to aspen types. Sites ranged from shallow heavy clay soils to deep loams. On 4 of the 10 sites, paired control plots (junipers will not be cut) were established to compare changes in plant community composition and structure over time between cut and untreated woodland plots. Several more plots will be established on sites to be treated in 1995.

Plant community composition will be monitored both before and after cutting or burning. Plant community composition will be measured no less than every 5 years. Within each treatment area a 60-x- 46 meter macroplot was established. All plant species present within the macroplot are listed for species constancy. Within the macroplot, three permanent 60 meter transects were established. Parameters measured are density and canopy cover of juniper, shrubs, grasses and forbs, cover of cryptogamic crusts, litter, bare-ground, and rock. Site parameters measured are soil depth, texture, C/N, slope, aspect, and elevation.

Understory Plant Succession Following Cutting of Western Juniper

An intensive juniper treatment study was set up in the Cucamonga drainage on Steens Mountain in 1991. The site is dominated by a mature juniper woodland, with dominant trees ranging in age from 70 to 90 years. Soils are predominantly clay loams, about 18-20 inches deep, overlaying a duripan. Juniper canopy cover is approximately 20-25 percent and the density of trees about 95 per/acre. Almost all of the mountain big sagebrush originally on the site was dead. Understory herbaceous basal cover prior to cutting was less than 3 percent, with much of the interspace between trees being bare ground. Herbaceous composition on the site was primarily made up of native perennial and annual species. Bare ground accounted for nearly 75 percent of the area. Rill erosion was evident throughout the site. It is unlikely that this site would have burned even under severe conditions.

METHODS

Eight 2-acre blocks were selected and half of each block (1 acres) was cut in August of 1991. Cut trees were left on site. Plant measurements were recorded in 1991 prior to cutting, and in 1992 and 1993. Measurements will again be recorded in 1995. Measurements included understory plant yield, basal and aerial cover, plant density, species composition, and diversity. Soil moisture throughout the growing season, weather, litter decomposition, C:N, and total N on the site were also measured.

RESULTS

As a general rule, all vegetation components measured showed significant increases following cutting of woodland plots in 1992 and 1993. Climatic conditions in 1992 and 1993 were substantially different. The year 1992 was a drought year and temperatures tended to be higher than average. Growing season (April - July) precipitation in 1992 was 4.5 inches. In 1993, much of eastern Oregon received record levels of precipitation and temperatures tended to be cooler than normal. Growing season precipitation on the site was 10 inches. The following results are from 1993, 2 years following cutting unless otherwise specified.

Plant biomass increased 2.2-fold with cutting, but was still only 40 lbs/ac, compared to 18 lbs/ac on the uncut plots in the first year following cutting (1992) during the drought 1992 year. However, in 1993, the second growing season following cutting understory biomass was over 300 lbs/ac on the cut sites compared to 50 lbs/ac on the uncut sites (fig. 1). Perennial forbs and grasses accounted for 97-98 percent of the total biomass. Annual plant species accounted for only 2-3 percent of the total biomass. Both soil water content measurements and plant water measurements indicated soil water remained available for a longer period, extending the growing season on out plots.

Plant density also increased significantly following cutting. The density of deep-rooted perennial grasses was 0.38 plants per square foot in both the interspace and old-tree canopy zones, three times greater than densities in uncut woodland plots. Perennial forb density increased only slightly following cutting, but plants were larger and produced much greater numbers of reproductive shoots.

Basal and canopy cover of herbaceous plants on cut plots were three times or more greater on the cut plots, as compared to the uncut plots (Fig. 2). Additional protection of the ground surface on the cut plots was provided by the cut juniper trees. The combined cover of cut juniper trees and herbaceous plants was 55 percent, compared to 25 percent on the untreated woodland.

Number of plant species and diversity was higher on cut plots during both years (Table 2). The much wetter conditions during 1993, compared to 1992, probably explains the increased species numbers in both treatments.

OLD GROWTH JUNIPER WOODLANDS

The recent expansion of western juniper woodlands has been well-documented throughout its range. However, we know little about the establishment of presettlement stands still in existence today. The life span of western juniper approaches 1,000 years and the bases of old dead trees can persist for well over 100 years. The overall goals of this project are to describe site characteristics of these old stands and the chronology of tree establishment. Specific questions to be addressed are:

(1) Did presettlement trees establish in pulses (e.g., ages are tightly grouped around certain time periods), or are the ages evenly scattered over time?
(2) Under what kind of climatic conditions did establishment occur?
(3) Are periods of establishment similar across the species range or is there a site effect?
(4) Are tree populations relatively stable on these sites, are they on the decline, or has there been a significant increase in new trees since 1900?
(5) Is the recent increase in juniper individuals a threat to the structure of old-growth stands and health of old trees?

Soils, geology, understory plant communities, elevation, slope, and aspect will be described for these sites. Tree canopy, density, age, and mortality will also be measured. Tree age will be compared to skeleton plots (a composite of tree ring widths) and tree ring chronologies developed for different areas across eastern Oregon and northeastern California to evaluate climatic conditions during establishment.

We hope to continue to add additional plots over the next several years.

RESULTS

Eight plots in old-growth sites were established and described, and one was aged during the summer of 1994. Plots are located in the Devils Plateau in Modoc County, California. Other plots are located on Steens Mountain and the Northern Great Basin Experimental Range (both located in Harney County, Oregon. All sites established were on shallow soils, typically less than 18 inches, overlaying fractured basalt. Soil textures range from clay to silty clay. Plant communities are dominated by low sagebrush - Sandberg bluegrass, with one-spike oatgrass, biscuitroot, wild onion, low pussytoes, hoods phlox, and numerous other forbs commonly associated with the site. Idaho fescue and bluebunch wheatgrass are common directly under the juniper canopy. Rock and bare ground usually account for > 50 percent of the ground cover. These sites, often called juniper tablelands appear to account for a large proportion of the old-growth juniper communities where the soil parent material is composed of basalt. Trees on the site ranged from 200 to 600 years old. It appears that a number of the older trees established between 1400 and 1430 A.D. Densities of old trees ranged from 5 to 25 per acre, and mortality of old trees varied from 8 to 50 percent. Young trees were present on all eight stands, and ranged from 10 to 115 trees per acre. It appeared that juniper densities on five of the eight stands were relatively stable. However, on the remaining three stands, tree densities have significantly increased during the past 100 years.

JUNIPER WOODLAND CLASSIFICATION

This project is in the early phases of development. The long-term goal is to develop a hierarchical classification system for: (1) juniper woodlands, (2) communities in a state of transition towards a woodland, and (3) communities with a high potential for juniper encroachment. The use of this classification system would be to:

(1) Determine the successional status of a given community.
(2) Predict the overstory and understory composition and structure once juniper fully occupies a site.
(3) Determine which plants will likely decrease or disappear as juniper increases.
(4) Define the point at which point-thresholds are reached or crossed (e.g., fire, soil erosion, understory recovery) during transition from shrub-grass or aspen communities to juniper woodlands.
(5) Help land managers prioritize juniper woodland treatments.

Publications

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Table 1. Preliminary plant community types and site characteristics of permanent plots on Steens Mountain within the western juniper woodland belt (n=number of permanent plots). 1994.

SITE	ELEVATION	SLOPE	ASPECT	SOIL DEPTH cm	SOIL TEXTURE
Aspen (n=3)	5900-6050	10-20	NNE	150-200	Loam (HAPLOBOROLL)
ARTRV/CAREX-STOC (n=0)			NNE	140-200	Loam (HAPLOBOROLL)
ARTRV/FEID mesic (n=4)	5700-6050	9-18	NNE	90-100	Loamy clay (ARGIXEROLL)
ARTRV/FEID xeric (n=11)	5460-6000	3-22	SW	70-135	Loamy clay (ARGIXEROLL)
ARAR/FEID (n=2)	5480-5535	2-4		90-110	Clay (ARGIXEROLL)
ARTRV/STTH (n=2)	5000	5-10	SW	40-60	Loamy clay restrictive layer
JUOC/ARAR/POSA (n=6)	5640-6020	0-3		30-55	Clay (HAPLOARGID)

ARAR - low sagebrush; ARTRV - mountain big sagebrush; FEID - Idaho fescue; JUOC - western juniper; POSA - Sandberg's bluegrass; STOC - western needlegrass; and STTH - Thurbers needlegrass.

Table 2. Number of species of various plant growth forms in cut and woodland juniper plots. Steens Mountain, 1994.

	1992		1993	
Growth Form	Cut	Woodland	Cut	Woodland
Perennial Grass	8	6	8	6
Annual Grass	2	1	2	2
Perennial Forb	11	3	17	7
Annual Forb (native)	9	4	10	7
Annual Forb (alien)	5	1	8	3
Total	35	16	45	25
Hill #1 Diversity Index	6.0	3.4	7.7	4.3

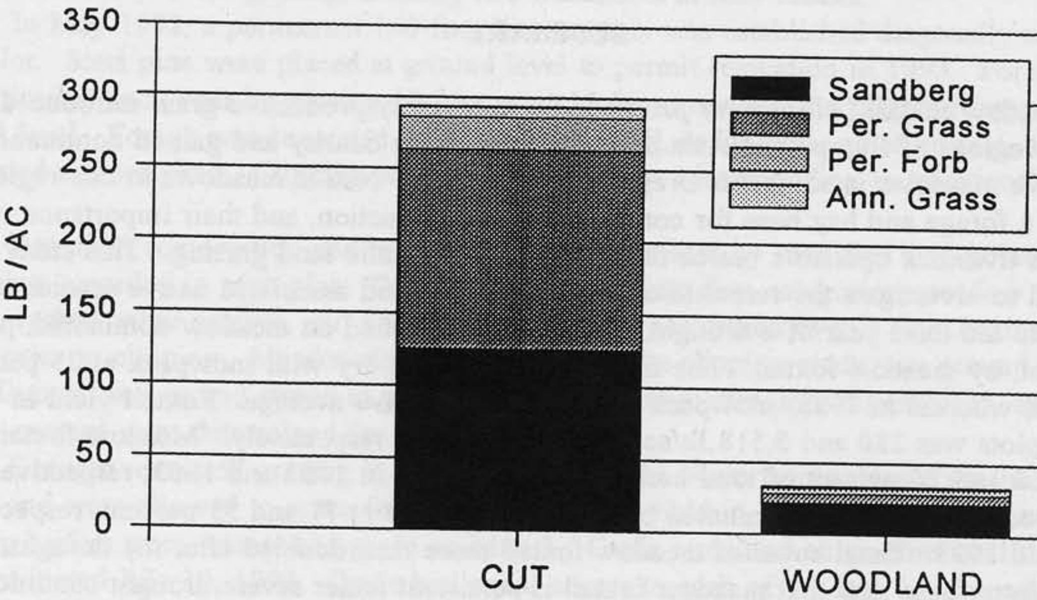

Figure 1: Biomass Production, 1993.

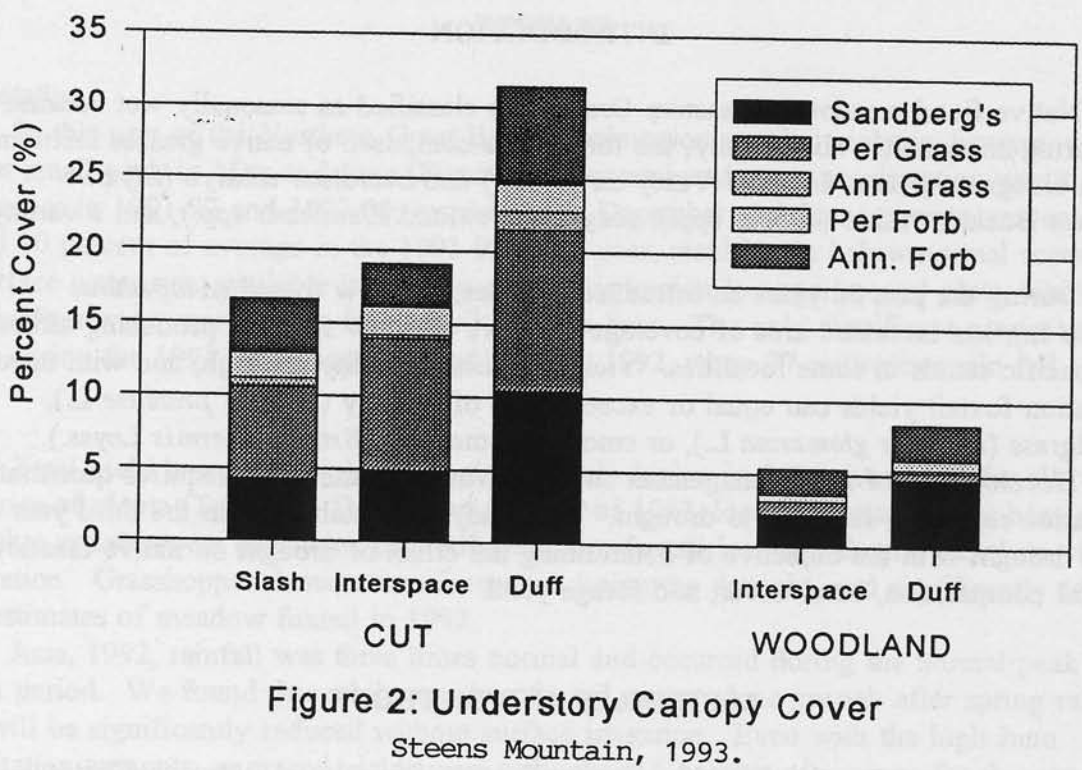

Figure 2: Understory Canopy Cover

Steens Mountain, 1993.