FORAGE PRODUCTION IN A CUT JUNIPER WOODLAND

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Summary

Western juniper expansion into the sagebrush steppe diminishes forage production, reduces plant and wildlife diversity, and negatively impacts hydrologic function. One goal of removing invading juniper woodlands is to restore herbaceous productivity. This study assessed forage production and plant successional dynamics for 12 years following juniper cutting. Biomass, cover, and density of understory species were compared between cut (CUT) and uncut woodland (WOODLAND). We also compared production and composition among three zones in the CUT treatment: old canopy, under juniper debris, and interspace.

Total biomass, cover, and density increased in the CUT treatment over time and were greater in the CUT when compared to the WOODLAND. Biomass increased from 322 lb/acre in 1993 to 966 lb/acre in 2003 in the CUT treatment. Biomass was 10 times greater in the CUT versus the WOODLAND. Densities of perennial grasses have remained stable at 10 plants/yd^2 since 1997. Herbaceous biomass and cover did not change between 1997 and 2003, indicating that by the sixth year after cutting, remaining open areas had been occupied.

Vegetation response in the CUT depended on zonal location. Cheatgrass dominated debris and canopy zones between the fifth and tenth year post-cutting. However, by 2003 perennial grass biomass was two times greater than annual grass in these zones. In interspace zones, perennial grasses were the dominant functional group with higher cover and biomass than other functional groups. Retaining juniper debris on this site did not benefit establishment and growth of perennial grasses compared to interspace and canopy zones.

Juniper cutting successfully restored forage production in this plant community and reduced the number of acres required per AUM from 33 to 3. For livestock operations, increasing the forage base improves management flexibility and expands available management options, which have both economic and ecological benefits. Increasing the forage base permits other juniper-dominated areas to be treated with proper post-treatment rest. Increasing the forage base in upland plant communities may also take pressure off riparian zones.

Introduction

The expansion and development of western juniper woodlands is of significant concern in the northern Great Basin. Western juniper is currently found on about 8.6 million acres in the northern Great Basin. Woodland dominance can result in reduced wildlife diversity, generate increased erosion and runoff, and reduce understory productivity and diversity of shrub-steppe plant communities. To address these undesirable consequences, western juniper has been controlled through a variety of treatments. Prescribed fire and hand cutting using chainsaws are two of the primary methods used to control juniper. Control of juniper increases availability of soil water and nutrients and thus commonly results in large increases in biomass and cover of herbaceous species. However, there is a lack of longer-term assessments after treatment by either fire or cutting in the western juniper system.

The purpose of this study was to evaluate longer-term vegetation changes after cutting of western juniper. This study was conducted from 1991 through 2003 on private land on Steens Mountain in southeast Oregon. We compared changes in herbaceous and shrub composition between cut and uncut woodlands. In the CUT treatment we also compared herbaceous response among three zones, and evaluated how quickly shrubs and juniper reestablish and develop after cutting. The three zones were 1) the interspace that was not influenced by juniper litter; 2) the old canopy, where juniper litter accumulated prior to cutting; and 3) the juniper debris zone, under cut trees where juniper litter accumulated.

Study Area and Methods

The study site was a big sagebrush/Thurber's needlegrass community and was located on Steens Mountain, in southeast Oregon. Elevation at the site is 5,100 ft and aspect is west facing. Juniper has dominated this site, eliminating the shrubs and suppressing herbaceous species. Tree canopy cover averaged 26 percent and tree density averaged 101 trees/acre. Bare ground was 90 percent in interspace zones (Fig. 1, *inside back cover*). Sandberg's bluegrass was the dominant understory species. Main species found on site include Thurber's needlegrass, bluebunch wheatgrass, and squirreltail. Annual precipitation at the Malheur National Wildlife Refuge weather station located near the study site averaged 10.8 inches over the past 34 years.

The experimental design was a randomized block with four blocks and two juniper treatments (CUT and uncut [CONTROL] woodland). Blocks were 2 acres in size and were established in summer 1991. Vegetation was characterized prior to tree cutting in September 1991. All trees in half of each block were cut using chainsaws, thus providing one CONTROL and one CUT plot per block. All cut juniper trees were left in place.

Shrub and tree cover were measured by line intercept along 5 100-ft m transects in 1993. In 1997 and 2003, shrub and tree cover were measured by line intercept along 3 165-ft transects.

Herbaceous density was measured in 1991–1997 and 2003. Biomass and canopy cover were measured in 1991–1993, 1996, 1997, and 2003. Density and canopy cover of herbaceous species were measured inside 2.2-ft^2 frames. Sampling in the CUT woodland was spatially stratified into three zones: interspace, canopy, and debris. In WOODLAND, zones were stratified into interspace and canopy. In 1993, herbaceous biomass was sampled in each CUT plot using 25 1-yd^2 frames per plot. Biomass was not sampled by zone in 1993 or 1996. In June 1997 and 2003, herbaceous biomass was sampled by zone in each plot using 25 1-yd^2 frames. Herbage was clipped to a 1-inch stubble height by functional group. Functional groups were Sandberg's bluegrass, perennial bunchgrasses (e.g., Thurber's needlegrass, bluebunch wheatgrass, squirreltail), perennial forbs, annual grasses (cheatgrass and Japanese brome), and annual forbs. Clipped herbage was dried at 48°F for 48 hours prior to weighing. To compare treatments across all the years, zonal biomass values in 1997 and 2003 were weighted by area occupied by each zone to obtain a treatment mean.

Results

Juniper cutting on this site successfully restored herbaceous cover and productivity, and density of desirable perennial grasses (Fig. 2, *inside back cover*). Total herbaceous plots biomass (Fig. 3), density (Fig. 4), and cover (Table 1) increased ($p < 0.001$) in the CUT over time and were greater ($p < 0.001$) in the CUT when compared to the WOODLAND. Biomass increased from 322 lb/acre in 1993 to 966 lb/acre in 2003 in the CUT treatment (Fig. 3). Biomass was 10 times greater in the CUT versus the WOODLAND in all years. Perennial grass density was about 5 times greater in the CUT compared to the WOODLAND (Fig. 4). In the CUT, densities of perennial grasses have remained stable at about 10 plants per yd^2 since 1997.

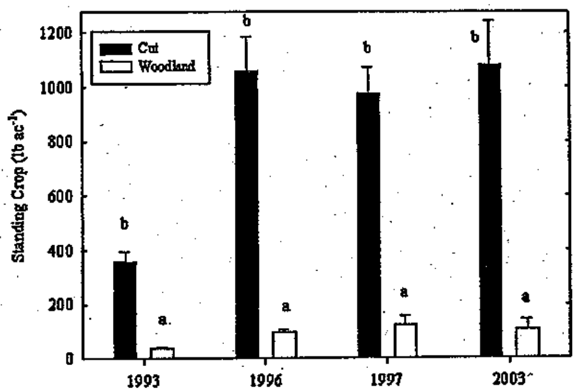

Figure 3. Herbaceous standing crop biomass (lb/acre) in cut and woodland treatments in 1993, 1996, 1997, and 2003. Data are in means plus one standard error. Different lower case letters indicate significant differences between treatments.

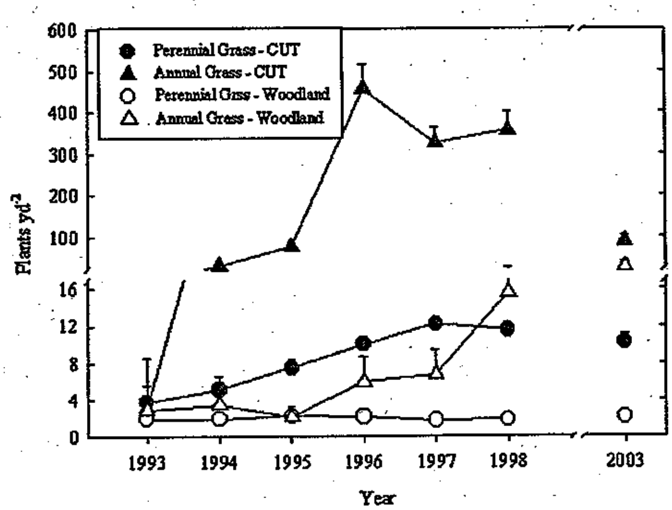

Figure 4. Densities of perennial grass and annual grass species. Values are weighted by zone to obtain treatment means. Values are in means plus one standard error.

Within the CUT treatment herbaceous composition has changed over time and has been influenced by zonal location. In interspace zones of the CUT treatment, perennial grasses were the dominant functional group with higher cover and biomass than other functional groups in all years (Figs. 5 and 6). However, between 1996 and 2001, cheatgrass dominated litter deposition areas (dead tree canopies and debris zones) (Figs. 5 and 6). The increase in cheatgrass in these areas may have been due to more favorable seedbed characteristics and increased nutrient and water availability. However, by 2003, cheatgrass decreased significantly ($p < 0.001$) in debris and canopy zones with corresponding increases in perennial grass biomass and/or cover.
In 2003, perennial grass biomass was two times greater than annual grass in canopy and debris zones. There may be several reasons for the decline in cheatgrass: dry conditions the past several years may have reduced cheatgrass establishment and growth, less favorable seedbed properties occur as litter is incorporated into the soil and exposure increases, and competition from perennials has increased.

Discussion and Management Implications

Juniper cutting resulted in a large increase in the forage base. In this study, acres required per AUM were reduced from 33 to 3 acres. From a livestock production standpoint, management flexibility and options are increased. Options include increasing stocking rates, keeping livestock in fields longer and thus permitting other juniper-dominated areas to be treated with proper post-treatment rest, and increasing flexibility in grazing systems using rest-rotational and deferment scheduling. Increasing the forage base in upland plant communities may take pressure off riparian zones.

Important ecological benefits include reducing runoff and soil erosion, and restoring habitat that is lost for many wildlife species when juniper dominates plant communities. Juniper cutting also increases soil water availability, and thus extends the growing season by 4 to 8 weeks (Bates et al. 2000). This permits herbaceous plants to complete their growth cycle from a production and reproductive standpoint. Increased seed production is a result of an extended growing season and in this study resulted in increased establishment of new plants.

Biomass and perennial grass density did not change significantly between 1996–1997 and 2003. This would indicate that it took 5 to 6 years for understory vegetation to fully develop and occupy the site.

Sagebrush and other shrubs have increased steadily since juniper was cut, but shrub cover remains far below potential for this site (Table 1). Juniper has also reestablished in the CUT treatment (Table 1) from the small individuals that were not controlled in the initial treatment and from juniper seed. Juniper density in 2003 was 200 trees per acre. These trees were either seedlings or juveniles less than 18 inches tall. Prior to cutting it only took 100 trees per acre to dominate this site. Unless controlled, there are presently enough young trees that, when mature, will dominate the site within 50–60 years.

We found that retaining juniper debris on site did not benefit establishment and growth of perennial grasses when compared to interspace and canopy zones (Figs. 5 and 6). The main perennial grass that moves into litter deposition zones is squirreltail. Other perennial grasses, especially Thurber's needlegrass, have been slow to establish and develop, if at all, in old canopy and debris zones. Production in debris zones has been less than in adjacent interspace and canopy zones. Debris represents about 20 percent of the area. This debris has extremely low decomposition rates. Juniper debris also increased annual grass presence on site although observations the past year indicate that cheatgrass may be declining.

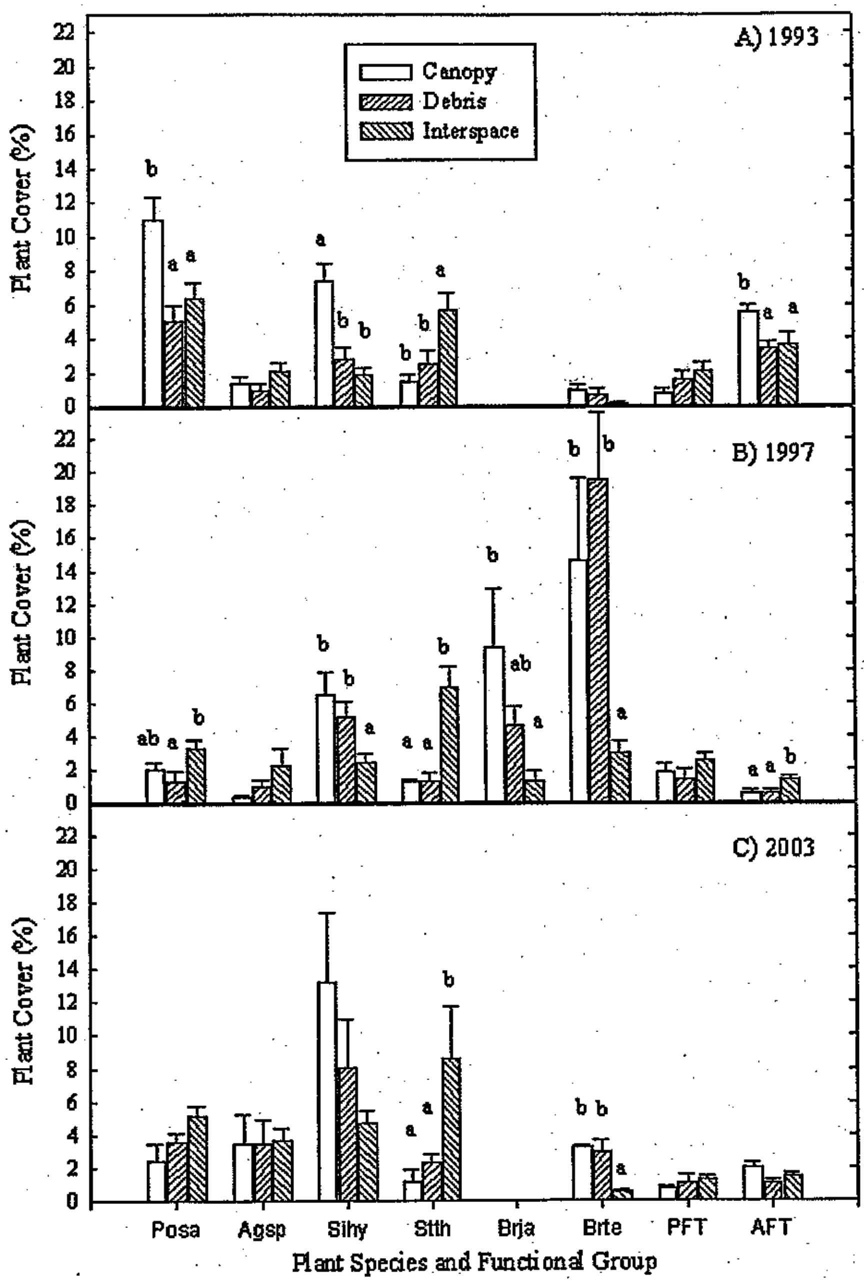

Figure 5. Herbaceous cover of plant species and functional groups (percent) by zone in (A) 1993, (B) 1997, and (C) 2003. Data are in means plus one standard error. Different lower case letters indicate significant differences between treatments. Species and functional groups are Posa (Sandburg's bluegrass) Agsp (bluebunch wheatgrass), Sihy (bottlebrush squirreltail), Stth (Thurber's needlegrass), Brja (Japanese brome), Brte (cheatgrass), PFT (perennial forbs), and AFT (annual forbs).

Table 1. Comparisons of cover (%) and tree and shrub density values collected on Steens Mountain, Oregon, as affected by juniper cutting treatment.

Year & treatment	Tree cover	Tree density[1]	Shrub cover	Shrub density	Litter[2]	Herbaceous cover	Bareground & rock
	%	no. ac^{-1}	%	no. ac^{-1}	%	%	%
1993							
Cut	0.0 ± 0.0 a[3]	85.4 ± 30.5 a	0.0 ± 0.0	24.4 ± 22.1	31.4 ± 2.4	19.0 ± 1.5 b	49.2 ± 1.6 a
Woodland	27.6 ±1.6 b	318.5 ± 27.3 b	0.0 ± 0.0	11.2 ± 8.9	27.5 ± 1.7	4.3 ± 0.5 a	68.2 ± 2.8 b
1997							
Cut	0.2 ± 0.2 a	129.7 ± 29.3 a	1.4 ± 1.0	887.5 ± 686.4 b	34.5 ± 2.0	29.3 ± 3.2 b	37.2 ± 2.6 a
Woodland	24.7 ± 2.0 b	335.4 ± 39.1 b	0.0 ± 0.0	14.8 ± 14.8 a	29.7 ± 1.8	5.5 ± 0.7 a	65.8 ± 3.5 b
2003							
Cut	0.7 ± 0.3 a	222.2 ± 32.7 a	2.5 ± 1.2	630.0 ± 309.0 b	34.1 ± 1.9	26.4 ± 2.5 b	39.6 ± 1.5 a
Woodland	24.7 ± 2.0 b	312.0 ± 14.8 b	0.0 ± 0.0	14.8 ± 14.8 a	28.7 ± 1.7	5.7 ± 0.9 a	66.3 ± 2.6 b

[1] Tree density includes all trees from seedling to large mature trees. Mature tree density averaged 101 trees ac^{-1}.
[2] Litter in cut plots includes litter in intercanopy, debris, and canopy zones. Litter in woodlands is primarily under trees with less than 2% in the interspace zones.
[3] Different lower case letters indicate significant differences between treatment means within a column ($p < 0.05$).

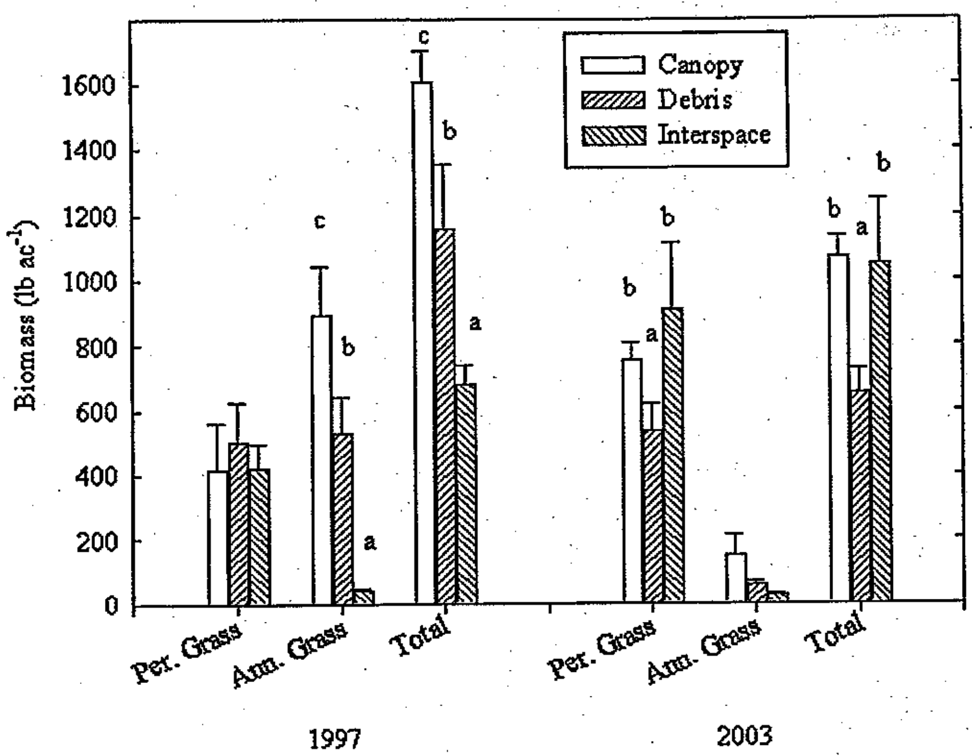

Figure 6. Functional group herbaceous biomass (lb/acre) by zone in 1997 and 2003. Data are in means plus one standard error. Different lower case letters indicate significant differences among zones. Functional groups are perennial grass (Per. Grass), annual grass (Ann. Grass), and total biomass (Total).

Conclusions

Temporal dynamics (changes over time)

1. Cutting juniper increased herbaceous cover and biomass within the first 2 years following treatment, but it took 5 years for peak production to be reached.
2. Production of perennial grasses has continued to increase with steady reductions in production of other functional groups.
3. Shrub species were establishing by the fourth year post-cutting but remain a minor component of the system 12 years after cutting.
4. Juniper has rapidly reestablished on site with densities sufficient to re-dominate the community in 40–50 years.

Spatial dynamics (change over space)

1. Succession in interspace zones was driven by species from the original plant community, with dominance by perennial grasses over the 12-year study period. Thurber's needlegrass and bluebunch wheatgrass established preferentially in interspace zones.
2. Succession in debris and canopy zones has been a function of both original species (initial floristics) and a few invaders (relay floristics). Annual grasses dominated mid-successional stages in debris and litter zones but not interspace zones.

3. Squirreltail was the main perennial grass to establish in debris and litter zones and has dominated later successional stages. Debris and litter zones have not been conducive to establishment of other perennial grasses at this point.

Literature Cited

Bates, J.D., R.F. Miller, and T.S. Svejcar. 2000. Understory dynamics in cut and uncut western juniper woodlands. J. of Range Manage. 53:119–126.