Medusahead Response 6 Years after Burning and Seeding in Sagebrush Steppe

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Abstract—A prescribed burn for western juniper (*Juniperus occidentalis*) reduction at Crooked River National Grassland in Oregon was conducted in 2011. Foliar cover by species or genus and functional group was measured every other year for 6 years to evaluate response to four treatments: unburned control, burned, burned-plus-native-seeding, and burned-plus-cultivar seeding. Additional measurements focused on expansion of medusahead (*Taeniatherum caput-medusae*) from localized patches and vegetative response to postburn grazing.

Keywords: bunchgrass, fire, grazing, medusahead, seeding

INTRODUCTION

Crooked River National Grassland (CRNG) covers 112,357 acres of sagebrush steppe in central Oregon. Administered by the Forest Service, U.S. Department of Agriculture, it is managed for public use that includes recreation, grazing, and wood-cutting, as well as for resource objectives of wildlife habitat and riparian protection. The invasion of exotic species, especially medusahead (the annual grass *Taeniatherum caput-medusae*), is of major concern to land managers, as is the expansion of western juniper (*Juniperus occidentalis*) into areas where it was excluded by fire historically. A conflict arises between the goal of restoring fire for juniper eradication and the reluctance to use fire where it may promote invasive annual grasses.

In 2011 the CRNG Coyote Hills unit was scheduled for a prescribed burn to reduce a 30-year growth of juniper. The unit had been ungrazed for 2 years and contained a healthy community of perennial bunchgrass (>2 plants m^{-2}) and sagebrush (*Artemisia tridentata* var. *tridentata* and var. *vaseyana*) with low-density medusahead and cheatgrass (*Bromus tectorum*), and scattered patches of dense medusahead thatch (patch size was 0.1–4.0 acres, average of 0.2 acre). An interdisciplinary team of managers anticipated that fire would stimulate growth of invasive annual grasses. We also perceived a time-sensitive need to eradicate junipers before the understory community was too depleted to recover, and thought the annuals could be managed later. At that time, widespread herbicide application had not yet been approved for CRNG, so we decided to investigate the effectiveness of seeding to minimize annuals by promoting perennial bunchgrasses after fire. We based our experimental design on a study by Davies (2010) that showed no increase in medusahead cover when burning was followed by seeding. (Davies' study showed a significant decrease in annual grass when fire was followed first with herbicide and then seeding, with results examined at 2 years post-burn.)

METHODS

We implemented a randomized complete block design in eight large medusahead patches in the Coyote Hills unit. All were at approximately 3,300 feet elevation on 5- to 10-percent slope with the same potential

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natural vegetation. Average (15-year) precipitation was 8 inches. Soil pits showed 25 to 40 percent clay in the A-horizon at each block. Half of the blocks were untreated controls and the other half were in sites that would be burned. Each block contained two plots; the control plots had one linear transect in the densest part of the patch plus four circumferential transects at 50, 100, 150, and 200 feet from the plot center. The burned plots had three parallel linear transects, which were randomly assigned to burned, native, and cultivar treatment, plus the same array of circumferential transects. Each linear transect was a 75-foot tape placed in the center of a 12 foot × 90 foot treatment lane. Foliar cover was measured with a 4-foot^2 frequency frame placed at four sample points on each linear transect. Three samples were measured on the circumferential transects at 90°, 180°, and 270° from the linear transect.

The burn prescription called for summer-like conditions to maximize juniper mortality. Approximately 10 percent of junipers had been cut and left to dry during the preceding winter to achieve a hotter burn. We burned the unit on July 27, 2011, but weather that day was typical of late spring (dry bulb temperature: 72–82 °F; relative humidity: 21–26 percent). The treatment blocks were burned completely. The following December we hand-broadcasted and raked the seed mixes into their randomly assigned lanes. Seed mixes (table 1) were applied at 15 lbs acre^{-2}. Snow accumulated on the site a month later.

Plots were measured just before the burn and remeasured in June every 2 years after the burn. This report summarizes data from the preburn, 2 year, 4 year, and 6 year intervals. One of the control plots was partially burned, so that plot and one of the treatment plots were omitted from the analysis. Data were analyzed using analysis of variance (ANOVA), two-factor without replication, in Microsoft® Excel™ (2016). Significant change was accepted as $P < 0.05$. Bar graphs represent the mean of 28 samples from 7 plots and whiskers show standard error. The

Table 1—Seed mixes applied in the treatment plots, Coyote Hills unit, Crooked River National Grassland, December 2011. Mixes were applied at 15 lbs acre^{-1}. PLS = pure live seed.

Species	Code	Seeds lb^{-1}	lbs PLS lb^{-1} mix	lbs PLS acre^{-1}
Native mix				
Prairie Junegrass	KOMA	2,315,000	0.03	0.45
Bottlebrush squirreltail	ELEL5	192,000	0.29	4.42
Bluebunch wheatgrass	PSSP6	140,000	0.07	0.98
Idaho fescue	FEID	450,000	0.02	0.32
Thurber’s needlegrass	ACTH7	225,000	0.42	6.27
Lewis’ flax	LILE4	293,000	0.04	0.65
Cultivar mix				
Intermediate wheatgrass	THIN6	88,000	0.29	4.42
Crested wheatgrass	AGCR	200,000	0.21	3.1
Sheep fescue	FEOV	680,000	0.11	1.64
Sherman big bluegrass	POSE	882,000	0.11	1.66
Russian wildrye	PSJU3	175,000	0.04	1.62
Lewis’ flax	LILE4	293,000	0.04	0.65

exclosure dataset did not meet all assumptions for ANOVA, so the grazed-ungrazed bar graphs lack whiskers and *P*-values. Those bar graphs show the mean of 32 samples from 8 plots.

Grazing Exclosure Subset

We also looked at the effect of postburn grazing. A 208 foot × 416 foot block (2 acres) was laid out in an area of moderate, diffuse medusahead cover. Sixteen linear transects were arranged on a grid across the block. After the burn, a fence was built to exclude cattle from half the block. Foliar cover by species was measured pre-burn and again at 6 years post-burn with four sample points per transect. The grazing schedule is shown in table 2.

RESULTS

Medusahead cover decreased steadily over 6 years in the unburned plots ($P = 0.04$), but after the second year it increased significantly in the treatment plots ($P = 0.005$) (fig. 1). Cheatgrass initially declined, then rebounded at all sites, with no significant difference among treatments at any of the time intervals ($P = 0.7$ at 6 years). Bulbous bluegrass (*Poa bulbosa*), an invasive small perennial bunchgrass, showed no change over 6 years in the unburned sites ($P = 0.1$), but increased at the other sites ($P = 0.02$). Despite the apparent spike at 2 years in burned sites, the overall percent cover was small and all four treatments showed no difference at each time interval ($P \geq 0.07$).

Table 2—Number and timing of livestock grazing on the Coyote Hills allotment, Crooked River National Grassland.

Grazing pattern at Coyote Hills		
Year	**Grazed days**	**Stock numbers**
2011	rested	0
2012	rested	0
2013	Aug 1–Sept 15	200 cow-calf pairs
2014	June 1–July 15	110 cows
2015	June 1–July 15	250 cow-calf pairs, 10 bulls
2016	June 1–July 15	200 cow-calf pairs, 25 bulls
2017	May 15–Aug 15	200 cow-calf pairs

Invasive forbs, dominated by stork's bill (*Erodium cicutarium*), increased in all the burned sites ($P \leq 0.005$) but not in the unburned sites ($P = 0.2$).

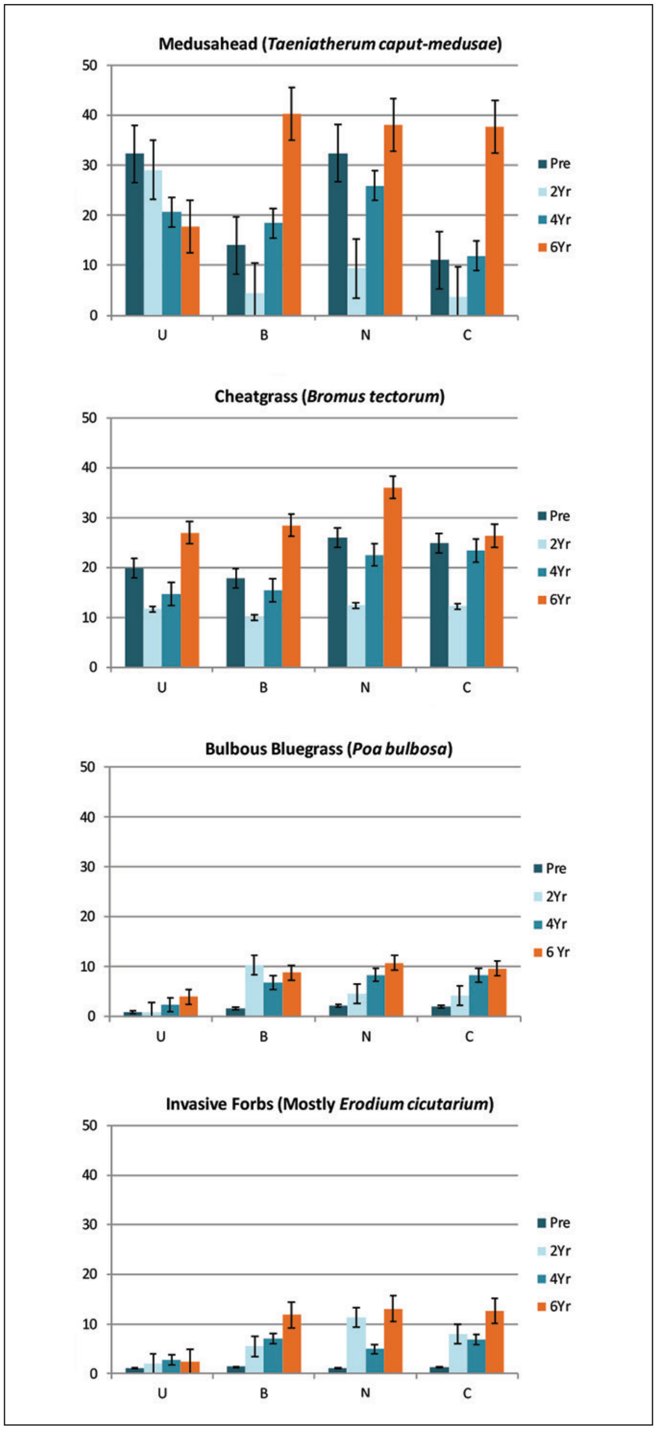

Figure 1—Mean percent foliar cover of invasive species by treatment type and time interval since the burn, Coyote Hills unit, Crooked River National Grassland. U, B, N, C = unburned, burned only, native-seeded after burn, and cultivar-seeded after burn, respectively. Colors represent preburn and 2 year, 4 year, and 6 year intervals. Whiskers show standard error.

Native large perennial bunchgrasses increased over time in the unburned plots ($P = 0.02$) but remained the same in all the burned treatments ($P \geq 0.08$) (fig. 2). Seeding had no effect, despite seed mixes that were predominantly bunchgrass (table 1). The native small perennial bunchgrass Sandberg bluegrass (*Poa secunda*) maintained the same amount of cover in all treatments at all intervals except at the cultivar sites, where it increased from preburn to 2 years ($P = 0.004$, while the others had $P \geq 0.2$ at 2 years). Native forbs increased over time at all sites regardless of treatment ($P \leq 0.006$). Mosses and lichens had no significant change between preburn and 6 years at the untreated and cultivar-seeded sites ($P > 0.07$), but decreased at the burned and native-seeded sites ($P \leq 0.05$).

There was an increase in medusahead cover on the circumferential transects, but due to greater variability with greater distance only the change at 50 feet was statistically significant ($P = 0.03$). The degree of expansion was relatively minor compared to densification within the block (fig. 3). Averaged across all samples within the burned blocks, medusahead cover increased from 19 percent pre-burn to 39 percent at 6 years ($P = 0.005$). The unburned blocks showed densification of the patch ($P = 0.03$) but no significant expansion.

Grazing Exclosure Results

At the exclosure site, the 6 year mean cover of medusahead was 18 percent in both the grazed and ungrazed blocks (fig. 4). Cheatgrass cover was 5 percent higher where grazed. Invasive bulbous bluegrass more than doubled where grazed, as did the cover of invasive forbs (predominantly *Erodium cicutarium*). Both native forbs and Sandberg bluegrass showed negligible difference in cover between grazed

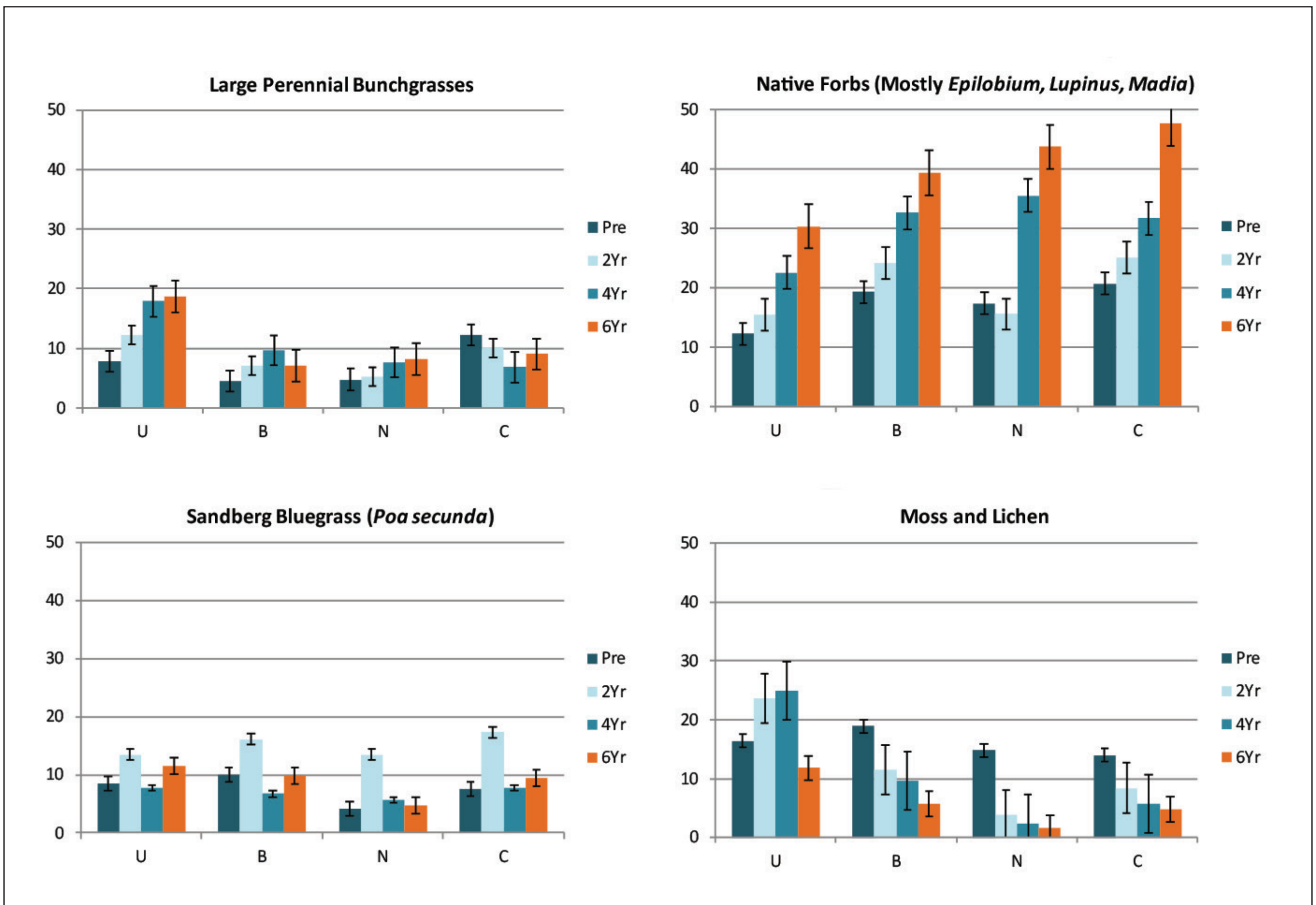

Figure 2—Mean percent foliar cover of native species by treatment type and time interval since the burn, Coyote Hills unit, Crooked River National Grassland. U, B, N, C = unburned, burned only, native-seeded after burn, and cultivar-seeded after burn, respectively. Colors represent preburn and 2 year, 4 year, and 6 year intervals. Whiskers show standard error.

and ungrazed blocks. Cryptogam cover was less than half as much where grazed, but the amounts were minimal post burn (≤ 0.10 percent). The biggest difference was in large perennial bunchgrasses, with cover less than half as much outside the exclosure (13 percent on grazed land, 39 percent on ungrazed land).

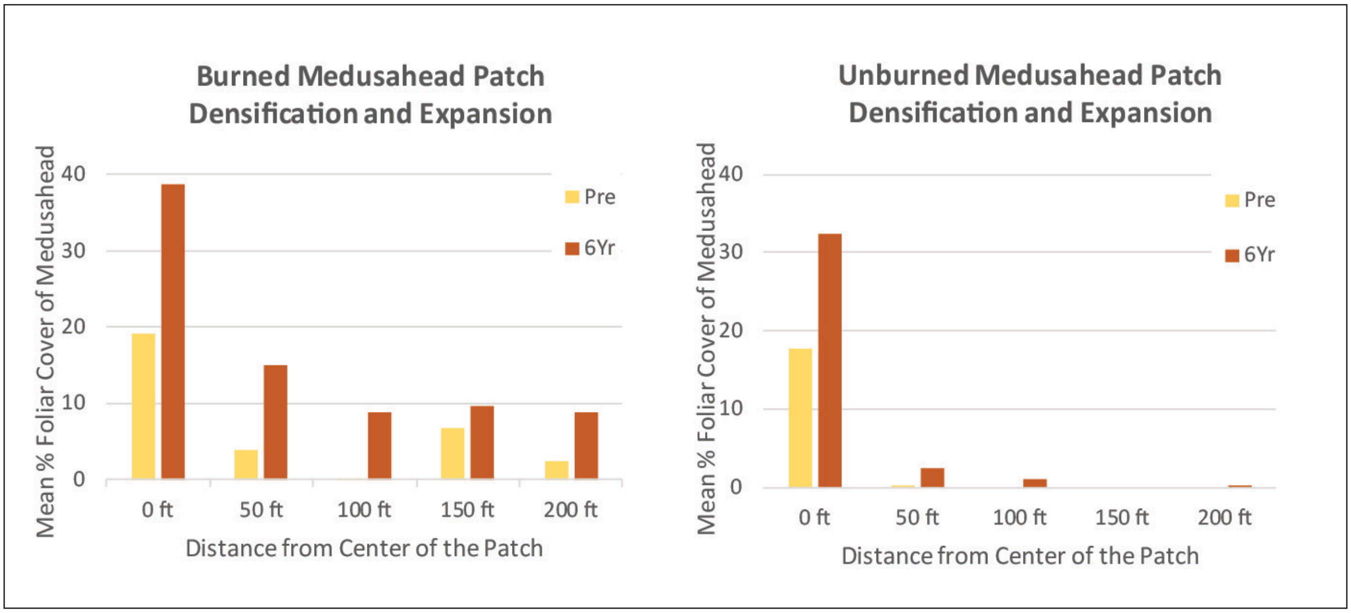

Figure 3—Densification and expansion of burned versus unburned medusahead patches at 6 years post-burn, Coyote Hills unit, Crooked River National Grassland.

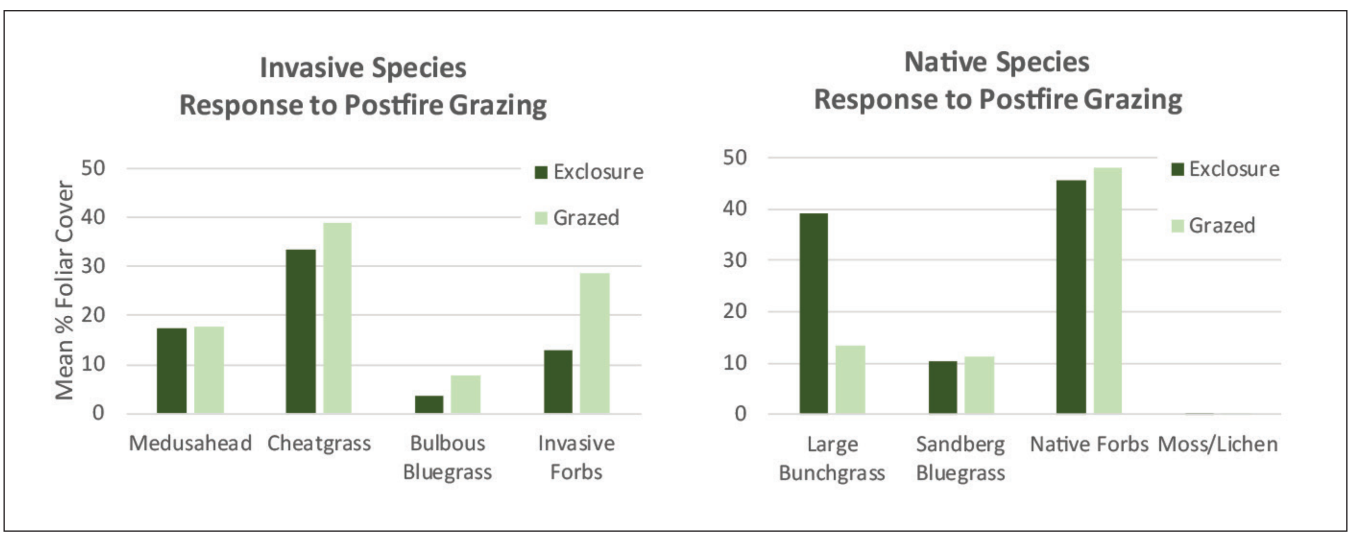

Figure 4—Invasive and native species cover in an ungrazed exclosure and equivalent grazed area, Coyote Hills unit, Crooked River National Grassland. Measurements are from 6 years post- burn with four seasons of livestock grazing (see table 2 for grazing pattern). Mosses and lichens had less than 1 percent cover overall.

DISCUSSION

Vegetative response to the burn was initially favorable but not predictive of later results. In the control and treatment blocks at the 2 year measurement we saw no increase in medusahead, a significant decrease in cheatgrass, and no change in large perennial bunchgrass density. At the 4 year interval, however, cover of nearly all the measured vegetation rebounded to the pretreatment levels. At 6 years the native forbs and all invasive species except for cheatgrass increased at burned sites compared to the unburned sites. Cheatgrass and Sandberg bluegrass remained relatively constant regardless of treatment, while the large perennial bunchgrasses increased in the unburned sites only. Mosses and lichens declined in two of the three burned treatments while remaining constant where unburned. The decline is very likely related to fire and weather, not the seed mix.

Unusually favorable weather seems to have played a role in the anomalous 2 year response. The burn occurred in July 2011, with low fire severity and phenology that probably retained a lot of seed in both the annuals and perennials. Spring precipitation in 2012 was much higher than average (fig. 5), which probably boosted the germination of perennial bunchgrasses and recovery from dormant roots. The following fall and spring were very dry, but ensuing years tracked closely with the 15 year average. Cows were back on the unit in August 2013 (after plot measurement) and then in spring and summer every year thereafter. The combination of these factors contributed to the effects seen in the 4 year and 6 year data.

Although both medusahead and cheatgrass were present before the burn at low density (<500 plants acre^{-1}), medusahead also occurred as "thatch" or high-

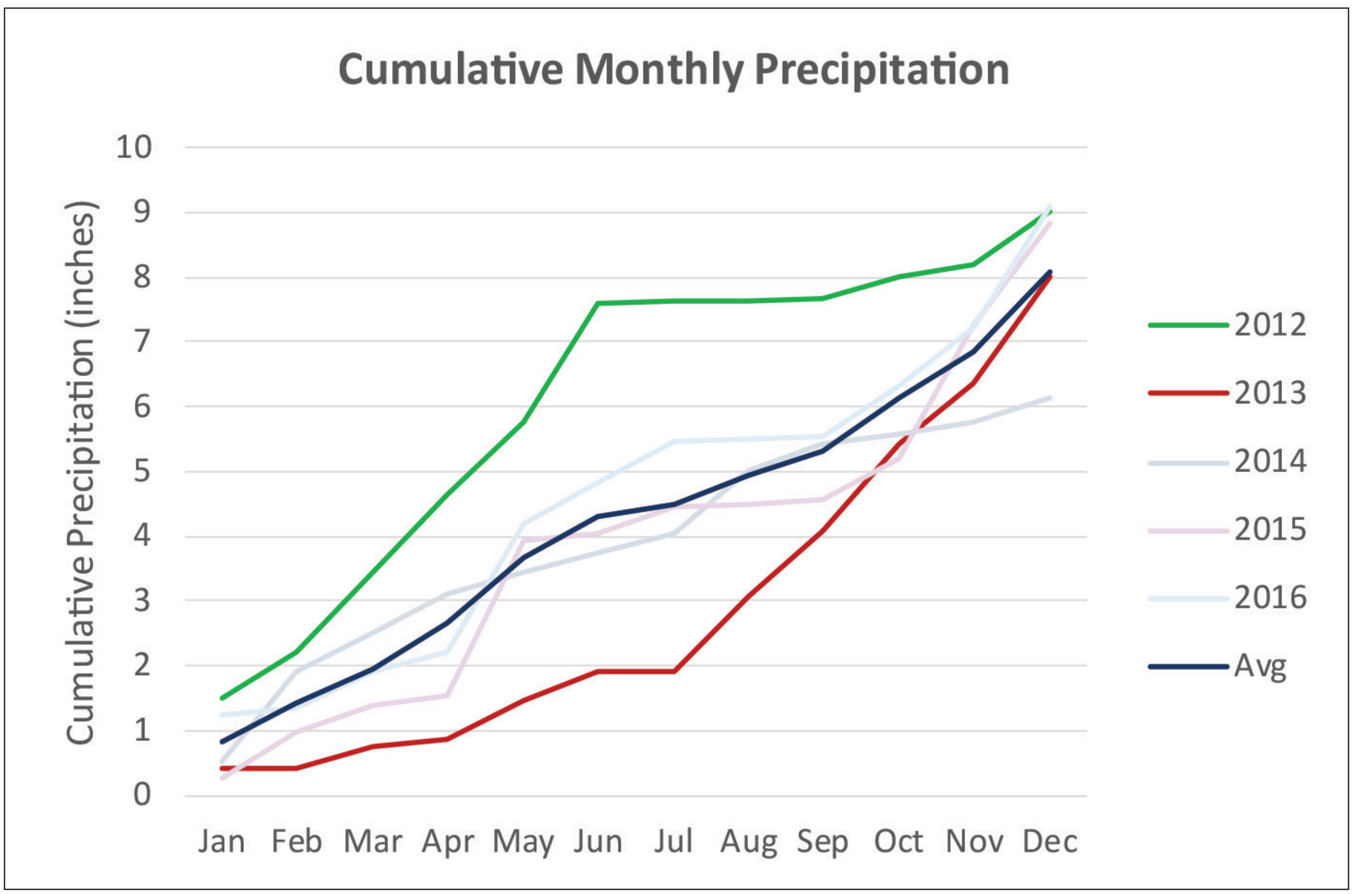

Figure 5—Cumulative monthly precipitation at the Redmond International Airport, about 20 miles southwest of the Coyote Hills burn unit, with approximately the same elevation and plant association.

density patches up to 4 acres in size with between 104 and 106 plants acre-1. All of the study blocks were located in these patches. The Natural Resources Conservation Service map units were Simas cobbly silty clay loam, Lickskillet-Redcliff very gravelly loam, and Schreir-Tub Complex silt loam (USDA NRCS 2011). We dug soil pits in each block and found a clayey horizon within the upper 5 inches of all but one soil pit. Young et al. (1999) and Kyser et al. (2014) noted that clay soils strongly favor medusahead. The patchiness of the medusahead infestation is seen in a box-and-whisker diagram (fig. 6). Native perennial bunchgrasses (fig. 7) and the other cover categories tended to be distributed more evenly on the landscape.

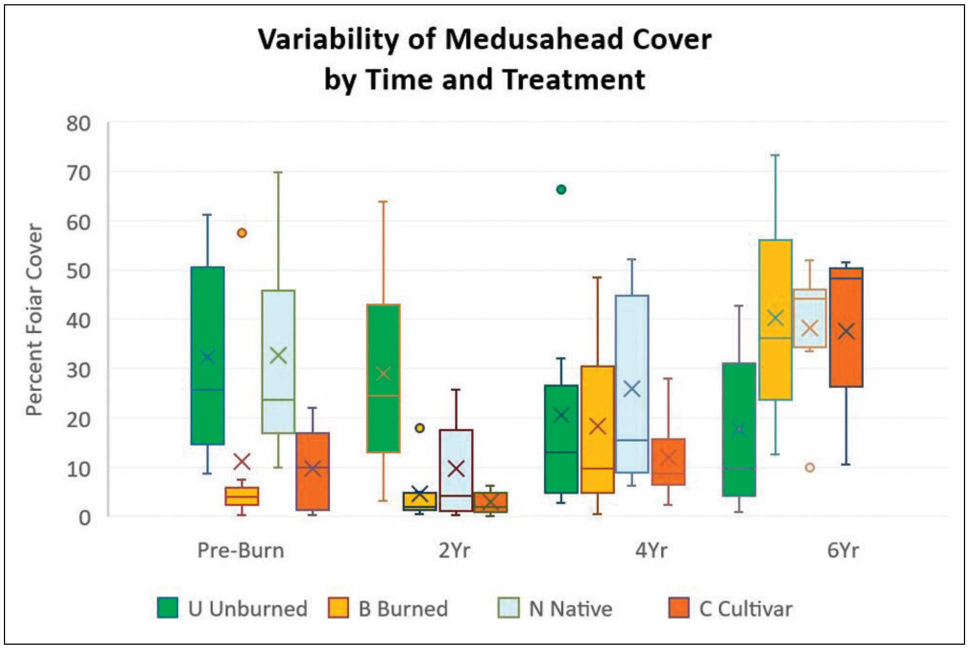

Figure 6—Uneven distribution of medusahead cover, Coyote Hills unit, Crooked River National Grassland. Each box summarizes 28 samples: X is the mean, whiskers are samples closest to 1.5 times the interquartile range, and dots are outliers.

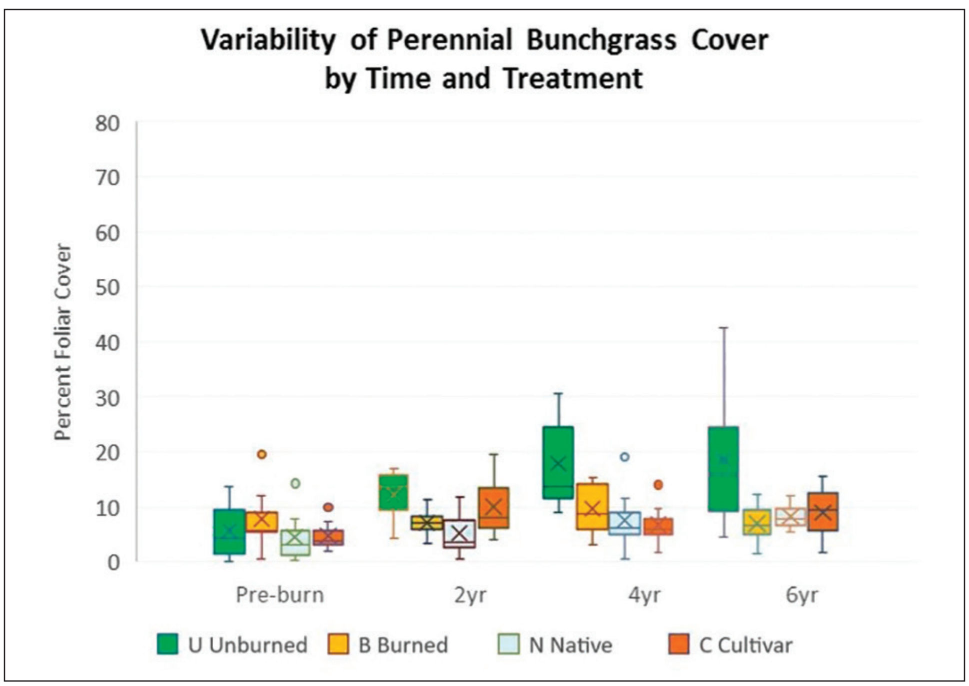

Figure 7—Relatively uniform distribution of large perennial bunchgrass cover compared with medusahead, Coyote Hills unit, Crooked River National Grassland. There is almost no difference among the burned treatment plots, but bunchgrass cover doubled in the unburned plots.

There was a lot of variability even among samples within one plot, although the means were sometimes similar across the treatments. Plot layout explains the relatively high preburn medusahead cover in the unburned and native transects compared to the burned and cultivar transects. The first transect of each plot was placed in the center of a medusahead patch, which tended to have the densest thatch. In control plots there was only the one unburned linear transect. In the other plots transects were centered in three parallel lanes 12 feet wide. After the fire three treatments (burned, native, cultivar) were randomly assigned to the parallel lanes using a random-number generator. By chance, the native-seed treatment was applied on the first transect in six out of eight plots.

Results of the exclosure portion of this project support Davies' (2018) finding that fire may have more influence than grazing on annual grass invasion. However, grazing seemed to promote invasive forbs and decrease perennial bunchgrass cover. Higher bunchgrass density is one of the key resistance-resilience indicators suggested by Chambers et al. (2014), but the foliar cover metric in this study may not be directly related. Further work at Coyote Hills may address some of these knowledge gaps.

Managers who seek to remove junipers for habitat and riparian restoration must now take into account the relative cover of invasive annual grasses and native perennial bunchgrasses (Davies 2012; James et al. 2015). Ecological site variables such as soil, precipitation, insolation, and existing plant community influence the trajectory of vegetative response to disturbance (Miller et al. 2013; Pyke et al. 2018). Our plot data suggest that medusahead easily colonizes locally clay-enriched epipedons but may be challenged to expand into less favorable sites, especially if there is competition from bunchgrass. In line with this, the grass seems more likely to densify in a clayey site than expand beyond it. Further study may determine soil-based thresholds useful for strategic management.

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