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CASE STUDY: Grazing Management on Seeded and Unseeded Post-Fire Public Rangelands[1]

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ABSTRACT

Public land management agency standard policy has been to delay grazing on burned areas for a minimum of 2 yr on both seeded and unseeded areas. This 2-yr grazing moratorium has not been specifically validated by research. Study objectives were to investigate seeding and not seeding as well as grazing and not grazing immediately after a fire. The study area was located on a fire-impacted Bureau of Land Management allotment in central Nevada that was divided into 4 large blocks. Treatments were imposed in a 2 × 2 × 2 factorial arrangement. Factors were seeded or unseeded, grazed or ungrazed, and 2 growing seasons. Grazing treatments were implemented in 2000, without pastures being rested. Post-treatment data was collected in 2001 and 2002. Baseline data indicated no difference between the 4 treatment areas. Fifty-three species of plants occurred in the area after the burn and 40 species in 2002. For the 2001 and 2002 analyses, total grass and shrub cover and density were not different. Forb cover was not different. Forb density was lower in grazed areas ($P = 0.04$). Forb density tended to be lower in 2001 than 2002 ($P = 0.09$) and lower in unseeded treatments, although no forbs were included in the rehabilitation seed mix. Cheatgrass density was lower in 2001 than 2002 ($P = 0.03$). Mean species richness decreased from 2001 to 2002 and was greater in the unseeded treatment ($P = 0.04$). There were no differences in diversity index values or percentage of similarity. For this study, grazing and aerial seeding had no effect on plant community response after fire.

Key words: fire, grazing, seeding, cattle, public land

INTRODUCTION

Wildland fires have had major impacts on vegetation systems throughout Nevada and the Great Basin. On lands managed by the Bureau of Land Management (**BLM**), general policy is to defer grazing (where allowed or permitted) for 2 or more years after a fire (BLM, 1999). The scientific evidence for this policy is sporadic, and many range scientists and managers question scientific basis for the policy (Sanders, 2000). Evaluations of expert opinions concerning range plants and their differential responses to fire and grazing show some disagreements (Rodriguez and Kaufmann, 1998). Rodriguez and Kaufman (1998) also cited a lack of knowledge as part of the problem, especially concerning fire. Sanders (2000) indicated that due to the great variety in plants, plant types, and ecological settings, as well as weather patterns, it is difficult to suggest one policy for an infinite variety of scenarios. Reports in mixed prairies show variable response to fire and grazing (Engle and Bidwell, 2001; Willms et al., 2002). In semidesert sagebrush areas, burned and unburned, and grazed and ungrazed, results were variable, and vegetation response often did not progress toward the preburn community composition or a new state (West and Yorks, 2002). These studies provide no indication that a 2-yr rest prior to grazing after a fire is ecologically necessary, but demonstrate that each area and fire circumstance is different and the timing of grazing after a fire is probably best determined site-specifically.

Burned areas with grazing potential include both rehabilitated (seeded) and nonrehabilitated areas. Identical grazing pressure on seeded and unseeded areas can re-

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sult in differential plant community effects (Vallentine, 1971). Additionally, Lynch (2003) indicated that grazing rehabilitated areas during the first 2 yr after fire increased seeding success if the timing of grazing reduced cheatgrass (*Bromus tectorum* L.) competition.

The objectives of this study were to determine the effects of grazing and no grazing on 1) perennial plant cover and density in both fire-rehabilitated (seeded) and unseeded areas; 2) cheatgrass cover and density in both fire-rehabilitated (seeded) and unseeded areas; and 3) plant community diversity in grazed and ungrazed treatments.

MATERIALS AND METHODS

Study Area

The study area was a fire-impacted BLM allotment on the Gund Ranch, operated by the University of Nevada Reno, about 65 km north of Austin, NV, near the geographic center of the state. The ranch is specifically located in Grass Valley, and the allotment runs north to south extending west to east from the valley bench to the top of the Simpson Park Mountains, with a predominantly west aspect. Several streams emanate from the top of the range, creating drainage valleys with north- and south-facing side slopes.

Allotment terrain varies from playa to high mountains, with elevations ranging between 1,700 and 3,000 m. Climate is characterized by warm, dry summers and cool, wet winters. Precipitation ranges from 20 cm in the valley to 40 cm in the mountains (based on records of the Gund Ranch, 2002). Prior to the fire, lower elevations (1,700 to 2,100 m) were dominated by basin big sagebrush (*Artemisia tridentata* sbsp. *tridentata* Nutt.) and black sagebrush (*Artemisia nova* A. Nels.), with an understory of Sandberg bluegrass (*Poa secunda* Presl), bottlebrush squirreltail (*Sitanion hystrix* [Nutt.] J. G. Smith), and Indian ricegrass (*Achnatherum hymenoides* [Roem. & Schutt.] Beckworth). At the mid elevations (2,100 to 2,500 m), vegetation composition was dominated by pinyon pine (*Pinus monophylla* Engelm), Utah juniper (*Juniperus osteosperma* Sarg.), and basin and black sagebrush, with an understory of bottlebrush squirreltail, Thurber needlegrass (*Stipa thurberiana* Piper), Indian ricegrass, Nevada bluegrass (*Poa nevadensis* Vasey ex Scribn.), and basin wildrye (*Elymus cinereus* Scribn. & Merr.). Vegetation in the upper elevations (2,500 to 3,000 m) was primarily low sagebrush (*Artemisia arbuscula* [Nutt.]), big sagebrush, Douglas rabbitbrush (*Chrysothamnus viscidiflourus* [Hook.] Nutt.), and serviceberry (Amelanchier alnifolia [Nutt.] Nutt. Ex. M. Roem.), with an understory of Idaho fescue (*Festuca idahoensis* Elmer), Bluebunch wheatgrass (*Psuedoroegneria spicata* [Pursh] R. Love) Sandberg bluegrass, Nevada bluegrass, and bottlebrush squirreltail. In 1999, a lightning-ignited fire burned nearly all of the allotment (approximately 50 km^2). Included in the burn were all of the vegetation types and areas that were being heavily encroached by Utah juniper and single leaf pinyon pine.

Field Methods

This project was treated as a case study because of the impossibility of replication. The burn was an uncontrolled, natural fire in a unique ecological setting. There was no (nor has there been since) existing similar ecological situations. The experimental design is pseudo-replicated. Replication was impossible; however, this does not mean that important information cannot be gleaned from the study. An all pairwise students *t*-test could have been conducted, but the inflated probability of a Type I error precludes its usefulness here. Our analysis is only relevant to this case. The case study approach is the most reasonable and useful for this situation.

The study area was divided into 4 large blocks (pastures) that had similar vegetation composition, soils, topography, riparian areas, fire intensity, precipitation zones, and historic wildlife and livestock use. The experiment was organized in a randomized complete block design with treatments arranged in a 2 × 2 × 2 factorial with 3 replications. Factors were seeding (seeded or unseeded), grazing (grazed or ungrazed), and years (2001 and 2002). A misapplication of seed by aerial broadcast into one area not meant for seeding forced a design with unequal replications. Pastures were randomly assigned 1 of 4 treatment combinations: 1) seeded and rested for 2 yr (standard practice); 2) unseeded and rested for 2 yr (to examine potential for natural recovery); 3) seeded and grazed as in prefire operations; and 4) unseeded and grazed. The trial was conducted over 2 yr. Treatments were designed to examine impacts of grazing, seeding, or both, on vegetation recovery. The seed mixture (Table 1) was applied aerially at a rate of 13.8 kg pure live seed per ha (12.3 lbs/acre).

Transects were randomly located in each treatment combination, and location recorded by global positioning system. Basal cover of herbaceous species and canopy cover of shrubs were determined by species using the line intercept method (Canfield, 1949). Within each treatment combination area, three 50-m transects were randomly located away from fences and watering points to avoid above average grazing intensities and other associated animal impacts. Density measurements by species were performed using 1-m^2 quadrats located along each transect at 3-m intervals (Hyder and Sneva, 1960) and are reported as plants per 1 m^2. Sampling was performed at the time of peak production,

Table 1. Seed mix species, application rate, and costs

Species	Seeding rate[1]
Bluebunch wheatgrass (*Festuca idahoensis* Elmer)	0.9
Idaho fescue (*Festuca idahoensis* Elmer)	0.9
Basin wildrye (*Elymus cinerus* Scribn. & Merr.)	0.3
Thickspike wheatgrass [*Agropyron dasystachym* (Hook.) Scribn]	9.1
Western wheatgrass (*Agropyron smithii* Rydb.)	1.3
Totals	12.3

[1]Pounds per acre pure live seed.

June 2001 and 2002. Percentage of similarity (number of shared species/total species × 100) was determined for each treatment group by year. Diversity was investigated using cover data for the species occurring in the quadrats by pairing grazing treatment and seeding treatments by year. Grazing and seeding treatments were also paired by year and compared. A Shannon-Weiner index value (Shannon and Weaver, 1949) was calculated for each pairing and then analyzed with a modified *t*-test (Zar, 1999). Sampling was also performed in June of 2000 prior to initiation of grazing treatments and seed germination to insure plant community composition was consistent across all treatment combinations as a quality control measure.

Each block (pasture) was bounded on the upper elevation side by the ridge top. Fences ran from the ridge top to the valley floor. Grazing treatments were implemented in 2000 (after collection of baseline data), without the pastures being rested, at seed set (July), and continued in 2001 and 2002. The grazing period was 60 d, from July 1 through August 31. Stocking rates were designed to achieve 50% utilization. Fences and riders maintained separation of grazing areas, providing uniform utilization within each grazing treatment. Approximately 200 animal unit months were utilized for both grazing treatments, although this number was adjusted annually to match forage produced by variable growing season conditions. The grazing animals were not treated any differently than under standard Gund Ranch conditions, which operate under a standard operating procedure as outlined in FASS (1999).

VassarStats Internet statistical package (Lowry, 2003) was used in all data analysis except for diversity. Percentage of cover data was transformed using the arcsine procedure (Zar, 1999) for analysis, but results are reported as percent. Density and cover differences were de-

Table 2. Number of species, percentage of similarity, mean species richness (SEM), and density of plants per square meter (SEM) for forbs, grasses, shrubs, and cheatgrass in 2000 for all individual treatments and main treatment effects

Treatment	Species by treatment (no.)	Similarity (%)	Mean species richness	Forbs	Grasses	Shrubs	Cheatgrass
Individual treatments (53 total)							
Grazed							
Seeded	38	71.7	14.8 (2.6)	24.0 (12.1)	6.0 (2.2)	0.5 (0.3)	13.6 (8.6)
Unseeded	37	69.8	19.3 (2.8)	29.0 (4.0)	9.6 (1.0)	0.5 (0.5)	15.6 (14.9)
Ungrazed							
Seeded	36	67.9	18.7 (1.8)	34.0 (18.2)	8.0 (6.1)	0.2 (0.3)	13.7 (13.6)
Unseeded	26	49.1	17.5 (0.5)	25.1 (8.8)	10.0 (5.0)	0.3 (0.3)	10.5 (10.5)
Main treatments							
Grazing component							
Grazed	47	88.7	16.7 (2.0)	26.1 (6.7)	7.6 (1.4)	0.5 (0.3)	14.4 (7.2)
Ungrazed	43	81.1	18.2 (1.0)	30.4 (10.6)	8.8 (3.7)	0.3 (0.2)	12.4 (8.2)
Seeding component							
Seeded	48	90.5	16.4 (1.7)	28.3 (9.7)	6.9 (2.6)	0.4 (0.2)	13.6 (6.9)
Unseeded	41	77.4	18.6 (1.6)	27.4 (3.7)	9.8 (1.7)	0.5 (0.3)	13.6 (8.9)

Table 3. Density of plants per square meter (SEM) and percentage of cover (SEM) in the 4 treatment groups and main treatments by year and major plant groupings for 2001 and 2002

Individual treatments	Density				Cover			
	Forbs	Grasses	Shrubs	Cheatgrass	Forbs	Grasses	Shrubs	Cheatgrass
Grazed								
Seeded								
2001	20.9 (6.7)	4.7 (1.8)	0.6 (0.4)	28.8 (9.9)	5.98 (2.15)	5.30 (2.1)	1.48 (1.19)	1.93 (0.96)
2002	20.7 (7.2)	4.9 (2.3)	0.5 (0.3)	180.8 (85.4)	5.79 (3.57)	1.44 (0.76)	2.00 (1.81)	2.92 (1.31)
Unseeded								
2001	11.0 (3.5)	10.2 (2.7)	0.7 (0.6)	12.1 (8.8)	7.50 (5.12)	5.97 (0.96)	2.73 (1.37)	0.43 (0.30)
2002	23.4 (6.3)	11.4 (2.5)	1.2 (0.7)	57.6 (30.6)	7.47 (3.27)	4.11 (1.03)	3.78 (2.12)	2.17 (1.92)
Ungrazed								
Seeded								
2001	29.5 (10.1)	6.2 (4.7)	0.3 (0.3)	14.1 (12.1)	5.03 (1.62)	3.00 (1.86)	1.27 (1.07)	0.77 (0.50)
2002	49.5 (7.2)	6.4 (4.9)	0.2 (0.2)	42.4 (30.5)	8.53 (3.53)	1.81 (1.37)	2.39 (1.99)	1.22 (0.98)
Unseeded								
2001	24.5 (6.1)	5.4 (0.8)	0.9 (0.7)	15.4 (15.4)	1.30 (0.74)	3.45 (0.05)	4.3 (3.50)	3.55 (3.55)
2002	33.4 (7.3)	6.1 (1.9)	1.1 (0.6)	146.9 (143.7)	9.29 (6.79)	1.63 (0.29)	4.79 (4.63)	2.33 (2.33)
Main treatments								
Grazed								
2001	16.7 (4.3)	7.0 (1.8)	0.6 (0.3)	21.6 (7.1)	6.6 (2.3)	5.6 (1.2)	2.0 (0.9)	1.3 (0.6)
2002	21.8 (4.6)	7.7 (2.0)	0.8 (0.3)	128.0 (53.3)	7.0 (2.4)	2.6 (0.8)	2.8 (1.3)	2.6 (1.00)
Ungrazed								
2001	27.5 (6.4)	5.9 (2.6)	0.5 (0.3)	14.6 (8.2)	8.2 (3.2)	3.2 (1.0)	2.5 (1.5)	1.9 (1.3)
2002	43.1 (6.0)	6. (2.8)	0.6 (0.3)	84.2 (54.8)	8.2 (2.8)	1.7 (0.8)	3.4 (1.9)	1.79 (1.0)
Seeded								
2001	24.6 (5.8)	5.3 (2.1)	0.5 (0.2)	22.5 (7.6)	5.6 (1.3)	4.3 (1.4)	1.4 (0.8)	1.4 (0.6)
2002	33.0 (7.5)	5.5 (2.3)	0.4 (0.2)	121.5 (54.8)	6.5 (2.3)	1.6 (0.7)	2.2 (1.2)	2.2 (0.9)
Unseeded								
2001	16.4 (4.3)	8.2 (1.9)	0.8 (0.4)	13.4 (6.9)	9.7 (3.9)	5.0 (0.8)	3.4 1.4)	1.7 (1.4)
2002	27.4 (4.8)	9.3 (2.0)	1.2 (0.4)	93.3 (53.1)	8.8 (2.9)	3.1 0.8)	4.2 (1.9)	2.2 (1.3)

termined at $P \leq 0.05$, and diversity differences at $P \leq 0.1$.

RESULTS AND DISCUSSION

For 2000 there were no differences among the 4 treatment groups for any parameter measured (Table 2); there were no interactions and no block effect, indicating a high degree of similarity between plots. For the 2001 to 2002 analyses, total grass and shrub cover and density were not different (Table 3). There was no difference in forb cover as well; however, grazed and ungrazed treatments differed in forb density (19.3 plants/m^2 vs. 35.3, respectively, P = 0.04, Table 3). The grazed treatment had lower forb density; most individual forb species densities were similar among treatment groups. Greater forb density was due to several dense patches of lupine (*Lupinus caudatus* Kell.) and hawksbeard (*Crepis acuminata* Nutt.) in the ungrazed areas and other plot nuances. Forb density tended to be different between years with lower density in 2001 than 2002 (21.5 plants/m^2 vs. 31.8, respectively, P = 0.09). Forb density was also lower in unseeded treatments, although no forbs were included in the rehabilitation seed mixture.

Cheatgrass density was less in 2001 than 2002 (18.7 plants/m^2 and 109.7, respectively, P = 0.03, Table 4). Cheatgrass increased with time, and both years were dryer than normal. Anecdotal observations indicated the burned area contained little cheatgrass prior to the fire, but gradually increased to 3-yr post-fire levels. There were no differences in main cover effects, nor were there any interactions.

Mean species richness decreased from 2001 to 2002 as annuals common after fire began to decline (Table 4), typical of plant composition response after fire (Parsons and Stohlgren, 1986). Species richness in the seeded and unseeded treatments was different and declined in both treatments between 2001 and 2002 (Table 4). The unseeded groups had a greater mean number of species (seeded 11.8, unseeded 15.4, P = 0.04). There was no evidence that seeded species were dis-

Table 4. Number of species, percentage of similarity, and mean species richness (SEM) in 2001 and 2002 for all treatments

Treatment	Total species	Species by treatment (no.)	Similarity (%)	Mean species richness[1]
2001	46	—	—	—
2002	40	—	—	—
Individual treatments				
Grazed				
Seeded				
2001	—	33	71.7	13.3 (2.2)
2002	—	26	65.0	10.5 (1.5)
Unseeded				
2001	—	33	71.7	16.0 (2.3)
2002	—	26	70.0	15.3 (2.0)
Ungrazed				
Seeded				
2001	—	28	60.9	12.3 (2.6)
2002	—	24	60.0	11.3 (2.4)
Unseeded				
2001	—	27	58.7	16.5 (1.5)
2002	—	19	47.5	13.5 (3.5)
Main treatments				
Grazed				
2001	—	42	91.3	14.4 (1.6)
2002	—	36	90.0	12.6 (1.5)
Ungrazed				
2001	—	36	78.2	14.0 (1.8)
2002	—	29	72.5	12.2 (1.8)
Seeded				
2001	—	41	89.1	12.8 (1.5)
2002	—	32	80.0	10.9 (1.2)
Unseeded				
2001	—	38	82.6	16.2 (1.4)
2002	—	31	77.5	14.6 (1.6)

[1]Mean species richness are different between seeded [11.8 (1.0)] and unseeded [15.4 (1.0)] groups for 2001 and 2002, $P = 0.04$.

placing antecedent native and non-native species. New seedling density was very low.

Diversity index value comparisons indicated no differences for any of the treatments. Both grazing and seeding treatments were not different within or between years. Percentage of similarity showed no differences (Table 4). Fifty-three species of plants occurred in the area 9 mo after the burn, and 40 species were recorded at the end of the study in 2002. Treatment areas were dominated by forbs, followed by grass and a few shrubs for both years of the study. Forb dominance after a fire is common (Hargis and McCarthy, 1986; Parsons and Stohlgren, 1989).

Seeding of burned areas on BLM land where recovery of desirable vegetation is not expected is a commonly followed policy, and in steep or rocky terrain it is typically broadcast-seeded using aircraft, as in this study. A large body of research has shown that aerial seeding is often unreliable (Wagenbrenner et al., 2002) and this coupled with very dry years provided poor results in this study. From 1972 to 2002, average rainfall at the Gund Ranch was approximately 25 cm. Rainfall in 2000 was 20.6 cm, but only 13.25 and 11.25 cm for 2001 and 2002, respectively. These were the 2 driest years of the previous 20. Lack of moisture undoubtedly had an effect on seeding response, and there was no masking of grazing effects due to average or above average soil moisture.

There was no measurable positive or negative effect from grazing, with few differences among treatment combinations. Differences that did occur were artifacts of plot location and inherent variability. There was no evidence detected that grazing enhanced seed-to-soil contact in the seeded areas, and there were no detectable detrimental grazing effects as well. Cheatgrass proliferation was occurring, but occurred equally across all treatment combinations. Grazing utilization was limited to 50% of annual production and was closely monitored. More intense or prolonged grazing may have provided different effects.

IMPLICATIONS

In this study, grazing neither inhibited post-fire recovery nor enhanced it, and aerial seeding was ineffective. The one difference in forb density was due to plot nuances and presence of isolated, but dense, lupine and hawksbeard colonies. Our results indicate that each allotment should be individually evaluated for appropriateness of grazing and seeding after fire, and that blanket recommendations are inappropriate. It is also important to emphasize that grazing protocols were strict and closely followed. Grazing on burned areas immediately after fire should be allowed only with carefully planned protocols and with specific land management objectives in place.

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