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Reducing Cheatgrass Fuel Loads Using Fall Cattle Grazing

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Summary: Cattle grazed a cheatgrass-dominated pasture during the fall dormant period for four years (2006-2009) and were provided a protein nutrient supplement to improve their distribution, uptake of dry feed and production performance. Cheatgrass standing crop was reduced by 43 percent to 80 percent each year, and cattle weight and body condition score increased each year. The fall-grazed site had less cover from cheatgrass than the ungrazed site had. The fall-grazed site also had no decline in perennial grass cover. Cheatgrass density was 64 percent less on the grazed site after two years, and had 19 fewer plants per square foot than the adjacent ungrazed area. The seedbank potential for cheatgrass decreased much more on grazed areas than on the adjacent ungrazed areas, with a 95 percent or greater reduction in the seedbank potential. The difference was due to the grazing treatment.

A partnership of Nevada counties; University of Nevada, Reno; and U.S. Department of Agriculture

Introduction

Cheatgrass (*Bromus tectorum L.*: Figure 1), also known as downy brome, is an annual grass (i.e., completes its life cycle in one growing season) that is native to Eurasia (Figure 2). It typically germinates in the fall, late winter or spring when moisture is available. Plants that germinate in the fall overwinter as seedlings and continue their growth as a "winter annual" in the spring. Cheatgrass invades many plant communities in the Great Basin and Intermountain West and displaces more desired plants, many of which provide valuable forage and/or habitat structure for wildlife. Cheatgrass thrives in disturbed areas, particularly when mineralized soil nitrogen is abundant. In wet years, there may be more than 10,000 cheatgrass plants per square yard. Perhaps the most significant problem with cheatgrass is its high flammability.

Cheatgrass competes for moisture with more desirable plant species on rangelands and pasture (but also cropland) because it often germinates earlier, grows faster and produces more seed than most native grasses and nonsprouting shrubs. Once cheatgrass becomes dense and continuous across large areas, it can shorten the fire-return interval on rangelands. Each subsequent fire typically results in more cheatgrass and fewer native grasses and shrubs. The presence of cheatgrass with its awned seed can reduce available forage, degrade wildlife diversity and habitat, and decrease land values (U.S. Department of Agriculture, 2012). In many situations, cheatgrass can inflict significant economic costs, including lowering weight gain of grazing livestock.

Figure 1. A drawing of a cheatgrass plant, enlarged spikelet and seed. (Source USDA PLANTS database, USDA NRCS PLANTS)

Several attributes make cheatgrass an optimal fine fuel to facilitate rangeland fires. First, it matures four to six weeks earlier in the growing season than most native grasses (except Sandberg bluegrass). Thus, the stems and leaves become dry and flammable earlier in the summer. Second, the fine nature of the abundant leaves and stems allows for rapid drying, which provides continuous fuels with high flammability longer into the fall. Third, each time a sagebrush community reburns quicker than the evolved fire cycle, cheatgrass assumes greater dominance, leading to a downward spiral of degradation. The normal mosaic burn pattern of the Great Basin and Intermountain West have been replaced by large, contiguous fires dominated by cheatgrass, particularly at lower elevations where annual precipitation is less than inches, and particularly on sites receiving less than 10 inches of annual precipitation. The natural fire-return interval for sagebrush plant communities is estimated to have been 30 to 100 years or more, but with the increase in cheatgrass populations, it has become as short as three to five years in some cheatgrass-invaded areas (Schmelzer et al., 2009).

Figure 2. Cheatgrass plant, photo by Sue Donaldson, University Nevada Cooperative Extension

Several biophysical components affect flame length and fire spread, but a typical cheatgrass fire on flat terrain with wind speeds of 20 miles per hour may generate flame lengths up to 8 feet high. These fires can travel more than 4 miles per hour. Grass fires are dangerous because they move quickly, and grasses act as ladder fuels igniting larger and more volatile vegetation that interfaces with shrub-dominated rangelands (Beck et al., 2012).

Cheatgrass Control Methods
Once established, cheatgrass is very persistent and difficult to control. Cheatgrass can be controlled mechanically, biologically, chemically, or by applying prescribed fire under specific conditions. An integrated approach using two or more techniques typically produces the best results. The key to controlling cheatgrass is diligence—once you begin the process, you must be persistent and continue with annual follow-up treatments for up to four or five years. That is the length of time that viable seed remains in the soil (USDA, 2012).

The integration of chemical management tools with cultural practices is recommended for successful control. However, application of these tools across large areas becomes financially and operationally prohibitive. Preventing seed production in the spring reduces the number of seeds in the soil, which may improve the outcome of integrated management. As with other weeds, preventing and minimizing invasion is critical. Practices such as proper grazing management, irrigation management and nutrient management will help maintain the high vigor and density of desired species and reduce the risk of cheatgrass becoming the ecologically dominant species (Menalled et al., 2008).

Since the early 1930s, spring grazing with livestock has been documented to control cheatgrass (Piemeisel, 1938). There are three challenges that spring (growing-season) grazing presents on the sagebrush-perennial grass rangelands of the Great Basin and Intermountain West, and these challenges must be overcome for successful and sustainable grazing (defined as maintaining perennial grasses) to occur. First, the amount of cheatgrass available for grazing varies (often greatly) from year to year, because it is an annual plant with an annual production that is highly dependent on the amount, periodicity and timing of precipitation, especially in the spring growing season (Stewart and Young, 1939; Fulcher and Mathews, 1965). Some years, cheatgrass germinates and establishes in the fall, but in other years, it may not germinate and establish until mid to late spring. The amount of cheatgrass available for spring grazing is always a moving target with large annual variation.

Second, in some years, cheatgrass has grazeable quantities in late winter, whereas in others, there is not enough production for grazing turnout until late spring, if at all. Standing crop on the same site may vary up to tenfold across years (Hull and Pechanec, 1947). This variability is untenable for most livestock operations because of the necessity to maintain stable herd numbers and the inability to plan on a consistent forage base (Young et al., 1987).

Third, perennial grasses and forbs, and palatable shrubs in the plant community may be at risk from overuse during the critical spring grazing period. Daubenmire (1940) noted that to suppress cheatgrass, grazing pressure had to be heavy enough to eliminate virtually all seed production. A small number of scattered but robust plants can produce a large amount of seed, which can rapidly facilitate repopulation of an infested area. Achieving heavy enough utilization levels on cheatgrass in the spring to nearly eliminate seed production almost always results in undesired collateral impact on the perennial species that are needed to fully occupy the site after cheatgrass declines. Although there are fewer ecological concerns about grazing near-monocultures of cheatgrass with few to no perennial grasses, many areas with cheatgrass still have widespread remnant perennial grass populations, which warrant consideration for their response (increase or decrease) to intense grazing during the short spring growing season (Mosley and Roselle, 2006).

Fall Grazing of Cheatgrass
Fall or winter grazing of cheatgrass by livestock as a fuel-reduction strategy is not a new idea (DeFlon, 1986; Tipton, 1994). The livestock production dilemma, however, is that as plants mature and become senescent, they have large declines in nutritional quality (Cook and Harris,1952;

Ganskopp and Bohnert, 2001). Supplementation is generally necessary in the fall when cheatgrass provides the bulk of the forage to ensure that nutritional needs of domestic grazers are met.

Research Objectives

The project goal was twofold: 1) improve understanding about the feasibility of using fall grazing as a management tool to reduce cheatgrass fuel loads and 2) increase understanding about the associated effects on perennial plant community characteristics and cattle performance. Three specific research objectives were established to address these goals: 1) determine the effects of pasture-scale, fall grazing of cheatgrass as a fuels-reduction practice; 2) determine potential plant-community effects; and 3) determine the associated effects on cattle body condition score (BCS) and weight.

Methods

The project was located on the Nevada Agriculture Experiment Station's Gund Ranch, in Grass Valley, north of Austin, Nev. This study site was selected because cheatgrass is widespread (i.e, a continuous fuel) and has large biomass production most years; there is a residual population of desirable bunchgrasses; and the valley bench location is adjacent to an upland site that burned in 1999 but has high-value, native perennial grasses. These conditions are widespread across much of Nevada's valley bottoms and alluvial fans; thus, they represent a common management issue across the state.

All vegetation data were collected along three 686-yard-long parallel transects spaced 164 yards apart, in adjacent grazed and nongrazed (control) areas. The total study area was 1,500 acres, with grazing treatments applied to 705 acres and the remainder left as an ungrazed control acres.

Cattle grazed for 278, 295, 191 and 456 animal unit months during 2006, 2007, 2008 and 2009, respectively. These animal unit months consisted of 185 cows and bulls grazing for 45 days in 2006, 240 animals for 37 days in 2007, 230 animals for 25 days in 2008, and 280 animals grazing for 49 days in 2009. Treatment dates were Oct. 31 to Dec. 14, Sep. 28 to Nov. 3, Sep. 9 to Oct. 4 and Sep. 9 to Oct. 26, during 2006, 2007, 2008 and 2009, respectively. The effect of the grazing treatment on cattle was evaluated with two measurements obtained at the beginning and end of the grazing period each year. These were weight and BCS (1 = emaciated to 9 = obese; Richards et al., 1986). Measurements were obtained on a subsample of about 25 percent of the cattle. All cattle used in the study were at least 5 years old, had a BCS score of at least 4 when turned into the study area, and were bulls or dry cows (calves were weaned before initiation of the study). The dry cows were in either the late-first or early second trimester of gestation.

The recommended nutritional requirement for cows during their second trimester of gestation is 6.2 percent crude protein (CP) and 46 percent total digestible nutrients (TDN) (Nutritional Research Council, 2000). The 2006 assay of cheatgrass nutritional quality found it was deficient in both crude protein and total digestible nutrients (3.4 and 49.6 percent, respectively); therefore, free-choice 14 percent all-natural crude protein liquid supplement (Anipro, XF Enterprises Inc., Greely, Colo.) was provided, formulated to regulate consumption at 1.0 pounds per day, per animal. The supplement was fed in 5-foot-diameter tubs spaced about 220 yards apart and moved periodically to encourage even utilization of the pasture. Protein supplementation was offered each year from 2007 through 2009. A cost analysis was not completed. However, it was estimated that the cattle consumed 1 to 1.5 pounds per head per day at a cost of $0.195 per pound of protein supplement. This would equate to a protein supplement cost of $0.195 to $0.292 per head per day.

Measurements of plant cover, density and pregraze standing crop were collected after plants had reached peak production. Cover was measured in July in both 2007 and 2008 with a 10-point frame

(Heady and Radar, 1958). The density of cheatgrass and perennial grasses was measured just before each fall grazing period with a 10.8-square-foot (1-m^2) circular quadrat. The entire quadrat was used for perennial grasses and one-quarter of it (randomly selected) was used for cheatgrass.

A soil seed-bank assay (Ball and Miller, 1989) was conducted on soil samples collected each September from 2007 through 2009. Soil samples were obtained each year along transects before application of the grazing treatment and after seed dehiscence (splitting of the seed head at maturity). Samples included the carryover seed bank as well as current-year seed production. Seedling emergence was used to determine seed-bank potential and composition.

Results

Fall grazing removed 43 to 80 percent of cheatgrass standing crop each year (Table 1). Grazing met the target of leaving 200 pounds per acre or less of cheatgrass fuel, an amount defined as a fuel load with the potential to generate extreme fire behavior and equivalent to a fire line intensity of 100 BTU (British Thermal Units) per foot square per second (BTU/ft.^{2}/sec) (Launchbaugh et al., 2008). When cheatgrass standing crop was less than 200 pounds per acre at the start of the grazing period, cattle could reduce fuel loads to well less than 100 pounds per acre.

Table 1. Pre- and post-grazing cheatgrass standing crop (lbs./ac.) and percentage (%) utilization in grazed treatment area, 2006 to 2009

Year	Pre-graze	Post-graze	% Removed
2006	442	95	79
2007	197	39	80
2008	66	14	79
2009	87	50	43

Cattle did not lose body weight or BCS during any year of the study (Table 2). Average weight gained per head increased from 16 to 45 pounds during the grazing period, depending upon the year. The gains in BCS each year were small, but most importantly, were never negative. The differences in body weight and BCS before and after the grazing period each year were never statistically significant ($P \leq 0.05$).

Table 2. Mean pre- and post-grazing cattle weights (lbs.), BCS, standard error (±), net gain and number of animals included for 2007 through 2009. (Net gain and BCS scores were not significantly different.)

Item	2007	2008	2009
Weight			
Pre-grazed wt.	1177±15	1192±15	1210±119
Post-grazed wt.	1193±18	1237±15	1241±110
Net gain	16	45	31
BCS			
Pre-grazed BCS	5.5±.07	5.6±.05	4.8±.38
Post-grazed BCS	5.8±.07	6.0±.05	5.0±.38
Net gain	0.3	0.4	0.2
No. of animals	41	57	49

Mean plant cover for cheatgrass in 2007 was similar on grazed and ungrazed sites (Table 3). In 2008, cheatgrass cover on the grazed site was almost 6 percent less than in 2007. Cheatgrass cover on the ungrazed site increased almost 2.5 percent from 2007 to 2008. There was at least a 95 percent chance that the decline in cheatgrass on the grazed site, and corresponding increase on the ungrazed sites, respectively, was due to the grazing treatment applied. Perennial grass cover on grazed sites either increased (crested wheatgrass and Sandberg bluegrass) or remained the same (needle-and-thread) from 2007 to 2008 (Table 3). On ungrazed sites, the cover of both crested wheatgrass and Sandberg bluegrass declined from 2007 to 2008. Needle-and-thread, however, increased on the ungrazed site across the two-year study. None of the changes in cover for the perennial grasses could be attributed to the grazing treatments with a 95 percent or greater probability. Annual forbs (primarily Russian thistle) always had less cover on the ungrazed sites, and declined on both the grazed and ungrazed sites during the study. There was a 95 percent or greater probability that the greater cover from annual forbs on the grazed sites was due to the grazing regime.

Table 3. Mean plant cover (%) by species or lifeform and grazing treatment (grazed and ungrazed) for 2007 and 2008.

Species or lifeform	Treatment	2007	2008	Change (%)
Cheatgrass (AG[1])	*Grazed**	20.8[a]	15.0[a]	-5.8
	Ungrazed	19.8[a]	22.2[b]	2.4
Crested wheatgrass (PG)	Grazed	0.9[a]	1.8[a]	0.8
	Ungrazed	1.6[a]	1.3[a]	-0.3
Needle-and-thread (PG)	Grazed	0.3[a]	0.3[a]	0.0
	Ungrazed	0.4[a]	0.9[a]	0.5
Sandberg bluegrass (PG)	Grazed	3.5[a]	3.9[a]	0.4
	Ungrazed	2.9[a]	1.8[a]	-1.1
Annual forbs	Grazed	3.9[a]	2.5[a]	-1.4
	Ungrazed	1.5[b]	0.7[b]	-0.8

AG[1] = annual grass and PG = perennial grass
* There is a 95% or greater probability that the mean values between years for a given species/lifeform and treatment (i.e., in a row) are different.
[a,b] Mean values within a species/lifeform with different column superscripts have a 95% or greater probability of being different due to the grazing treatment applied.

After two years of grazing, cheatgrass density was 63 percent less on grazed sites and 48 percent less on ungrazed sites (Table 4). The decline in cheatgrass density on both the grazed and ungrazed sites from 2007 to 2008 reflects a general climatic effect between the two years. However, there is at least a 95 percent probability that the 15 percent greater decline for cheatgrass on the grazed site is from the fall grazing regime. The response of annual forbs was similar to cheatgrass. Annual forbs declined 72 percent on the grazed site and 56 percent on the ungrazed area. Changes in density for other species were small and probably not biologically significant.

Species or Lifeform	Treatment	2007	2008
Cheatgrass (AG[1])	*Grazed**	85[a]	31[a]
	*Ungrazed**	96[a]	50[b]
Crested wheatgrass (PG)	Grazed	0.06[a]	0.08[a]
	*Ungrazed**	0.06[a]	0.14[b]
Needle-and-thread (PG)	Grazed	0.10[a]	0.04[a]
	Ungrazed	0.00[b]	0.00[b]
Sandberg bluegrass (PG)	Grazed	0.87[a]	0.81[a]
	Ungrazed	0.42[b]	0.76[a]
Annual forbs	*Grazed**	3.33[a]	0.93[a]
	*Ungrazed**	0.44[b]	0.19[b]

Table 4. Plant density (plants/ft.^{2}) by category and grazing treatment (grazed and ungrazed) for 2007 and 2008.

AG[1] = annual grass and PG = perennial grass.
* There is a 95% or greater probability that the mean values between years for a given species/lifeform and treatment (i.e., in a row) are different.
[a,b] Mean values within a species/lifeform with different column superscripts have a 95% or greater probability of being different due to the grazing treatment applied.

There was a clear trend of decreasing cheatgrass standing crop on the grazed compared to the ungrazed sites (Table 5), and there was a 95 percent or greater chance the decline was due to the fall grazing treatment. On the grazed site, cheatgrass standing crop in 2009 was 55 percent less than in 2007. However, cheatgrass standing crop on the ungrazed site had increased 2 percent compared to 2007. In 2009, there was three times as much cheatgrass standing crop on the ungrazed site than on the adjacent grazed area. The trend for crested wheatgrass and annual forbs was similar (Table 5). After three years, standing crop for both plant types increased dramatically on both the grazed and ungrazed areas, with the percentage of increase being similar on both the grazed and ungrazed sites. Crested wheatgrass, however, had become the primary forage species on the grazed site, but remained secondary forage on the ungrazed area. The increase in crested wheatgrass standing crop on grazed areas appears to be from a dramatic increase in plant size since crested wheatgrass density only increased 0.2 plants per square foot on the grazed site. Larger plants will have larger root systems. Thus, the decline in cheatgrass and associated increase in crested wheatgrass (with dormant-season grazing) may be sufficient to tilt the competitive balance in favor of perennial species, provided the current grazing regime remains intact.

Dormant-season grazing dramatically decreased cheatgrass seed-bank potential compared to the ungrazed area (Table 6). In 2007, the grazed area had almost 1,000 plants per square foot, which was165 more plants per square foot than the ungrazed site. After three years, the grazed site had 83 percent fewer cheatgrass seeds per square foot, while the ungrazed site had 62 percent fewer

Table 5. Annual standing crop (lbs./ac.) by plant species/type and grazing treatment (grazed and ungrazed) for 2007 through 2009.				
Species or lifeform	**Treatment**	**2007**	**2008**	**2009**
Cheatgrass (AG[1])	*Grazed**	197^{ad}	66^{bd}	87^{cd}
	*Ungrazed**	262^{ae}	120^{be}	267^{ae}
Crested wheatgrass (PG)	*Grazed**	55^{ad}	141^{bd}	474^{cd}
	*Ungrazed**	22^{ae}	211^{bd}	187^{be}
Needle-and-thread (PG)	Grazed	12^{ad}	13^{ad}	
	Ungrazed	0^{ad}	0^{ad}	
Sandberg bluegrass (PG)	Grazed	14^{ad}	17^{ad}	
	Ungrazed	8^{ae}	20^{ae}	
Annual forbs	*Grazed**	82^{ad}	172^{bd}	500^{cd}
	*Ungrazed**	30^{ae}	231^{be}	191^{be}

AG[1] = annual grass and PG = perennial grass.
* There is a 95% or greater probability that the mean values between years for a given species/lifeform and treatment (i.e., in a row) are different.
[a,b,c] Row mean values within a species/lifeform and treatment with different superscripts have a 95% or greater probability of being different by year.
[d,e] Column means within a species/lifeform with different superscripts have a 95% or greater probability of being different due to the grazing treatment applied.

Cheatgrass seeds per square foot. More importantly, the grazed area had 142 fewer cheatgrass seeds (i.e., potential plants) per square foot than the ungrazed areas. The consistency and magnitude of this change (fewer germinable seeds on grazed vs ungrazed sites) in both 2008 and 2009 strongly suggests that dormant-season grazing can dramatically decrease the potential seed bank of cheatgrass. Equally important is the ***apparent*** lack of any adverse effect on the potential seed bank of desired perennial grasses due to dormant-season grazing (Table 6). The density of seed from both crested wheatgrass and needle-and-thread both increased slightly on grazed sites, and the percent decline of Sandberg bluegrass was similar on the grazed (23 percent) and ungrazed (20 percent) sites. The results for the perennial grasses, however, are less conclusive because data were not collected in 2009. Seed bank potential for annual forbs appeared to respond more to annual conditions than to grazing regime, which suggests a weather-driven process. As with the perennial grasses, the data collection period was too short to make a strong definitive conclusion.

Table 6. Seed-bank potential (average number of plants/ft.^{2}) by category and grazing treatment (grazed and ungrazed) for 2007 through 2009. Blank cells indicate data was not collected for that species or lifeform that year.				
Species or lifeform	**Treatment**	**2007**	**2008**	**2009**
Cheatgrass (AG[1])	*Grazed**	991^{ac}	190^{bc}	169^{bc}
	*Ungrazed**	826^{ad}	347^{bd}	311^{bd}
Crested wheatgrass (PG)	Grazed	7.4^{ac}	16^{ac}	
	Ungrazed	7.4^{ac}	9^{ac}	
Needle-and-thread (PG)	Grazed	0^{ac}	3^{ac}	
	Ungrazed	8^{ac}	0^{ac}	
Sandberg bluegrass (PG)	Grazed	83^{ac}	64^{ac}	
	Ungrazed	234^{ad}	187^{ad}	
Annual forbs	*Grazed**	138^{ac}	67^{bc}	
	*Ungrazed**	91^{ac}	36^{bc}	

AG[1] = annual grass and PG = perennial grass.
* There is a 95% or greater probability that the mean values between years for a given species/lifeform and treatment (i.e., in a row) are different.
[a,b,c] Row mean values within a species/lifeform and treatment with different superscripts have a 95% or greater probability of being different by year.
[d,e] Column means within a species/lifeform with different superscripts have a 95% or greater probability of being different due to the grazing treatment applied.

Conclusions

This case study demonstrated that a prescription of fall grazing met the management target of reducing cheatgrass standing crop at the end of the grazing period to 100 pounds or less per acre, without placing the grazing animal or plant community at risk. The reduction of cheatgrass to the target level decreased residual fuels carried over on the site to the next fire season.

Prescription fall (dormant-season) grazing eliminates many of the planning challenges associated with spring-based (growing-season) grazing systems. Such targeted grazing can also shift the competitive balance between cheatgrass and perennial grasses within a short time period and is likely to maintain the shift as long as an appropriate grazing treatment is applied on a regular basis. The cheatgrass seed bank still remained relatively high after three years of fall grazing, despite a very large decline (83 percent). Therefore, permanent cessation of the fall grazing treatment would likely result in a return of cheatgrass dominance and unacceptable fuel loads. It is possible that the perennial plant community may increase to a point where cheatgrass standing crop is moderated without repeated applications of grazing prescriptions. This can happen if spring/summer grazing management provides periodic rest during the growing season so the perennial grasses retain enough leaf area to produce a large amount of carbohydrates that can be invested in large root systems (to acquire water and nutrients), and a large number of buds used to regrow large plants the next growing-season.

By predetermining the nutritional quality of cheatgrass, a prescription can be crafted so that detrimental effects to livestock health and the desirable plant community can be minimized or avoided.

Although the economic inputs and outcomes of the prescription were beyond the scope of this study, fuel reductions through prescribed grazing of cheatgrass will likely lower fire-related costs and risks associated with human life, property and resource degradation. Prescribed fall grazing may have particular utility as a fire-break tool for areas with highly regarded resource values, such as critical wildlife habitat areas and wildland-urban interfaces. Like all management tools, prescribed grazing of cheatgrass to reduce fuel loads is not a one-size-fits-all solution to cheatgrass management issues. Any prescription plan has to address the needs and constraints (biological, ecological, operational and economic) of the ecological site and its existing plant community, the livestock used to graze the site, and the operator/manager of those livestock.

For a report of the entire study, *Case Study: Reducing cheatgrass (Bromus tectorum L.) fuel loads using fall cattle grazing*, go to: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CCgQFjAB&url=http%3A%2F%2Fwww.msuextension.org%2Fcounties%2FStillwater%2Farticles%2FFall%2520Grazing%2520Cheatgrass%2520Thesis.pdf&ei=3yBIVPPWJeKIigKI1oHQDg&usg=AFQjCNFF4HaI4ZV5PGzif1yKaknodXzHUg&sig2=U-enHsO5gvp99YIJIvp8-A&bvm=bv.77880786,d.cGE.

Publications Cited

Ball, D. A., and S. D. Miller. 1989. A comparison of techniques for estimation of arable soil seedbanks and their relation to weed flora. Weed Research 29:365–374.

Beck, G., J. Davison, and E. Smith, 2012. Cheatgrass and wildfire, Colorado State University Extension, Fact Sheet No. 6.310.

Cook, W. C., and L. E. Harris. 1952. Nutritive value of cheatgrass and crested wheatgrass on spring ranges of Utah. Journal of Range Management 5:331–337.

Daubenmire, R. F. 1940. Plant succession due to overgrazing in the *Agropyron* bunchgrass prairie of southeastern Washington. Ecology 21:55–64.

DeFlon, J. G. 1986. The case for cheatgrass. Rangelands 8:14–17.

Fulcher, G., and W. Mathews. 1965. Discussion. Pages 81–83 in Proceedings of the Cheatgrass Symposium, Vale, Ore. U.S. Department of Interior, Bureau of Land Management, Portland, Ore.

Ganskopp, D., and D. Bohnert. 2001. Nutritional dynamics of 7 northern Great Basin grasses. Journal of Range Management, 54:640–647.

Heady, H. F., and L. Radar. 1958. Modifications of the point frame. Journal of Range Management, 11:96–98.

Hull, A. C., and J. F. Pechanec. 1947. Cheatgrass: a challenge to range research. Journal of Forestry 45:555-564.

Launchbaugh, K. L., B. Brammer, M. L. Brooks, S. C. Bunting, P. Clark, J. Davison, M. Fleming, R. Kay, M. Pellant, D. Pyke, and B. Wylie. 2008. Interactions among livestock grazing, vegetation type, and fire behavior in the Murphy Wildland Fire Complex in Idaho and Nevada, July 2007. Open-File Report 2008–1214. U.S. Geological Survey, Reston, Virg.

Menalled, F., J. Mangold, and E. Davis, 2008, Cheatgrass: identification, biology and integrated management, Montana State University Extension, Mont. 200811AG New 10/08.

Mosley, J. C., and L. Roselle. 2006. Targeted livestock grazing to suppress invasive annual grasses. Chapter 8 in Targeted Grazing: A Natural Approach to Vegetation Management and Landscape Enhancement. Accessed April 5, 2013. http://www.webpages.uidaho.edu/rx-grazing/Handbook.htm.

National Research Council, 2000. Nutrient requirements of domestic animals. No. 7 Nutrient Requirements of Beef Cattle. National Acadamy of Sciences and National Research Council, Washington, DC.

Piemeisel, R. L. 1938. Changes in weedy plant cover on cleared sagebrush land and their probable causes. U.S. Department of Agriculture Technical Bulletin No. 654. Washington, D.C.

Richards, M. W., J. C. Spitzer, and M. B. Warner. 1986. Effect of varying levels of postpartum nutrition and body condition at calving on subsequent reproductive performance in beef cattle. Journal of Animal Science 62:300–306.

Schmelzer, L., 2009. Fall back to cheatgrass grazing, Progressive Rancher Magazine. June/July, 2009 issue, pages 16-17.

Schmelzer, L., B. Perryman , B. Bruce , B. Schultz , K. McAdoo , G. McCuin , S. Swanson, J. Wilker, and K. Conley Ⅱ. 2014. Case Study: reducing cheatgrass (*Bromus tectorum* L.) fuel loads using fall cattle grazing. The Professional Animal Scientist 30:270–278.

Stewart, G., and R. A. Young. 1939. The hazard of basing permanent grazing capacity on *Bromus tectorum*. Agronomy Journal 31:1002–1015.

Tipton, F. H. 1994. Cheatgrass, livestock, and rangeland. Pages 414–416 in Proceedings,— Ecological Management of Annual Rangelands. S. B. Monsen and S. G. Kitchen, compilers. U.S. Department of Agriculture Forest Service General Technical Report INTGTR-313., Intermountain Forest and Range Experiment Station, Ogden, Utah.

U.S. Department of Agriculture Forest Service, 2012. Field guide for managing cheatgrass in the Southwest, TP-R3-16-4.

Young, J. A., R. A. Evans, and B. L. Kay. 1987. Cheatgrass. Rangelands 9:266–270.