Boulder County Parks and Open Space Small Grants Final Report 2009

Managing Downy Brome Seed Production and Litter to Exhaust its Soil Seed Reserve

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Section 1: Abstract

Downy brome (*Bromus tectorum* L.) is a noxious winter annual weed that has invaded over 100 million acres in the western U.S. It degrades rangeland and natural areas, decreases crop yields, and is a tremendous fire hazard. An experiment was initiated where management targeted seed production, which is a fundamental mechanism for its survival and persistence over time. The current year seed production and litter was removed as a first step to exhaust its soil seed reserve. The experiment is a 3 (mowing heights) by 2 (seed/litter treatments) by 2 (herbicide treatments) factorial arranged as a randomized complete block. Treatments to remove seed and litter were invoked when downy brome was at the end of its life cycle but before seed dispersal (June 22, 2009). Plateau was applied in July, 2009 before the late summer/fall generation of downy brome germinated. Removal of litter, regardless of mowing height, resulted in decreased downy brome cover in October compared to the non-treated control plot. Downy brome cover in non-treated control plots was almost 20-fold greater than where downy brome was mowed at 6 inches, litter removed, and sprayed with Plateau; mowed at 6 inches and litter removed; and mowed at 2 inches, litter removed, and sprayed with Plateau.

Section 2: Introduction and Literature Review

Downy brome, or cheatgrass, is an invasive annual grass that is a huge problem throughout the western U.S. Downy brome often is depicted as a poster child for invasive species because of the tremendous ecological and economic damages that it causes. We understand how to manage downy brome in many situations but the sheer magnitude of the problem is so daunting that management programs often are not applied long enough to be effective or they are not applied at all. Downy brome litter protects seedlings from desiccation in semi-arid to arid environments thus, allowing completion of its life cycle and

production of the next generation of plants; and litter also binds up applied herbicides making them unavailable to eliminate seedlings. Because downy brome only reproduces by seed, the key to its successful management is to exhaust its soil seed reserve. Managing downy brome seed production and litter targets a fundamental biological and ecological survival mechanism of this invasive weed in semi-arid environments, such as the shortgrass steppe of Colorado.

Downy brome infests over 100 million acres in the western U.S. (Whisenant 1990). Its native range is much of Europe, the northern rim of Africa, and southwestern Asia (Young, 2000; Novak and Mack 2001). Downy brome success in the U.S. is attributed to it evolving under similar conditions in its native range and being preadapted to western rangeland (Mosley et al. 1999). Because downy brome reproduces only from seed, the key to its successful management is to eliminate its soil seed reserve. Seedbed characteristics, such as litter, soil texture, and microtopography affect germination of downy brome seeds (Evans and Young 1970, 1972; Young and Evans 1973). Downy brome will germinate and establish on bare mineral soil in mesic parts of the northern mixed-grass prairie and Pacific bunchgrass biomes but in drier environments, downy brome must be covered by soil or litter to successfully establish (Evans and Young 1972, 1987). Hulbert (1955) observed that all or nearly all downy brome seeds germinated in the field when conditions were favorable and indicated that ungerminated seeds rarely survived longer than 1 year. More recently however, researchers found that downy brome seeds survive 2 to 3 years in the soil (Evans and Young 1987; Young and Evans 1975). Upon dispersal on the Great Plains, downy brome seeds display an after-ripening period (Meyer et al. 1997) that prevents precocious germination during hot dry summer months that would cause seedling death. Downy brome seeds dispersed into unfavorable microenvironments may acquire secondary dormancy (Young et al. 1969), which creates the 2 to 3 year soil seed reserve. Other researchers have examined mowing to manage downy brome. Populations in Northeast Preserves in Oregon were decreased after 3 years of mowing (Rice and Randall 1999) while repeated mowing at 3-week intervals during spring and summer was as effective as glyphosate at another Oregon location (Ponzetti 1997). However, developing plants were targeted in both studies as opposed to exhausting the soil seed reserve. Downy brome is exceptionally competitive and depletion of soil moisture is one of its principal mechanisms

by which it eliminates perennial grasses (Melgoza et al. 1990; Melgoza and Nowak 1991) and the use of soil moisture during the winter and early spring months is one of the primary reasons that seeding efforts to replace downy brome fail (Mosley et al. 1999). High fecundity during times of good environmental conditions (Young et al. 1987) and successful seed production during unfavorable conditions (Tisdale and Hironaka 1981) are keys to downy brome persistence in the western U.S. (Mosley et al. 1999). We hypothesize that managing downy brome seed production and litter by removing its current generation of seed immediately before dispersal and collecting litter will dramatically decrease its soil seed reserve the first year such management is imposed, and will eliminate its soil seed reserve within 2 to 3 years. Such an approach will significantly improve the probability of seeded species establishment and foster successful management and reclamation of downy brome infested sites.

Section 3: Methods

We initiated an experiment to test the hypothesis that mowing to collect seed and litter will exhaust the soil seed reserve of downy brome. The experiment is balanced and designed as a 3 (mowing heights; zero, 2 inches, and 6 inches tall) by 2 (seed/litter treatments; leave seed/litter on site and collect seed/litter to remove from site) by 2 (herbicide treatments; with and without Plateau at 8 fl oz product/A) factorial arranged as a randomized complete block. All treatments were replicated four times and plot size is 10 by 30 ft. We established the experiment in a downy brome monoculture to provide the best opportunity to test the hypothesis. There are 10 treatments:

1. No mow, no herbicide (control treatment);
2. No mow, Plateau 8 fl oz/A;
3. Mow 2 inches tall, leave seed and litter, no herbicide;
4. Mow 2 inches tall, leave seed and litter, Plateau 8 fl oz/A;
5. Mow 2 inches tall, collect seed and litter, no herbicide;
6. Mow 2 inches tall, collect seed and litter; Plateau 8 fl oz/A;
7. Mow 6 inches tall, leave seed and litter, no herbicide;

8. Mow 6 inches tall; leave seed and litter, Plateau 8 fl oz/A;
9. Mow 6 inches tall, collect seed and litter, no herbicide;
10. Mow 6 inches tall, collect seed and litter, Plateau 8 fl oz/A.

Mowing treatments were imposed when downy brome was at the end of its life cycle, just before seeds were dispersed June 22, 2009. Plateau was applied on July 15, 2009. Baseline data were taken on June 18, 2009 before treatments were imposed and included cover of downy brome and cover of all other species (by species) and soil cores. The latter were taken in each plot using a 0.25 m^2 quadrat; four 2.25" soil cores were collected from within the quadrat that was randomly located four times within each plot. . Cover and soil cores were taken again in October to determine the influence of treatment. The 16 soil cores that were taken from each plot were pooled and returned to the university to determine seed numbers. Soil was placed in flats and watered regularly and emerged downy brome seedlings were counted and removed daily day for 3 weeks. Remaining downy brome seed was carefully hand-removed by sifting soil. All data were subjected to analysis of variance and treatment means were separated using Tukey's HSD. We tried using a soil elutriator from USDA-ARS but successful removal of seed by this method failed. We will collect cover data (not soil cores) in March and April, 2010 to obtain another dataset on the effect of treatments in this experiment.

Section 4: Results

There were no differences among treatments for any baseline data (Tables 1 and 2) thus, the experiment was free from bias before treatments were initiated. Baseline downy brome cover ranged from 83 to 94% and averaged 89%. Cover of all other species (kochia, prickly lettuce, and annual rye was less than 4%. Baseline seed data are reported as seeds/0.25 ft^2 of soil surface because sixteen 2.25 inch soil cores were taken in each plot and because most seed are located in the litter and on the soil surface. Soil cores taken comprised about 0.08% of the surface area of any plot and multiplying seed data by the inverse of 0.08% will produce an estimate of downy brome seeds per plot for a given treatment.

Treatments were invoked in June and treatment effects were noticeable at the October data collection. Downy brome cover differed by treatment and ranged from 0.3 to 38%. Removal of litter, regardless of mowing height, resulted in decreased downy brome cover in October compared to the non-treated control plot (Table 1). Much of the seed produced by the 2008-09 downy brome plants was collected during mowing (for those treatments where litter was collected) thus, allowing fewer individuals to successfully germinate and establish in fall 2009. Using Plateau also had an effect as long as litter was removed or mowing height was 2 inches. Mowing at 6 inches, removing litter, and spraying Plateau allowed 3.1% downy brome cover, mowing at 6 inches and removing litter produced 2.4% cover, and mowing at 2 inches, removing litter, and spraying Plateau produced 0.3% downy brome cover and these three treatments produced less downy brome cover than the non-treated control plots. Variation across the study area for downy brome cover was fairly substantial and differences due to treatment were not overly pronounced. Cover of other species was taken in October and no differences were found among treatments even though kochia cover was quite high in some plots. Again, variability masked any treatment differences.

As anticipated, baseline soil seed numbers were very low and there were no differences among plots before treatments were invoked. Mowing to a 2-inch height, collecting litter, and using no herbicide produced fewer downy brome seeds in the soil seed reserve at the October data collection than mowing to a 6-inch height, leaving the litter, and using no herbicide, and the control where no treatments were exerted. The effect of short stubble and no litter apparently had an immediate influence on soil seed numbers but this treatment did not differ from the similar stubble height and litter management plus using Plateau, which was somewhat surprising. It is distinctly possible that removing the soil cores from plots treated with Plateau eliminated the effect of Plateau on germinating seedlings (i.e., in intact plots, one would anticipate that the germinating seedlings would not survive after the herbicide was absorbed). Cover data in spring 2010 will help to determine whether this was the case or not. No other treatments differences were observed from the October dataset. Also, no treatment differences were observed within the November downy brome seed collection.

We will invoke treatments again in 2010 to continue to test our hypothesis that we can exhaust the downy brome soil seed reserve by mowing and collecting the litter.

Treatment	Downy brome		Kochia		Prickly lettuce		Annual rye	
	% Cover							
	Baseline	Oct 8	Baseline	Oct 8	Baseline	Oct 8	Baseline	Oct 8
Mow 6" + litter; + Plateau	89 a	28 abc	0.4 a	33 a	1.9 a	0 a	3.1 a	0 a
Control; no mow or herbicide	85 a	38 a	3.8 a	31 a	0 a	0 a	1.9 a	0 a
Mow 2" + litter; no herbicide	83 a	6 bc	1.4 a	29 a	2.5 a	0 a	1.3 a	0 a
Mow 2" no litter; no herbicide	93 a	4.6 bc	1.8 a	4.5 a	0.6 a	0 a	0 a	0 a
Mow 6" no litter; + Plateau	88 a	3.1 c	2.3 a	28 a	0 a	0.6 a	1.3 a	0 a
No mow + Plateau	89 a	34 ab	0.3 a	12 a	0 a	0 a	1.9 a	0 a
Mow 6 " no litter; no herbicide	94 a	2.4 c	1.5 a	14.4 a	1.3 a	0 a	1.9 a	0a
Mow 2" no litter; + Plateau	94 a	0.3 c	3.4 a	3.3 a	0 a	0 a	0a	0 a
Mow 2" + litter; + Plateau	90 a	4.3 bc	0.5 a	19.4 a	0 a	0 a	2.5 a	0 a
Mow 6" + litter; no herbicide	89 a	21 abc	0 a	22 a	0 a	0a	3.8 a	0 a

Table 1. Baseline percent cover by plant species collected June 18, 2009 and percent cover by species as influenced by treatment collected October 8, 2009. Means followed by the same letter are not different; Tukey's HSD (0.05).

Treatment	Downy brome seeds/0.25 ft^2		
	Baseline	October 8, 2009	November 17, 2009
Mow 6" + litter + Plateau	5.5 a	416 ab	473 a
Control; no mow, no herbicide	1.0 a	866 a	468 a
Mow 2" + litter, no herbicide	1.5 a	506 ab	459 a
Mow 2" no litter, no herbicide	1.3 a	294 b	298 a
Mow 6" no litter + Plateau	0.3 a	471 ab	285 a
No mow + Plateau	0.8 a	648 ab	512 a
Mow 6" no litter, no herbicide	0.3 a	651 ab	370 a
Mow 2" no litter + Plateau	1.0 a	301 ab	271 a
Mow 2" + litter + Plateau	1.3 a	530 ab	382 a
Mow 6" + litter, no herbicide	0.0 a	754 a	594 a

Table 2. Baseline downy brome seeds per 0.25 ft^2 of soil surface and number of seeds per 0.25 ft^2 of soil surface as influenced by treatment and collected October 8, 2009. Means followed by the same letter are not different; Tukey's HSD (0.05).

Section 5: Discussion

It is apparent that removal of litter had an impact on downy brome plants that were present when cover data were taken in fall 2009. Most of the seed was harvested and removed with those treatments where litter was collected and this simple procedure can have a profound effect on subsequent generations of downy brome, However, this is only the first of several years where such treatments would have to be exerted to exhaust the downy brome soil seed reserve.

An insufficient rate of Plateau was applied to effectively control germinating seedlings in those plots where litter was not collected as part of the treatment combination. The effect of litter can be overcome by increasing the rate of the herbicide but 8 fl oz/acre is a fairly standard rate and

one often used by public land managers where Plateau is part of the management approach. Alternatively, as was previously mentioned above, removing soil cores from plots negated the effect of Plateau because the herbicide layer in intact soil could have been dramatically altered and an insufficient amount of herbicide then was available to exterminate germinating seedlings. Plating out the soil into flats may have markedly disturbed the layer of Plateau that otherwise would have been present in intact plots and caused seedlings to succumb to treatment. Treatments with high seed numbers in October (e.g. the control and mowing to a 6-inch height, leaving litter in place, and not using a herbicide) generally had lower seed numbers in November, likely caused by recruitment earlier in the fall thus, decreasing the soil seed bank by normal biological means.

This experiment needs to be continued to adequately test the hypothesis that mowing and collecting litter (with or without the use of Plateau) can be used to exhaust the downy brome soil seed reserve causing its eradication.

Section 6: Conclusions

This is an experiment in progress and final conclusions will be withheld until it is complete. At this time, however, it is apparent that one can decrease the population of the next generation of downy brome by mowing and collecting the litter just before downy brome sets seed. Such a labor intensive approach would have to be restricted to high value areas to justify the expenditure. The other possible mechanism to exhaust downy brome seed in this experiment is the use of Plateau but we did not observe 100% control in plots where it was included in the treatments. However, seedlings that occurred in Plateau treated plots (and in other plots as well) will have to survive the winter and those results will not be known until next spring. It is foolhardy to anticipate eradication of a highly successful invasive weed such as downy brome by exerting a system of management for only one season. Re-applying treatments in 2010 likely will produce more differences among treatments in fall 2010 and spring 2011 and exhaustion of downy brome seed in some treatments may be closer to fruition than fall in 2009.

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