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RESEARCH NOTE

Integrated Treatment With a Prescribed Burn and Post-emergent Herbicide Demonstrates Initial Success in Managing Cheatgrass in a Northern Colorado Natural Area

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ABSTRACT: Eradicating the invasive species cheatgrass (Bromus tectorum) presents a significant challenge to land managers across the western United States and can require integrated and adaptive management, including biological, chemical, and prescribed fire control strategies. Resource managers in the Larimer County Open Space Program in Northern Colorado began a cheatgrass reduction program at the Devil's Backbone Open Space preserve that consisted of prescribed burns in fall 2007 and spring 2008, followed by post-emergent imazapic treatments at 0.44 L/ha. The fire was characterized as a slow-moving, highly consumptive burn, and managers monitored results intermittently following the integrated treatments. Post treatment, average cheatgrass cover was reduced from 82% to 9% from 2007 to 2009 based on six permanent monitoring transects. While quantitative data was not taken for the emergence of native grasses and forbs, incidence of bare ground did not increase significantly following treatment. This case study suggests a highly consumptive burn can decrease cheatgrass from the seed bank and create favorable conditions for vegetation other than cheatgrass to return. More research and long-term monitoring building upon this pilot study could help to understand if this combined treatment is a viable long-term reduction strategy.

Index terms: Bromus tectorum, Colorado Front Range, imazapic, integrated management, prescribed burns

INTRODUCTION

Cheatgrass (*Bromus tectorum)*, a non-native invasive annual grass, has the ability to establish monotypic stands and occupy a range of sites with a wide variety of temperature and moisture conditions (Young and Allen 1997). Cheatgrass expansion continues to present a formidable challenge for natural area managers, as underscored by the $20 million annual cost attributed to cheatgrass invasion in the Great Basin (Knapp 1996). Cheatgrass expansion in Colorado is less studied, but it is becoming an increasing problem as climate change models predict an elevated invasion risk (Bradley 2009). Biodiverse, ecotonal regions, like the Front Range of Northern Colorado, are especially threatened by cheatgrass invasion because they host rare plant species and communities like Bell's twinpod (*Physaria belli*) and New Mexico feathergrass (*Cercocarpus montanus / Hesperostipa neomexican*) (Colorado Natural Heritage Program 2011).

Management options to control cheatgrass include biological, chemical, and fire management, each presenting opportunities and challenges. Chemical control can be effective in decreasing cheatgrass; however, treatments often must be repeated for multiple years to achieve the desired reduction (Zouhar 2003). The herbicide imazapic (Plateau®) can selectively control cheatgrass by spraying pre- and post-emergence with limited adverse effects on some species of perennial grasses, including some native wheatgrass species (Shinn and Thill 2002; Dewey et al 2003; Kyser et al. 2007). However, higher rates of application can adversely impact some native shrub communities (Vollmer and Vollmer 2008; Baker et al. 2009).

In post-fire conditions, cheatgrass often expands, taking advantage of resource availability and dispersing seed (Young et al. 1987). Fires occurring prior to cheatgrass seed dispersal often do not effectively control the viable seed bank, which can later germinate and reestablish (Young et al. 1969). While in many cases cheatgrass responds positively to fire, research suggests that prescribed fires with adequate fuel loads and higher intensities could reduce cheatgrass cover by controlling germination (Keeley and McGinnis 2007). Additionally, timing and intensity of prescribed fires can vary in the impact on target species, total area consumed, and proportion of seedbank reduction (Ditomaso et al. 2006). While a single burn may lead to initial decreases of cheatgrass, recovery of the species often occurs after an additional two to three years if native perennial seedlings fail to establish within the first growing season (Mosely et al. 1999). However, repeated prescribed burning may be prohibited, impractical, or inappropriate as a stand-alone management strategy (Ditomaso et al. 2006).

Prescribed burning to control invasive weeds, including cheatgrass, has been indicated to improve the effect of foliar herbicide applications by removing biomass, thatch, and older plant tissues, allowing for direct herbicide contact with the soil (Ditomaso et al. 2006). In a study conducted in a Wyoming Habitat Management Area, a wildfire burn followed by imazapic application suppressed cheatgrass by 65% to 95% in comparison to a 30% to 50% suppression with herbicide treatment alone (Admundson, unpubl. data). An improved effect of imazapic to reduce cheatgrass has also been observed following prescribed burns; however, this strategy has yet to be fully explored (Ditomaso et al. 2006).

We evaluated the results of an experimental integrated management effort at the Devil's Backbone Open Space preserve in Larimer County, Colorado. The preserve is managed by the Larimer County Open Space Program, which established a management objective to decrease cheatgrass cover to less than 25% and increase the cover of native grasses and forbs from 2007 to 2010 (Larimer County Open Space 2006). To meet this objective, the Larimer County Open Space Program implemented an adaptive management plan consisting of a combination of two prescribed burns and multiple applications of imazapic. Here, we investigated the results of this management plan and its effect on decreasing cheatgrass cover over a three-year period.

MATERIALS AND METHODS

The study site is a natural area located northwest of Loveland, Colorado, covering approximately 607 hectares and receiving an average of 384 mm of precipitation per year with an average temperature of 9.44 °C (Western Regional Climate Center 2005). Soils in the area include haplustolls and altvan loams (USDA Natural Resources Conservation Service 2009). The vegetation is classified as a combination of Rocky Mountain Lower Montane Foothills Shrublands, Western Great Plains Foothill, and Piedmont Grasslands (USGS National Gap Analysis Program 2004). Primary vegetation includes cheatgrass as well as western wheatgrass (*Agropyron smithii*), blue grama (*Bouteloua gracilis*), fringed sage (*Artemisia frigida*), rabbitbrush (*Chrysothamnus nauseosus*), and cottonwood trees (*Populus augustifolia*). The elevation is 1615 m on average (USGS 2009). The natural fire regime for this region is variable, as ecotonal regions like the study site generally exhibit variable fire regimes highly dependent on site-specific variables (Drecker 2007a,b). The area previously experienced impact from domestic livestock (Larimer County Open Space 2006).

Prior to treatment, six 50-m transects were permanently established in the proposed burn area using a GIS-based stratified random sampling technique (Theobald et al. 2007). On 8 October 2007, four of six transects were fixed within the boundaries of the planned fall 2007 prescribed burn area, and the final two transects were placed on 19 March 2008, within the planned spring 2008 burn area. Municipal restrictions created a dynamic and uncertain schedule for obtaining the required burn permits. The resulting short time period between the official notice of a possible burn and the scheduled treatment prevented the establishment of more permanent monitoring transects. Cover estimates of the six transects were conducted on the same day of their placement using a point intercept technique (Elzinga et al. 1998). Flora that came in contact with the transect line were recorded at 1 m intervals as cheatgrass, other non-native species, native grasses, other native species, litter, or bare ground, giving a total of 50 point intercepts per 50 m transect. Because managers encountered difficulty identifying emergent grasses in winter conditions, the data classes were pooled and analyzed as cheatgrass, other vegetation, litter, and bare ground**.** All six transects were monitored again on 13 June 2008, 11 September 2008, and 12 August 2009.

Fire was applied to 21 ha of Devil's Backbone Open Space on 11 October 2007, and an additional 30 ha were burned on 25 March 2008. Hot, long residual burns were desired in order to remove the thick duff layer of cheatgrass, thereby targeting seed in the duff and topsoil. Highly consumptive burns were also designed to improve imazapic effect by allowing direct contact with the soil. To achieve these fire characteristics, burning was set against the wind, causing slow movement of the fire. Backing fire and strip/spot head firing were the ignition patterns used within the unit interior. The primary fuel sources in the burn units were 0.3 m to 0.45 m grasses and sparse rabbitbrush. Fires were ignited using drip torches and were allowed to burn freely unless re-ignition was needed. Burn boundaries were a two-track dirt road and a drainage. All boundaries were disked to mineral soil 6.1 m wide for additional burn control. Wind, relative humidity, temperature, burn time, and flame height were collected during the burns.

Based on a previous study conducted in Fort Collins, Colorado, regarding the selectivity of imazapic application for cheatgrass control and its effects on other vegetation, managers decided on applications of imazapic pre-emergence at 0.44 L/ha (Sebastian et al. 2004). Following prescribed burns, any non-natives that emerged were broadcast sprayed with imazapic in the early spring or early fall, depending on the burn timing. During the broadcast spraying, managers observed that some areas failed to receive imazapic application. These sites were revisited for single incidences of spot spraying in the fall of 2008, 2009, and 2010 using imazapic at 0.44 L/ha. This annual spot spraying remains part of the ongoing management plan. Reseeding in the burn area was not needed because native flora returned, but disk lines were reseeded in November of 2010 using a native seed mix.

A one-way analysis of variance (ANOVA) was used to compare the percent cover of cheatgrass before treatment and after the prescribed burns and imazapic application. To compare the percent cover change between the permanent monitoring plots, a repeated measures analysis was performed. The least square means were compared with a *t*-test to assess the difference between the fall 2007 burn and the spring 2008 burn. The change in bare ground after treatment was assessed through a paired *t*-test. The ANOVA and bare ground paired *t*-test were carried out in the JMP 4 (2004) statistical program and the repeated measures analysis was performed in SAS 9.2 (2008).

RESULTS AND DISCUSSION

Pre- and Post- Treatment Site Characterization

Prior to treatment, cheatgrass was dominant in the Devils Backbone Open Space and exhibited monotypic stands. At six permanent monitoring plots, average percent cover was measured at 81.5% (N = 6, SD = 7.94). Other species encountered in the transects were representative of a Rocky Mountain lower montane foothills shrublands including some non-native weeds. After treatment, vegetation besides cheatgrass increased 46.4% between 2007 and 2009 (t = 3.61, p = 0.01). Visual observation at the transect sites suggested that Western wheatgrass, blue grama, and mullein (*Verbascum*) were present in the valley.

Fire characteristics

Observation after burning revealed that both thatch and duff layers were successfully consumed. In the fall 2008 burn, the flame length was between 0.61 m and 0.91 m with a rate of spread of 0.011 – 0.016 m/s. In the spring 2008 burn, the backing flame length was less than 0.30 m with a rate of spread of 0.011 m/s. Heading flame length was approximately 1.22 m with a rate of spread of 0.11 m/s. One burn unit was burned twice as it did not burn hot enough to consume the duff layer.

The timing of a burn can be important in determining the resulting plant communities, which can include altered species composition as well as vegetation patterns (Kerns et al. 2006). Studies have shown that prescribed burns in the spring result in a significant reduction of grasses, forbs, and overall species diversity, whereas fall burns favor the establishment of fire-tolerant species and increased species diversity (Wendtland 1993; Brockway et al. 2002). In addition to timing, factors such as exposure to direct sunlight, soil moisture, and soil N can also be important to the relative success of a prescribed burn (Keeley and McGinnis 2007). While Larimer County considered these factors, administrative and legal restrictions largely determined the timing of the burn.

Cheatgrass Reduction

After prescribed burns and imazapic applications, the average cheatgrass cover was reduced from 64% to 9 % from 2007 to 2009 (F = 35.5, p = 0.001). There was no recorded difference of effect between the fall and spring burns from the permanent monitoring plots (cheatgrass: t = -0.64, p = 0.53, bare ground: t = -1.59, p = 0.14, other vegetation: t = -1.80, p = .09). A repeated measures analysis between six permanent sampling plots that were burned revealed a significant reduction in cheatgrass cover between 2007 and 2009 (Table 1, Figure 1). Before treatment at the permanent monitoring plots, there were no recorded incidences of bare ground. After burning, average bare ground cover was 5.2% in fall 2008 and 8% in 2009. There was no significant change between fall 2008 and 2009 (t = 3.67, p > 0.05). After treatment, other vegetation besides cheatgrass increased 46.4% between 2007 and 2009 (t = 3.61, p = 0.01), and other vegetation besides cheatgrass increased 51.7% between 2007 and 2011 (t = 6.01, p = 0.002).

A mixed management treatment of a slow, consumptive burn followed by imazapic effectively reduced cheatgrass cover among the permanent monitoring plots. Vegetation cover other than cheatgrass has increased significantly and bare ground incidence, once absent among the permanent monitoring plots, now represents levels closer to the average of the shortgrass steppe ecosystem (Lauenroth 2008). While research shows that cheatgrass often responds positively to wildfires (Young et al. 1969, 1987; Melgoza et al. 1990), this case study suggests that an integrated management plan of prescribed burn and imazapic application can remove cheatgrass from the seed bank and create favorable conditions for other vegetation to return. During the monitoring of cheatgrass cover, the density of specific native species was not estimated. While the absence of density and cover estimates prohibits an understanding of why certain native grasses emerged and to what extent they are present, the observed reduction in cheatgrass suggests promising initial results.

Local private property owners can be averse to burns on proximate natural areas, which presents a challenge to public land managers tasked with the reduction of invasive grasses (Kreuter and Woodward 2008). In circumstances where cheatgrass monotypism persists, a prescribed burn followed by imazapic application may be a valid option for the reduction of cheatgrass cover. Evidence of an integrated burn-imazapic success can be a valuable outreach tool for managers who consider prescribed burning as an option to control a non-native, invasive plant species.

Table 1. Percent cover of cheatgrass at 6 permanent monitoring plots following mixed treatment of prescribed burns and herbicide application carried out in fall 2007 and spring 2008.

	2007	2008 Spring	2008 Fall	2009	2007 - 2009
Mean cheatgrass cover (%)	81.5	38.8	17.6	9.2	—
SD	10.9	16.7	20.5	11.4	—
P value[1]	—	0.004	0.241	0.007	<.001
N	6	6	5[2]	6	6
Df	15	15	15	15	15

[1] Represents the change in means from the previous sampling time.
[2]In fall 2008, data from one transect was lost.

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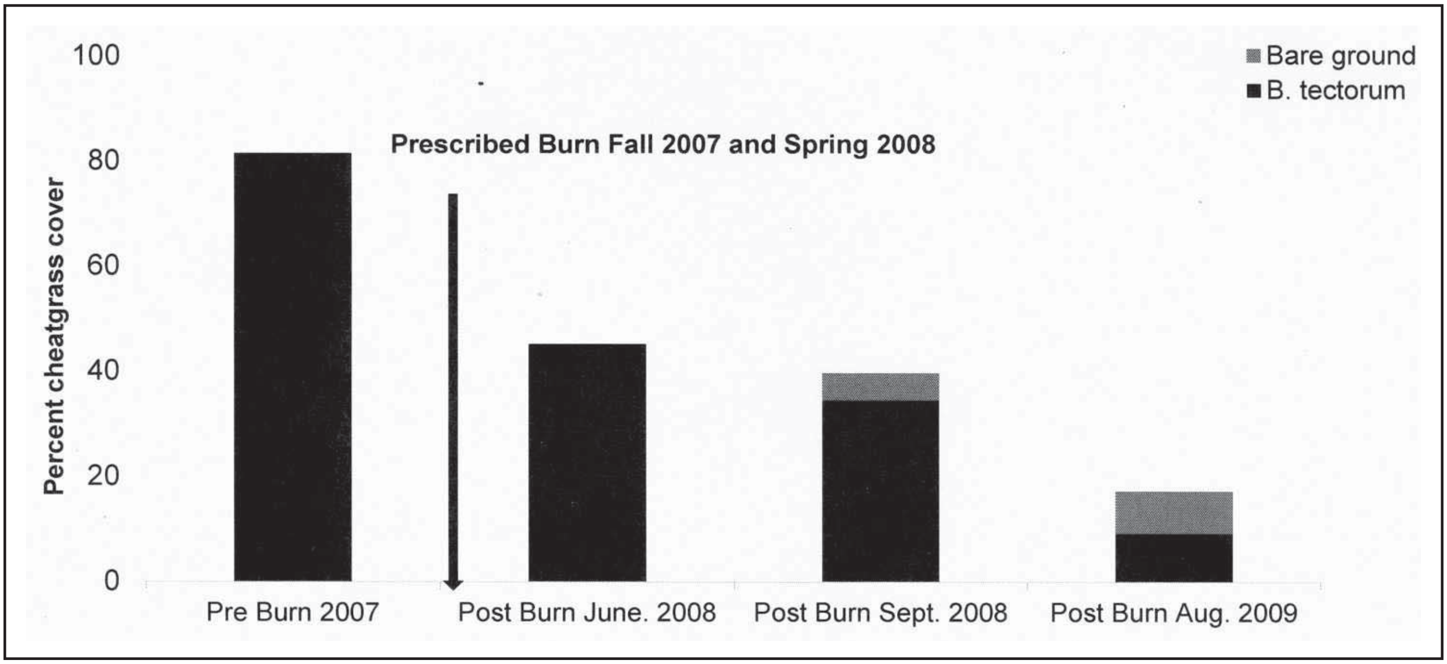

Figure 1. Cheatgrass cover before and after treatment as well as bare ground incidence. Bars represent the average cover from 6 permanent monitoring plots. See Table 1 for standard deviation.

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