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Does fall prescribed burning *Artemisia tridentata* steppe promote invasion or resistance to invasion after a recovery period?☆

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Abstract

Artemisia tridentata ssp. *wyomingensis* (Beetle & A. Young) S.L. Welsh-bunchgrass communities were used to analyze the influence of disturbances on invasibility after a recovery period. These communities evolved with periodic fires shifting dominance from shrubs to herbaceous species. However, fire can facilitate *Bromus tectorum* L. invasion of these plant communities. We evaluated the invasibility of *A. tridentata* ssp. *wyomingensis*-bunchgrass communities 4 years after prescribed fall burning at six sites by comparing burned to unburned (control) communities. These communities did not have *B. tectorum* present prior to introduction. *B. tectorum* was introduced at 1, 10, 100, 1000, and 10,000 seeds m^{-2} in burned and unburned communities. *B. tectorum* individuals established only when introduced at 10,000 seeds m^{-2}. In the areas seeded at 10,000 seeds m^{-2}, *B. tectorum* density and cover were more than three-fold higher in the control than burned treatments ($P = 0.04$ and 0.08, respectively). Total herbaceous vegetation cover, density, and production increased with burning ($P < 0.01$, 0.02, and < 0.01, respectively). Bare ground and inorganic nitrogen were higher in the control than the burned treatment ($P = 0.02$ and < 0.01, respectively). Prescribed fall burning of late seral *A. tridentata* ssp. *wyomingensis*-bunchgrass communities stimulated the herbaceous component and increased the resistance of the communities to *B. tectorum* invasion 4 years post-burn. However, we do not suggest the use of prescribed burning in communities where invasive annual grasses are present or in close proximity. We acknowledge that our results would probably have been drastically different if *B. tectorum* or other invasive annual grasses had been a component of the plant communities prior to prescribed burning or became a component immediately after burning.
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Keywords: *Bromus tectorum*; Disturbance theory; Fire; Invasive plants; Prescribed burning; *Artemisia tridentata* ssp. *wyomingensis*

1. Introduction

The current threat of exotic plant invasions after disturbances requires that ecologists and policy makers understand the influence of prescribed fire-induced disturbances in ecosystems that were historically

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maintained by periodic disturbances. Historically, *Artemisia tridentata* ssp. *wyomingensis* (Beetle & A. Young) S.L. Welsh (Wyoming big sagebrush)-bunchgrass steppe communities were maintained by periodic wildfires (Wright and Bailey, 1982). Modern day burning, however, may promote the invasion of these communities by *Bromus tectorum* (Stewart and Hull, 1949; Young and Allen, 1997). Understanding how prescribed burning followed by a recovery period (plant community has been allowed to respond to the shift in dominance) affects community susceptibility to *B. tectorum* L. (cheatgrass) invasion will provide information resource managers need to more accurately assess the effects prescribed fire may have in the *A. tridentata* ssp. *wyomingensis* steppe. Also, this information will provide a better understanding of the potential role of disturbances in other ecosystems that historically experienced similar infrequent disturbances.

A. tridentata ssp. *wyomingensis* communities are considered the least resilient and most susceptible of the *A. tridentata* Nutt. (big sagebrush) complex to invasion by exotic weeds (Miller and Eddleman, 2000). Many *A. tridentata* ssp. *wyomingensis*-bunchgrass communities have been converted to *B. tectorum*-dominated annual grasslands, particularly in the Intermountain West due to increased fire frequencies (Miller and Eddleman, 2000; Whisenant, 1990). The majority of the exotic annual grasslands dominated by *B. tectorum* in the Intermountain West were probably formerly *A. tridentata* ssp. *wyomingensis* steppe (Miller and Eddleman, 2000).

The decline of intact *A. tridentata* ssp. *wyomingensis*-bunchgrass communities has generated debate regarding the value and risks associated with using prescribed fire to mimic historic fire regimes. Prescribed burning of *A. tridentata* ssp. *wyomingensis*-bunchgrass steppe has generally been avoided because it is assumed to increase the invasibility of these communities by increasing safe site and resource availability. More safe sites increases the likelihood that propagules of invading species will reach a safe site upon introduction and this could potentially alter succession of the plant community to an undesirable state (Pickett et al., 1987; Sheley and Krueger-Mangold, 2003; Sheley et al., 1996). Of particular concern in *A. tridentata* ssp. *wyomingensis*-bunchgrass steppe is the potential for prescribed burning to promote invasion of exotic annual grasses. Invasion by exotic annual grasses, especially *B. tectorum*, can produce fire return intervals that are too short for reestablishment of *A. tridentata* and are detrimental to desirable herbaceous vegetation (Stewart and Hull, 1949; Whisenant, 1990).

Stewart and Hull (1949) and Young and Allen (1997) have implied that *B. tectorum* rapidly invades *A. tridentata* ssp. *wyomingensis*-bunchgrass communities after fire. However, the majority of *A. tridentata* rangeland they described supported *B. tectorum* and/or were in depleted states prior to the fire. Ecologists and land managers have assumed that burning *A. tridentata*-bunchgrass communities increases resources for *B. tectorum*. The initial impact of the burning usually increases resources (Davies et al., 2007; Hobbs and Schimel, 1984; Young and Allen, 1997), which would favor *B. tectorum* invasion (Young and Allen, 1997). However, Blank et al. (1994) reported decreases in nitrate following wildfire in *A. tridentata* communities, but their study sites were already invaded with *B. tectorum*. Previous studies were conducted immediately post-fire, largely consisting of previously invaded *A. tridentata* communities, and/or did not measure invasibility. Thus, information is lacking describing the influence of prescribed burning followed by a recovery period on the invasibility of late seral *A. tridentata* ssp. *wyomingensis*-bunchgrass communities not already invaded by *B. tectorum*.

Because *A. tridentata* ssp. *wyomingensis*-bunchgrass communities are estimated to have evolved with fire return intervals of 50–100 years (Wright and Bailey, 1982), they may need periodic (~75 years) burns to maintain resistance to invasion. However, current management practices (e.g. wildfire suppression) have or will probably lengthen fire return intervals in some late seral *A. tridentata* ssp. *wyomingensis*-bunchgrass communities. These practices leave the *A. tridentata*-bunchgrass communities in an *A. tridentata*-dominated state, potentially to the detriment of community invasion resistance. Attempts to stabilize a system in one particular vegetation-dominated state by removing natural disturbances often reduces community resilience by eliminating the mechanisms that allow the system to adapt to external change, making them more likely to cross-ecological thresholds and experience dramatic shifts in state (Groffman et al., 2006).

Native plant communities can be seed- or site-limited and this can influence invasibility. For example, Tilman (1997) reported native grasslands in his study were seed-limited. However, Turnbull et al. (2000) in a review of several studies concluded plant communities could be seed- or site-limited. We found no literature detailing whether late seral *A. tridentata* ssp. *wyomingensis*-bunchgrass communities are seed- or site-limited.