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Original Research

Evaluating Mechanical Treatments and Seeding of a Wyoming Big Sagebrush Community 10 Yr Post Treatment☆

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ABSTRACT

Increased cover of perennial grasses and forbs would increase the wildlife and forage value of many Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis* Beetle & Young) communities, as well as increase their resistance to weeds. We compared six mechanical treatments in conjunction with seeding a Wyoming big sagebrush community in northern Utah over a 10-yr period. The treatments included disk plow followed by land imprinter, one-way Ely chain, one- and two-way pipe harrow, all applied in fall, and meadow aerator applied in fall and spring. A mixture of native and introduced grasses and forbs was broadcast seeded at 18.3 kg PLS ha^{-1} after the disk and before the imprinter and all other treatments. The experiment was installed in three randomized blocks, and density and cover data were collected before treatment in 2001 and 1, 2, 5, and 10 yr after treatment. All treatments initially reduced sagebrush and residual herbaceous cover and increased seeded species cover compared with the untreated control. By 10 yr after treatment, sagebrush cover was 24.5% ± 0.35% on the control, 1.6% ± 0.28% on the disk imprinter treatment, and 11.7% ± 0.79% on all other treatments. At that time, seeded grass cover was 16.5% ± 1.22% on the disk imprinter treatment and an average of 2% ± 0.1% on all other mechanical treatments. Sagebrush seedlings were recruited in all of the mechanical treatments, but least in the disk imprinter treatment. After 10 yr, the untreated control was dominated by decadent sagebrush and rabbitbrush, the disk imprinter treatment was dominated by seeded perennial grasses, and the other mechanical treatments shared dominance of sagebrush and native perennial grasses. Mechanical treatments changed the composition of this community while retaining sagebrush, but greatest understory increases were associated with greatest control of sagebrush and establishment of seeded species by disk imprinting.

Introduction

Sagebrush (*Artemisia* L.) steppe vegetation covers millions of hectares in western North America in seven floristic provinces (Wisdom et al., 2005; Pyke et al., 2015). Sagebrush communities typically include shrubs, perennial grasses, and forbs (Miller et al., 2011). However, sagebrush species and cover, as well as that of associated perennial and annual herbs, vary greatly across the sagebrush steppe in relation to environmental potential and disturbance (Davies et al., 2006; Miller et al., 2011; Pyke et al., 2015). Wyoming big sagebrush (*Artemisia tridentata* Nutt. ssp. *wyomingensis* Beetle & Young) is the dominant shrub on lower elevation and drier cold desert alluvial fans and valleys (Miller et al., 2011). This vegetation type provides important forage and habitat for wildlife, as well as livestock grazing (Davies et al., 2006). Wyoming big sagebrush communities are more easily degraded than those of other big sagebrush subspecies and probably need active management to increase herbaceous understories (Miller and Eddleman, 2001; Davies et al., 2012b; Davies and Bates, 2014). State and transition successional models portray the relative abundance of Wyoming big sagebrush and perennial grass mainly as a function of fire, livestock grazing, and interaction of the two (Stringham et al., 2003; Briske et al., 2008; Chambers et al., 2014). Heavy livestock grazing supports sagebrush while moderate-severity fire supports perennial grass dominance (Miller et al., 2013; Chambers et al., 2017). In addition to depleting perennial grasses, heavy grazing may also reduce fire frequency and further support sagebrush dominance (Miller and Heyerdahl, 2008). West (1983) estimated that about 25% of the sagebrush steppe had become stagnant due to dense, competitive stands of sagebrush, which prevents the recovery of perennial herbaceous species even when grazing is reduced or removed (Blaisdell et al., 1982; West et al., 1984; Bork et al., 1998; Davies et al., 2014).

Managing composition of big sagebrush communities has evolved from sagebrush reduction and seeding grasses for improvement of herbaceous forage production for livestock to promoting mixed shrub, grass, and forb communities to support wildlife habitat or ecosystem

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conservation (Young et al., 1979; Blaisdell et al., 1982; Roundy, 1996; Davies et al., 2011; Miller et al., 2011; Pyke et al., 2015). Big sagebrush communities with higher cover of deeper-rooted perennial grasses are considered to be more resistant to dominance by cheatgrass (*Bromus tectorum* L.), which is considered the greatest threat to this ecosystem (D'Antonio and Vitousek, 1992; Chambers et al., 2007; Miller et al., 2011; Chambers et al., 2014, 2017). Because big sagebrush and perennial grass roots use the same soil depth for water and nutrient uptake for growth, they are competitive for resources (Ryel et al., 2008, 2010; Lefler and Ryel, 2012). This can make finding techniques that retain Wyoming big sagebrush plants but restore depleted perennial grass understories a challenge. Compared with prescribed fire, mechanical shrub reduction has the advantages of easier and more flexible implementation, potentially lower mortality of perennial species, especially sagebrush, and less risk in urban-wildland interface areas (Davies et al., 2012b). Although mechanical sagebrush control generally increases perennial herbaceous vegetation, results can be highly variable depending on the amount of control, as well as the site, residual species, and subspecies of sagebrush (Watts and Wambolt, 1996; Davies et al., 2012a, 2012b; Hess and Beck, 2012; Pyke et al., 2014).

Wyoming big sagebrush communities that lack a perennial grass understory may end up dominated by cheatgrass after mechanical shrub reduction (Davies et al., 2012b). When perennial grasses are lacking, mechanical brush control may be used to help establish seeded species (Davies et al., 2012b). Mechanical treatments vary in amount of sagebrush control but may also help disturb the soil and bury seeds, thereby promoting establishment of seeded species or invasive weeds (Skousen and Brotherson, 1989). Treatments need to be tested across a range of sites and environmental potential. Sagebrush steppe located more northerly than Great Basin or semidesert sagebrush was recognized by Kuchler (1964) as having less sagebrush dominance and greater perennial herbaceous potential (West, 1983; West and Young, 2000; Miller et al., 2011). Because of the competitive relationships of sagebrush and perennial herbs, longer-term effects of treatments should be considered.

Treating big sagebrush communities can have negative consequences. Reductions in Wyoming big sagebrush could lead to declines in wildlife populations (Beck et al., 2009; 2012; Rhodes et al., 2010). Hess and Beck (2012) found that sagebrush canopy cover recovered quicker after mowing than burning, but there were few differences in grass canopy cover between treated and untreated sites, suggesting that mowing was ineffective in increasing perennial grass structure. While seeding may be required in addition to sagebrush reduction to increase understory cover, the desired cover could be limited by insufficient establishment or time for established plants to mature (Davies and Bates, 2014). Resilience to management treatments and resistance to annual exotic invasion are associated with soil temperature/moisture regimes, with warmer and drier Wyoming big sagebrush sites showing less resilience or resistance than upper elevation mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* [Rybd.] Beetle) sites (Chambers et al., 2014).

The objective of this study was to evaluate over a 10-yr period the effects of six mechanical treatments and seeding in a Wyoming big sagebrush steppe community in the Wyoming Basin area of northern Utah. There are a variety of implements for sagebrush thinning and control. This study was initiated to compare the Lawson aerator used for sagebrush thinning, with other mechanical treatments that have been commonly used for this purpose (Stevens and Monsen, 2004). We evaluated the response and recovery rate of sagebrush, the response of residual understory plants, and the establishment of seeded grasses and forbs in relation to the mechanical treatments.

Methods

Study Area

The study site is located in Rich County (lat 41°20'N, long 111°9'W, elevation 2 000 m), in northern Utah on private land owned by Deseret Land & Livestock and public lands managed by the US Department of the Interior Bureau of Land Management. The study site is located about 2.5 km south of Neponset Reservoir. The major land resource area is 034A—Cool Central Desertic Basins and Plateaus. The ecological site description is semidesert loam (Wyoming big sagebrush/bluebunch wheatgrass *(Pseudoroegneria spicata)* (R034AA220UT) (US Department of Agriculture — Natural Resources Conservation Service unpublished draft ecological site description). The study plots are on soils from the Lariat series and classified as coarse-loamy, mixed frigid Xerollic Calciorthids. The typical pedon is Lariat fine sandy loam, moderately deep, well drained, and derived from sandstone. Average annual precipitation is about 230 — 300 mm (USDA, 1981).

The study area is characterized by rolling hills covered by Wyoming big sagebrush. Western wheatgrass (*Pascopyrum smithii* [Rydb.] A. Löve), Sandberg bluegrass (*Poa secunda* J. Presl), longleaf phlox (*Phlox longifolia* Nutt.), carpet phlox (*Phlox hoodii* Richardson), and yellow rabbitbrush (*Chrysothamnus viscidiflorus* [Hook] Nutt. ssp. *viscidiflorus.*) are all common species. Perennial bunchgrasses such as bluebunch wheatgrass and needle and thread (*Hesperostipa comata* [Trin. & Rupr.] Barkworth) were rare.

The area is used by pronghorn *(Antilocapra americana),* mule deer *(Odocoileus hemionus),* elk *(Cervus elaphus),* and greater sage grouse *(Centrocercus urophasianus)* during different periods of the year. Domestic livestock also graze the area as part of Deseret Land & Livestock's short-duration, high-intensity grazing system, but cattle grazing was excluded from the study site for the duration of this experiment.

Experimental Design

In October 2001, five mechanical treatments were applied including 1) disk plow followed by a land imprinter, 2) one-way chaining using an Ely chain, 3) one-way pipe harrow, 4) two-way pipe harrow, and 5) meadow aerator (fall). In April 2002, the meadow aerator was applied as a spring treatment. The experiment was a randomized complete block with three blocks. Each treatment plot in each block was a 1.1-ha strip (61 × 183 m) surrounded by a 15-m buffer of untreated sagebrush. Blocks were separated by 40-m strips to allow adequate space for equipment to move from plot to plot.

Revegetation

Each treatment plot except the undisturbed control plot was seeded with a mixture of native and introduced grasses, forbs, and four-wing saltbush (*Atriplex canescens* [Pursh] Nutt.) (Table 1). The same seed mix and seeding rate (18.3 kg PLS ha^{-1}) were used on each plot. Seed was applied using a broadcast seeder mounted on the back of a tractor and was applied before the treatments with the exception of the disk plow and land imprinter. Seed on the disk treatment was applied using a seed box on the imprinter, which dropped seed directly in front of the imprinter after the soil had been disked. The two-way pipe harrow treatment was seeded after the first pass and before the second pass of the harrow. All treatment plots were seeded in the fall, except the spring meadow aerator plots, which were seeded in the spring.

Vegetation Sampling

We conducted pretreatment vegetation sampling during the summer of 2001. Post-treatment sampling was completed in the summers of 2002, 2003, 2006, and 2011. Each treatment was sampled using a permanently marked 150-m transect divided into five 30-m baseline transects. One 30-m cross transect was placed perpendicular to each baseline transect at a random number along the baseline transect. Twenty evenly spaced 0.25 m^2 quadrats were read on the same side of each 30-m cross transect for a total of 100 quadrats. Aerial cover was ocularly estimated, and density was counted for all species occurring within each quadrat. Cover values were also determined for total