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Disturbance History, Management, and Seeding Year Precipitation Influences Vegetation Characteristics of Crested Wheatgrass Stands☆

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ABSTRACT

Crested wheatgrass (*Agropyron cristatum* [L] Gaertm. and *Agropyron desertorum* [Fisch.] Schult.) has been seeded across millions of hectares of the sagebrush steppe and is often associated with native species displacement and low biological diversity. However, native vegetation composition of these seedings can be variable. To gain better understanding of the correlation between vegetation characteristics of crested wheatgrass seedings and their seeding history and management, we evaluated 121 crested wheatgrass seedings across a 54 230-km^2 area in southeastern Oregon. Higher precipitation in the year following seeding of crested wheatgrass has long-term, negative effects on Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *wyomingensis* Beetle & Young) cover and density. Wyoming big sagebrush cover and density were positively correlated with age of seeding and time since fire. We also found that preseeding disturbance (burned, scarified, plowed, or herbicide) appears to have legacy effects on plant community characteristics. For example, herbicide-treated sites had significantly fewer shrubs than sites that were burned or scarified preseeding. Native vegetation cover and density were greater in grazed compared with ungrazed crested wheatgrass stands. The results of this study suggest a number of factors influence native vegetation cover and density within stands of seeded crested wheatgrass. Though disturbance history and precipitation following seeding can't be modified, management actions may affect the cover and abundance of native vegetation in crested wheatgrass stands. Notably, grazing may reduce monoculture characteristics of crested wheatgrass stands and fire exclusion may promote sagebrush and perennial forbs.

Introduction

Crested wheatgrass (*Agropyron cristatum* [L] Gaertm. and *Agropyron desertorum* [Fisch.] Schult.), an introduced perennial bunchgrass, has been seeded across 6–11 million hectares of western North American rangelands (Lesica and DeLuca, 1996; Ambrose and Wilson, 2003; Hansen and Wilson, 2006). Crested wheatgrass was originally seeded in sagebrush (*Artemisia* L.) communities to increase livestock forage and reduce halogeton (*Halogeton glomeratus* [M. Bieb.] C.A. Mey), a plant that is toxic to sheep (Miller, 1943; Miller, 1956; Frischknecht and Harris, 1968; Vale, 1974). Crested wheatgrass is still seeded into sagebrush rangelands following wildfires because of its ability to suppress exotic annual grasses (Arredondo et al., 1998; Davies et al., 2010b). In addition, it often costs less and establishes better than native species (Pellant and Lysne, 2005; Boyd and Davies, 2010; James et al., 2012; Davies et al., 2015); reduces erosion; and increases livestock forage (Dormaar and Smoliak, 1985; Smoliak and Dormaar, 1985; Dormaar et al., 1995).

Although crested wheatgrass may compete effectively with undesirable weed species, its competitiveness can cause formation of near monocultures and significantly decrease cover and richness of native species and reduce wildlife habitat value (Looman and Heinrichs, 1973; Christian and Wilson, 1999; Heidinga and Wilson, 2002). Some crested wheatgrass seedings remain near-monocultures for decades (Hull and Klomp, 1966; Looman and Heinrichs, 1973; Marlette and Anderson, 1986), while others have a higher native vegetation component, particularly shrubs (Reynolds and Trost, 1981; McAdoo et al., 1989; Nafus, 2015). Greater amounts of native vegetation in crested wheatgrass stands are often desired because they correspond to increasing diversity and more suitable habitat for native wildlife (Vale, 1974; Reynolds and Trost, 1981; Parmenter and MacMahon, 1983; McAdoo et al., 1989). Although some of the variation in native vegetation cover and diversity in crested wheatgrass seedings can be explained by site and environmental factors (Raven, 2004; Williams, 2009; Nafus, 2015), it remains unclear why some crested wheatgrass seedings are almost monocultures and others have more native vegetation.

Vegetation characteristics in crested wheatgrass stands may be influenced by precipitation along with preseeding disturbances, including mechanical, burning and herbicide treatments, and postseeding disturbances, including fire and livestock grazing management (Hull and Klomp, 1967; Shown et al., 1969; Cox and Anderson, 2004). Fire,

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herbicide and mechanical treatments were often applied before seeding crested wheatgrass to prepare the soil for seeding and reduce residual vegetation (Vale, 1974). Preseeding disturbance, in combination with seeding year precipitation, may influence the initial recovery of native vegetation species, particularly sagebrush, and establishment of seeded crested wheatgrass (Hull and Klomp, 1967; Cluff et al., 1983; Cox and Anderson, 2004), which, in turn, may affect long-term plant community dynamics. On Wyoming big sagebrush (*Artemisia tridentata* Nutt. subsp. *wyomingensis* Beetle & Young) sites where crested wheatgrass was not seeded, sagebrush control method influenced long-term recovery of sagebrush (Wambolt and Payne, 1986; Watts and Wambolt, 1996). On sites seeded with crested wheatgrass, however, there is a lack of information about long-term differences in native vegetation cover and abundance associated with preseeding disturbances and seeding year precipitation.

Livestock management after seeding crested wheatgrass may influence plant community dynamics. Although crested wheatgrass is tolerant of grazing and can withstand heavy grazing for many years (Cook et al., 1958; Hull and Klomp, 1966, 1974; Caldwell et al., 1981; Laycock and Conrad, 1981), heavy grazing may favor more grazing-tolerant native bunchgrasses such as Sandberg bluegrass (*Poa secunda* J. Presl) (Hyder and Sawyer, 1951). Heavy spring grazing may be associated with increased shrub cover and reduced crested wheatgrass dominance (Laycock, 1967), whereas moderate grazing in native Wyoming big sagebrush plant communities does not generally appear to alter shrub cover (Rice and Westoby, 1978; Courtois et al., 2004; Yeo, 2005; Davies et al., 2010a; Strand et al., 2014). Information on grazing management, especially grazed compared with ungrazed, influence on native vegetation abundance and cover in crested wheatgrass stands is limited.

Fire is another factor that may influence vegetation composition of crested wheatgrass stands. Wyoming big sagebrush and some native bunchgrass species are not as fire tolerant as crested wheatgrass. Sagebrush is readily killed by fire and is estimated to take decades to centuries to recover (Wambolt and Payne, 1986; Skinner and Wakimoto, 1989; Baker, 2006). Crested wheatgrass burns quickly with little heat transfer into the soil and is therefore more resilient to fire than many native bunchgrass species (DePuit, 1986; Skinner and Wakimoto, 1989). Following fire, crested wheatgrass can take advantage of reduced competition and increase by threefold to sixfold in the next couple of years (Ralphs and Busby, 1979).

Crested wheatgrass has been extensively seeded across millions of acres of historic sage grouse and other sagebrush-associated wildlife habitat and it is, therefore, important to investigate factors that may influence native vegetation in crested wheatgrass stands (Knick et al., 2003; Schroeder et al., 2004; Pellant and Lysne, 2005; Davies et al., 2011). The purpose of this study is to investigate the correlations between plant community characteristics of crested wheatgrass stands and seeding year precipitation, disturbance history, and management. We predicted that increased grazing pressure would be positively associated with higher shrub cover and abundance, and that native vegetation cover and density would be greater on grazed compared with ungrazed crested wheatgrass stands. We also expected native vegetation cover and density would vary by preseeding disturbance and precipitation in the year following seeding and that sites that were seeded or burned more recently would have lower native vegetation cover and density.

Methods

Site Selection

Personnel from the US Department of Interior Bureau of Land Management (BLM) of the Burns, Lakeview, and Vale Districts, Fish and Wildlife Service (USFWS), and the Oregon Department of State Lands (ODSL) were consulted to obtain locations of all crested wheatgrass seedings in their jurisdiction. One-hundred and twenty-one sites were located across southeastern Oregon and then measured in June to August of 2012 and 2013. All sites sampled had been identified as having been seeded with crested wheatgrass and contained at least 0.25 crested wheatgrass plants per m^2 to ensure that they had been successfully seeded.

Study Area

Study sites were selected across a 54 230 km^2 area in southeastern Oregon. Study locations were generally in Wyoming big sagebrush-bunchgrass ecological sites, though a few locations were more alkaline and had been characterized by shrubs such as spiny hopsage (*Grayia spinosa* [Hook.] Moq.) and greasewood (*Sarcobatus vermiculatus* [Hook.] Torr.). All study locations were seeded with crested wheatgrass 10 to 50 years before sampling largely using drill seeding methods. Long-term annual precipitation for study locations averaged between 200 and 360 mm (PRISM Climatic Group, 2014). Annual precipitation amounts (from 1 October to 30 September) averaged for study locations were 74% and 75% of the long-term average (30 years) in 2011–2012 and 2012–2013, respectively (PRISM Climatic Group, 2014). Precipitation in the study area generally arrives during the cool season, and summers are typically hot and dry. Topography and soils were variable across the study area. Elevation of sites ranged from 819 m to 1739 m above sea level.

Vegetation Characteristics

A randomly located 50 × 60 m plot was used to sample each site. Four parallel 50-m transects were spaced at 20-m intervals perpendicular to the 60-m side of the plot. Herbaceous vegetation basal cover and density were estimated by species inside 40 × 50 cm quadrats located at 3-m intervals on each 50-m transect (starting at 3 m and ending at 45 m, resulting in 15 quadrats per transect and 60 quadrats per plot). We used basal cover as opposed to foliar cover as some sites were grazed before sampling. Basal cover was estimated to the nearest 1% base on markings that segmented the quadrats into 1%, 5%, 10%, 25%, and 50%. Bunchgrasses were considered separate individuals if crowns were separated by > 5 cm. Sandberg bluegrasses (*Poa secunda* J. Presl) were considered separate individuals if there was > 1 cm between crowns. Dead portions within the perimeter of the live portion of the crown were included in the basal cover estimate when they were < 5 cm in diameter. Shrub canopy cover by species was measured using the line intercept method (Canfield, 1941). Shrub canopy gaps < 15 cm were included in cover estimates. Shrub density was determined by counting all individuals rooted in four, 2 × 50 m belt transects centered over each of the four 50-m transects. Species were summarized by functional group: Sandberg bluegrass, crested wheatgrass, large native perennial bunchgrasses, perennial forbs, annual grasses, annual forbs, and shrubs. Some functional groups only contained one species because of unique characteristics. Sandberg bluegrass was analyzed separately because it responds differently to management and disturbance (McLean and Tisdale, 1972; Winward, 1980; Yensen et al., 1992), and it is smaller in stature and develops earlier than other native bunchgrasses in these communities (James et al., 2008). Crested wheatgrass was analyzed separately because it was the only non-native bunchgrass. Species richness was determined by counting all species found in the sixty 40 × 50 cm quadrats. Vegetation diversity was calculated from density measurements using the Shannon-Weiner diversity index (Krebs, 1998). Wyoming big sagebrush was included in the shrub functional group but was also evaluated independently because of its importance to the habitat requirements of many sagebrush-associated wildlife species (Davies et al., 2011).