Forest Ecology and Management 409 (2018) 307–316

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

Quaking aspen woodland after conifer control: Herbaceous dynamics☆

Jonathan D. Bates*, Kirk W. Davies

United States Department of Agriculture, Agricultural Research Service, USA.

ARTICLE INFO

Keywords:
Cheatgrass
Fire severity
Forbs
Invasive plants
Piñon-juniper

ABSTRACT

Western juniper (*Juniperus occidentalis* Hook.) woodlands are replacing low elevation (< 2100 m) quaking aspen (*Populus tremuloides* Michx.) stands in the northern Great Basin. Restoring aspen woodlands is important because they provide wildlife habitat for many species and contain a high diversity of understory shrubs and herbaceous species. We measured herbaceous cover, density, and diversity for 15 years following two juniper control treatments in aspen woodlands. Treatments included cutting one-third of mature juniper trees followed by early fall burning (Fall), cutting two-thirds of the juniper followed by early spring burning (Spring), and untreated woodlands (Control). Junipers were selectivly cut to increase dry surface fuels to carry fire and kill the remaining conifers. The Fall treatment resulted in significant initial reductions in herbaceous cover and a long-term reduction in perennial forb cover and diversity. Herbaceous recovery in the Fall treatment was dominated by non-native species which represented about 68% of total herbaceous cover. By the end of the study the main non-natives in the Fall treatment were Kentucky bluegrass (*Poa pratensis* L.) and cheatgrass (*Bromus tectorum* L.). In contrast, native perennials in Spring and Control treatments represented, on average, above 60% of total herbaceous cover. Herbaceous cover in the Spring treatment increased and was greater than the Fall treatment and the Control. Perennial forb cover in the Spring treatment was 2- and 6-times greater than Control and Fall treatments, respectively. Perennial forb density was about 7 times greater in the Spring than Fall treatment. Because of lower fire severity, spring burning resulted in greater recovery of the herbaceous layer while maintaining a more diverse native understory than fall burning. The severe fire effects from fall burning aspen woodlands probably requires reseeding of native perennials to maintain understory composition and diversity and limit weed encroachment.

1. Introduction

Quaking aspen (*Populus tremuloides* Michx.) woodlands are important plant communities in the interior mountains of the western United States. Aspen woodlands typically deliver diverse understory communities supporting a wide variety of wildlife species (Houston, 1954; Maser et al., 1984; DeByle, 1985; Mueggler, 1985, 1988; Kuhn et al., 2011). Aspen woodlands are of two main types, seral and stable stands. In seral aspen woodlands, disturbance, especially fire, is important for maintaining stands, mainly, to prevent replacement by conifers (Harniss and Harper, 1982; Strand et al., 2009; Krasnow et al., 2012; Rogers et al., 2014; Krasnow and Stephens, 2015). Stable aspen stands are maintained by continual tree recruitment by root sprouting, although stand maintenance may be augmented by overstory mortality from drought, pathogens, and aging (Shinneman et al., 2013; Rogers et al., 2014).

The decline of seral aspen stands has been documented across much of the Mountain West (Bartos and Campbell, 1998) and Great Basin, USA (DiOrio et al., 2004; Miller and Rose, 1995; Wall et al., 2001). Seral aspen woodlands have declined due to lack of fire disturbance and encroachment by conifers (Bartos and Campbell, 1998; Wall et al., 2001; Kulakowski et al., 2013; Shinneman et al., 2013), excessive browsing by native ungulates (Gruell, 1979; Bartos et al., 1994; Kay, 1995; Seager et al., 2013), past management (Rogers et al., 2014), and potentially episodic events, such as drought, resulting from climate warming (Rehfeldt et al., 2009; Worrall et al., 2013). An extensive survey of aspen in the northern Great Basin reported 75% of aspen woodlands below 2150 m in elevation have either been replaced or are in the process of being supplanted by western juniper (*Juniperus occidentalis* Hook.) (Wall et al., 2001). These aspen woodlands are seral communities that depend on disturbance, primarily fire, to regenerate stands and prevent replacement by juniper. Similar to other regions of the Mountain West, reintroduction of fire, prescribed or natural, is considered necessary for restoring and maintaining seral aspen

☆ The Eastern Oregon Agricultural Research Center is jointly funded by the USDA-Agricultural Research Service and Oregon State Agricultural Experiment Station. USDA-ARS and Oregon State University are equal opportunity providers and employers.
* Corresponding author at: USDA-ARS, EOARC, 67826-A Hwy. 205, Burns, OR 97720, USA.
E-mail address: jon.bates@ars.usda.gov (J.D. Bates).

https://doi.org/10.1016/j.foreco.2017.11.032
Received 24 August 2017; Received in revised form 10 November 2017; Accepted 15 November 2017
0378-1127/ Published by Elsevier B.V.

woodlands in the Great Basin (Wall et al., 2001; Strand et al., 2009; Krasnow et al., 2012).

Conifer replacement of aspen typically reduces understory biomass and diversity (Bartos and Campbell, 1998; Stam et al., 2008; McCullough et al., 2013). In the northern Great Basin, as juniper cover increased herbaceous plant cover decreased and bare ground increased (Wall et al., 2001). The response of herbaceous understories to conifer control in aspen woodlands varies, and is contingent upon method of conifer treatment, disturbance severity, site characteristics, and residual herbaceous composition. Prescribed burning produces variable fire severities and intensities which influence plant composition and successional response in aspen and encroaching conifer woodlands (Bartos and Mueggler, 1981; Bartos et al., 1994; Bates et al., 2006, 2014; Krasnow and Stephens, 2015; Williams et al., 2017).

Recovery of herbaceous understories following fire and other conifer treatments in aspen stands have focused on short-term succession. One long-term study indicated herbaceous biomass remained greater in light, moderate, and heavily burned aspen stands than unburned controls for 12 years after prescribed fire (Bartos et al., 1994). However, Bartos et al. (1994) suggested the suppression of aspen suckers by elk and cattle may have contributed to persistently elevated herb production. Thus, longer-term treatment evaluations are necessary to ascertain the effectiveness of conifer treatments on recovery of herbaceous understories and adjust and improve management practices.

The objective of the study was to assess herbaceous community responses 15 years (2002–2016) after prescribed fire treatments removed western juniper from seral-montane aspen sites in southeast Oregon. Vegetation responses at these sites were previously evaluated for three years after fall (Fall) and spring (Spring) burning (Bates et al., 2006). This assessment indicated juniper treatments were effective at increasing cover and density of aspen and cover of herbaceous understories compared to untreated woodlands. Fall burning was of high severity and was more effective at increasing aspen than low severity Spring burning. Fall burning caused high mortality of native perennials and recovery was dominated by fire-stimulated native forbs, non-native weeds, and Kentucky bluegrass (*Poa pratensis* L.), a rhizomatous grass not originally native to the western U.S. The herbaceous understory in the Spring treatment remained intact resulting in higher cover and diversity of native perennials.

We hypothesized that herbaceous cover would be greater in Fall and Spring treatments compared to untreated areas as there remained sizeable areas of bare ground (30–60%) for further colonization three years after fire treatments. Additionally, we hypothesized herbaceous composition differences, measured in early succession (Bates et al., 2006), between Spring and Fall treatments would persist with the Spring treatment having greater cover and composition of native perennials and the Fall treatment having higher composition of annual and non-native species.

2. Materials and methods

2.1. Site description

The study site was located along a four km stretch of Kiger Creek Canyon on Steens Mountain, southeastern Oregon (Geo URI 42.829465–118.555172). Aspen stands were scattered along toe slopes above the riparian zone and in concave slopes in adjacent uplands from 1645 to 1930-m elevation. Individual aspen stands were small, averaging 0.4-ha in area, and ranging from 0.20 to 2-ha in size. Surrounding plant communities consisted of mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana* (Nutt.) Beetle & A. Young) grassland and mountain mahogany (*Cercocarpus ledifolius* (Nutt.) Torr. & Gray) thickets. Aspen was reduced in cover and density and stands were dominated by western juniper (Bates et al., 2006). Juniper woodlands in the study were considered to be in late- to closed-successional phases and all aspen stands were in decline using descriptions from Miller and Rose (1995), Bartos and Campbell (1998), and Wall et al. (2001). There was a high diversity of forbs and grasses with 89 species identified. Western snowberry (*Symphoricarpus oreophilus* Gray) and wax currant (*Ribes cereum* Dougl.) were the common shrubs with another eight shrubs contributing minor levels of cover (Bates et al., 2006).

The Ecological Site Description for the sites is ASPEN 16–35 PZ (NRCS, 2017). The aspen stands are of the seral montane aspen/conifer type (Shepperd et al., 2006; Shinneman et al., 2013; Rogers et al., 2014). Soils were mainly the Hackwood series with soil textures ranging from gravelly loams to loams extending to depths of 100 cm or deeper and underlain by fractured basalt (NRCS, 2006). The closest weather station is the Fish Lake SNOTEL site, about 9–13 km southeast and 400–700 m higher in elevation than the study sites. Water year precipitation (October 1–September 30) at the SNOTEL site has averaged 1049 mm the past 17 years. Most aspen areas in the western United States receive at least 380 mm of precipitation annually or are able to access elevated water tables (Jones and DeByle, 1985).

2.2. Study design and burn applications

The study was a randomized complete block design (Peterson, 1985). Ten, 0.60-ha blocks were established in aspen stands in May 2000. A block consisted of three treatment plots: an untreated control (Control), juniper cutting followed by fall prescribed fire (Fall), and juniper cutting followed by early spring prescribed fire (Spring). Plots were about 0.20-ha, including buffer strips between treatments.

Cutting involved felling mature (dominant and subcanopy) juniper trees, evenly distributed through the stand. Junipers were cut in winter and early spring, 2000–2001, and allowed to dry during the summer. An average of 106 (range 55–175) juniper trees were cut per hectare in Fall plots, representing about 1/3 of the dominant and subcanopy juniper. An average of 232 (range 140–372) juniper trees were cut per hectare in Spring plots, representing around 2/3 of the dominant and subcanopy juniper. Trees were cut to increase the level of dry surface (0–4 m) fuels to carry fire through stands. Fall burning was applied in October 2001 by the Bureau of Land Management (BLM), Burns District, Oregon. The prescribed fires were spot head fire using helicopter-dropped delayed action ignition devices (DIADS). DIADS were chemically injected ping-pong balls. Spring burns were head fires, applied in late April 2002 using drip torches with a 50:50 mixture of gas and diesel. Fuel continuity of the cut junipers was sufficient for fire to carry with minimal re-ignition during spring burning.

Fire severity was estimated by adapting severity categories developed by Bartos et al. (1994) for evaluating plant community response to fire. Severity categories were light (1–20% of litter and understory consumed, needles and small branches of downed juniper consumed, and only a few mature aspen/juniper killed), moderate (21–80% of litter and understory consumed, large branches and trunks remained on downed juniper, and < 90% of adult aspen/juniper killed), and high (81–100% of litter and understory consumed, only trunks of downed juniper remaining, and > 90% of adult aspen/juniper killed) (Bates et al., 2006). Soil and fuel moisture, and humidity were lower and wind speed was greater for the Fall versus Spring treatment. In the Fall treatment, all downed wood but trunks were consumed, litter and understory consumption was > 95%, and mature juniper and aspen kill were 99% and 100%, respectively. Fire severity in the Fall treatment was high. In the Spring treatment, consumption of surface litter and the understory was less than 1% and only suspended needles and small branches of felled juniper were consumed. About 55% of remaining live juniper and 76% of the adult aspen stems were killed by the fire. Fire severity in the Spring treatment was rated as having no impact to the understory and having moderately high impacts on live trees. Further details on fire conditions and fuel moisture are in Bates et al. (2006).

Livestock were excluded from the area two years pre-treatment and for three years post-treatment. Livestock used the area in a deferred rotational system during summers (2005–2016) and all grazing took