Forest Ecology and Management 409 (2018) 233–240

Contents lists available at ScienceDirect

Forest Ecology and Management

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

Quaking aspen woodland after conifer control: Tree and shrub dynamics☆

Jonathan D. Bates*, Kirk W. Davies

United States Department of Agriculture, Agricultural Research Service, USA

ARTICLE INFO

Keywords:
Prescribed fire
Fire severity
Piñon-juniper
Western juniper
Western snowberry

ABSTRACT

Western juniper (*Juniperus occidentalis* spp. *occidentalis* Hook.) woodlands are replacing many lower elevation (< 2100 m) quaking aspen (*Populus tremuloides* Michx.) stands in the northern Great Basin. We evaluated two juniper removal treatments (Fall, Spring) to restore aspen woodlands in southeast Oregon, spanning a 15-year period. The Fall treatment involved cutting 1/3 of the juniper followed by a high severity broadcast burn one year later in October 2001. The Spring treatment involved cutting 2/3 of the juniper followed by a low severity broadcast burn 18 months later in April 2002. The cut trees increased the amount of dry fuels to carry fire through stands. We tested the effectiveness of treatments at removing juniper from seedlings to mature trees, assessed aspen ramet recruitment and development, and evaluated recovery of the shrub layer. In the Fall treatment, burning eliminated all remaining juniper trees and saplings, stimulated an 8-fold increase in aspen density (16,000 ha^{-1}) and increased aspen cover 6-fold compared to the untreated controls. After 15 years, aspen density in the Spring treatment was about 1/3 of the Fall treatment, however, aspen cover did not differ from the Fall treatment. Because spring burning was less effective at removing juniper, leaving about 20% of the mature trees and 50% of the saplings, retreatment of conifers will be necessary to maintain the aspen community. In the Fall treatment, juniper began establishing within 15 years after conifer control indicating retreatment might be necessary earlier than expected. Total shrub cover and density in the Spring treatment was greater than the control and Fall treatments. Cover and density of sprouting shrub species, particularly western snowberry (*Symphoricarpus oreophilus* Gray), increased and were greater in the Spring treatments than the Fall treatment where they had declined. Shrubs that increased in the Fall treatment were species where seed germination is enhanced by fire, especially snowbrush (*Ceanothus velutinus* Douglas ex Hook) and wax currant (*Ribes cereum* Dougl.). If an objective is to maintain or increase native understories the Spring treatment was more effective than the Fall treatment for recovering the shrub layer.

1. Introduction

Quaking aspen (*Populus tremuloides* Michx.) woodlands are important plant communities in the interior mountains of the western United States. Aspen woodlands provide habitat for many wildlife species (Maser et al., 1984; Kuhn et al., 2011) and may contain a high diversity of understory shrub and herbaceous species (Bartos and Mueggler, 1981, 1982; McCullough et al., 2013). Aspen woodlands are of two main types, seral and stable stands. In seral aspen woodlands, disturbance, especially fire, is important for maintaining stands particularly to prevent replacement by conifers (Strand et al., 2009; Krasnow et al., 2012; Shinneman et al., 2013; Krasnow and Stephens, 2015). Stable aspen stands are maintained by continual tree recruitment by root sprouting, although stand maintenance may be enhanced by overstory mortality from drought, pathogens, and aging (Shinneman et al., 2013).

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; Worrall et al., 2013), excessive browsing by native ungulates (Gruell, 1979; Bartos et al., 1994; Kay, 1995), and dieback of stands brought on by recent large-scale episodic droughts (Worrall et al., 2013). The decline of seral aspen stands has been well documented in the Rocky Mountain States (Bartos and Campbell, 1998) and the Great Basin (DiOrio et al., 2004, Miller and Rose, 1995, Wall et al., 2001). In the northern Great Basin there has been significant encroachment of western juniper (*Juniperus occidentalis* spp. *occidentalis* Hook.) into aspen woodlands below 2120 m (Wall et al., 2001). The recovery of aspen woodlands using prescribed fire can be challenging because of the limited periods when fuel moisture and weather conditions are favorable for burning (Jones and DeByle, 1985a). In addition, juniper dominance may reduce understory cover and biomass and limit abilities for fire to carry in plant

☆ The Eastern Oregon Agricultural Research Center is jointly funded by the USDA-Agricultural Research Service and Oregon State Agricultural Experiment Station.
* 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.2017.11.019
Received 24 August 2017; Received in revised form 1 November 2017; Accepted 7 November 2017
0378-1127/ Published by Elsevier B.V.

communities (Miller et al., 2005; Roundy et al., 2014a).

We evaluated aspen, juniper and shrub responses over 15 years (2002–2016) after prescribed fire treatments (2001) were applied to control western juniper in upland aspen stands in southeast Oregon. Vegetation dynamics at these sites were initially evaluated for 3 years post-treatment (Bates et al., 2006). This evaluation indicated that partial juniper cutting followed by fall (FALL) and spring (SPRING) fire treatments were effective at increasing cover and density of aspen and cover of herbaceous understories compared to untreated woodlands. High severity fall burning was more effective at killing junipers of all age classes and increasing aspen than low severity spring burning.

The objectives of our study were to: (1) compare recovery of aspen and shrub density and cover in Fall and Spring treatments to untreated woodlands; and (2) evaluate cover and density response of western juniper to treatment. After 15 years, we hypothesized aspen and shrub cover and density would have continued to increase and be greater in Fall and Spring treatments compared to untreated woodlands as there remained large areas of open space for further expansion of aspen and shrubs three years after treatments. We hypothesized that juniper cover and density would be greater in Spring than Fall treatments, because many small trees survived the spring burn (Bates et al., 2006).

2. Materials and methods

2.1. Site description

The study sites were located along a 4 km stretch of Kiger Creek Canyon on Steens Mountain, Harney County, Oregon (Geo URI 42.829465-118.555172). Sites were on private and public (BLM –Bureau of Land management) property. Aspen stands were scattered along toe slopes above the riparian zone and on concave slopes in the uplands from 1645 to 1930 m elevation. Aspen plots averaged 0.6 ha, and ranged from 0.2 to 2-ha. Adjacent plant communities were mountain big sagebrush (*Artemisia tridentata* spp. *vaseyana* (Nutt.) Beetle & A. Young) grassland and curl-leaf mountain mahogany (*Cercocarpus ledifolius* (Nutt.) Torr. & Gray) thickets. Aspen stands were dominated by western juniper. Juniper began establishing in these stands in the 1860′s and juniper that established prior to 1940 dominated the overstory (Miller and Bates, 2001). Juniper woodlands were rated as being in late to closed phases and all aspen stands were fragmented and in decline using descriptions by Bartos and Campbell (1998), Miller and Rose (1995), and Wall et al. (2001). These stands are characterized by tree cover dominated by conifers, aspen recruitment and cover are low and fragmented, and standing dead and fallen large aspen trees are prevalent.

The Ecological Site Description for the sites are 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). 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 (Snow telemetry) site, 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 (Fig. 1). Most aspen areas in the western United States receive at least 380 mm of precipitation annually or are able to access addition water from snow drifts, subsurface flow, and elevated water tables (Jones and DeByle, 1985b).

Western snowberry (*Symphoricarpus oreophilus* Gray) and wax currant (*Ribes cereum* Dougl.) were the most common shrubs. Other shrubs that were minor components of the shrub layer, included black elderberry (*Sambucus racemosa* L.), rubber and green rabbitbrush (*Ericameria nauseosa* (Pall. ex Pursh) G.L. Nesom & Baird; *Chrysothamnus viscidiflorus* (Hook.) Nutt.), Wood's rose (*Rosa woodsii* Lindl.), and western serviceberry (*Amelanchier alnifolia* Nutt.). Occasional trees included curl-leaf mountain mahogany and common chokecherry (*Prunus virginiana* L.). Species identification used nomenclature from USDA Plants Database (2017).

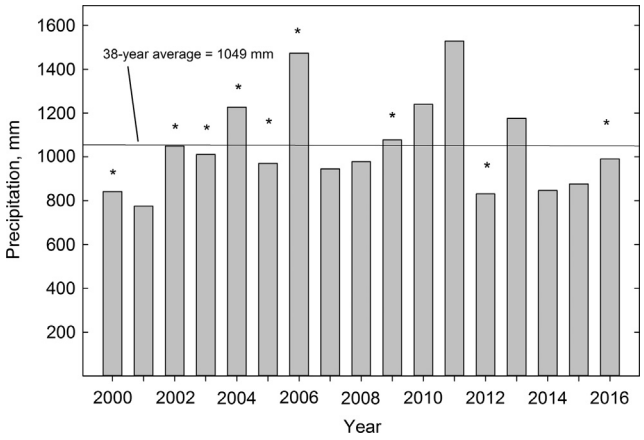

Fig. 1. Water year precipitation (Oct 1-Sept 30), 2000–2016, and 38 year average from the Fish Creek Snotel, Oregon, (42°43′N; 118°38′ min W; Elevation: 2335 m). Asterisks indicate years when aspen plots were measured.

2.2. Study design and burn applications

We used a randomized block design (Peterson, 1985). Ten, 0.60-ha blocks were established in aspen stands in May 2000. A block consisted of three plots: an untreated woodland (control), juniper cutting followed by fall prescribed fire (Fall), and juniper cutting followed by early spring prescribed fire (Spring). Buffer strips to separate treatments resulted in treatments plots of about 0.13 ha. Livestock were excluded from the area two years prior and the first three years after conifer treatment.

Cutting involved felling mature (dominant and subcanopy) juniper trees, evenly distributed through the stand. Junipers were cut in winter and spring 2001 and allowed to dry prior to burning. An average of 106 (range 55–175) juniper trees were cut in Fall plots, which represented approximately 1/3 of the dominant and subcanopy juniper. An average of 232 (range 140–372) juniper trees were cut in Spring plots, representing approximately 2/3 of the dominant and subcanopy juniper. The cut trees served to increase the level of dry fuels (0–4 m in height) to carry fire through stands. Fall burning was applied in October 2001 by personnel of the Bureau of Land Management (BLM), Burns District, Oregon. The prescribed fire technique used was a spot head fire using helicopter-dropped delayed action ignition devices (DIADS). DIADS were chemically injected ping-pongs. To prevent dropping of ignition devices in Control and Spring treatments these areas were marked with strips of butcher block paper, located 100–200 m from plots requiring protection. Spring burning were head fires, applied in late April 2002 using drip torches containing a 50:50 mixture of gasoline and diesel. Fuel continuity of the cut junipers was sufficient for fire to carry with minimal re-ignition.

Fire severity was estimated by adapting severity categories developed by Bartos et al. (1994) for evaluating plant community response to fire (Bates et al., 2006). Greater litter and fuel moisture content and higher relative humidity during spring burning resulted in a less severe fire. About 55% of remaining live juniper and almost 76% of the adult aspen stems were killed by the fire treatment. Fire severity in the Spring treatment was rated as having no impact to the understory and having moderate impact to remaining live juniper. In the Fall treatment, all downed juniper material but the trunks were fully consumed. Litter and understory consumption was > 95% and juniper and aspen kill were 99% and 100%, respectively. Fire severity in the Fall treatment was high (Bates et al., 2006).