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Response of Conifer-Encroached Shrublands in the Great Basin to Prescribed Fire and Mechanical Treatments

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Abstract

In response to the recent expansion of piñon and juniper woodlands into sagebrush-steppe communities in the northern Great Basin region, numerous conifer-removal projects have been implemented, primarily to release understory vegetation at sites having a wide range of environmental conditions. Responses to these treatments have varied from successful restoration of native plant communities to complete conversion to nonnative invasive species. To evaluate the general response of understory vegetation to tree canopy removal in conifer-encroached shrublands, we set up a region-wide study that measured treatment-induced changes in understory cover and density. Eleven study sites located across four states in the Great Basin were established as statistical replicate blocks, each containing fire, mechanical, and control treatments. Different cover groups were measured prior to and during the first 3 yr following treatment. There was a general pattern of response across the wide range of site conditions. There was an immediate increase in bare ground and decrease in tall perennial grasses following the fire treatment, but both recovered by the second or third growing season after treatment. Tall perennial grass cover increased in the mechanical treatment in the second and third year, and in the fire treatment cover was higher than the control by year 3. Nonnative grass and forb cover did not increase in the fire and mechanical treatments in the first year but increased in the second and third years. Perennial forb cover increased in both the fire and mechanical treatments. The recovery of herbaceous cover groups was from increased growth of residual vegetation, not density. Sagebrush declined in the fire treatment, but seedling density increased in both treatments. Biological soil crust declined in the fire treatment, with no indications of recovery. Differences in plant response that occurred between mechanical and fire treatments should be considered when selecting management options.

Key Words: sagebrush, cheatgrass, nonnative species, piñon–juniper, restoration, Utah juniper, western juniper, single-needle piñon, resilience

INTRODUCTION

Since the 1860s, several species of piñon and juniper have expanded into grassland, sagebrush-steppe, and aspen communities, increasing 125–625% in the central and northern portions of the Great Basin and river basins to the north and west (Cottam and Stewart 1940; Adams 1975; Burkhardt and Tisdale 1976; Tausch et al. 1981; Tausch and West 1988; Miller and Rose 1995; Tausch and West 1995; Gedney et al. 1999; Miller and Rose, 1999; Wall et al. 2001; Johnson and Miller 2006; Weisberg et al. 2007; Miller et al. 2008). In response to these recently formed conifer-encroached shrublands, private landowners and public agencies have treated large areas across the interior West by removing trees with prescribed fire and mechanical methods. The rationale for tree removal has included fuel reduction, restoration of sage-steppe communities and watersheds, and enhanced forage and wildlife habitat. Unfortunately, plant-community response to tree removal is not always consistent or predictable, and succession may not move in a desirable direction following treatment (Miller et al. 2013). Successional trajectories following tree removal in conifer-encroached shrublands can range from a progression toward native shrub-steppe communities (Tausch and Tueller 1977; Everett and Sharrow 1985a; Skousen et al. 1986; Stager and Klebenow 1987; Rose and Eddleman 1994; Bates et al. 2000, 2006, 2007; Coultrap et al. 2008) to no change in native understory vegetation (Everett and Sharrow 1985a; Yorks et al. 1994; Bates et al. 2006; Bristow 2010), to large increases in invasive annuals, at least during the first few years after tree removal (Barney and Frischknecht 1974; Koniak 1985; Skousen et al. 1986; Bates et al. 2007).

The initial stages of succession following treatment may be largely dependent on pre-existing conditions. Several studies have proposed a successional model following piñon and juniper removal that progresses from native and/or nonnative annuals to perennial grass-forb to perennial grass-forb shrub to young trees occupying a site, and eventually to mature woodland (Erdman 1970; Barney and Frischknecht 1974; Koniak 1985; Skousen et al. 1989). However, vegetation

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dominating the initial phase of succession has been reported to depend upon pre-existing plant composition (Bunting 1985) and can start with a strong response of native perennials (Everett and Sharrow 1985b; Bates et al. 2000, 2007). Conversely, where native herbaceous vegetation is depleted the potential for recovery is limited (Yorks et al. 1994) and invasive annuals may continue to dominate many years after disturbance (Koniak 1985). This may result in a shift of conifer-encroached shrublands to new steady states dominated by introduced annuals and biennials following treatment or wildfire (Pellant and Hall 1994; Tausch 1999; Holmes and Miller 2010; Miller et al. 2011).

Piñon- and juniper-encroached shrublands occur over a wide range of environmental conditions and are represented by continually changing gradients in climate, elevation, aspect, slope, geology, soils, and disturbance regimes (West et al. 1978, 1998; Gedney et al. 1999; Miller et al. 2000, 2005, 2011, 2013). This makes current region-wide recommendations difficult and possibly unreliable. However, generalized state-and-transition models that account for specific site attributes (e.g., soil moisture/temperature regimes) may link sites with similar attributes, enabling managers to apply results from one location to another (Bestelmeyer et al. 2009; Chambers et al. 2013; Miller et al. 2013, 2014; Chambers et al. 2014). A key question to address is—Are there predictable patterns in understory response to conifer removal? Although numerous studies have evaluated plant response to tree removal, most studies have been conducted at one location and lack comparability because they vary widely in predisturbance plant composition, the kind and severity of disturbance (e.g., wildfire versus prescribed fire treatment), posttreatment disturbance, and site attributes. A single study conducted at one time and in one or a few places cannot describe the general patterns of plant succession following tree removal across the wide range of environmental variables that characterize conifer encroached shrublands. And there have been surprisingly few studies that made replicated side-by-side comparisons between mechanical and prescribed fire treatments (Miller et al. 2013). The study by Everett and Sharrow (1985a), which evaluated mechanical tree removal across central Nevada, is one of the few multilocational studies conducted in the Intermountain West. Their results showed a distinct pattern in vegetation response across a large area in central Nevada. The results from regional studies that cover a meaningful portion of site variation greatly enhance our ability to evaluate the response of different plant and ground-cover groups under a wide range of conditions, and thus allow us to develop general state-and-transition models. Such studies can describe patterns of variation in plant successional trajectories in conifer-encroached shrublands across a large region, evaluate the consistency of response, identify attributes that may be linked to the response, and allow for the evaluation and extrapolation of results from one site to another. In addition, studies that combine before and after measurements with unmanipulated controls across multiple sites allow for the evaluation of treatment effects in the context of both temporal and spatial variation (Carpenter 1990).

The Sagebrush Treatment Evaluation Project (McIver et al. 2010) set up such a region-wide study to evaluate patterns of understory plant succession after tree removal and to identify important attributes for the development of predictive models. Study sites were located in conifer-encroached shrublands across a broad geographic area in the northern Great Basin and basins to the north and west. Each study site was a complete block of prescribed fire, mechanical, and control treatments, applied over relatively large plots (>8 ha). We asked three questions relative to understory plant response to tree removal by fire and mechanical treatments: 1) how do different plant and ground-cover groups respond across a relatively wide range of tree-encroached sites, 2) how consistent was the response to tree removal across a wide range of sites, and 3) do understory cover groups respond differently to removal of juniper and/or piñon by fire versus mechanical treatments during the first 3 posttreatment years?

METHODS AND MATERIALS

Study Area

Eleven sites were selected across a broad geographical area in Utah, Nevada, California, and Oregon, encompassing a wide range of environmental conditions (Fig. 1) (McIver et al. 2010). Criteria used to select sites were 1) the dominant shrub was *Artemisia tridentata* Nutt., 2) there was no evidence that these stands had recently been dominated by old-growth juniper or piñon pine (absence of large stumps and/or logs), 3) soils were loams, 4) native grasses and forbs were present in the understory, and 5) introduced species were present but not a dominant component (observed cover of nonnatives was equal to or less then native herbs). The sites represented four different cover types, each reflecting a different dominant tree species (Table 1). Four study sites were located in western juniper (*Juniperus occidentalis* Hook.) in California and Oregon, three sites in singleleaf piñon (*Pinus monophylla* Torr. & Frém.) and Utah juniper (*Juniperus osteosperma* [Torr.] Little) in Nevada, and in Utah, two sites in Utah juniper, and two sites in Utah juniper and Colorado piñon (*Pinus edulis* Engelm). The sites are located within five climate-based major land resource areas (MLRAs), which include the Malheur High Plateau, Klamath Basin, Upper Snake River, Central Nevada Basin and Range, and Salt Lake Basin (US Department of Agriculture–Natural Resources Conservation Service [USDA-NRCS] 2011) (Table 1; Fig. 1). Sites vary considerably in elevation, topography, soils, current vegetation, and climate (Table 1). Soil temperature and moisture regimes ranged from warm–mesic to cool–frigid and aridic–xeric to xeric, respectively. Tree canopy cover within and across the 11 sites varied widely within and across study sites (see figure 4 in Roundy et al. 2014a) from relatively open ($<5\%$) to closed ($>20\%$). The predominant shrubs and grasses present on the sites prior to treatment are listed in Table 1.

Although all sites are classified as cold desert, weather patterns differ markedly across this geographic range. Sites in California and Oregon have a Pacific Maritime climate, with nearly all precipitation originating in the Pacific Ocean and falling between November and June. This area, which includes the western juniper cover type, lies north of the polar front gradient where temperatures are cooler, summer precipitation lower, and winter precipitation higher (Mitchell 1976). In contrast, sites in Nevada and Utah are located south of the