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Short-Term Response of Sage-Grouse Nesting to Conifer Removal in the Northern Great Basin☆

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ABSTRACT

Conifer woodlands expanding into sage-steppe (*Artemisia* spp.) are a threat to sagebrush obligate species including the imperiled greater sage-grouse *(Centrocercus urophasianus)*. Conifer removal is accelerating rapidly despite a lack of empirical evidence to assess outcomes to grouse. Using a before-after-control-impact design, we evaluated short-term effects of conifer removal on nesting habitat use by monitoring 262 sage-grouse nests in the northern Great Basin during 2010–2014. Tree removal made available for nesting an additional 28% of the treatment landscape by expanding habitat an estimated 9603 ha (3201 ha [±480 SE] annually). Relative probability of nesting in newly restored sites increased by 22% annually, and females were 43% more likely to nest within 1000 m of treatments. From 2011 (pretreatment) to 2014 (3 yr after treatments began), 29% of the marked population (9.5% [±1.2 SE] annually) had shifted its nesting activities into mountain big sagebrush habitats that were cleared of encroaching conifer. Grouping treatments likely contributed to beneficial outcomes for grouse as individual removal projects averaged just 87 ha in size but cumulatively covered a fifth of the study area. Collaboratively identifying future priority watersheds and implementing treatments across public and private ownerships is vital to effectively restore the sage-steppe ecosystem for nesting sage-grouse.

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Introduction

Conifer woodlands have been expanding into sagebrush (*Artemisia* spp.) and grassland ecosystems throughout the western United States since European-American settlement and are considered a major threat to sagebrush and grassland obligate species (Bragg and Hulbert, 1976; Miller and Tausch, 2001; Briggs et al., 2002; Grant et al., 2004; Miller et al., 2005, 2011; Davies et al., 2011). For example, the most abundant encroaching conifer species in the northern Great Basin, western juniper *(Juniperus occidentalis)*, has expanded ~10-fold during the past 130 years and currently occupies ~3.6 million ha in California, Nevada, Oregon, Idaho, and Washington (Miller and Tausch, 2001; Miller et al., 2005). In addition, various other species of juniper (*Juniperus* spp.) and piñon pine (*Pinus* spp.) are increasing threats throughout sagebrush systems (Miller et al., 2011; United States Fish and Wildlife Service [USFWS], 2015).

Conifer expansion and infill reduce grass and forb abundance and diversity by limiting nutrients, water, sunlight, and space and increasing surface water runoff and erosion (Buckhouse and Gaither, 1982; Gaither and Buckhouse, 1983; Miller et al., 2011). Increased runoff, interception of rainfall, and increased transpiration of conifers often lower the water table and reduce springflow and streamflow (Baker, 1984; Wilcox, 2002). Conifer encroachment is categorized into three successional phases (Miller et al., 2005). Initially, conifers are present with shrubs and herbaceous plants still dominant (phase I), followed by a stage in which conifers codominate the vegetation community (phase II). Finally, the landscape is dominated by conifers with decreased understory (phase III).

Phase I and phase II transitional woodland habitats support a high diversity of shrub, grass, and forest animal species (O'Meara et al., 1981; Maser et al., 1984a, 1984b; Sedgewick, 1987; Miller et al., 2005); however, most are generalist or forest-dependent species, which flourish while sagebrush-obligate birds and mammals decline (Lloyd et al., 1998; Coppedge et al., 2004; Grant et al., 2004; Horncastle et al., 2005; Woods et al., 2013). Recent studies report negative impacts from conifer expansion to lek occupancy in greater sage-grouse

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(*Centrocercus urophasianus,* hereafter sage-grouse; Baruch-Mordo et al., 2013) and declines in habitat quality for nesting (Gregg, 1992; Doherty et al., 2010), brood rearing (Atamian et al., 2010; Casazza et al., 2011), and wintering (Doherty et al., 2008; Freese, 2009). Tree encroachment can increase perch availability for corvids and raptors that prey on sage-grouse (Paton, 1994; Wolff et al., 1999; Manzer and Hannon, 2005), which may be one of the underlying mechanisms affecting sage-grouse populations.

Growing concern for sage-grouse, an obligate sagebrush species requiring large, contiguous tracts of habitat (Knick and Connelly, 2011), has led to an unprecedented rangewide conservation response to reduce threats to the species and ecosystems on which they depend (USFWS, 2015). A combination of land management policy revisions and conservation efforts has been undertaken to address a wide range of threats from energy development to wildfire (USFWS, 2015). Among the suite of conservation actions, removal of encroaching conifers at landscape scales has become an increasingly important strategy for maintaining extant populations (Baruch-Mordo et al., 2013). In Oregon alone, the amount of conifer-encroached lands treated by partners through the Sage Grouse Initiative (SGI) grew 1411% from 2010 to 2014, addressing roughly two-thirds of the phase I encroachment on priority private lands (Natural Resources Conservation Service [NRCS], 2015).

While sage-grouse biologists have long recommended conifer removal to benefit sage-grouse (Connelly et al., 2000), little research has examined the spatial and temporal effects of conifer management on sage-grouse populations and behavior (USFWS, 2015). Commons et al. (1999) reported increased lek counts of Gunnison sage-grouse *(Centrocercus minimus)* after piñon-juniper removal in Colorado. Frey et al. (2013) documented increased use of sagebrush habitats following conifer removal. While both studies increased knowledge of treatment effects, additional research with more rigorous designs is needed to further validate the results and expand inference to other areas.

Using a before-after-control-impact (BACI) framework, we evaluated the effects of conifer management on nest-site selection across landscape-scale treatment and control sites in southern Oregon. Our objective was to evaluate spatial and temporal treatment effects to inform management decisions and outcomes of ongoing conservation efforts. Specifically, we predicted that conifer removal would result in 1) additional nests within and nearer to cut areas, 2) increased available nesting habitat, and 3) greater posttreatment nesting in mountain big sagebrush (*Artemisia tridentata* ssp. *vaseyana*; MBS), the habitat type most impacted by conifer encroachment (Miller and Eddleman, 2001).

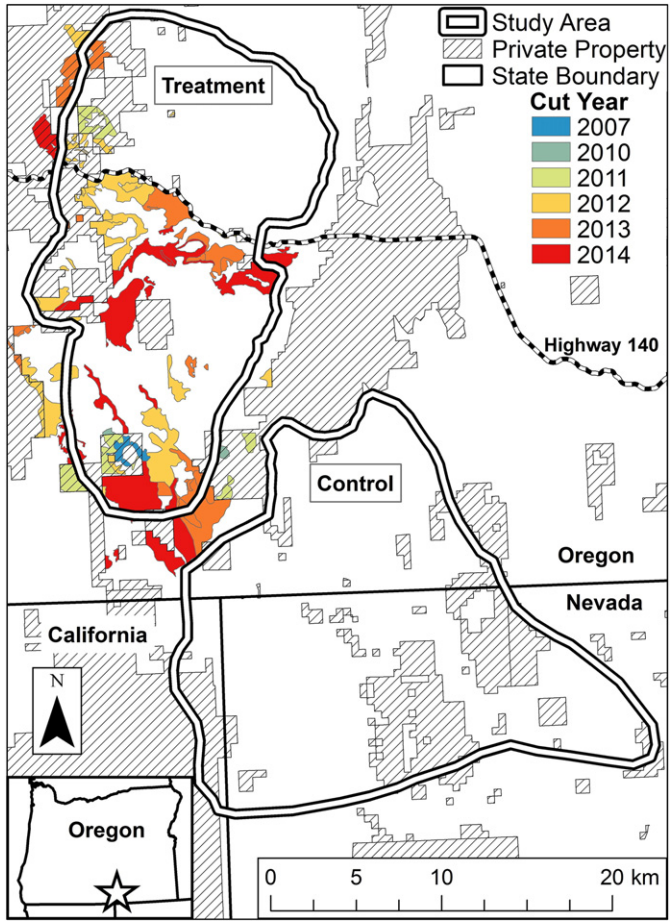

Figure 1. Treatment and control study areas in (star in inset) used to assess greater sage-grouse response to conifer management in Lake County, Oregon, 2010–2014. Colored polygons delimit years of conifer removal. Although some removal began as early as 2007, a majority of the cutting began in 2012.

Methods

Study Area

Data were collected in a treatment area in southern Lake County in south-central Oregon between the Warner Mountains and the Warner Valley and a control area in southern Lake County south of Warner Valley extending into Modoc County, California north of Cowhead Lake and into Washoe County, Nevada north of Mosquito Lake (Fig. 1). We delineated discrete boundaries for treatment and control study areas guided by natural barriers (e.g., canyons, cliffs, forest), as well as observed sage-grouse movements (see Fig. 1). The treatment area totaled 34 000 ha and ranged in elevation from 1490 m to 2100 m with an average of 1770 m above sea level. The control area totaled 40 000 ha and ranged in elevation from 1360 m to 2180 m with an average of 1680 m above sea level. Pretreatment conifer cover was 3.0% and 3.9% throughout the treatment and control areas, respectively, calculated from data acquired from the NRCS (Falkowski and Evans, 2012; Poznanovic et al., 2014). Mean monthly temperature from 2000 to 2014 was 8.7°C (min: 6.4°C, max: 10.7°C). Mean annual precipitation from 2000 to 2014 was 17.8 cm (min: 11.0 cm, max: 33.0 cm). Both areas were dominated by low sagebrush *(Artemisia arbuscula)* habitat, but other dominant species included MBS at higher elevations, Wyoming big sagebrush (*A. t.* ssp. *wyomingensis*) at lower elevations, and other interspersed shrubs including antelope bitterbrush *(Purshia tridentata),* rabbitbrush (*Chrysothamnus* spp.), saltbrush (*Atriplex* spp.), and mountain mahogany (*Cercocarpus* spp.). We also identified mountain shrub habitat, which was generally codominated by MBS and other shrubs such as antelope bitterbrush and mountain mahogany. We combined mountain shrub with the MBS habitat type for analysis. Western juniper occurred in patchy distributions from mid to high elevation.

Conifer Management

The Bureau of Land Management (BLM) removed juniper on federal land while the NRCS, in association with the Oregon Department of Fish and Wildlife, assisted landowners with juniper removal on private land within and surrounding the treatment area (see Fig. 1). Treatments generally occurred from late fall to early spring and were designed to maximize shrub retention. Most of the treated areas were phase I to phase II encroachment (Miller et al., 2005) with generally intact understory herbaceous and shrub vegetation. Most treatments were conducted by hand-cutting with brushsaws and chainsaws, but 444 ha were machine cut (e.g., feller-buncher) in fall 2013 to spring 2014. Additional slash treatment of cut conifers was conducted where necessary to reduce woody fuels and a vertical structure. Various treatments were implemented depending on tree size and density, understory, and landowner preference [on private land] but mostly consisted of cut-leave, cut-lop, cut-burn, and cut-pile-burn. Cut-leave involved cutting trees without

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