Rangeland Ecology & Management 70 (2017) 493–503

Contents lists available at ScienceDirect

Rangeland Ecology & Management

journal homepage: http://www.elsevier.com/locate/rama

Original Research

Resource Selection by Greater Sage-Grouse Reveals Preference for Mechanically-Altered Habitats☆

Jared J. Baxter [a,*], Rick J. Baxter [a], David K. Dahlgren [b], Randy T. Larsen [a,c]

[a] Department of Plant and Wildlife Sciences, Brigham Young University, Provo, UT 84602, USA
[b] Assistant Professor, Wildland Resources Department, Utah State University, Logan, UT 84322, USA
[c] Associate Professor and Assistant Curator of Birds, Monte L. Bean Life Sciences Museum, Brigham Young University, Provo, UT 84602, USA

ARTICLE INFO

Article history:
Received 7 May 2016
Received in revised form 4 January 2017
Accepted 16 January 2017

Keywords:
cross validation
information theoretic approach
mechanical treatment
mountain big sagebrush
sagebrush removal
Strawberry Valley

ABSTRACT

Effective conservation requires an understanding of how species respond to management actions. For species of conservation concern such as greater sage-grouse *(Centrocercus urophasianus)*, this understanding is urgently needed. We developed resource selection functions to assess the influence of mechanical treatments of mountain big sagebrush *(Artemisia tridentata vaseyana)* on habitat selection by greater sage-grouse during the critical brooding period. We measured multiple vegetation components, including shrub, grass, and forb cover, at random locations before and after sagebrush treatments. We then used model selection and a 19-yr telemetry data set (1998 − 2016) to evaluate response of greater sage-grouse to treatments. Statistical models were built using 418 locations from 72 females with broods (333 locations, 61 females pretreatment; 85 locations, 11 females post treatment). Using a difference in means comparison, we found shrub canopy cover decreased (mean ± SE) from 31.81% ± 0.70% to 16.16% ± 0.89% following mechanical treatment. Grass cover increased from 12.02% ± 0.51% to 31.33% ± 1.52% after treatment. Post-treatment forb cover (12.58% ± 1.23%) did not differ from pretreatment estimates (12.39% ± 0.61%). Overall, greater sage-grouse selected areas that were 1) distant from trees, paved roads, and powerlines; 2) high in elevation; 3) near treatment edges; and 4) consisting of gentle slopes. Post-treatment sage-grouse showed stronger selection for treatments and treatment edges than did pretreatment sage-grouse. Maps predicting probability of selection by brood-rearing sage-grouse showed increased use in and around mechanically treated areas. This altered pattern of selection by sage-grouse with broods suggests mechanical treatments may be a suitable way to increase use of mountain big sagebrush during the brooding period.

Introduction

Loss and degradation of habitat threaten species across the globe (Pimm and Raven, 2000; Dirzo and Raven, 2003; Foley et al., 2005). The quantity and quality of habitats available to wildlife, including the rangelands of western North America, continue to decline due to the impacts of anthropogenic development, wildfires, climate change, and invasive species (Wisdom et al., 2005; Bradley, 2010). Obligate species are more sensitive to habitat alterations and are at increased risk of extinction compared with generalist species, especially when habitats are lost or degraded (Saab and Rich, 1997; Julliard et al., 2003; Colles et al., 2009). Obligate species often have low adaptive ability and require effective, species-based management actions to mitigate impacts of habitat fragmentation and loss (Goble et al., 2012). Examining how species respond to management actions, whether through experimental or observational studies, is essential to guide effective conservation of vulnerable and imperiled species and their habitats.

The distribution of sagebrush (*Artemisia* spp.) has dramatically decreased across western North American rangelands in recent decades, creating one of North America's most pressing conservation challenges (Knick, 1999; Connelly et al., 2004). Big sagebrush (*A. tridentata* ssp.) once dominated 400 000 − 600 000 km^2 in western North America (Beetle, 1960; McArthur and Stevens, 2004). Recent estimates suggest there has been a 50 − 60% reduction in sagebrush since the beginning of the 19th century (Schroeder et al., 2004). Anthropogenic impacts are recognized as having the greatest influence on this decline in sagebrush (Walker et al., 2007; Leu and Hanser, 2011; Wisdom et al., 2011). Additionally, encroachment by juniper (*Juniperus* spp.) woodlands and invasion by species such as cheatgrass *(Bromus tectorum)* have further impacted sagebrush ecosystems (Miller et al., 2011; Knick et al., 2013). Such a significant reduction and alteration in

☆ This work was supported by the Utah Reclamation, Mitigation, and Conservation Commission; Western Association of Fish and Wildlife Agencies; Sportsmen for Fish and Wildlife; Utah Division of Wildlife Resources; US Forest Service; and Brigham Young University.

* Correspondence: Jared Baxter, Plant and Wildlife Sciences, Brigham Young University, Provo, UT 84602, USA.
E-mail address: baxter.jaredj@gmail.com (J.J. Baxter).

http://dx.doi.org/10.1016/j.rama.2017.01.007

sagebrush systems has had profound effects on the distribution and abundance of sagebrush-obligate or near-obligate species, such as greater sage-grouse *(Centrocercus urophasianus;* hereafter, sage-grouse) (Connelly et al., 2004; Crawford et al., 2004; Wisdom et al., 2011). Sage-grouse have become a species of great conservation concern following their range-wide decline over recent decades. Loss of quality brood-rearing habitat, in particular, has been implicated as a major factor in the range-wide decline (Aldridge and Brigham, 2002; Connelly et al., 2004; Crawford et al., 2004). Due to the decline in the amount and contiguity of sagebrush in North America, conservation and restoration of remaining suitable habitat have become increasingly important for sage-grouse.

Sage-grouse require sagebrush throughout all phases of their life cycle, but specific needs vary by season. Nesting and winter habitats are predominantly characterized by tall, dense stands of sagebrush (Connelly et al., 2000). In contrast, a productive and diverse understory of grasses and forbs with relatively sparse sagebrush cover is more typical of brood-rearing habitat (Klebenow, 1969; Wallestad, 1971; Drut et al., 1994). In some areas where brood-rearing habitat may be limiting, managers have reduced sagebrush cover using chemical, mechanical, or other (e.g., fire or grazing) means in an attempt to improve quality of brood-rearing habitat (Utah DWR, 2013; BLM, 2015). Plant community response to these sagebrush treatments, however, is highly variable and often dependent on the method used, subspecies of big sagebrush, and environmental conditions (e.g., precipitation, soil moisture) following treatment. Prescribed fire and mechanical treatments in Wyoming big sagebrush *(Artemisia tridentata wyomingensis)* generally produced either neutral or negative (e.g., invasion of exotic annual grasses) responses in herbaceous cover and understory (Davies et al., 2011; Beck et al., 2012; Davies et al., 2012b; Hess and Beck, 2012). Annual grass cover, for example, increased sevenfold by the third year following mowed treatments in Oregon (Davies et al., 2011). In Wyoming, perennial grass cover and height in mowed treatments did not differ from reference sites (Hess and Beck, 2012). In contrast, production of forbs and grasses favored by sage-grouse increased in the immediate years following mechanical treatment in mountain big sagebrush *(Artemisia tridentata vaseyana)* (Dahlgren et al., 2006; Davies et al., 2012c).

These studies produced data on the response of vegetation following treatments in sagebrush, yet little is known about how sage-grouse respond to these changes. Some evidence suggests that females with broods used areas where sagebrush cover was reduced (40% down to 10 − 15%), particularly within 30 − 90 m of treatment edges (Klebenow, 1970; Dahlgren et al., 2006; Thacker, 2010; Dahlgren et al., 2015). Female sage-grouse with broods favored treated areas if they contained increased availability of herbaceous plants (e.g., forbs) and associated arthropods, which are linked to improved nutrition for sage-grouse (Gregg et al., 2008; Dahlgren et al., 2015). If these nutritional components were not present following treatment of sagebrush, sage-grouse avoided treated areas (Martin, 1970). To our knowledge, however, there are no published reports examining habitat selection both before and after sagebrush removal, including using a geographic information system (GIS) to account for other features that may influence habitat selection. We took advantage of a 19-yr telemetry data set that spanned periods before and after mechanical treatment of sagebrush to assess response of sage-grouse to these actions.

The objectives of our study were to assess the effectiveness of mechanical treatments by 1) measuring shrub and herbaceous cover in treated and untreated sagebrush communities and 2) evaluating the influence of mechanical treatments on habitat selection by female sage-grouse with chicks during the brooding period (June − August) in a high-elevation (2 300 − 2 600 m) system dominated by mountain big sagebrush. We predicted that 1) herbaceous understory cover would increase with decreasing shrub cover resulting from mechanical treatment and 2) sage-grouse would demonstrate increased use of areas in and near treatments during the brood-rearing period following mechanical treatments. Our results present important findings with implications for the management of sagebrush throughout the West and for the conservation of greater sage-grouse.

Methods

Study Area

Strawberry Valley was located in Wasatch County, Utah, south and east of the Uinta and Wasatch mountain ranges, respectively. Strawberry Reservoir was the dominant feature in the valley comprising nearly 7 000 surface ha at full pool. At elevations ranging from 2 300 to 2 600 m, the climate was characterized by cool summers (13.5°C mean air temperature) and cold winters (−8.7°C mean air temperature) with annual precipitation of 77.5 cm (NRCS National Water and Climate Center, 2015). The majority of precipitation fell as snow from December to March, with snowpack often lasting into the early brood-rearing period (late May). No severe droughts or fires occurred in Strawberry Valley during our study years. No grazing by domestic livestock occurred in the study area, and the population of sage-grouse was not subject to hunting pressure by humans.

Mountain big sagebrush and silver sagebrush *(Artemisia cana)* were the dominant shrubs in the area, typical of mesic sagebrush ecosystems. Common forbs found in our study area included silvery lupine *(Lupinus argenteus),* sticky purple geranium *(Geranium viscosissimum),* and sulphur-flower buckwheat *(Eriogonum umbellatum)*. Common grasses included needle-and-thread *(Stipa comata),* Kentucky bluegrass *(Poa pratensis),* and prairie Junegrass *(Koeleria cristata)*.

Defining availability of habitats to animals has the potential to influence resource selection functions (RSFs). Thus, it is important to delineate an area that is biologically relevant to the species of interest and appropriate for the question asked. We limited our study area for the RSF in our analysis to a 50% minimum convex polygon (MPC; Worton, 1989) derived from 19 years of brood locations, centered on the lek nearest to the treated areas (Fig. 1). We then added a 1-km buffer (Aldridge and Boyce, 2007; Carpenter et al., 2010; Sovern et al., 2015) to the MCP, which represented the approximate upper end of daily brood movements (Wallestad, 1971). This buffer allowed us to capture additional areas likely associated with those broods found on the MCP boundary. We created the MCP using Home Range Tools 2.0 (Rodgers et al., 2012) in ArcMap 10.3 (ESRI, Redlands, CA). With this process, we delineated a total study area of 10 080 ha, which was then reduced by 33.7% to 6 680 ha after subtracting unavailable areas (i.e., Strawberry Reservoir).

Our objective with this delineation was not to estimate home range size or assess habitat selection across the broad area used by semimigratory sage-grouse in this population. Instead, our goal was to delineate an area available to brooding female sage-grouse in and around the areas mechanically altered and subsequently to determine if grouse with broods in this area selected for or against mechanical treatments (Gillies et al., 2006; Tardy et al., 2014; Losier et al., 2015). With this approach, we achieved a study area that was biologically relevant to sage-grouse with broods and appropriate for our particular study objectives while avoiding overestimations that can occur with 95% MCPs (Burgman and Fox, 2003).

Mechanical Treatments

The Utah Division of Wildlife Resources (UDWR) and US Forest Service (USFS) mechanically treated sagebrush using either a chain harrow (chain with sections of railroad tracks welded to it) or brushhog (mower). Approximately 165.7 ha of mountain big sagebrush were treated in 2009, 177.6 ha in 2011, and 91.9 ha in 2014, totaling 435.2 ha (6.5% of study area). Individual treatment plots (polygons) ranged in size from 0.4 ha to 14.9 ha, with an overall mean ($\pm$ SE) of 3.6 $\pm$ 0.2 ha (Fig. 1). Treatments were implemented in September of each year, avoiding the critical period of brood-rearing and in association with seed set by sagebrush. These treatments were designed to