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Greater Sage-Grouse and Range Management: Insights from a 25-Year Case Study in Utah and Wyoming☆

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A B S T R A C T

Conservation of sagebrush (*Artemisia* spp.) systems is one of the most difficult and pressing concerns in western North America. Sagebrush obligates, such as greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse), have experienced population declines as sagebrush systems have degraded. Science-based management is crucial to improve certainty in range management practices. Although large-scale implementation of management regimens within an experimental design is difficult, long-term case studies provide opportunities to improve learning and develop and refine hypotheses. We used 25 years of data across three large landscapes in northern Utah and southwestern Wyoming to assess sage-grouse population change and corresponding land management differences in a case study design. Sage-grouse lek counts at our Deseret Land and Livestock (DLL) study site increased relative to surrounding populations in correspondence with the implementation of small-acreage sagebrush treatments designed to reduce shrub cover and increase herbaceous understory within a prescriptive grazing management framework. The higher lek counts were sustained for nearly 15 years. However, with continued sagebrush treatments and the onset of adverse winter conditions, DLL lek counts declined to levels consistent with surrounding areas. During summer, DLL sage-grouse broods used plots of small, treated sagebrush mosaics more than untreated reference sites. We hypothesize that sagebrush treatments on DLL increased availability of grasses and forbs to sage-grouse, similar to other studies, but that cumulative annual reductions in sagebrush may have reduced availability of sagebrush cover for sage-grouse seasonal needs at DLL, especially when extreme winter weather occurred.

Introduction

Increasing losses in biodiversity across the globe demand an unprecedented scale and certainty in application of conservation actions to slow declines (Waldron et al., 2013). Most imperiled are species with high vulnerability and low adaptive capacity that can only be maintained through species-specific management actions (Goble et al., 2012). Science-based management underpins conservation effectiveness, and without it, well-intentioned practitioners may implement actions that are ineffective or even detrimental to species recovery. Effectiveness of management actions can take decades to assess given inherent variability in climate and lag times that can span years to decades, particularly for species with low reproductive rates and longer life spans. Moreover, although experimental design and replication are trademarks of science-based management, replicated experiments can be difficult or even impossible to conduct on large scales. In these scenarios, case studies can offer an approach that provides reliable information and serves as a valuable precursor to hypothesis testing (Hebblewhite, 2011).

Conservation of sagebrush (*Artemisia* spp.) ecosystems is one of the most pressing issues in western North America (Knick and Connelly, 2011). Sagebrush occurs across a large portion of western North America where sagebrush communities and their associated fauna are threatened by energy development, urbanization, conversion to cropland, invasion of exotic plants and subsequent catastrophic wildfire,

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conifer encroachment, and sagebrush eradication (Naugle, 2011; Knick et al., 2013; Murphy et al., 2013). Loss and degradation of sagebrush communities have led to conservation challenges for a variety of species (Baker et al., 1976; Miller and Eddleman, 2000; Bradley, 2010). At greatest risk are obligate species found only in this ecotype (Oyler-McCance et al., 2001; Ingelfinger and Anderson, 2004; Holloran, 2005).

Greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) are sagebrush obligates that use this ecosystem throughout all phases of their life cycle. As with other sagebrush obligates, sage-grouse populations have declined in response to habitat loss and degradation (Garton et al., 2011). New outcome-based science is quantifying the efficacy of proactive conservation measures to stem population losses (e.g., conifer removal [Baruch-Mordo et al., 2013] and conservation easements [Copeland et al., 2013]), but examples of increasing populations as a direct result of management intervention are rare, leaving practitioners unsure of management actions that could be implemented proactively to further conservation of sage-grouse.

The detrimental impacts of sagebrush canopy removal or reduction on sagebrush obligate species across large areas are widely known (Beck et al., 2012). The efficacy of small-scale (e.g., < 200-ha mosaics) shrub removal in sage-grouse management, however, remains fiercely debated. On one hand, removal or thinning of sagebrush in small areas in mosaic patterns within sagebrush landscapes may promote growth of grasses and forbs, which could improve brood-rearing habitat and sage-grouse recruitment (e.g., Dahlgren et al., 2006). Conversely, removal of shrubs may reduce availability of sagebrush during winter, reduce nesting habitat, facilitate invasion of exotic plants, and further fragment existing sagebrush systems. Because sage-grouse are currently being considered for federal Endangered Species Act listing (Stiver, 2011), a better understanding of the response of sage-grouse to small-scale sagebrush canopy reduction with applications of mechanical, chemical, or prescribed fire is needed. Long-term case studies have been suggested as alternative options to assess the efficacy of these practices and provide important learning opportunities for practitioners (Krausman et al., 2009). To date, however, no such long-term studies exist.

In northern Utah, the 76 700-ha private Deseret Land and Livestock (DLL) ranch reported a dramatic increase in average males counted per lek between the late 1980s and early 2000s (Danvir, 2002). However, in 2010, lek counts on DLL declined to levels approximating surrounding populations. DLL employed range management practices during this period that were distinctly different from the surrounding areas in northern Utah and western Wyoming. These practices included a prescriptive grazing strategy where cattle were managed in three or four large herds and rotated through pastures for short periods of time (Danvir et al., 2005). Combined with prescriptive grazing, sagebrush treatments were conducted at small (generally < 200-ha) scales in mid- and high-elevation sagebrush communities. The surrounding areas largely consisted of U.S.D.I. Bureau of Land Management (BLM) allotments with limited inclusions of nonfederal land. These areas were managed using different grazing regimens and few sagebrush management projects. The DLL ranch provided habitat for a sage-grouse population adjacent to populations in north Rich County (RICH) and southwestern Wyoming (WWY). All three populations have been monitored using spring lek counts of male sage-grouse as an index of abundance for multiple decades.

The purpose of this case study was to document changes in sage-grouse populations over the past 25 years and begin to assess response of sage-grouse to differences in long-term, landscape-level (e.g., across multiple allotments or an entire 75 000 ha ranch) management actions. We first compared counts of breeding males (i.e., number of males per lek) between our three study areas. Next, we considered available data on brood counts and sage-grouse use of treatment areas on DLL. Although our approach lacks a true experimental design, it is a long-term retrospective case study that considers the preponderance of evidence accumulated over a 25-year period. Our intention was to use these data to provide information that begins to fill knowledge gaps and develop hypotheses that could be tested in replicated experimental designs in the future.

Study Areas

We identified three study areas for retrospective analysis that included 1) Deseret Land and Livestock (DLL) located in Morgan, Rich, and Weber Counties, Utah; 2) north Rich (RICH) located in Rich County, Utah; and 3) western Wyoming (WWY) located in Uinta and Lincoln Counties, Wyoming (Fig. 1). Sage-grouse habitats in each study area shared similar soils, elevations, vegetation types, and weather patterns. The study areas contained two Major Land Resource Regions (MLRAs) (USDA Agriculture Handbook 296, 2006). Sage-grouse occurred on the study areas throughout MLRA 34A (Cool Central Desertic Basins and Plateaus) and in the lower elevations of MLRA 47 (Wasatch and Uinta Mountains). Occupied habitat throughout the study areas ranged in elevation from 1 950 to 2 600 m on substrate composed of shale- and sandstone-derived Aridisols and Entisols.

Sage-grouse habitat in our study areas included at least three community types based on elevation: 1) low elevations (<2000 m) were dominated by Wyoming big sagebrush *(A. tridentata wyomingensis)* or low sagebrush *(A. arbuscula)* and Douglas rabbitbrush *(Chrysothamnus viscidiflorus)*; 2) midelevation (between 2000 m and 2100 m) habitats were dominated by basin big sagebrush *(A. t. tridentata)* with inclusions of low sagebrush, often intermixed with rabbitbrush; and 3) high elevation (>2100 m) sagebrush communities were dominated by mountain big sagebrush *(A. t. vaseyana)*, with intermixed bitterbrush *(Purshia tridentata)*, serviceberry *(Amalanchier alnifolia)* or snowberry *(Symphoricarpos albus)*, and inclusions of aspen *(Populus tremuloides)* and Douglas fir *(Pseudotsuga meniziesii)* at the highest elevations. Mean annual precipitation was 25 cm at lower elevations and 55 cm at higher elevations. Irrigated, native riparian, and meadow habitats (<5% of study area) occurred along the Bear and Green River drainages.

Anthropogenic influences in each study area included livestock grazing by domestic cattle as the primary land use. During our study period we estimated active well density at 4.54 wells per 100 km^2, 1.96 wells per 100 km^2, and 2.86 wells per 100 km^2 for DLL, RICH, and WWY, respectively in 6.4-km buffers (see Walker et al., 2007) around known leks. Well spudding rates during the study period were 2.22 per 100 km^2, 0.44 per 100 km^2, and 0.76 per 100 km^2, for DLL, RICH, and WWY, respectively (Utah data from http://stage.mapserv.utah.gov/oilgasmining; Wyoming data from http://wogcc.state.wy.us). Well pad densities in all three areas were extremely low compared with density thresholds (e.g., 150 wells per 100 km^2) showing negative impacts to sage-grouse populations in other areas (Harju et al., 2010). Therefore we did not consider differences in oil and gas well densities between study areas as likely to influence sage-grouse populations.

The three study areas differed in land ownership, grazing management strategies, and frequency of sagebrush removal. The RICH study area was 158 100 ha in size, including ~ 53% publicly owned and 47% privately owned lands. The WWY study area was 407 000 ha in size, including ~64% publicly and 36% privately owned lands. The RICH and WWY study areas were primarily federally owned lands, principally controlled by the U.S. Department of Interior, Bureau of Land Management (BLM); U.S. Department of Agriculture; and U.S. Forest Service (USFS). Most of the private rangelands "checker-boarded" within the RICH and WWY areas were managed as part of BLM allotments. Allotments in the northern and southern portion of the WWY area were generally single pastures grazed May–September. The central portion of the area consisted of the Uinta-Cumberland allotment, which used a four-pasture deferred-rotation grazing plan in which pastures were grazed for 1–2 months per pasture May–October. Allotments in RICH included single pastures grazed May–September. Few pastures in RICH or WWY received growing-season rest, and cattle were generally stocked at a rate of 2.5–5 AUM $\cdot$ ha^{-1}. Conversely, DLL consisted of 76 700 ha, 93% of which was privately owned with the remaining 7% BLM inholdings.

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