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Research Note

Land Use Diversification and Intensification on Elk Winter Range in Greater Yellowstone: Framework and Agenda for Social-Ecological Research☆

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ABSTRACT

Amenity migration describes the movement of peoples to rural landscapes and the transition toward tourism and recreation and away from production-oriented land uses (ranching, timber harvesting). The resulting mosaic of land uses and community structures has important consequences for wildlife and their management. This research note examines amenity-driven changes to social-ecological systems in the Greater Yellowstone Ecosystem, specifically in lower elevations that serve as winter habitat for elk. We present a research agenda informed by a preliminary and exploratory mixed-methods investigation: the creation of a "social-impact" index of land use change on elk winter range and a focus group with wildlife management experts. Our findings suggest that elk are encountering an increasingly diverse landscape with respect to land use, while new ownership patterns increase the complexity of social and community dynamics. These factors, in turn, contribute to increasing difficulty meeting wildlife management objectives. To deal with rising complexity across social and ecological landscapes of the Greater Yellowstone Ecosystem, future research will focus on property life cycle dynamics, as well as systems approaches.

Introduction

The 1990s ushered in a new period of land use in many high-amenity rural areas with important conservation and biodiversity values. Alongside an expansion of new land uses (Sorice et al., 2014), new land use patterns (Gill et al., 2010), and rapid human in-migration (Hansen et al., 2002; Gude et al., 2006; Gosnell and Abrams, 2011), mixed conservation outcomes have accompanied this amenity transition: a well-resourced cohort of advocates for conservation encourage rest and revitalization of some lands and waterways (Gosnell et al., 2006), while increased development and population growth contribute to habitat loss and increased pressure on regional ecosystem services. The amenity transition has also precipitated change in key institutions of resource management, as planning boards, conservation districts, and watershed groups show growing diversity in values and goals of their membership (Robbins et al., 2012). No longer a new but rather a well-established dynamic, the amenity transition continues to generate new land uses and community changes with important social-ecological implications and the potential for larger destabilizing effects.

Land Use Change in the Greater Yellowstone Ecosystem

The Greater Yellowstone Ecosystem (GYE) is one of the world's last remaining intact large-scale ecosystems and provides critical habitat for numerous iconic wildlife species (Marston and Anderson, 1991). Many such animals including elk, deer, pronghorn, bighorn sheep, and bison migrate across geographies that link the protected core of the GYE—Yellowstone and Grand Teton National Parks—with public and private lands where human activities have a decisive imprint. Over the past 40 years, the region has experienced immense growth; the human population from 1970 to 1999 increased by 58% (Gude et al., 2006). As a result of the region's multidecade transition away from the dominance of primary industries (farming, timber, mining) into an economy reliant on services, amenity consumption, and nonlabor income, the GYE has witnessed a rapid expansion of amenity ranch ownership, as well as exurban, suburban, and urban development (Hansel et al., 2002).

These changes have important implications for how elk move on and use private lands in the GYE. Private land typically provides low-

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elevation winter habitat and important migratory corridors to (Burcham et al., 1999) and access to high-protein forage (such as cultivated hay and alfalfa). Elk also may use private land and/or housing structures as safe harbors from hunters and predators (Proffitt et al., 2011). Alongside changes to the physical landscape that shift the distribution of elk attractants and deterrents, new landowners may differ in their tolerance for the presence of elk on their property (largely expressed through different approaches to elk hunting). This heterogeneity can amplify conflict among stakeholder groups (Hegel et al., 2009). For example, elk in this region present a disease risk for the transmission of brucellosis to cattle (Cross et al., 2010), which can result in the depopulation of cattle herds or extended quarantines. The mixture of amenity and livestock owners and their diverse attitudes toward wildlife (Gosnell et al., 2006) can limit the options for wildlife managers.

This note addresses transitions in the ownership and management of private lands that serve as critical seasonal habitat for elk in the GYE. Previous research has examined drivers of regional development and land use change (Gude et al., 2006) and land tenure transition (Haggerty and Travis, 2006); however, the continued pressure of amenity migration on current wildlife management objectives (Cross et al., 2010) necessitates further investigation. This study enlists an exploratory, mixed methods approach as means to generate hypotheses and assess future research needs. The approach includes spatial analysis to assess recent land use trends affecting elk winter range in the Montana portion of the GYE. We also solicited expert opinion to characterize the range of ways that private land owners of elk winter range interact with elk and wildlife management. Here, we apply the results to updating and expanding the conceptual framework for understanding the interactions between the amenity transition, ecology, and wildlife management in the GYE (DeFries et al., 2007; Bennett and McGinnis, 2008).

Methods

We applied a mixed methods strategy to track ecological and social change on elk winter range in the Montana portion of the GYE. We spatialized descriptive statistics on the rate and volume of land use change across elk winter range in the study area. We then collected qualitative data from local wildlife biologists to capture their expert knowledge about the diversity of landowner approaches to land use. Elk winter ranges (EWRs) are spatial areas designated by state wildlife biologists using available location and habitat data; they represent the probable location of elk herds during winter (Foundation, 2014). Elk winter range units serve as the basis for analysis because they describe geographies with high likelihood of elk-human encounters. Within the Montana portion of the GYE there are 28 unique EWRs consisting of a total of 3.3 million acres of land with 51% (or 1.6 million acres) in private holdings.

Quantifying Land Use Change

We quantified change in two land use characteristics relevant to elk movements and density (Hegel et al., 2009; Proffitt et al., 2011): the amount of new residential structures (and associated parcel subdivision) and the amount of center pivot-irrigated alfalfa. (For a detailed description of the data processing and computational approaches, see Appendix SI, available online at https://doi.org/10.1016/j.rama.2017.11.002.) Briefly, we derived residential housing patterns from Gude's, 2017 dataset (after their 2006 dataset), which associates residential structures to the quarter-section geography on an annual basis. A comparison of two versions of the Montana cadastral database (2007 and 2016) provided changes in parcel patterns (MSL, 2007, 2016). The alfalfa data were derived from the 2007 and 2015 US Department of Agriculture's Cropland Data Layer (USDA, 2007, 2015). Using global information system analysis, we ranked each variable by relative and absolute change at the EWR level, sorted the distribution into thirds (tertiles), and aggregated all three variables into a "social-impact" index to identify winter ranges undergoing high, medium, and low levels of combined land use change.

Administrative Challenges for Wildlife Management

We used a map-assisted focus group to understand the social aspects of the changing private landscape and generate hypotheses for future work. Partners at the Montana Department of Fish, Wildlife and Parks assisted in selecting recognized experts ($n = 7$) in wildlife management who work at the local, regional, and state scales as participants. Experts were chosen on the basis of their official capacity in administering wildlife management policies and programs. Alongside maps of their associated management jurisdictions, we asked participants to consider how the quality of the "fit" between private land management and wildlife management priorities varies across private landscapes in the Montana GYE and to discuss the range of perceived motivations behind practices affecting elk winter range habitat and elk distribution and density. Maps were used to generate discussion; detailed notes were taken during the conversation and coded for emergent themes.

Results

Physical Land Use Change

Land use in the GYE is undergoing various levels of change including substantial increases across all three land use variables (Table 1). The number of new residential structures tracks closely with the region's explosive population growth, which was 17% from 2005 to 2015 for the six counties (American Community Survey Office, 2016).

Elk winter ranges associated with known amenity development such as EWR 108 (Madison Valley), 95 and 87 (Paradise Valley), and 122 (Big Sky Resort) show high rates of land use change across all three land use variables (Fig. 1).

Land Use and Wildlife Management Conflicts

Wildlife manager focus group participants identify a complex pattern of land use and elk interactions on private elk winter range. Participants assigned the greatest potential for conflict between landowner and wildlife management objectives to "border areas" with opposing land management practices (e.g., a fence line and meadow managed by individuals with high tolerance for elk next to properties where elk are actively hazed).

Table 1
Summary and descriptive statistics of private land use changes within Greater Yellowstone Ecosystem (GYE) study sites. Change in residential structures and number of parcels is the decadal change (from 2004 to 2013 and 2007 to 2016, respectively). Given data availability, change in acres of alfalfa was computed over a 9-yr interval (2007−2015).

		Volume change	Percent change
Across Montana GYE counties	Acres of irrigated alfalfa	+51 000	288%
	Number of residential structures	+3 371	18%
	Number of parcels <320 acres	+2 355	5.2%
Within elk winter ranges	Acres of irrigated alfalfa	+22 368	351%
	Number of residential structures	+1 374	16%
	Number of parcels <320 acres	+1 524	8.6%

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