Chapter 30
The Future of Rangeland Wildlife Conservation—Synopsis

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Abstract *Rangeland Wildlife Ecology and Conservation* provides a broad array of information on rangeland ecology in association with rangeland-dependent wildlife species. Management of land-use practices from livestock grazing to vegetation manipulation are addressed, as well as ecosystem threats that put the future of rangeland-wildlife at risk. Large-scale pervasive issues, such as climate change and land-use alterations, increase uncertainty for the future of our rangeland resources. Ecosystem services that are essential to sustaining human life may be the most concerning issue as we continue to face further resource degradation. However, such concerns could provide the impetus for general societal support of future conservation actions. Our book addresses emerging topics, such as the interaction of rangelands with riparian habitat, biodiversity, insects, wetland birds, herpetofauna, meso- and large carnivores, and avian predators, subjects that have previously received less attention in relation to rangeland ecosystems. Future conservation of rangeland-wildlife will require more integration from the rangeland and wildlife professions, from academic efforts to individual practitioners. The objective of *Rangeland Wildlife Ecology and Conservation* is to provide a valuable information resource and encourage increased integration for students and early professionals from both disciplines.

Keywords Conservation · Future · Rangeland · Threats · Wildlife

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30.1 Introduction

Rangeland Wildlife Ecology and Conservation spans information on the foundations and history of rangeland and wildlife sciences to subject matter on rangeland wildlife taxa and contemporary issues. While thorough published works already exist for such topics as arthropods (Chap. 26), waterfowl (Chap. 13), riparian systems (Chap. 7), raptors (Chap. 14), and herpetofauna (Chap. 25), to our knowledge, these subjects have never been synthesized and presented in the context of rangelands and their management. *Rangeland Wildlife Ecology and Conservation* also provides new insights about taxa that are relatively well understood such as prairie grouse (Chap. 9), sage-grouse (Chap. 10), rangeland ungulates (Chaps. 17–23), and burrowing rodents (Chap. 15). Our extensive authorship consists of the top contemporary professionals across the subject matter expertise, especially in North America.

Both rangeland and wildlife science have undergone parallel changes over time, including a shift from utilitarian resource management to a focus on ecological and ecosystem-based approaches covering a broad context of ecological services and intrinsic values, but still including renewable resource production such as livestock grazing and hunter harvest (Chap. 29). Both rangeland and wildlife professions developed following broad-scale over-exploitation of resources. The rangeland discipline originated from an agrarian need to sustainably manage rangelands for livestock production, whereas the origins of the wildlife profession began with the necessity to regulate sustainable harvest of wild game species.

Even now in the early 21st Century, livestock production remains the dominant and nearly ubiquitous land use within rangelands globally and in North America (Asner et al. 2004; Chap. 4). In some instances, livestock production on rangelands has potential to impact rangeland-dependent wildlife species. This can lead to perceived, and at times real, conflicts between those who see livestock grazing as inherently degrading to rangeland habitat and those who feel that wildlife issues are an impediment to livestock production. These contrasting views will likely remain a significant source of future discord relative to rangeland and wildlife issues. Like most ecological issues, the truth and resolutions are likely found somewhere in the middle.

30.2 Consistent Themes

30.2.1 Management and Conservation

Several management and conservation themes emerged from chapters within this book. Livestock grazing was the most addressed theme. Although livestock grazing has been practically universal on North American rangelands, its application has been highly variable with many operational options (see Chap. 4). Stocking rate has been identified as the most important characteristic of grazing management decisions with

potential impacts on rangelands (Briske et al. 2008; 2013). However, there remains debate concerning grazing systems and their implementation across a variety of landscape types, especially areas with low annual precipitation and high variation in topography and vegetation communities (Teague 2014).

Effects of wildfire and prescribed fire was commonly discussed among chapters, with Chapter 6 solely focused on fire effects on rangeland wildlife habitats. For both rangeland and wildlife professionals, understanding first-order (i.e., direct and immediate influences of fire) and second-order (i.e., non-fire factors that influence post-fire ecosystem processes) impacts of fire is critical for future management (Chap. 6). Fire has historically been a major ecosystem driver in rangeland systems. However, the temporal and spatial scale of fire occurrence varies drastically across rangeland types. In some prairie grassland systems, fire can be prescribed in relatively short time scales (i.e., up to annually) while in more arid rangeland systems fire is not generally considered a management tool, but an ecosystem threat. In these drier climates, fire is often intrinsically related to invasion of unwanted plants including non-native annual grasses, which further exacerbates the risk of fire ecologically and as a management tool in these systems (see Chap. 10). Nevertheless, prescribed fire can be a low cost and effective way to increase and maintain heterogeneity in some rangeland ecosystems, and heterogeneity supports increased biodiversity (Chap. 8).

Variability in vegetation or vegetation communities within a system are key characteristics of ecosystem heterogeneity. When management objectives include multispecies and ecosystem services, heterogeneity within ecosystems is crucial. Heterogeneity can include changes in dominant vegetation types across a landscape but could also encompass multiple age structures of a specific vegetation type. Biodiversity within rangeland systems is linked to the degree of heterogeneity. Management actions meant to support heterogeneity and biodiversity should always include specific objectives, even when there is a lack of complete knowledge to consistently predict outcomes. Heterogeneity and biodiversity are contemporary concepts that have been part of the shift in rangeland ecology from a focus on livestock production to a broader ecosystem-based approach to managing rangelands.

Different approaches to wildlife and rangeland management between public and private lands are addressed in several chapters. Both public and private rangelands occur throughout North America, with varying landscape proportions of each depending on location. Most grasslands in central North America are privately owned and managed, while the proportion of public land increases in western shrub steppe and hot deserts. Historically, federal public land grazing permits were tied to deeded private lands in the local area. The idea was that permittees had to own enough private land to support their livestock during the off-season (i.e., winter). Local private land requirements for permittees helped to address the problem of nomadic livestock herds that could remove forage resources in an area leaving local communities and rangeland resources at risk. Most management decisions on private rangelands are at the discretion of the landowner, although available government assistance programs for private rangelands may have specific requirements. Management decisions on federal rangelands include multiple-use and sustained yield mandates and in-depth procedural planning under the National Environmental Policy Act (1970; NEPA).

NEPA usually includes environmental assessments and public input, which generally increases the amount of time needed to make and implement management actions.

30.2.2 Threats

Rangelands of North America are faced with multiple threats that jeopardize their ability to provide wildlife habitat, forage for livestock, and other ecosystem services in the future. Many of these threats are interrelated with compounding impacts, such as wildfire and invasion of non-native annual grasses. The future conservation and management of rangelands by natural resource professionals will largely be oriented toward addressing these threats. As reviewed throughout this book, threats can vary across temporal and spatial scales. Without a clear understanding of the importance of scale, managers may not make optimal decisions even with the best intentions. Specifically, a management action that addresses threats in the context of large intact rangelands might intensify threats in more fragmented landscapes. For example, using vegetation treatments to enhance livestock forage and/or wildlife habitat quality could be a viable and appropriate management alternative in a large intact rangeland, whereas the same actions might be detrimental to the same wildlife species that occupy, but tend to be at more risk in, fragmented rangelands.

Habitat loss and degradation has been and continues to be the most significant threat to rangelands due to multiple factors. Historically, Euro-American settlement of western North America under the Homestead Acts and the resulting conversion of grassland and shrubland into row crop agriculture precipitated the most significant loss of rangelands in any one period. While not quite universal, it is likely that the most arable land, especially in the Great Plains, has been converted to cropland during the past 160 years. In many of these cropland-dominated landscapes, relic rangelands provide the most significant and broadest suite of ecosystem services, including the cleaning and storage of water, sequestration of carbon, habitat for pollinators and other wildlife species, and other critical environmental services. Rangelands provide the bulk of summer forage for livestock production in the shrub steppe and deserts of the western states, and periodic disturbances, such as that provided by livestock grazing, are often critical for the maintenance of functioning, intact rangelands. As such, livestock production provides a market-based incentive for having and maintaining productive intact rangelands. Conversion of rangelands to cropland remains a significant threat, especially as commodity prices increase and more drought-resistant crops are developed.

Energy and exurban development are major threats to rangelands, leading to habitat loss and fragmentation. These anthropogenic developments impact wildlife populations through direct habitat loss and indirect avoidance of developed areas and infrastructure including roads, well pads, and other man-made structures. Many rangeland wildlife species of conservation concern also require large intact contiguous habitat for population persistence. While some opportunities exist to return cropland to rangeland communities, like the U.S.D.A Conservation Reserve

Program (CRP), conservation and management cannot reverse the large-scale conversion of rangelands that occurred during Euro-American settlement. Rather, maintaining remaining rangelands, with emphasis on the largest and most intact areas, is the most significant and highest order of conservation action that can be undertaken at this time. The future of rangeland wildlife and livestock grazing largely rests on society's collective will to keep our remaining rangelands intact and maintain their ecosystem functions.

Fire is an important ecosystem process for rangelands globally. However, the timing of fire within specific rangeland types has often decoupled from the system's historical fire regime. For example, sagebrush (*Artemisia* spp.) systems with high levels of cheatgrass (*Bromus tectorum*) invasion within the Great Basin are burning with much higher frequency, at higher altitudes, and across larger areas compared to the past (Brooks et al. 2015; Smith et al. 2022). Comparatively, many rangelands in prairies of the Great Plains are burning much less frequently, or in the special case of the Flint Hills of Kansas and Oklahoma, they are purposely burned with greater frequency compared to fire periodicity under which these systems evolved (Baldwin et al. 2022). These shifts in fire frequency are severely impacting rangelands across North America, in some areas resulting in an altered state of annual-dominated grasslands or in other areas vegetation communities devoid of non-graminoids and at high risk of tree encroachment (Miller et al. 2017). Rangeland wildlife are effected by these changes in fire frequency, typically through impacts on their habitats, in many cases with negative consequences.

Disease risk to wildlife, livestock, and humans was another common theme throughout the chapters in this book. Most significant was the transference of various diseases between wildlife and livestock, especially for large ungulates. In some interactions the cases are usually infrequent and largely manageable. While in other cases, like domestic and bighorn sheep (*Ovis aries*), disease is a significant issue that has shaped the distribution and persistence of wild sheep populations. Furthermore, disease influences management options such as population augmentation and reintroductions. The interaction of disease among wildlife, livestock, and humans will likely remain a threat to rangeland systems for the foreseeable future.

Climate change has generally compounded the threats described above. Current climate change models suggest continued increases in temperature and higher variability in the amount and timing of precipitation (Melillo et al. 2014). Rangeland systems and their distributions across North America have largely been shaped by both temperature and precipitation regimes over thousands of years (Chap. 3). For example, the Intermountain West has evolved with a pattern of winter-dominated precipitation resulting in high elevation snowpack that provides key water resources to the entire watershed in the drier springs and summers. Rangeland ecosystems, and the services and provisions they provide (e.g., wildlife habitat, livestock production), are highly dependent on snowpack within the region. As snowpack levels become inconsistent, lessen, or precipitation shifts to winter rain, significant impacts to rangelands will occur. Similarly, the Great Plains' grasslands evolved with summer-dominated precipitation, so the region's plant communities and associated wildlife have life histories that are adapted accordingly. Changes in the timing of precipitation

in the Great Plains could significantly alter these grassland ecosystems, including wildlife and human food production. Currently, high levels of uncertainty surround our ability to predict the consequences of climate change, making informed projections of conservation and management outcomes extremely challenging. Adaptive management that includes consistent monitoring and science-based research will be needed to address the effects of climate change on rangelands in the future.

30.3 Innovative Topics

Rangeland Wildlife Ecology and Conservation provides coverage of emerging and innovative topics within the context of rangeland systems. Chapters on insects (Chap. 26), amphibians and reptiles (Chap. 25), wetland birds (Chap. 13), and avian predators (Chap. 14) are, to our knowledge, the first syntheses relating these groups to rangeland ecology and management. Additionally, Chap. 7 provides unique perspectives on the management and inter-dependence of riparian areas with adjacent rangelands, whereas Chap. 21 (feral equids), Chap. 24 (large carnivores), and Chap. 28 on living with predators draws attention to contemporary, yet contentious rangeland topics. These innovative chapters speak to the historical shift within the rangeland discipline from a focus on livestock production to broader ecological approaches. Biodiversity (Chap. 8), heterogeneity (Chap. 6), and ecosystem services have become fundamental concepts for both rangeland and wildlife professionals to understand when managing rangelands in the future. Moreover, rangelands are almost always working landscapes that require an understanding of social-economic pressures that constrain land and wildlife management decisions (Chaps. 27, 28). Without a comprehensive understanding, professionals are destined to become overly narrow in their approach to rangeland and wildlife management.

30.4 Current State of Rangeland-Dependent Wildlife

Conservation is a growing concern for many rangeland-associated wildlife species in North America. Rangelands that were once considered "left-over" and of little value during Euro-American settlement and expansion because they were not arable are now viewed through a conservation lens as invaluable landscapes and ecosystems. However, anthropogenic pressures continue to build and are the main source of threats to the future of rangelands and associated wildlife.

Many rangeland-associated wildlife are rangeland obligates, or at least rangeland-dependent, species. For example, many grassland and shrub-steppe passerines rely wholly on rangelands to meet their life-cycle needs (Chap. 12). Pronghorn (*Antilocapra americana*; Chap. 19), prairie dogs (*Cynomys* spp.; Chap. 15), and jackrabbits (*Lepus* spp.), are rangeland-dependent, though not obligated to a specific rangeland type, throughout their entire life-cycle. Prairie grouse (*Tympanuchus* spp.; Chap. 9)

and sage-grouse (*Centrocercus* spp.; Chap. 10) are grassland and sagebrush steppe obligates, respectively, with complete dependence on these specific rangeland types to meet all their life-cycle needs. Not only do these grouse rely on rangelands but they are landscape species with populations that require large amounts of intact contiguous habitat space to ensure persistence. Other rangeland-associated wildlife, such as mule deer (*Odocoileus hemionus*; Chap. 17) and elk (*Cervus canadensis*; Chap. 20), similarly require significant space to meet their needs, especially migrating to and using wintering habitat where they exhibit a high degree of rangeland dependence. For many of these rangeland species, future conservation issues will only intensify as threats continue to build over time. Landscape species with low tolerance for habitat fragmentation and other alterations have already, or will shortly, join the first tier of conservation-reliant species in North American rangelands.

30.5 Future Conservation of Rangeland Wildlife

One often overlooked problem, which applies to most ecological conservation concerns, is our state of societal connection, or lack thereof, to wildlands and the ecosystems they support. Humans are inherently connected to and dependent on ecosystem processes through the biosphere (Folke et al. 2011). Human societies increasingly disconnect from ecosystems through use of non-renewable resources and meeting their biophysical needs ex-regionally (Dorninger et al. 2017). Basic processes essential to all life (e.g., clean water, clean air, and food production) are seen as separate or distant operations in relation to society's every-day consciousness. Such disconnect can lead to a lack of understanding and prioritization for the sustainability of our natural resources. This has certainly been the case when we consider the history of rangelands, especially their widespread loss and degradation in North America and globally. Whereas many extant rangelands are society's historical leftovers, the future of rangelands ultimately depends on society's conscious proactivity towards sustainability and conservation.

Ecosystem services can be defined as the services from ecosystems that sustain life. Clean water and air may be the most broadly applicable and important ecosystem services to society. Among others, key ecosystem services include food production, pollination, flood control, and decomposition. For example, pollinators of all kinds (e.g., insects, birds) are crucial to global human food production and are increasingly declining in number and diversity (Chap. 26). Natural ecosystem processes provide flood control when precipitation exceeds normal levels. One of the more significant, but unsung, ecosystem services is the decomposition provided by our natural systems, including carbon storage, the breakdown of pollutants and waste, especially the processing role invertebrates play in decomposition (Chap. 26). Without functioning ecosystems that provide for the disintegration of organic matter, the buildup of waste would quickly become unmanageable on a global scale. For many areas around the world, extant and intact rangelands provide significant ecosystem services as some of the most prevalent undeveloped lands with a full suite of functioning ecological

processes. In central North America where large landscapes of historical grasslands have been converted to row crop agriculture, remnant rangelands provide most of the ecosystem services currently available for those regions. Rangeland management, including livestock grazing, is integral to maintaining these undeveloped lands and the services they provide (Chap. 4).

Rangeland wildlife will likely become increasingly more significant to society in the future. Their importance is especially imperative when it comes to prioritizing limited monetary resources towards conservation efforts. However, human societies can either proactively conserve rangelands or they will be forced to retroactively address them due to the loss of essential services that support human life, likely through public policy mandates. Proper and proactive maintenance is almost always less expensive, in most cases orders of magnitude less, than restoration efforts. Rangeland wildlife will benefit from such maintenance, albeit likely with a secondary status compared to ecosystem services and are certainly essential players in those ecosystem services our society requires.

30.5.1 Knowledge Gaps

As demonstrated throughout *Rangeland Wildlife Ecology and Conservation*, many rangeland wildlife species often require large spatial extents to meet their life-history needs. However, we are still lacking key information on spatial and temporal scales of habitat associations and their relative importance for many rangeland-associated species. For example, we are beginning to understand key habitat associations for migrant passerine breeding grounds on which to develop habitat targets for management, yet the relative importance of non-breeding habitats and their management are largely unknown (Chap. 12). A similar lack of key information exists for non-migratory species as well; for example, juvenile survival to recruitment is notoriously difficult to research and understudied in game birds (Chaps. 9, 10, and 11). Identifying limiting factors for wildlife populations could be misguided without an understanding of their full annual life-cycle and habitat requirements.

We need more information concerning the importance of connectivity of intact rangeland habitats for many wildlife species. For many species of conservation concern, there are negative impacts from habitat fragmentation. However, there is also a lack of understanding of the size, spatial arrangement, and connectivity of habitats that would increase the probability of population persistence. Furthermore, we do not understand how habitat quality, or other factors, may interact with the spatial scale of intact habitats required by populations. For example, the size and quality of grassland habitats may constrain or mediate how grassland-obligate species respond to energy development (Lloyd et al. 2022). Knowing species' needs for connectivity, scale of intact habitat, and how these interact with other environmental factors may be critical for future conservation as threats to remaining rangeland habitat increases.

Until recently, wildlife movement and habitat selection has generally been empirically evaluated separately from population demographics and dynamics. The historical lack of integration may be due in part to a deficiency in analytical methods to simultaneously model behavior and vital rates, although *post-hoc* evaluations have been conducted (Kirol et al. 2015; Coates et al. 2017; Sandford et al. 2017). Yet we know that movements, space use, and habitat selection, are linked to survival and reproductive state and vital rates (Dudley et al. 2022; Gelling et al. 2022). Analytical advancements to empirically evaluate the impact of behavior on wildlife vital rates will likely be one of the more significant advances in ecology in the future (Pakanen 2011; Decesare et al. 2013). Understanding of rangeland wildlife, and other species, will increase accordingly and for natural resource managers the effectiveness of conservation actions can be better predicted.

Dietary and nutritional needs for wildlife are closely related to movement and habitat selection. The influence of diet and nutrition on wildlife behavior is a relatively understudied topic but has significant implications, especially for rangeland wildlife. For some prominent species, such as mule deer, research in the last few years has shown that nutritional availability on rangelands drives behavior and resulting body conditions influence survival and reproduction (Tollefson et al. 2010; Merkle et al. 2016). Relatively recent research has linked variation in plant nutrient availability to habitat selection for sage-grouse, with physiological adaptations for local plants (Frye et al. 2013). However, for many rangeland wildlife species there is a paucity of information available concerning the influence of diet and nutrition on behavior and vital rates. Within the rangeland discipline, there has been considerable research concerning nutrition availability related to livestock and their behavior (e.g., Vallentine 2000), but more research in this area is needed for rangeland wildlife.

30.5.2 Integration of Rangeland and Wildlife Ecology

Integration can be defined as bringing people or groups with particular characteristics into equal participation and is increasingly needed for rangeland and wildlife disciplines to direct successful conservation efforts. Much could be done to increase the cross-over of ecological concepts, research questions, and methodologies in both fields. However, the most important integration will require rangeland and wildlife professionals to work collaboratively to address rangeland ecosystem and conservation challenges. Successful integration will come from the willingness of individuals in each profession to build relationships of trust and understanding. While rangeland and wildlife disciplines share much in common, there has been a long-time professional divide with some strongly held biases, with an accompanying assumed superiority, on both sides (Chap. 29). However, in recent years we have been encouraged by the blurring of that line and many examples of both disciplines' scientists and managers working together. One area that could use improvement is when wildlife professionals conduct and publish research that includes or addresses topics from the rangeland discipline. The Society for Range Management produced a glossary

of terms commonly used in rangeland management and we encourage its use for consistent terminology (Bedell 1998; rangelandsgateway.org/glossary).

Another area that could use improvement between the professions is more recognition of the validity of prioritized values within the "other" discipline. Although many values are shared between disciplines, the prioritization order for those values can often differ and lead to a sense of disparity. For example, we have found that some rangeland professionals can come across as skeptical of the validity of wildlife conservation issues on rangelands. At times there seems to have been contempt for being "forced" to deal with wildlife issues within the broader field of rangeland management. Similarly, in our experience some wildlife professionals seem to hold the opinion that livestock grazing is ubiquitously detrimental to wildlife and habitat or is of lower importance or consequence compared to wildlife values on rangelands.

We see a need for professionals from both disciplines to show more respect for the values held by one another. For rangeland managers, there is a need to recognize that concerns over wildlife species on rangelands have strong state and federal policies and regulations in place that mandates conservation in addition to great public interest in wildlife. For wildlife managers, there is a need to recognize the legitimate ties livestock production has with both public and private rangelands. For private lands, property taxes must be paid, and for most landowners, monetary resources used to pay taxes must come from the land. In many cases, reductions in ranching profits lead to property sales and land conversion and development that is detrimental to wildlife and their habitats (Plachter and Hampicke 2010). Some natural resource professionals may not realize that most public grazing permits are tied to local private lands and communities. Leases of federal grazing permits include prioritization to specific private entities (e.g., individual permittee, ranch.). The sale of private livestock operations often includes the federal grazing lease, giving prioritization of grazing permits on specified allotments to the buyer. Additionally, producers usually have significant private investment in their publicly permitted allotments, such as water developments, fencing, etc. Livestock grazing on both public and private lands is foundational to the economy of many rural communities (Lewin et al. 2019).

Aldo Leopold wrote that "conservation will ultimately boil down to rewarding the private landowner who conserves the public interest." Perhaps more than any other ecosystem, the goals of livestock producers and conservationists are aligned, because the natural processes that sustain wildlife habitat and functioning rangeland ecosystems are often the same processes that sustain viable livestock production. Recent shifts toward working lands conservation programming that incentivize landowners and producers for conservation-based rangeland management (e.g., federal, state, and NGO working lands conservation programs), have been novel and impactful (NRCS 2020). However, we feel a more direct and explicit integration of the economics of livestock production into adaptive management planning for wildlife would benefit both ends. As most of our remaining rangelands are working lands, two things are needed to conserve rangelands and associated wildlife: (1) economic models that value ecological function, and (2) ecosystem models that incorporate social-economics.

30.6 Summary

Rangeland Wildlife Ecology and Conservation provides a broad array of information on rangeland ecology in association with rangeland-associated wildlife species. Management of land-use practices from livestock grazing to vegetation manipulation are addressed, as well as ecosystem threats that put the future of rangeland-wildlife at risk. Large-scale pervasive issues, such as climate change and land-use alterations, increase uncertainty for the future of our rangeland resources. Ecosystem services that are essential to sustaining human life may be the most concerning issue as we continue to face further resource degradation. However, such concerns could provide the impetus for increased societal interest in future conservation actions. This book addresses emerging and innovative topics, such as the interaction of rangelands with riparian habitat, insects, wetland birds, herpetofauna, and avian predators, subjects that have not been previously well synthesized in relation to rangeland ecosystems. Future conservation of rangeland-wildlife will require more integration from the rangeland and wildlife professions, from academic efforts to individual practitioners. The objective of *Rangeland Wildlife Ecology and Conservation* has been to present a valuable information resource for students and early professionals from both disciplines that also encourages increased integration. We invite readers to integrate rangeland and wildlife science to find creative solutions to the emerging conservation issues presented in this book.

References

Asner GP, Elmore AJ, Olander LP et al (2004) Grazing systems, ecosystem responses, and global change. Annu Rev Environ Resour 29:261–299. https://doi.org/10.1146/annurev.energy.29.062403.102142

Baldwin C, Davidson J, Coleman L (2022) Pyric legacy: prescribed burning in the Flint Hills region, USA. In Weir JR, Scasta JD (eds) Global application of prescribed fire, CRC Press, Boca Raton, FL, USA, p 144

Briske D, Derner J, Brown J et al (2008) Benefits of rotational grazing on rangelands: an evaluation of the experimental evidence. Rangel Ecol Manag 61:3–17

Briske DD, Bestelmeyer BT, Brown JR et al (2013) The Savory method can not green deserts or reverse climate change: a response to Allan Savory TED video. Rangelands 35:72–74

Brooks ML, Matchett JR, Shinneman DJ et al (2015) Fire patterns in the range of greater sage-grouse, 1984–2013—implications for conservation and management. US Geological Survey Open-File Report 2015–1167, Reston, VA

Coates PS, Prochazka BG, Ricca MA et al (2017) Pinyon and juniper encroachment into sagebrush ecosystems impacts distribution and survival of greater sage-grouse. Rangel Ecol Manag 70:25–38

Decesare N, Hebblewhite M, Bradley M et al (2013) Linking habitat selection and predation risk to spatial variation in survival. J Anim Ecol 83:343–252. https://doi.org/10.1111/1365-2656.12144

Dorninger C, Abson DJ, Fischer J et al (2017) Assessing sustainable biophysical human-nature connectedness at regional scales. Environ Res Lett 12.https://doi.org/10.1088/1748-9326/aa68a5

Dudley IA, Coates PS, Prochazka BG, Davis DM, Gardner SC, Delehaty DJ (2022) Maladaptive nest-site selection and reduced nest survival in female sage-grouse following wildfire. Ecosphere 12:e4282. https://doi.org/10.1002/ecs2.4282

Folke C, Jansson A, Rockstrom J et al (2011) Reconnecting to the biosphere. Ambio 40:719–738. https://doi.org/10.1007/s13280-011-0184-y

Frye GG, Connelly JW, Musil DD, Forbey JS (2013) Phytochemistry predicts habitat selection by an avian herbivore at multiple spatial scales. Ecol 94:308–314. https://doi.org/10.1890/12-1313.1

Gelling E, Pratt AC, Beck JL (2022) Linking microhabitat selection, range size, reproductive state, and behavioral state in greater sage-grouse. Wildl Soc Bull 46:e1293. https://doi.org/10.1002/wsb.1293

Kirol CP, Beck JL, Huzurbazar SV et al (2015) Identifying greater sage-grouse source and sink habitats for conservation planning in an energy development landscape. Ecol Appl 25:968–990. https://doi.org/10.6084/m9.figshare.c.3296837.v1

Lewin PA, Wulfhorst JD, Rimbey NR et al (2019) Implications of declining grazing permits on public land: an integrated social and economic impact analysis. Western Economics Forum 17:86–97

Lloyd JD, Aldridge CA, Allison TD, LeBeau CW, McNew LB, Winder VL (2022) Prairie grouse and wind energy: the state of the science and implications for risk management. Wildl Soc Bul 46:e1305. https://doi.org/10.1002/wsb.1305

Melillo JM, Richmond TT, Yohe G (2014) Climate change impacts in the United States: third national climate assessment. U.S. Global Change Research Program

Merkle JA, Monteith KL, Aikens EO et al (2016) Large herbivores surf waves of green-up during spring. Proc of the Royal Soc Bio Sci 283(1833):20160456

Miller RF, Naugle DE, Maestas JD et al (2017) Special issue: targeted woodland removal to recover at-risk grouse and their sagebrush-steppe and prairie ecosystems. Rangel Ecol Manag 70:1–8. https://doi.org/10.1016/j.rama.2016.10.004

Natural Resources Conservation Service [NRCS] (2020) Quantifying outcomes of working lands for wildlife (WLFW) for benefit of landowners and at-risk wildlife. USDA Natural Resources Conservation Service Conservation Effects Assessment Project (CEAP). https://www.nrcs.usda.gov/publications/ceap-wildlife-2020-quantifying-wlfw-benefit.pdf

Pakanen V (2011) Linking demography with dispersal and habitat selection for species conservation. PhD Dissertation, Acta Universitatis Ouluensis A583

Plachter H, Hampicke U (2010) Large-scale livestock grazing: a management tool for nature conservation. Springer-Verlag, Berlin Heidelberg, Germany, p 477

Sandford CP, Kohl MT, Messmer TA et al (2017) Greater sage-grouse resource selection drives reproductive fitness under a conifer removal strategy. Rangel Ecolo Manag 70:59–67

Smith JT, Allred BW, Boyd CS, Davies KW, Jones MO, Kleinhesselink AR, Maestas JD, Naugle DE (2022) Where there's smoke, there's fuel: dynamic vegetation data improve predictions of wildfire hazard in the Great Basin. Rangel Ecol Manage 89:20–32. https://doi.org/10.1016/j.rama.2022.07.005

Teague WR (2014) Deficiencies in the Briske et al. rebuttal of the Savory Method. Rangelands 36:37–38.https://doi.org/10.2111/1551-501X-36.1.37

Tollefson TN, Shipley LA, Myers WL et al (2010) Influence of summer and autumn nutrition on body condition and reproduction in lactating mule deer. J Wildl Manage 74:974–986. https://doi.org/10.2193/2008-529

Vallentine JF (2000) Grazing management. Academic Press, San Diego, CA, USA