Section I. Wyoming Basin Rapid Ecoregional Assessment Overview and Synthesis

Chapter 1. Introduction and Overview

By Natasha B. Carr, Cynthia P. Melcher, and Zachary H. Bowen

Contents

Figures

Tables

Introduction

Purpose of the Rapid Ecoregional Assessment

The Bureau of Land Management (BLM) is responsible for multiple-use resource planning and management for more than 245 million acres of public lands. Recognizing the need for additional information to support planning and decisionmaking over large geographic areas, the BLM has recently developed a Landscape Approach. The BLM's new approach incorporates multiscale information to assess the condition and trends of ecological resources, including the direct and indirect effects of land use. A key component of BLM's Landscape Approach is the Rapid Ecoregional Assessment (REA) program. The overall goals of REAs are to identify important ecosystems and wildlife habitats at broad spatial scales; identify where these resources are at risk from development, wildfire, invasive species, and climate change; quantify cumulative effects of anthropogenic stressors as required by the National Environmental Policy Act; and assess current levels of risk to ecological resources across a range of spatial scales and jurisdictional boundaries by assessing all lands within an ecoregion.

The REAs provide an assessment of (1) baseline conditions for long-term monitoring of broad-scale conditions and trends; (2) landscape-level intactness of ecological communities, habitats for priority species, and the ecoregion overall; and (3) a predictive capacity for evaluating future risks. They also can identify data gaps and important ecological attributes of communities and habitats, which can inform development of monitoring strategies for assessing status and trends. The BLM state and field offices and other stakeholders may use this information to facilitate land-use planning and prioritize actions for conservation, restoration, and development, including ascribing best-management practices and usage authorizations. By addressing priority management issues identified by multiple Federal and state agencies working collaboratively, REAs also foster interagency collaboration and help to ensure that REA results and products are relevant to multiple stakeholders. Although the REAs are informational tools and not decisionmaking documents, they provide a vehicle for creating stronger, more effective and efficient collaboration and cooperation among all parties interested in regional land and resource management.

Components of the Rapid Ecoregional Assessment

Management Questions

For each REA, BLM land managers and other partners provide a range of regionally significant Management Questions that serve as the foundation for the REA process and products. The Management Questions not only frame the conservation planning and land-management priorities for a given ecoregion, they also help to ensure that the most relevant datasets are compiled, analyzed, and summarized. Additionally, the Management Questions address information needs for developing best-management practices and establishing priorities for conservation, restoration, or development.

Conservation Elements

Conservation Elements represent the regionally significant species and ecological communities that are of management concern. The emphasis on ecological communities is based on the premise that intact and functioning ecological systems are more resistant to both natural and human stressors, and more resilient to these agents of change (Noss, 1987; Poiani and others, 2000; Parrish and others, 2003). Because it is not feasible to manage or monitor all species individually, protection of intact ecological communities may help to serve as a safety net for species not addressed specifically by the REA. There are significant species or species assemblages of management concern that may not be adequately addressed at the community level, and these may be specifically addressed as Conservation Elements.

Key Ecological Attributes

Key ecological attributes are characteristics of species and communities that may affect their long-term persistence or viability. The attributes can include both biological and physical environments (hereafter biophysical) and ecological processes that collectively regulate the occurrence (such as distribution and abundance), landscape structure (such as patch sizes and structural connectivity of patches), and landscape dynamics (such as natural disturbances) of species and ecological communities.

Change Agents

The REA identifies and assesses primary factors, or Change Agents, that currently affect or are likely to affect the condition of species and communities in the future. Minimally, the Change Agents to be evaluated for the entire ecoregion include

- development (including urban, energy, roads, dams, and diversions),
- wildfire,
- invasive species, and
- climate change.

Assessment Management Team

An REA Assessment Management Team consists of BLM managers, partner agencies, and technical specialists representing the ecoregion. The Assessment Management Team is responsible for ensuring that management needs and conservation priorities are addressed by identifying the Management Questions, Conservation Elements, and Change Agents to be evaluated by the REA.

Ecoregions, Landscapes, Assessments, and Scale

Ecoregional assessments involve spatial analyses conducted at broad scales to quantify landscape-level features of habitats and identify species' strongholds, and quantify both natural and anthropogenic disturbances (Hanser and others, 2011). Broad-scale assessments, such as REAs, can lead to improved understanding of systems across jurisdictional boundaries. Local-level assessments (such as at the field office or project level) provide more detailed information on individuals, populations, and habitats than can be determined from ecoregion-level assessments but lack the broad-scale context, which is important for assessing cumulative effects (Knick and others, 2011). Ecoregional assessments provide information that can be used at a variety of spatial scales and are intended to be used in conjunction with local-level assessments for decisionmaking.

Wyoming Basin Ecoregional Assessment

Background on the Wyoming Basin Ecoregion

Ecoregions are largely defined by broad ecological systems, and the Wyoming Basin Ecoregion (hereafter, "the Wyoming Basin") comprises a series of large basins dominated by a broad expanse of the sagebrush ecosystem (Omernik, 1987). The Wyoming Basin has a greater percentage of sagebrush than any other ecoregion (Rowland and Leu, 2011). The perimeter of the Wyoming Basin Ecoregion is defined by the Rocky Mountains to the west (including the Absaroka, Wind River, and Wyoming Ranges), south (Uinta and Medicine Bow Mountains and Park Range), and east (the Laramie and Big Horn Mountains). The ecoregion encompasses the Big Horn, Wind River, Green River, Great Divide, and Laramie Basins (fig. 1–1). The Red Desert is a vast area considered as having high ecological value, and encompasses the Green River, Great Divide, and Washakie Basins. Major rivers include the Wind, Big Horn, Green, Sweetwater, Bear, Little Snake, Yampa, North Platte, and Laramie Rivers (fig. 1–2).

The Wyoming Basin has some of the highest-quality wildlife habitats remaining in the Intermountain West (Sawyer and others, 2005). The wide variety of vegetation types includes intermountain basins dominated by sagebrush, greasewood, and saltbush shrublands; foothill shrublands that flank the adjacent high mountains and are dominated by montane sagebrush steppe interspersed with deciduous and conifer woodlands; montane and subalpine forests dominated by conifer and aspen; and flowing and ponded surface waters and their attendant riparian habitats scattered throughout (Knight, 1994).

Overall, the Wyoming Basin's diverse ecological communities support dozens of nongame species of conservation concern, as designated by the states of Wyoming, Montana, Idaho, Utah, and Colorado (Idaho Department of Fish and Game, 2005; Utah Department of Natural Resources, 2005; Colorado Division of Wildlife, 2006; Wyoming Game and Fish Department, 2010; Montana Fish, Wildlife, and Parks, 2014). The Wyoming Basin also supports some of the largest U.S. populations of game species, including pronghorn, mule deer, elk, moose, and bighorn sheep as well as the greatest densities of greater sage-grouse within the species' range, and several subspecies of cutthroat trout and other species of native and sport fish (Wyoming Game and Fish Department, 2010; Rowland and Leu, 2011). In addition, the ecoregion encompasses the longest migration routes reported for mule deer and pronghorn, up to 158 and 258 kilometers (km) (98.2 and 163.3 miles [mi]), respectively (Sawyer and others, 2005).

The Wyoming Basin's vast open spaces also support ranching and agricultural operations that are important to the region's economy and contribute to the conservation of seasonal habitats and migration corridors for wildlife (Sawyer and others, 2005, 2006; Sawyer and Kauffman, 2011). Some of the Nation's most sought-after outdoor recreation opportunities are found in this region, which helps to ensure long-term economic stability in many local communities. In addition, conservation easements on private lands help to promote the conservation of wildlife species.

The Wyoming Basin also contains abundant energy resources, including some of the largest natural gas reserves in the lower 48 States (U.S. Departments of the Interior, Agriculture, and Energy, 2003). Some of the best wind-energy potential on publicly managed lands in the United States is in the Wyoming Basin (U.S. Departments of the Interior, Agriculture, and Energy, 2003). Although the Wyoming Basin has long been a provider of the Nation's energy, the recent and projected pace of both renewable and nonrenewable energy development is unprecedented in the Basin's history.

Combined with increased residential and industrial development, fast-paced energy development is resulting in notable habitat loss and degradation, including habitat fragmentation and increased human activity (Naugle, 2011). Given that more than 60 percent of the Wyoming Basin is publicly owned, decisions regarding current and future land-use management, conservation, restoration, and mitigation efforts on public lands in the Wyoming Basin have the potential to significantly affect regional ecological resources (see Hanser and others [2011] for additional background information on the Wyoming Basin).

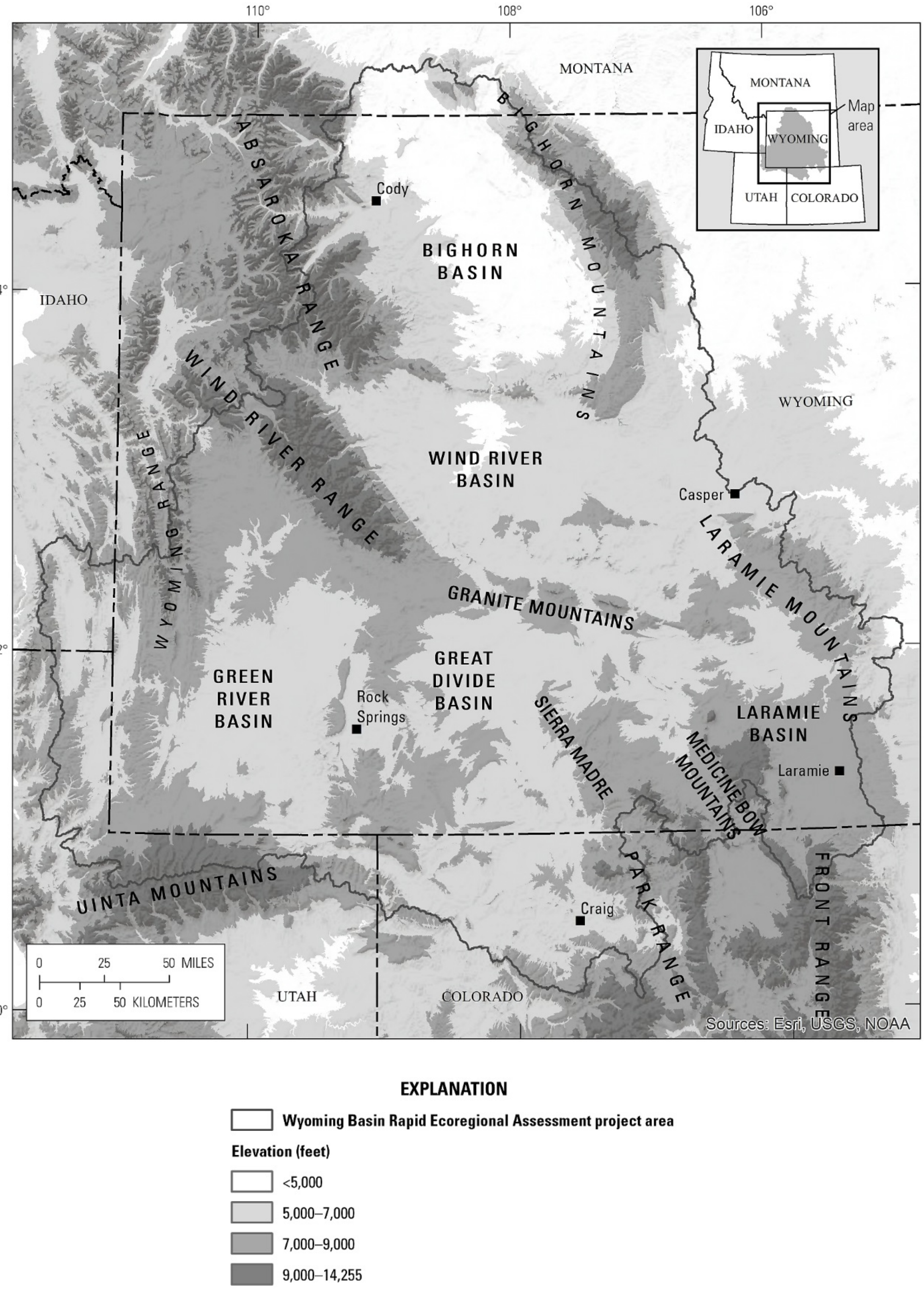

Figure 1–1. Major terrestrial landforms in Wyoming Basin Ecoregion.

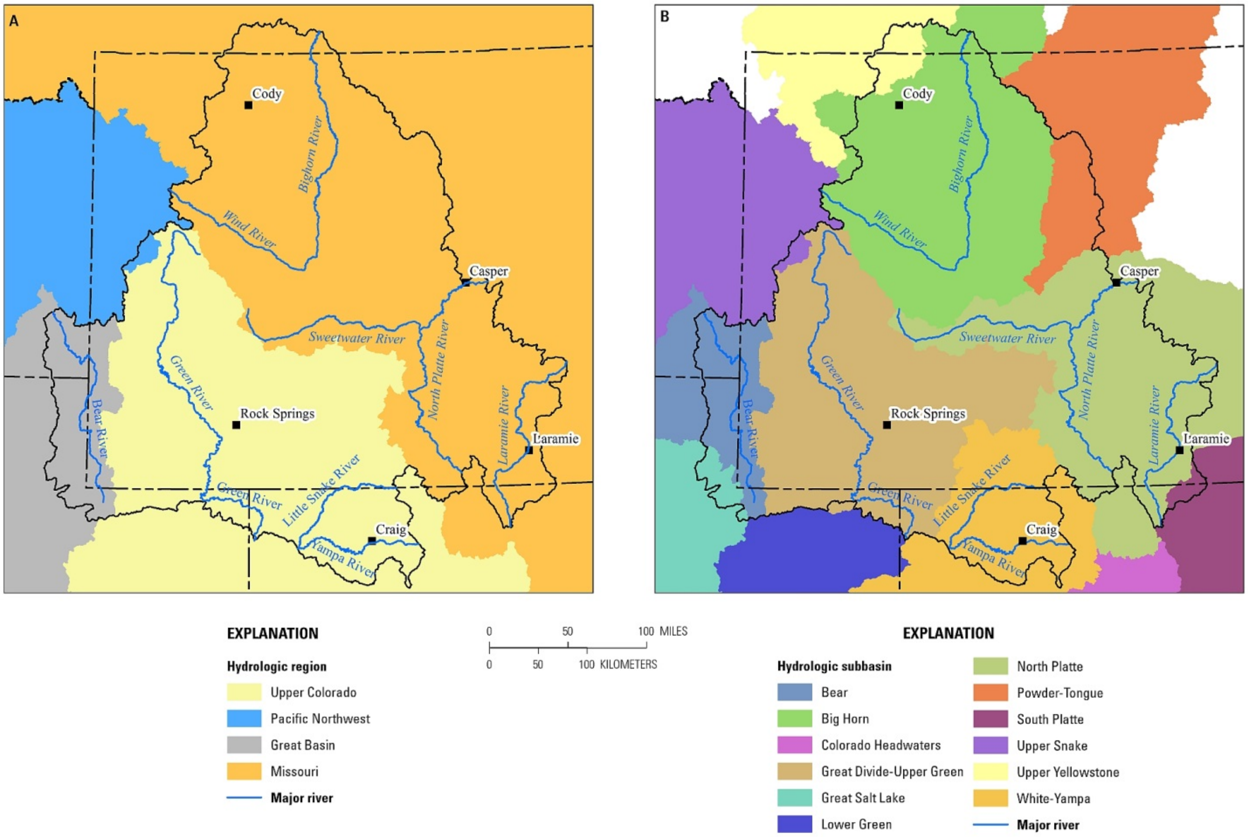

Figure 1–2. Major hydrologic features in Wyoming Basin Ecoregion by (*A*) hydrologic region (first-level watershed) and (*B*) hydrologic subbasin (second-level watershed) as defined by Seaber and others (1987).

The Wyoming Basin Rapid Ecoregional Assessment Project Area

The Wyoming Basin Ecoregion (as defined by Omernik, 1987) encompasses 133,656 square kilometers (km^2) (51,604.87 square miles [mi^2], most of which is in Wyoming, with small extensions into northwestern Colorado, northeastern Utah, southeastern Idaho, and south-central Montana (fig. 1–3). The Wyoming Basin REA project area, however, extends somewhat beyond the Wyoming Basin Ecoregion to include the entire area of all fifth-level watersheds that intersect the Wyoming Basin perimeter (Carr and others, 2013). The project area overlaps the jurisdiction of all or parts of 17 BLM Field Offices (9 in Wyoming, 4 in Colorado, 2 in Utah, and 1 each in Idaho and Montana), 2 U.S. Fish and Wildlife Regions (9 National Fish and Wildlife refuges), 3 U.S Department of Agriculture Forest Service regions (12 National Forests), 2 National Park Service regions (3 National Parks and Monuments), and tribal lands (2 American Indian Reservations), as well as the state agencies that represent and manage wildlife, natural resources, and parks (fig. 1–4, table 1–1). The adjacent ecoregions are predominantly mountainous to the north, west, and south, and grasslands to the east (Carr and others, 2013).

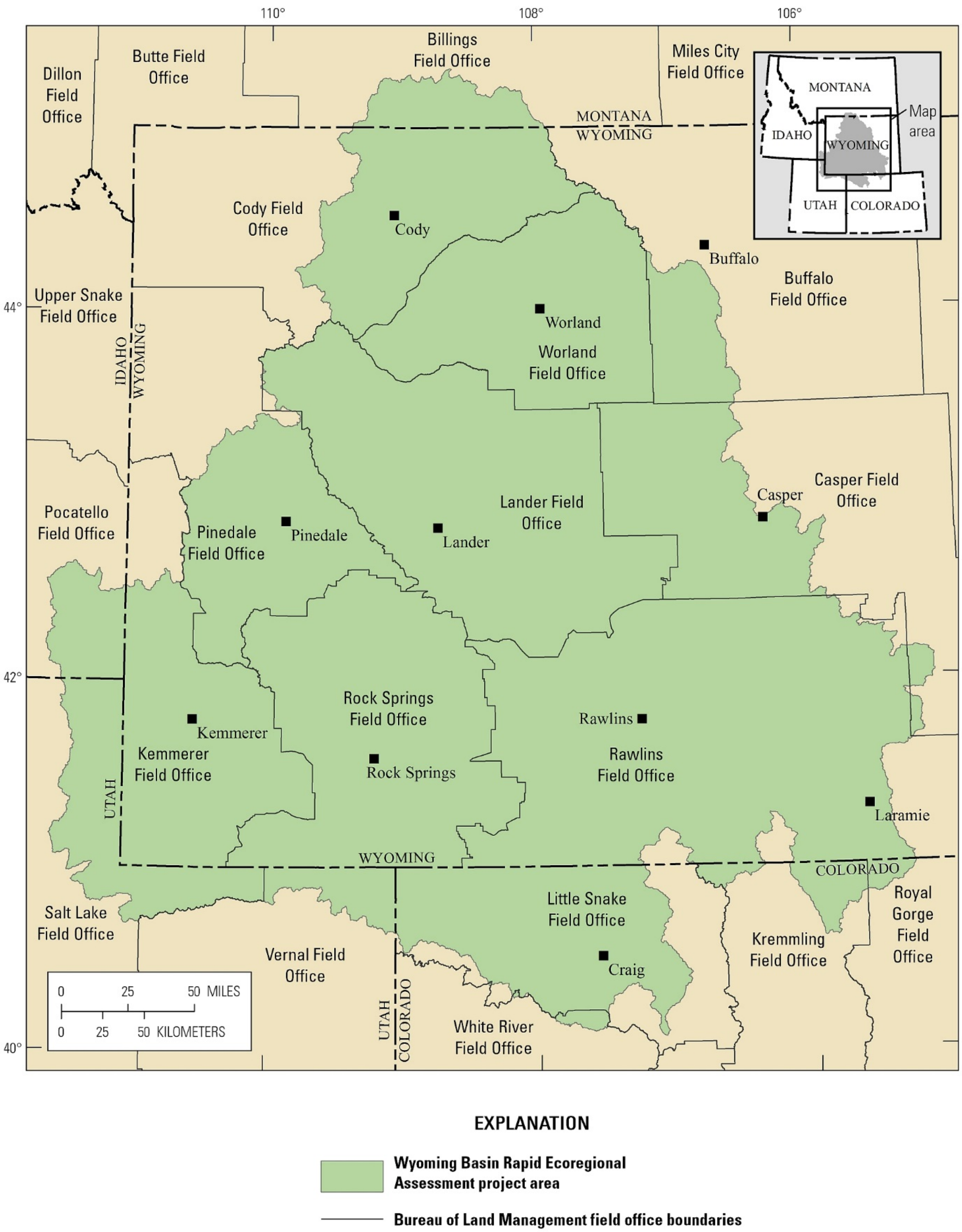

Figure 1–3. The Wyoming Basin Rapid Ecoregional Assessment project area. Bureau of Land Management field office boundaries intersecting the project area are shown.

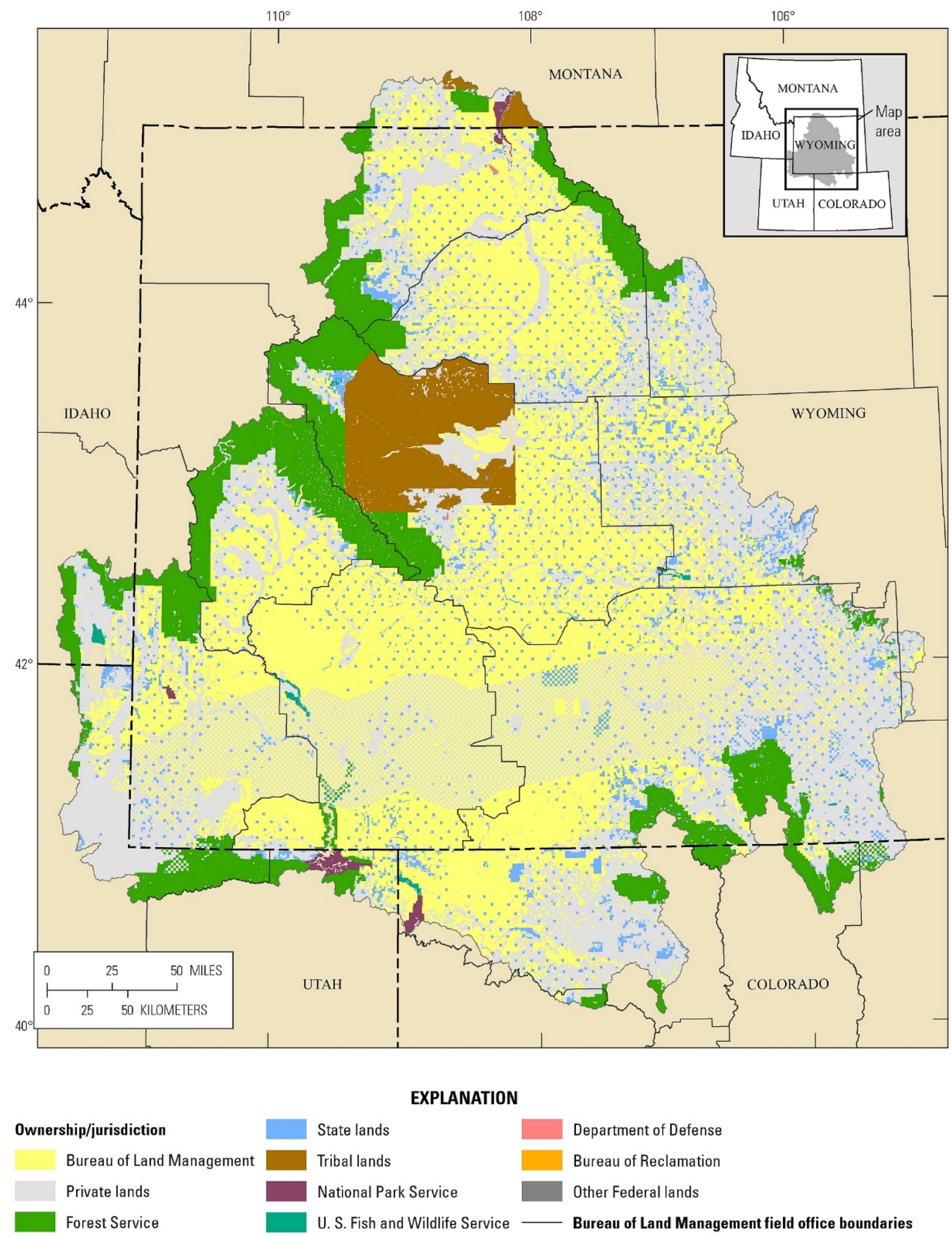

Figure 1–4. Land ownership and jurisdictions in Wyoming Basin Rapid Ecoregional Assessment project area. National Park Service lands include Dinosaur National Park, Fossil Butte National Monument, and Bighorn Canyon National Recreation Area. U.S. Department of Agriculture Forest Service lands include Shoshone, Routt, and Roosevelt National Forests. U.S. Fish and Wildlife Service lands include Seedskadee, Cokeville, Mortenson Lake, Brown's Park, Bear Lake, Bamforth, Hutton Lake, and Pathfinder National Wildlife Refuges. Tribal lands include the Wind River and Crow Indian Reservations. Department of Defense lands include Powell Air Force Station. Bureau of Reclamation lands include Bighorn, Big Sandy, Fontenelle, Flaming Gorge, Seminoe, Pathfinder, and Buffalo Bill Reservoirs.

Table 1–1. Area and percentage of land managed or owned by different entities in the Wyoming Basin Rapid Ecoregional Assessment project area (based on fig.1–4).

[ha, hectare]

Ownership/Jurisdiction	Area (ha)	Percent of project area
Bureau of Land Management	7,542,621	42
Private	6,032,135	34
Forest Service[1]	2,174,365	12
States	1,072,238	6
Tribal	775,900	4
Lakes/reservoirs	146,675	1
National Park Service	61,500	<1
U.S. Fish and Wildlife Service	28,979	<1
Department of Defense	2,011	<1
Bureau of Reclamation	421	<1

[1] U.S. Department of Agriculture Forest Service.

Management Questions

The Management Questions developed by the Assessment Management Team were organized into two themes: Core and Integrated (Carr and others, 2013). The Management Questions were tailored for each species and community to evaluate its landscape-level status and the potential threats posed by Change Agents. Management Questions also were used to evaluate the individual and cumulative effects of Change Agents for the entire ecoregion.

Conservation Elements

Ecological Communities

Seven major ecological communities (hereafter, "communities") were selected as Conservation Elements in the Wyoming Basin (table 1–2, fig. 1–5) (Carr and others, 2013). We selected the terrestrial communities based on the dominant species and life forms (for example, shrublands, woodlands, and forests). Terrestrial communities include (1) sagebrush steppe, (2) desert shrublands, (3) foothill shrublands and woodlands, and (4) montane/subalpine forests and alpine zone. Aquatic communities were based on the hydrologic regime or the presence of woody vegetation and include (1) streams and rivers, (2) wetlands, and (3) riparian forests and shrublands. Sagebrush steppe is the dominant community, covering more than half of the ecoregion. In contrast, mixed desert shrublands, wetlands, and riparian communities each cover <10 percent of the Wyoming Basin, but have important ecological functions. The communities are described in relevant chapters in the Assessments of Communities (Section III).

Table 1–2. Ecological communities evaluated as Conservation Elements for the Wyoming Basin Rapid Ecoregional Assessment.

System	Ecological communities[1]	Percent of the Wyoming Basin project area[2]
Aquatic	Lakes and reservoirs	0.6
	Streams and rivers	2.3
	Wetlands	1.0
	Riparian forests and shrublands	2.1
Terrestrial	Sagebrush steppe[3]	50.5
	Desert shrublands	9.6
	Foothill shrublands and woodlands	16.0
	Montane and subalpine forests and alpine zone	13.4

[1] Lakes and reservoirs were mapped but not evaluated as a Conservation Element. The alpine zone only occurs outside of the ecoregion boundary but falls within the project area.

[2] Developed and agricultural areas not included.

[3] Scientific names for all species mentioned in this report are provided in the Scientific Names of Species Used in This Report list immediately after the Table of Contents in the Front Matter section.

Species and Species Assemblages

A preliminary list of priority species and species assemblages (Carr and others, 2013) was developed by the BLM and the Assessment Management Team and evaluated for inclusion in the REA (see Chapter 2—Assessment Framework). A total of 14 species and species assemblages were included in the final list of Conservation Elements (table 1–3).

Change Agents

We evaluated the four primary Change Agents required for the REA (development, fire, invasive species, and climate change). We also considered insects and disease, grazing, and off-highway vehicle use, based on input from the Assessment Management Team. Fire and climate (for example, drought) are inherent drivers of ecosystem dynamics in the Wyoming Basin, but fire and climatic regimes may be influenced by human activities (Rowland and Leu, 2011). In turn, human alteration of natural disturbance regimes can lead to habitat loss and other negative effects on species and species assemblages.

Development Overview

The types of development that were evaluated include residential, agricultural, and industrial. Several of the major types of development identified as priorities for the REA are highlighted in the sections that follow.

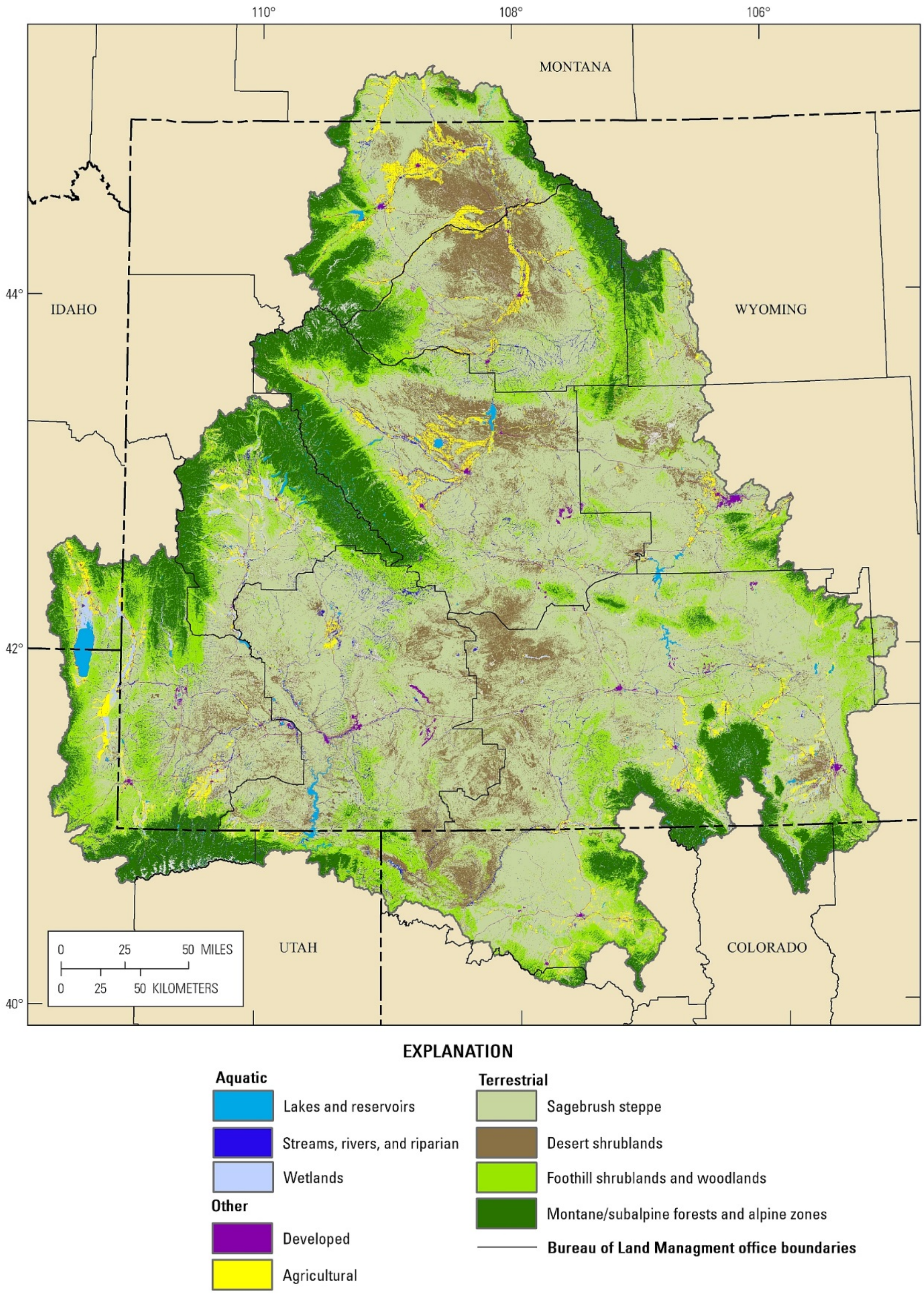

Figure 1–5. Distribution of ecological communities for the Wyoming Basin Rapid Ecoregional Assessment (REA) project area. Areas dominated by agriculture and developed lands are also indicated. Lakes and reservoirs were not evaluated for the REA (table 1–2).

Table 1–3. Species and species assemblages evaluated as Conservation Elements.

Species and assemblages
Aspen forests and woodlands
Five-needle pine forests and woodlands—limber pine and whitebark pine
Juniper woodlands
Cutthroat trout
Three-fish assemblage—roundtail chub, flannelmouth sucker, and bluehead sucker
Northern leatherside chub
Sauger
Spadefoot assemblage—Great Basin spadefoot and plains spadefoot
Greater sage-grouse
Golden eagle
Ferruginous hawk
Sagebrush-obligate songbirds—Brewer's sparrow, sagebrush sparrow, and sage thrasher
Pygmy rabbit
Mule deer

Energy, Minerals, and Associated Infrastructure

Development of energy and minerals, and the associated infrastructure, has been accelerating throughout many areas of the Wyoming Basin (Rowland and Leu, 2011). This ecoregion is underlain by some of the largest onshore oil and gas reserves in the conterminous United States, and it has some of the greatest potential for wind-energy development in the intermountain West. The potential consequences of energy development include direct and indirect habitat loss due to surface disturbance, disturbance from human activities, the fragmenting effects of roads and energy infrastructure, direct mortality (such as collisions with wind turbines or vehicles), invasive plant species introduced along roads and other infrastructure, and alteration of aquifers and hydrological regimes (such as from coal bed methane operations) (Sawyer and others, 2006, 2009; Doherty and others, 2011; Finn and Knick, 2011; Naugle and others, 2011; Rowland and Leu, 2011). See Hanser and others (2011) for additional information on energy development in the Wyoming Basin.

Dams and Water Diversions

Water use for human consumption, irrigation, and energy development, are threatening aquatic ecosystems across the western United States (Sabo and others, 2010; McDonald and others, 2012). Dams and water diversions alter the natural flow regime to which freshwater organisms are adapted (Poff and others, 1997). For fish, hydrologic alteration can lead to declines in abundance (Poff and Zimmerman, 2010) and shifts in community composition (Freeman and Marcinek, 2006).

Grazing

Historically, grazing and browsing (hereafter, “grazing”) by wildlife, livestock, and wild horses, have influenced ecosystems in the Wyoming Basin (Beever and Aldridge, 2011). Grazing effects are complicated by foraging selection and preferences exhibited by animals consuming vegetation (preference is what the animal eats without environmental constraints, and selection is what the animal eats due to a constraint) (Rutter, 2010). Of the primary introduced species within the Wyoming Basin, horses are the most selective, grazing primarily on grass; cattle primarily select grass but with greater proportions of forbs and shrubs than consumed by horses; and sheep select even greater proportions of forbs and shrubs (Stoddart and others, 1955; Lyons and others, 1996). Of the primary native species, mule deer prefer shrubs; pronghorn antelope prefer shrubs with a large component of forbs; and elk prefer grass with relatively smaller proportions of shrubs and forbs (Lyons and others, 1996). The actual selection of forage is influenced by temporal factors such as seasonality (Rutter, 2010), environmental factors such as topography (Stoddard and others, 1955), and distance to and availability of water (Volesky and others, 1996). Another factor that complicates forage selection is animal physiology, such as whether the animal is monogastric (one simple stomach) or a ruminant (multiple gastric components) (Lyons and others, 1996). Of the primary large species within the Wyoming Basin, only horses are monogastric.

Effects of grazing and grazing management (for example, sagebrush removal to enhance forage production) on plant and animal communities can be both direct and indirect. Effects include trampled riparian vegetation, removal of vegetative cover, and dispersal of seeds from invasive plant species (Rowland and Leu, 2011). Of particular concern is reduced cover and forage for nesting sagebrush-dependent birds, such as sage-grouse (Beever and Aldridge, 2011). Grazing also can reduce competition between herbaceous plants and the seedlings of woody plants, facilitating the establishment of juniper and pines, as well as mountain mahogany and other deciduous shrubs.

Based on data summarized by Veblen and others (2014), coupled with the complexity of animal foraging needs, local multispecies interactions, and local environmental constraints, we concluded that an ecoregion-wide assessment of grazing was not feasible for the Wyoming Basin REA because data describing grazing intensity and effects either were not available or were not consistently measured across the entire project area (Carr and others, 2013). These factors are further compounded by the fact that the Wyoming Basin contains multiple vegetative communities with varying composition, structure, and functions. To effectively analyze the impacts of grazing, “step-down” (localized) data can be used to account for the multiple, complex factors involved.

Fire and Other Disturbances

Fire

Fire is a dominant process affecting landscape structure and dynamics in many ecological systems. The ecological role of fire varies among plant communities and their corresponding fire regimes, which are dictated in large part by the interplay between climate and fuels (Baker, 2009; Littell and others, 2009). Because fire is a natural driver of ecological systems, it is challenging to tease apart the influences of natural versus anthropogenic factors that shape current fire regimes. The degree to which fire regimes have been altered by human activities varies within and among vegetation communities (Littell and others, 2009). Active fire suppression, grazing (by reducing fine fuels), and other management activities can affect vegetation communities by altering the frequency and severity of fire across the landscape (Baker, 2009). Also, increasing frequency of droughts and increasing temperatures for certain projected climate scenarios have the potential to promote greater fire size and frequency (Littell and others, 2009).

Insects and Disease

Insects and disease include both native and introduced organisms. Mountain pine beetle, a native species, can serve as an important disturbance agent in coniferous forests of the Rocky Mountains, especially ponderosa and lodgepole pine forests, and may affect more land area than fires during outbreak years. Conditions generally are not conducive to widespread beetle outbreaks, but widespread drought and warm temperatures can contribute to a shift from endemic to epidemic levels (Bentz and others, 2010; Jewett and others, 2011).

Recently introduced diseases, such as West Nile virus and white pine blister rust can be especially devastating to species that lack any natural immunity. Sage-grouse are particularly vulnerable to West Nile virus (Walker and Naugle, 2011), and white pine blister rust is a major threat to the five-needle pine communities in Wyoming (Keane and others, 2011). In addition, the current widespread and severe outbreak of mountain pine beetle in conjunction with the occurrence of white pine blister rust, is of particular concern for five-needle pines (whitebark pine and limber pine [Keane and others, 2011]).

Invasive Species

Aquatic and terrestrial invasive species occur throughout the ecoregion. The negative effects of invasive species include displacement of native communities, degradation of habitat quality and forage, and altered fire regimes (Rowland and Leu, 2011). There also can be interactions among invasive species and other Change Agents. For example, the spread of invasive plant species can be promoted by development activities. Species that are pervasive in much of the Wyoming Basins include cheatgrass, Russian olive, tamarisk, crested wheatgrass, halogeton, and Russian thistle (Nielson and others, 2011). Cheatgrass and tamarisk are not as pervasive in the Wyoming Basin as they are in warmer regions of the United States, but they can be locally abundant, and both species have the potential to expand in the Wyoming Basin for projected future climate scenarios (Rowland and Leu, 2011). Invasive aquatic species include introduced fish, such as rainbow trout, which have the potential to interbreed with genetically pure native fish species, such as cutthroat trout.

Climate Change

Climate change has the potential to change the landscape in fundamental ways, with possible consequences for natural communities and synergistic interactions with other Change Agents. Based on climate projections, the Wyoming Basin could experience changes in snowpack that in turn could change water availability, including annual runoff and runoff seasonality (see Chapter 7—Climate Analysis). For example, warming even without any decrease in precipitation could lead to increased evapotranspiration from watersheds and decreased annual runoff (Bureau of Reclamation, 2011). Climate change can influence fire regimes, promote expansions of invasive plant species, and affect hydrological regimes. Changes to water temperature and flow regime are of particular concern for fish populations, especially the cold-water fishes, including cutthroat trout. Furthermore, the timing, or phenology, of critical biological events, such as spring bud burst, emergence from overwintering, and the start of migrations, can shift, with potential consequences for species and habitats (Knutson and Heglund, 2012).

Ecosystem Conceptual Diagram

We developed a general conceptual diagram for the Wyoming Basin ecoregion to highlight the primary Change Agents, ecological systems, communities, and species that will be evaluated as a part of the Wyoming Basin REA (fig. 1–6). The climate and physiography of the ecoregion limit where species and communities occur on the landscape and influence the dynamics and spatial distribution of communities. Both natural drivers and anthropogenic Change Agents alter the dynamics and spatial distribution of communities across the ecoregion. Feedback and interactions (such as competition, predation, flows of energy, and species movements) occur within and among terrestrial and aquatic systems and Change Agents (Miller, 2005).

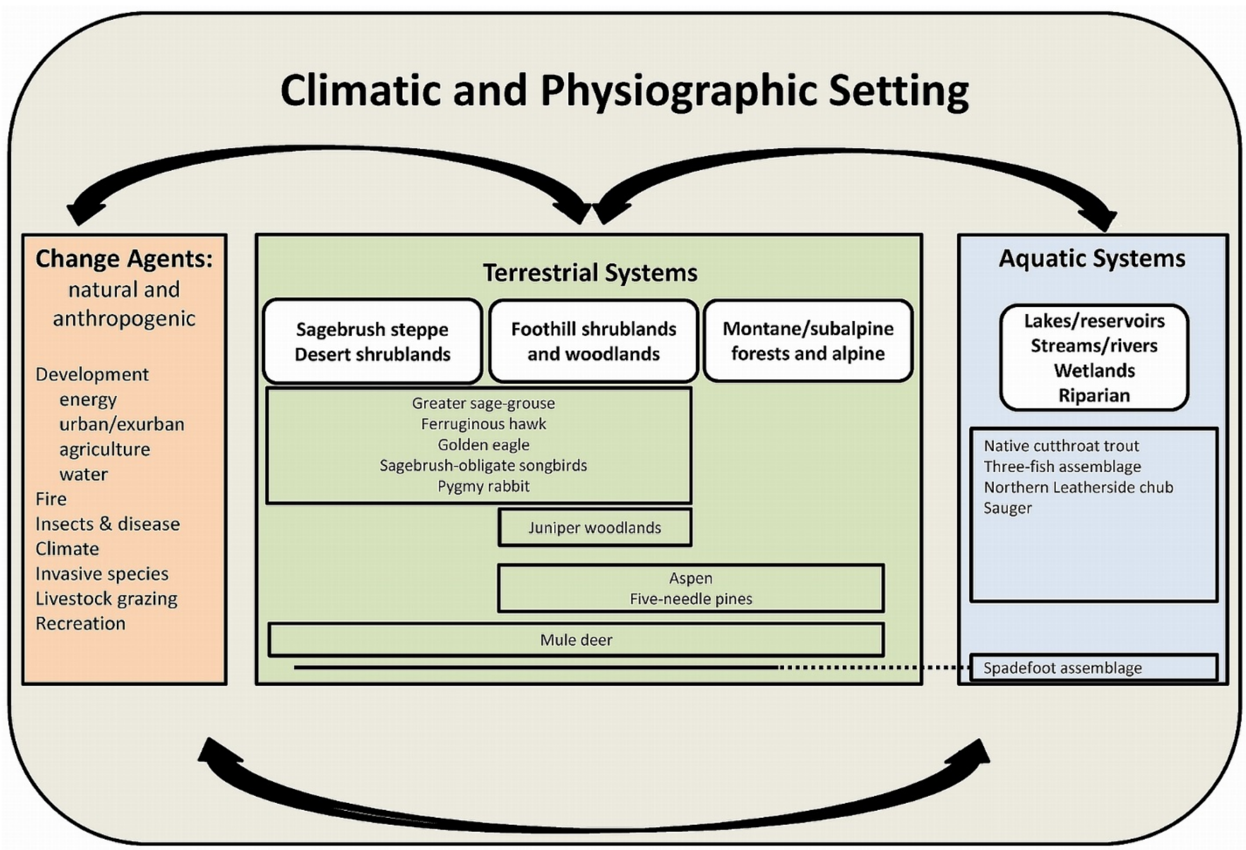

Figure 1–6. Overall conceptual diagram representing primary components of the Wyoming Basin Rapid Ecoregional Assessment. Ecological communities are shown in white boxes, and species and assemblages are shown in green (terrestrial) and blue (aquatic) boxes. The width of boxes corresponds to the ecological communities used by the species or assemblage listed in the box. The spadefoot assemblage uses both aquatic and terrestrial habitats (the dashed line indicates that the systems above the dashes are excluded). The arrows represent the direction of influence and feedback among the ecosystem components. Livestock grazing and off-highway vehicles lack sufficient data to evaluate regionally for this ecoregion.

The broad array of species and communities included in the Wyoming Basin REA collectively represent many of the pressing ecological and management issues of the ecoregion (fig. 1–6). Because sagebrush shrublands (including sagebrush steppe and foothill shrublands) is the dominant ecosystem in the ecoregion (table 1–2, fig. 1–5), and because development activities are prevalent in this system, there is an inevitable emphasis on species that occur in sagebrush shrublands. Several species, such as mule deer and golden eagle, have generalized habitat requirements; some species, such as the spadefoot assemblage, use both terrestrial and aquatic systems; and others, such as sagebrush-obligate songbirds, are largely restricted to sagebrush dominated systems in the Wyoming Basin.

Landscape Intactness

Assessments of landscape condition typically address landscape structure (such as patch size or structural connectivity) as a way of quantifying the gradient in the level of intensity of human activities and their potential effects on species and communities (for example, see Sanderson and others, 2002; Leu and others, 2008; Theobald 2010). Spatial models of human land uses, such as energy, roads and other types of infrastructure, can be used to make inferences about the condition of ecological systems at broad spatial extents. To assess landscape intactness for the overall Wyoming Basin ecoregion, we evaluated how development can alter landscape structure (see Chapter 2—Assessment Framework and Chapter 29—Landscape Intactness).

Management Implications

The REAs summarize information at broad spatial scales and can be used to help inform management decisions in conjunction with information at local scales (fig. 1–7). For example, the REA can be used as a screening tool to identify potential areas for conservation, restoration, and development projects. Local-level information or additional surveys or research can be used to assess conditions not quantified by the REA due to the lack of region-wide data (such as population sizes of species, occurrence of invasive species). Additionally, the REAs can provide assessments of spatially explicit cumulative effects of Change Agents, especially development. The REAs also can augment local project-level information to provide the broader spatial context for evaluating potential impacts of proposed actions and alternatives that cannot be determined with fine-scale information alone. The REAs, therefore, contribute to multiscale information necessary for implementing the BLM's Landscape Approach.

The BLM's REA program is closely aligned with the U.S. Department of Interior's (DOI) "A strategy for improving the mitigation policies and practices of The Department of the Interior" on DOI lands (Clement and others, 2014). A primary objective of the DOI Landscape Strategy is to shift from project-level to broad-scale, science-based management that helps to avoid, minimize, and compensate for adverse impacts to natural resources. Specifically, REAs address the following key components outlined by the DOI Landscape Strategy: development of assessment methods that promote consistency in management decisions; identification of ecological characteristics that promote ecosystem resilience in rapidly changing environmental conditions; and fostering collaboration among land-management agencies.

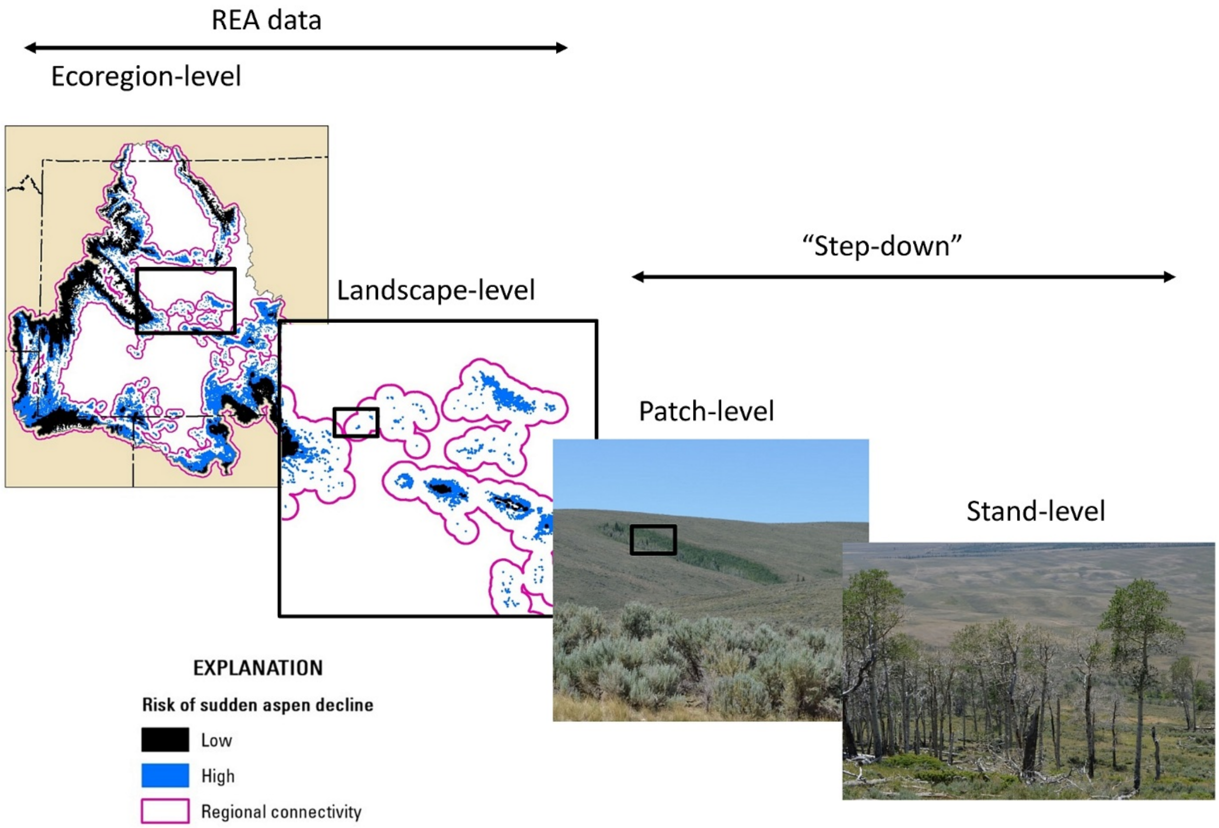

Figure 1–7. Multiple scales of information for use in the "step-down" process for assessing local-level conditions based on Rapid Ecoregional Assessments (REA). The "step-down" process refers to the use of local- or project-level information in conjunction with data from larger extents such as the landscape level, field office level, and (or) regional level REA data. The local level provides details not available from broad-scale data and can be used to validate model output from the REA; however, it lacks information on the larger ecological context or cumulative effects available from broader scales. For example, risk of sudden aspen decline can be evaluated at multiple scales spanning regional to stand levels.

References Cited

Baker, W.L., 2009, Fire ecology in Rocky Mountain landscapes: Washington, D.C., Island Press, 605 p.

Beever, E.A., and Aldridge, C.L., 2011, Influences of free-roaming equids on sagebrush ecosystems, with a focus on greater sage-grouse *in* Knick, S.T., and Connelly, J.W., eds., Greater sage-grouse—Ecology and conservation of a landscape species and its habitats: Studies in Avian Biology, v. 38, p. 185–202.

Bentz, B.J., Régnière, Jacques, Fettig, C.J., Hansen, E.M., Hayes, J.L., Hicke, J.A., Kelsey, R.G., Negrón, J.F., and Seybold, S.J., 2010, Climate change and bark beetles of the western United States and Canada—Direct and indirect effects: Bioscience, v. 60, no. 8, p. 602–613.

Bureau of Reclamation, 2011, SECURE Water Act Section 9503(c)—Reclamation Climate Change and Water, Report to Congress, 2011, at http://www.usbr.gov/climate/SECURE/.

Carr, N.B., Garman, S.L., Walters, Annika, Ray, Andrea, Melcher, C.P., Wesner, J.S., O'Donnell, M.S., Sherrill, K.R., Babel, N.C., and Bowen, Z.H., 2013, Wyoming Basin Rapid Ecoregional Assessment work plan: U.S. Geological Survey Open-File Report 2013–1223, 58 p., http://dx.doi.org/10.3133/ofr20131223.

Clement, J.P., Belin, d'A., Bean, M.J., Boling, T.A., and Lyons, J.R., 2014, A strategy for improving the mitigation policies and practices of The Department of the Interior—A report to the Secretary of the Interior from the Energy and Climate Change Task Force: Washington, D.C., U.S. Department of the Interior, Energy and Climate Change Task Force, 25 p., http://www.doi.gov/news/upload/Mitigation-Report-to-the-Secretary_FINAL_04_08_14.pdf.

Colorado Division of Wildlife, 2006, Colorado State Wildlife Action Plan: Denver, Colo., Colorado Division of Wildlife, at http://cpw.state.co.us/aboutus/Pages/StateWildlifeActionPlan.aspx.

Doherty, K.E., Naugle, D.E., Copeland, H.E., Pocewicz, Amy, and Kiesecker, J.M., 2011, Energy development and conservation tradeoffs—Systematic planning for greater sage-grouse in their eastern range, *in* Knick, S.T., and Connelly, J.W., 2011, Greater sage-grouse—Ecology and conservation of a landscape species and its habitats: Studies in Avian Biology, v. 38, p. 505−516.

Finn, S.P., and Knick, S.T., 2011, Chapter 3—Changes to the Wyoming Basins landscape from oil and natural gas development, in Hanser, S.E., Leu, Matthias, Knick, S.T., and Aldridge, C.L., eds., in Sagebrush ecosystem conservation and management—Ecoregional assessment tools and models for the Wyoming Basins: Lawrence, Kans., Allen Press, p. 69–87.

Freeman, M.C., and Marcinek, P.A., 2006, Fish assemblage responses to water withdrawals and water supply reservoirs in piedmont streams: Environmental Management, v. 38, p. 435−450.

Hanser, S.E., Leu, Matthias, Knick, S.T., and Aldridge, C.L., eds., 2011, Sagebrush ecosystem conservation and management—Ecoregional assessment tools and models for the Wyoming Basins: Lawrence, Kans. Allen Press, 409 p.

Idaho Department of Fish and Game, 2005, Idaho Comprehensive Wildlife Conservation Strategy: Boise, Idaho, Idaho Conservation Data Center, Idaho Department of Fish and Game, at http://fishandgame.idaho.gov/cms/tech/CDC/cwcs.cfm.

Jewett, J.T., Lawrence, R.L., Marshall, L.A., Gessler, P.E., Powell, S.L., and Savage, S.L., 2011, Spatiotemporal relationships between climate and whitebark pine mortality in the Greater Yellowstone Ecosystem: Forest Science, v. 57, p. 320–335.

Keane, R.E., Tomback, D.F., Murray, M.P., and Smith, C.M., 2011, The future of high-elevation fire-needle white pines in western North America, Proceedings of the High Five Symposium, June 28–30, 2010, Missoula, Mont.: Fort Collins, Colo., U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, RMRS–P–3, 376 p.

Knick, S.T., Hanser, S.E., Leu, Matthias, Aldridge, C.L., Nielson, S.E., Rowland, M.M., Finn, S.P., and Wisdom, M.J., 2011, Chapter 11—Management considerations, *in* Hanser, S.E., Leu, Matthias, Knick, S.T., and Aldridge, C.L., eds., Sagebrush ecosystem conservation and management—Ecoregional assessment tools and models for the Wyoming Basins: Lawrence, Kans., Allen Press, p. 387–409.

Knight, D.H., 1994, Mountains and plains—The ecology of Wyoming landscapes: New Haven, Conn., Yale University Press, 339 p.

Knutson, M.G., and Heglund, P.J., 2012, Chapter 12—Resource managers rise to the challenge of climate change, *in* Beever, E.A., and Belant, J.L., Ecological consequences of climate change—Mechanisms, conservation, and management: Boca Raton, Fla., CRC Press, p. 261−281.

Leu, Matthias, Hanser, S.E., and Knick, S.T., 2008, The human footprint in the West—A large-scale analysis of anthropogenic impacts: Ecological Applications, v. 18, no. 5, p. 1119‒1139.

Littell, J.S., McKenzie, D., Peterson, D.L., and Westerling, A.L., 2009, Climate and wildfire area burned in western U.S. ecoprovinces, 1916−2003: Ecological Applications, v. 19, p. 1003–1021.

Lyons, R.K., Forbes, T.D.A., and Machen, Rick, 1996, What range herbivores eat—And why: Lubbock, Tex., Texas Agricultural Extension Service, Texas A&M University System, B–6037, 9 p.

McDonald, R.I., Olden, J.D., Opperman, J.J., Miller, W.M., Fargione, Joseph, Revenga, Carmen, Higgins, J.V., and Powell, Jimmie, 2012, Energy, water and fish—Biodiversity impacts of energy-sector water demand in the United States depend on efficiency and policy measures: PLoS ONE, v. 7, no. 11, p. 1−17.

Miller, M.E., 2005, The structure and functioning of dryland ecosystems—Conceptual models to inform long-term ecological monitoring: U.S. Geological Survey Scientific Investigations Report 2005–5197, 64 p., plus 3 appendixes.

Montana Department of Fish, Wildlife, & Parks, 2014, Montana State Wildlife Action Plan: Helena, Mont., Montana Fish, Wildlife & Parks, 444 p., at http://fwp.mt.gov/fishAndWildlife/conservationInAction/swap2014Plan.html.

Naugle, D.E., ed., 2011, Energy development and wildlife conservation in western North America: Washington, D.C., Island Press, 305 p.

Naugle, D.E., Doherty, K.E., Walker, B.L., Holloran, M.J., and Copeland, H.E., 2011, Energy development and conservation trade-offs—Systematic planning for greater sage-grouse in their eastern range, *in* Garton, E.O., Connelly, J.W., Horne, J.S., Hagen, C.A., Moser, A., and Schroeder, M.A., 2011, Greater sage-grouse—Ecology and conservation of a landscape species and its habitats: Studies in Avian Biology, v. 38, p. 489−516.

Nielsen, S.E., Aldridge, C.L., Hanser, S.E., Leu, Matthias, and Knick, S.T., 2011, Chapter 10—Occurrence of non-native invasive plants—The role of anthropogenic features, *in* Hanser, S.E., Leu, Matthias, Knock, S.T., and Aldridge, C.L., Sagebrush ecosystem conservation and management—Ecoregional assessment tools and models for the Wyoming Basins: Lawrence, Kans., Allen Press, p. 357−386.

Noss, R.F., 1987, From plant communities to landscapes in conservation inventories—A look at The Nature Conservancy (USA): Biological Conservation, v. 41, p. 11–37.

Omernik, J.M., 1987, Ecoregions of the conterminous United States: Annals of the Association of American Geographers, v. 77, p. 118−125, scale 1:7,500,000.

Parrish, J.E., Braun, D.P., and Unnasch, R.S., 2003, Are we conserving what we say we are? Measuring ecological integrity within protected areas: BioScience, v. 53, p. 851–860.

Poff, N.L., and Zimmerman, J.K.H., 2010, Ecological responses to altered flow regimes—A literature review to inform the science and management of environmental flows: Freshwater Biology, v. 55, p. 194−205.

Poff, N.L., Allan, J.D., Bain, M.B., Karr, J.R., Prestegaard, K.L., Richter, B.D., Sparks, R.E., and Stromberg, J.C., 1997, The natural flow regime: Bioscience, v. 47, p. 769−784.

Poiani, K.A., Richter, B.D., Anderson, M.G., and Richter, H.E., 2000, Biodiversity conservation at multiple scales—Functional sites, landscapes, and networks: BioScience, v. 50, p. 133–146.

Rowland, M.M., and Leu, Matthias, 2011, Study area description, *in* Hanser, S.E., Leu, Matthias, Knick, S.T., and Aldridge, C.L., eds, Sagebrush ecosystem conservation and management— Eecoregional assessment tools and models for the Wyoming Basins: Lawrence, Kans., Allen Press, p. 10–45.

Rutter, S.M., 2010, Review—Grazing preferences in sheep and cattle—Implications for production, the environment and animal welfare: Canadian Journal of Animal Science, v. 90, p. 285−293.

Sabo, J.S., Sinha, T., Bowling, L.C., Schoups, G.H.W., Wallendere, W.W., Campana, M.E., Cherkauer, K.A., Fuller, P.L., Graf, W.L., Hopmans, J.W., Kominoski, J.S., Taylor, C., Trimble, S.W., Webb,

R.H., and Wohl, E.E., 2010, Reclaiming freshwater sustainability in the Cadillac Desert: Proceedings of the National Academy of Sciences of the United States of America, v. 107, p. 21256—21262.
Sanderson, E.W., Redford, K.H., Vedder, Amy, Coppolillo, P.B., and Ward, S.E., 2002, A conceptual model for conservation planning based on landscape species requirements: Landscape and Urban Planning, v. 58, p. 41–56.
Sawyer, H.S., and Kauffman, M.J., 2011, Stopover ecology of a migratory ungulate: Journal of Animal Ecology, v. 80, p. 1078–1087.
Sawyer, H., Kauffman, M.J., and Nielson, R.M., 2009, Influence of well pad activity on winter habitat selection patterns of mule deer: Journal of Wildlife Management, v. 73, no. 7, p. 1052–1061.
Sawyer, H., Lindzey, F., and McWhirter, D., 2005, Mule deer and pronghorn migration in western Wyoming: Wildlife Society Bulletin, v. 33, no. 4, p. 1266–1273.
Sawyer, H., Nielson, R.M., Lindzey, F., and McDonald, L.L., 2006, Winter habitat selection of mule deer before and during development of a natural gas field: Journal of Wildlife Management, v. 70, no. 2, p. 396–403.
Seaber, P.R., Kapinos, F.P., and Knapp, G.L., 1987, Hydrologic unit maps: U.S. Geological Survey Water-Supply Paper 2294, 63 p., at http://pubs.usgs.gov/wsp/wsp2294/.
Stoddart, L.A., Smith, A.D., and Box, T.W., 1955, Chapter 8—Management for proper range use, *in* Stoddart, L.A., Smith, A.D., and Box, T.W., eds., Range Management, 3rd ed., New York, McGraw-Hill, p. 256−289.
Theobald, D.M., 2010, Estimating natural landscape changes from 1992 to 2030 in the conterminous US: Landscape Ecology, v. 25, p. 999–1011.
U.S. Departments of the Interior, Agriculture, and Energy, 2003, Scientific inventory of onshore Federal lands' oil and gas resources and reserves and the extent and nature of restrictions or impediments to their development: Washington, D.C., Bureau of Land Management, Report BLM/WO/GI–03/002–3100, 161 p.
Utah Department of Natural Resources, 2005, Utah Comprehensive Wildlife Conservation Strategy: Salt lake City, Utah, State of Utah Department of Natural Resources, Division of Wildlife Resources Publication Number 05–19, at http://wildlife.utah.gov/cwcs/.
Volesky, J.D., Schacht, W.H., and Waller, S.S., 1996, G80–504 Proper livestock grazing distribution on rangeland: Lincoln, Nebr., University of Nebraska, at http://digitalcommons.unl.edu/extensionhist/1315/.
Veblen, K.E., Pyke, D.A., Aldridge, C.L., Casazza, M.L., Assal, T.J., and Farinha, M.A., 2014, Monitoring of livestock grazing effects on Bureau of Land Management land: Journal of Rangeland Ecology and Management, v. 67, p. 68−77.
Walker, B.L., and Naugle, D.E., 2011, West Nile virus ecology in sagebrush habitat and impacts on greater sage-grouse, *in* Knick, S.R., and Connelly, J.W., eds., Greater sage-grouse—Ecology and conservation of a landscape species and its habitats: Studies in Avian Biology, v. 38, p. 127–142.
Wyoming Game and Fish Department, 2010, State wildlife action plan: Cheyenne, Wyo., Wyoming Game and Fish Department, at http://wgfd.wyo.gov/web2011/Departments/Wildlife/pdfs/SWAP_2012_FULL0001898.pdf.