# Section I. Wyoming Basin Rapid Ecoregional Assessment Overview and Synthesis

## Chapter 3. Synthesis of Key Findings for the Wyoming Basin Rapid Ecoregional Assessment

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## Introduction

This chapter summarizes information presented in the other chapters of this report, including background information on the Bureau of Land Management and Rapid Ecoregional Assessments (REAs), and the REA components that are addressed by the Wyoming Basin REA. In addition, we provide two-page summaries for each Change Agent (development, invasive species, fire, and climate change) and Conservation Element (species and communities) assessed by the Wyoming Basin REA.

## The Rapid Ecoregional Assessment

The overall goals of the REA 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. The Bureau of Land Management (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 the development of 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 the REA results and products are relevant to multiple stakeholders. Although the REAs are informational tools and not decision-making 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.

### Management Questions

For each REA, BLM land managers and other partners provide a broad 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 help to ensure that the most relevant datasets are compiled, analyzed, and summarized. Additionally, they also address information needed 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 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 anthropogenic stressors, and more resilient to these agents of change. 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 that are of management concern, which 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 the biological or physical environment (hereafter biophysical) and ecological processes that collectively regulate the occurrence (distribution and abundance), landscape structure (patch sizes and structural connectivity of patches), and landscape dynamics (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. The Change Agents to be evaluated for the entire ecoregion minimally include

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

## The Wyoming Basin Rapid Ecoregional Assessment Project Area

The Wyoming Basin Ecoregion (as defined by Omernick, 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. 3–1). 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 (Appendix). 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. 3–2, table 3–1). The adjacent ecoregions are predominantly mountainous to the north, west, and south, and grasslands to the east (Carr and others, 2013).

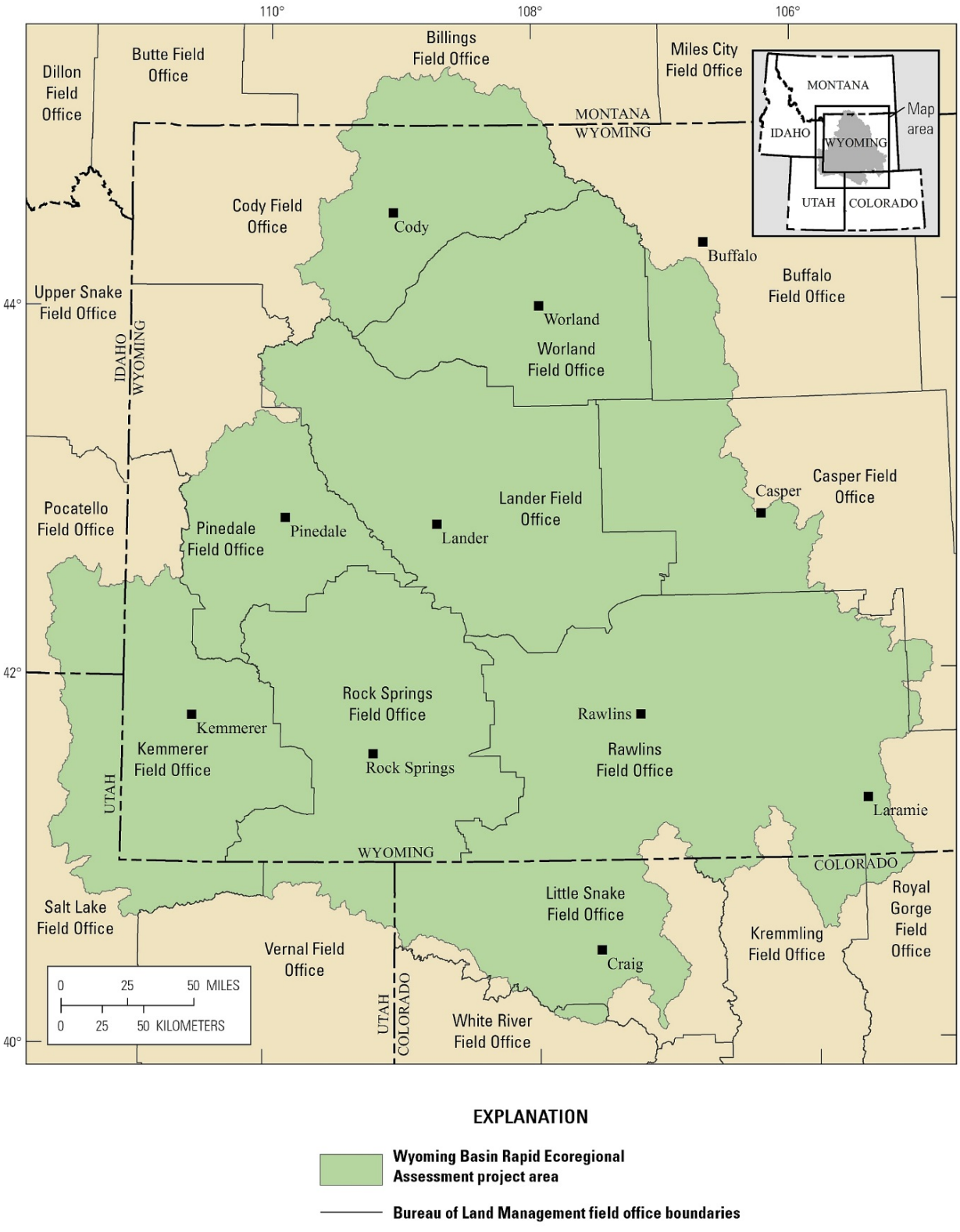


Figure 3–1. The Wyoming Basin Rapid Ecoregional Assessment project area. Bureau of Land Management field office boundaries intersecting the project area are shown.

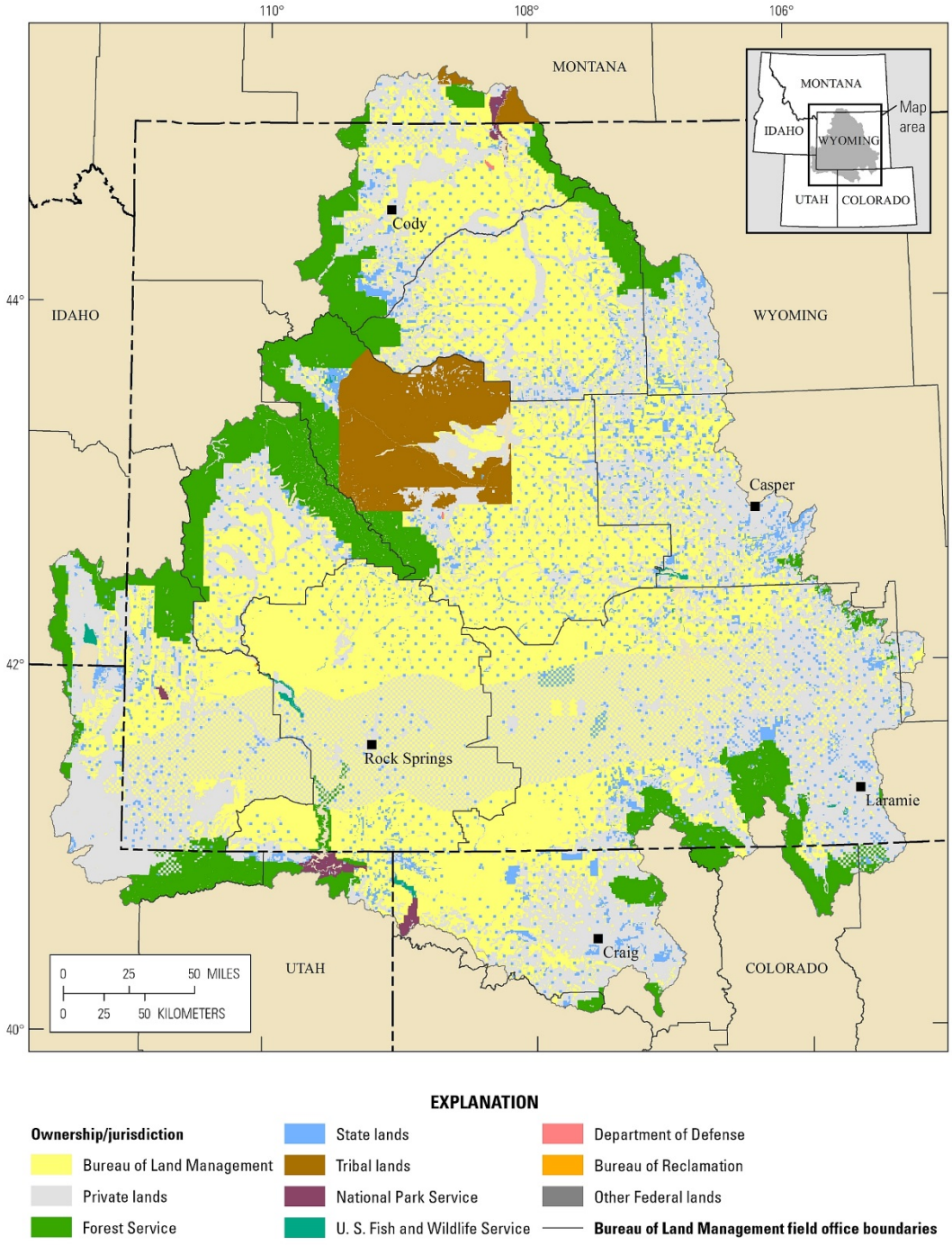


Figure 3–2. Land ownership and jurisdictions in the Wyoming Basin Rapid Ecoregional Assessment project area. National Park Service lands include Dinosaur National Park, Fossil Butte National Monument, and Bighorn Canyon National Recreation Area. U.S. Department of Agriculture Forest Service lands include Routt, Roosevelt, and Shoshone 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 3–1. Area and percentage of land managed or owned by different entities in the Wyoming Basin Rapid Ecoregional Assessment project area (based on fig. 3–2).

[ha, hectare]

| Jurisdiction | Area (ha) | Percentage of project area |
|---|---|---|
| Bureau of Land Management | 7,542,621 | 42 |
| Private | 6,032,135 | 34 |
| Forest Service | 2,174,365 | 12 |
| States | 1,072,238 | 6 |
| Tribal lands | 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 |

## Conservation Elements

### Ecological Communities

Seven major ecological communities were evaluated for the REA (table 3–2; fig. 3–3). 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, aspen, limber and whitebark pine, mixed desert shrublands, grasslands, mountain shrub, and riparian communities each cover <10 percent of the Wyoming Basin, but they have important ecological functions. The communities are described in relevant chapters in the Assessments of Communities (Section III).

### Species and Species Assemblages

A total of 14 species and species assemblages were evaluated by the REA (table 3–3).

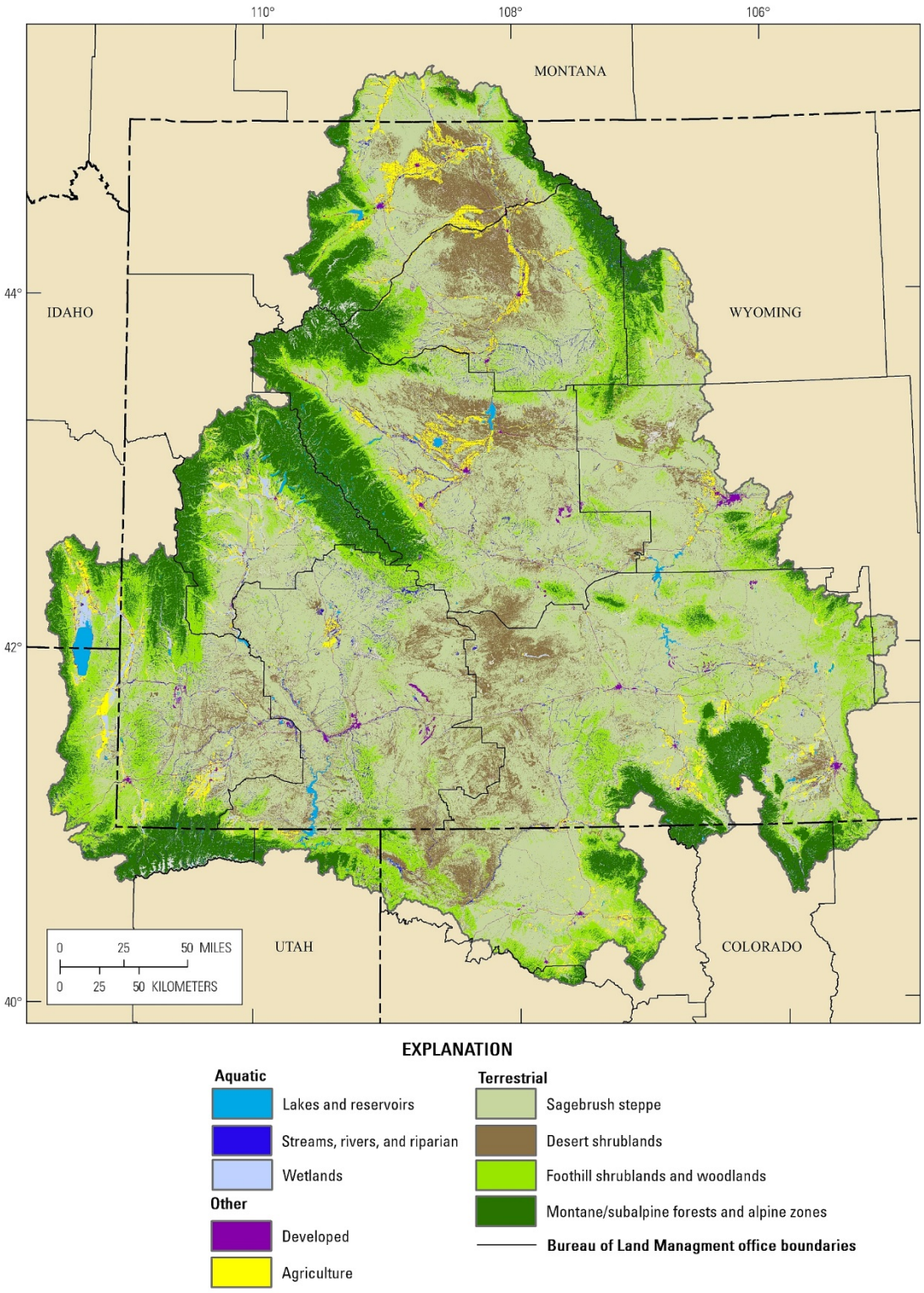


Figure 3–3. Distribution of ecological communities and dominant land use, for the Wyoming Basin Rapid Ecoregional Assessment (REA) project area. Lakes and reservoirs were not evaluated for the REA (table 3–2).

Table 3–2. Percent of area by ecological communities evaluated as Conservation Elements for the Wyoming Basin Rapid Ecoregional Assessment.

| System | Ecological communities | Percent of the Wyoming Basin project area[2] |
|---|---|---|
| Aquatic | Lakes and reservoirs[1] | 0.6 |
| | Streams and rivers | 2.3 |
| | Wetlands | 1.0 |
| | Riparian forests and shrublands | 2.1 |
| Terrestrial | Sagebrush steppe | 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.

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

| Species and species assemblages[1] |
|---|
| Aspen forests and woodlands |
| Five-needle pine forests and woodlands—Limber pine and white-bark 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 |

[1] Scientific names for all species mentioned in this report are provided in the Scientific Names of Species Used in This Report list on page xi.

## 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. It is important to note that 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. In turn, human alteration of natural disturbance regimes can lead to habitat loss and other negative effects on species and species assemblages.

## Management Implications

The REAs summarize information at broad spatial scales and can be used to inform management decisions in several ways. First, the REA can be used as a screening tool to identify potential areas for conservation, restoration, and development. Local-scale information or additional surveys or research can be used to assess conditions not quantified by the REA due to the lack of regionwide data (such as population sizes of species, occurrence of invasive species). In addition, the REAs can provide an assessment of spatially-explicit cumulative effects of Change Agents, especially development. The REAs also can augment project level information to provide the broader spatial context for evaluating potential impacts of proposed actions and alternatives than can be determined with fine-scale information alone. The REAs, therefore, provide critical multiscale information necessary for implementing the BLM's Landscape Approach. The BLM's REA program is closely aligned with the Department of Interior's *A Strategy for Improving the Mitigation Policies and Practices of the Department of the Interior* (2014 [hereafter, "Landscape Strategy"]) for improving mitigation policies and practices on U.S. Department of Interior lands. A primary objective of the 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 2014 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.

## References Cited


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## Summaries for Change Agents and Conservation Elements

This section includes the two-page summaries for each Change Agent, ecological community, and species assessed by the Wyoming Basin REA. We also provide a summary for landscape intactness for the entire Wyoming Basin REA project area, which is a primary objective of the REA. The summaries highlight some of the key findings presented in each chapter of Section II (Change Agents), Section III (Assessments of Ecological Communities), Section IV (Assessments of Species and Species Assemblages), and Section V (Landscape Intactness). More details can be found in the individual chapters.

The two-page summaries include the following information. For each Change Agent there is a map of the Change Agent, other relevant figures, and summary points. The two-page summaries for each Conservation Element include the list of all Management Questions addressed by the REA; a development score map and graph for the species or community; an example of one additional Core Management Question and resulting map; a set of maps providing an overview of landscape-level ecological values, risks, and conservation potential; and a summary of key findings. Because rankings of conservation potential are *very* sensitive to the input data used and the criteria used to develop the ranking thresholds, they are not intended as stand-alone maps. Rather, they are best used as an initial screening tool to compare regional rankings in conjunction with the geospatial data for Core Management Questions and information on local conditions that cannot be determined from regional REA maps. The two-page summary for Landscape Intactness provides the Management Questions and example maps for several Management Questions for terrestrial and aquatic systems.


Figure 3–4. State locator reference for all maps provided in the two-page summaries.

# Development:

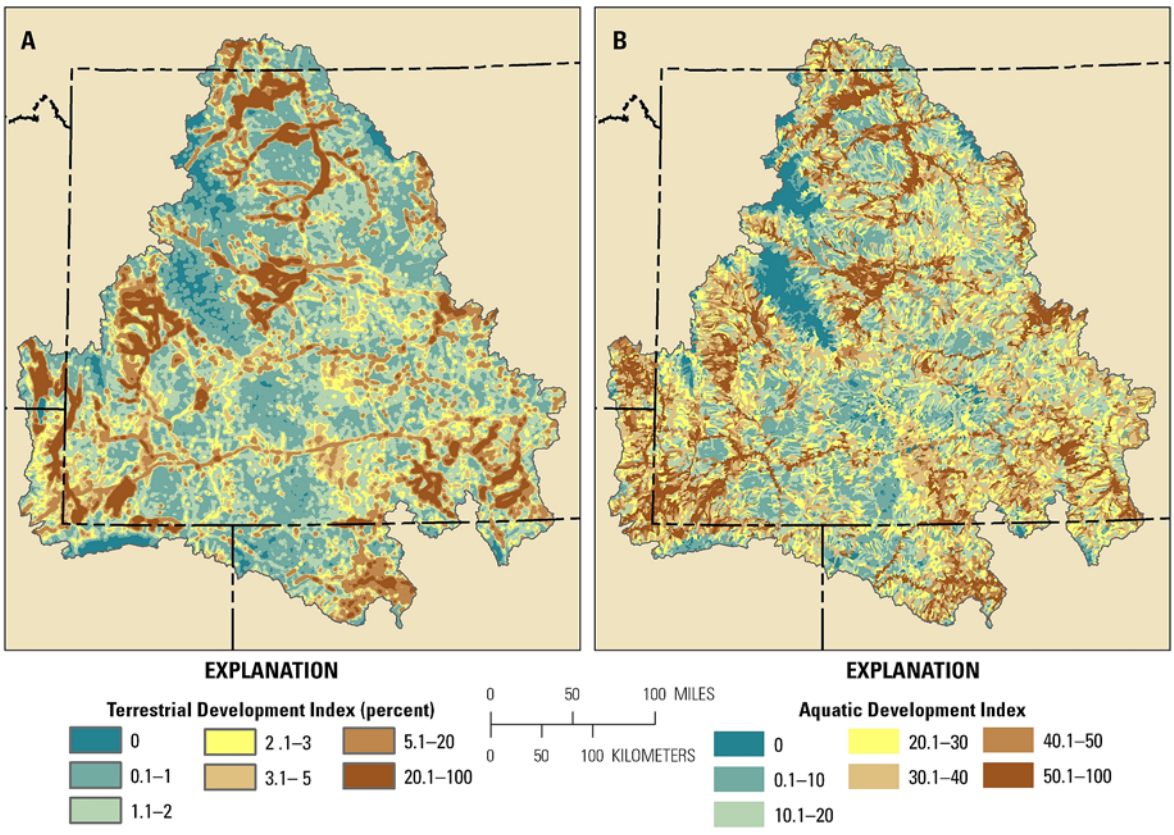
## Terrestrial
## Aquatic

### Management Questions

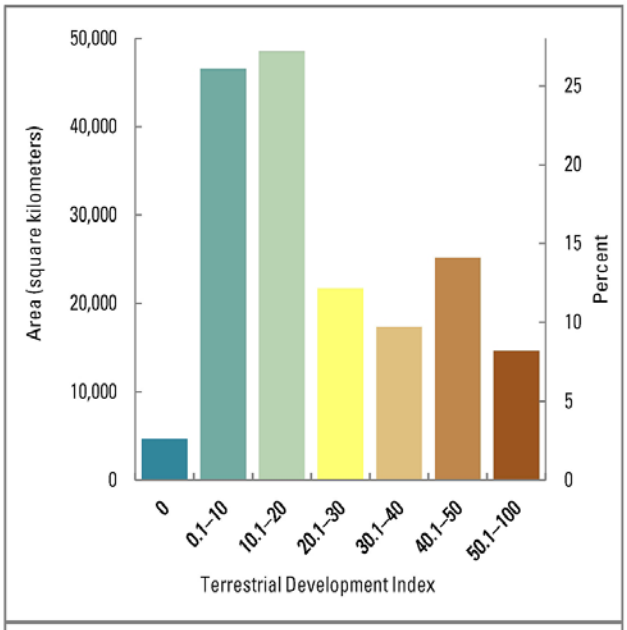
- Where does development pose the greatest threat to terrestrial systems in the ecoregion, and where are the large, relatively undeveloped patches? (Left map below)
- How do terrestrial development levels vary by transportation, energy and minerals, agriculture, and urban development classes?
- Where does development pose the greatest threat to aquatic systems in the ecoregion, and where are the relatively undeveloped catchments and watersheds? (Right map below)
- How do aquatic development levels vary by transportation, energy and minerals, dams and diversions, and agriculture and urban development classes?

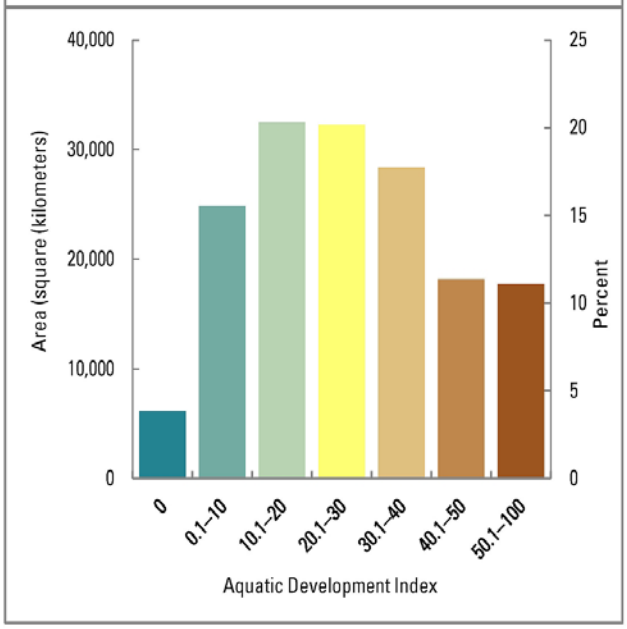
Photo credit: U.S. Geological Survey.

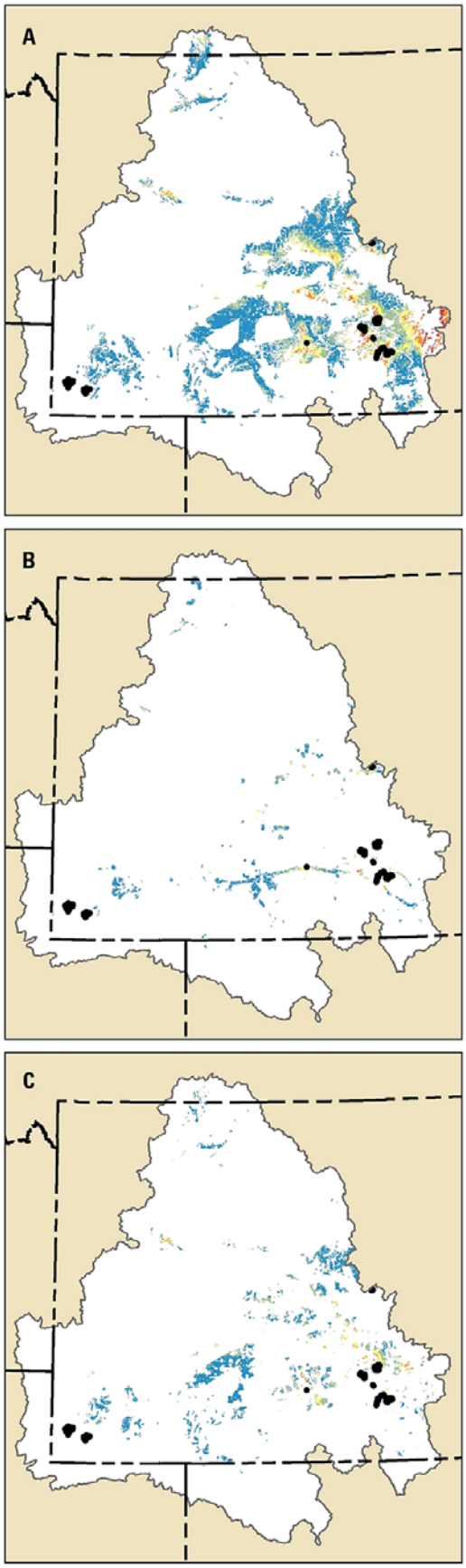
- Where are areas with high potential for future oil and gas development in relation to current and projected oil and gas development and in relation to existing oil and gas leases?
- Where are the relatively undeveloped areas that have high potential for future oil and gas development?
- Where are areas with high potential for wind development and how does potential for wind development vary with areas of high development scores versus relatively undeveloped scores? (Right map panel following page)




(*A*) Terrestrial and (*B*) Aquatic Development Index scores for the Wyoming Basin Rapid Ecoregional Assessment project area.



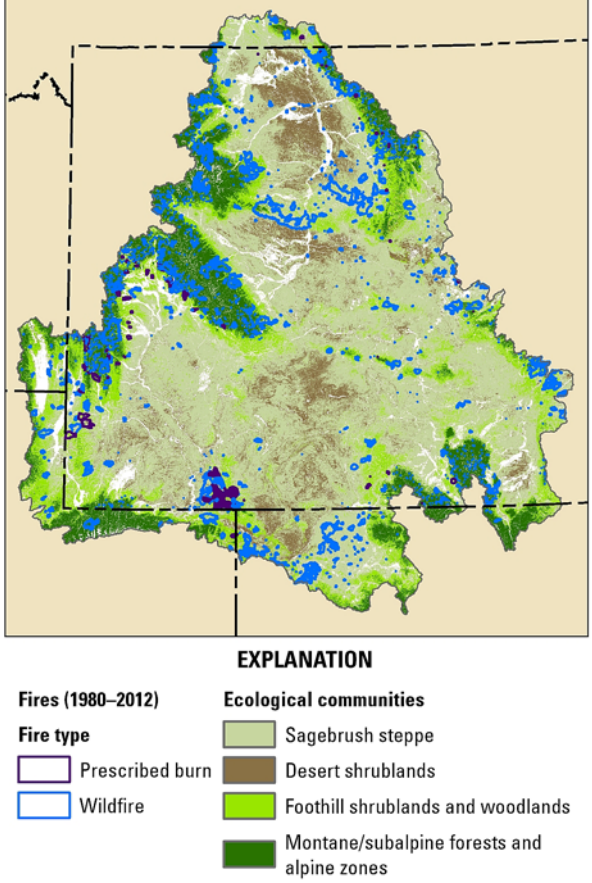

Potential for wind-energy development (*A*) across entire project area; (*B*) in areas of high terrestrial development (Terrestrial Development Index scores >5 percent); and (*C*) in relatively undeveloped areas (TDI scores ≤1 percent).

# Wildland Fire

Photo credit: Gavin Lovell, Bureau of Land Management.

## Key Points

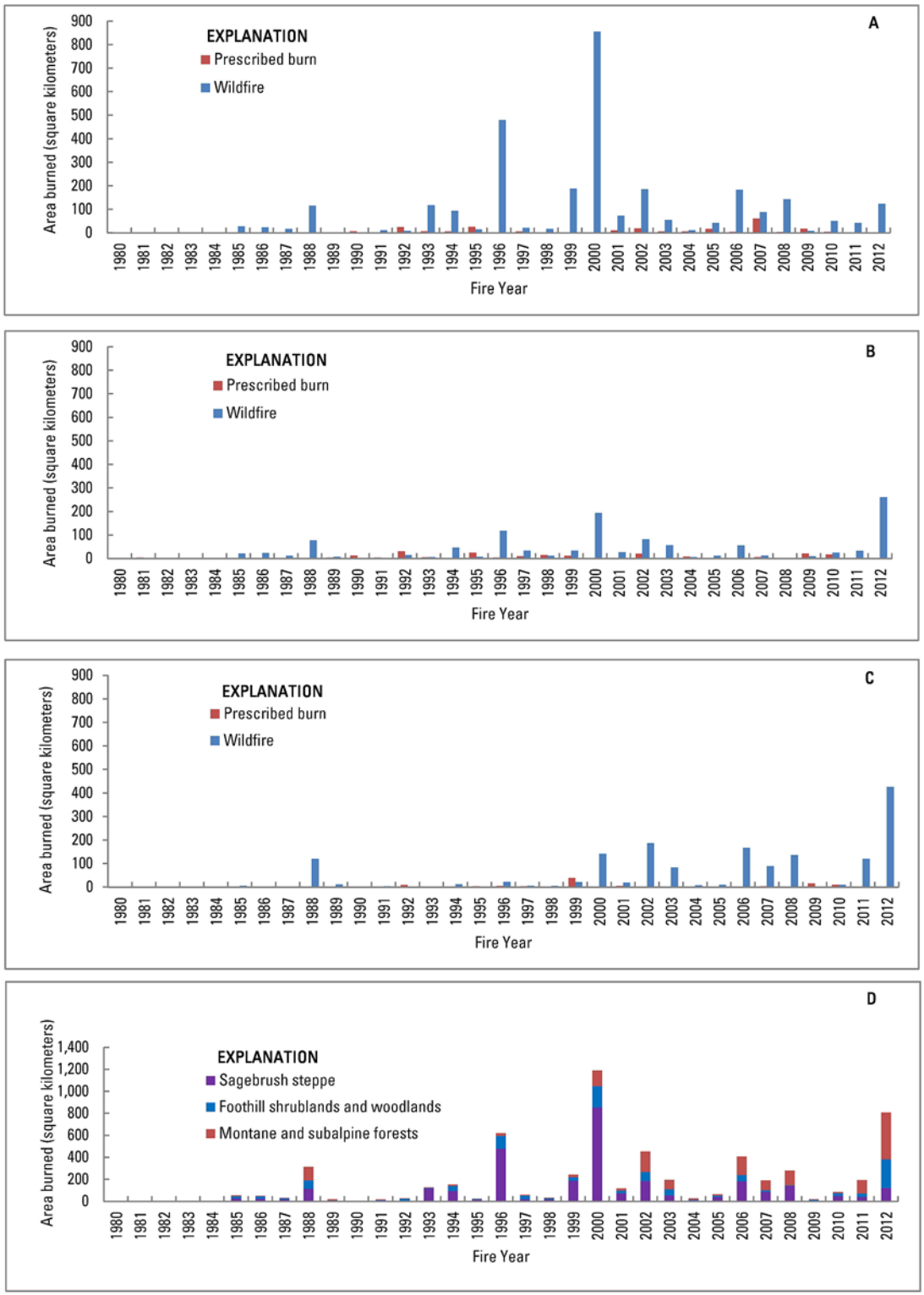
- The length of the wildfire season has increased since 1980.
- Fire occurrence in the Wyoming Basin is characterized by extremes. Typically the total acreage burned in a given year is small, and large, severe fires occur infrequently but account for most of the area burned. Annual wildfire area has varied from no fires reported in 1982 to 130,000 hectares (322,000 acres) in 2000.
- The spread of invasive species, especially cheatgrass, has potential to modify the size and intensity of wildfire in grassland and shrubland communities.
- Climatically driven disturbance effects may be less rapid within the Wyoming Basin than in other ecoregions in which fire occurrence appears much more climate sensitive.
- Climatic conditions and shifts in wildfire patterns have the potential to alter ecological communities.
- In the future, high-elevation forests may experience a significant increase in wildfire extent and intensity. The lower-elevation grasslands and shrublands may experience a decrease in wildfire activity.
- Wildfire regimes have varied greatly during the past 13,000 years. As an example, fire rotation intervals have ranged from 90 to 250 years on the Yellowstone Plateau.
- Vegetation also has shown considerable variation over the past 40,000 years, including an expansion of Utah juniper starting 2,800 years ago.
- The average area burned between 1980 and 2012 was 18,674 hectares (46,100 acres).




Wildfire and prescribed fire locations and perimeters (1980–2012) in the Wyoming Basin Rapid Ecoregional project area. Small fires are not visible at this scale. Minimum mapping acreage for a wildfire is 16.2 hectares (40 acres).

Area of ecological communities burned between 1980 and 2012 in the Wyoming Basin Rapid Ecoregional Assessment project area.

| Ecological communities | Total area burned (hectares) | Percent burned | Average annual area (hectares) burned |
|---|---|---|---|
| Sagebrush steppe | 300,491 | 3.34 | 9,106 |
| Foothill shrublands and woodlands | 120,151 | 4.21 | 3,641 |
| Montane and subalpine forests and alpine zones | 161,563 | 6.48 | 4,896 |
| Other (primarily riparian forests and desert shrublands) | 34,058 | 1.34 | 1,032 |
| Total all | 616,263 | 3.7 | 18,674 |



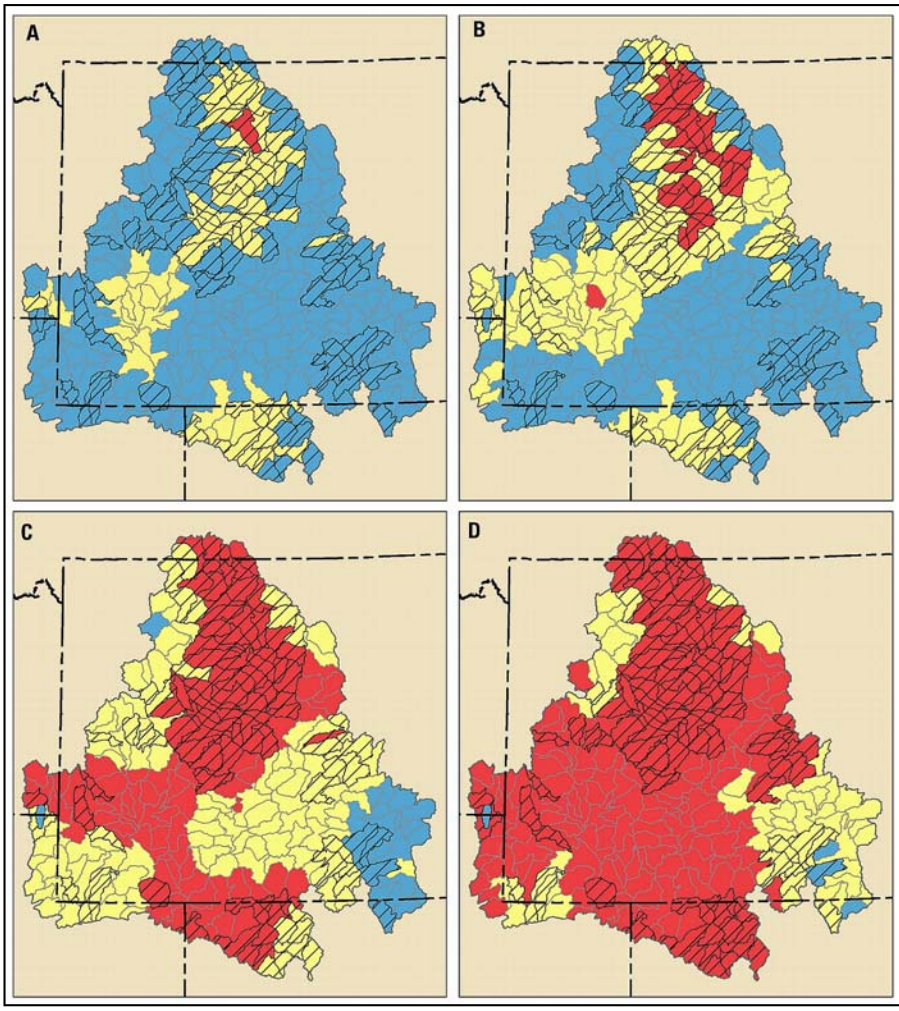

Wildfire and prescribed fire acres burned, by year, 1980–2012. (*A*) Annual acres burned in the sagebrush steppe; (*B*) annual acres burned in the foothill shrublands and woodlands; (*C*) annual acres burned in the montane/subalpine; and (*D*) Total annual acres burned in the three major ecological communities.

# Invasive Species

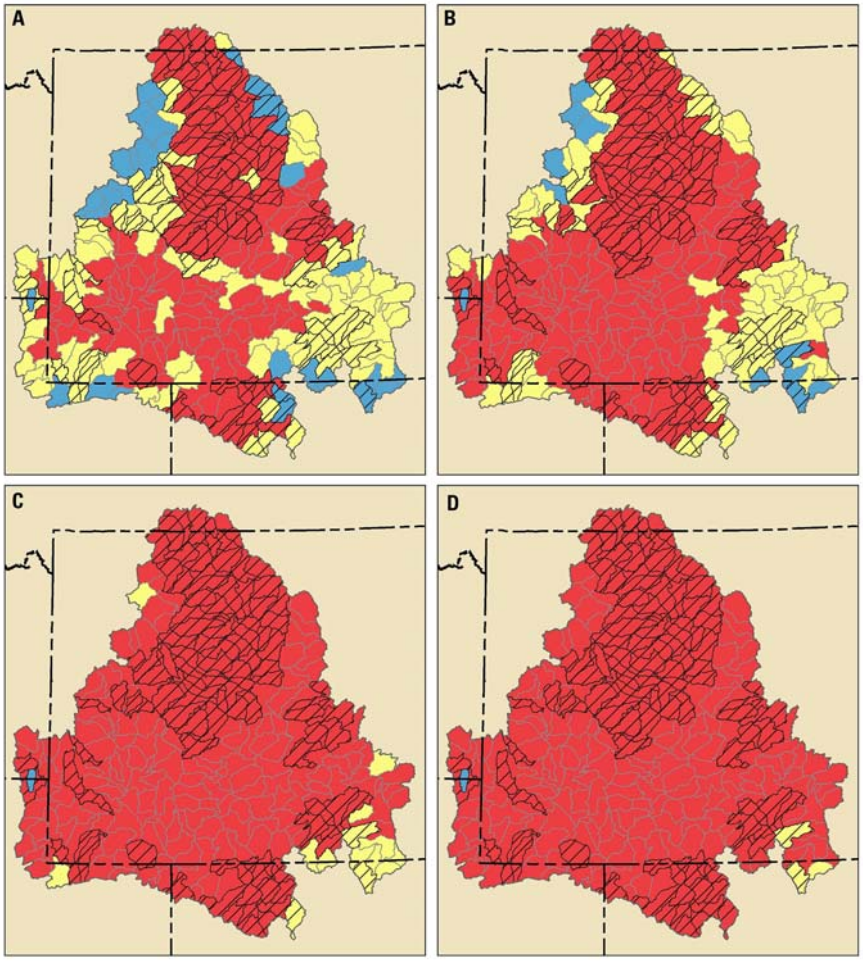
## Management Questions

- Where are the known populations of Russian olive and tamarisk?
- Where is riparian vegetation at risk from expansion of Russian olive based on recent and projected climatic conditions? (Map below)
- Where is riparian vegetation at risk from expansion of tamarisk based on recent and projected climatic conditions? (Top map following page)

Photo credits: White pine blister rust, U.S. Department of Agriculture Forest Service; Russian olive and tamarisk, U.S. Geological Survey; and walleye, LuRay Parker, Wyoming Game and Fish Department.




Current and projected risk for expansion of Russian olive, summarized by fifth-level watersheds for the Wyoming Basin Rapid Ecoregional Assessment project area. Current risk of expansion based on suitability models using *(A)* recent climatic conditions (1980–2009); projected risks based on climate scenario II (see Chapter 6) for *(B)* 2030; (*C*) for 2060; and (*D*) for 2090. Expansion risk is classified as lowest for probabilities <0.33, medium for probabilities between 0.34 and 0.66, and highest for probabilities >0.67. Probabilities are based on occurrence models (see Chapter 6). Hatched lines denote watersheds where LANDFIRE indicated Russian olive and (or) tamarisk presence.




Current and projected risk for expansion of tamarisk summarized by fifth-level watersheds for the Wyoming Basin Rapid Ecoregional Assessment project area. Current risk of expansion based on suitability models using (*A*) recent climatic conditions (1980–2009); projected risks based on climate scenario II (see Chapter 6) for (*B*) 2030; (*C*) for 2060; and (*D*) for 2090. Expansion risk is classified as lowest for probabilities <0.33, medium for probabilities between 0.34 and 0.66, and highest for probabilities >0.67. Probabilities are based on occurrence models (see Chapter 6). Hatched lines denote watersheds where LANDFIRE indicated Russian olive and (or) tamarisk presence.


## Summary

Currently, Russian olive and tamarisk have somewhat limited distributions in riparian areas of Wyoming, although changing climate and disturbance patterns, especially wildfire, have the potential to greatly increase the risk from invasive species. Although cheatgrass is an invasive species of concern in the Wyoming Basin, occurrence data were not sufficient for modeling cheatgrass occurrence or to evaluate the potential for cheatgrass to spread.

Other nonnative and invasive species addressed by the Wyoming Basin Rapid Ecoregional Assessment were evaluated for species or species assemblages as shown in the table to the right

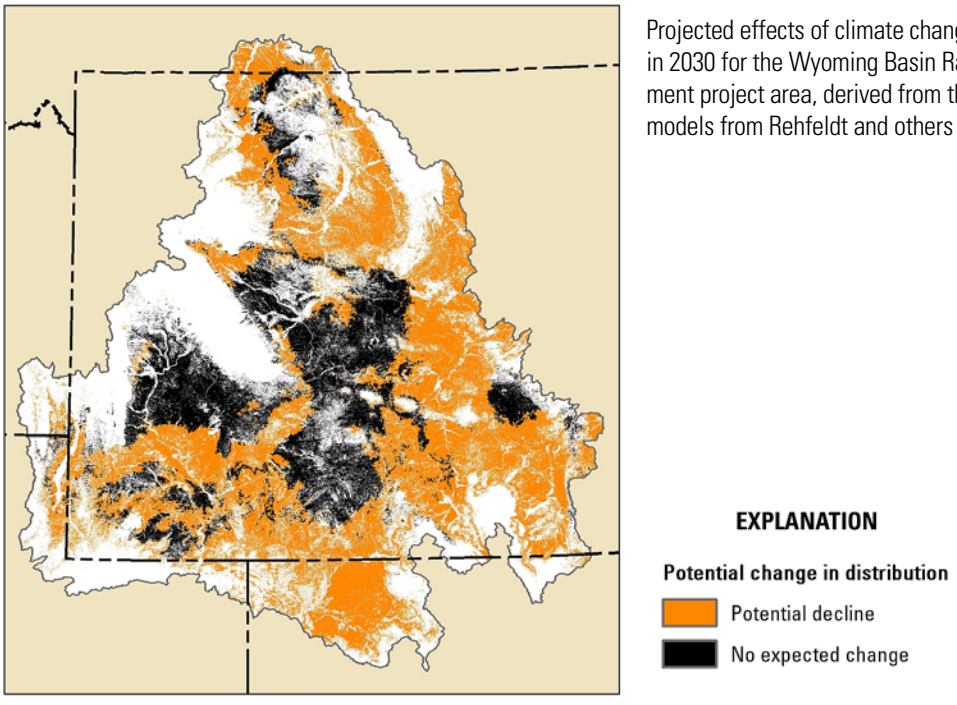

Invasive species addressed by the Wyoming Basin Rapid Ecoregional Assessment.

| Conservation Element | Nonnative and invasive species |
|---|---|
| Riparian | Russian olive and tamarisk |
| Five-needle pine forests | White pine blister rust |
| Cutthroat trout | Whirling disease; nonnative trout |
| Sauger | Walleye |
| Three-fish assemblage | White sucker and burbot |
| Northern leatherside chub | Nonnative trout |
| Greater sage-grouse | West Nile virus |

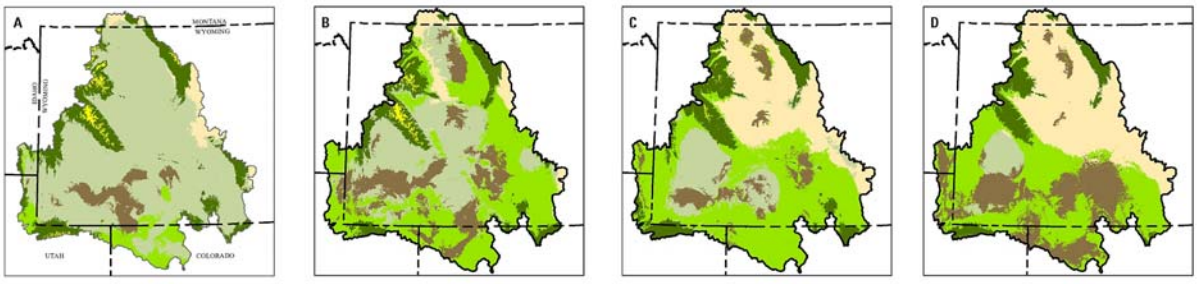
# Climate Analysis

## Key Points

- Temperatures in the Wyoming Basin Rapid Ecoregional Assessment project area have warmed by almost 1.1 ºCelsius (ºC; 2 ºFahrenheit [ºF]) in the past 30 years, which is statistically significant. In contrast, precipitation does not show a statistically significant trend compared to precipitation variability of the recent past. (Lower two map panels following page)
- Based on the climate models evaluated for the REA, the Wyoming Basin is projected to warm by about 1.4 ºC (2.5 ºF), with a modeled range of 0.8–1.9 ºC (1.5–3.5 ºF) by 2030. The projected increase in temperature is higher for the period ending in 2060, with an average increase of about 2.7 ºC (4.9 ºF) and a range from 1.5–2.7 ºC (2.7–4.9 ºF).
- Projections indicate an increase in the minimum temperatures of the coldest days, and an increase in the frequency and temperature of the hottest days. Projected temperatures for 2060 indicate that summers may be as warm as or warmer than the hottest summers in the recent climate.
- Climate projections do not show a dramatic change in annual average precipitation. Historical variability in precipitation is high.
- Snow water equivalent on April 1 is projected to decrease by at least 20 percent or more by 2030 in many areas, although not in the higher mountains. Based on projections of earlier snowmelt and runoff, soil moisture has the potential to increase earlier in the spring and dry out earlier in the growing season.
- Paleoclimate reconstructions of streamflow show considerable variability in records within the last 500 years, including years-to-decades of wetter or drier conditions in reconstructed streamflows.
- The projected changes in temperature and shifts in precipitation and streamflow variables have implications for the Wyoming Basins ecosystems. These could include changes in elevation of climate zones, shifts in timing of peak streamflow, shifts in the seasonal pattern of soil moisture, and a longer growing season. Projected changes in the distribution of bioclimatic conditions conducive for ecological communities indicates the potential for a decrease in the area of sagebrush steppe, montane and subalpine forests, and alpine zones for climate scenario I (see Chapter 2). (Map below and top map panel following page)




Projected effects of climate change on sagebrush steppe in 2030 for the Wyoming Basin Rapid Ecoregional Assessment project area, derived from the bioclimatic envelope models from Rehfeldt and others (2012).

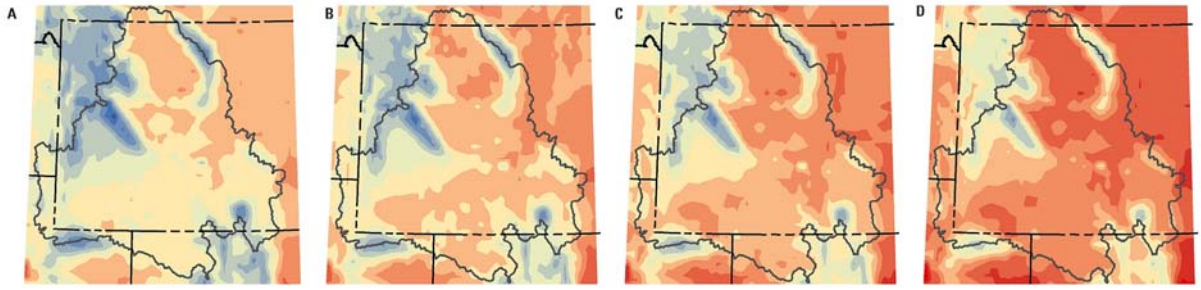



**EXPLANATION**

**Terrestrial biomes**

- Plains grassland
- Desert shrublands
- Sagebrush steppe
- Foothill shrublands and woodlands
- Mountain and subalpine forests
- Alpine

The (*A*) current distribution bioclimatic conditions suitable for biomes in the Wyoming Basin Rapid Ecoregional Assessment project area developed by Rehfeldt and others (2012) and the potential distribution of bioclimatic conditions based on CCCM3 climate model and emissions scenario A2 (see Chapter 2) for (*B*) 2030, (*C*) 2060, and (*D*) 2090.

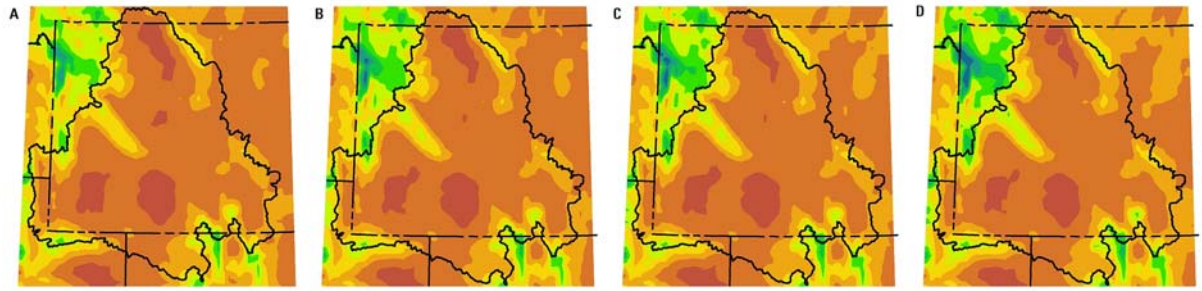



**EXPLANATION**

**Average annual temperature (degrees Celsius)**

| | | |
|---|---|---|
| ≤-6 | 0–2 | 8–10 |
| -6– -4 | 2–4 | 10–12 |
| -4– -2 | 4–6 | 12–14 |
| -2–0 | 6–8 | 14–16 |

Historical and projected average annual temperatures for the Wyoming Basin Ecoregional Assessment project area during the (*A*) historical period (1961-1990), and three future periods: (*B*) 2016-2030, (*C*) 2046-2060, and (*D*) 2076-2090 based on the ensemble mean model and emissions scenario A2 (see Chapter 7). Data from bias-corrected spatial disaggregation, 12-kilometer (7.5-mile) resolution.




**EXPLANATION**

**Average annual precipitation (centimeters)**

| | | |
|---|---|---|
| ≤ 20 | 80–100 | 160–180 |
| 20–40 | 100–120 | 180–200 |
| 40–60 | 120–140 | |
| 60–80 | 140–160 | |

Historical and projected average annual precipitation for the Wyoming Basin Ecoregional Assessment project area during the (*A*) historical period (1961–1990), and three future periods: (*B*) 2016–2030, (*C*) 2046–2060, and (*D*) 2076–2090 based on the ensemble mean model and emissions scenario A2 (see Chapter 7). Data from bias-corrected spatial disaggregation, 12-kilometer (7.5-mile) resolution.

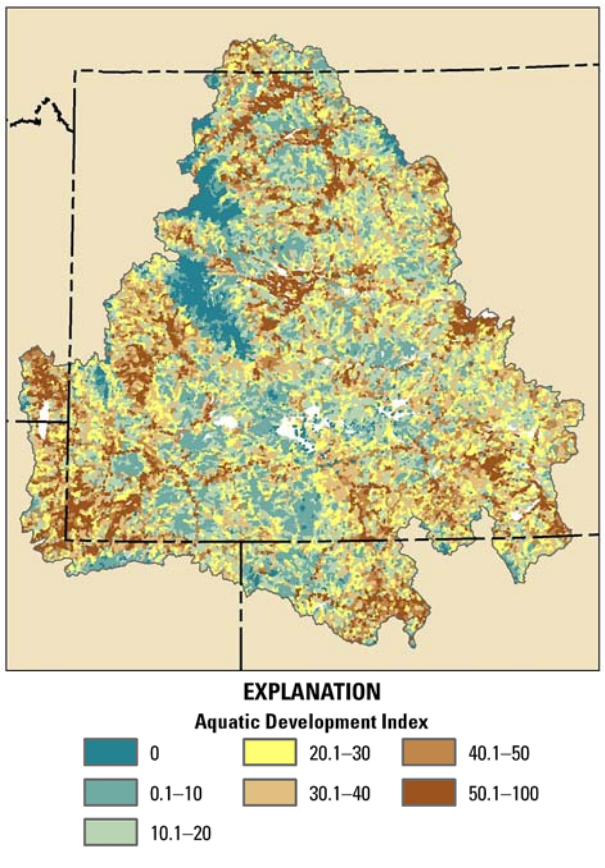
# Streams and Rivers

## Management Questions

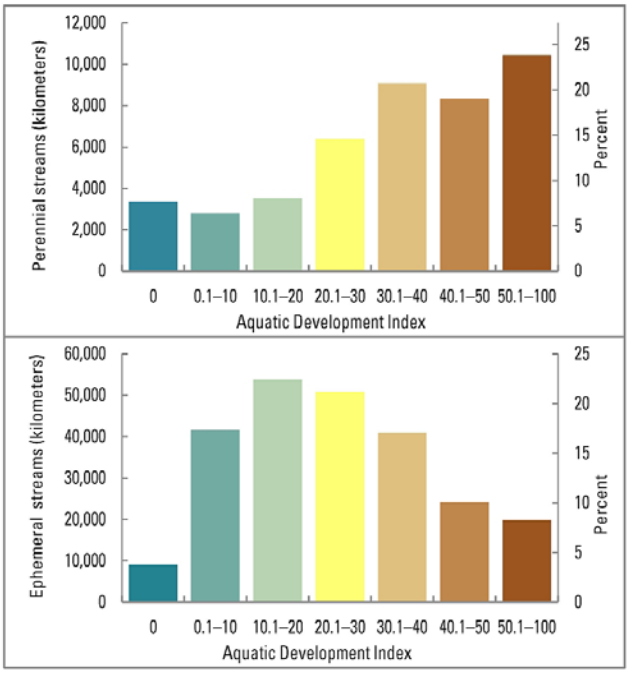
- What is the amount and distribution of streams and rivers, and how does hydroperiod vary?
- Where is woody riparian vegetation present along perennial streams?
- Where does development pose the greatest threat to streams and rivers, and where are the large, relatively undeveloped areas? (Left map below)
- Where has development fragmented streams and rivers, altered flows, and decreased structural connectivity? (Top left map following page)
- Where are streams and rivers with a high proportion of nonnative riparian vegetation?
- Which watersheds have had the most area burned by recent fires?

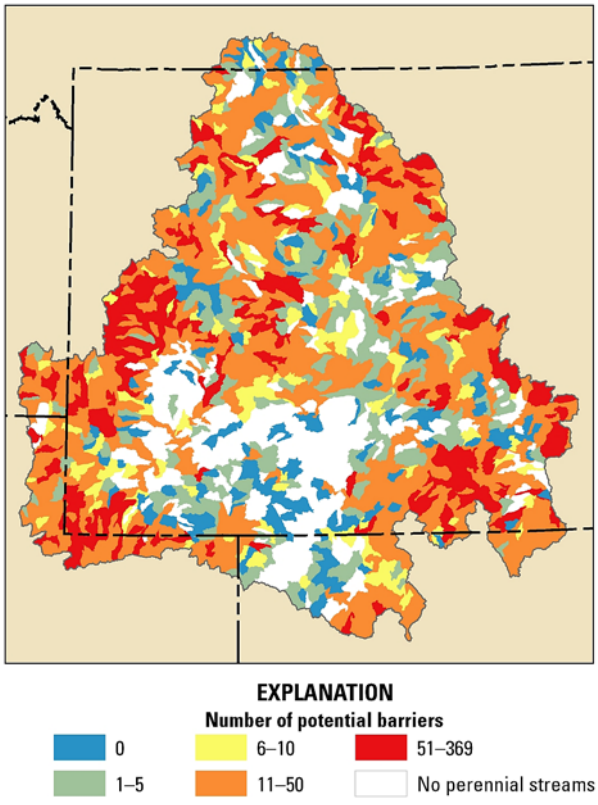
Photo credit: U.S. Fish and Wildlife Service.

- Where are streams and rivers currently at risk from low summer flows?
- Where could streams and rivers be at risk from projected shifts in hydrological regimes in 2040?
- How does risk from development vary by land ownership or jurisdiction for streams and rivers?
- Where are the fifth-level watersheds with the greatest landscape-level ecological values? (Top right map following page)
- Where are the fifth-level watersheds with the greatest landscape-level risks? (Center right map following page)
- Where are the fifth-level watersheds with the greatest conservation potential? (Bottom right map following page)




Aquatic Development Index scores for streams and rivers in the Wyoming Basin Rapid Ecoregional Assessment project area.



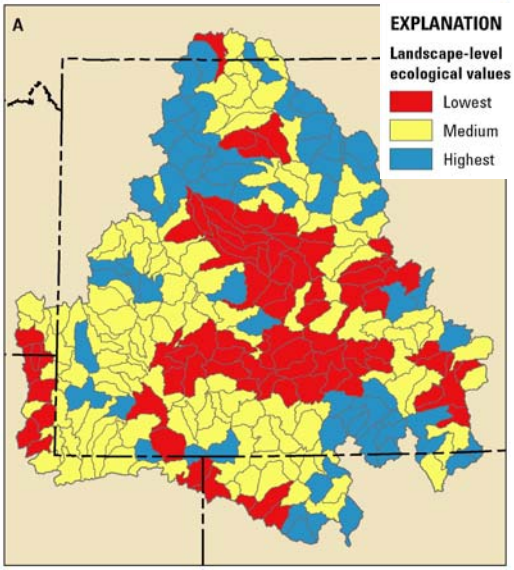


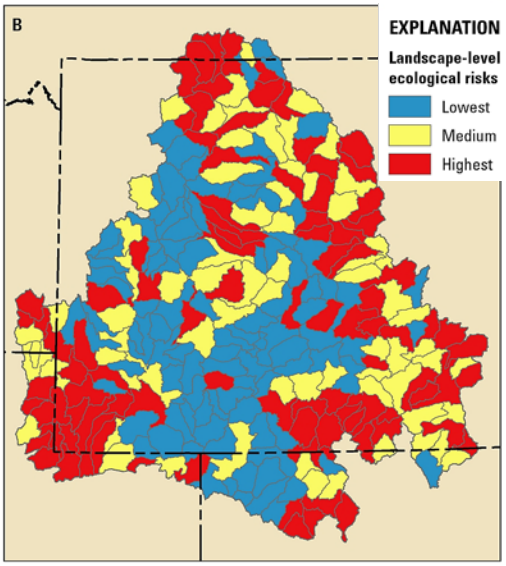

Potential barriers (dams, diversions, and road crossings on streams) in perennial streams summarized by sixth-level watershed.

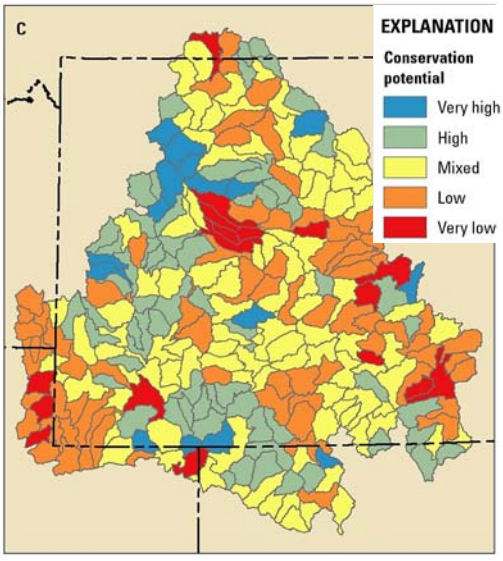

## Summary

In the Wyoming Basin, streams, rivers, and associated riparian habitat account for just 2.3 percent of the landscape, yet they have a disproportionately large influence on many species, both aquatic and terrestrial. Most of these streams and rivers flow through sagebrush steppe, the dominant ecological community in the Wyoming Basin, and are intermittent or ephemeral in nature. There are three large perennial river systems in the Wyoming Basin: the Wind, Bighorn, Green, and North Platte Rivers.

Development poses threats to the hydrology, structural connectivity, and integrity of streams and rivers throughout the Wyoming Basin, especially for perennial systems. The major sources of development are roads and agricultural activities. Many watersheds have a high number and extensive distribution of potential barriers posed by roads and water diversions. Many streams are intermittent in nature and (or) have very low mean flows due to the semiarid nature of this ecoregion, which makes them especially vulnerable to dewatering as a result of diversions and projected climate change.

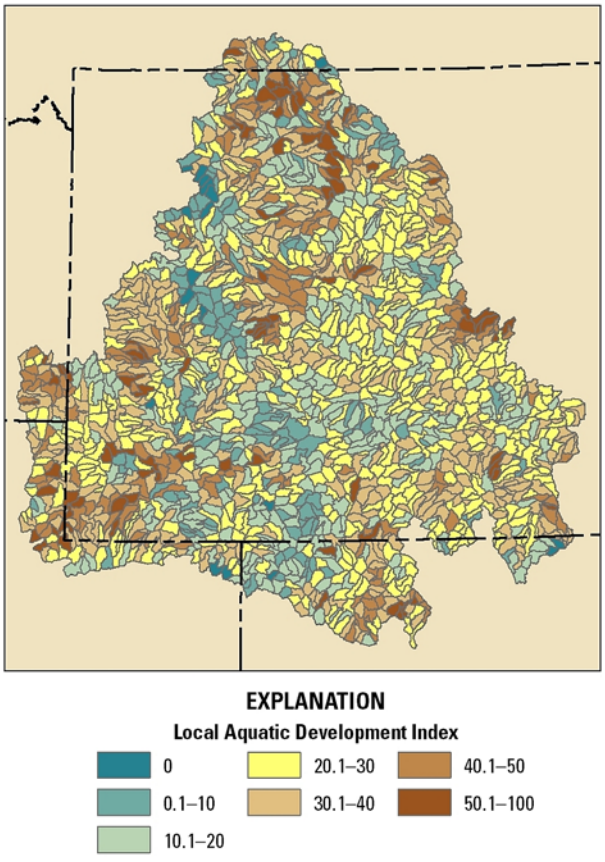

(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of streams and rivers summarized by fifth-level watershed.

# Wetlands

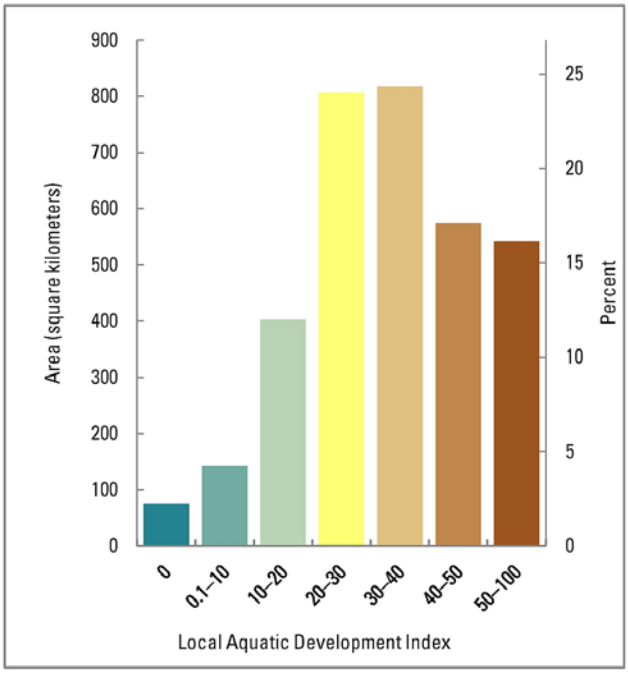
Photo credit: Cynthia P. Melcher, U.S. Geological Survey.

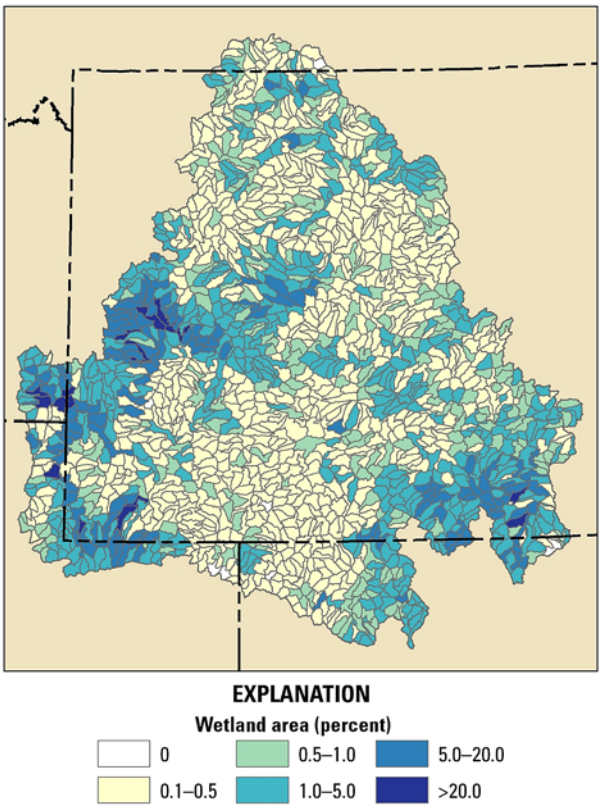
## Management Questions

- Where are baseline wetlands, by functional type and hydroperiod, and what is the total area of each? (Top left map following page)
- Where are the sixth-level watersheds with the greatest wetland area?
- Where does development pose the greatest threat to wetlands, and where are the relatively undeveloped wetlands? (Left map below)
- How has development affected the structural connectivity of wetlands relative to baseline conditions?
- Which wetlands are potentially created or altered by agriculture?
- How does risk from development vary by land ownership or jurisdiction for wetlands?
- Where are the fifth-level watersheds with the greatest landscape-level ecological values? (Top right map following page)
- Where are the fifth-level watersheds with the greatest landscape-level risks? (Center right map following page)
- Where are the fifth-level watersheds with the greatest conservation potential? (Bottom right map following page)




Local Aquatic Development Index scores for wetlands, summarized by sixth-level watershed, in the Wyoming Basin Rapid Ecoregional Assessment project area.





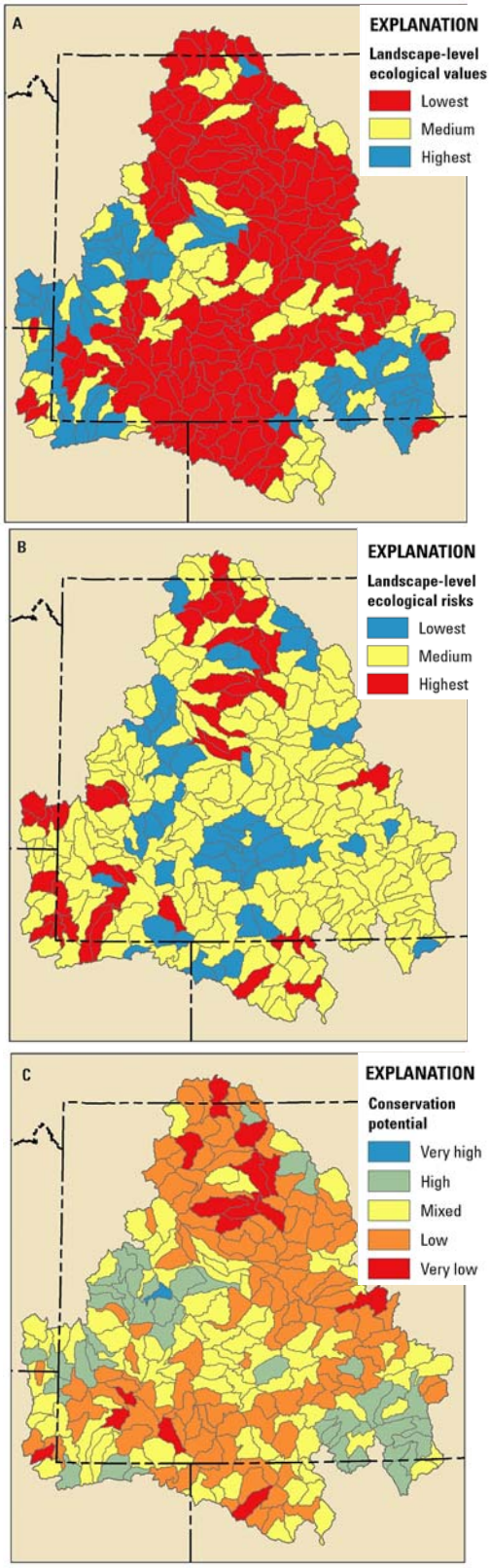

Percent of sixth-level watershed area that is classified as wetlands in the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

Wetlands are unevenly distributed in the Wyoming Basin. In most of the region, overall wetland area is low, with greater densities of wetlands present in the Wind River Basin; Laramie Plains; Uintah Mountains; Upper Green, Bear, Little Snake, Shoshone, and Bighorn Rivers. Areas with high percentages of wetland are also highly connected. Most highly connected, and less developed wetland complexes occur at higher elevations or along rivers.

Moderate to high development levels may exist in watersheds with high densities of wetlands, which reflects the fact that many wetlands in developed areas are artificially created or altered by irrigation. This likely reflects the fact that many developed wetlands are artificially altered by irrigation. More than half of the existing wetlands in the Wyoming Basin are used for agriculture. In the Laramie River Basin (in southeast Wyoming), 65 percent of surface and subsurface inflows to wetlands come directly from irrigation, changing natural wetland hydrology and increasing total wetland density.

Differences in structural connectivity between baseline and developed wetlands may be particularly detrimental to limited-dispersal amphibians. Structural connectivity of baseline wetlands is high for amphibians that can travel <0.5 kilometers (0.31 miles); however, structural connectivity of relatively undeveloped areas often exceeds 1 kilometer (0.62 miles), which may exceed the dispersal capabilities of many amphibian species.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of wetlands, summarized by fifth-level watershed.

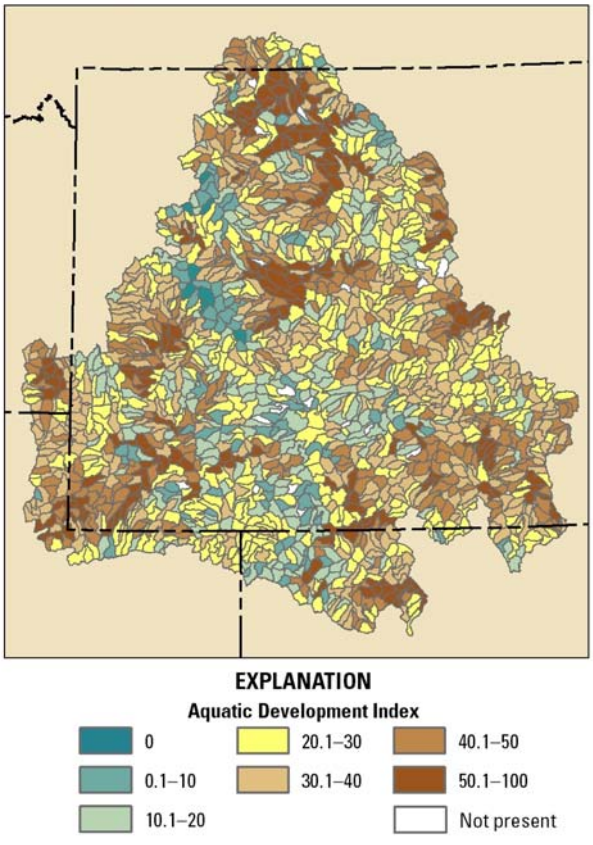
# Riparian Forests and Shrublands

## Management Questions

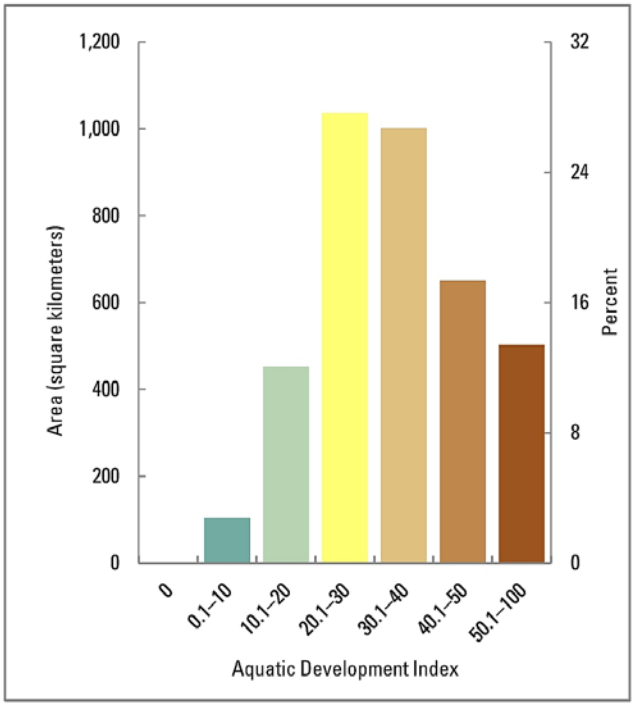
- Where are baseline riparian forests and shrublands, and what is their total area?
- Where are the largest areas of riparian vegetation in the Wyoming Basin?
- Where does development pose the greatest threat to baseline riparian forests and shrublands, and where are the large, relatively undeveloped areas? (Left map below)
- Where do dams pose an ongoing threat to downstream riparian areas?
- Where are Russian and (or) tamarisk olive present? (Top left map following page)
- Where could riparian vegetation be at risk from Russian olive and tamarisk expansion by 2030?

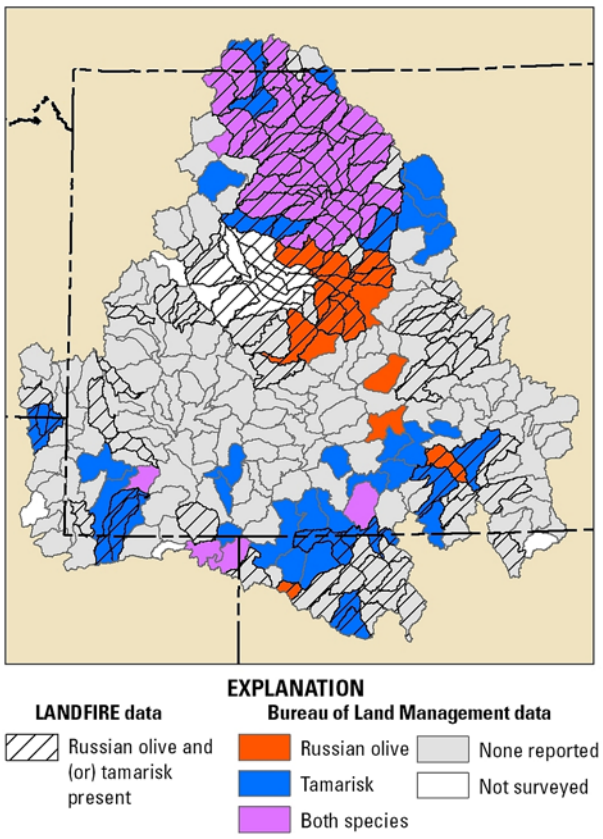
Photo credit: Bureau of Land Management.

- How does risk from development vary by land ownership or jurisdiction for riparian forests and shrublands?
- Where are the watersheds with the greatest landscape-level ecological values? (Top right map following page)
- Where are the watersheds with the greatest landscape-level risks? (Center right map following page)
- Where are the watersheds with the greatest conservation potential? (Bottom right map following page)




Aquatic Development Index scores for riparian areas, summarized by sixth-level watershed, in the Wyoming Basin Rapid Ecoregional Assessment project area.

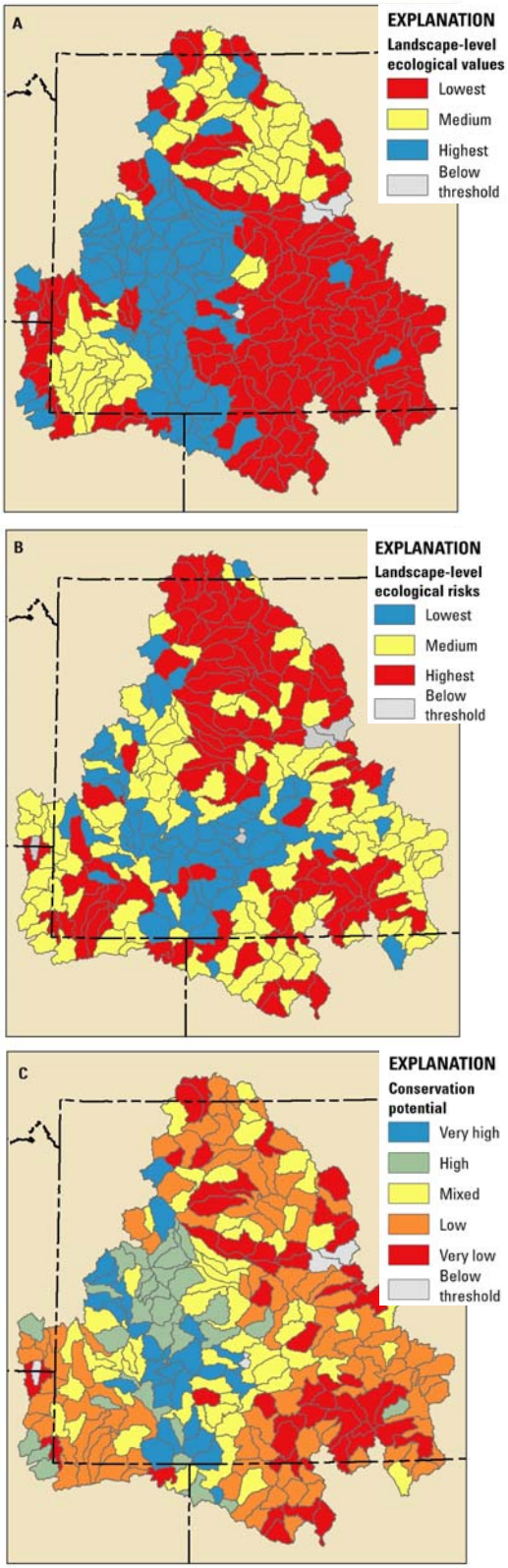





Presence of Russian olive and (or) tamarisk, based on Bureau of Land Management (BLM) field office data and LANDFIRE data for the Wyoming Basin Rapid Ecoregional Assessment project area, summarized by fifth-level watershed.


## Summary

Riparian forests and shrublands are sparsely and unevenly distributed throughout the Wyoming Basin and represent only 2 percent of the total area. Except in some portions of the Great Divide Basin, most watersheds have some riparian vegetation present. Most watersheds, particularly at lower elevations, have been negatively affected by development, most commonly by agriculture, energy, and dams. Private lands account for almost half of the total riparian area, and are experiencing higher development pressure from the presence of roads, dams, industry, energy, and agriculture. Russian olive and tamarisk are present in many northern and some southern watersheds, but data on invasive species are quite limited regionwide. Invasive species surveys may be useful in watersheds where Bureau of land Management occurrence data are lacking, LANDFIRE indicates that invasives species are present, and the conditions conducive to invasive species occurrence are present. Moderately sized and connected riparian areas and large but isolated high-density riparian areas in the Wyoming Basin may provide important refugia and stopover habitat for animals dispersing or migrating across expanses of sagebrush and desert shrubland.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of riparian areas, summarized by fifth-level watershed.

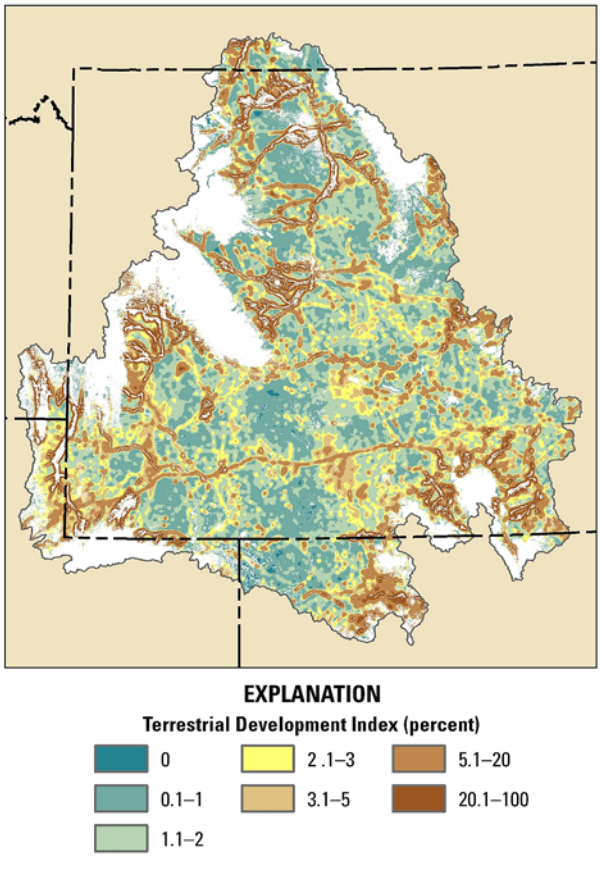
# Sagebrush Steppe

## Management Questions

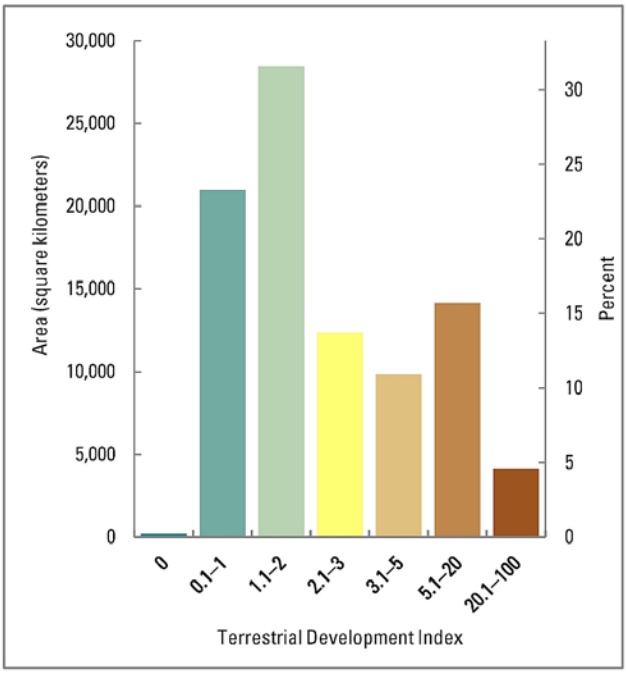
- Where is baseline sagebrush steppe, and what is the total area?
- Where does development pose the greatest threat to baseline sagebrush steppe, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline sagebrush steppe, and where are the large, relatively undeveloped patches?
- How has development affected the structural connectivity of sagebrush steppe relative to baseline conditions? (Top left map following page)
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped sagebrush steppe patches?
- Where are sagebrush-juniper ecotones with potential for juniper expansion?

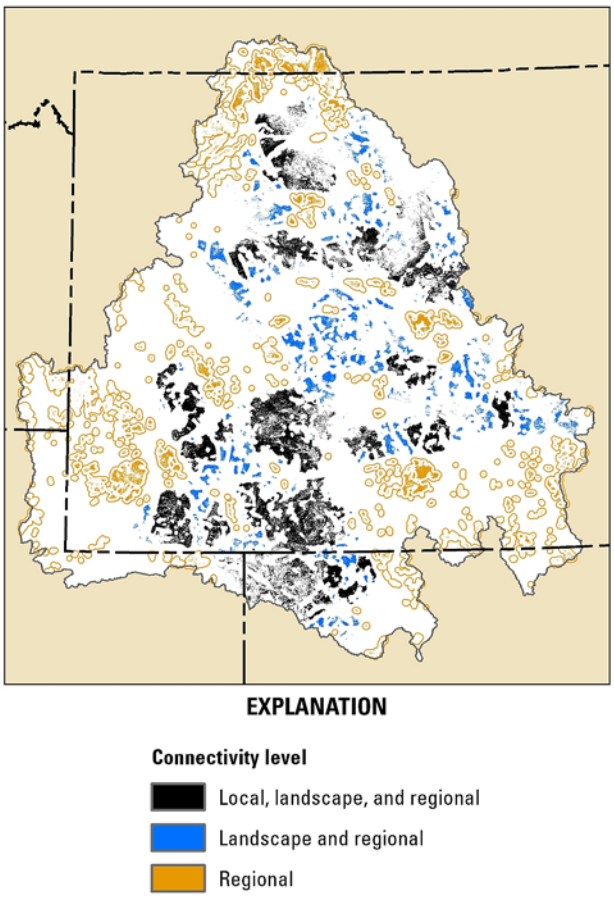
Photo credit: Cameron Aldridge, Colorado State University.

- Where have recent fires occurred in baseline sagebrush steppe, and what is the total area burned per year?
- What is the potential distribution of sagebrush steppe in 2030?
- How does risk from development vary by land ownership or jurisdiction for sagebrush steppe?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for sagebrush steppe in the Wyoming Basin Rapid Ecoregional Assessment project area.



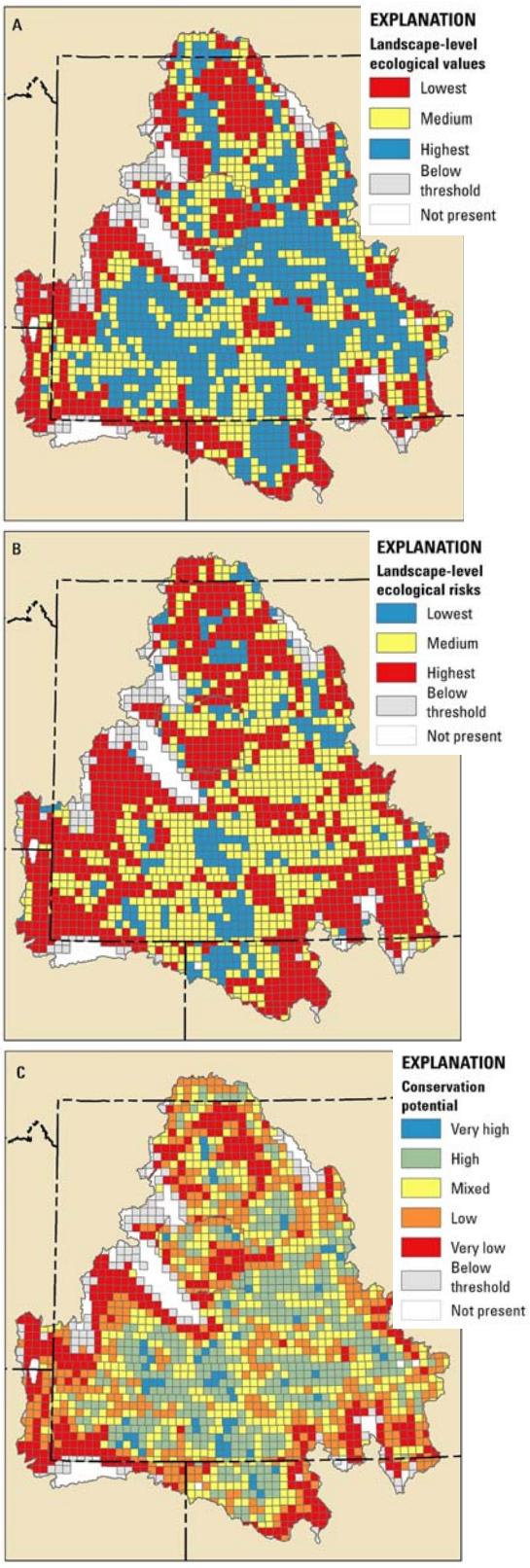



Structural connectivity of relatively undeveloped patches of sagebrush steppe in the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

Sagebrush steppe is widely distributed in the Wyoming Basin and accounts for approximately 53 percent of the land area. Development is pervasive, and only 23 percent of sagebrush steppe is relatively undeveloped. Development (including roads, energy, and agriculture) has fragmented and decreased structural connectivity. Much of the remaining relatively undeveloped sagebrush steppe occurs in scattered patches, most of which are <1,000 square kilometers (386 square miles); only two patches of relatively undeveloped steppe >1,000 square kilometers (386 square miles) remain, representing <4 percent of the total area.

Data limitations make it difficult to evaluate decades- to centuries-long regional patterns of sagebrush steppe dynamics. Juniper woodland expansion into steppe does not appear to be a region-wide problem. Since 1990, relatively little sagebrush steppe has burned in the Wyoming Basin; recent fires appear consistent with historical fire pattern frequency and size. If cheatgrass becomes more common, however, fire could pose a much greater threat. At current development rates, particularly for energy development, sagebrush steppe is expected to experience further fragmentation, loss, and degradation. Potential invasive species risk and projected climate change could further compound these problems.

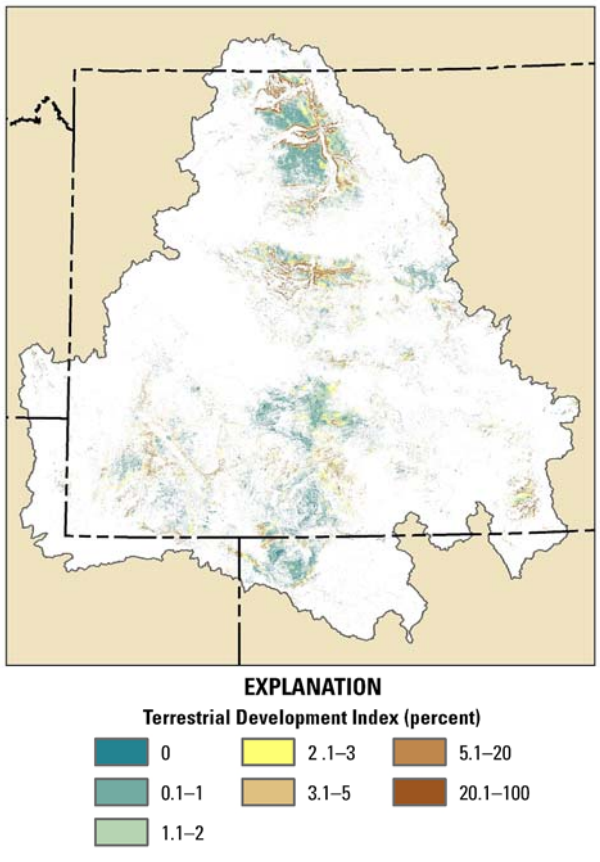

(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of sagebrush steppe summarized by township.

# Desert Shrublands

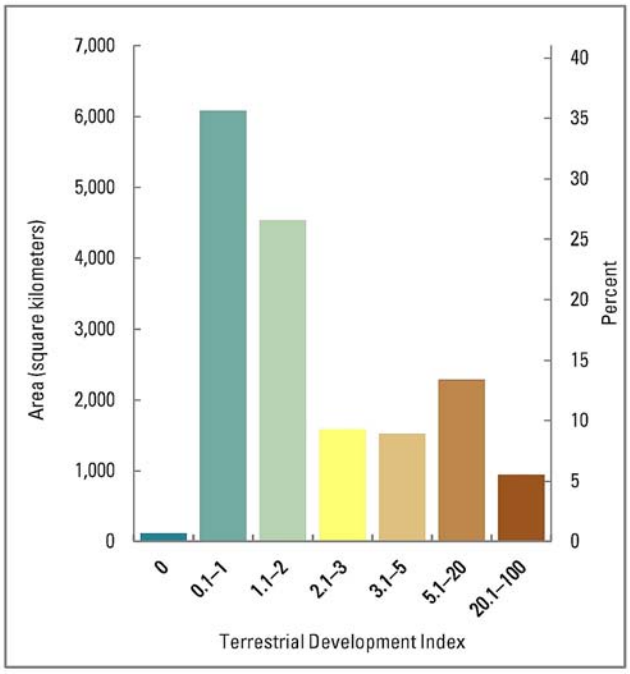
Photo credit: Natasha B. Carr, U.S. Geological Survey.

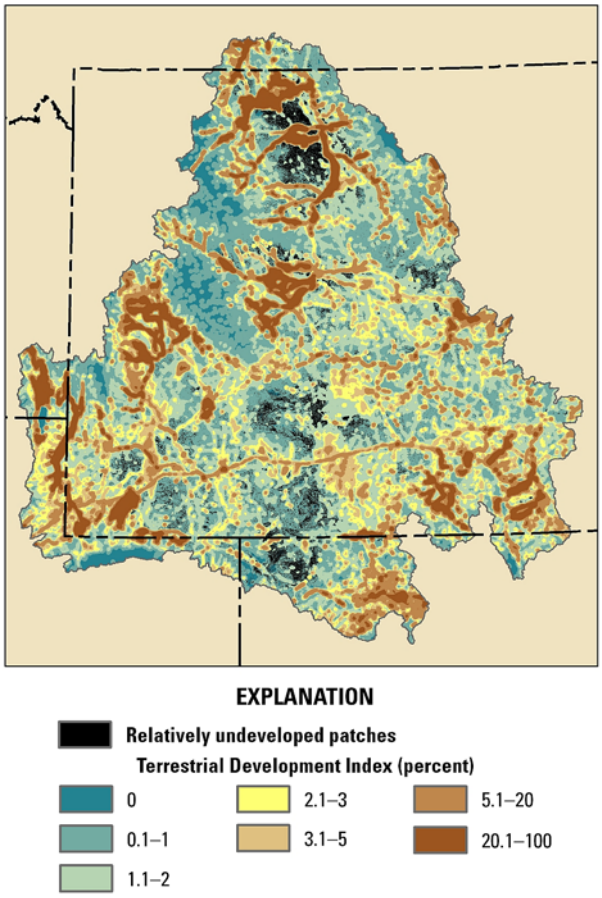
## Management Questions

- Where are baseline desert shrublands, and what is the total area?
- Where does development pose the greatest threat to baseline desert shrublands, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline desert shrublands, and where are the large, relatively undeveloped patches?
- How has development affected structural connectivity of desert shrublands relative to baseline conditions?
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped desert shrubland patches? (Top left map following page)
- Where have recent fires occurred in baseline desert shrublands, and what is the total area burned per year?
- What is the potential distribution of desert shrublands in 2030?
- How does risk from development vary by land ownership or jurisdiction for desert shrublands?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for desert shrublands in the Wyoming Basin Rapid Ecoregional Assessment project area.

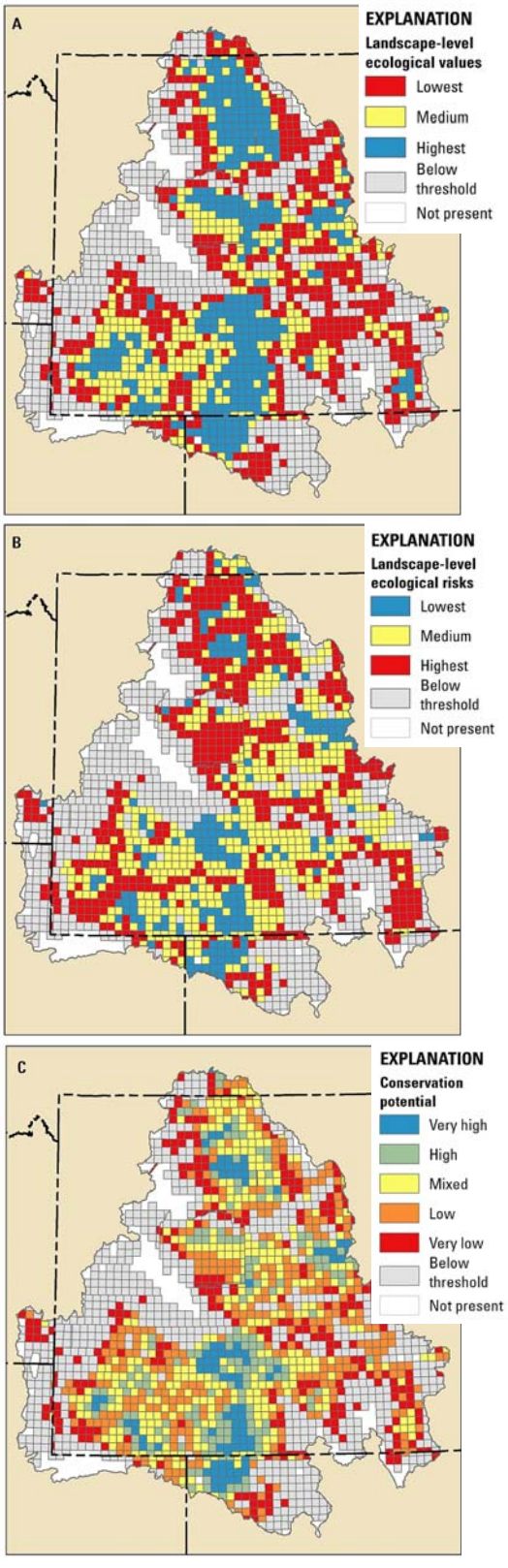





Terrestrial Development Index (TDI) Scores for lands surrounding relatively undeveloped desert shrublands. Higher TDI scores (for example, >5 percent) represent potential movement barriers among relatively undeveloped patches. Lower TDI scores (<2 percent) represent potential movement corridors.


## Summary

Desert shrublands are widely distributed in the Wyoming Basin but cover only about 10 percent of the land area. Development is pervasive across desert shrublands and has increased fragmentation and decreased structural connectivity. Development is highly clustered in desert shrublands, and 36 percent of the desert shrublands are relatively undeveloped. Many relatively undeveloped areas fall under Bureau of Land Management jurisdiction. Species of management concern, such as mountain plover, are strongly tied to sparsely vegetated habitats prevalent in desert shrublands. Vulnerability to climate scenarios evaluated here is expected to be low because desert shrublands are more tolerant of decreasing precipitation and increasing temperatures than sagebrush steppe.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of desert shrublands summarized by township.

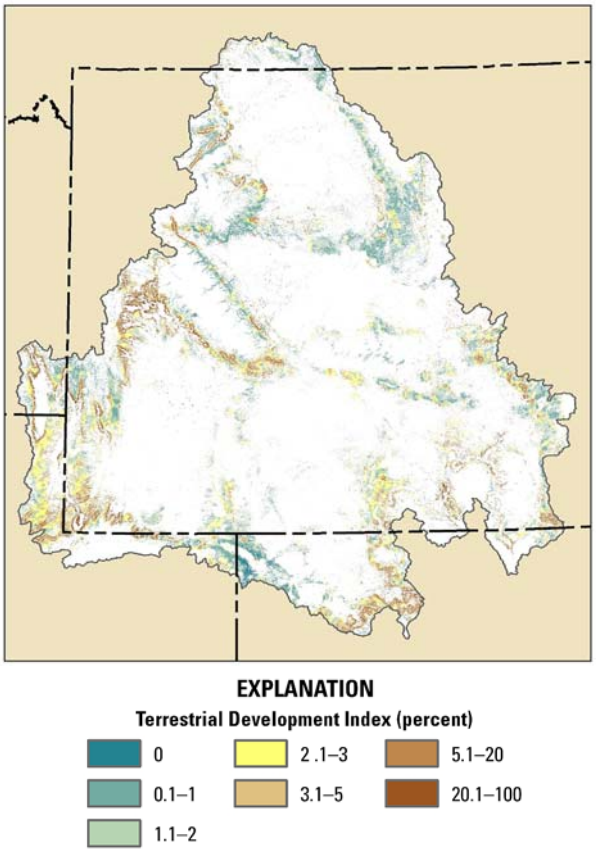
# Foothill Shrublands and Woodlands

## Management Questions

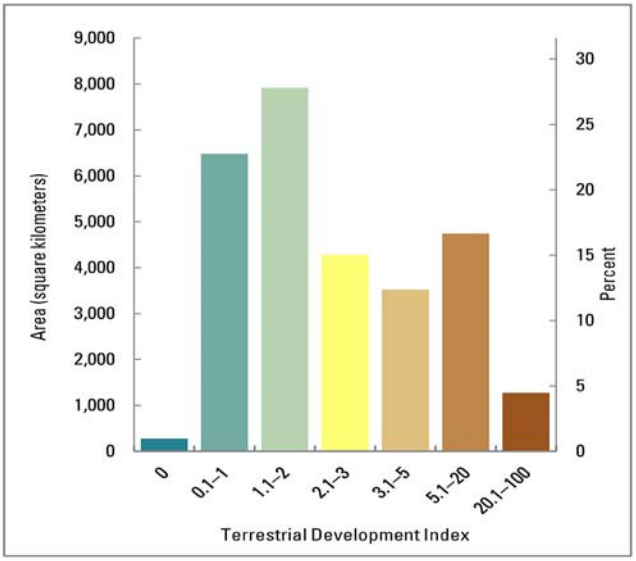
- Where are baseline foothill shrublands and woodlands, and what is the total area?
- Where does development pose the greatest threat to baseline foothill shrublands and woodlands, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline foothill shrublands and woodlands, and where are the large, relatively undeveloped patches? (Top left map following page)
- How has development affected structural connectivity of foothill shrublands and woodlands relative to baseline conditions?

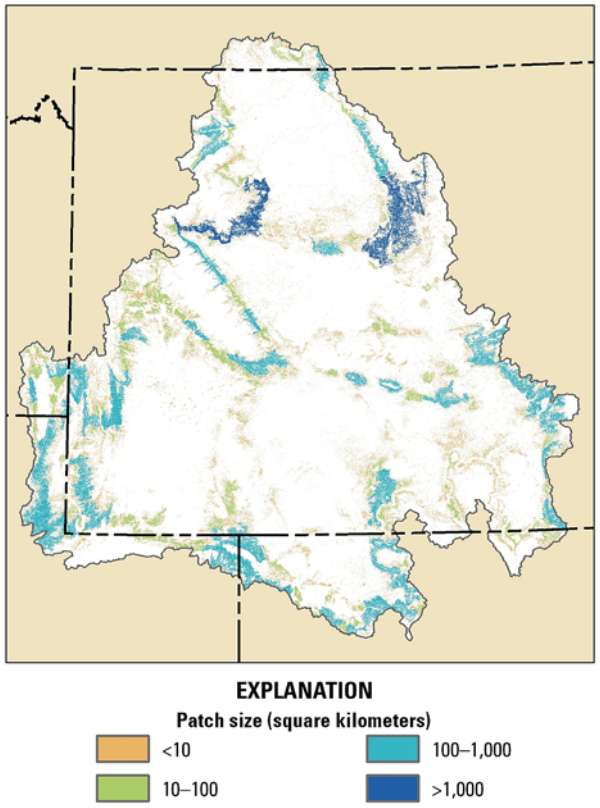
Photo credit: Natasha B. Carr, U.S. Geological Survey.

- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped foothill shrubland and woodland patches?
- Where have recent fires occurred in baseline foothill shrublands and woodlands, and what is the total area burned per year?
- What is the potential distribution of foothill shrublands and woodlands in 2030?
- How does risk from development vary by land ownership or jurisdiction for foothill shrublands and woodlands?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for baseline foothill shrublands and woodlands in the Wyoming Basin Rapid Ecoregional Assessment project area.

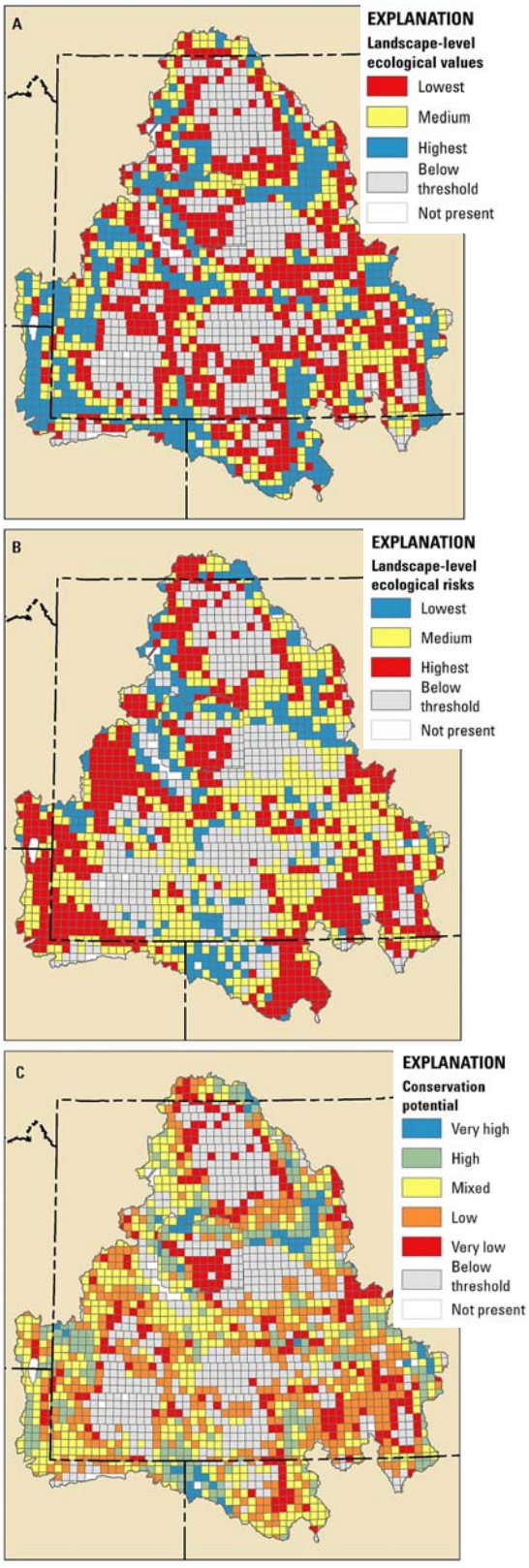





Patch sizes of baseline foothill shrublands and woodlands for the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

Foothill shrublands and woodlands are associated with lower elevations of all of the mountain ranges in the Basin and account for 16 percent of the Wyoming Basin. Development is pervasive, as 27 percent of the foothill shrublands and woodlands remain relatively undeveloped. Much of the foothill areas that remain relatively undeveloped occur in scattered patches, all of which are <1,000 square kilometers (386 square miles). Foothill shrublands and woodlands were once well connected within the Basin, but development (including roads, energy, and agriculture) has fragmented and decreased structural connectivity. Based on current rates of development, particularly energy development, foothill shrublands and woodlands are expected to undergo further fragmentation, loss, and degradation. This ecological community provides crucial winter range for mule deer and habitat for sagebrush obligate species, including greater sage-grouse, sagebrush-obligate songbirds, and pygmy rabbits; thus, the high development rates can affect numerous species. Other foothill species, including aspen, juniper woodlands, and limber pine (five-needle pine assemblage), also face threats (including sudden aspen decline and white pine blister rust), which could alter the structure and functions of the ecological community. The potential risk from invasive plant species, such as cheatgrass, could further compound these problems.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of foothill shrublands and woodlands summarized by township

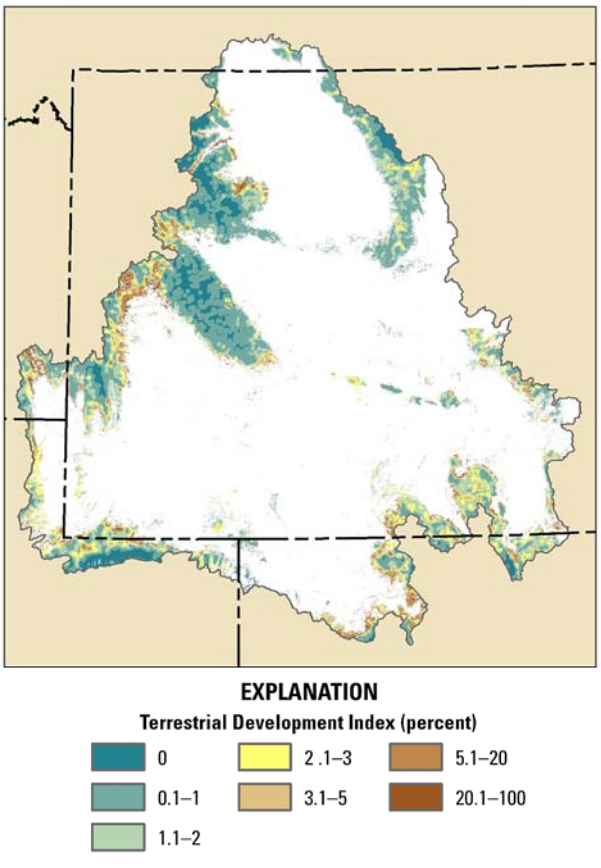
# Montane and Subalpine Forests and Alpine Zones

## Management Questions

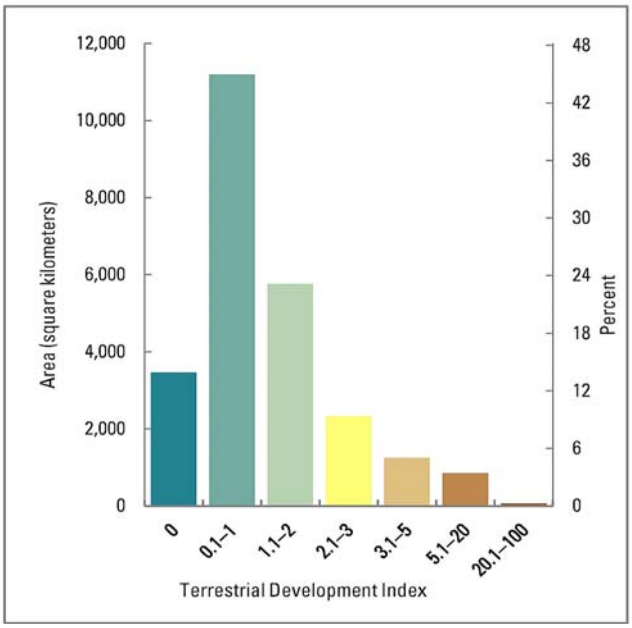
- Where are baseline mountain forests and alpine zones, and what is the total area?
- Where does development pose the greatest threat to baseline mountain forests and alpine zones, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline mountain forests and alpine zones, and where are the large, relatively undeveloped patches?
- How has development affected structural connectivity of mountain forests and alpine zones relative to baseline conditions?
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped patches of mountain forests and alpine zones?

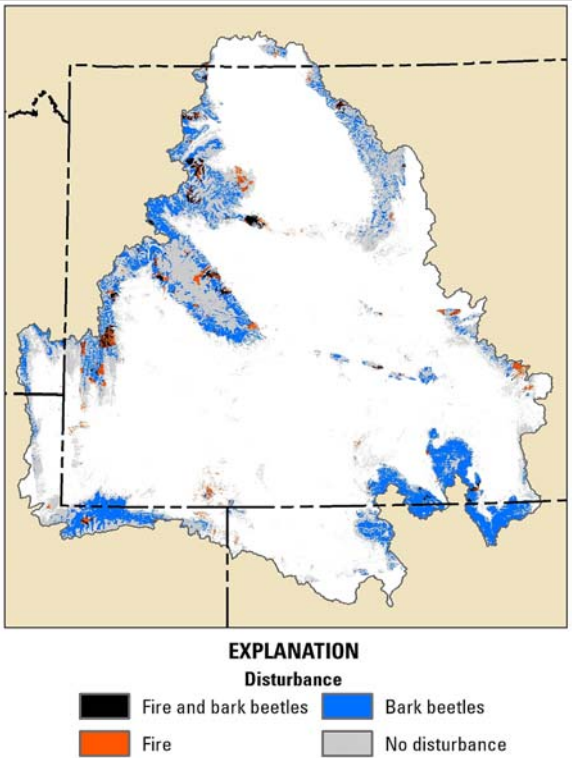
Photo credit: Natasha B. Carr, U.S. Geological Survey.

- Where have mountain forests been disturbed by recent fires and bark beetle outbreaks, and what is the total area of forest affected by each disturbance? (Top left map following page)
- What are the potential distributions of mountain forests and alpine zones in 2030?
- How does risk from development vary by land ownership or jurisdiction for mountain forests and alpine zones?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for montane and subalpine forests and alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area.



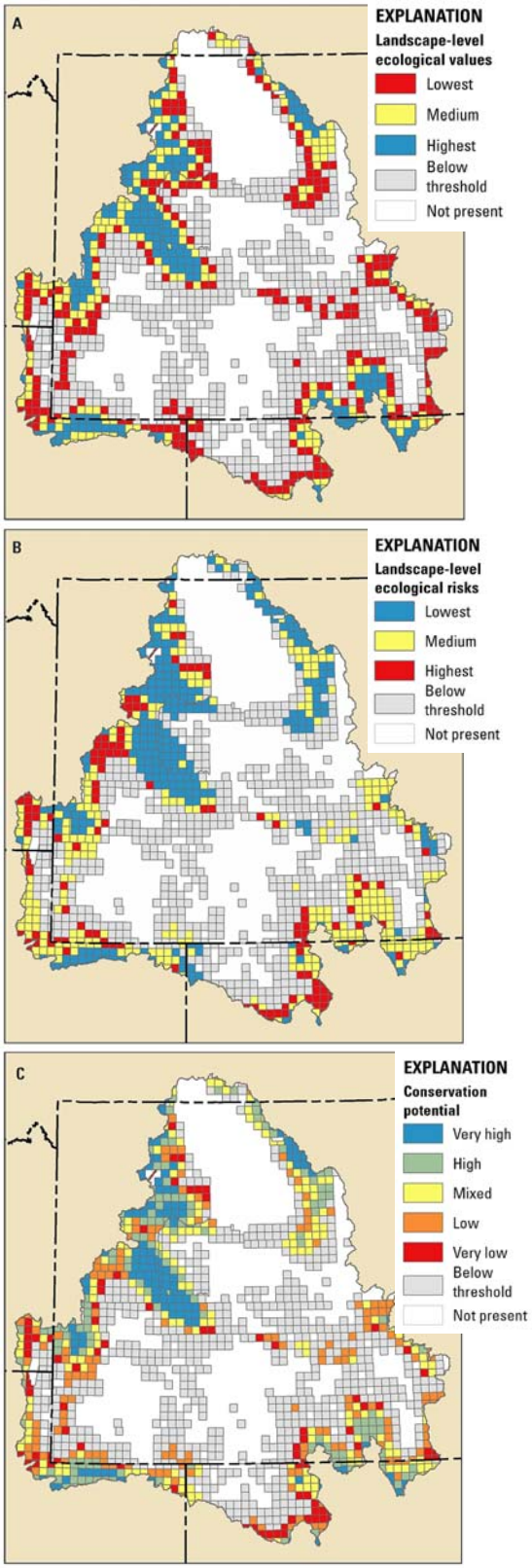



Locations of prescribed burns and wildfires (since 1980) and bark beetle outbreaks (since 1997) in montane and subalpine forests and alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

Mountain forests and alpine zones are patchily distributed and cover about 14 percent of the Wyoming Basin. This is the least developed ecological community, as only 4 percent has a Terrestrial Development Index (TDI) score of >5 percent. Development (roads, energy, and agriculture) has fragmented and decreased structural connectivity. All relatively undeveloped areas (TDI ≤1 percent) occur in patches <5,000 square kilometers (1,930 square miles). Patches are naturally discontinuous, but development has reduced structural connectivity, especially at lower elevations. Relatively undeveloped patches that are highly connected are associated with large mountain ranges. Some relatively undeveloped areas occur in locally isolated mountain ranges.

Recent bark beetle outbreaks have affected nearly half of the mountain forest community. The isolated nature of some forests and time required for some tree species to reach sexual maturity could result in long recovery times. Wildlife species that depend on or have mutualistic relationships with tree species in these habitats could be negatively affected. The distribution of bioclimatic conditions conducive for mountain forests is projected to shift upslope in most mountain ranges and become nearly absent in the Granite Mountains by 2030. Alpine conditions are projected to contract by 2030.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of montane forests and alpine zones summarized by township.

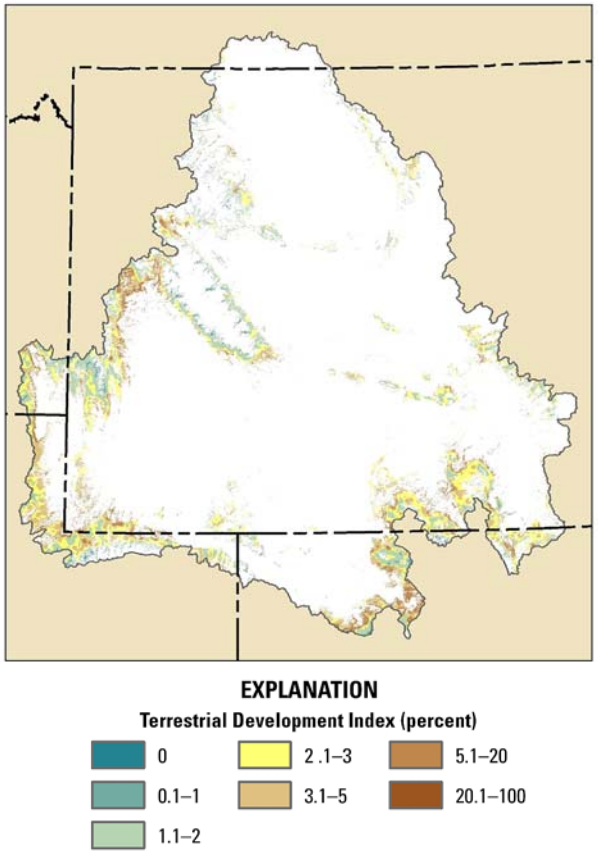
# Aspen Forests and Woodlands

## Management Questions

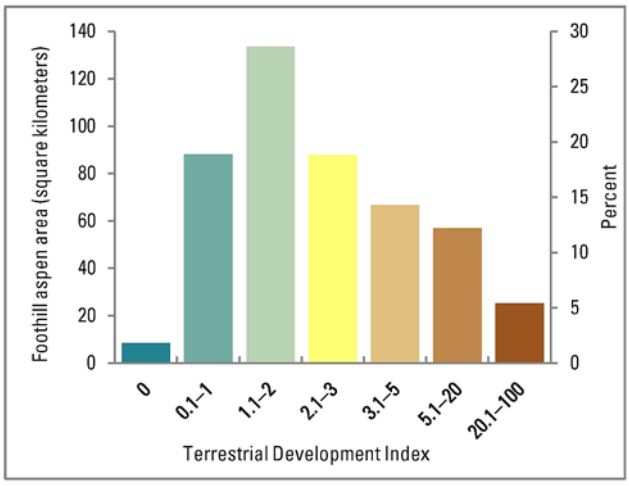
- Where are the two baseline aspen functional types (mountain slope and foothill), and what is the total area of each?
- Where does development pose the greatest threat to baseline aspen, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline aspen, and where are the large, relatively undeveloped patches?
- Where are aspen core areas, and how is core area affected by the presence of roads and railroads?
- Where are baseline aspen stands with high levels of structural connectivity, and which stands function as stepping stones?
- Where are potential barriers and corridors that may affect animal movements among baseline aspen patches?

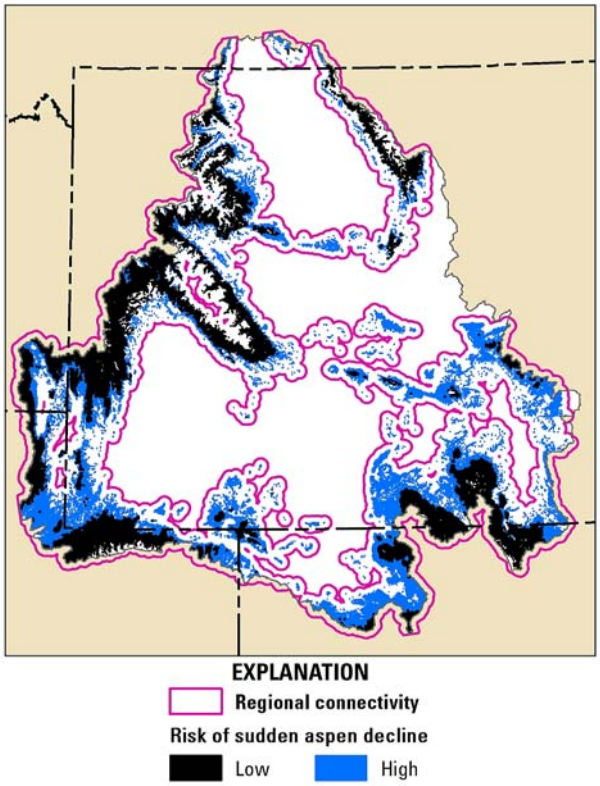
Photo credit: Natasha B. Carr, U.S. Geological Survey.

- Where does aspen have a greater vulnerability to sudden aspen decline based on climatic risk factors, and how would the loss of these stands affect the structural connectivity of aspen? (Top left map following page)
- Where are mountain slope aspen-conifer ecotones with potential for conifer or aspen expansion, and which aspen stands may undergo competitive release as a result of recent disturbances?
- What is the potential distribution of aspen in 2030?
- How does risk from development vary by land ownership or jurisdiction for mountain slope and foothill aspen?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for aspen forests and woodlands in the Wyoming Basin Rapid Ecoregional Assessment project area.



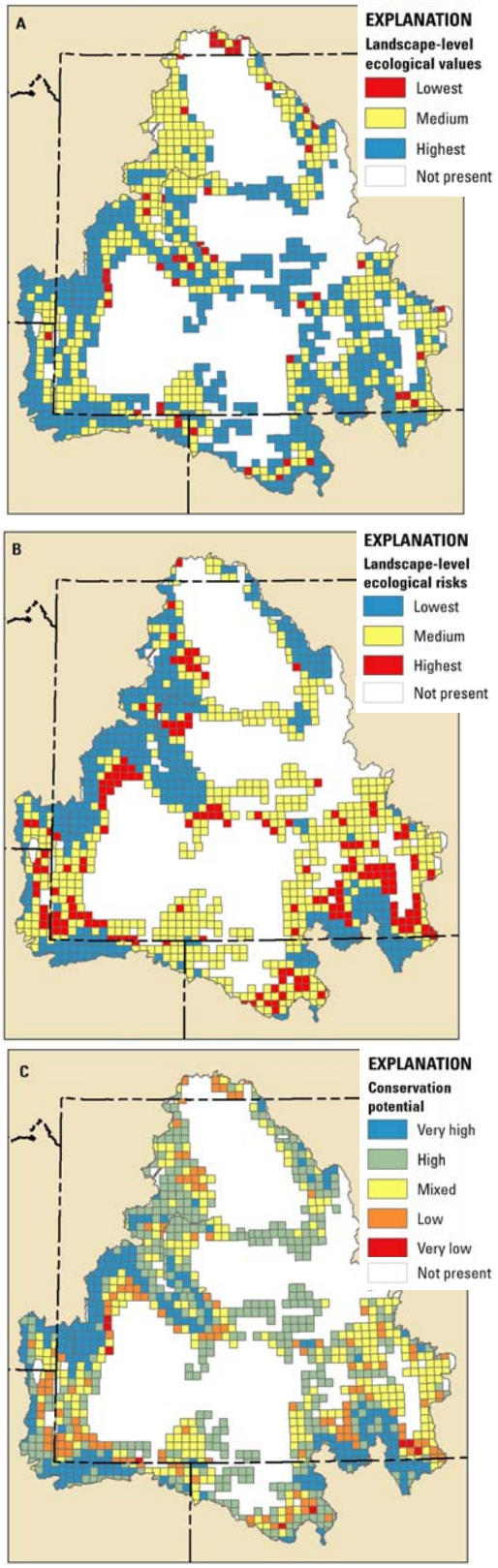



The risk for sudden aspen decline in relation to regional connectivity of baseline aspen forests and woodlands in the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

Most aspen in the Wyoming Basin Rapid Ecoregional Assessment project area occurs along the periphery, with 10 percent occurring in the ecoregion proper. Most aspen is classified as mountain slope and only 10 percent is classified as foothill aspen. Over 66 percent of mountain slope aspen is currently managed by Federal and state agencies, including the largest relatively undeveloped areas. Only 42 percent of foothill aspen is currently managed by Federal and state agencies. Most of the federally managed foothill aspen falls under Bureau of Land Management jurisdiction; most of the federally managed mountain slope aspen is under U.S. Department of Agriculture Forest Service jurisdiction.

Foothill aspen is more vulnerable to Change Agents than mountain slope aspen. The cumulative effects of development, herbivory along natural or artificial (road) edges, potential for sudden aspen decline, and projected climate changes are expected to have greater impacts on foothill aspen due to the drier and hotter setting, smaller patch size, lower connectivity, and greater levels of development in proximity to foothill aspen compared to mountain slope aspen. Mountain slope aspen is currently relatively secure and may not require active management to maintain it on the landscape. However, foothill aspen represents significant management challenges because fire is not required for stand maintenance.

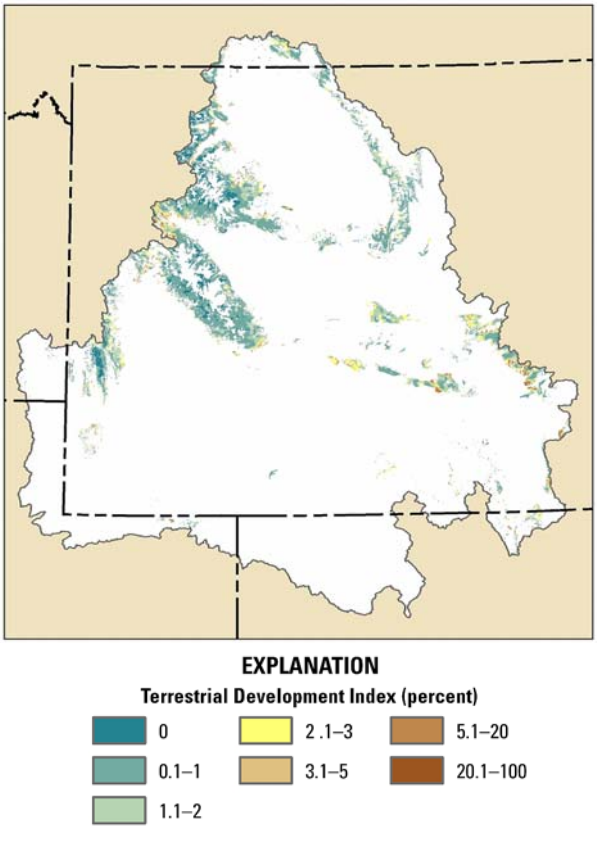

(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of aspen summarized by township.

# Five-Needle Pine Forests and Woodlands

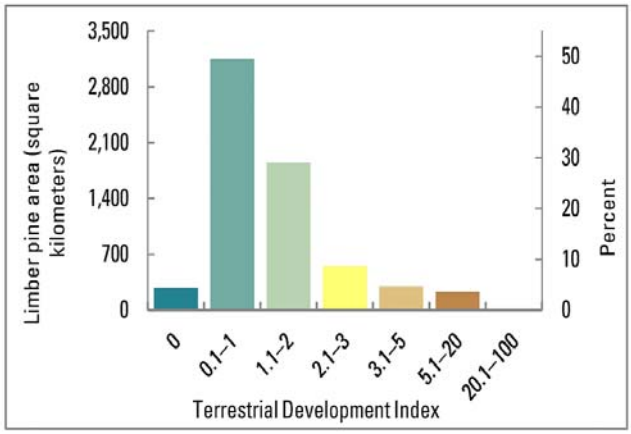
Photo credit: Natasha B. Carr, U.S. Geological Survey

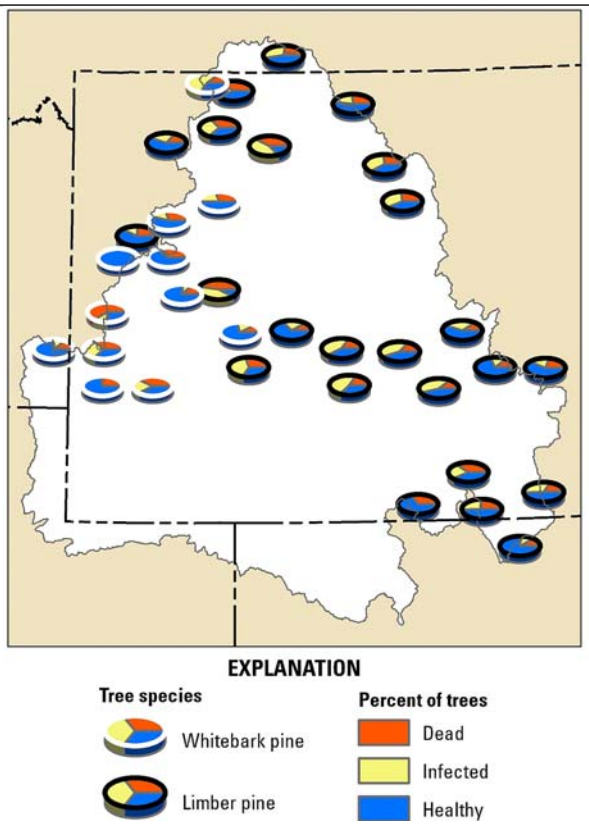
## Management Questions

- Where are the baseline five-needle pine species (whitebark and limber pine), and what is the total area of each?
- Where does development pose the greatest threat to baseline five-needle pine forests and woodlands, and where are the relatively undeveloped stands? (Left map below)
- How has development fragmented baseline five-needle pine forests and woodlands, and where are the large, relatively undeveloped patches?
- Where are baseline five-needle pine stands with high structural connectivity and stands that function as stepping stones?
- Where are potential barriers and corridors that may affect animal movements among baseline five-needle-pine patches?
- Where have recent fires and bark beetle outbreaks occurred in baseline five-needle pine stands, and what is the total area affected?
- What limber pine stands in Wyoming and Colorado are at risk for white pine blister rust? (Top left map following page)
- What is the distribution of white pine blister rust infection in five-needle pine stands, and what is the combined mortality from bark beetle infestation? (Top left map following page)
- What is the potential distribution of five-needle pines in 2030?
- How does development risk vary by land ownership for baseline five-needle pine forests and woodlands?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for baseline five-needle pine forests and woodlands in the Wyoming Basin Rapid Ecoregional Assessment project area.



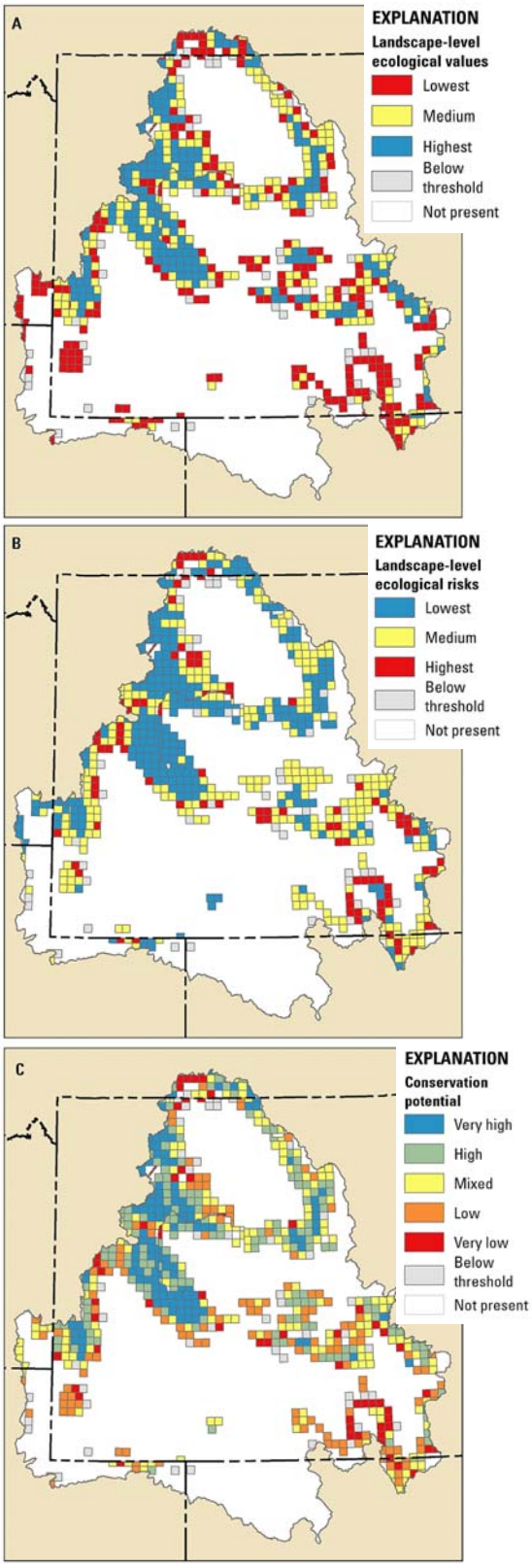



Ratio of healthy, dead, and infected five-needle pine trees. Pie charts represent survey plot averages of data on bark beetles and white pine blister rust for whitebark pine stands in the Greater Yellowstone Ecosystem (Greater Yellowstone Whitebark Pine Monitoring Working Group, 2013) and limber pine stands in Wyoming and Colorado (Cleaver, 2014) .


## Summary

Almost 70 percent of five-needle pine falls within federal jurisdiction; U.S. Department of Agriculture Forest Service lands have the greatest proportion of whitebark pine; Bureau of Land Management lands, the greatest proportion of limber pine. Development poses a limited and localized threat to five-needle pines, which are more common at higher elevations and along steeper rocky slopes where development levels are lowest. High Terrestrial Development Index scores occur in limber pine stands at lower elevations, whereas roads at higher elevations fragment some of the largest whitebark pine stands.

The widespread, virulent nature of white pine blister rust is of concern for the long-term viability of five-needle pines forests. The extent of the recent bark beetle outbreak compounds the risks posed by blister rust. The long time required for five-needle pines to reach sexual maturity and the isolated nature of many stands could delay recovery time following widespread mortality. This could negatively affect Clark's nutcracker and pinyon jay populations, which consume and disperse the seeds, and some grizzly bear populations. Projected changes in the bioclimatic envelope for five-needle pine under some climate scenarios indicate the potential for additional declines over the next 75 years.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of five-needle pine forests and woodlands summarized by township.

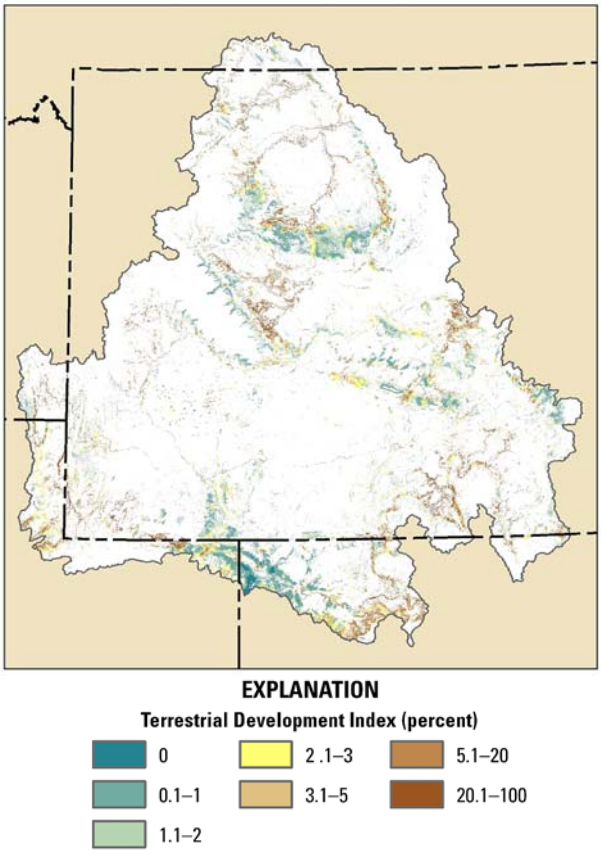
# Juniper Woodlands

## Management Questions

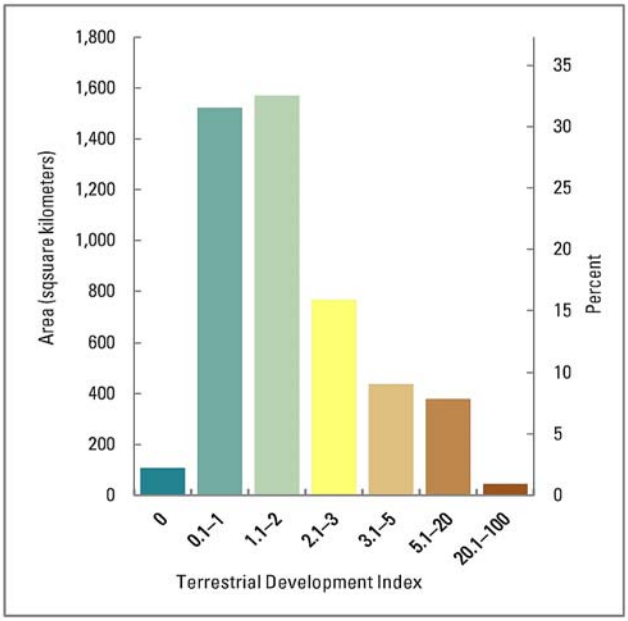
- Where are baseline juniper woodlands, and what is the total area?
- Where does development pose the greatest threat to baseline juniper woodlands, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline juniper woodlands, and where are the large, relatively undeveloped patches?
- Where are baseline juniper woodlands with high structural connectivity, and which woodlands function as stepping stones?
- Where are potential barriers and corridors that may affect animal movements among baseline juniper woodland patches?

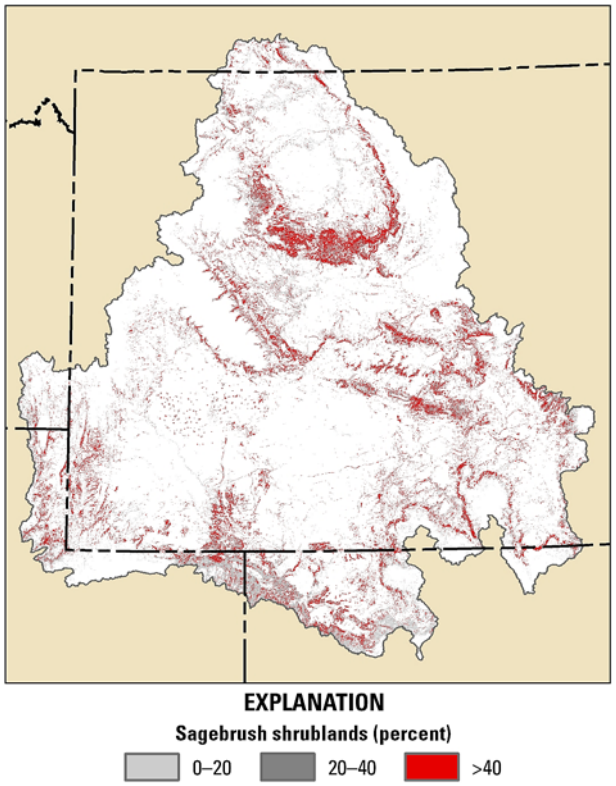
Photo credit: Bureau of Land Management.

- Where are the juniper-sagebrush ecotones with potential for juniper expansion? (Top left map following page)
- Where have recent fires occurred in baseline juniper woodlands, and what is the total area burned per year?
- What is the potential distribution of juniper woodlands in 2030?
- What are the levels of development by land ownership or jurisdiction for baseline juniper woodlands?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for juniper woodlands in the Wyoming Basin Rapid Ecoregional Assessment project area.



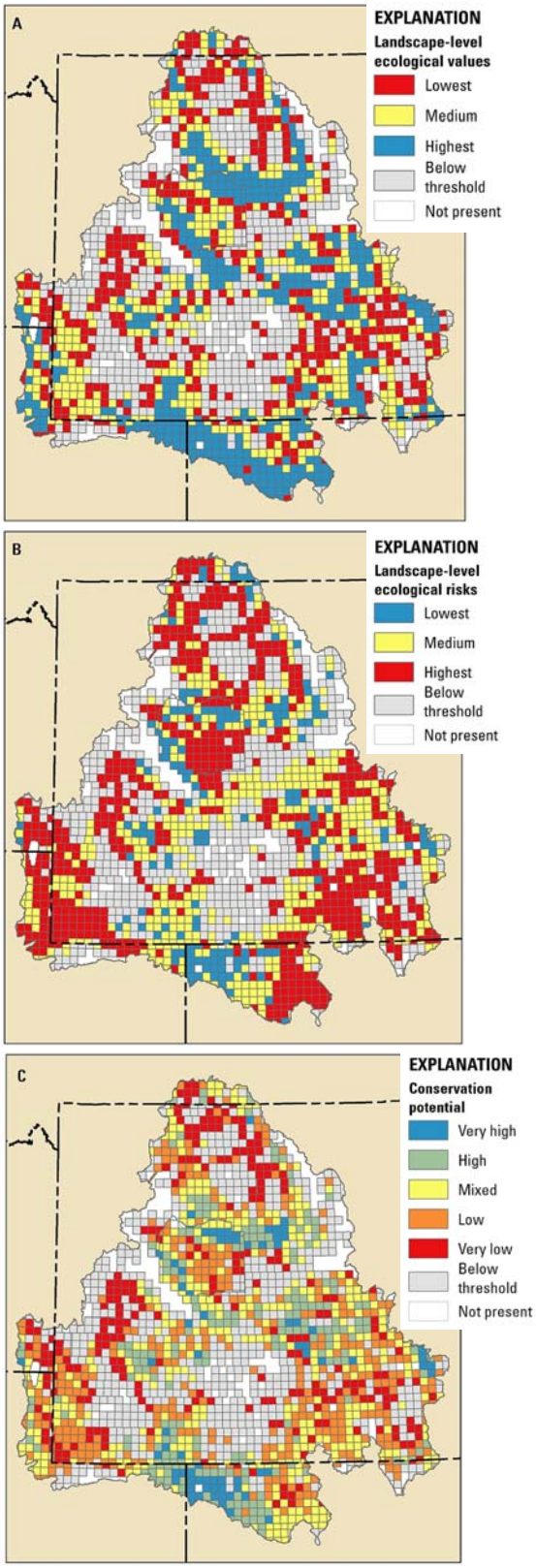



Juniper woodland-sagebrush shrubland ecotones in the Wyoming Basin. Ecotones are indicated by juniper woodlands cells with a higher percent of sagebrush shrublands within 30 meters (98.4 feet) (red).


## Summary

Juniper woodlands occupy a limited area of the Wyoming Basin Rapid Ecoregional project area, but they provide important habitats for many species. Most juniper woodlands are small and widely dispersed. These numerous small patches can function as vital stepping stones connecting larger juniper woodland complexes. Many of the small patches have high levels of development, resulting in decreased structural connectivity among relatively undeveloped complexes, which could pose problems for species that rely on juniper woodlands for food and cover. Almost half of the woodlands are under Bureau of Land Management jurisdiction and have relatively low development scores.

The small size of juniper woodland patches in a matrix of sagebrush shrublands leads to a high proportion of woodland edge. Over decades and centuries, patch edges can expand and contract in response to climate variability and time since fire. The degree to which distribution of juniper woodland is a consequence of fire suppression and grazing or the result of longer term dynamics represents a critical information gap. Fire patterns over the past several decades appear consistent with the historical fire regime with a fire-return interval of several centuries. Fire suppression has not played a major role in juniper woodland expansion.

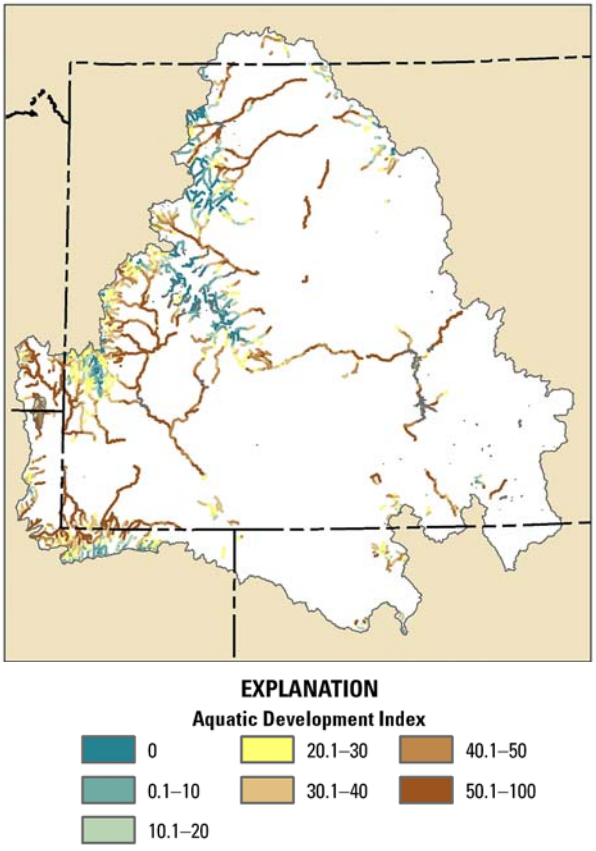

(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of juniper woodlands summarized by township.

# Cutthroat Trout

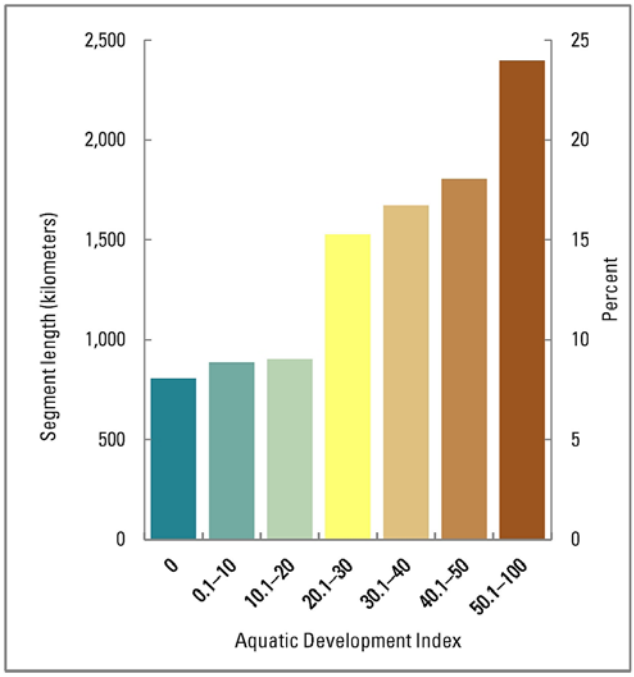
## Management Questions

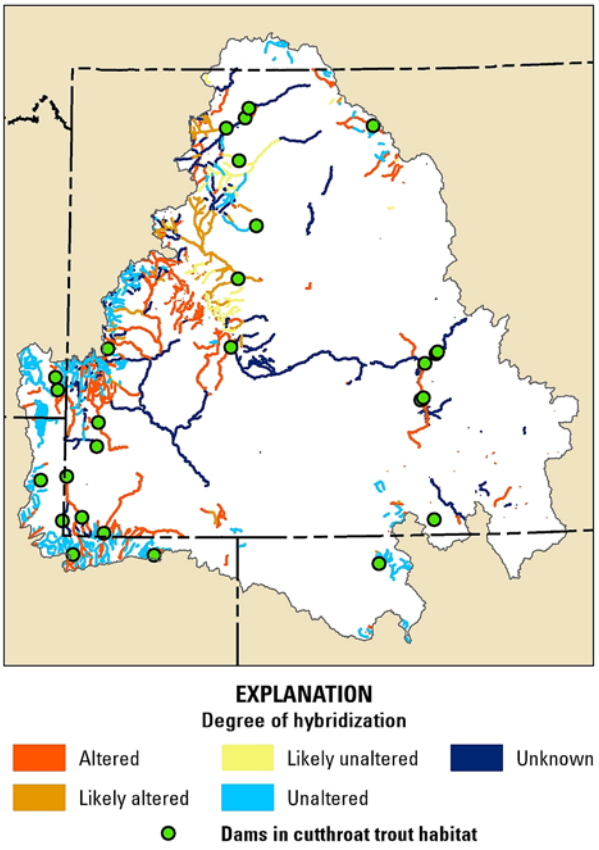
- Where is baseline occupied cutthroat trout habitat, and what is the total amount occupied by native/introduced populations and by each subspecies?
- Where does development pose the greatest threat to baseline cutthroat trout habitat, and where are the large, relatively undeveloped habitats? (Left map below)
- Where do diversions and road crossings pose potential barriers to cutthroat trout movements, and where are watersheds with the highest structural connectivity?
- Where are genetically pure populations of cutthroat trout, and where are populations at risk from hybridization? (Top left map following page)
- Where are cutthroat trout populations at risk of competition and predation by nonnative salmonid species?
- Where are cutthroat trout populations at risk from whirling disease?
- Where are cutthroat trout populations currently at risk from low summer flows?
- Where are cutthroat trout populations at risk from projected shifts in mean summer flow, timing of peak streamflow, and temperature increases in 2040?
- How does risk from development vary by land ownership for cutthroat trout habitat?
- Where are the fifth-level watersheds with the greatest landscape-level ecological values? (Top right map following page)
- Where are the fifth-level watersheds with the greatest landscape-level risks? (Center right map following page)
- Where are the fifth-level watersheds with the greatest conservation potential? (Bottom right map following page)

Photo credit: Carlin Girard, University of Wyoming.




Aquatic Development Index scores for cutthroat trout habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.





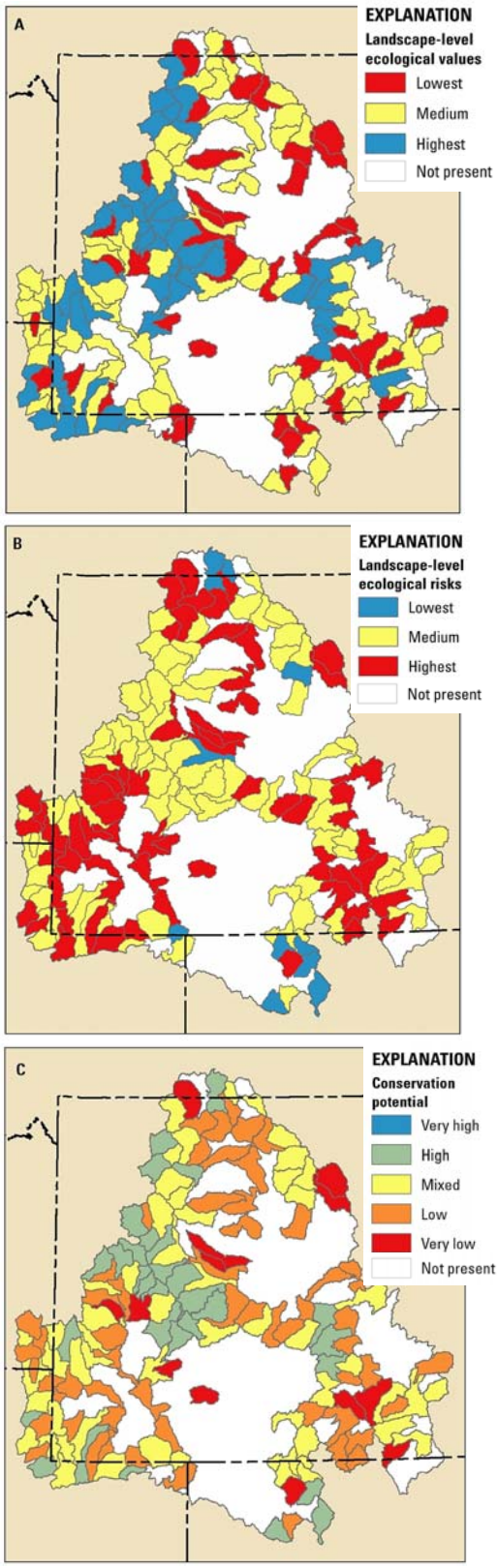

Degree of hybridization of cutthroat trout populations with rainbow trout in the Wyoming Basin Rapid Ecoregional Assessment project area.

## Summary

Cutthroat trout are present primarily in the western portion of the Wyoming Basin Rapid Ecoregional Assessment project area, with the larger native populations occurring in the Greybull, Wind, Bear, Upper Green, and Little Snake River drainages and introduced populations occurring in the North Platte and Lower Green River drainages.

Habitat has been fragmented by dams, especially for mainstem populations. Barriers generally have negative effects, but barriers can isolate genetically pure populations from introduced rainbow trout. Most of the habitat occupied by cutthroat trout is highly developed from roads and agriculture. The Bear and Green River drainages are highly developed although headwaters remain relatively undeveloped. The Bear River drainage has high development scores due to extensive agriculture, many water diversions, and high road density, yet it also has long segments supporting genetically pure native cutthroat trout.

The greatest risk from a projected increase in temperature was in the northeast portion of the Wyoming Basin. Most of the populations in that region, however, were introduced and consequently are of lower conservation concern than native cutthroat trout populations.

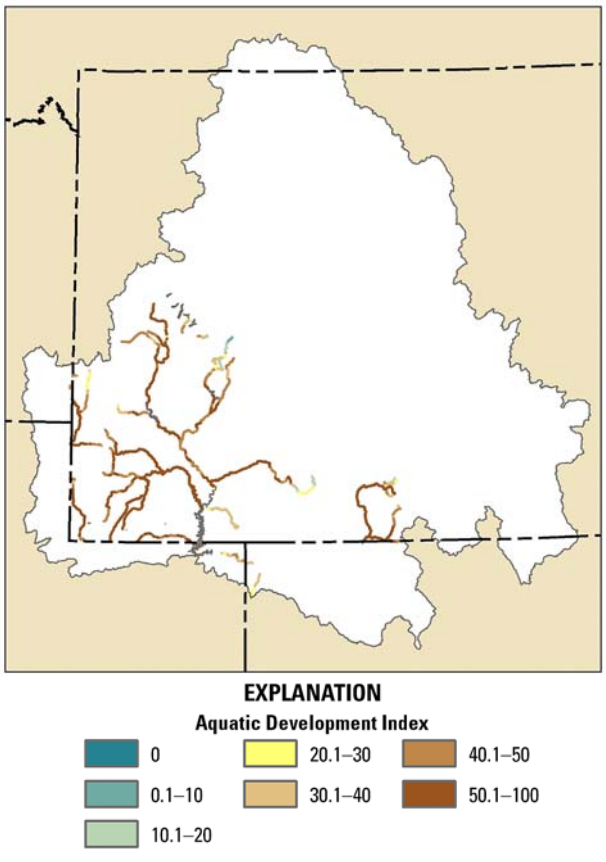



(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of cutthroat trout habitat summarized by fifth-level watershed.

# Three-Species Fish Assemblage:

## Bluehead Sucker
## Flannelmouth Sucker
## Roundtail Chub

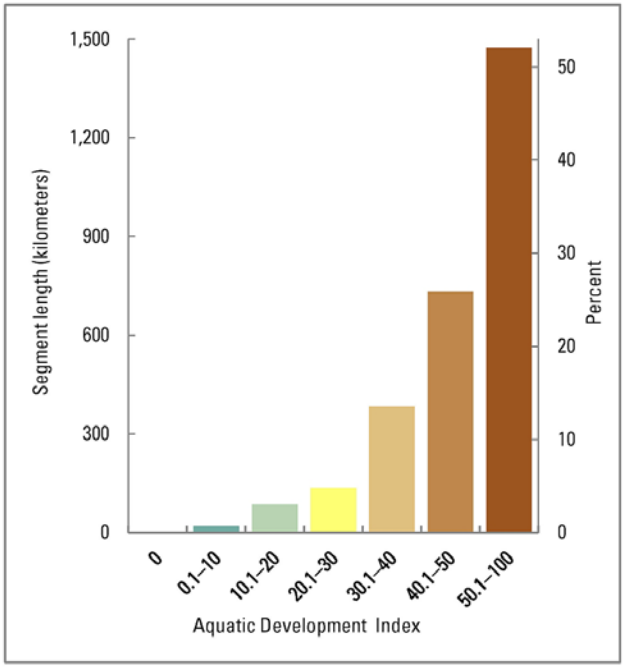
Photo credits: Bluehead sucker, Carlin Girard, University of Wyoming and roundtail chub, Wikimedia, Creative Commons Attribution-Share Alike 4.0.

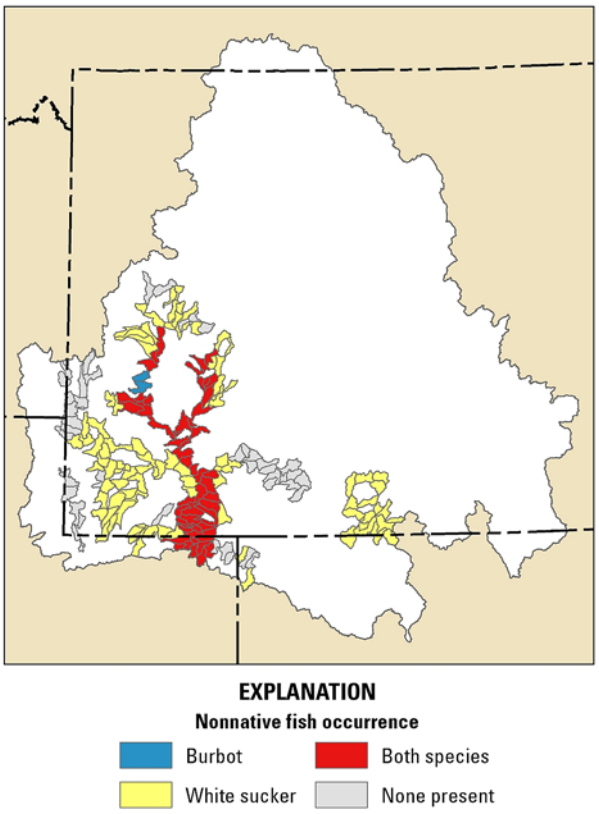



Aquatic Development Index scores for the three-species fish assemblage habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.

## Management Questions

- Where is baseline habitat for the three-species assemblage, and what is the total amount occupied per species?
- Where does development pose the greatest threat to baseline three-species assemblage habitat, and where are the relatively undeveloped habitats? (Left map below)
- Where do dams, diversions, and road crossings pose potential barriers to three-species assemblage movements, and where are watersheds with the highest structural connectivity?
- Where are three-species assemblage populations at risk of hybridization and competition or predation from nonnative species? (Top left map following page)
- Where could three-species assemblage populations be at risk from projected shifts in hydrological regime in 2040?
- How does development risk vary by land ownership or jurisdiction for three-species assemblage habitat?
- Where are the fifth-level watersheds with the greatest landscape-level ecological values? (Top right map following page)
- Where are the fifth-level watersheds with the greatest landscape-level risks? (Center right map following page)
- Where are the fifth-level watersheds with the greatest conservation potential? (Bottom right map following page)



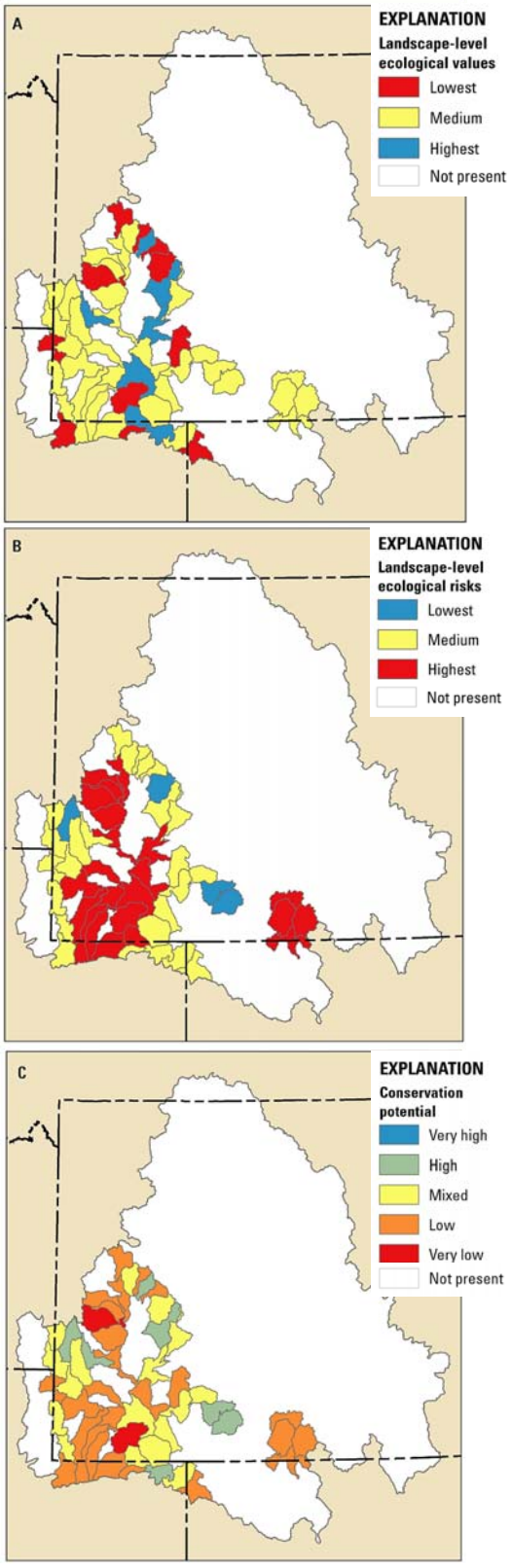



Potential risk from competition, predation, and hybridization based on the co-occurrence of burbot and white sucker with the three-species assemblage in the Wyoming Basin Ecoregional Assessment project area. Burbot is a potential competitor and predator of all three-species, whereas the white sucker can hybridize with both native suckers.


## Summary

The three species that make up the fish assemblage form the foundation of the native fish community of the Colorado River drainage. The distributions of all three species within the Wyoming Basin are limited, and most of the habitat has high levels of development. Relatively undeveloped habitat for the fish assemblage is restricted to short, highly disconnected segments in small creeks and a short portion of the main stem of the Green River. Fragmentation of habitat by dams poses significant threats to the viability of the three species' populations, and water diversions can further increase isolation of remaining populations.

Two introduced fish species, the burbot and white sucker, widely co-occur with the fish assemblage and pose significant risks. Burbot, which are both predators and competitors, are largely limited to the main stems of the Green, New Fork, and Big Sandy Rivers. White suckers broadly overlap the distribution of both bluehead and flannelmouth suckers and have hybridized with both of the native species across much of their range in the Basin.

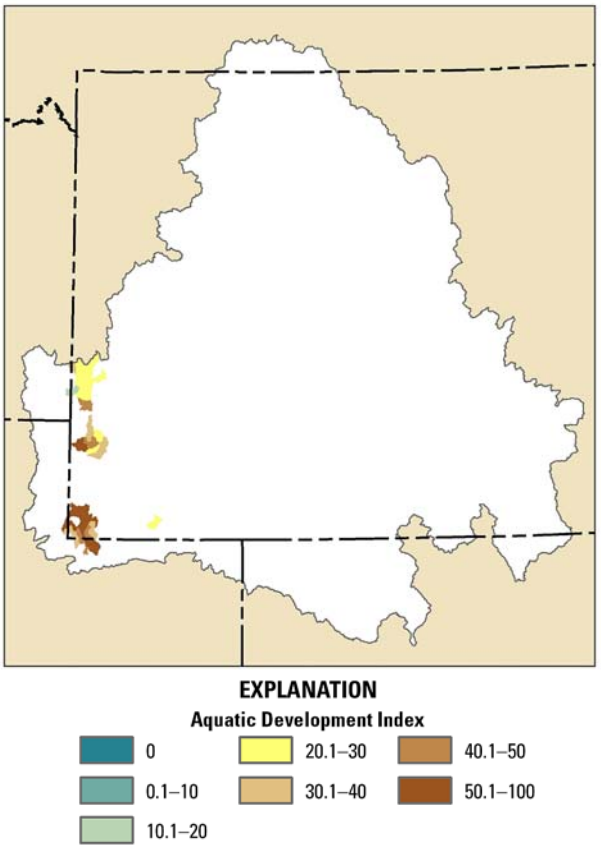

(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of three-species assemblage habitat, summarized by fifth-level watershed.

# Northern Leatherside Chub

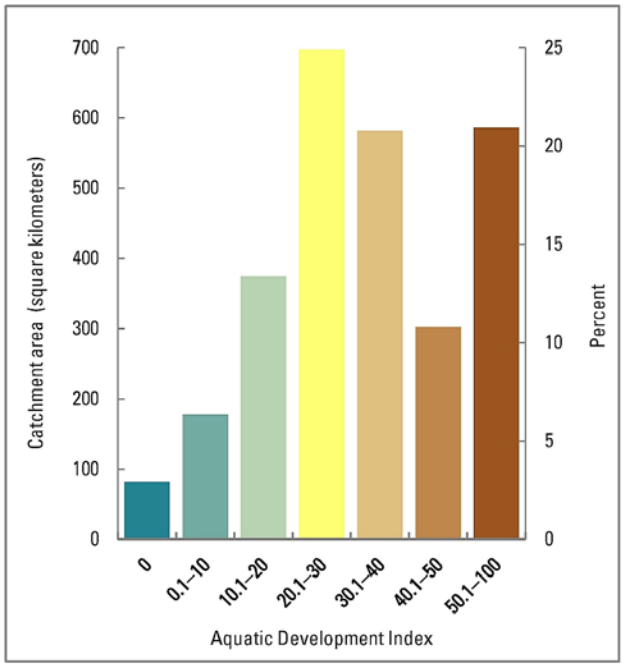
Photo credit: Ester J. Stokes, Wikimedia, public domain.

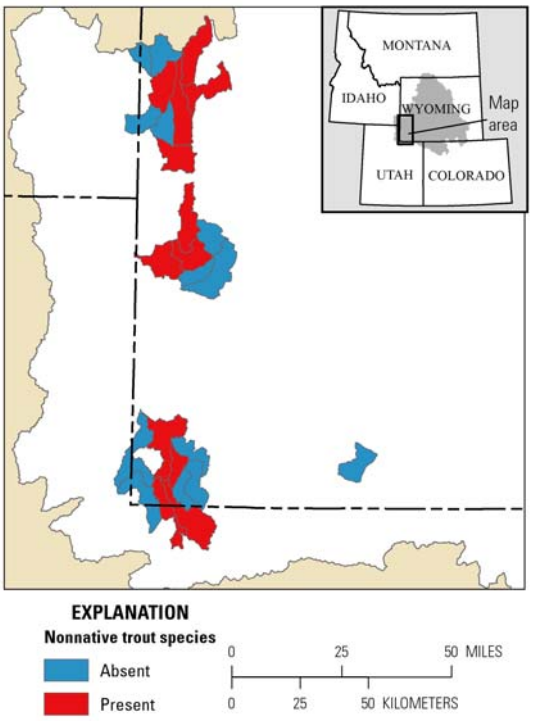
## Management Questions

- Where is baseline occupied northern leatherside chub habitat?
- Where does development pose the greatest threat to northern leatherside chub habitat? (Left map below)
- Where do dams, diversions, and stream-road crossings pose potential barriers to northern leatherside chub movements, and where are watersheds with the highest structural connectivity?
- Where are northern leatherside chub populations at risk of competition and predation by nonnative salmonid species? (Top left map following page)
- How does risk from development vary by land ownership or jurisdiction for northern leatherside chub habitat?
- Where are the fifth-level watersheds with the greatest landscape-level ecological values? (Top right map following page)
- Where are the fifth-level watersheds with the greatest landscape-level risks? (Center right map following page)
- Where are the fifth-level watersheds with the greatest conservation potential? (Bottom right map following page)




Aquatic Development Index scores for fifth-level watersheds that have known occurrences of northern leatherside chubs in the Wyoming Basin Rapid Ecoregional Assessment project area.



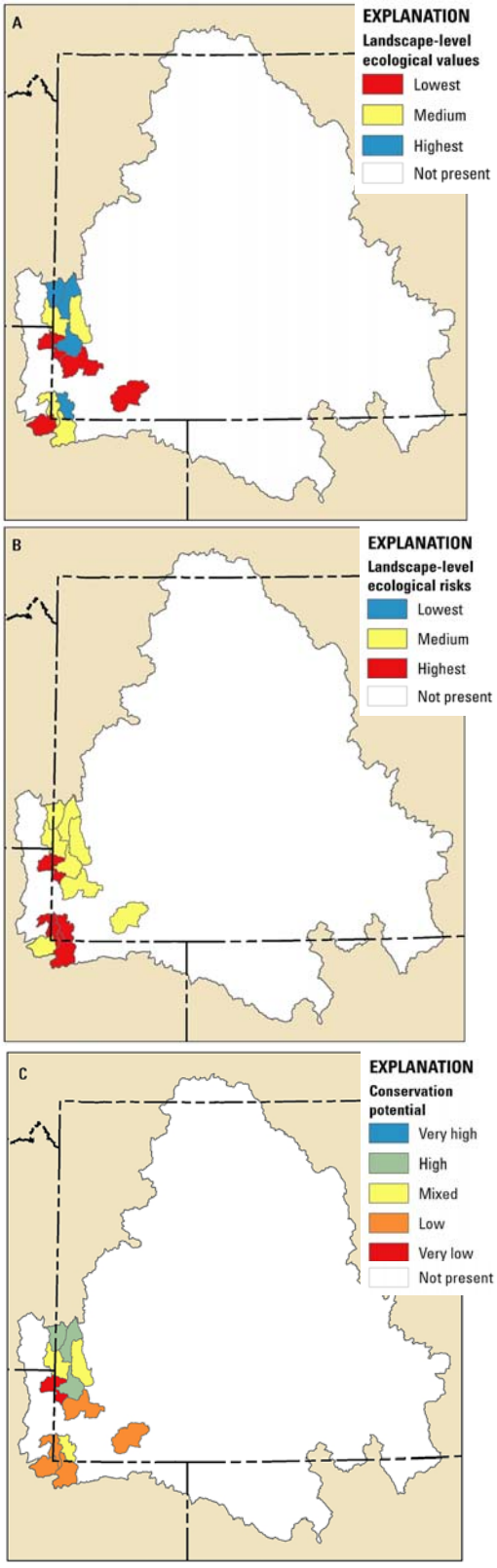



Potential risk of competition and predation to northern leatherside chub in the Wyoming Basin Rapid Ecoregional Assessment project area. Risk is based on the presence of nonnative trout species including brown trout, rainbow trout, and brook trout in sixth-level watersheds.


## Summary

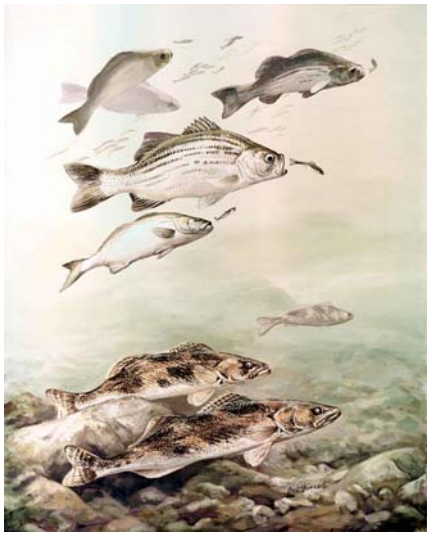
The Wyoming Basin includes most of the extant populations of northern leatherside chub, and these are limited to the far southwestern portion of the Basin, specifically the Bear River drainage, including the mainstem and its major tributaries. A potential introduced population may exist in the Green River drainage. Watersheds occupied by this chub are heavily developed for agricultural use, particularly in the southwestern part of their range where there are more than 200 potential barriers (dams, diversions, road crossings) per watershed. Effects of these barriers likely vary; reservoirs are typically impassible to chub, while road-crossing effects depend on culvert design. Diversions pose a risk by trapping chub in canals once water flow is shut off.

Highest conservation potential areas are in the northern part of the chub's range. This includes healthy populations in Dry Fork Creek, which has low levels of development and occurs largely on public land. The southern range has higher levels of development but supports some of the largest chub populations; the high development levels, low structural connectivity, and private land ownership in these areas present significant management challenges. Wyoming Game and Fish Department classified northern and southern sites as "…crucial to conserving and maintaining populations of terrestrial and aquatic wildlife for the present and future," and "…habitats where enhancement activities can be opportunistically performed."


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of northern leatherside chub habitat summarized by fifth-level watershed.

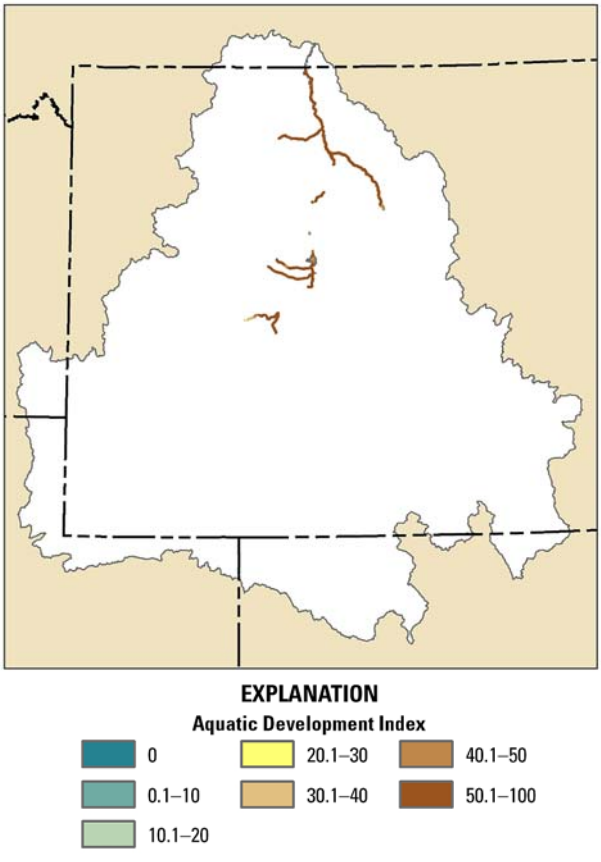
# Sauger



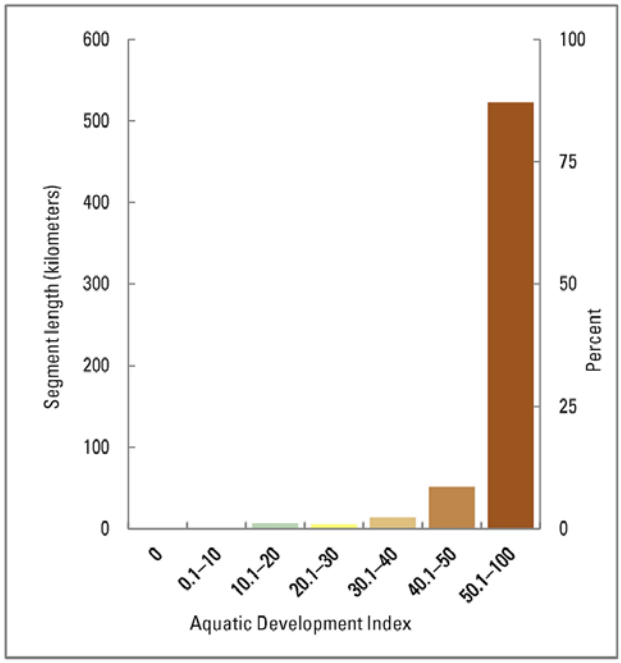
Artwork credit: Robert W. Hines, U.S. Fish and Wildlife Service.

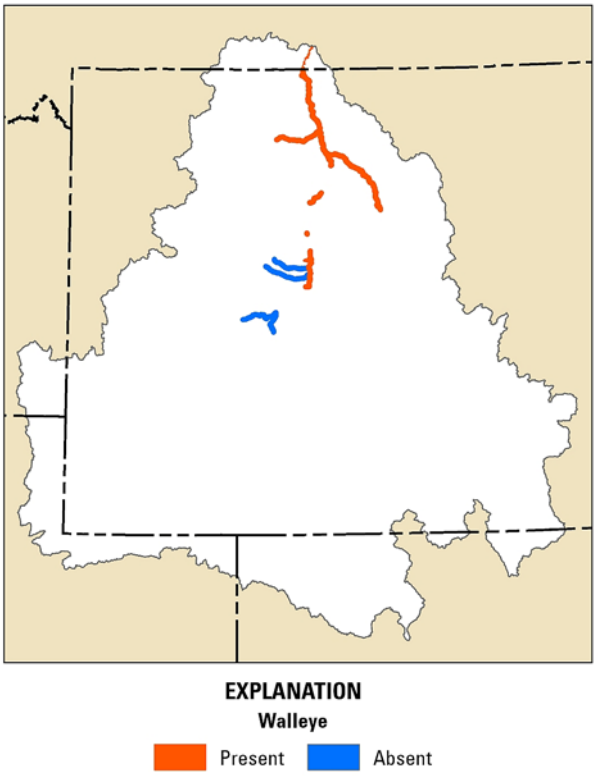
## Management Questions

- Where is baseline sauger habitat, and what is the total area occupied?
- Where does development pose the greatest threat to baseline sauger habitat, and where are the large, relatively undeveloped habitats? (Left map below)
- Where do dams, water diversions, and stream–road crossings pose potential barriers to sauger movements, and where are watersheds with high structural connectivity?
- Where are sauger populations at risk from competition and hybridization with walleye? (Top left map following page)
- Where are sauger populations currently at risk from low summer flows?
- How does risk from development vary by land ownership for sauger habitat?
- Where are the fifth-level watersheds with the greatest landscape-level ecological values? (Top right map following page)
- Where are the fifth-level watersheds with the greatest landscape-level risks? (Center right map following page)
- Where are the fifth-level watersheds with the greatest conservation potential? (Bottom right map following page)




Aquatic Development Index scores for sauger habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.



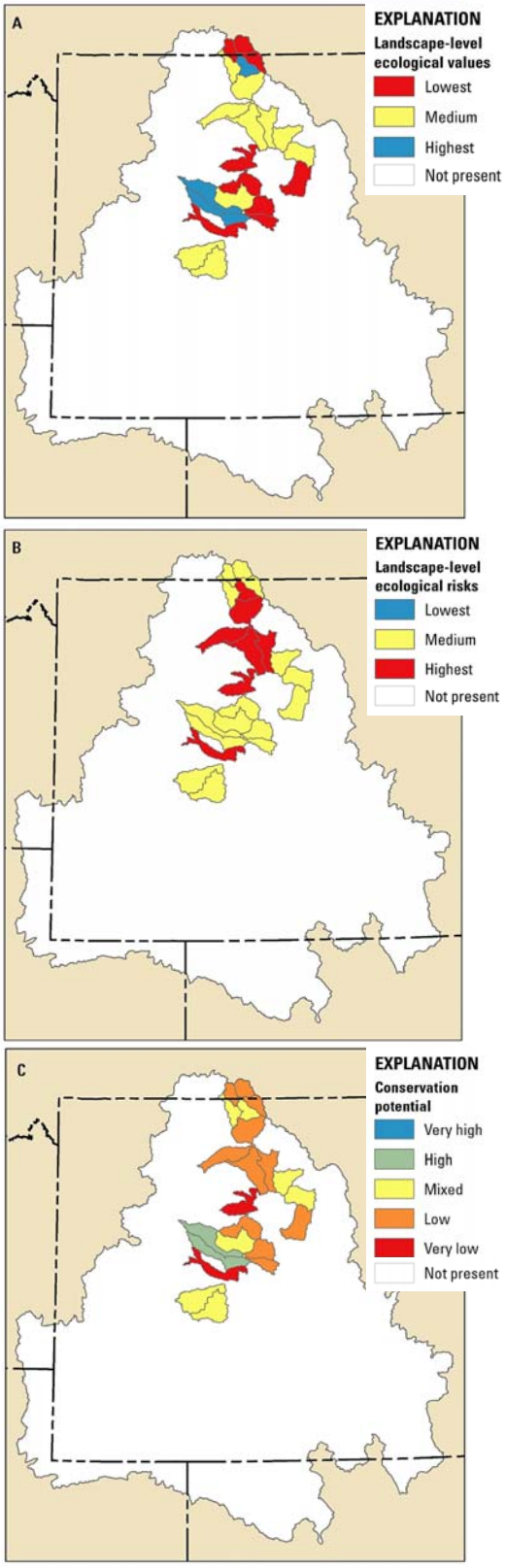



Competition and hybridization risk posed by walleye occurrence in sauger habitat within the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

The current range of sauger in the Wyoming Basin is limited to the Bighorn and Wind River drainages. These populations are among the last genetically pure sauger populations in the Missouri River Basin and are a conservation priority. Most sauger populations, however, are at risk for hybridization with walleye due to extensive overlap of the two species distributions within the Wyoming Basin. Walleye pose risks as potential predators, competitors, and disease carriers. Walleye and sauger do not co-occur in the Wind, Little Wind, and the Popo Agie Rivers, so sauger populations here are important for maintaining genetically pure sauger populations, although the isolation from larger populations is a concern.

Development poses significant threats to habitat quality. Most habitat except a small area of the Popo Agie River has moderate to high development levels. The Bighorn and Wind River drainages have high agricultural development, extensive roads, and many water diversions. The Boysen and Yellowtail dams have fragmented the remaining sauger populations, and potential barriers posed by water diversions restrict fish movements. These barriers limit access to spawning habitat, compounding the problems posed by the highly restricted distribution of this species.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of sauger summarized by fifth-level watershed.

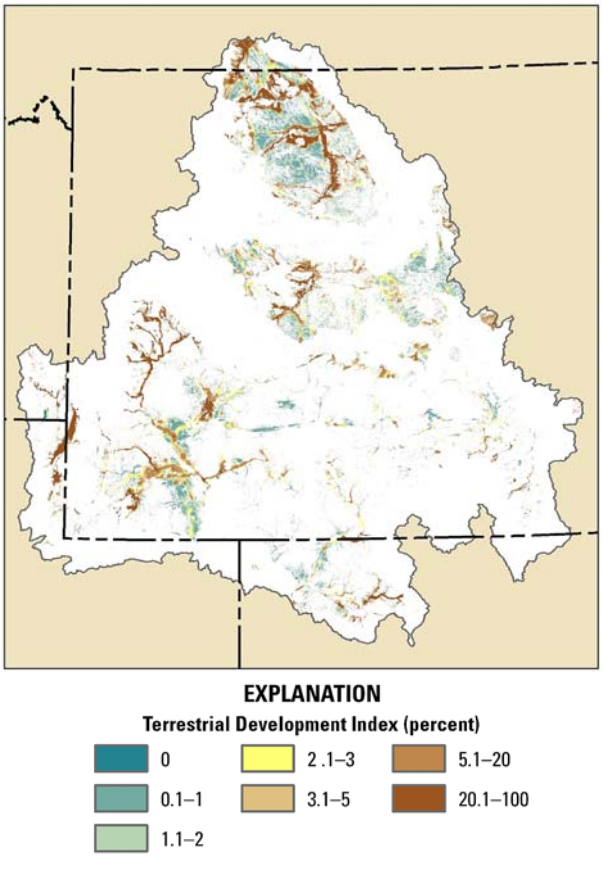
# Spadefoot Assemblage:

## Great Basin Spadefoot
## Plains Spadefoot

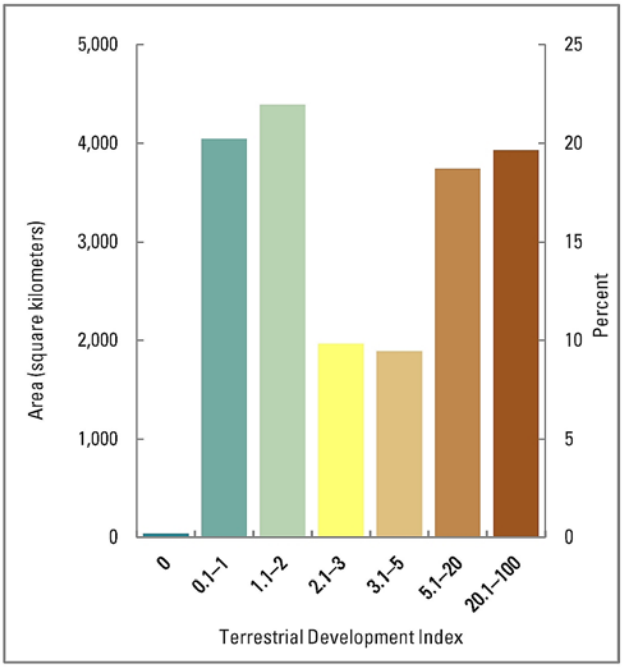
Photo credit: Great Basin spadefoot, National Park Service.

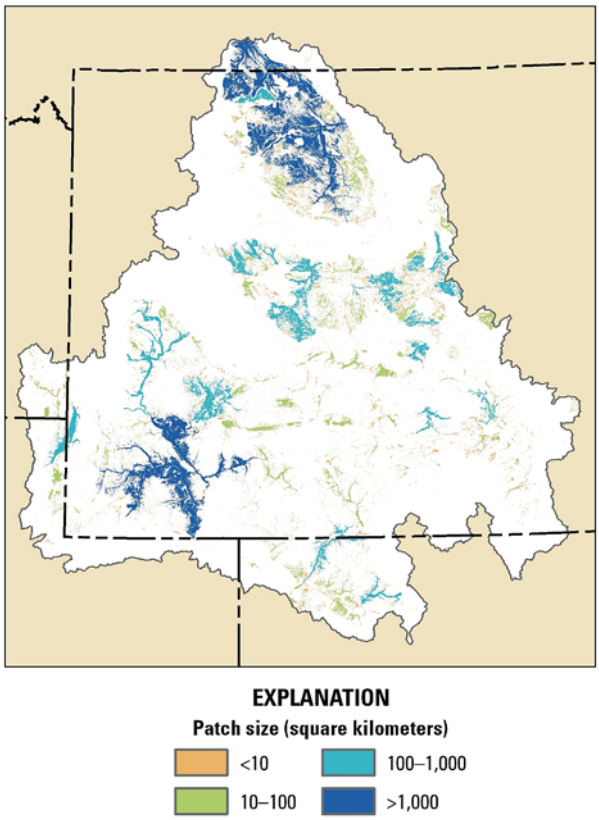
## Management Questions

- Where is baseline spadefoot habitat, and what is the total area?
- Where does development pose the greatest threat to baseline spadefoot habitat, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline spadefoot habitat, and where are the large, relatively undeveloped patches? (Top left map following page)
- How has development affected connectivity of spadefoot habitat relative to baseline conditions?
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped habitat patches?
- Where have recent fires occurred in spadefoot habitat, and what is the total area burned per year?
- How does risk from development vary by land ownership for spadefoot habitat?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for baseline spadefoot habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.

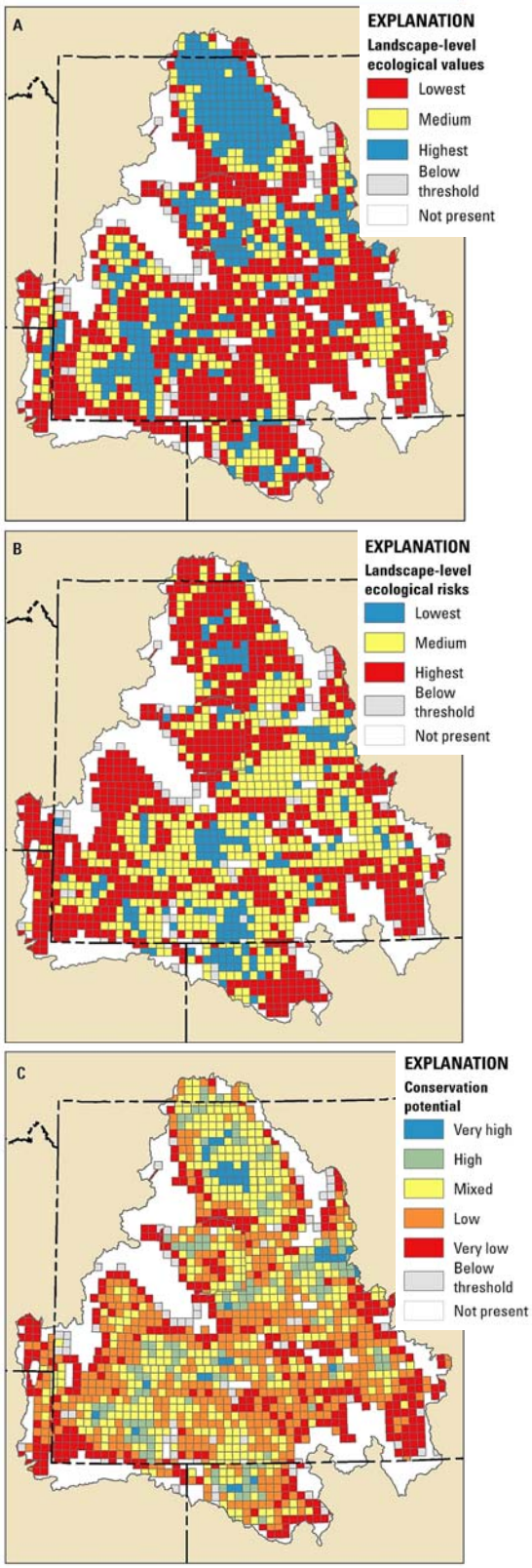





Patch sizes of baseline spadefoot habitat for the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

Spadefoot habitat is widely distributed in the Bighorn Basin but is patchily distributed throughout much of the rest of the Wyoming Basin. Agricultural conversion, roads, and energy development have cumulatively led to habitat loss, increased fragmentation, and decreased connectivity of Great Basin and plains spadefoot habitat. These species require connectivity between breeding and wintering sites, and therefore, development that disrupts movement (roads and agriculture) is a concern. In addition, Great Basin and plains spadefoots are sensitive to pesticides, herbicides, and other toxins in their breeding wetlands associated with agricultural and energy development. A large proportion of the spadefoot habitat in the Basin is managed by the Bureau of Land Management (BLM) and spadefoot habitat on BLM lands has much lower development values than on other land ownerships and jurisdictions.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of Great Basin and plains spadefoot habitat summarized by township

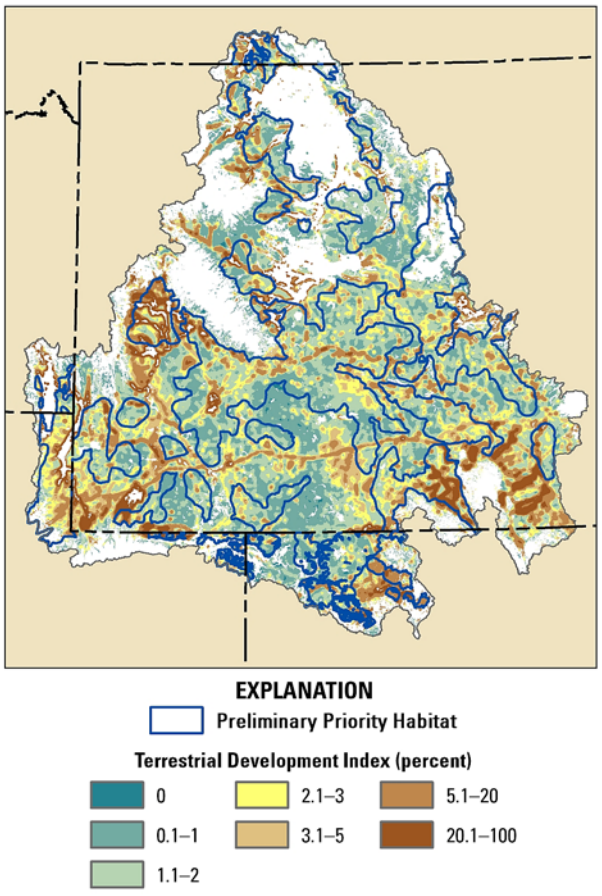
# Greater Sage-Grouse

## Management Questions

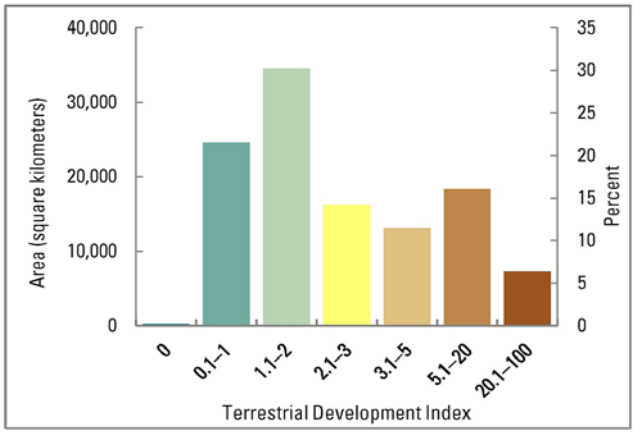
- Where are baseline habitat and Preliminary Priority Habitat for greater sage-grouse, and what is the total area of each?
- Where does development pose the greatest threat to baseline greater sage-grouse ("sage-grouse") habitat, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline sage-grouse habitat, and where are the large, relatively undeveloped patches?
- How has development affected structural connectivity of sage-grouse habitat relative to baseline conditions?
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped habitat patches?

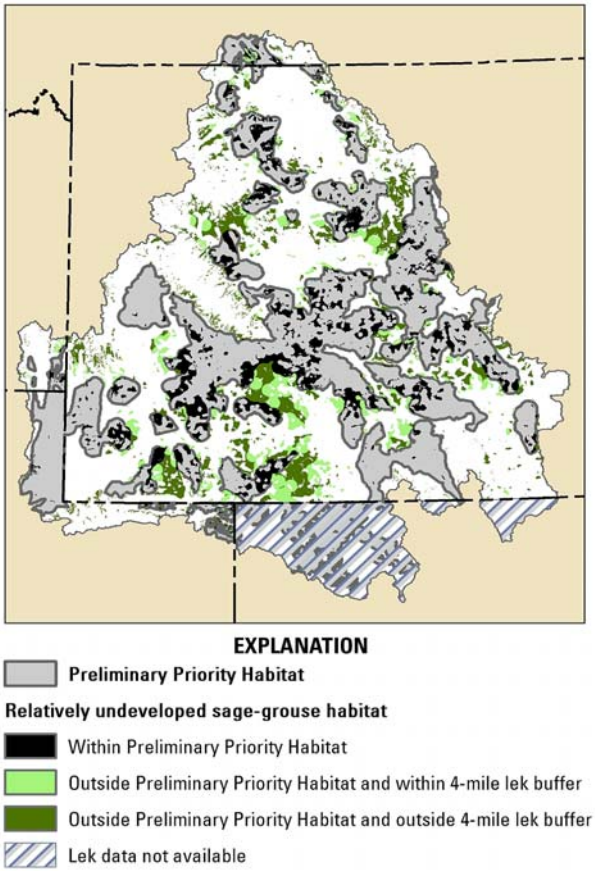
Photo credit: Stephen Ting, U.S. Fish and Wildlife Service.

- Where are sage-grouse leks at risk from expansion of juniper woodlands?
- Where have recent fires occurred in baseline sage-grouse habitat, and what is the total area burned per year?
- What is the potential risk from West Nile virus currently and in 2050?
- Where is relatively undeveloped sage-grouse habitat within 6.4 kilometers (4 miles) of leks that falls outside of the Preliminary Priority Habitat designation? (Top left map following page)
- How does risk from development vary by land ownership for sage-grouse habitat?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for baseline greater sage-grouse habitat in the Wyoming Basin Rapid Ecoregional



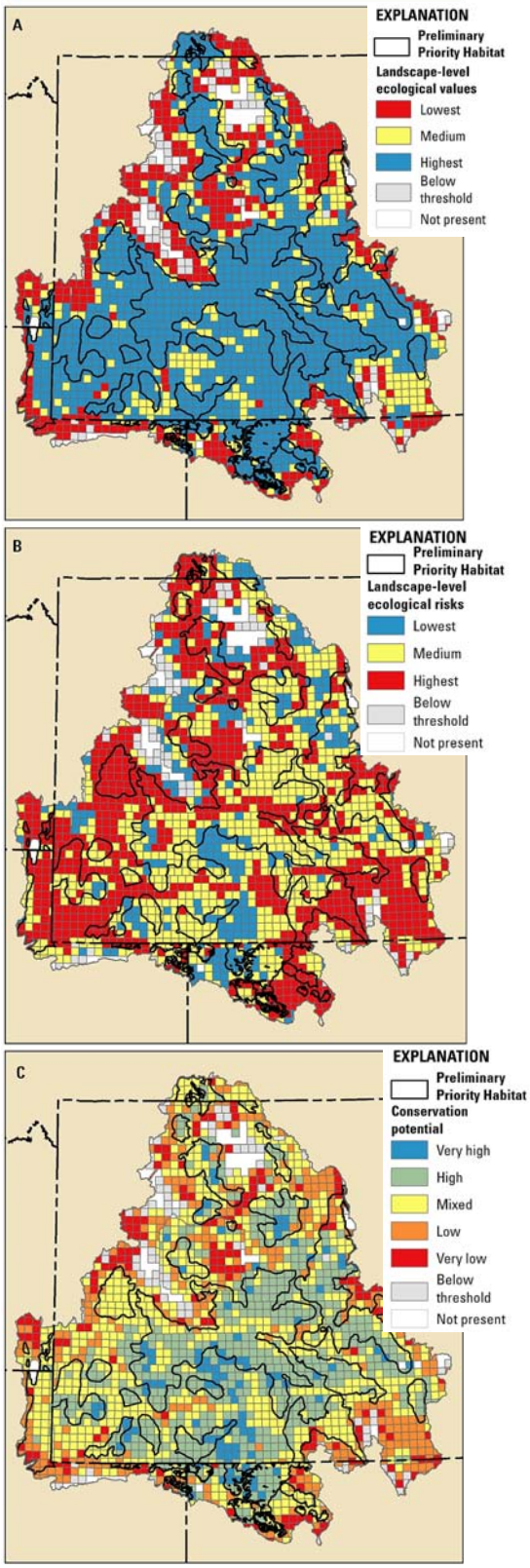



Relatively undeveloped greater sage-grouse habitat in relation to 6.4-kilometer (4-mile) lek buffers and Preliminary Priority Habitat designation in the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

Greater sage-grouse habitat, once widely distributed and highly connected throughout the Wyoming Basin, has seen increased fragmentation and decreased structural connectivity of baseline habitat due to agricultural conversion, roads, and energy development. Although 66 percent of baseline habitat has low terrestrial development (≤3 percent) only 23 percent is relatively undeveloped (≤1 percent). Relatively undeveloped patches are all <5,000 square kilometers (2,000 square miles), compared to baseline conditions in which most habitat patches exceed 109,069 square kilometers (42,111 square miles). Regional connectivity for baseline habitat occurs at an interpatch distance of 0.3 kilometers (0.2 miles) compared to 3.8 kilometers (2.3 miles) for relatively undeveloped areas. Some of the largest relatively undeveloped areas do not have Preliminary Priority Habitat designation. Such areas lacking protected status may serve as potential sage-grouse conservation sites.

Potential future risks to sage-grouse include continued energy development. Projections based on climate change scenarios indicating an increased risk of habitat loss and West Nile virus, and potential for the loss of additional habitat from widespread fires.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of greater sage-grouse habitat summarized by township.

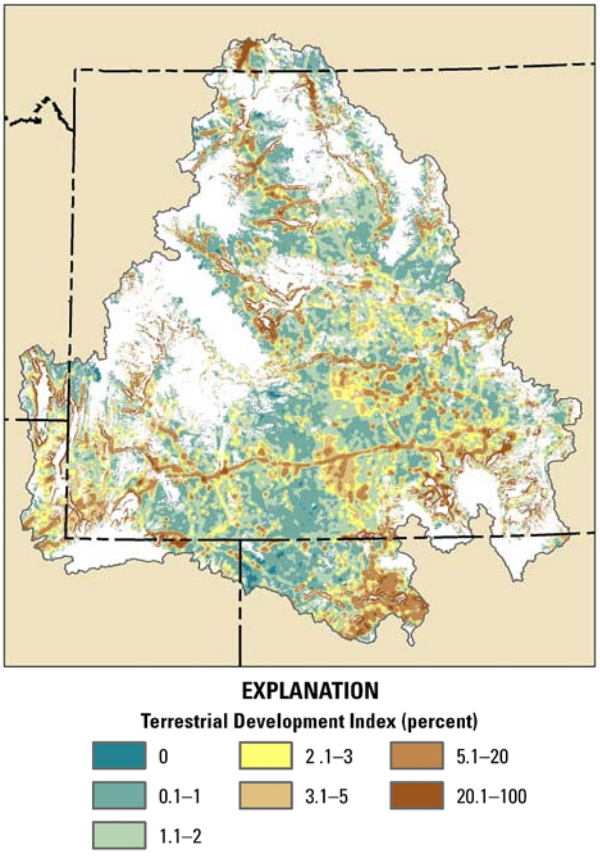
# Golden Eagle

## Management Questions

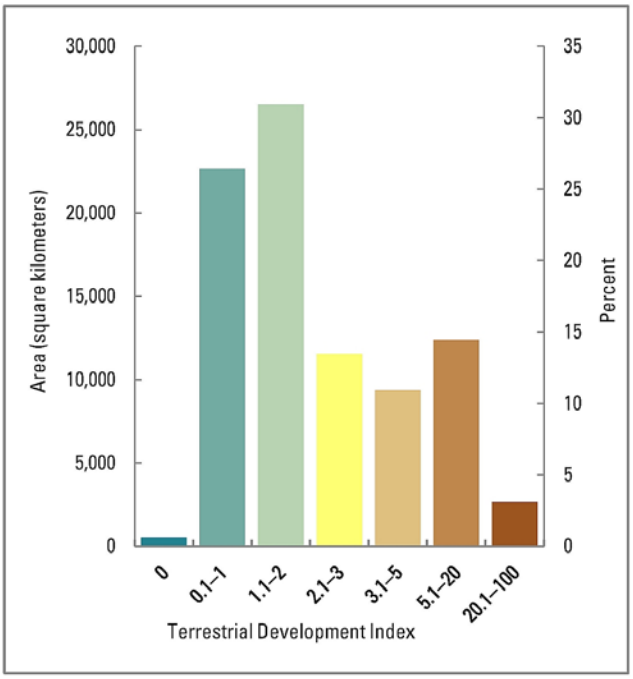
- Where is baseline golden eagle nesting habitat, and what is the total area?
- Where does development pose the greatest threat to baseline golden eagle habitat, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline golden eagle habitat, and where are the large, relatively undeveloped patches?
- How has development affected structural connectivity of golden eagle habitat relative to baseline conditions?
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped habitat patches?
- Where are existing wind-energy facilities, and where are areas with high wind-energy potential in golden eagle habitat? (Top left map following page)

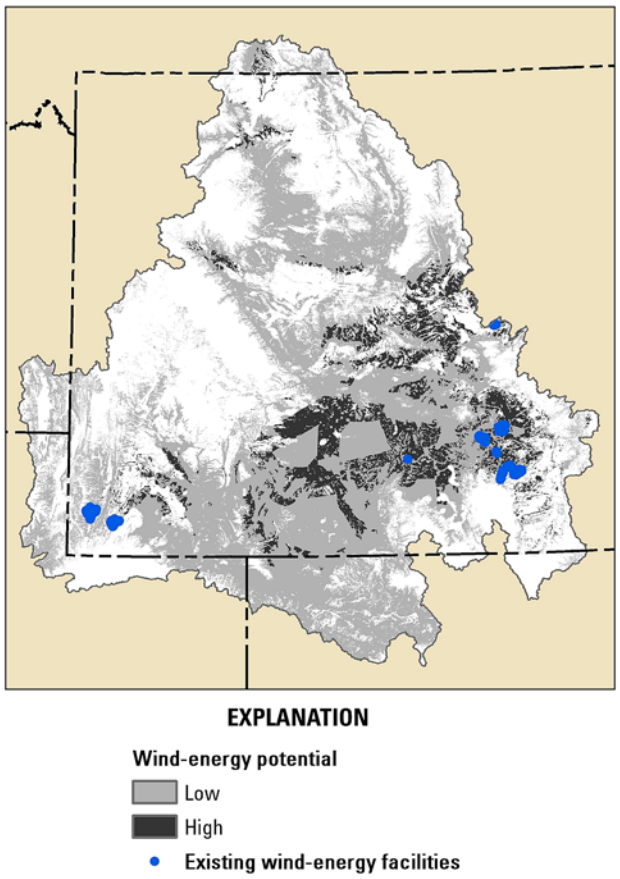
Photo credit: Aldis Garvso, Mountain Post-Digital Imaging.

- Where have recent fires occurred in baseline golden eagle habitat, and what is the total area burned per year?
- How does risk from development vary by land ownership for golden eagle habitat?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores of baseline golden eagle habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.

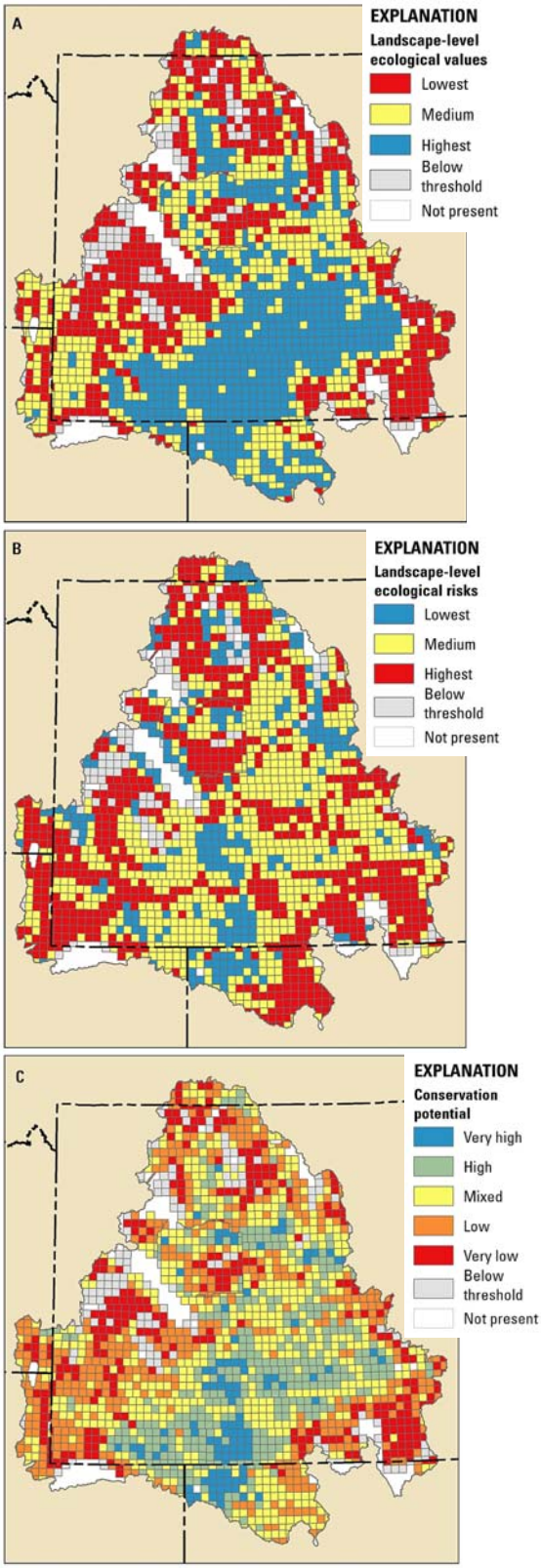





Potential for wind-energy development and existing wind-energy facilities within baseline golden eagle habitat in the Wyoming Basin Rapid Ecoregional assessment project area.


## Summary

Golden eagle nesting habitat is widely distributed throughout much of central and southern Wyoming and adjacent areas of Idaho, Utah, and Colorado. Agricultural conversion, roads, and energy development have cumulatively led to habitat loss, increased fragmentation, and decreased structural connectivity of golden eagle habitat. Golden eagles, however, may respond differently to different types of development, depending on time of year. They are especially sensitive to disturbance at their nest sites; therefore development that causes high levels of human activity may lead to a reduction in nesting productivity. Golden eagle collisions with vehicles along highways are also a concern. Golden eagles are especially vulnerable to mortality from wind turbines and 16 percent of their habitat within the Basin occurs in regions with high wind development potential. The majority of the golden eagle nesting habitat in the Basin is managed by the Bureau of Land Management.

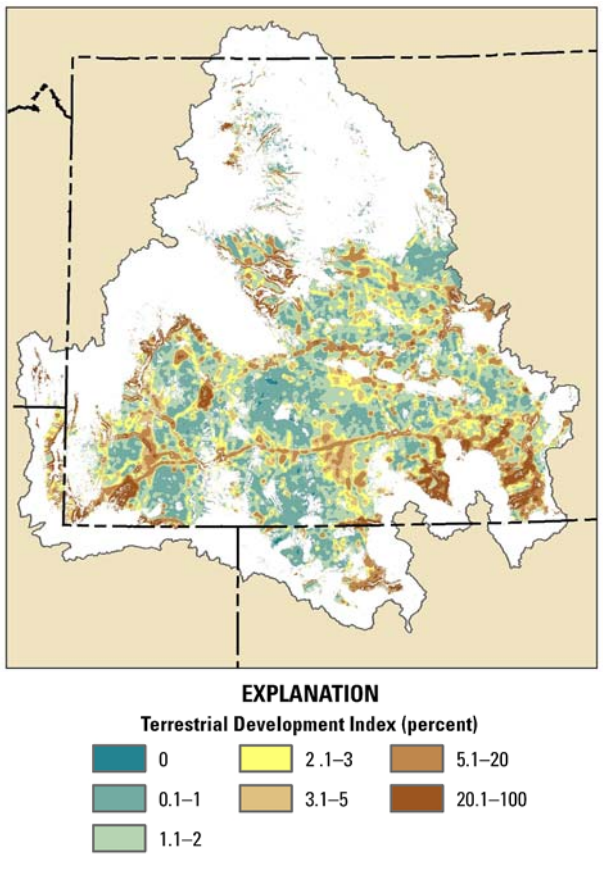

(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of townships with golden eagle habitat.

# Ferruginous Hawk

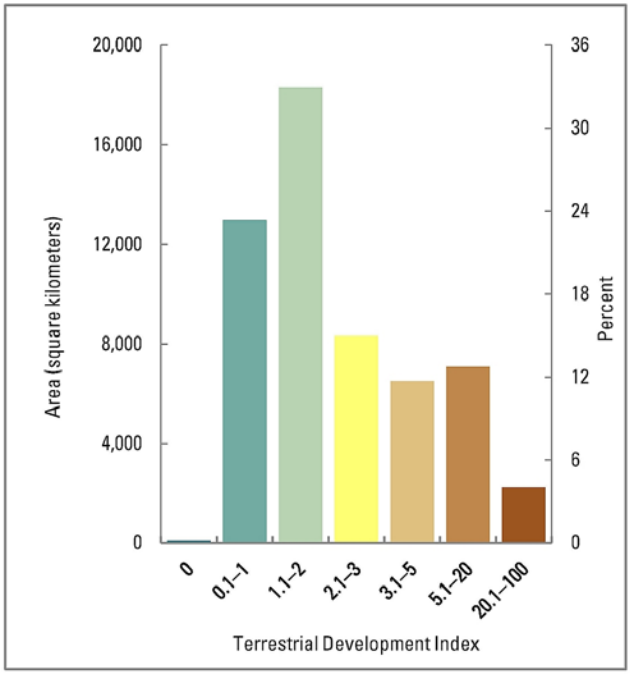
Photo credit: Brett Billings, U.S. Fish and Wildlife Service.

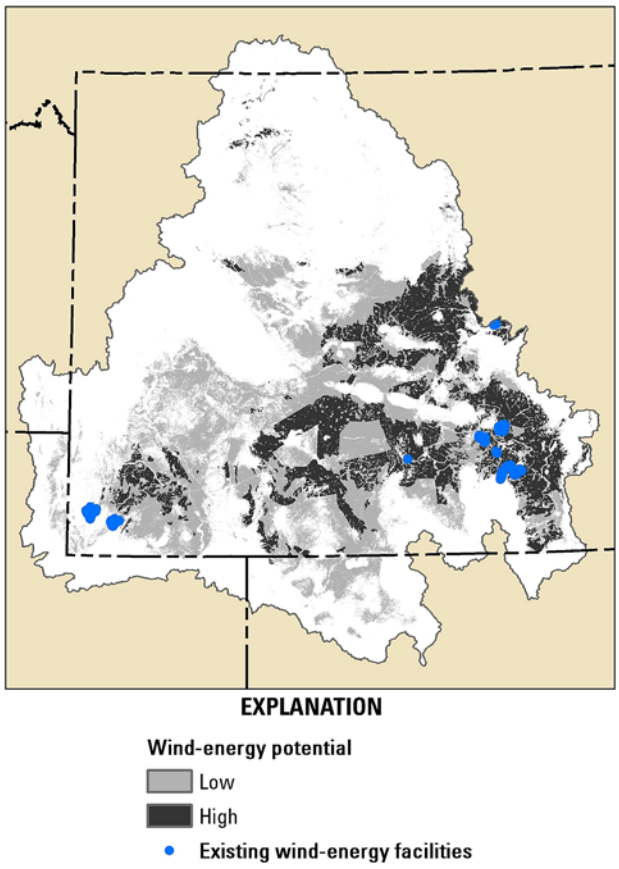
## Management Questions

- Where is baseline ferruginous hawk habitat, and what is the total area?
- Where does development pose the greatest threat to baseline ferruginous hawk habitat, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline ferruginous hawk habitat, and where are the large, relatively undeveloped patches?
- How has development affected structural connectivity of ferruginous hawk habitat relative to baseline conditions?
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped habitat patches?
- Where are existing wind-energy facilities, and where are areas with high wind-energy potential in baseline ferruginous hawk habitat? (Top left map following page)
- Where have recent fires occurred in baseline ferruginous hawk habitat, and what is the total area burned per year?
- How does risk from development vary by land ownership or jurisdiction for ferruginous hawk habitat?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for baseline ferruginous hawk habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.

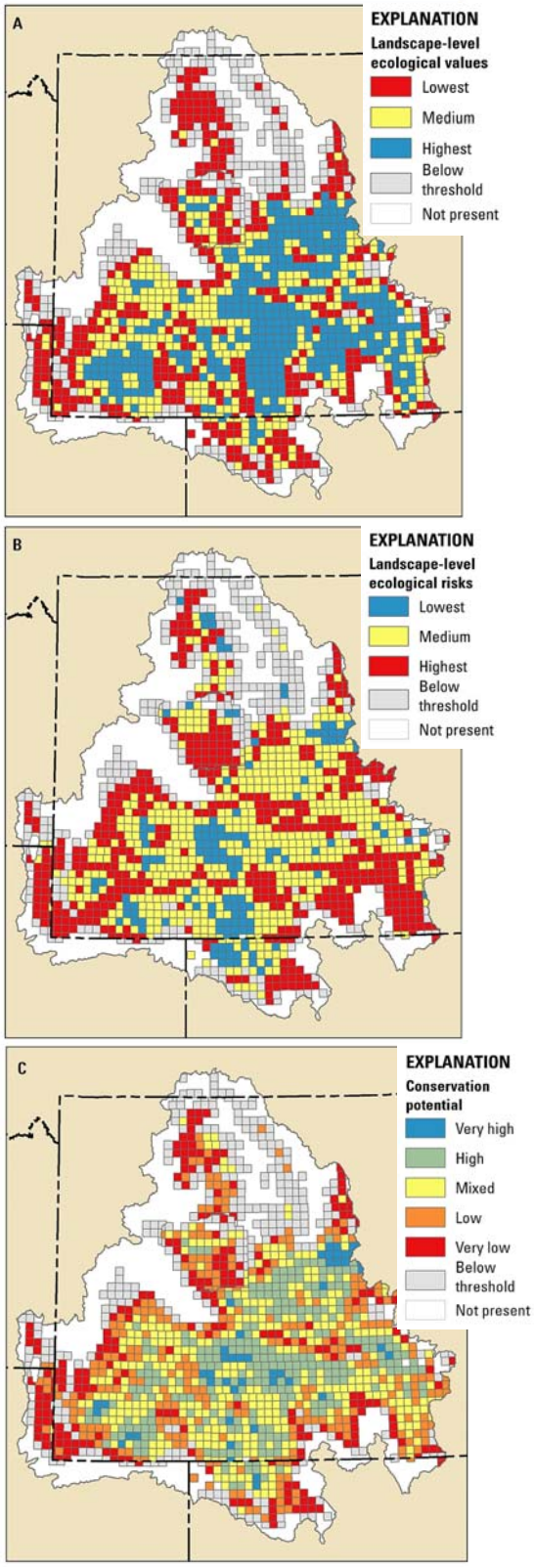





Potential for wind-energy development and existing wind-energy facilities within baseline ferruginous hawk habitat in the Wyoming Basin Rapid Ecoregional assessment project area.


## Summary

Ferruginous hawk habitat is widely distributed throughout much of central and southern Wyoming and adjacent areas of Idaho, Utah, and Colorado. Agricultural conversion, roads, and energy development have cumulatively led to habitat loss, increased fragmentation, and decreased structural connectivity of ferruginous hawk habitat. Ferruginous hawks, however, may respond differently to different types of development. They are more sensitive to disturbance at their nest sites than other buteos; therefore development that results in high levels of human activity may lead to reduced nesting productivity. In addition, ferruginous hawks are vulnerable to mortality from wind turbines and 29 percent of their habitat within the Basin occurs in regions with high wind-development potential. The majority of the ferruginous hawk habitat in the Basin is managed by the Bureau of Land Management.

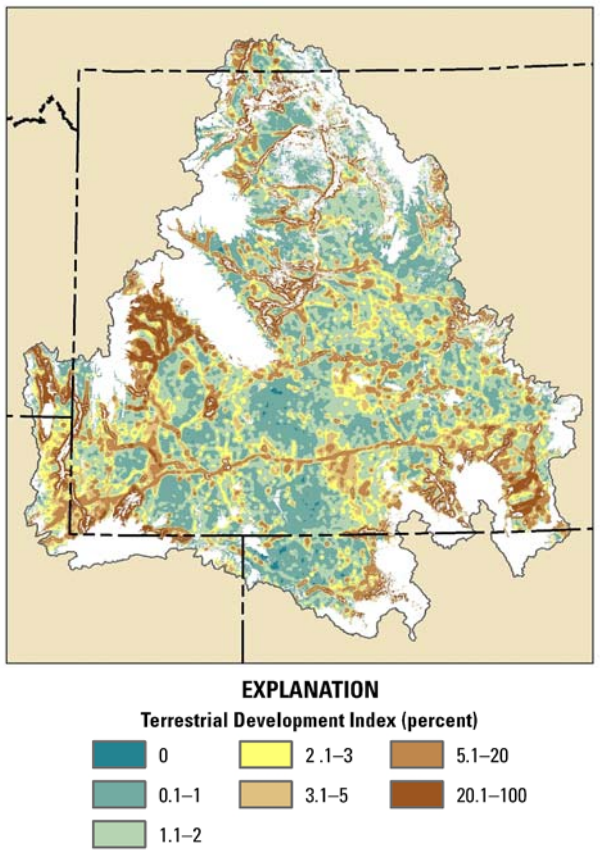




(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of ferruginous hawk habitat summarized by township.

# Sagebrush-Obligate Songbirds:

## Brewer's Sparrow
## Sagebrush Sparrow
## Sage Thrasher

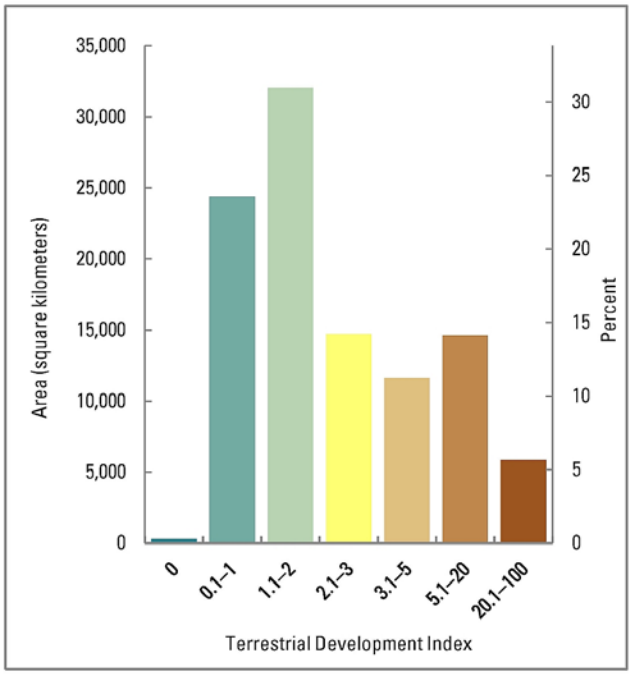
Photo credits: Brewer's sparrow, Elaine R. Wilson, Nature's Pics Online, Creative Commons Attribution-Share Alike 3.0; sagebrush sparrow, Bureau of Land Management; and sage thrasher, ©Dave Showalter.

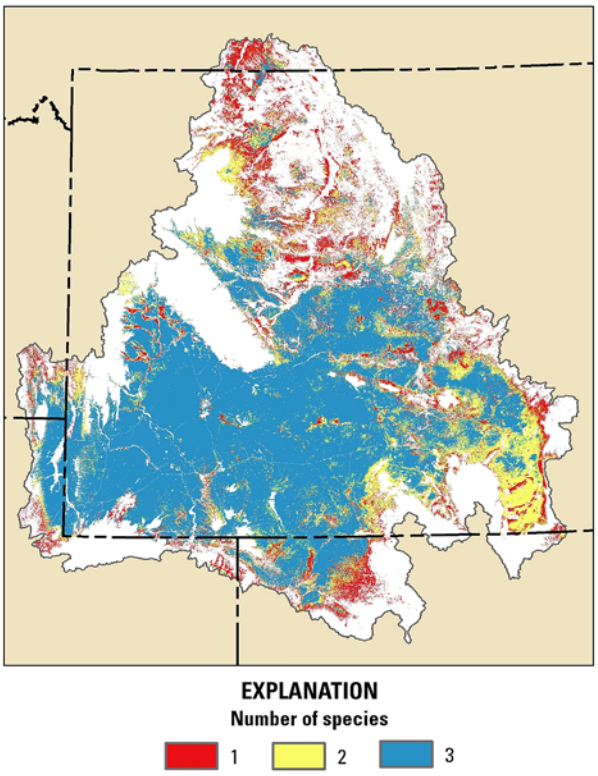



Terrestrial Development Index scores for sagebrush-obligate songbird habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.

## Management Questions

- Where is baseline sagebrush-obligate songbird (SOS) habitat, and what is the total area? (Top left map following page)
- Where does development pose the greatest threat to baseline sagebrush-obligate songbird habitat, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline sagebrush-obligate songbird habitat, and where are the large, relatively undeveloped patches?
- How has development affected structural connectivity of sagebrush-obligate songbird habitat relative to baseline conditions?
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped habitat patches?
- Where have recent fires occurred in sagebrush-obligate songbird habitat, and what is the total area burned per year?
- How does risk from development vary by land ownership for sagebrush-obligate songbird habitat?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)



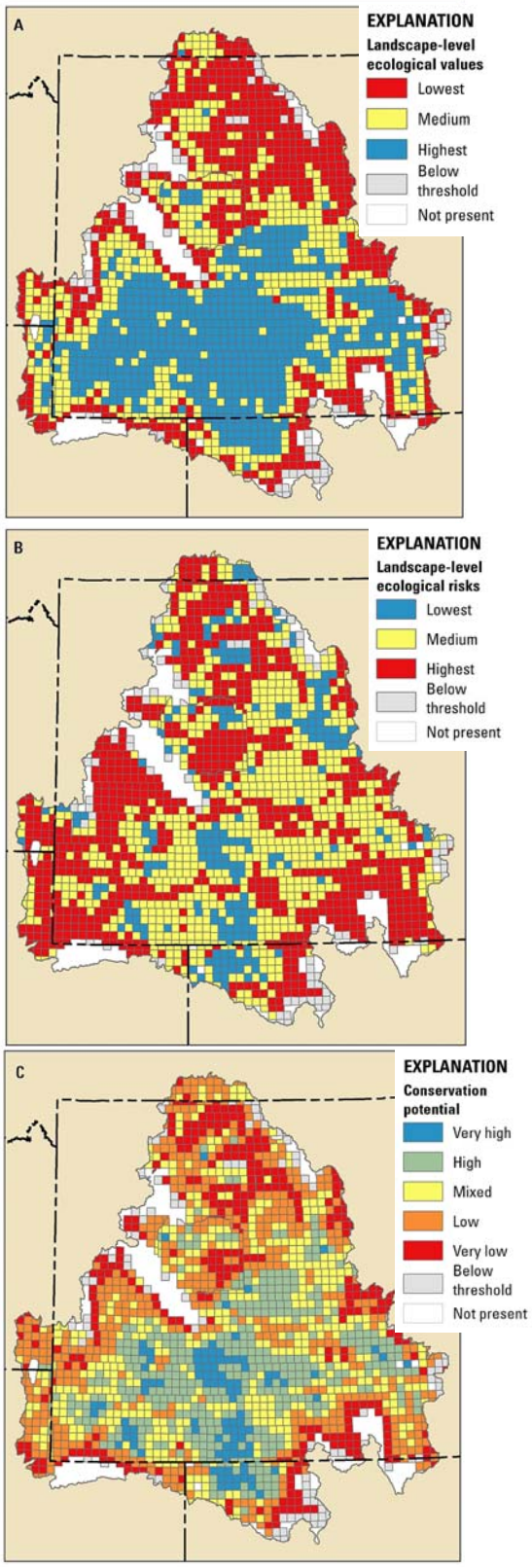



Number of sagebrush-obligate songbird species in the Wyoming Basin Rapid Ecoregional Assessment project area based on occupancy models for Brewer's sparrow, sagebrush sparrow, and sage thrasher.


## Summary

Total baseline habitat for the three sagebrush-obligate songbird species combined is 103,537 square kilometers (39,976 square miles) or 58 percent of the Wyoming Basin area, and there is a close correspondence in the distributions of sagebrush-obligate songbird species. A total of 23 percent of their habitat is relatively undeveloped, whereas 20 percent has high levels of development (Terrestrial Development Index score >5 percent). Baseline sagebrush-obligate songbird habitat is highly connected, especially in the southern area, but development has effectively fragmented and reduced structural connectivity of their habitat. The largest patches of relatively undeveloped habitat are found northeast and southwest of Rock Springs. Previous research indicates that Brewer's and sagebrush sparrows may be more sensitive to energy development than sage thrasher.

All three species are listed as Species of Greatest Conservation Need in Wyoming due to habitat loss, degradation, and fragmentation. The majority of the modeled sagebrush-obligate songbird habitat in the Basin is managed by the Bureau of Land Management or is on private lands, and risk from development is similar for both types of land. Some of the townships with the highest conservation potential for sagebrush-obligate songbird habitat occur within areas that may function as strongholds for sagebrush shrublands under projections of climate change.


(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of sagebrush-obligate songbird habitat summarized by township.

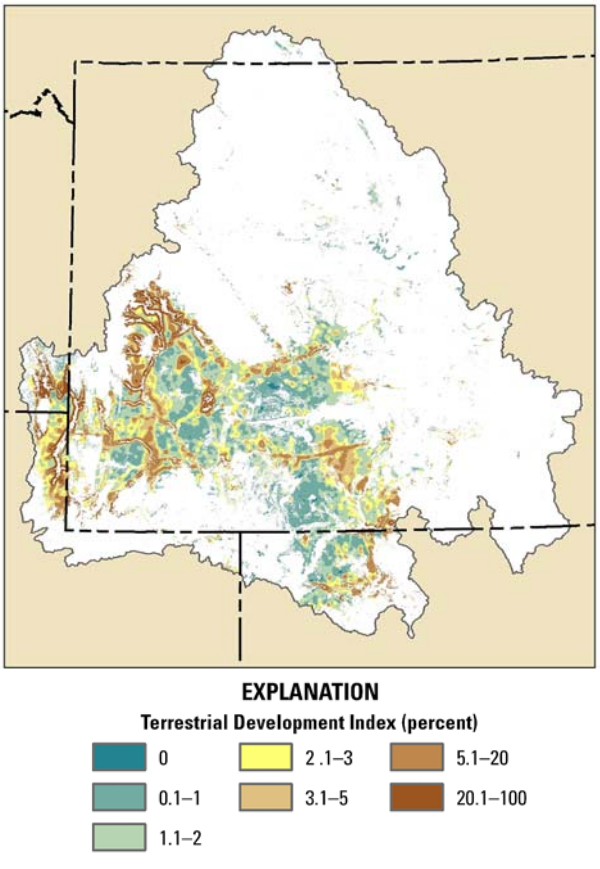
# Pygmy Rabbit

## Management Questions

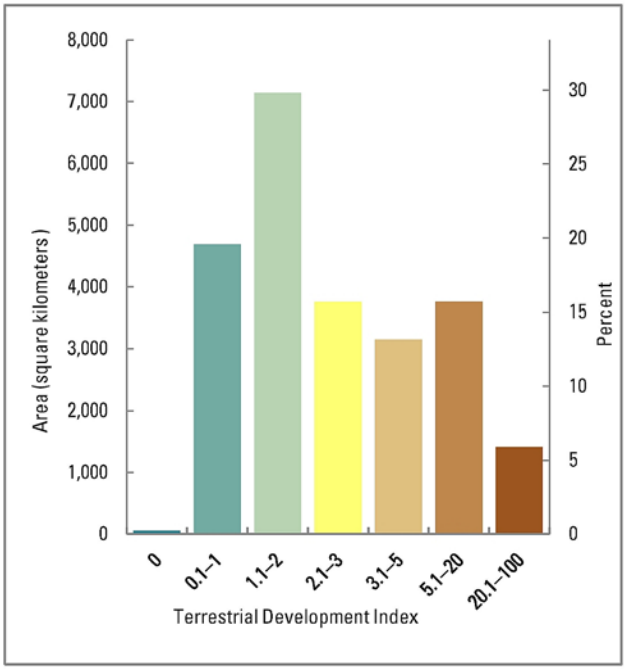
- Where is baseline pygmy rabbit habitat, and what is the total area?
- Where does development pose the greatest threat to baseline pygmy rabbit habitat, and where are the relatively undeveloped areas? (Left map below)
- How has development fragmented baseline pygmy rabbit habitat, and where are the large, relatively undeveloped patches?
- How has development affected structural connectivity of pygmy rabbit habitat relative to baseline conditions?
- Where are potential barriers and corridors that may affect animal movements among relatively undeveloped habitat patches? (Top left map following page)

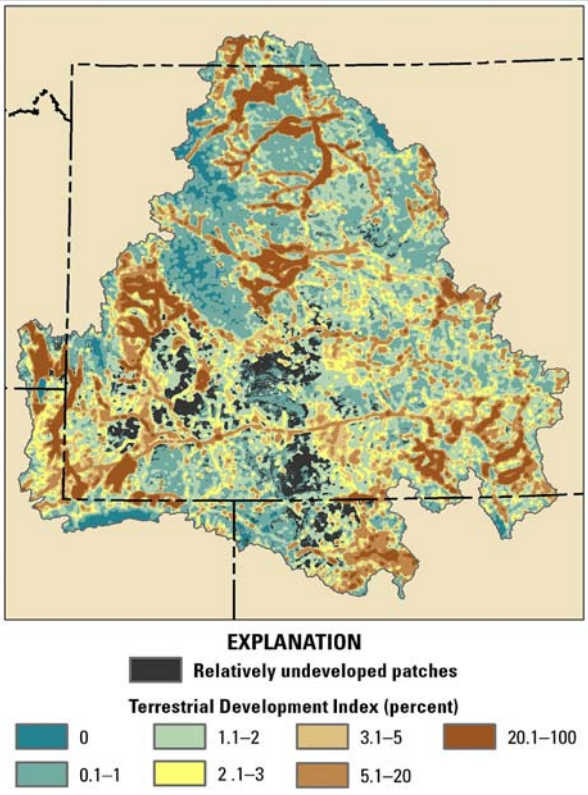
Photo credit: Steve Germaine, U.S. Geological Survey.

- Where have recent fires occurred in baseline pygmy rabbit habitat, and what is the total area burned per year?
- How does risk from development vary by land ownership or jurisdiction for pygmy rabbit habitat?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for pygmy rabbit habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.



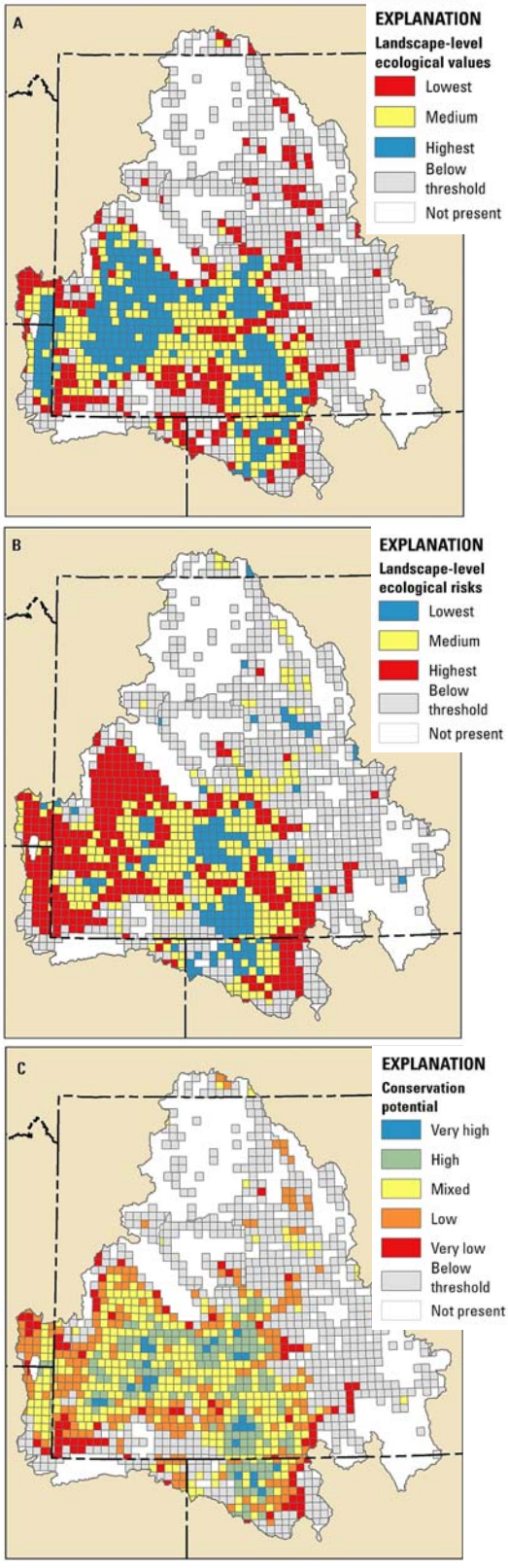



Potential barriers and corridors as a function of Terrestrial Development Index (TDI) score for lands surrounding relatively undeveloped pygmy rabbit habitat. Higher TDI scores (for example, >5 percent) represent potential movement barriers among relatively undeveloped habitat patches. Lower TDI scores ( <2 percent) represent potential movement corridors.


## Summary

Baseline pygmy rabbit habitat totals 23,950 square kilometers (9,247.2 square miles) or 13 percent of the Wyoming Basin Ecoregional Assessment project area. Approximately 20 percent of potential pygmy rabbit habitat is relatively undeveloped and 35 percent is highly developed. Development has effectively fragmented habitat into smaller patches relative to baseline conditions; approximately 8 percent of relatively undeveloped areas are in patches >100 square kilometers (38.6 square miles). The largest patches of relatively undeveloped habitat are west of Rock Springs and south of Rawlins,. Development also has reduced structural connectivity of potential pygmy rabbit habitat and barriers may result from I-80 and the high density of roads and energy development south of Pinedale (fragmenting large, relatively undeveloped habitat). Pygmy rabbit dispersal may be impeded by high levels of development outside relatively undeveloped areas.

Most pygmy rabbit habitat is managed by the Bureau of Land Management (BLM) and 28 percent is on private land. Habitat on BLM lands is less developed and most of the habitat on private land occurs in a checkerboard distribution with BLM land. Many of the townships with the highest conservation potential for pygmy rabbit habitat occur within areas that may provide strongholds for sagebrush shrublands under projections of climate change.

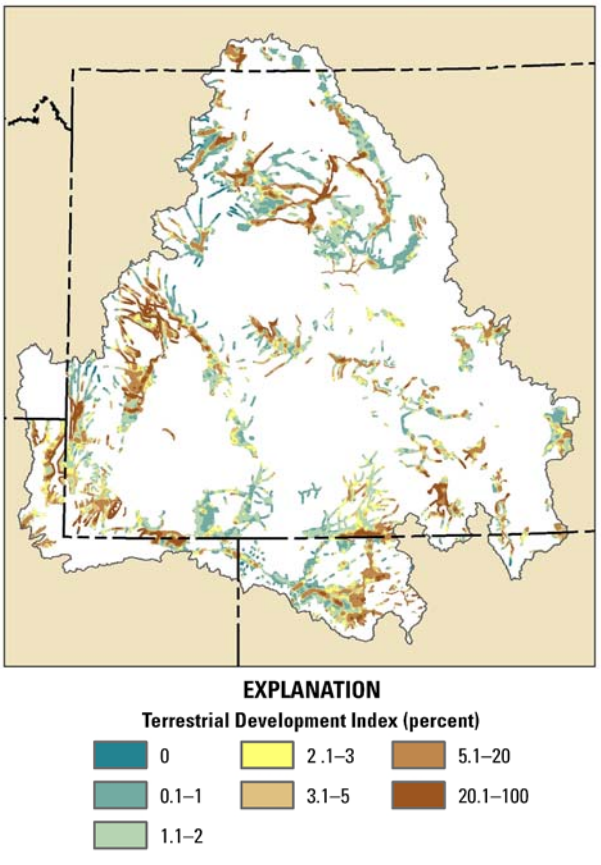

(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of pygmy rabbit habitat summarized by township.

# Mule Deer

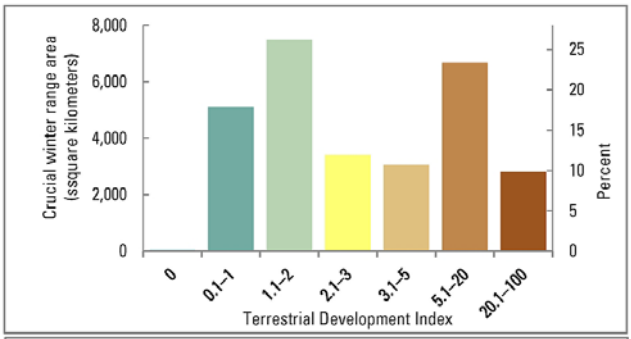
Photo credit: Joe Ruis, Mule Deer Migration Initiative.

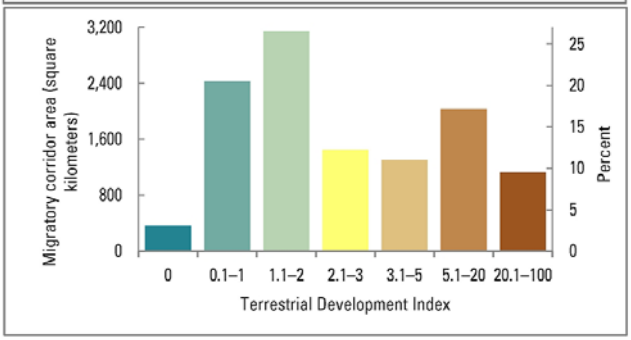
## Management Questions

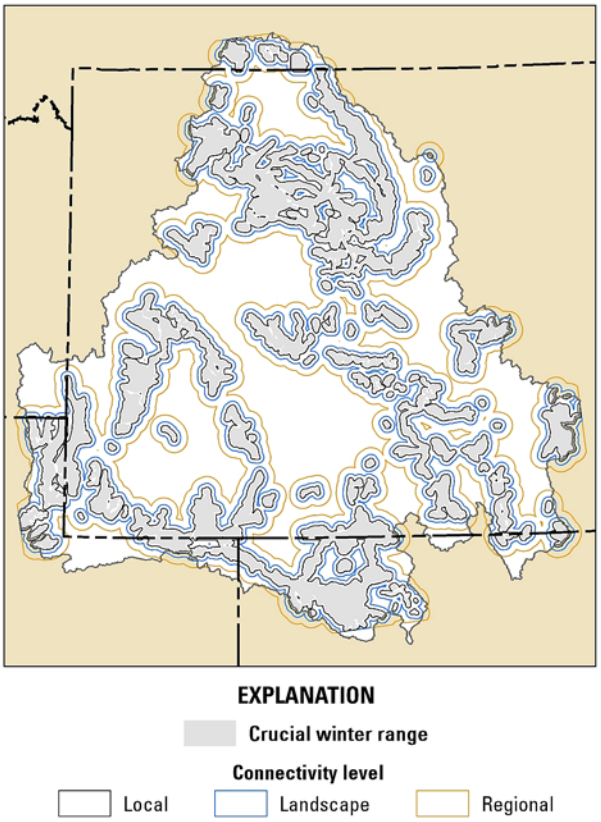
- Where are baseline mule deer crucial winter range and migration corridors, and what is the total area and elevation of crucial winter range?
- What is the amount and distribution of vegetation types providing forage and cover on crucial winter range?
- Where does development pose the greatest threat to crucial winter range, and where are the relatively undeveloped patches? (Left map below)
- How has development fragmented baseline crucial winter range, and where are the large, relatively undeveloped patches?
- How has development affected structural connectivity of crucial winter range? (Top left map following page)
- Where are potential barriers that may affect mule deer movements among crucial winter ranges?
- Where has chronic wasting disease been detected in the Wyoming Basin?
- Where have recent fires occurred in crucial winter range, and what is the total area burned per year?
- What is the risk from development by land ownership for baseline mule deer crucial winter range?
- Where are the townships with the greatest landscape-level ecological values? (Top right map following page)
- Where are the townships with the greatest landscape-level risks? (Center right map following page)
- Where are the townships with the greatest conservation potential? (Bottom right map following page)




Terrestrial Development Index scores for mule deer crucial winter range and migration corridors in the Wyoming Basin Rapid Ecoregional Assessment project area.





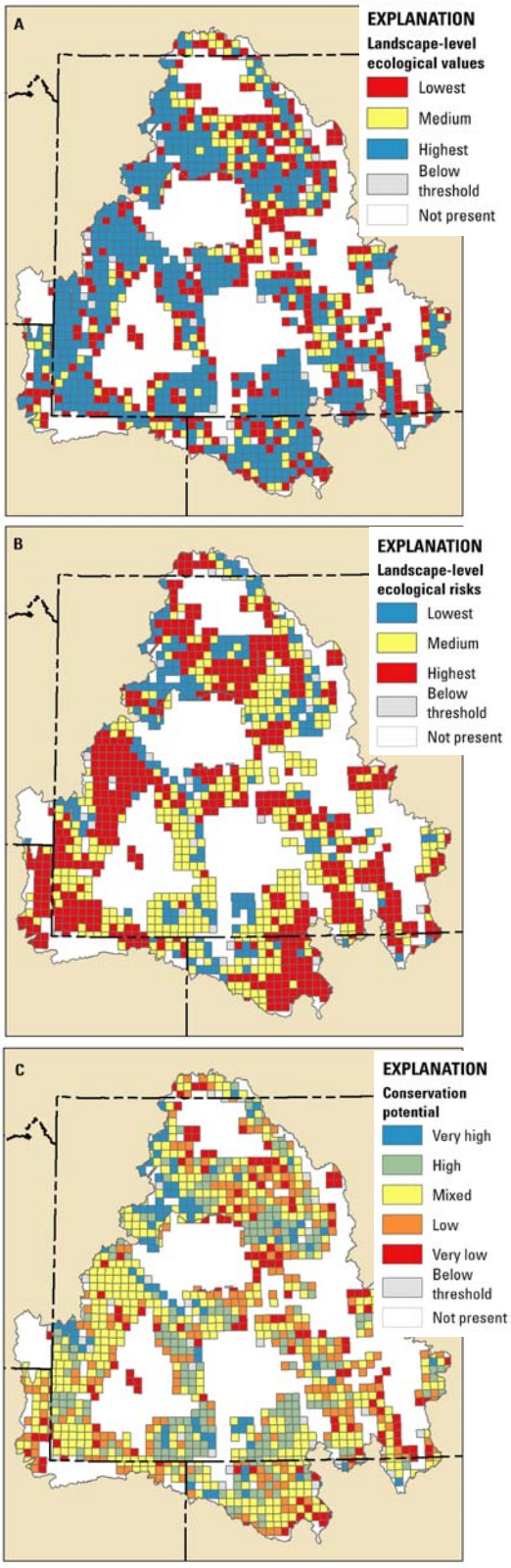

Structural connectivity of baseline mule deer crucial winter range in the Wyoming Basin Rapid Ecoregional Assessment project area.

## Summary

Mule deer crucial winter range occurs on approximately 16 percent of the Wyoming Basin Ecoregional Assessment project area, primarily at elevations between 1,400−1,700 meters (4,593−5,577 feet). Dominant vegetation is sagebrush shrublands, a major winter forage; deciduous shrublands and riparian areas also provide forage. Juniper provides thermal cover and concealment on crucial winter range and during migration. Consequently, management to control juniper could have negative effects on mule deer populations. Agricultural lands have mixed effects on wintering mule deer: winter wheat and alfalfa offer forage, but most agricultural lands do not provide cover.

Relatively undeveloped areas may provide refuge from disturbance during the vulnerable winter, migration, and parturition periods. Development levels, particularly from roads and energy development, on crucial winter range and along migration corridors are high in many areas. Even low levels of development can cause the indirect loss of crucial winter range. Direct and indirect loss of winter range may have population-level effects, as disturbance along roads and from activities at energy fields could affect over-winter survival.

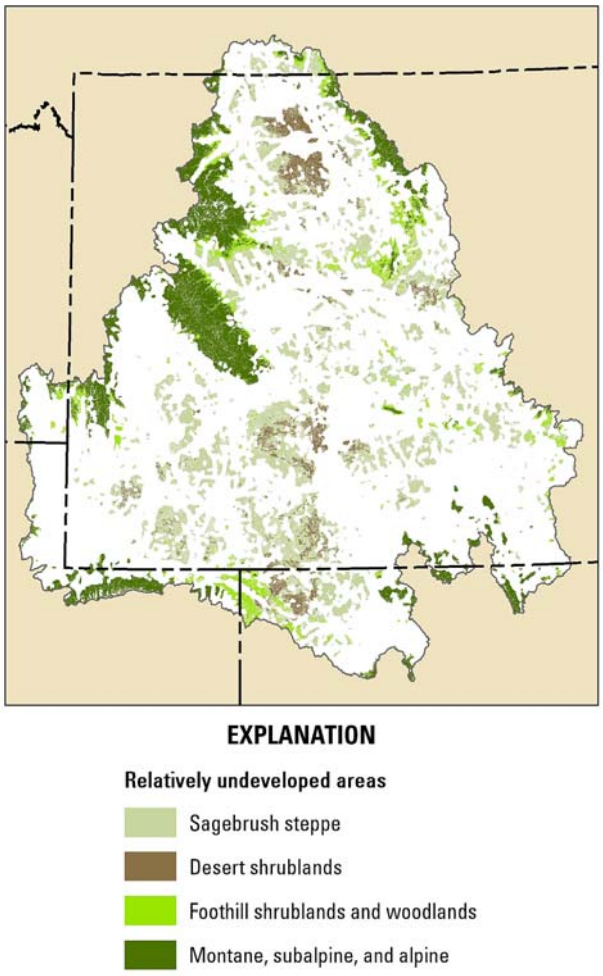
Analyses for the Rapid Ecoregional Assessment focused on crucial winter range due to the availability of region-wide information and because of the vulnerability of wintering deer.




(*A*) Landscape-level ecological values, (*B*) ecological risks, and (*C*) conservation potential of mule deer crucial winter range and migration corridors summarized by township .

# Landscape Intactness

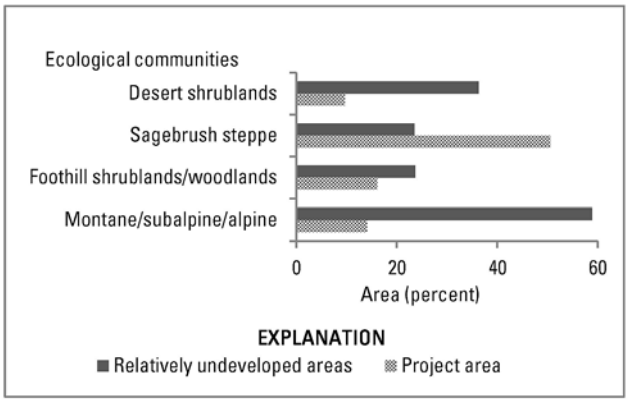
Photo credit: Phil Stoffer, U.S. Geological Survey.

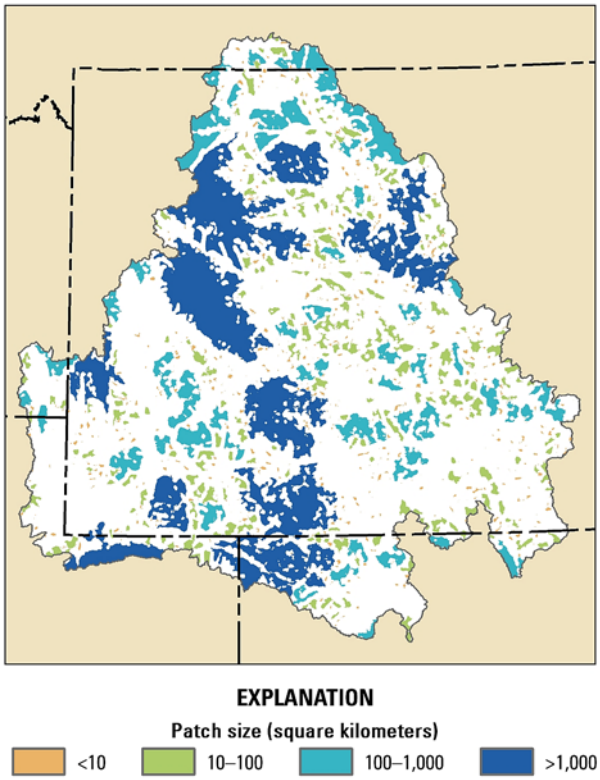



Distribution of terrestrial ecological communities within relatively undeveloped areas in the Wyoming Basin Rapid Ecoregional Assessment project area.

## Management Questions

- Where are the relatively undeveloped terrestrial areas? (Bottom left map below)
- Where are the largest relatively undeveloped patches?
- Where are relatively undeveloped areas with high structural connectivity, and which areas function as stepping stones that connect large, relatively undeveloped areas ?
- Where does development pose potential barriers to animal movements among relatively undeveloped areas?
- What is the distribution and percent of each terrestrial ecological community within relatively undeveloped areas?
- Where are the relatively undeveloped aquatic areas?
- Where has development fragmented streams and rivers, altered flows, and decreased connectivity?
- What is the land ownership or jurisdiction and protected status of relatively undeveloped areas?
- Where are the potential changes in the distribution of terrestrial communities for the Wyoming Basin Rapid Ecoregional Assessment project area and historic trails?
- Where are the projected changes in distribution of terrestrial communities for relatively undeveloped areas?
- How well do relatively undeveloped areas represent terrestrial species evaluated as Conservation Elements?
- Where are the townships with the highest conservation potential for terrestrial Conservation Elements? (Top right map following page)
- Where are the sixth-level watersheds with the highest conservation potential for aquatic Conservation Elements? (Bottom right map following page)



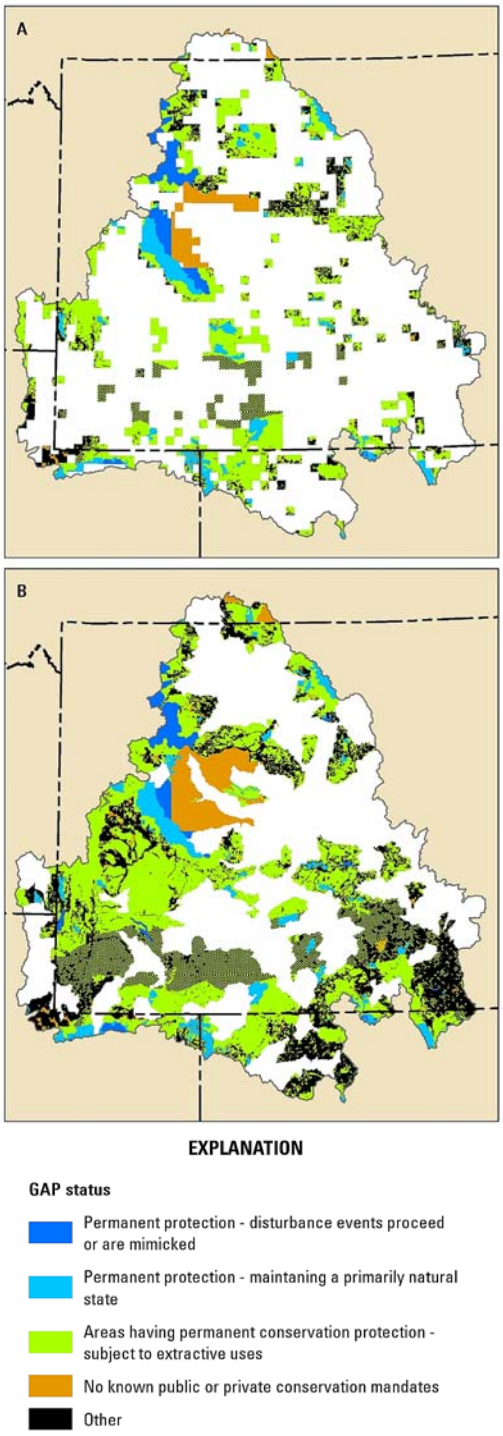



Patch sizes of relatively undeveloped areas for the Wyoming Basin Rapid Ecoregional Assessment project area.


## Summary

Large relatively undeveloped areas within the Wyoming Basin Ecoregional Assessment project area represent potential areas with high landscape intactness. Most of the relatively undeveloped areas occur on Federal lands, and most of these lands are under Bureau of Land Management jurisdiction and subject to extractive use. For terrestrial systems, relatively undeveloped areas cover 29 percent of the project area, most of which fall within the largest relatively undeveloped patches. Sagebrush steppe, which covers 55 percent of the ecoregion, is underrepresented in relatively undeveloped areas, as only 20 percent of sagebrush steppe falls within the relatively undeveloped areas.

For most terrestrial species, townships with the highest conservation potential correspond to relatively undeveloped areas for the entire ecoregion. For aquatic species, however, there were many watersheds with high conservation potential that were outside of the relatively undeveloped watersheds for the entire ecoregion. Because areas with high conservation potential for species and communities may occur outside of the largest relatively undeveloped areas for the ecoregion, landscape intactness at the ecoregion level is useful but not sufficient in evaluating conservation potential of public lands. Conservation potential for ecological communities and priority species may help to identify other areas of high ecological value and low risk.


(*A*) Townships with very high conservation potential for at least one terrestrial species evaluated as a Conservation Element and (*B*) sixth-level watersheds with high or very high conservation potential for at least one aquatic species by level of protection as defined by GAP Status (U.S. Geological Survey, 2012) in the Wyoming Basin Rapid Ecoregional Assessment project area,