Section IV. Assessments of Species and Species Assemblages

Chapter 23. Greater Sage-Grouse

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Distribution and Ecology

The greater sage-grouse (hereafter referred to as sage-grouse) is the largest member of the grouse family (Phasianidae) in North America. Historically, the species occurred throughout much of the sagebrush shrublands and is considered a sagebrush obligate (Knick and Connelly, 2011). A striking feature of sage-grouse breeding biology is the birds' use of lekking grounds (leks), where males perform complex displays to attract and mate with females. Because leks are often located in areas with low, open vegetation, males can be observed easily; therefore, most estimates of population size are derived from counts of males at leks (Connelly and others, 2004). The sage-grouse currently occupies approximately 56 percent of its estimated historical range (Schroeder and others, 2004), and many populations have been declining for several decades (Garton and others, 2011). More recently, the overall population trend appears more stable, although populations continue to decline in some regions (Garton and others, 2011). As a result of widespread declines in their distribution and abundance, the U.S. Fish and Wildlife Service recently concluded that the greater sage-grouse warranted listing as a threatened or endangered species, but immediate action was precluded by higher priority listing candidates; this decision is subject to reevaluation in 2015 (U.S. Fish and Wildlife Service, 2013).

Sage-grouse are closely tied to sagebrush shrublands for food and cover, but specific habitat requirements vary throughout the year. Sage-grouse leks are situated in areas with minimal shrub cover, which enhances the visibility of displaying males, and adjacent to relatively dense sagebrush, which provides escape, thermal, and feeding cover (Patterson, 1952; Gill, 1965). Females usually nest within 6.4 kilometers (km; 4 miles [mi]) of the leks where they breed (Colorado Greater Sage-grouse Steering Committee, 2008). Nests are generally located in areas where sagebrush canopy cover is greater and grasses are taller than they are in surrounding available habitats (Hagen and others, 2007). Additionally, tall, dense, herbaceous cover tends to increase the probability of successful hatching (Holloran and others, 2005). Chicks initially are reared near the nest in sagebrush-dominated areas (Connelly and others, 2000). During the first few weeks after hatching, insects compose the bulk of the chick's diet, with forbs becoming a greater proportion of the diet later in summer when broods move to more mesic areas (Johnson and Boyce, 1990; Connelly, Rinkes, and Braun, 2011). In winter, sage-grouse rely almost exclusively on sagebrush for forage and shelter (Connelly, Rinkes, and Braun, 2011). To meet their seasonal habitat needs, sage-grouse need large areas of relatively interconnected sagebrush (Connelly, Rinkes, and Braun, 2011).

Because of their value as a game species, their iconic status, and their potential value as an umbrella species for conservation of sagebrush shrublands in the western United States (Rowland and others, 2006; Hanser and Knick, 2011), a number of conservation strategies have been initiated by Federal and State agencies to protect and conserve sage-grouse. The first comprehensive conservation strategy was developed by the Western Association of Fish and Wildlife Agencies, including a range-wide assessment of population trends (Connelly and others, 2004). To assess population and habitat trends independently of administrative boundaries, the Western Association of Fish and Wildlife Agencies identified seven sage-grouse management zones based largely on regional differences in the floristic composition of sagebrush shrublands (Stiver and others, 2006). The Wyoming Basin ecoregion closely corresponds to Management Zone II, which includes the largest sage-grouse population (minimum population estimated at approximately 42,500 males in 2007) (Garton and others, 2011). Estimates of sage-grouse populations in the Wyoming Basin indicate a pronounced decline between 1978 and the mid-1980s, but since 1987, populations appear to have remained relatively stable with no significant trends (Garton and others, 2011); however, confidence levels for population estimates prior to the mid-1980s are much lower than they are for more recent population estimates.

Landscape Structure and Dynamics

Landscape-level features are important to understanding seasonal habitat requirements and movements of sage-grouse (Doherty and others, 2008; Knick and others, 2013). The sage-grouse has been identified as a landscape species because it relies on extensive areas of sagebrush shrublands that include a variety of specific habitat elements for leks, nest sites, brood rearing, and wintering (Connelly and others, 2004). The species also has been documented using riparian meadows, edges of agricultural fields, and occasionally patchy sagebrush habitats located near woodlands (Connelly, Rinkes, and Braun, 2011).

Sage-grouse populations exhibit a variety of movement patterns throughout the year. Resident populations remain within year-round home ranges, moving only short distances between seasonal habitat types. Migratory populations move longer distances among breeding, brood-rearing, summering, and (or) wintering ranges. Some populations include both resident and migratory individuals (Connelly and others, 2000). Migration patterns likely depend on the juxtaposition of vegetation types that meet crucial seasonal habitat requirements (Connelly and others, 2000). Although seasonal movement patterns are still poorly understood for many populations, some sage-grouse populations have been documented moving up to 160 km (99.4 mi) annually as they travel among breeding, summering, and wintering ranges (Connelly, Hagen, and Schroeder, 2011). In general, populations of sage-grouse have persisted in areas where sagebrush dominates 50−79 percent of the landscape (Aldridge and others, 2008; Wisdom and others 2011; Knick and others, 2013); however, seasonally specific spatial requirements of this species, such as the amount of suitable winter range necessary to maintain a population or the minimum sagebrush patch size required for nesting, is unknown. Quite likely, the seasonal spatial requirements are variable, depending on local landscape configurations, the quality of habitats available, and population size (Connelly, Hagen, and Schroeder, 2011).

Historically, large fires in sagebrush shrublands were infrequent but would have burned significant portions of sage-grouse habitat during years with large fires (Bukowski and Baker, 2013). The response of sage-grouse to such large fires is unknown but possibly had a significant effect on regional habitat availability and sage-grouse populations every few centuries. However, the broad expanse of sagebrush and associated sage-grouse populations prior to Euro-American settlement may have buffered populations from infrequent habitat losses during years of extensive fire. Because development has led to the loss and fragmentation of sagebrush shrublands, further loss of sagebrush as a result of large fires is generally viewed as a threat to maintaining viable sage-grouse populations in most regions (Manier and others, 2013).

Change Agents

The Western Association of Fish and Wildlife Agencies Integration Team (Stiver and others, 2006) identified and prioritized seven threats to sage-grouse populations for eastern portions of the species' range, including the Wyoming Basin ecoregion, as follows: energy development, infrastructure, livestock herbivory, dispersed recreation, agriculture, fences, and invasive plants. Below we summarize the effects of these and other Change Agents on sage-grouse.

Development

Human populations have grown substantially over the past century, primarily in western portions of sagebrush shrublands (Knick and others, 2011), with negative consequences for sage-grouse. Indeed, areas where sage-grouse have been extirpated have considerably higher human densities than occupied habitat (Aldridge and others, 2008; Wisdom and others, 2011).

Energy and Infrastructure

All types of oil and gas development have consistently negative effects on sage-grouse across their range (Naugle and others, 2011). Even low densities of energy development can negatively affect lek attendance. In Wyoming, male lek attendance has been found to decline if well-pad densities exceeded 1−3 pads per 2.6 square kilometers (km^2; 1.5 square miles [mi^2]) within 3.2−8 km (2−5 mi) of a lek (Harju and others, 2010; Naugle and others, 2011). Because sage-grouse have a strong fidelity to their seasonal ranges, there is generally a 2- to 10-year time lag before male lek attendance begins to decline after energy development begins (Holloran, 2005; Walker and others, 2007; Harju and others, 2010); therefore, observations immediately following installation of energy infrastructure may not reflect the long-term effects. Female survival and reproductive output also have been shown to decline in areas where energy development is occurring (Naugle and others, 2011).

Studies of sage-grouse responses to wind-energy development are currently underway, and it is premature to draw conclusions from them (Manier and others, 2013). There are, however, similar types of infrastructure and disturbance associated with renewable and nonrenewable energy (such as roads, transmission lines and other elevated structures). Therefore, renewable energy development is likely to have similar negative effects on sage-grouse populations (Manier and others, 2013).

Roads are ubiquitous across the range of sage-grouse; almost all existing sage-grouse habitat falls within 2.5 km (1.55 mi) of a paved road (Knick and others, 2011). Studies have documented decreased male attendance at leks near roads (Remington and Braun, 1991; Holloran, 2005), avoidance of roads by nesting and summering females (LeBeau, 2012), and reduced nest-initiation rates for females attending leks near roads (Lyon and Anderson, 2003). Across western portions of the sage-grouse's range, persistence of leks decreases with increasing density of interstates, paved highways, and secondary roads within a 5-km (3.1-mi) radius (Knick and others, 2013). Along Interstate 80 in Wyoming and Utah, no leks were found within 2 km (1.2 mi) of the interstate, and lek density was lower within 7.5 km (4.7 mi) compared to lek densities >7.5 km from the interstate (Connelly and others, 2004). Dispersed recreation along improved and four-wheel drive roads is also expected to negatively affect the species, but these effects have not been established empirically (Knick and others, 2011).

Power lines may result in indirect habitat loss, as sage-grouse tend to avoid tall structures (Connelly and others, 2004); however, there is limited evidence for effects of power lines on sage-grouse (Manier and others, 2013). In western portions of the range, leks were absent where power line densities were >200 m/km^2 (1699.5 ft/mi^2) (Knick and others, 2013). Other studies have documented that lek attendance by males decreased after construction of a transmission line

(Ellis, 1985), brood-rearing females avoided habitat near transmission lines (LeBeau, 2012), and direct mortality of yearlings resulted from collisions with power lines (Beck and others, 2006).

Agricultural Activities

Conversion of sagebrush to croplands has reduced and fragmented sage-grouse habitat (Knick and others, 2011). Of the sagebrush habitat already converted to cropland, 75 percent is located where soils are deeper and more productive (Connelly and others, 2004). Wisdom and others (2011) compared locations from which sage-grouse have been extirpated to those where they persist and found that extirpation was more likely where cropland exceeded 25−27 percent of the surrounding areas. In addition, studies have found that lek persistence and population size were negatively correlated with conversion of sagebrush to agriculture in areas around leks (Smith and others, 2005; Walker and others, 2007; Knick and others, 2013).

Compared to agricultural conversion, effects of livestock grazing on soils and vegetation of sagebrush shrublands are often less dramatic, although grazing is more widespread across the ecoregion (Knick and others, 2011). Around water and mineral sources, however, high concentrations of livestock can lead to removal of vegetation and compaction of soils (Knick and others, 2011). Livestock grazing primarily influences sage-grouse by altering the structure and composition of the vegetation (Knick and others, 2011). There are few published studies that have evaluated direct impacts of livestock grazing on sage-grouse and results are mixed. Light livestock grazing in mesic upland meadows can promote forb growth and availability, which may benefit summering sage-grouse (Beck and Mitchell, 2000). In addition, sage-grouse will use sheep salting grounds as leks (Beck and Mitchell, 2000). In contrast, sage-grouse avoid heavily grazed wet meadows in summer, and livestock have been observed trampling nests and causing nest desertions (Beck and Mitchell, 2000). Overall, effects of grazing appear to vary by ecological context and stocking levels. Fences also have negative effects on sage-grouse. They can be barriers to movements (especially woven-wire fences), can serve as predator travel corridors or perches, and can be the cause of direct mortality (collisions during flight) (Braun, 1998). Fences tend to be especially problematic for sage-grouse when they are located near leks, in areas of low topographic relief, bisect winter concentration areas, or border riparian areas (Christiansen, 2009; Stevens and others, 2012).

Altered Fire Regime

The interactive effects of cheatgrass and concomitant alteration of fire regimes (see Altered Fire Regimes in Chapter 11—Sagebrush Steppe and Chapter 5—Wildland Fire) is a concern, primarily in the Columbia Basin, Great Basin, and Snake River Plain (Knick and Hanser, 2011). In the Wyoming Basin, however, fire regimes are still fairly consistent with the pattern of historical fire regimes (Bukowski and Baker, 2013), although locally cheatgrass and its potential to alter fire regimes is becoming a cause for concern. Although fire regimes do not appear to have been greatly altered in the Wyoming Basin, changes in fire size or frequency may be problematic because habitat loss and fragmentation may have decreased the capacity of sage-grouse populations to withstand the effects of larger, more frequent fires (Bukowski and Baker, 2013). There is also little scientific evidence supporting the benefits of prescribed fire to sage-grouse, especially in habitats dominated by Wyoming big sagebrush (Beck and others, 2012); indeed, recent conservation strategies have suggested that prescribed fire is unnecessary in sagebrush systems and could be detrimental to sage-grouse populations (Connelly and others, 2011; Manier and others, 2013). Prescribed fire has been commonly used to control the expansion of juniper woodlands into sage-grouse habitats, which is a concern in some areas (Knick and others, 2011; Baruch-Mordo and others, 2013; Knick and others, 2013). The degree to which fire exclusion (including the effects of grazing on fuels) is the cause of juniper woodland expansion, or if expansion is largely a natural consequence of long-term landscape dynamics along sagebrush-juniper ecotones, is unclear and could vary across the sage-grouse's range (see Chapter 17—Juniper Woodlands).

Invasive Species

Invasive plants in sagebrush systems, especially invasive annual grasses such as cheatgrass, can alter plant-community structure, composition, and productivity and can competitively exclude native plants that provide cover and forage for sage-grouse (Rowland and others, 2010). Recruitment of male sage-grouse at leks in central Nevada was consistently low in areas with high proportions of exotic grasslands within 5 km (3.2 mi) of leks (Blomberg and others, 2012). The primary risk from exotic annual grasses, however, is the potential conversion of sage-grouse habitat to annual grasslands as a result of increasing fire frequency and intensity following cheatgrass invasion (see Invasive Plants in Chapter 11—Sagebrush Steppe).

Disease

West Nile virus is a potential threat to populations of sage-grouse (Walker and Naugle, 2011). Since 2002, when it was first detected in sage-grouse populations, West Nile virus has been detected throughout the sage-grouse's range (Kilpatrick and others, 2007). Sage-grouse lack resistance to West Nile virus, and exposure to the virus is fatal (Clark and others, 2006) to all age classes, which could lead to local and regional population declines (Walker and Naugle, 2011). The occurrence of surface water in association with oil and gas wells, stock ponds, and other artificial water bodies provides breeding opportunities for mosquito vectors of West Nile virus, thereby increasing opportunities for transmitting the virus to sage-grouse (Walker and Naugle, 2011). If temperatures increase in the region as projected by climate change models, West Nile virus outbreaks could become more severe because higher temperatures promote faster development of mosquito larvae and shorter incubation times for the virus (Walker and Naugle, 2011).

Climate Change

In addition to habitat changes that may result from shifts in sagebrush shrublands, sage-grouse population dynamics also may be affected by changes in climatic conditions. For example, in central Nevada, chick survival and population growth increased in years with higher precipitation, whereas annual adult male survival was lower in years with higher maximum temperatures (Blomberg and others, 2012). The results of this study suggest that decreased precipitation and increased temperatures, as well as ecological processes expected to result from climate change, could negatively influence sage-grouse population dynamics, especially in southern portions of the species range (Blomberg and others, 2012).

Rapid Ecoregional Assessment Components Evaluated for Sage-Grouse

A generalized, conceptual model was used to highlight some of the key ecological attributes and Change Agents affecting sage-grouse (fig. 23–1). Key ecological attributes addressed by the REA include (1) the distribution of sage-grouse habitat (area and proximity to leks), (2) landscape structure (patch sizes and structural connectivity), and (3) landscape dynamics (fire occurrence and conifer expansion risk; table 23–1). The Change Agents evaluated include development, West Nile virus, and climate change (table 23–2). Ecological values and risks used to assess the conservation potential for sage-grouse habitat by township are summarized in table 23–3. Core and Integrated Management Questions and the associated summary maps and graphs are provided in Table 23–4.

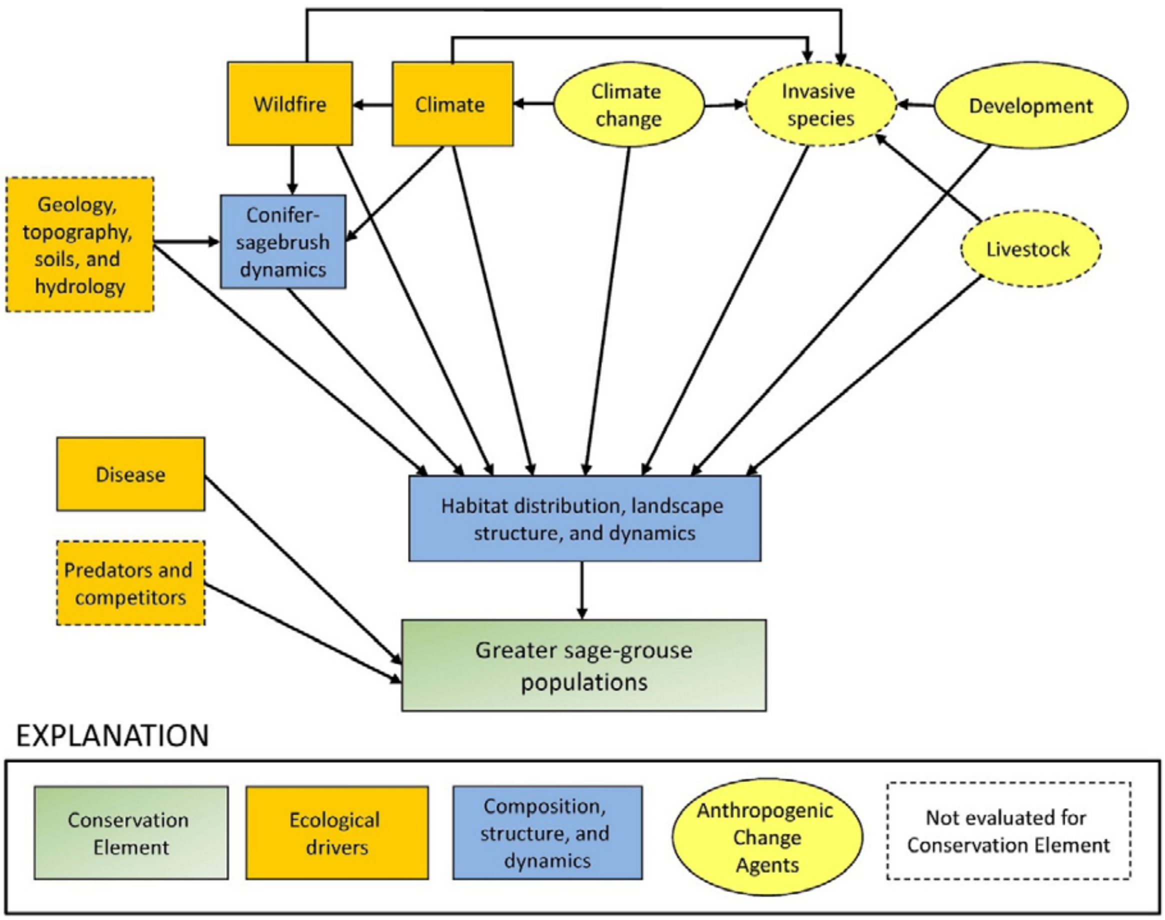

Figure 23–1. Generalized conceptual model of greater sage-grouse habitat for the Wyoming Basin Rapid Ecoregional Assessment (REA). Biophysical attributes and ecological processes regulating the occurrence, structure, and dynamics of sage-grouse populations and habitat are shown in orange rectangles; additional ecological attributes are shown in blue rectangles; and anthropogenic Change Agents that affect key ecological attributes are shown in yellow ovals. The dashed lines indicate components not addressed by the REA. Livestock and invasive plants are Change Agents that were not evaluated due to the lack of region-wide data.

Table 23‒1. Key ecological attributes and associated indicators of baseline greater sage-grouse habitat[1] for the Wyoming Basin Rapid Ecoregional Assessment.

[km, kilometer; mi, mile]

Attributes	Variables	Indicators
Amount and distribution of habitat	Total area	Habitat distribution derived from vegetation and abiotic variables (Hanser and others, 2011)[2]
	Proximity to leks	Area of habitat within 6.4 km (4 mi) of leks
Landscape Structure	Patch size	Patch-size frequency distribution
	Structural connectivity[3]	Interpatch distance that provides an index of structural connectivity for baseline patches at local, landscape, and regional (0.27 km; 0.17 mi) levels
Landscape dynamics	Fire occurrence[4]	Locations of fires and annual area burned since 1980
	Potential conifer expansion risk near leks	See Chapter 17—Juniper Woodlands

[1] Baseline conditions are used as a benchmark to evaluate changes in the amount and landscape structure of sage-grouse habitat due to Change Agents. Baseline conditions are defined as the potential current distribution of greater sage-grouse habitat derived from existing abiotic and biotic variables without explicit inclusion of Change Agents (see Chapter 2—Assessment Framework and the Appendix).

[2] Baseline habitat is derived from the greater sage-grouse general-use model without development variables developed by Hanser and others (2011) for the Wyoming Basin (Appendix). Lek data were provided by Wyoming Game and Fish Department; Idaho Department of Fish and Game; Utah Division of Wildlife Resources; and Montana Fish, Wildlife & Parks. Lek data were not available for Colorado.

[3] Structural connectivity refers to the proximity of patches at local, landscape, and regional levels but does not reflect species-specific measures of connectivity. See Chapter 2—Assessment Framework.

[4] See Wildland Fire section in the Appendix.

Table 23‒2. Anthropogenic Change Agents and associated indicators influencing sage-grouse habitat for the Wyoming Basin Rapid Ecoregional Assessment.

[km^2, square kilometer; mi^2, square mile; km, kilometer; mi, mile]

Change Agents	Variables	Indicators
Development	Terrestrial Development Index[1]	Percent of sage-grouse habitat in seven development classes using a 16-km^2 (6.18-mi^2) moving window
		Patch-size frequency distribution for sage-grouse habitat that is relatively undeveloped or has low development scores compared to baseline conditions
		Interpatch distances that provide an index of structural connectivity for relatively undeveloped patches at local (0.27 km; 0.17 mi), landscape (2.97 km; 1.85 mi), and regional (3.78 km; 2.35 mi) levels
Disease	West Nile virus[2]	Potential risk for West Nile virus using current and projected climate scenarios
Climate change	Potential changes in sagebrush shrublands	See Chapter 11─Sagebrush Steppe

[1] See Chapter 2—Assessment Framework.

[2] Derived from model results for current conditions and in 2050 (Harrigan and others, 2014).

Table 23–3. Landscape-level ecological values and risks for greater sage-grouse habitat. Ranks were combined into an index of conservation potential for the Wyoming Basin Rapid Ecoregional Assessment.

[km, kilometer; mi, mile]

	Variables[1]	Relative rank: Lowest	Relative rank: Medium	Relative rank: Highest	Description[2]
Values	Area	<35	35–79	<79	Percent of township modeled as sage-grouse habitat
	Proximity to leks	<20	20–80	>80	Percent of habitat within township that is within 6.4 km (4 mi) of leks
Risks	Terrestrial Development Index (TDI)	<1	1–3	>3	Mean TDI score by township

[1] Township was used as the analysis unit for conservation potential on the basis of input from the Bureau of Land Management. A minimum area threshold of total area per township was established for sagebrush steppe to minimize the effects of extremely small areas and put greater emphasis on large areas (see table A–19 in the Appendix).

[2] See tables 23–1 and 23–2 for description of variables.

Table 23–4. Management Questions addressed for greater sage-grouse for the Wyoming Basin Rapid Ecoregional Assessment.

[km, kilometer; mi, mile]

Core Management Questions	Results
Where are baseline habitat and Preliminary Priority Habitat for greater sage-grouse, and what is the total area of each?	Figure 23–2
Where does development pose the greatest threat to baseline greater sage-grouse habitat, and where are the relatively undeveloped areas?	Figures 23–3 and 23–4
How has development fragmented baseline greater sage-grouse habitat, and where are the large, relatively undeveloped patches?	Figures 23–5 and 23–6
How has development affected structural connectivity of greater sage-grouse habitat relative to baseline conditions?	Figure 23–7
Where are potential barriers and corridors that may affect animal movements among relatively undeveloped habitat patches?	Figure 23–8
Where have recent fires occurred in baseline greater sage-grouse habitat, and what is the total area burned per year?	Figures 23–9 and 23–10
What is the potential risk from West Nile virus currently and in 2050?	Figure 23–11
Integrated Management Questions	**Results**
Where is relatively undeveloped greater sage-grouse habitat within 6.4 km (4 mi) of leks that falls outside of the Preliminary Priority Habitat designation?	Figures 23–12 and 23–13
How does risk from development vary by land ownership or jurisdiction for greater sage-grouse habitat?	Table 23–5, Figure 23–14
Where are the townships with the greatest landscape-level ecological values?	Figure 23–15
Where are the townships with the greatest landscape-level risks?	Figure 23–16
Where are the townships with the greatest conservation potential?	Figure 23–17

Methods Overview

We identified baseline sage-grouse habitat using the greater sage-grouse general habitat-use model developed by Hanser and others (2011) derived from sage-grouse pellet surveys. Predictor variables in the model included percent cover of sagebrush shrublands (sagebrush steppe and mountain big sagebrush, which is part of the foothill shrublands and woodlands community) and riparian vegetation, annual minimum temperature, topographic roughness, and elevation (table 23–1). We masked out forest, open water, and elevations >2,900 m (9,514 ft). The map of potential habitat in baseline condition used a probability of occurrence threshold >0.25; this probability threshold was used to minimize omission errors derived from an independent dataset of lek locations (95 percent of leks included at a 0.25 threshold). We used the top model of Hanser and others (2011) that was derived from vegetation and topographic features but did not include development variables (roads, oil and gas well pads), which allowed us to compare (1) baseline conditions to relatively undeveloped habitat (Terrestrial Development Index [TDI] score ≤1 percent), and (2) the spatial characteristics of sage-grouse habitat to areas with little or no development.

We obtained spatial data for sage-grouse habitats designated as Preliminary Priority Habitat (PPH) (referred to as Greater Sage-Grouse Core Areas in Wyoming) from State wildlife agencies. The PPH was identified by state agencies in cooperation with the Bureau of Land Management (BLM) using the following general approach: each State agency initially delineated PPH by mapping leks and lek complexes and then applied a 6.4-km (4-mi) buffer around each one; PPH boundaries included buffers of leks used by a majority of the male population within a state (see Doherty and others, 2011). The PPH polygons were then refined using habitat suitability models (Colorado) (see Rice and others, 2013), expert knowledge of sage-grouse distribution, habitat conditions, and land-use patterns. Subsequent to the analysis of PPH in the REA, habitat designated for sage-grouse as Preliminary Priority Habitat (PPH) was used to finalize Priority Habitat Management Areas (Bureau of Land Management and U.S. Department of Agriculture Forest Service, 2015). Because there were differences between PPH used for the REA and the newly designated Priority Habitat Management Areas, we retained the PPH designation to reflect the dataset used for analysis.

We assessed development levels in sage-grouse habitat using the Terrestrial Development Index (TDI) map, and then used the resulting output to calculate patch size and structural connectivity metrics. We mapped the structural connectivity of relatively undeveloped habitat at three interpatch distances derived from connectivity analysis; local (0.27 km; 0.17 mi), landscape (2.97 km; 1.85 mi), and regional (3.78 km; 2.35 mi) levels. We used development levels to identify areas that may function as barriers or corridors by overlaying relatively undeveloped habitat patches on the TDI map. The perimeters of fires in sage-grouse habitat since 1980 were compiled from several data sources to assess fire frequency and extent (table 23–1). To evaluate potential risk of West Nile virus (currently and in 2050), we used output from spatial West Nile virus models developed by Harrigan and others (2014).

Landscape-level ecological values (area of habitat, proximity to leks) and risk (TDI score) were compiled into an overall index of conservation potential for each township (table 23–3). Conservation potential was summarized by township based on overall landscape-level values and risks (table 23–3). Landscape-level values and risks, and conservation potential rankings are intended to provide a synthetic overview of the geospatial datasets developed to address Core Management Questions in the REA. Because rankings 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. See Chapter 2—Assessment Framework and the Appendix for additional details on the methods.

Key Findings for Management Questions

Where are baseline habitat and Preliminary Priority Habitat for greater sage-grouse, and what are the total areas of each (fig. 23–2)?

- Baseline sage-grouse habitat totals 117,670 km^2 (45,432.6 mi^2) or 66 percent of the Wyoming Basin project area (80.2 percent of the ecoregion proper).
- Greater sage-grouse habitat is well distributed throughout lower elevations in the Wyoming Basin with the exception of the Bighorn Basin (fig. 23–2).
- A total of 65,764 km^2 (25,391.6 mi^2) is currently designated PPH, representing 56 percent of baseline habitat and 44.2 percent of the ecoregion proper.
- There are 83,454 km^2 (32,331.8 mi^2) of habitat within 6.4 km (4 mi) of currently occupied leks, which represents 71 percent of baseline habitat.

Where does development pose the greatest threat to baseline greater sage-grouse habitat, and where are the relatively undeveloped areas (figs. 23–3 and 23–4)?

- A total of 22.8 percent of baseline habitat is classified as relatively undeveloped (TDI score $\leq$1 percent) (figs. 23–3 and 23–4).
- Other development thresholds have been established for sage-grouse habitat. For example, 22.4 percent of baseline sage-grouse habitat has a TDI score that exceeds the 5 percent threshold established by the Office of the Governor of Wyoming (2011). In comparison, 33.8 percent of baseline sage-grouse habitat exceeds the 3 percent development threshold established by the Sage-Grouse National Technical Team (2011). It is important to note that our results are based on a moving-window size of 16 km^2 (6.18 mi^2).
- Development scores for PPH are similar to those for baseline sage-grouse habitat.
- The surface disturbance footprint from agriculture, transportation (railroads and roads, including roads associated with energy development), and energy and minerals development all contribute to the TDI scores for sage-grouse habitat, but the relative importance of each of these development classes varies across the ecoregion (see Chapter 4—Development).
- TDI scores for baseline sage-grouse habitat are similar to those for sagebrush steppe overall (see Chapter 11—Sagebrush Steppe).

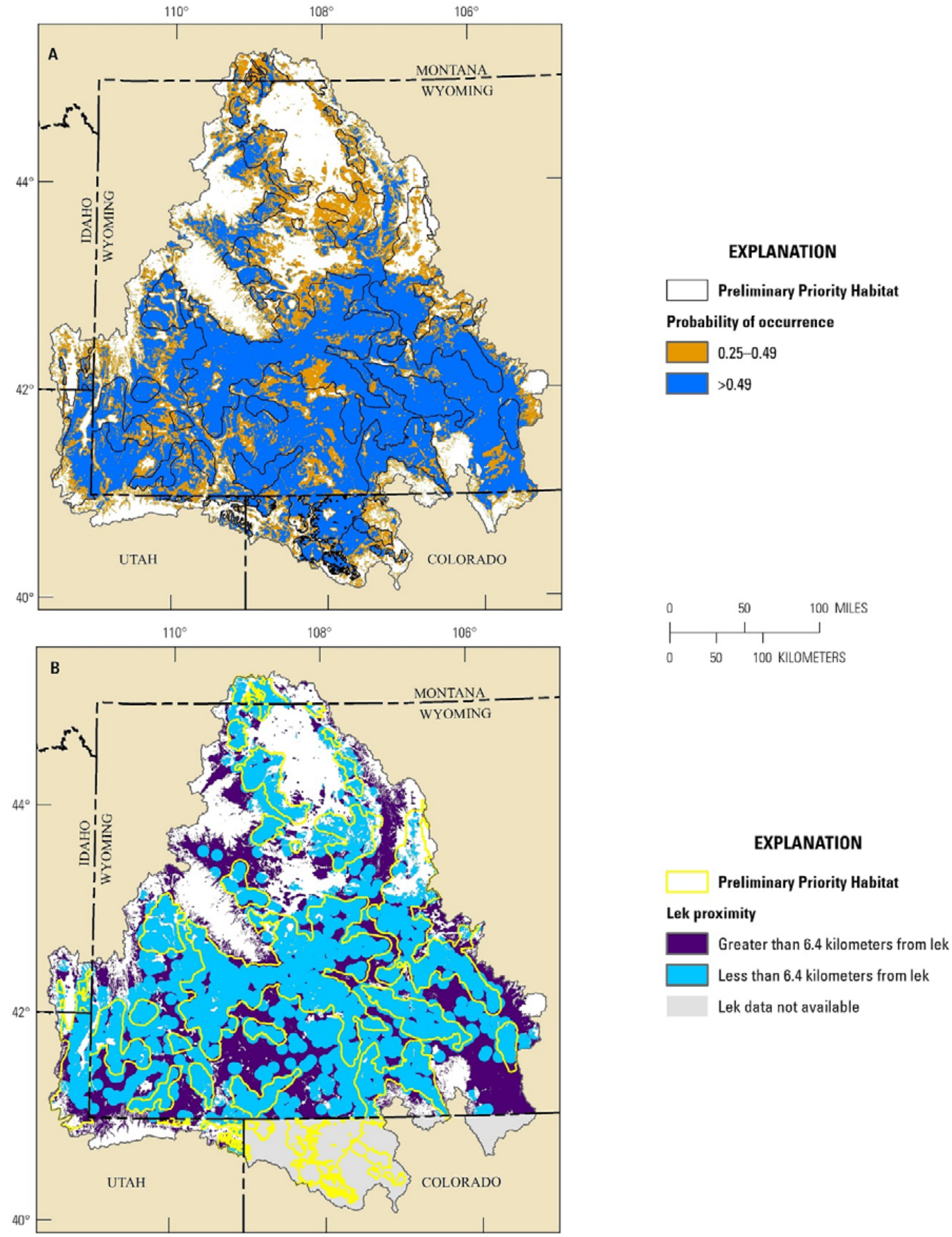

Figure 23–2. Distribution of baseline greater sage-grouse habitat in the Wyoming Basin Rapid Ecoregional Assessment project area. (*A*) Sage-grouse probability of occurrence derived from a habitat model developed by Hanser and others (2011) and (*B*) sage-grouse habitat (using probability of occurrence threshold >0.25) that is less than or greater than 6.4 km (4 mi) from leks. Preliminary Priority Habitats are included on each map.

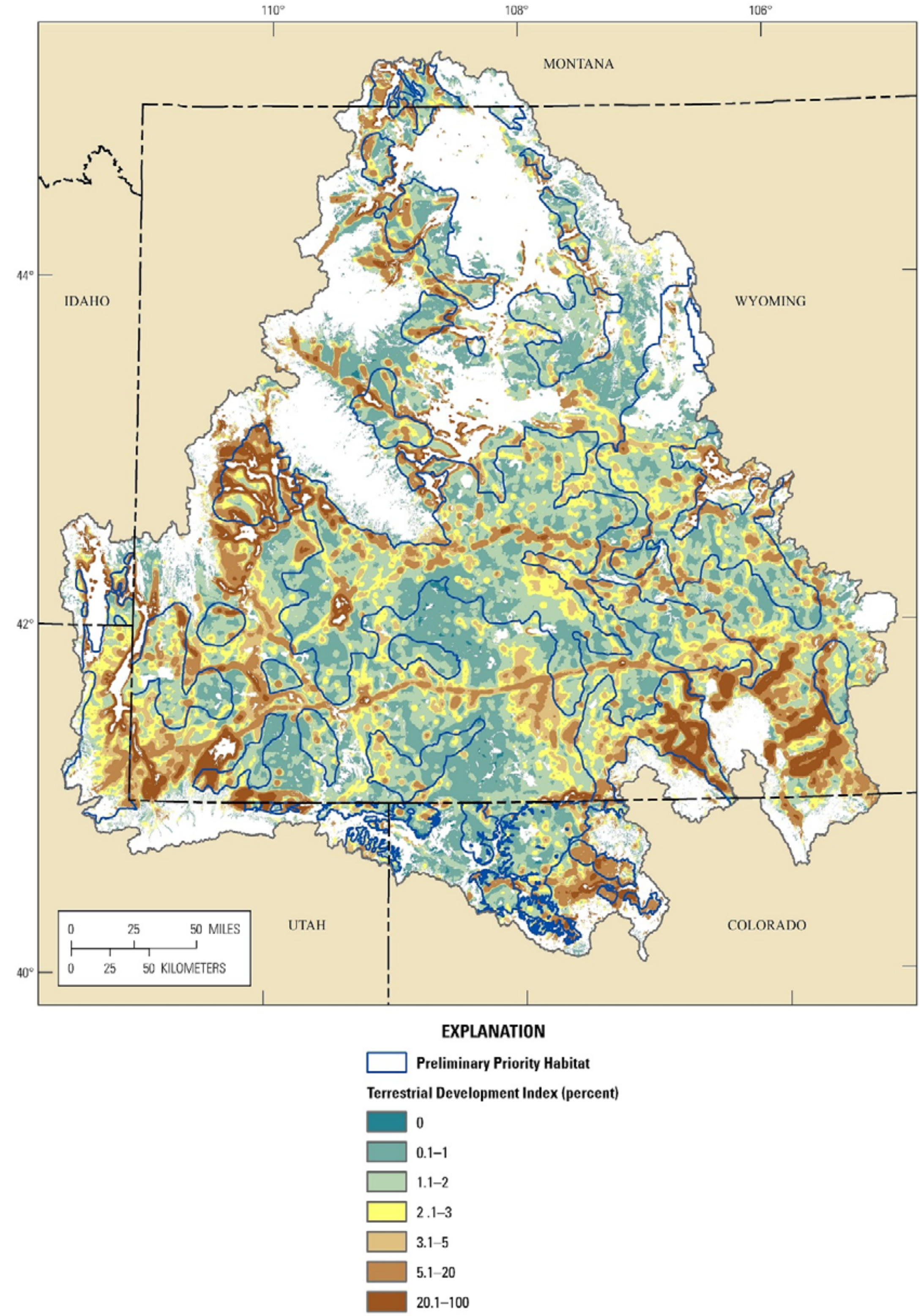

Figure 23–3. Terrestrial Development Index scores for baseline greater sage-grouse habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.

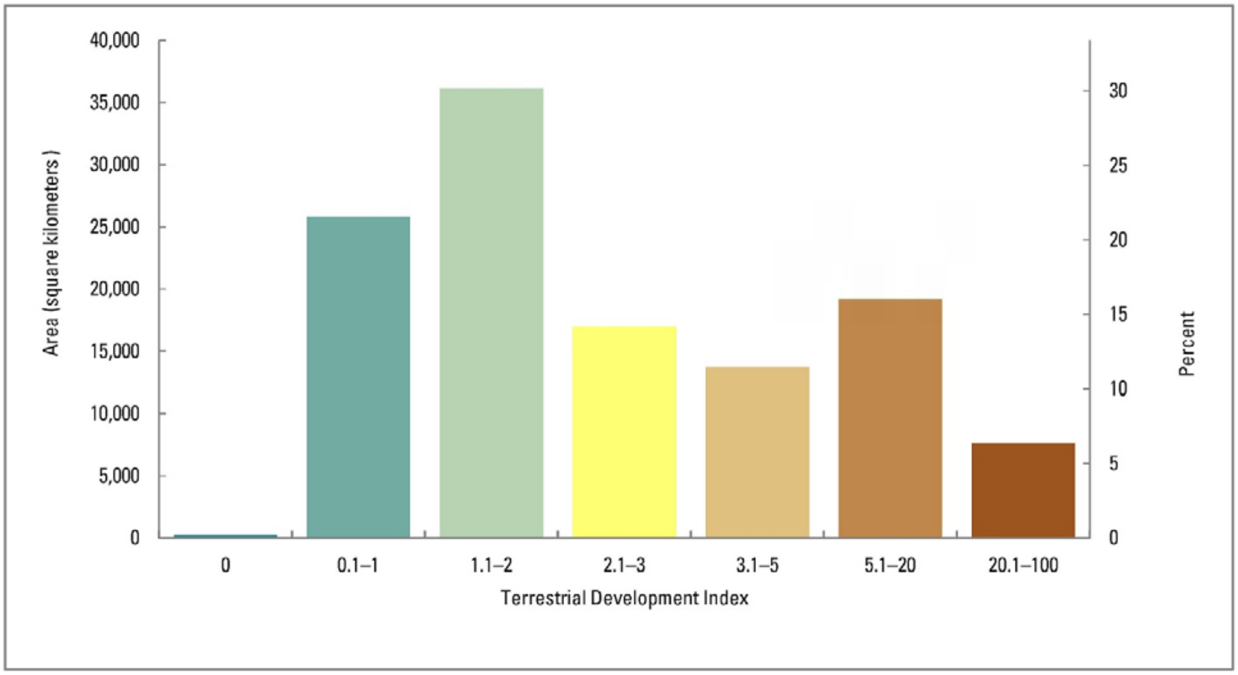

Figure 23–4. Area and percent of greater sage-grouse habitat as a function the Terrestrial Development Index in the Wyoming Basin Rapid Ecoregional Assessment project area.

How has development fragmented baseline greater sage-grouse habitat, and where are the large, relatively undeveloped patches of greater sage-grouse habitat (figs. 23–5 and 23–6)?

- Development has effectively fragmented sage-grouse habitat into smaller patches relative to the baseline conditions. All patches of relatively undeveloped sage-grouse habitat are <5,000 km^2 (1,931.5 mi^2), whereas 92 percent of baseline sage-grouse habitat occur within patches >5,000 km^2 (1,931.5 mi^2) (figs. 23–5 and 23–6).
- Several large areas of relatively undeveloped habitat >1,000 km^2 (386.1 mi^2) remain. Only one of these areas occurs in the northeastern portion of the Basin (fig. 23–6).
- Relatively undeveloped habitat patches <1,000 km^2 are scattered throughout the Basin (fig. 23–6).

How has development affected structural connectivity of greater sage-grouse habitat relative to baseline conditions (fig. 23–7)?

- Baseline sage-grouse habitat was highly connected, with local-, landscape-, and regional-level connectivity occurring at a 0.27-km (0.17-mi) interpatch distance.
- Development has greatly diminished the structural connectivity of sage-grouse habitat. Relatively undeveloped habitat is highly fragmented. Although local-level connectivity (0.27 km [0.17 mi]) was the same as baseline conditions, interpatch distances for landscape- (2.97 km [1.85 mi]) and regional-level connectivity (3.78 km [2.35 mi]) compared to baseline conditions for relatively undeveloped habitat were at least tenfold greater than baseline conditions.

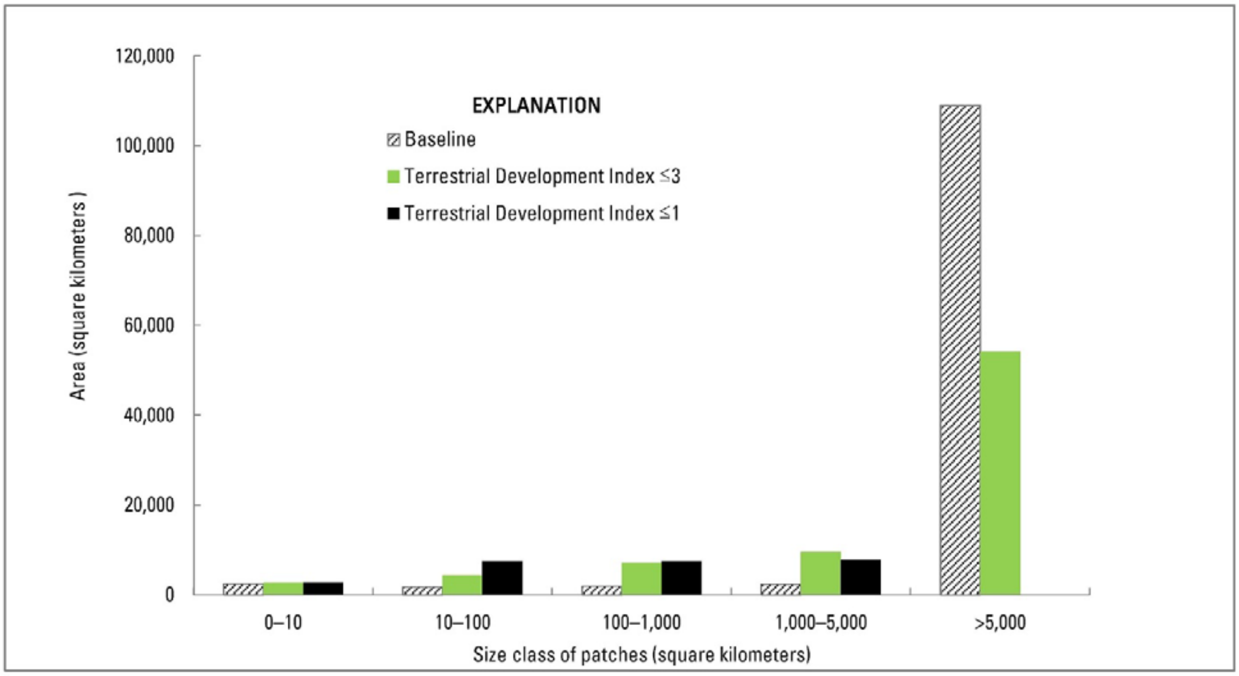

Figure 23–5. Area of greater sage-grouse habitat as a function of patch size for baseline conditions and two development levels: (1) Terrestrial Development Index (TDI) score ≤3 percent, and (2) TDI score ≤1 percent (relatively undeveloped areas) in the Wyoming Basin Rapid Ecoregional Assessment project area.

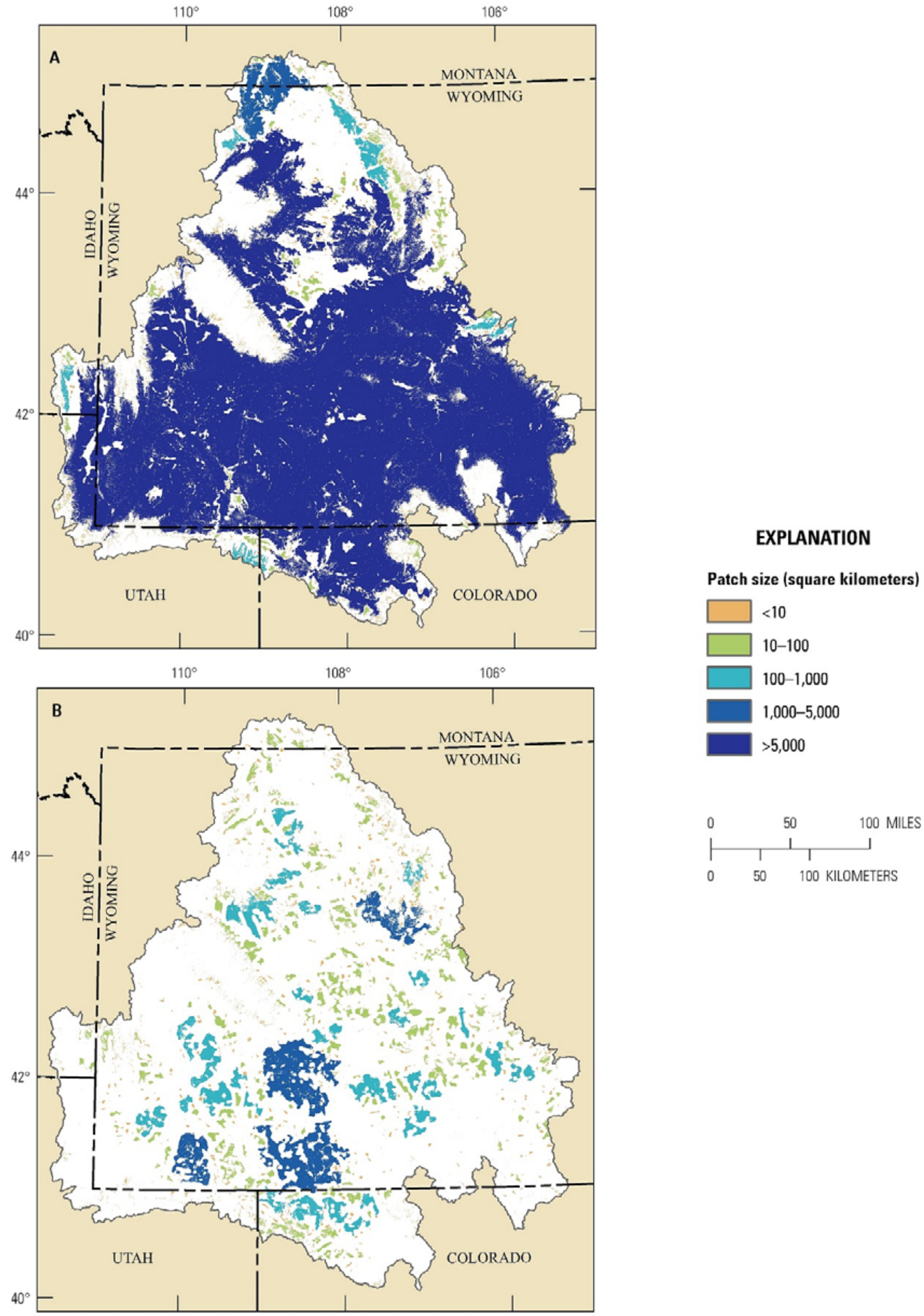

Figure 23–6. Patch sizes of greater sage-grouse habitat in the Wyoming Basin Rapid Ecoregional Assessment project area for (A) baseline conditions and (B) relatively undeveloped areas (Terrestrial Development Index score ≤1 percent).

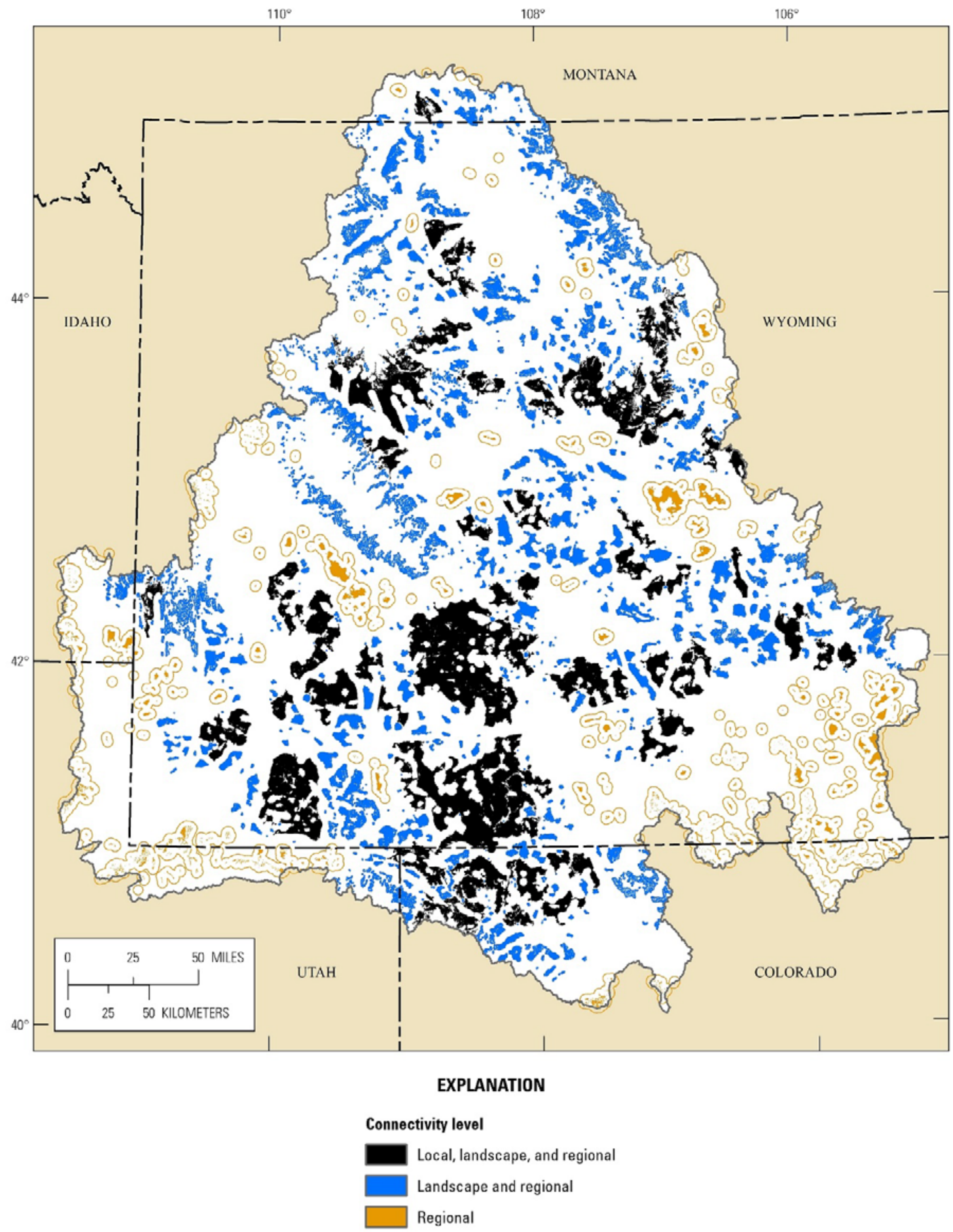

Figure 23–7. Structural connectivity of relatively undeveloped greater sage-grouse habitat in the Wyoming Basin Rapid Ecoregional Assessment project area. Black polygons include large and highly connected habitat patches. Blue polygons include habitat patches that contribute to both landscape and regional connectivity. Orange polygons represent isolated clusters of patches surrounded by developed areas or other cover types not typically used by sage-grouse.

Where are potential barriers and corridors that may affect animal movements among relatively undeveloped habitat patches (fig. 23–8)?

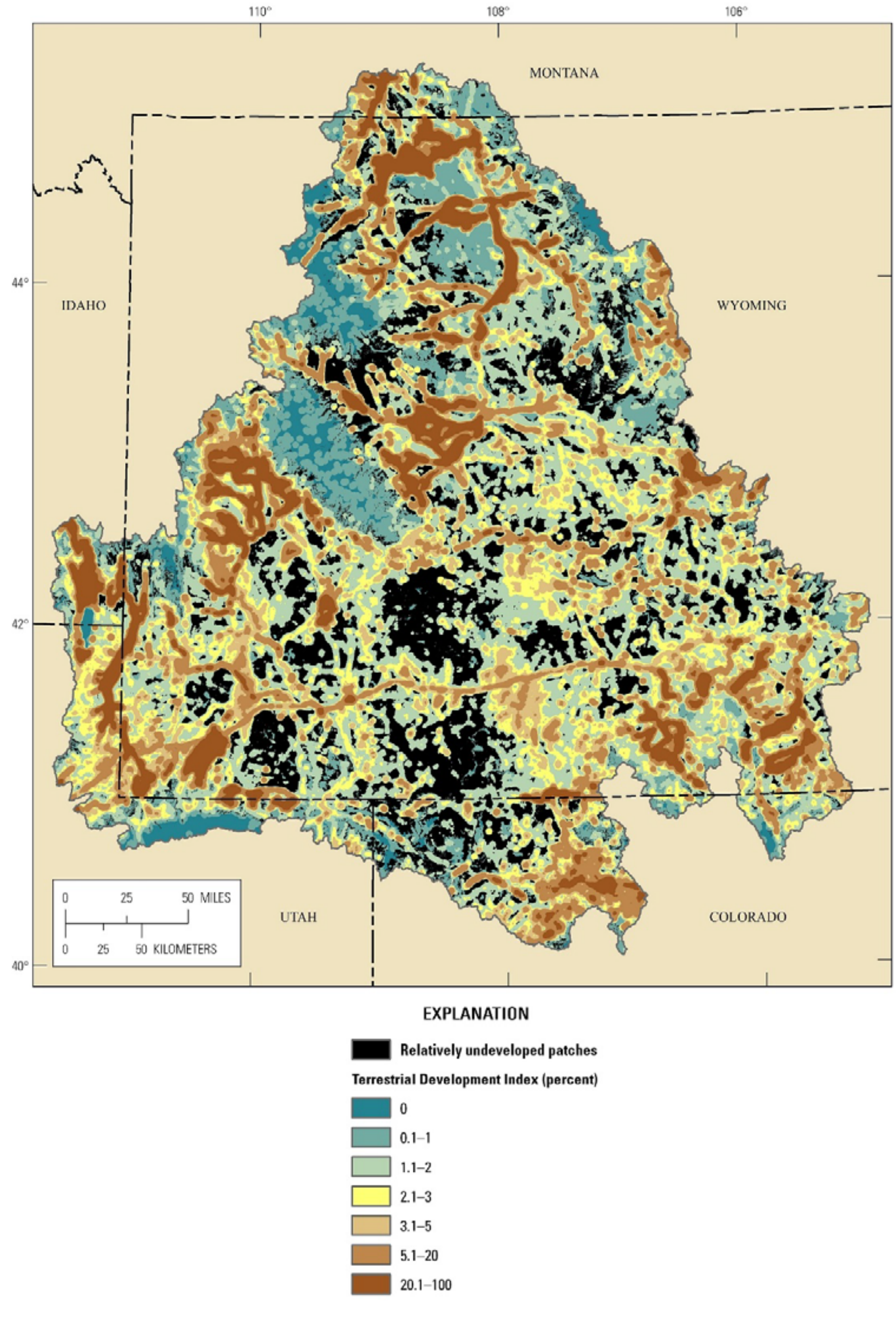

Figure 23–8. Potential barriers and corridors as a function of Terrestrial Development Index (TDI) score for lands surrounding relatively undeveloped greater sage-grouse habitat. Higher TDI scores (for example, >5 percent) represent potential barriers to movement among relatively undeveloped habitat patches. Lower TDI scores (for example, <2 percent) represent potential corridors for movements among patches.

Where have recent fires occurred in baseline greater sage-grouse habitat, and what is the total area burned per year (figs. 23–9 and 23–10)?

- Typically only a small fraction of sage-grouse habitat has burned each year since 1980. Cumulatively, 2.1 percent (2460 km^2 [949.8 mi^2]) of sage-grouse habitat has burned since 1980 (figs. 23–9 and 23–10).
  In most years, fires are small and burn only a small portion of sage-grouse habitat, with most of the area burned in three large fire years (1996, 2000, 2012) (fig. 23–9); see Chapter 5—Wildland Fire for more comprehensive discussion of fire).

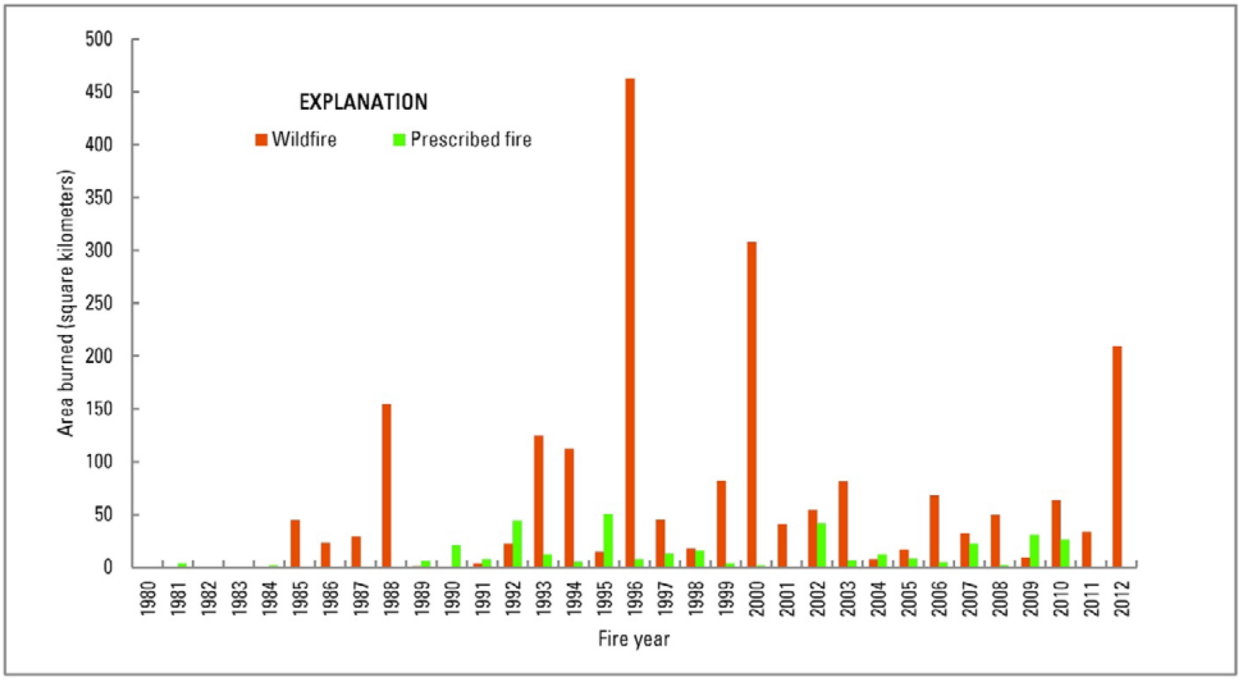

Figure 23–9. Annual area burned by wildfires and prescribed fires in baseline greater sage-grouse habitat since 1980 in the Wyoming Basin Rapid Ecoregional Assessment project area.

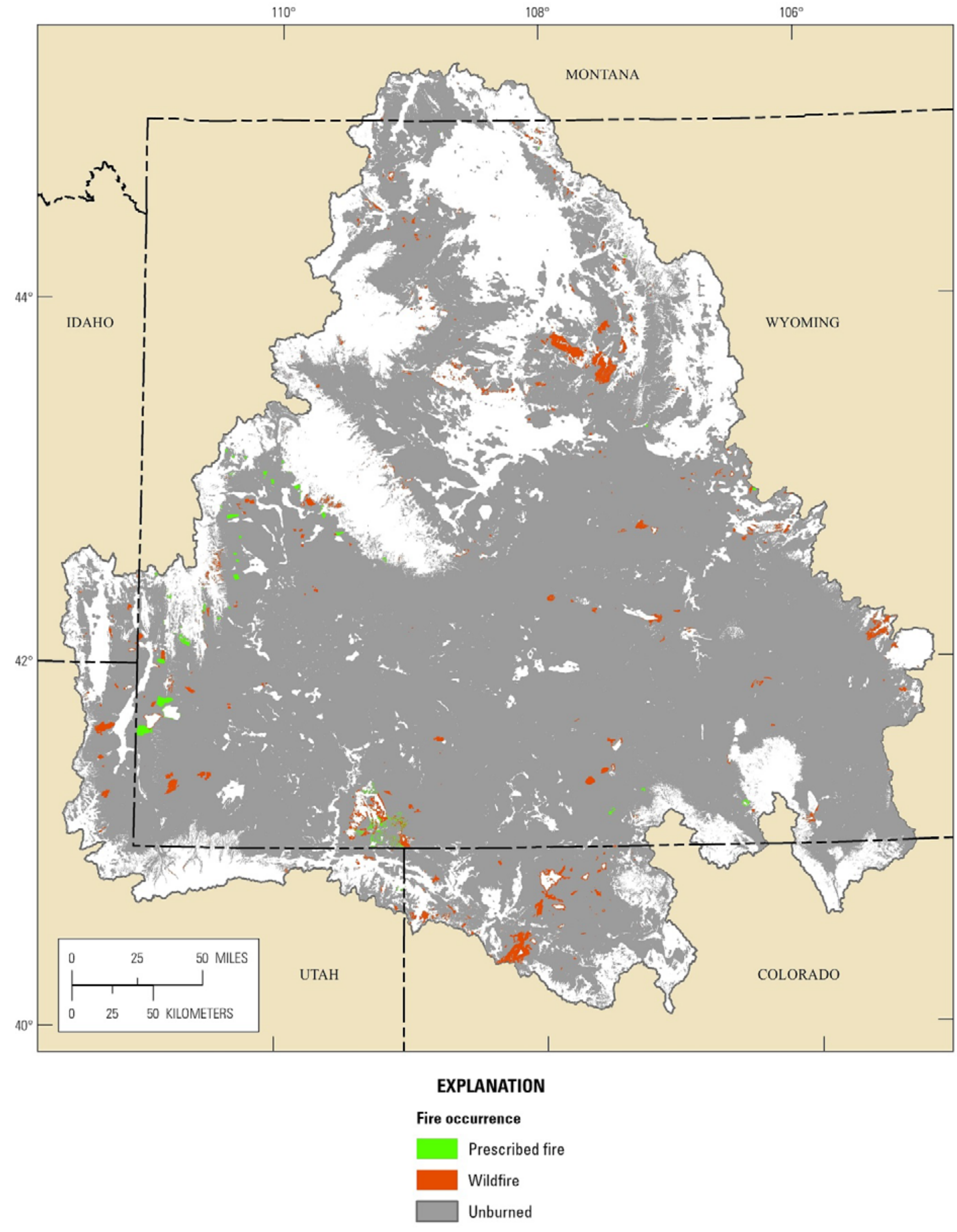

Figure 23–10. Occurrence of wildfires and prescribed fires in baseline greater sage-grouse habitat since 1980 in the Wyoming Basin Rapid Ecoregional Assessment project area.

What is the potential risk from West Nile virus currently and in 2050 (fig. 23–11)?

- Risk for West Nile virus has the potential to increase throughout much of the Wyoming Basin in 2050 derived from climate projections, except for areas directly north and west of Rock Springs, Wyoming (fig. 23–11).
- These results corroborate the projections of Schrag and others (2011) for Wyoming.

Where is relatively undeveloped greater sage-grouse habitat within 6.4 km (4 mi) of leks that falls outside of the Preliminary Priority Habitat designation (figs. 23–12 and 23–13)?

- Forty-six percent of relatively undeveloped sage-grouse habitat falls within areas designated as PPH (figs. 23–12 and 23–13).
- More than half of the relatively undeveloped habitat falling outside of PPH is also >6.4 km (4 mi) from leks. These areas represent sage-grouse habitat that may contribute to the size and structural connectivity of relatively undeveloped areas within PPH (figs. 23–12 and 23–13).

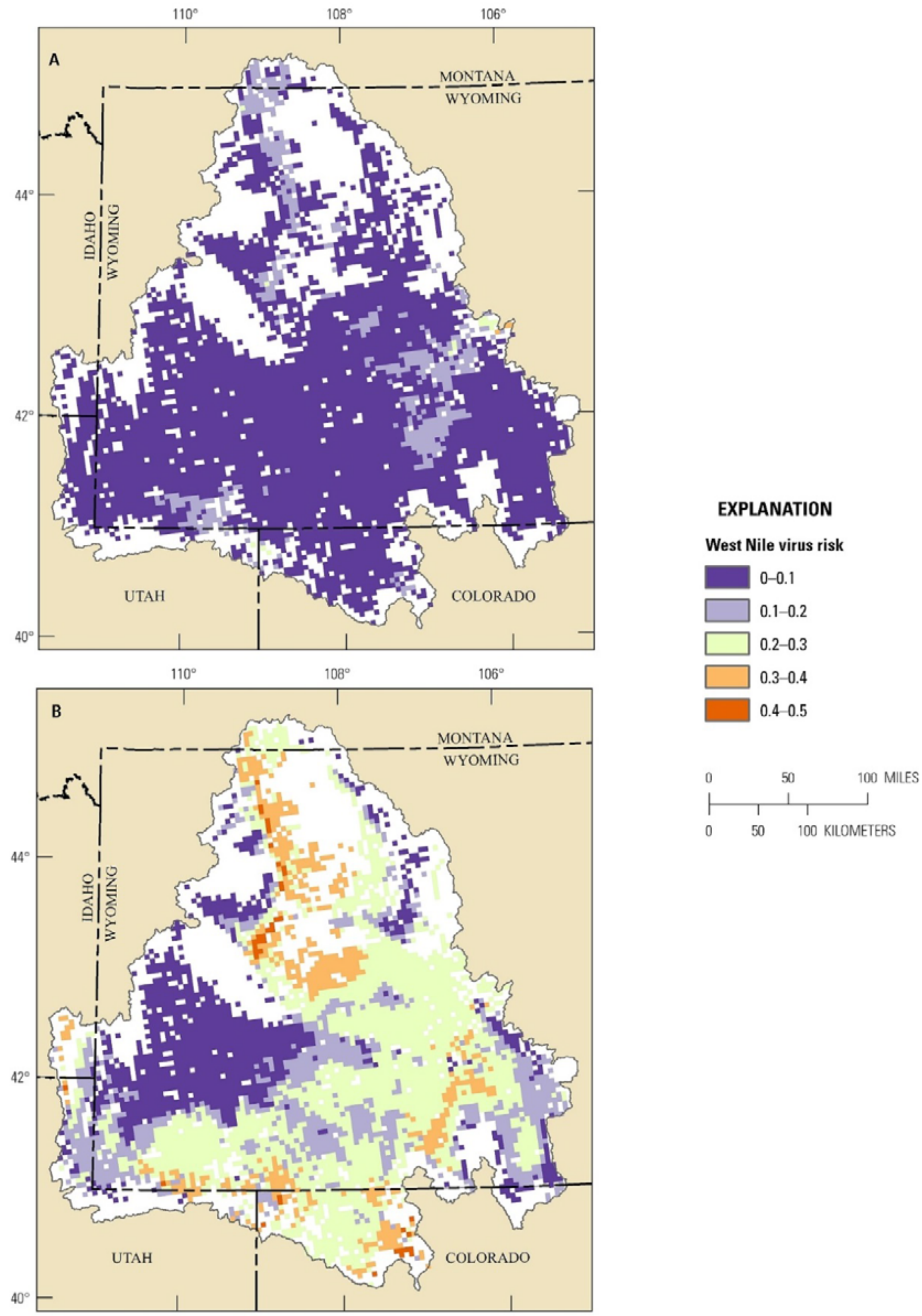

Figure 23–11. Potential risk of West Nile virus in baseline greater sage-grouse habitat in the Wyoming Basin Rapid Ecoregional Assessment project area. (*A*) Current risk and (*B*) projected risk in 2050 derived from probability of West Nile virus presence in vectors as modeled by Harrigan and others (2014).

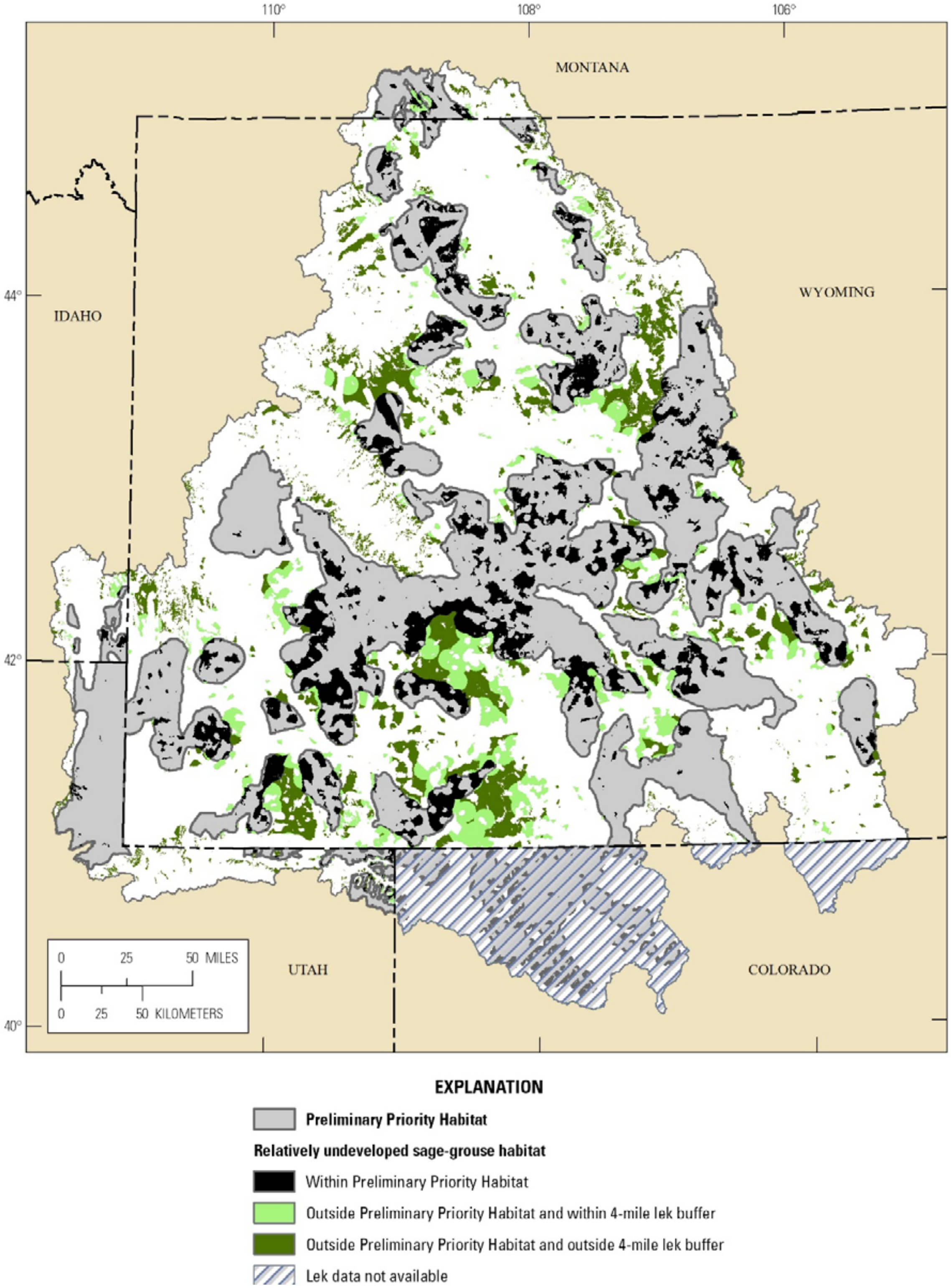

Figure 23–12. Relatively undeveloped greater sage-grouse habitat in relation to 6.4-km (4-mi) lek buffers and Preliminary Priority Habitat designation in the Wyoming Basin Rapid Ecoregional Assessment project area.

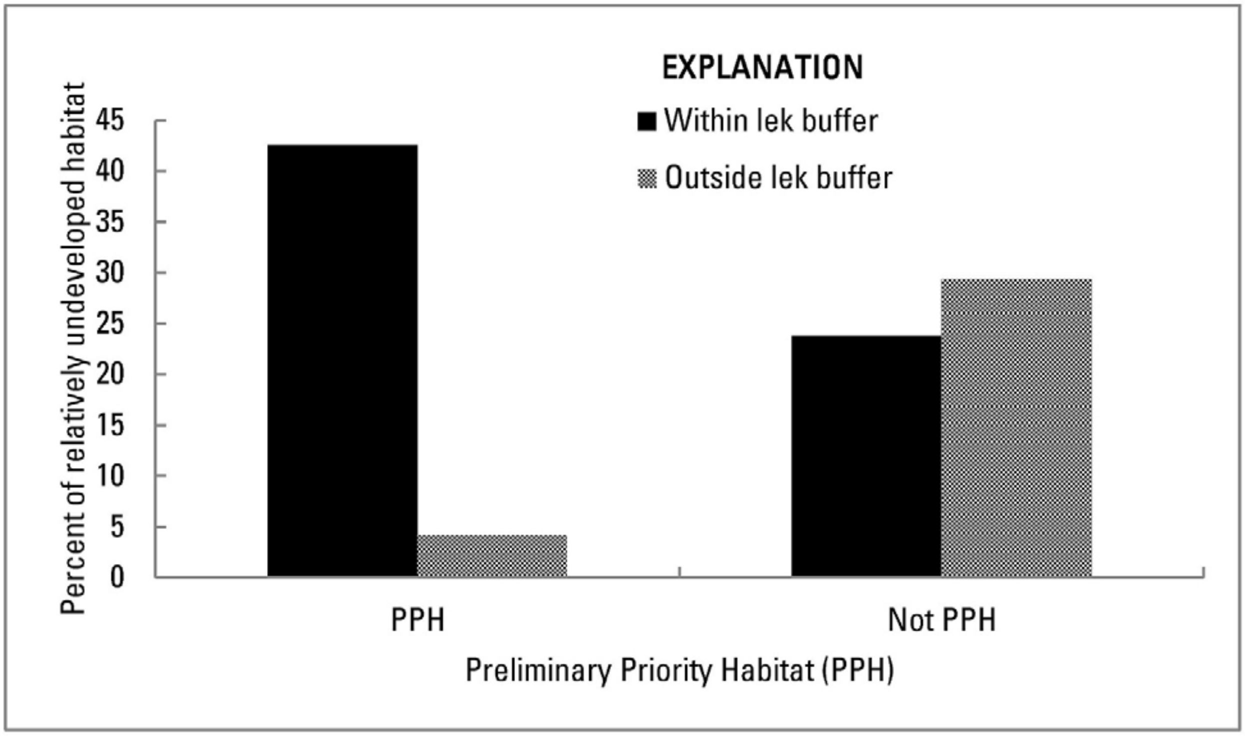

Figure 23–13. Percent of relatively undeveloped greater sage-grouse habitat within and outside 6.4-km (4-mi) lek buffers as it relates to Preliminary Priority Habitat designation in the Wyoming Basin Rapid Ecoregional Assessment project area.

How does risk from development vary by land ownership or jurisdiction for greater sage-grouse habitat (table 23–5, fig. 23–14)?

- Nearly half of greater sage-grouse habitat occurs on BLM lands, and another 36.5 percent is in private ownership (table 23–5).
- Sage-grouse habitat on BLM and U.S. Department of Agriculture Forest Service lands has a lower proportion of highly developed land than all other land ownerships (fig. 23–14).
- Tribal lands hold the greatest proportion of sage-grouse habitat with low development scores, followed by all U.S. Department of Agriculture Forest Service and BLM lands (fig. 23–14).

Table 23−5. Area and percent of greater sage-grouse habitat by land ownership or jurisdiction in the Wyoming Basin Rapid Ecoregional Assessment project area.
[km^2, square kilometer]

Ownership or jurisdiction	Area (km^2)	Percent
Bureau of Land Management	56,673	48.2
Private	42,997	36.5
State/County	8,451	7.2
Tribal	4,471	3.8
Other Federal[1]	2,282	1.9
Forest Service[2]	1,909	1.6
Private conservation	829	0.7

[1] National Park Service, Department of Defense, Department of Energy, Bureau of Reclamation, and U.S. Fish and Wildlife Service.

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

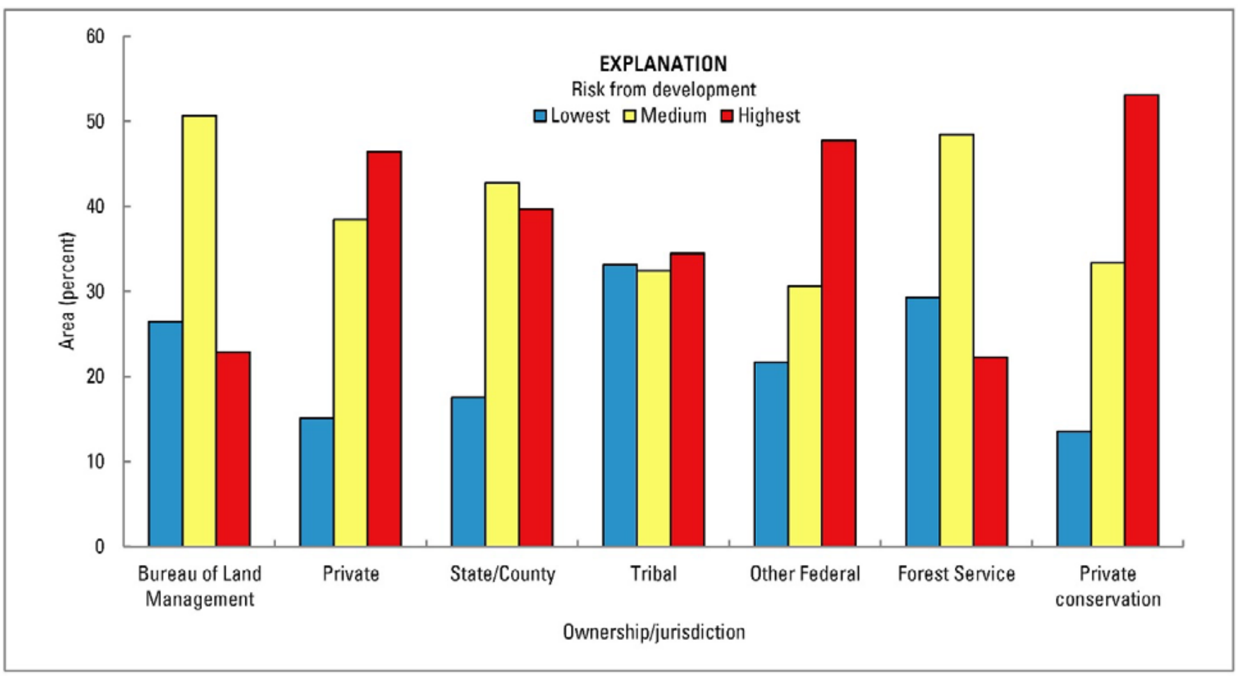

Figure 23–14. Relative ranks of risk from development, by land ownership or jurisdiction, for greater sage-grouse habitat in the Wyoming Basin Rapid Ecoregional Assessment project area. Rankings are lowest (Terrestrial Development Index [TDI] score <1 percent), medium (TDI score 1−3 percent), and highest (TDI score >3 percent). [Forest Service, U.S. Department of Agriculture Forest Service]

Where are the townships with the greatest landscape-level ecological values, and where are the townships with the greatest landscape-level risks (figs. 23–15 and 23–16)?

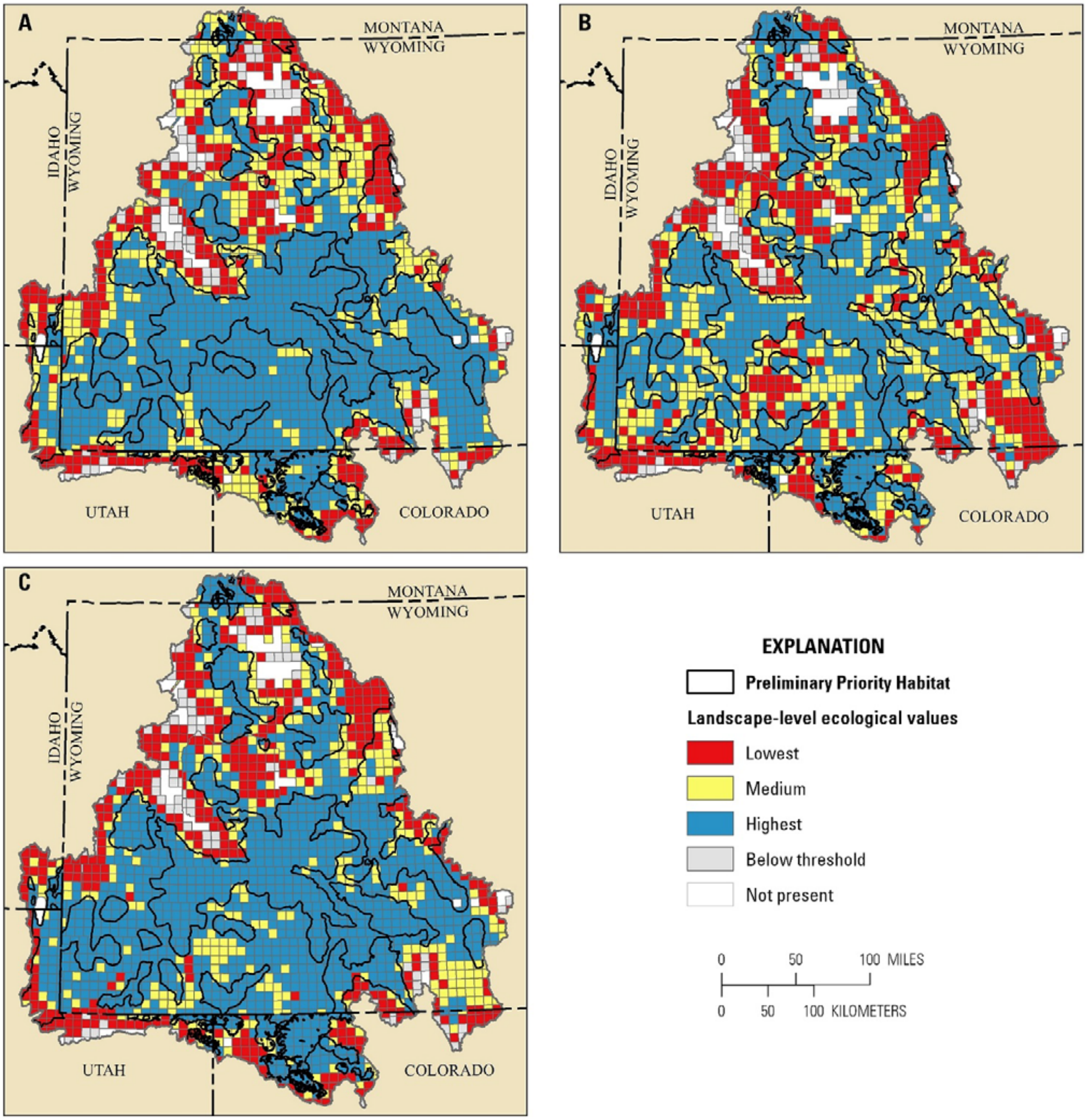

Figure 23–15. Ranks of landscape-level ecological values for greater sage-grouse habitat, summarized by township, in the Wyoming Basin Rapid Ecoregional Assessment project area. (*A*) Total area, (*B*) proximity to leks, and (*C*) overall values (see table 23–3 for overview of methods).

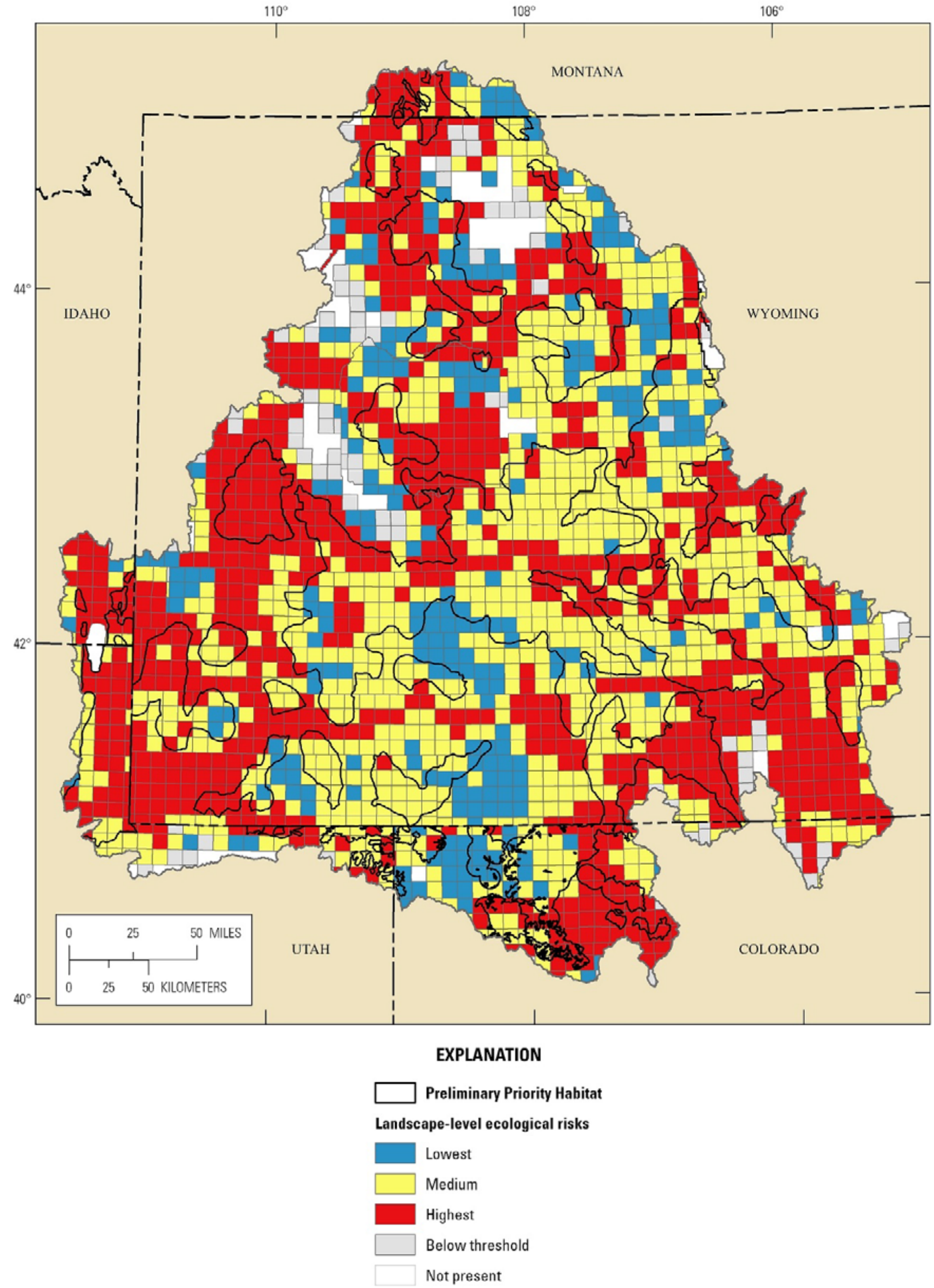

Figure 23–16. Ranks of landscape-level ecological risks for greater sage-grouse habitat, summarized by township, in the Wyoming Basin Rapid Ecoregional Assessment project area. Landscape-level risks based on Terrestrial Development Index (see table 23–3 for overview of methods).

Where are the townships with the greatest conservation potential (fig. 23–17)?

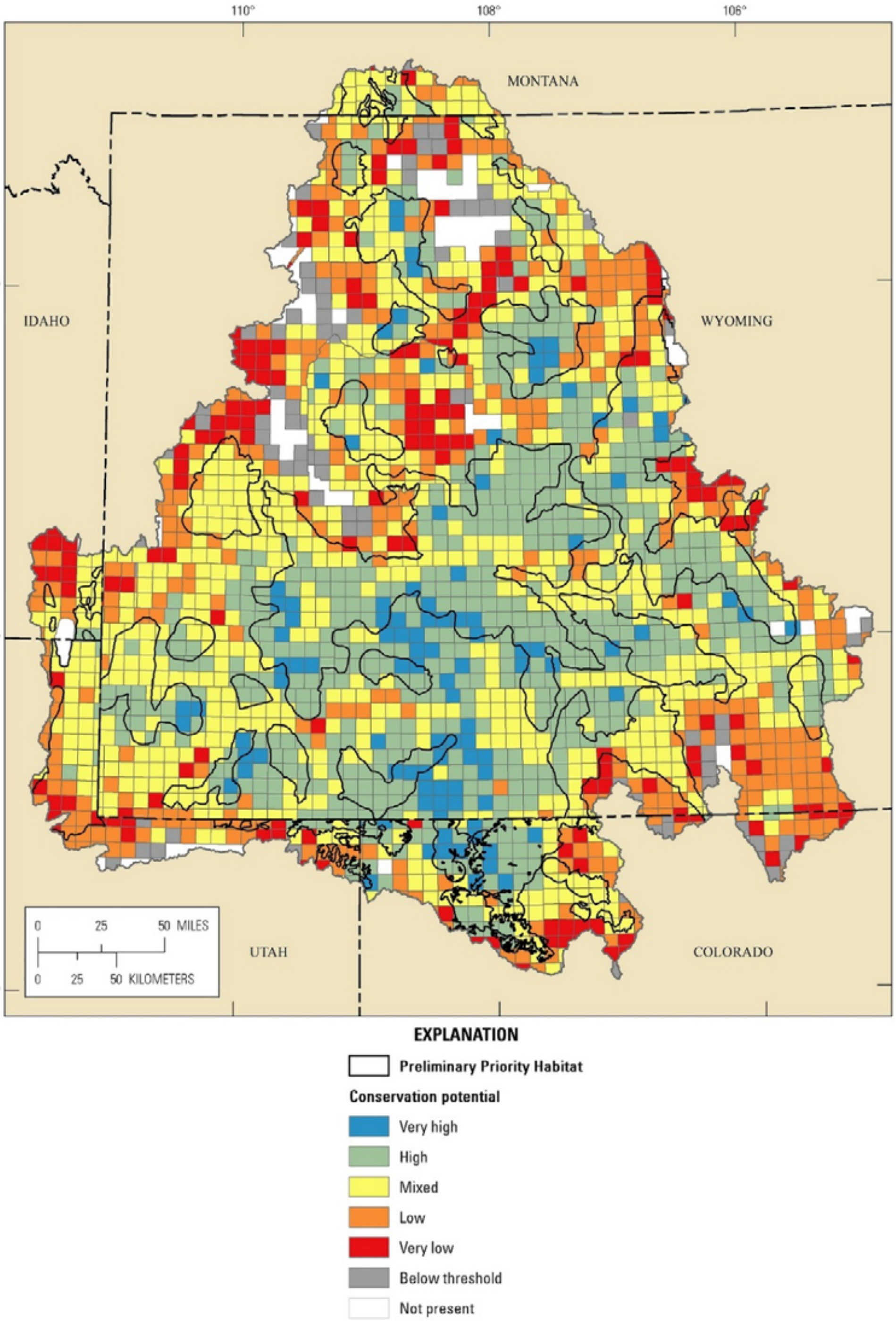

Figure 23–17. Conservation potential of greater sage-grouse habitat, summarized by township, in the Wyoming Basin Rapid Ecoregional Assessment project area. Highest conservation potential identifies areas that have the highest landscape-level values and the lowest risks. Lowest conservation potential identifies areas with the lowest landscape-level values and the highest risks. Ranks of conservation potential are not intended as stand-alone summaries and are best interpreted in conjunction with the geospatial datasets used to address Core Management Questions.

Summary

Greater sage-grouse habitat was once widely distributed and highly connected throughout the Wyoming Basin. Agricultural conversion, roads, and energy development, have cumulatively led to increased fragmentation and decreased structural connectivity of baseline sage-grouse habitat. Although 66 percent of baseline sage-grouse habitat has low levels of terrestrial development (Terrestrial Development Index [TDI] ≤3 percent), only 22.8 percent is relatively undeveloped (TDI ≤1 percent). The relatively undeveloped patches are all <5,000 square kilometers (km^2) (1,931 square miles [mi^2]), compared to baseline conditions in which almost all sage-grouse habitat falls within a patch exceeding 109,067 km^2 (42,111 mi^2). Regional connectivity for baseline sage-grouse habitat occurs at an interpatch distance of 0.27 (kilometers (km) (0.17 miles [mi]) compared to 3.78 km (2.3 mi) for relatively undeveloped areas. Some of the largest relatively undeveloped areas do not have PPH designation. Such areas lacking protected status may serve as potential conservation sites for sage-grouse in the Wyoming Basin.

Given the lack of relatively undeveloped habitat, the potential future risks to sage-grouse from continued energy development are of concern. In addition, projections using climate change scenarios indicate a potential for increased risk of habitat loss and West Nile virus throughout much of the current distribution of greater sage-grouse in the Wyoming Basin. There are areas with relatively lower risk of West Nile virus where sagebrush is expected to be stable even for projected changes in climates in the areas north and west of Rock Springs, Wyo. (Schrag and others, 2011; see Chapter 11—Sagebrush Steppe). Although some of this potential low-risk zone fell within PPHs, much of this area had relatively high development scores, which may increase on the basis of current rates of energy development in the region.

Although fire occurrence affect limited areas of sage-grouse habitat in the Wyoming Basin and may be similar to historical landscape dynamics, the loss of additional habitat, especially from widespread fires, could magnify the threats posed by Change Agents. Indeed, 7−23 percent of priority sage-grouse habitats in Washington, Oregon, and California burned in 2012 (Murphy and others, 2013). This illustrates the potential for large fires to affect significant portions of priority habitats in a single year. We were unable to evaluate the potential consequences of livestock and cheatgrass due to data limitations, yet these Change Agents remain of significant concern. Local data can be used to evaluate grazing and cheatgrass effects on the condition and conservation potential of sage-grouse habitats.

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