Section IV. Assessments of Species and Species Assemblages

Chapter 28. Mule Deer

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Key Ecological Attributes

Distribution and Ecology

The mule deer is widely distributed throughout western North America from the southern Alaska and Yukon Territory south through Baja California and central Mexico, and from the Pacific Coast east to about the 100th meridian. The Rocky Mountain mule deer is the only subspecies in the Wyoming Basin ecoregion, where they are most likely to be found in shrublands and open woodlands associated with topographic breaks, such as foothills, ridges, and draws (Wallmo, 1981).

Mule deer populations are declining throughout much of their range, and current population numbers are much lower than they were in the 1940s to 1960s (Bishop and others, 2009). Climate variation, habitat changes, and predation are thought to be among the factors contributing to the declines (Bishop and others, 2009; Hurley and others, 2011). In Wyoming, the estimated number of mule deer declined by 31 percent between 2000–2011, from about 540,000 to 376,000 deer (Mule Deer Working Group, 2013). From the 1980s to early 2010, the population in the Wyoming Range, one of the largest in the West, declined from more than 50,000 to 29,500 deer (Wyoming Game and Fish Department, 2011) and is a State management concern (Wyoming Game and Fish Department, 2011). Decreasing productivity in many regions of the West, as measured by fawn-doe ratios (a measure of recruitment), appears to be one of the primary demographic factors contributing to population declines (Carpenter, 1998). In Wyoming, fawn production has declined approximately 20 percent since the 1980s, likely due to reduced habitat availability (Mule Deer Working Group, 2013).

Mule deer in the Wyoming Basin are found in a broad range of vegetation types including shrublands, grasslands, woodlands, forests, and riparian habitats, as well as agricultural lands. Crucial habitat components include ample, nutritious forage, thermal and escape cover, and water (Wallmo, 1981; Anderson and Wallmo, 1984; Wiggers and Beasom, 1986; Mule Deer Working Group, 2004). Mule deer diets vary by region, season, and forage availability, but they primarily browse on shrubs and small trees, as well as succulent forbs and nutritious grasses. In winter, the mule deer rely heavily on shrubs for forage in winter and shift to forbs and grasses in spring (Kufeld and others, 1973; Anderson and Wallmo, 1984). Survivorship and fecundity are strongly influenced by forage quantity and quality; high-quality forage is highly digestible and contains relatively high levels of crude protein (Anderson and Wallmo, 1984). Malnutrition can be a significant cause of winter mortality, reduced reproduction, and increased susceptibility to predation (Julander and others, 1961; Bender and others, 2007; Bishop and others, 2009). The need for access to free water is important when temperatures and energetic demands are high, such as during the rut or lactation, and when forage quality is low (Boroski and Mossman, 1998). Ideally, distances between water sources are <2–4.8 kilometers (km) (2–3 miles [mi]) (Mule Deer Working Group, 2009). In winter, mule deer meet their water needs by eating snow if available (Wallmo, 1981).

Landscape Structure and Dynamics

Rangewide, mule deer home range sizes vary from 49–3,379 hectares (ha) (121–8,350 acres), depending on region, season, gender, body condition, reproductive status, habitat conditions, and other factors (Anderson and Wallmo, 1984; Kie and others, 2002). Mule deer home-range size can be influenced by the heterogeneity of vegetation types (Kie and others, 2002). Home-range size also may be smaller in relatively mesic regions where forage is more plentiful than it is in drier regions where forage is scarce and (or) of poor quality (Rodgers and others, 1978; Wallmo, 1981).

Although mule deer use a broad range of vegetation types year round, their winter range is restricted by cold temperatures and deep snow, and most populations in the Wyoming Basin are migratory (Wallmo, 1981; Monteith and others, 2011; Sawyer and Kauffman, 2011; Anderson and others, 2012; Webb, Dzialak, Kosciuch, and others, 2013). Winter range provides access to forage and protection from adverse weather (Mule Deer Working Group, 2007) necessary to help deer survive the climatic stress of winter (Monteith and others, 2011). Snowpack can restrict movements, limit access to forage, and deplete energy reserves (Monteith and others, 2011). To help maintain body weight in winter, mule deer need access to relatively snow-free foraging areas with vegetation that can meet their winter maintenance nutrient needs (Anderson and others, 2012; Monteith and others, 2013). Sagebrush, bitterbush, and serviceberry are all important winter forage (Monteith and others, 2013). Thermal cover provided by conifers and primarily juniper can moderate winter mortality, especially during more extreme cold and snowy conditions (Pierce and others, 2012; Webb, Dzialak, Kosciuch, and others, 2013). Because the amount of suitable winter range is more limited than summer range, population densities are generally greater on winter range (Mule Deer Working Group, 2009), and depletion of food resources on the winter range can cause animals to shift to food resources that have lower nutritional value (Monteith and others, 2011; Pierce and others, 2012). Availability of suitable winter range is considered an important factor limiting mule deer populations (Wallmo, 1981).

Access to high-quality forage and cover is also important during migration and likely can affect the condition of animals arriving on winter range in the fall or prior to parturition in spring (Wallmo, 1981; Sawyer and Kauffman, 2011; Wyoming Game and Fish Department, 2011; Webb, Dzialak, Houchen, and others, 2013). In the Wyoming Basin, mule deer may move considerable distances from high-elevation summer range to low-elevation winter range. In the Upper Green River Basin and the Lower Great Divide Basin, telemetry data showed that animals moved 18–114 km (11.2 –70.8 mi) during migration (Sawyer and Kauffman, 2011). Male mule deer often move beyond their home ranges during the rut (late fall through late winter), and documented dispersal movements of young males range 5−200 km (3–124 mi), depending on habitat productivity (Anderson and Wallmo, 1984). The timing of migration can be influenced by the availability of forage, snow depth, temperature, and animal age and nutritional condition (Wallmo, 1981; Sawyer and others, 2009; Monteith and others, 2011). Availability of forage with a high nutritional value, which in spring is closely associated with phenological advancement (green-up), can affect the rate of movement and use of stopover sites during migration (Sawyer and Kauffman, 2011). Indeed, energy constraints during migration appear to be a primary driver of migration strategies in mule deer (Monteith and others, 2011; Sawyer and Kauffman, 2011). Populations often show strong fidelity to home ranges and migration routes (Julander and others, 1961; Wallmo, 1981; Kufeld and others, 1989; Sawyer and Kauffman, 2011)

Drought and fire can affect the availability of forage. Drought can decrease the availability of forage, whereas fire has mixed effects. Low-intensity, infrequent fire sets back seral stages, opens the denser habitats, recycles nutrients, and increases the nutritional value of new vegetative growth (Hobbs and Spowart, 1984; Clements and Young, 1997). In shrubland-grassland mosaics, fire exclusion can permit mulches to accumulate, which can shade out warmseason, and promote cool-season, grasses (DeVos and McKinney, 2007). Infrequent, but large fires in sagebrush systems can enhance the growth of forbs, grasses, and re-sprouting shrubs and trees, but woody forage and cover provided by sagebrush and juniper can take decades to return to prefire densities (See Chapter 11―Sagebrush Steppe and Chapter 5—Wildland Fire).

Associated Species of Management Concern

Aspen provides forage and cover for mule deer, but high levels of herbivory by ungulates such as mule deer can negatively affect regeneration in aspen woodlands, especially those stands that are at risk from sudden aspen decline (see Chapter 15—Aspen Forests and Woodlands). Mule deer are important prey for mountains lions (Fitzgerald and others, 1994), coyotes, gray wolves, bobcats, and bears (Wallmo, 1981). Smaller predators prey on mule deer fawns and adults in poor condition, and adult mountain lions can kill adult mule deer in good condition.

Change Agents

Development

Energy and Infrastructure

Overall, energy and urban/exurban development and infrastructure are contributing to the loss and fragmentation of mule deer habitat, especially along migration corridors and in crucial winter ranges (Wyoming Game and Fish Department, 2011). Direct habitat loss results from habitat conversion, but substantially greater indirect habitat loss may occur as a result of barriers along migration routes and high levels of disturbance (Sawyer and others, 2006). Roads, fences, energy transmission structures, and other infrastructure associated with development, as well as human activities, such as traffic and noise, all represent potential barriers (Sawyer and others, 2013).

Most anthropogenic features are semipermeable barriers that restrict or alter movements, thereby altering functional attributes of migration routes (Sawyer and others, 2013). Mule deer responses to barriers are influenced, at least in part, by the extent and intensity of development, and by levels of human activity or disturbance (Sawyer and Kauffman, 2011; Sawyer and others, 2006). In Wyoming, moderate levels of oil and gas development did not appreciably affect mule deer migration patterns, but at higher levels, mule deer detoured from traditional routes, increased their rates of movement nearly twofold, and reduced their time spent at crucial stopovers (Sawyer and others, 2013). In some cases, increased movement rates may be offset by longer use of stopovers after passing through developed areas (Sawyer and others, 2013). In western Colorado, migrating mule deer responded similarly to low and moderate levels of energy development but were more sensitive to high levels of development (Lendrum and others, 2012). Additionally, deer traveling through more developed areas tended to select habitats that provided more concealment cover, whereas those travelling through less developed areas selected habitats that provided access to foraging and concealment (Lendrum and others, 2012). Mule deer fidelity to migration routes also plays a role in their responses to barriers posed by development (Lendrum and others, 2012).

On crucial winter range, avoidance of wells pads and roads effectively reduces habitat availability (Sawyer and others, 2006; Sawyer and others, 2009; Rost and Bailey, 1979). A recent study in Wyoming showed that mule deer on their winter range are highly sensitive to the levels of disturbance associated with well pads in both development and production phases (Sawyer and others, 2006, 2009). The average number of vehicle trips per day for producing wells with pipelines was 2–5 as opposed to 4–9 for wells that required tanker trucks to collect fluid by-products; areas with the highest predicted mule deer use were 2.61 km versus 4.30 km (1.6 versus 2.7 mi) from well pads with and without pipelines, respectively. These avoidance distances correspond to indirect habitat losses of 2,100–5,800 ha (5,189–14,332 acres) compared to direct habitat loss from well pads averaging 1.2–1.6 ha (3–4 acres) in size. Wells that were actively being drilled had considerably more disturbance and the number of vehicle passes ranged from 86 to 145 per day; the corresponding areas with the highest predicted mule deer use were 7.49 km (4.65 mi) away. Furthermore, even after three years mule deer did not acclimate to energy development (Sawyer and others, 2006).

In addition to direct and indirect habitat loss (Rost and Bailey, 1979; Webb, Dzialak, Kosciuch, and others, 2013), roads can represent a significant source of mule deer mortality. In 1991, at least 500,000 deer (all deer species) were killed on highways in the United States, with an increasing trend from 1981 to 1991 (Romin and Bissonette, 1996). Motorized recreational vehicles including off-highway vehicle (OHV) and snowmobiles, also can disturb and negatively affect mule deer (Ouren and others, 2007).

Agriculture and Grazing

Cropland conversion has resulted in habitat loss for mule deer in the Wyoming Basin, particularly along riparian floodplains. Mule deer sometimes forage heavily in agricultural lands, which may partially offset losses of food resources but not the loss of escape or thermal cover (Mule Deer Working Group, 2009). Mule deer may leave their summer ranges earlier than they did historically to feed on high-quality food resources in agricultural lands before the plants senesce and their nutritional value decreases (Garrott and others, 2013). Mule deer also may forage on crops and pastures in early spring, when the deer are in poor nutritional status, and female energy demands are high due to pregnancy (Garrott and others, 2013).

Chronic overgrazing by livestock can reduce mule deer cover and the quantity, quality (including digestibility), and palatability of mule deer forage (Julander and others, 1961; Clements and Young, 1997; Vavra and others, 2007). Moreover, moderate to heavy levels of livestock grazing can prompt mule deer to shift their home ranges (Loft and others, 2013) and may promote invasions of nonnative plants (see section below). Brush control and plantings of nonnative grasses to enhance forage production for livestock also diminish crucial mule deer winter browse and cover (Clements and Young, 1997).

Invasive Species

It is not clear how invasive species ultimately may affect mule deer. Interactive effects of fire and invasive species (see Chapter 11—Sagebrush Steppe) can lead to the loss of shrubland habitats required by mule deer for crucial winter forage and cover (Clements and Young, 1997; DeVos and McKinney, 2007), as well as perennial grasses and forbs consumed by mule deer. In some cases, however, ungulates have been found to prefer nonnative plants over their native counterparts (Austin and others, 1994).

Insects and Disease

Mule deer are susceptible to various diseases and parasites that can cause mortality or predispose them to mortality from other causes (Wallmo, 1981). Currently, the disease of greatest concern among Rocky Mountain mule deer is chronic wasting disease. By 2000, the estimated incidence of chronic wasting disease among Colorado mule deer was 15 percent (Gross and Miller, 2001; Mule Deer Working Group, 2004). Two other diseases of potential concern include bluetongue virus and epizootic hemorrhagic disease (Mule Deer Working Group, 2004), which have potential to interact with climate change (see section below).

Climate Change

The potential effects of projected climate change on mule deer are equivocal. Although milder winter temperatures could ameliorate winter die-offs of mule deer (DeVos and McKinney, 2007), this could lead to population fluctuations that result in habitat degradation. Because the migratory behavior of deer is sensitive to proximate cues (forage availability, climate), the timing of migration could shift due to changing climate (Monteith and others, 2011). Climate change projections indicate that low-elevation aspen woodlands, which provide important cover and forage for mule deer during parturition (DeVos and McKinney, 2007), could be at increased risk for sudden aspen decline (see Chapter 15—Aspen Forests and Woodlands). Recent research on factors that influence distributions of biting midges, which serve as vectors of bluetongue and epizootic hemorrhagic disease, suggests that climate change could alter the distribution and incidence of mule deer diseases (Schmidtmann and others, 2011). Increased carbon dioxide (CO_2) concentrations could potentially affect the nutritional quality and quantity of mule deer forage (DeVos and McKinney, 2007).

Rapid Ecoregional Assessment Components Evaluated for Mule Deer

A generalized, conceptual model was used to highlight some of the key ecological attributes and Change Agents affecting mule deer (fig. 28–1). Key ecological attributes addressed by the REA include (1) the distribution of mule deer habitat (crucial winter range and migration corridors), (2) landscape structure (patch sizes and structural connectivity of mule deer crucial winter range), and (3) landscape dynamics (fire occurrence) (table 28–1). The Change Agents evaluated include development, and chronic wasting disease (table 28–2). Ecological values and risks used to assess the conservation potential by township are summarized in table 28–3. Core and Integrated Management Questions and the associated summary maps and graphs are provided in table 28–4.

Methods Overview

Almost the entire Wyoming Basin provides year-round habitat (derived from maps provided by State wildlife agencies; table 28–1). We identified crucial winter range and migration corridors as key ecological attributes (parturition habitat is also important but regionwide data were not available). Definitions of crucial winter range varied by each state and winter range was not identified in Idaho portions of the project area. The locations of migration corridors were provided by Colorado and Wyoming but the precision and accuracy of the mapped corridors varied substantially across the region. Such differences in source data can lead to differences in results across state boundaries. Crucial winter range and migration corridor locations were used to quantify baseline mule deer habitat within the region. Due to variation in the precision of corridor data, we used only crucial winter range for most subsequent analyses.

We used LANDFIRE Existing Vegetation Types to quantify forage and cover types present on crucial winter range. We assessed development levels in crucial winter range and for 2-km- (1.2-mi-) wide buffers centered on migration corridors, using the TDI map. The map of TDI scores for crucial winter range was used to calculate patch size and structural connectivity metrics. We mapped the structural connectivity of baseline crucial winter range at local (1.8 km [1.12 mi]), landscape (5.31 km [3.30 mi]), and regional (11.79 km [12.53 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.

In addition to the overall TDI, we evaluated the development levels for transportation (roads and railroads) and energy development for mule deer habitat separately because mule deer will use agricultural areas to forage but are particularly sensitive to disturbance effects from roads and energy development (Sawyer and others, 2009; Lendrum and others, 2012; Sawyer and others, 2013). The moving-window size (16 square kilometers [km^2]) used to summarize the disturbance footprint corresponds to the indirect habitat loss (21–58 km^2 [8.1–22.4 square miles [mi^2]) resulting from mule deer avoiding a well pad in Wyoming (Sawyer, Kauffman, Nielson, and others, 2009). We did not address potential effects of climate-change scenarios because mule deer use a wide variety of vegetative communities; therefore, it would be difficult to interpret how potential changes in the distribution of vegetation would influence habitat availability (see Chapter 7—Climate Analysis). Information on the distribution of chronic wasting disease by county was obtained from the Centers for Disease Control and Prevention (2013).

Landscape-level ecological values (area of baseline habitat and length of migration corridors) and risk (TDI score) were compiled into an overall index of conservation potential for each township (table 28–3). Conservation potential was summarized by township based on overall landscape-level values and risks (table 28–3). 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.

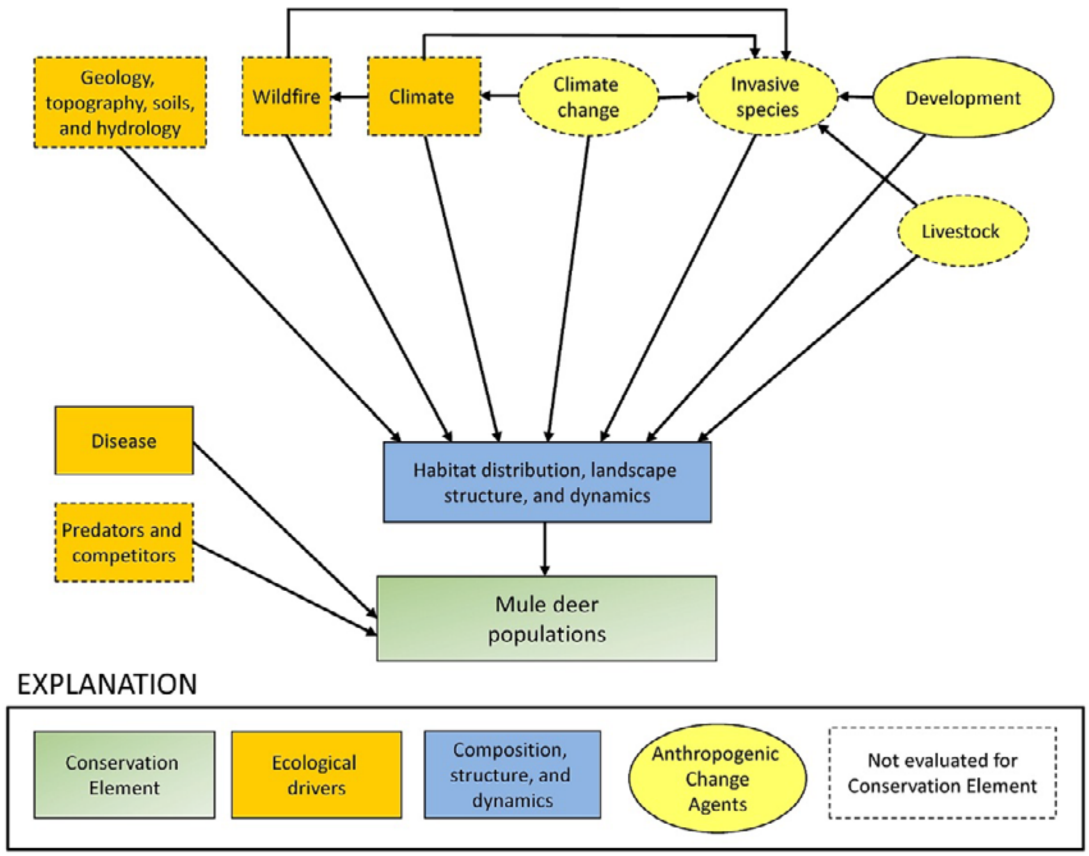

Figure 28–1. Generalized conceptual model for mule deer for the Wyoming Basin Rapid Ecoregional Assessment (REA). Biophysical attributes and ecological processes regulating the occurrence, structure, and dynamics of mule deer habitat and populations are shown in orange rectangles; additional ecological attributes are shown in blue rectangles; and anthropogenic Change Agents that affect key ecological attributes are shown in yellow ovals. The dashed rectangles indicate components not addressed by the REA. Livestock and invasive plants are Change Agents that were not evaluated due to the lack of regionwide data.

Table 28–1. Key ecological attributes and associated indicators of baseline mule deer habitat[1] for the Wyoming Basin Rapid Ecoregional Assessment.

[km, kilometer; mi, mile]

Attributes	Variables	Indicators
Amount and distribution of habitat	Total area of mule deer crucial winter range	Mapped locations of habitat[2]
	Migration corridors	Mapped locations of habitat[2]
Landscape structure	Patch size of crucial winter range	Patch-size frequency distribution
	Structural connectivity of crucial winter range[3]	Interpatch distances that provide an index of structural connectivity for baseline patches at local (1.8 km; 1.12 mi), landscape (5.31 km; 3.3 mi), and regional (11.79 km; 12.53 mi) levels
Landscape dynamics	Fire occurrence[4]	Locations of fires and annual area burned since 1980

[1] Baseline conditions are used as a surrogate for reference conditions to evaluate changes in the amount and landscape structure of mule deer habitat due to Change Agents. Baseline conditions are defined as the current distribution of mule deer habitat derived from delineated habitat provided by State wildlife agencies without explicit inclusion of Change Agents (see Chapter 2—Assessment Framework).
[2] Crucial winter range and migration corridor locations provided by Wyoming Game and Fish Department, Idaho Department of Fish and Game, Utah Division of Wildlife Resources, Montana Fish, Wildlife & Parks, Colorado Parks and Wildlife.
[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 and the Appendix.
[4] See Wildland Fire section in the Appendix.

Table 28–2. Anthropogenic Change Agents and associated indicators influencing mule deer for the Wyoming Basin Rapid Ecoregional Assessment.

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

Change Agent	Variables	Indicators
Development	Terrestrial Development Index (TDI)	Percent of mule deer crucial winter range and migration corridors in seven development classes using a 16-km^2 (6.18-mi^2) moving window
	TDI score for transportation, energy, and minerals	Percent of mule deer crucial winter range and migration corridors in seven development classes using a 16-km^2 (6.18-mi^2) moving window
	TDI score	Patch-size frequency distribution for mule deer habitat that is relatively undeveloped or has low development scores compared to baseline habitat[1]
	TDI score	Interpatch distances that provide an index of structural connectivity for relatively undeveloped patches at local (7.2 km; 4.5 mi), landscape (11.5 km; 7.1 mi), and regional (23.9 km; 14.9 mi) levels
Disease	Chronic wasting disease[2]	Mapped occurrence of chronic wasting disease

[1] See Chapter 2—Assessment Framework.

[2] Occurrence data on chronic wasting disease from Centers for Disease Control and Prevention (2013).

Table 28–3. Landscape-level ecological values and risks for mule deer. Ranks were combined into an index of conservation potential for the Wyoming Basin Rapid Ecoregional Assessment.

[km, kilometer]

	Variables[1]	Relative rank: Lowest	Relative rank: Medium	Relative rank: Highest	Description[2]
Values	Area of crucial winter range	<17	17–49	>49	Percent of township
	Length of migration corridors	<3 km		≥3 km	Length of migration corridors mapped by township
Risks	Terrestrial Development Index (TDI)	<1	1–3	>3	Mean TDI score by township[2]

[1] Townships were used as an 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 mule deer habitat 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 28–1 and 28–2 for description of variables and the Appendix.

Table 28–4. Management Questions addressed for mule deer for the Wyoming Basin Rapid Ecological Assessment.

Core Management Questions	Results
Where are baseline mule deer crucial winter range and migration corridors, and what is the total area and elevation of crucial winter range?	Figure 28–2
What is the amount and distribution of vegetation types providing forage and cover on crucial winter range?	Figure 28–3, Table 28–5
Where does development pose the greatest threat to crucial winter range, and where are the relatively undeveloped areas?	Figures 28–4 to 28–7
How has development fragmented baseline crucial winter range, and where are the large, relatively undeveloped patches?	Figures 28–8 and 28–9
How has development affected structural connectivity of crucial winter range?	Figure 28–10
Where are potential barriers that may affect mule deer movements among patches of crucial winter ranges?	Figure 28–11
Where has chronic wasting disease been detected in the Wyoming Basin?	Figure 28–12
Where have recent fires occurred in crucial winter range, and what is the total area burned per year?	Figures 28–13 and 28–14
Integrated Management Questions	**Results**
How does risk from development vary by land ownership or jurisdiction for mule deer crucial winter range?	Table 28–6, Figure 28–15
Where are the townships with the greatest landscape-level ecological values?	Figure 28–16
Where are the townships with the greatest landscape-level risks?	Figure 28–17
Where are the townships with the greatest conservation potential?	Figure 28–18

Key Findings for Management Questions

Where are baseline mule deer winter range and migration corridors, and what is the total area and elevation of crucial winter range (fig. 28–2)?

- Baseline mule deer crucial winter range totals 27,934 km^2 (10,785 mi^2) or 15.7 percent of the Wyoming Basin project area.
- Crucial winter range occurs between 1,105 and 3,200 meters (m) (3,625–10,499 feet [ft]) in elevation, with 74 percent occurring between 1,400- and 1,700-m (4,593–5,577 ft) elevations.

What is the amount and distribution of vegetation types providing forage and cover on crucial winter range (table 28–5, fig. 28–3)?

- Sagebrush, which provides important winter forage, is the dominant vegetation type on crucial winter range (table 28–5).
- Conifers, which provide thermal cover and concealment, occur on 6.9 percent of crucial winter range and are most common in the southern and eastern portions of the range (fig. 28–3).
- Deciduous shrublands have high nutritional value but only occur on 4.1 percent of crucial winter range. However, because this vegetation type often occurs as small patches, it is poorly mapped by LANDFIRE.
- Other vegetation types used for forage occurring on crucial winter range include riparian/wetlands and agricultural lands.

Where does development pose the greatest threat to baseline mule deer habitat, and where are the relatively undeveloped areas (figs. 28–4 to 28–7)?

- Only 18 percent of crucial winter range and 23.5 percent of migration corridors are classified as relatively undeveloped (TDI score ≤1 percent) (figs. 28–4 and 28–5).
- Less than 1 percent of crucial winter range is farther than 2.2 km (1.37 mi) from development (represented by TDI score ≤1), which corresponds to documented distances at which mule deer avoid well pads in Wyoming (Sawyer, Kauffman, and Nielson, and others, 2009).
- High development levels (as indicated by TDI score >5 percent) occur on 33 percent of crucial winter range (fig. 28–5).
- 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 mule deer winter range and migration corridors, but the relative importance of each of these development classes varies spatially across the ecoregion (see Chapter 4—Development). Because mule deer will use agricultural lands for forage, we separately evaluated the surface disturbance footprints from roads, energy, and minerals.
- Most crucial winter range and migration corridors have low to moderate levels of roads and energy development (as represented by TDI score between 0.5 and 2 percent) (figs. 28–6 and 28–7). A total of 45 percent has a TDI score of ≤1 percent (fig. 28–7).

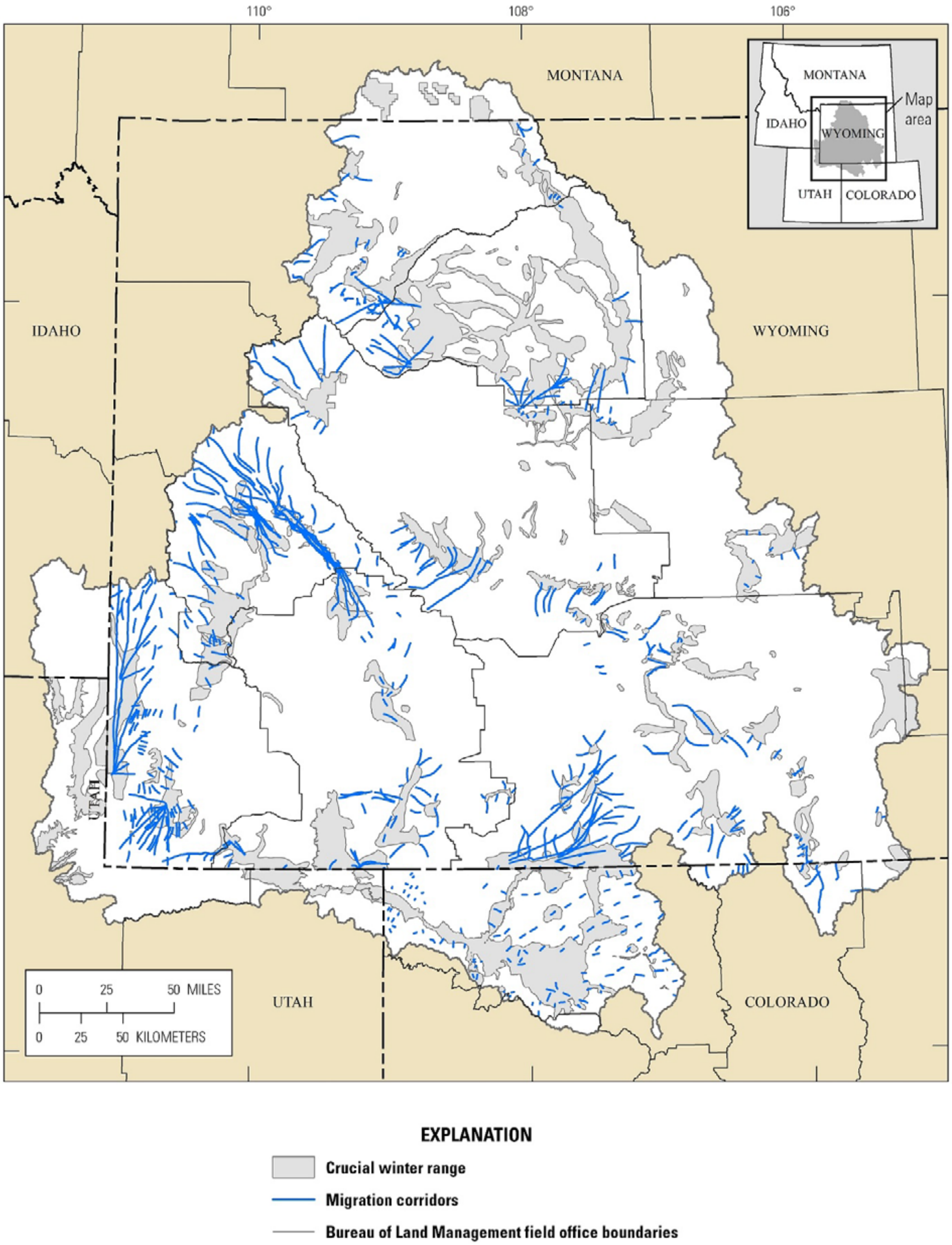

Figure 28–2. The distribution of mule deer crucial winter range and migration corridors in the Wyoming Basin Rapid Ecoregional Assessment project area.

Table 28–5. Area and percent of vegetation types on mule deer crucial winter range for the Wyoming Basin Rapid Ecoregional Assessment.

[km^2, square kilometer]

Vegetation Type[1]	Area (km^2)	Percent
Sagebrush shrublands	19,604	70.2
Grasslands	2,043	7.3
Conifer	1,917	6.9
Agricultural lands	1,220	4.4
Deciduous shrublands	1,141	4.1
Invasive species	842	3.0
Other	500	1.8
Riparian/wetlands	395	1.4
Aspen	271	1.0

[1] Vegetation types derived from LANDFIRE.

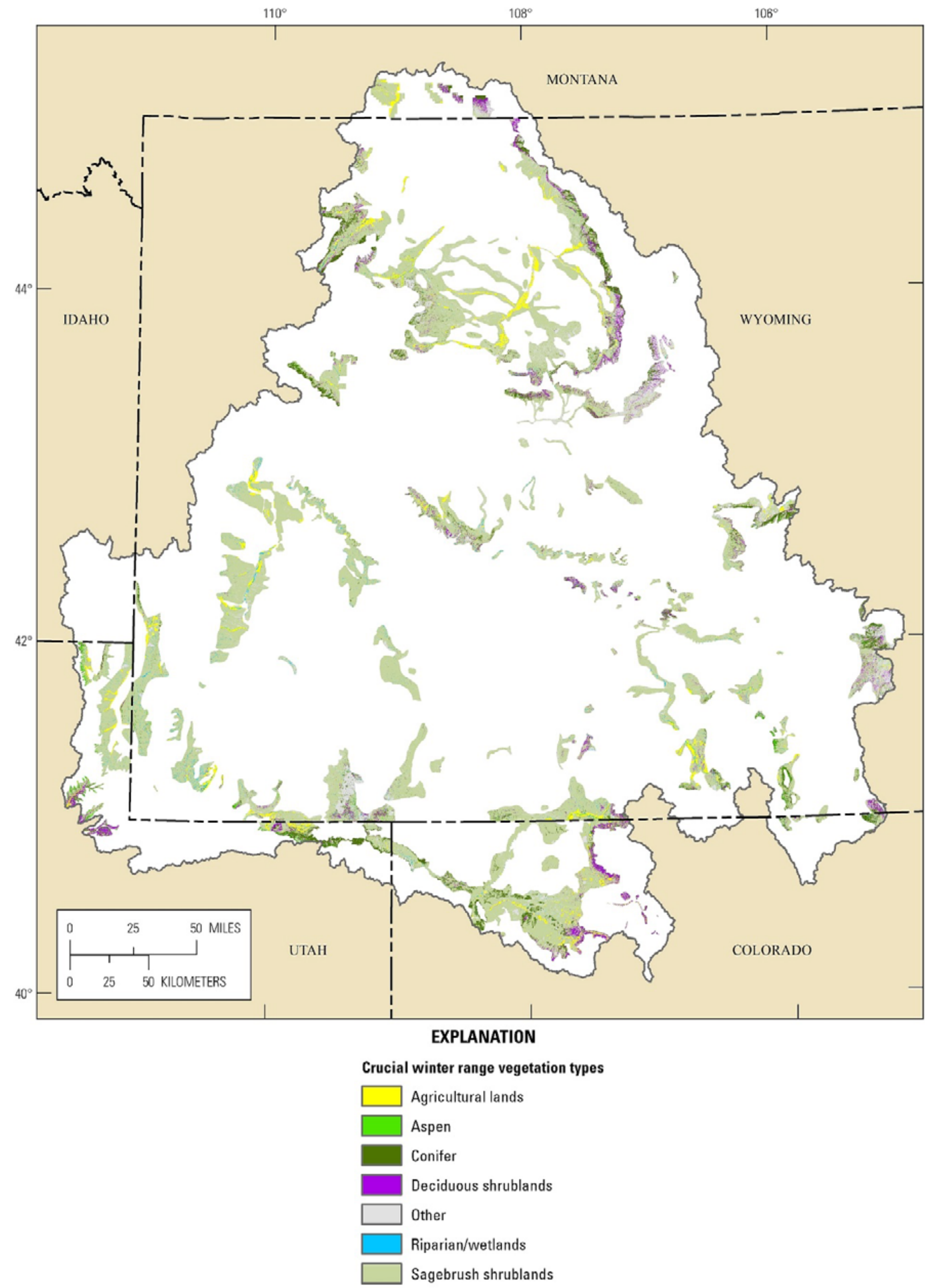

Figure 28–3. The distribution of major vegetation types used for forage and cover by mule deer on crucial winter range in the Wyoming Basin Rapid Ecoregional Assessment project area.

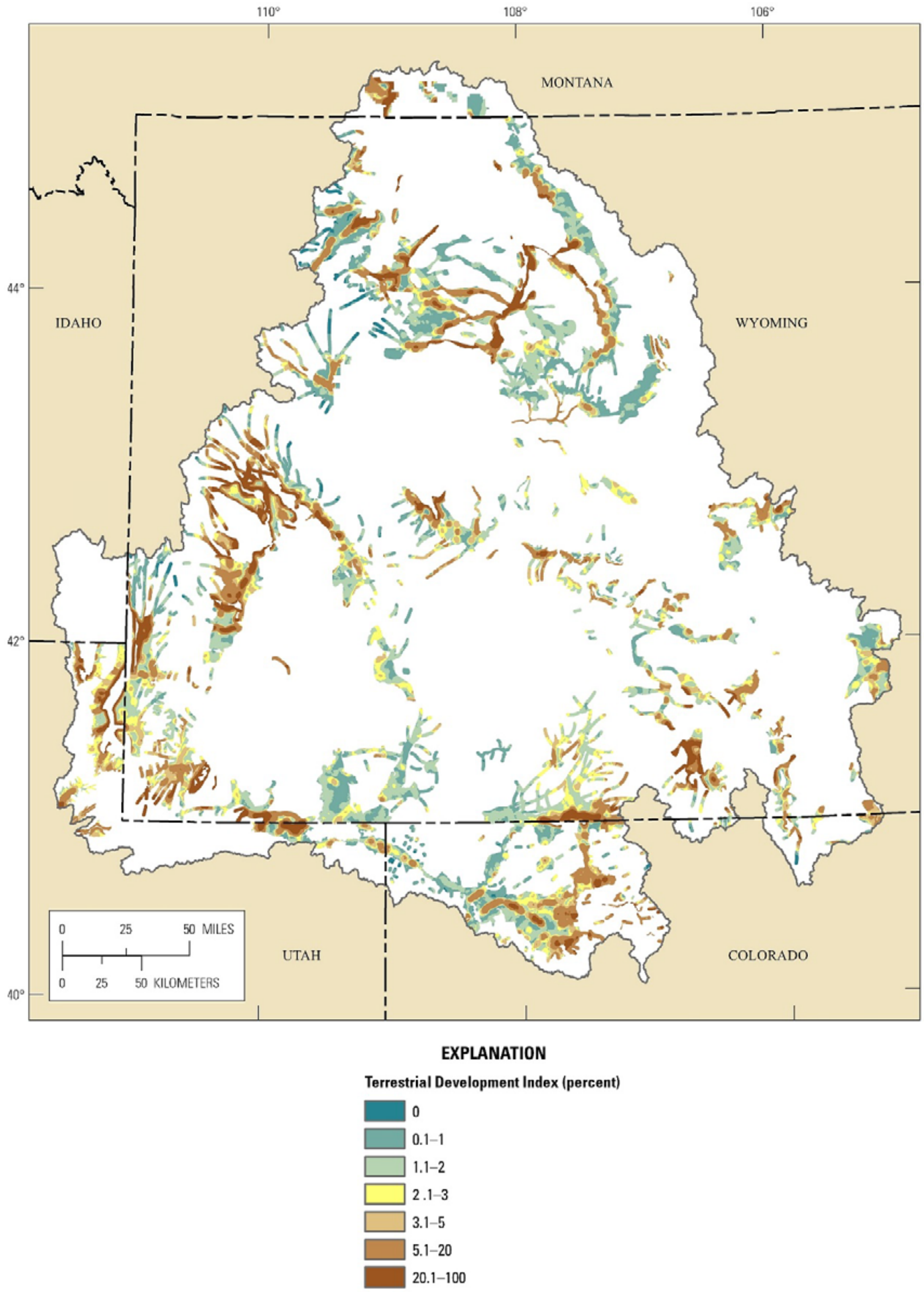

Figure 28–4. Terrestrial Development Index scores for mule deer crucial winter range and migration corridors in the Wyoming Basin Rapid Ecoregional Assessment project area.

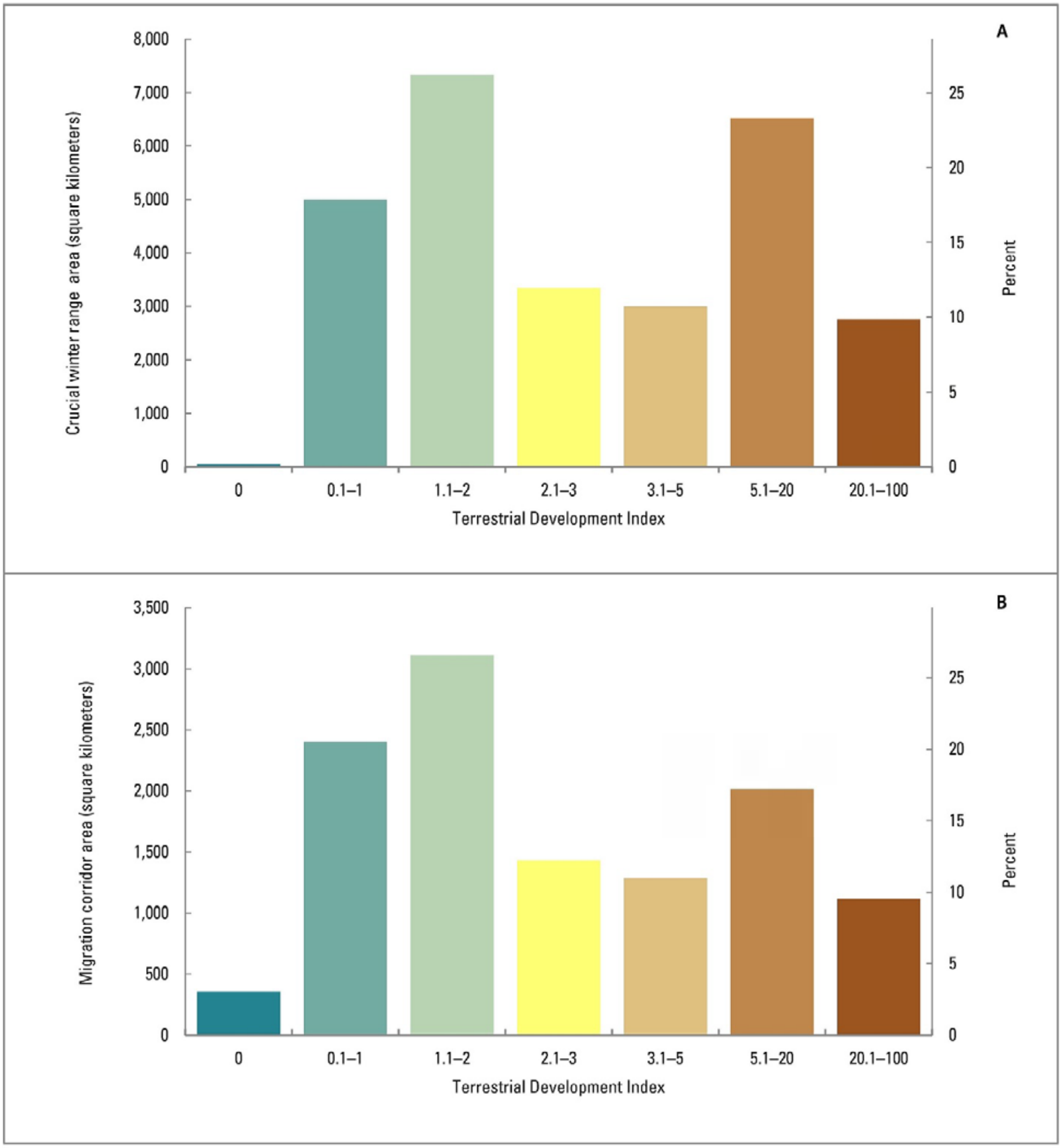

Figure 28–5. Area and percent of baseline mule deer (*A*) crucial winter range and (*B*) migration corridors as a function of the Terrestrial Development Index in the Wyoming Basin Rapid Ecoregional Assessment project area.

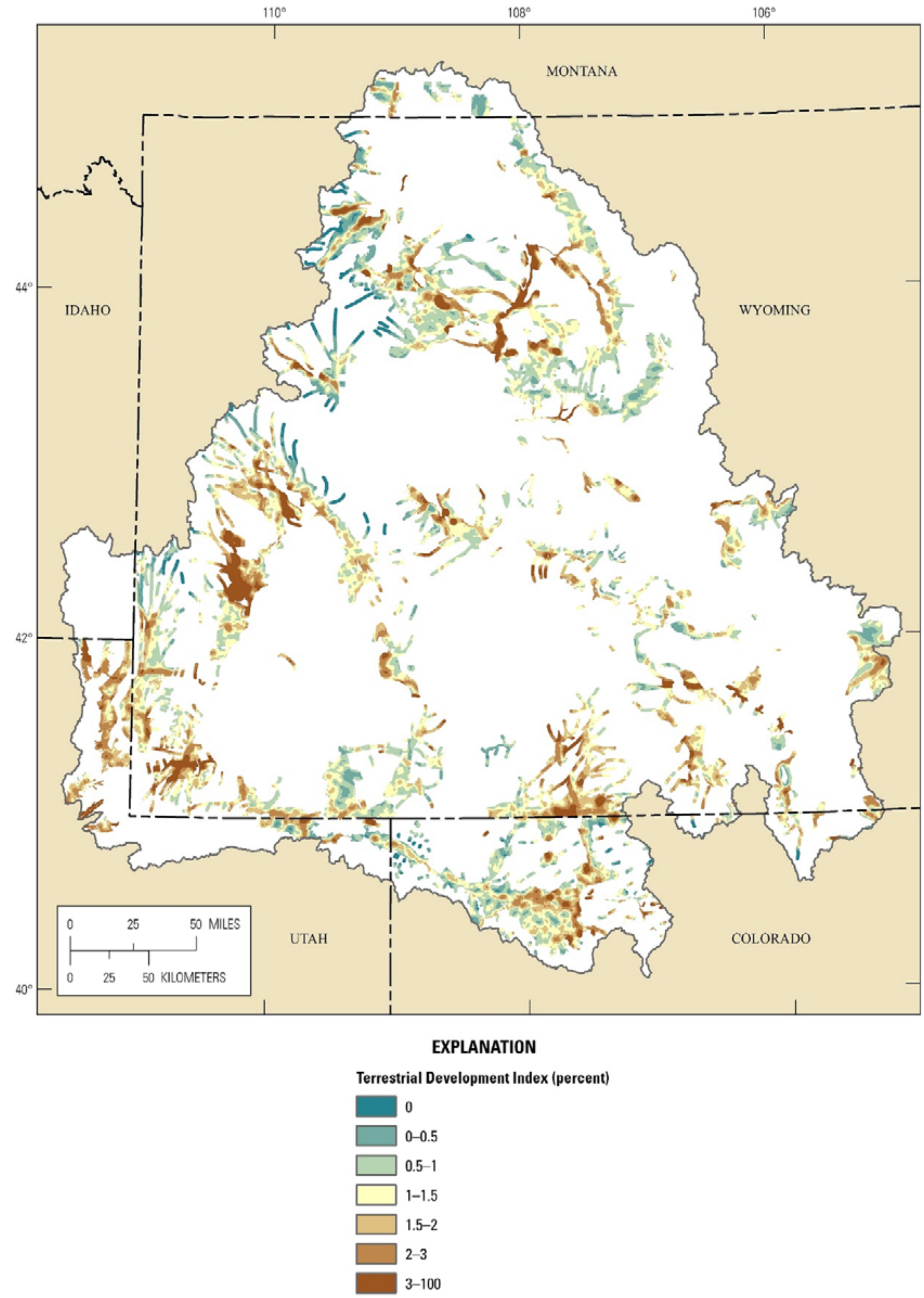

Figure 28–6. Terrestrial Development Index scores for roads, railroads, energy, and minerals occurring on mule deer crucial winter range and migration corridors in the Wyoming Basin Rapid Ecoregional Assessment project area.

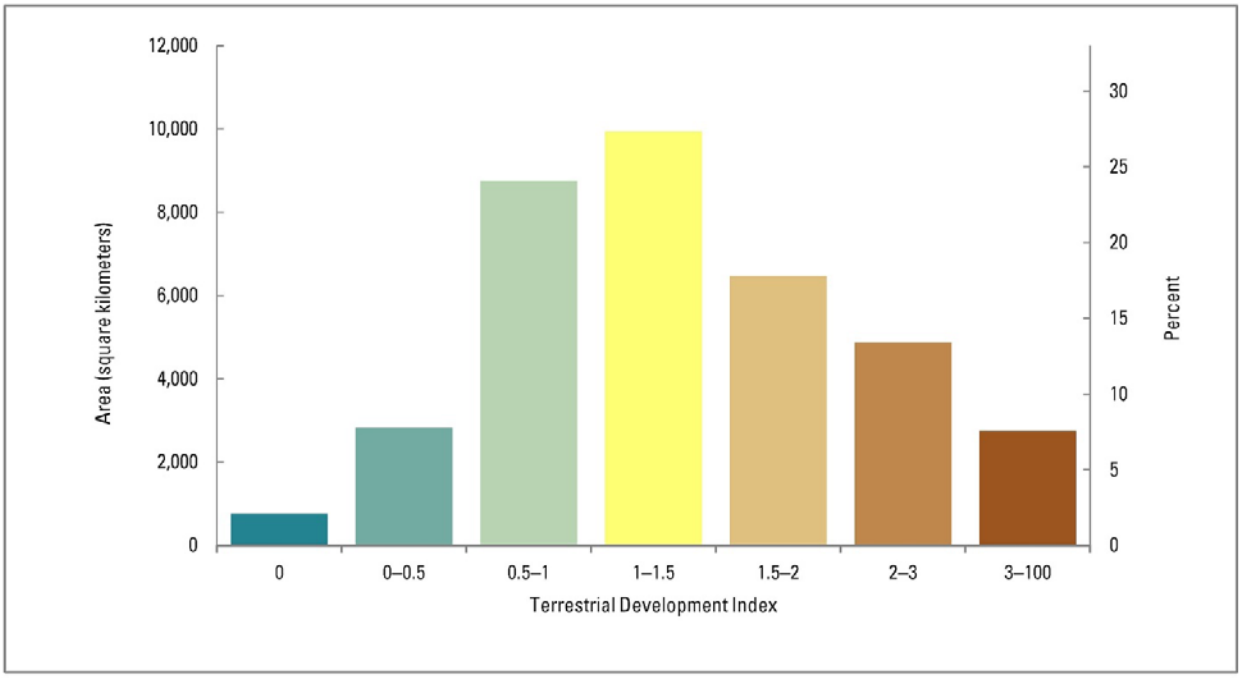

Figure 28–7. Area and percent of baseline mule deer crucial winter range and migration corridors as a function of the Terrestrial Development Index score for roads, railroads, energy, and minerals in the Wyoming Basin Rapid Ecoregional Assessment project area.

How has development fragmented baseline mule deer crucial winter range, and where are the large, relatively undeveloped patches of mule deer habitat (figs. 28–8 and 28–9)?

- Development has effectively fragmented mule deer crucial winter range into smaller patches relative to the baseline conditions. All patches of relatively undeveloped mule deer crucial winter range are <1,000 km^2 (386 mi^2), whereas 47 percent of baseline mule deer crucial winter range occurs within patches >1,000 km^2 (386 mi^2) (figs. 28–8 and 28–9).
- Several large areas of relatively undeveloped habitat between 100 and 1,000 km^2 (38.6 and 386 mi^2) remain (fig. 28–9).

How has development affected the structural connectivity of mule deer crucial winter range relative to baseline conditions (fig. 28–10)?

- Baseline mule deer crucial winter range was connected at local (1.8 km [1.12 mi]), landscape (5.31 km [3.3 mi]), and regional (11.79 km [12.53 mi]) levels.
- Development has greatly diminished the structural connectivity of mule deer crucial winter range. Interpatch distances for relatively undeveloped crucial winter range is double that of baseline conditions at landscape (11.5 km [7.1 mi]), and regional (23.9 km [14.9 mi]) levels.

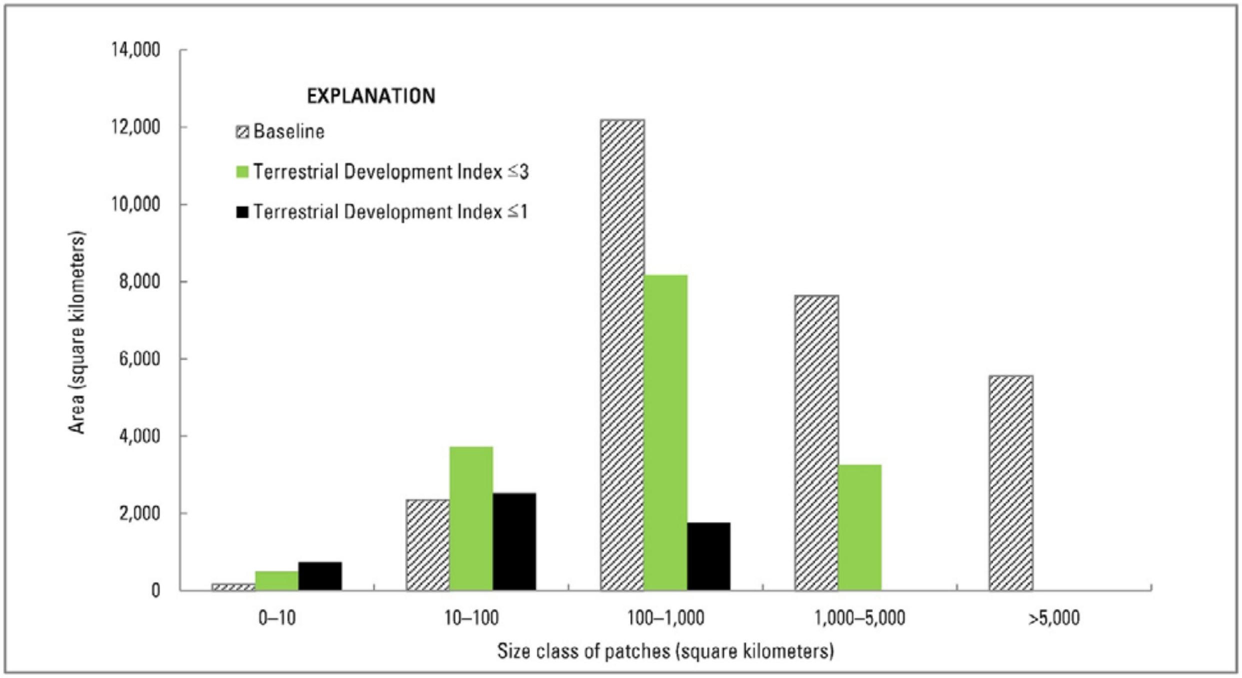

Figure 28–8. Area of mule deer crucial winter range as a function of patch size for baseline conditions and for two development levels: (1) Terrestrial Development Index (TDI) score ≤3 percent), and (2) relatively undeveloped areas (TDI score ≤11 percent) in the Wyoming Basin Rapid Ecoregional Assessment project area.

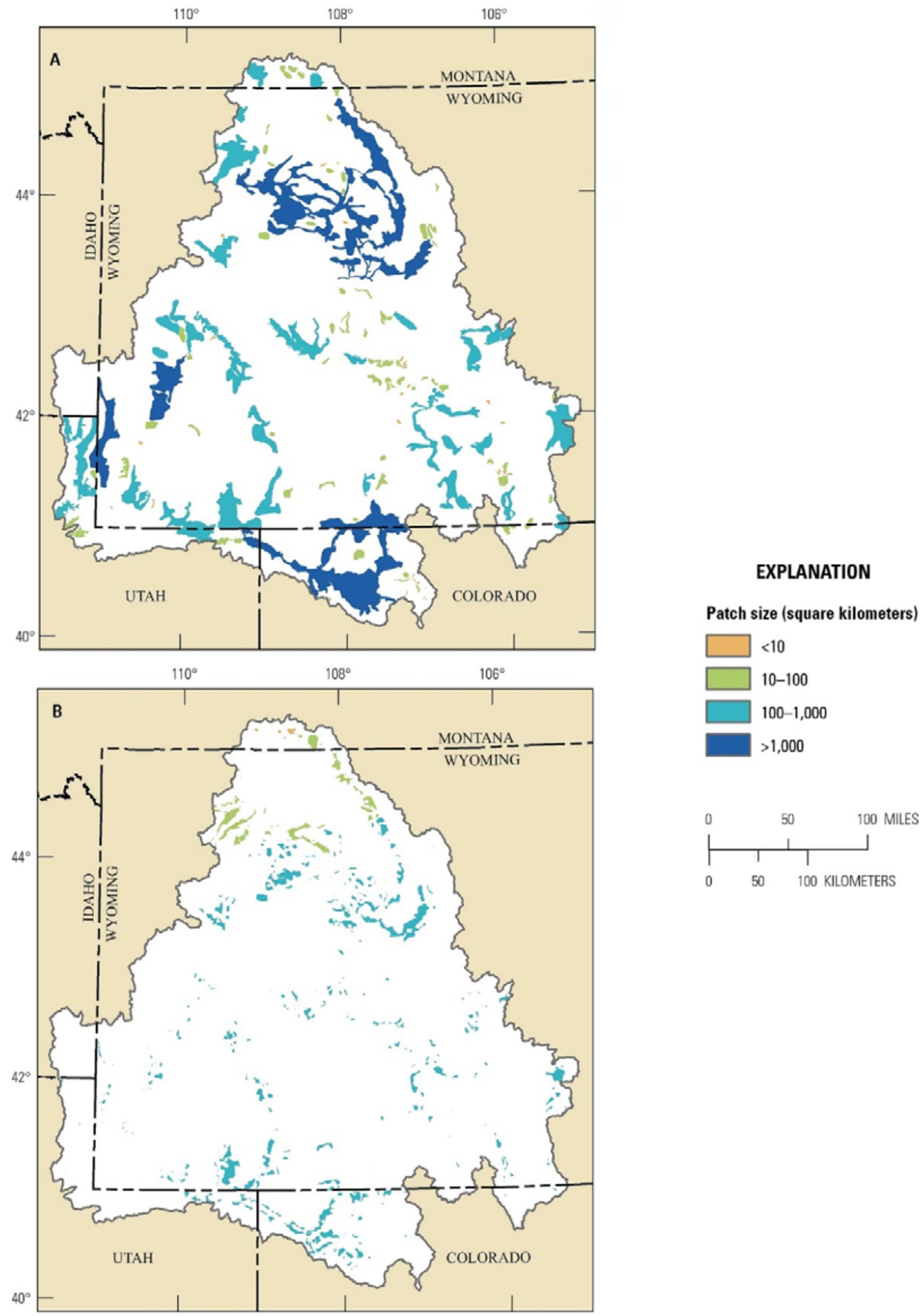

Figure 28–9. Patch sizes of mule deer crucial winter range in the Wyoming Basin Rapid Ecoregional Assessment project area for (*A*) baseline conditions and (*B*) relatively undeveloped areas (Terrestrial Development Index score ≤1 percent).

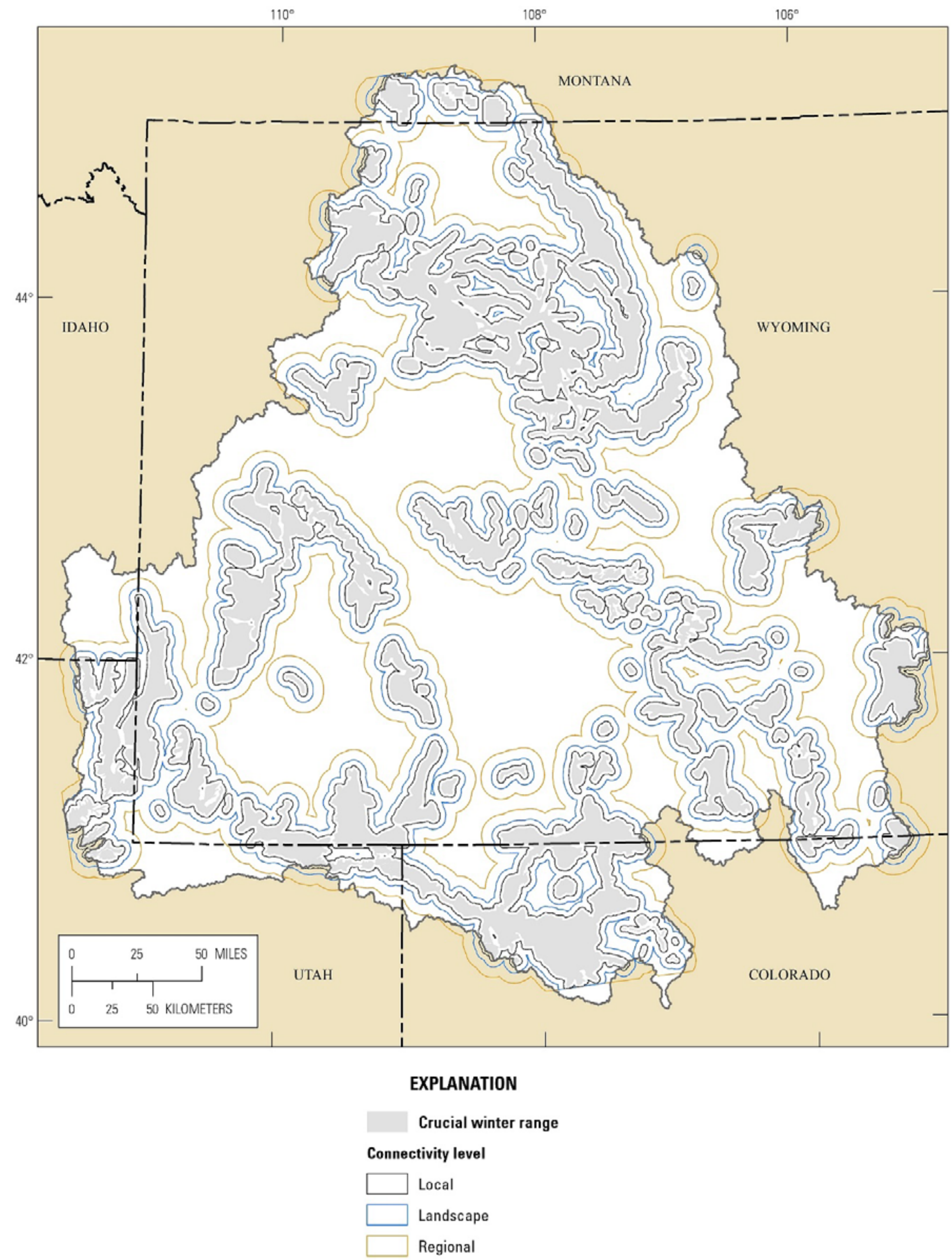

Figure 28–10. Structural connectivity of baseline mule deer crucial winter range in the Wyoming Basin Rapid Ecoregional Assessment project area. Gray polygons represent crucial winter range connected at local levels; blue polygons represent areas connected at landscape levels; and orange polygons represent areas connected at regional levels.

Where are potential barriers that may affect mule deer movements among patches of crucial winter ranges (fig. 28–11)?

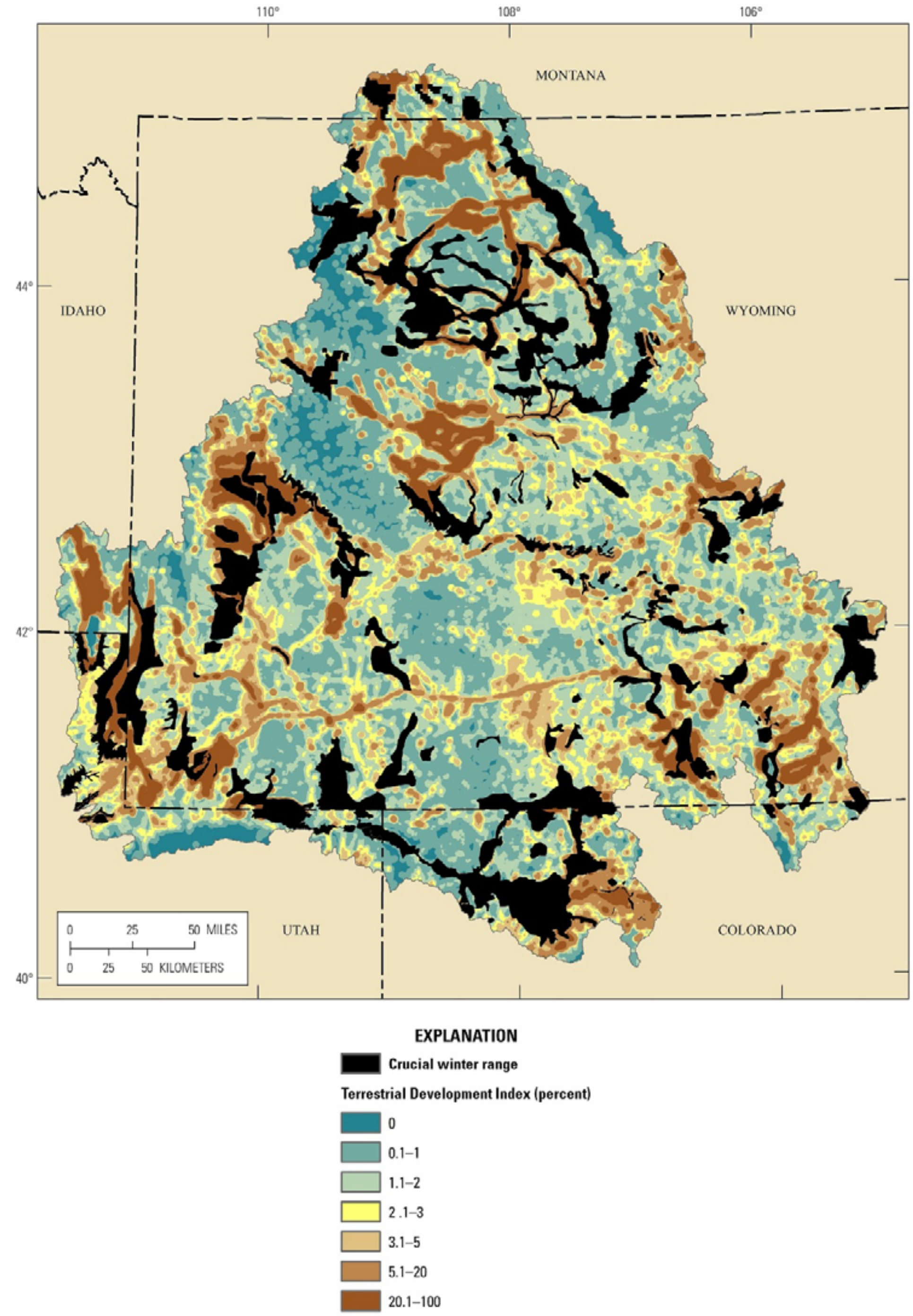

Figure 28–11. Terrestrial Development Index (TDI) scores for lands surrounding baseline mule deer crucial winter range. High TDI scores may represent potential barriers to movement among relatively undeveloped habitat patches, whereas low TDI scores <2 percent may represent potential corridors for movements among patches.

Where has chronic wasting disease been documented in the Wyoming Basin (fig. 28–12)?

- Chronic wasting disease occurrence has been documented throughout the eastern and southern portions of the Wyoming Basin and along the Wyoming Front Range.

Where have recent fires occurred in crucial winter range, and what is the total area burned per year (figs. 28–13 and 28–14)?

- Typically only a small fraction of crucial winter range has burned each year since 1980 (fig. 28–13). Cumulatively, a total of 1,505 km^2 (581.1 mi^2), or 5.4 percent, of crucial mule deer winter range has burned since 1980 (fig. 28–14).
- In most years, fires were small and burned only a small portion of mule deer winter range, with most of the area burned by fires occurring in 1996 and 2000 (figs. 28–13 and 28–14).

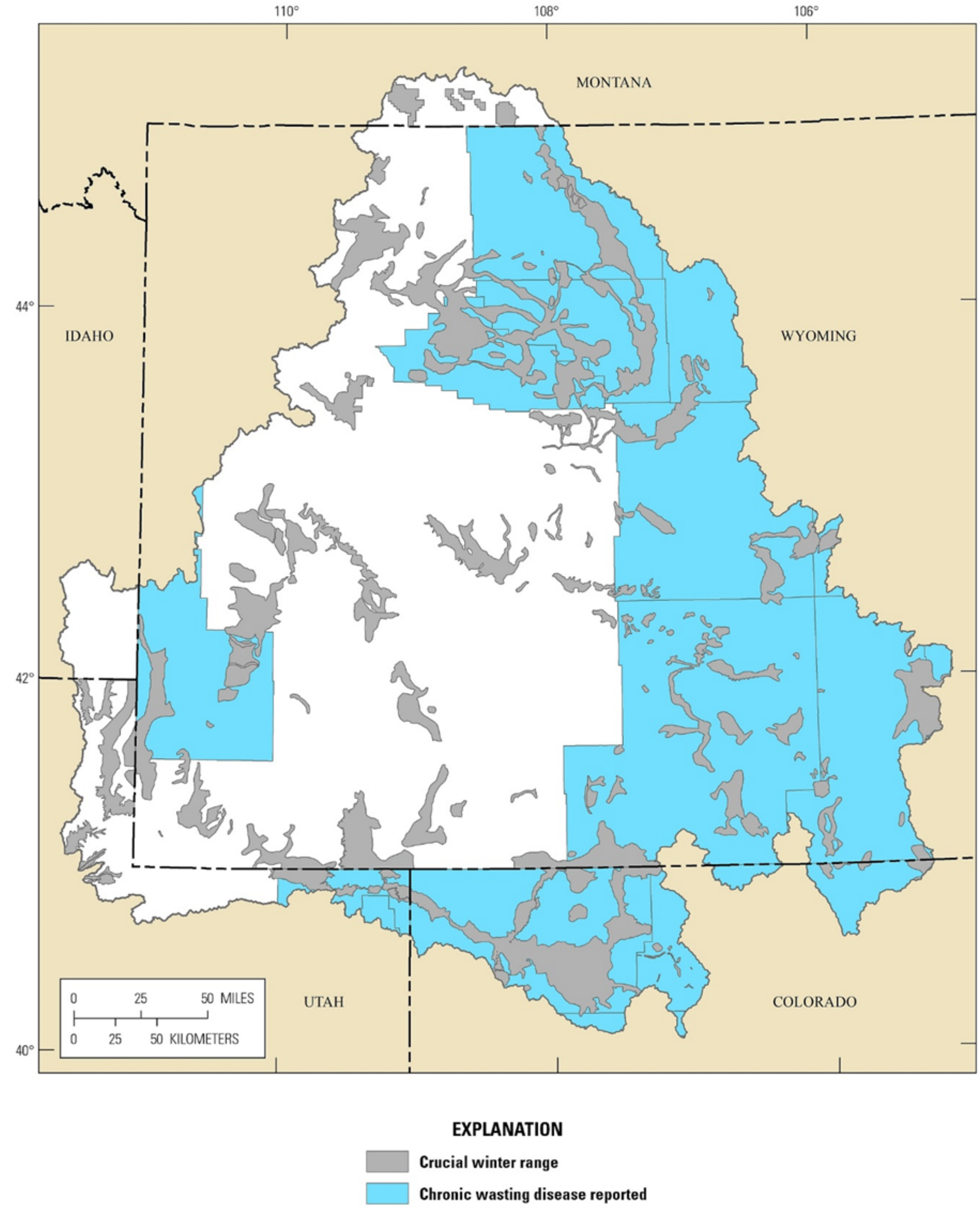

Figure 28–12. Occurrence of chronic wasting disease in the Wyoming Basin Rapid Ecoregional Assessment project area. The location of crucial winter range is shown for reference, but year round mule deer range occurs throughout the Wyoming Basin.

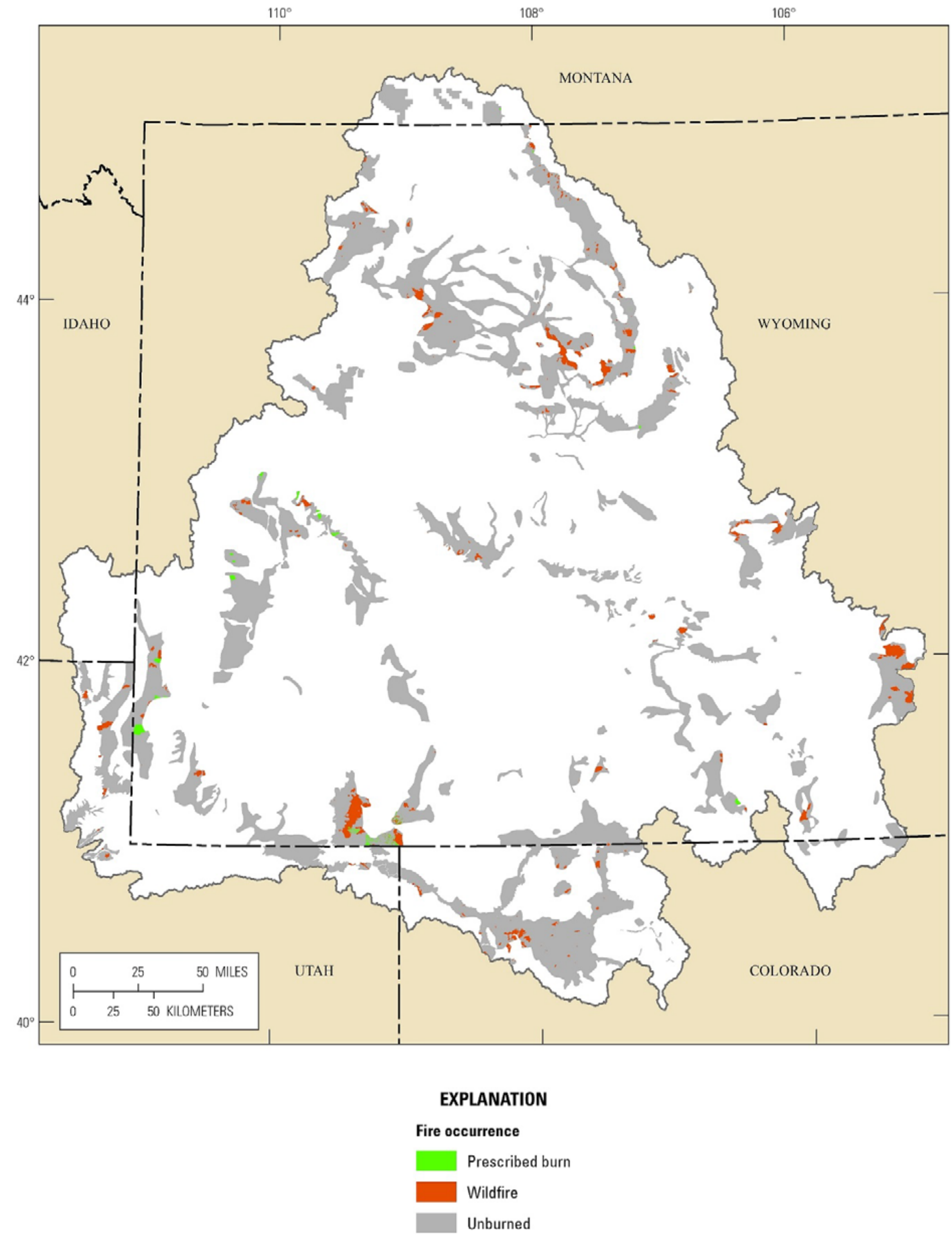

Figure 28–13. Occurrence of wildfires and prescribed fires in mule deer crucial winter range since 1980 in the Wyoming Basin Rapid Ecoregional Assessment project area.

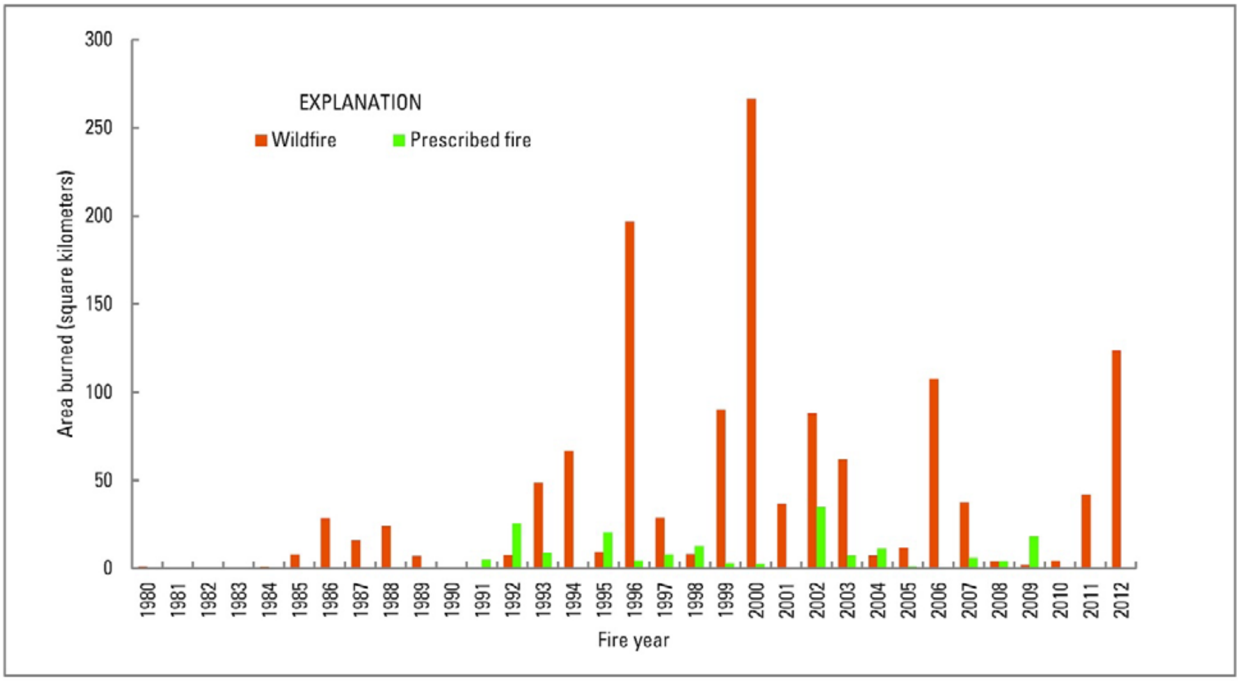

Figure 28–14. Annual area burned by wildfires and prescribed fires in baseline mule deer crucial winter range since 1980 in the Wyoming Basin Rapid Ecoregional Assessment project area.

How does risk from development vary by land ownership or jurisdiction for mule deer crucial winter range (table 28–6, fig. 28–15)?

- Nearly half of mule deer crucial winter range occurs on BLM lands, and another 37 percent is under private ownership (table 28–5).
- Mule deer crucial winter range on BLM and U.S. Department of Agriculture Forest Service lands have the lowest percent of area at high risk from development (fig. 28–15). U.S. Department of Agriculture Forest Service lands have the greatest percent area at low risk from development.

Table 28–6. Area and percent of mule deer crucial winter range by land ownership in the Wyoming Basin Rapid Ecoregional Assessment project area.

[km², square kilometer]

Ownership	Area (km²)	Percent of Area
Bureau of Land Management	15,805	43.5
Private	13,387	36.8
State/County	3,358	9.2
Forest Service[1]	2,930	8.1
Private conservation	368	1.1
Other Federal[2]	206	1.0

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

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

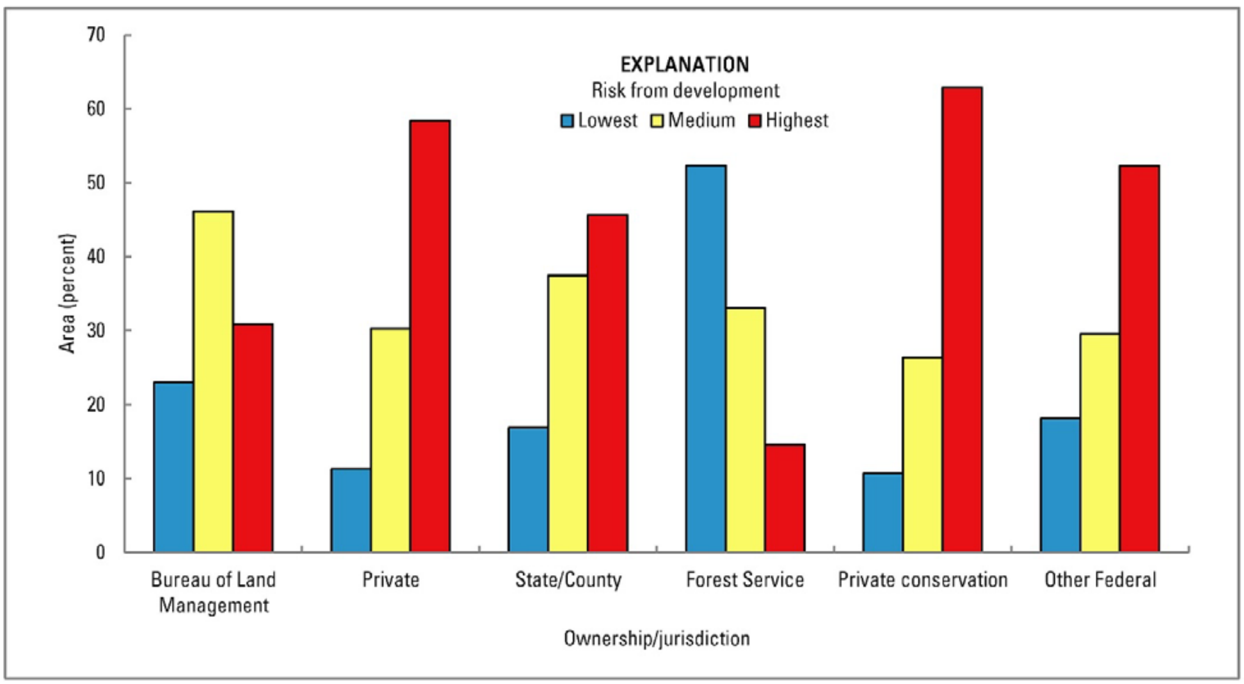

Figure 28–15. Relative ranks of risk from development, by land ownership or jurisdiction, for mule deer crucial winter range in the Wyoming Basin Rapid Ecoregional Assessment project area. Rankings are lowest (Terrestrial Development Index [TDI] score <1 percent), medium (TDI score between 1 and 3 percent), 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 (fig. 28–16)?

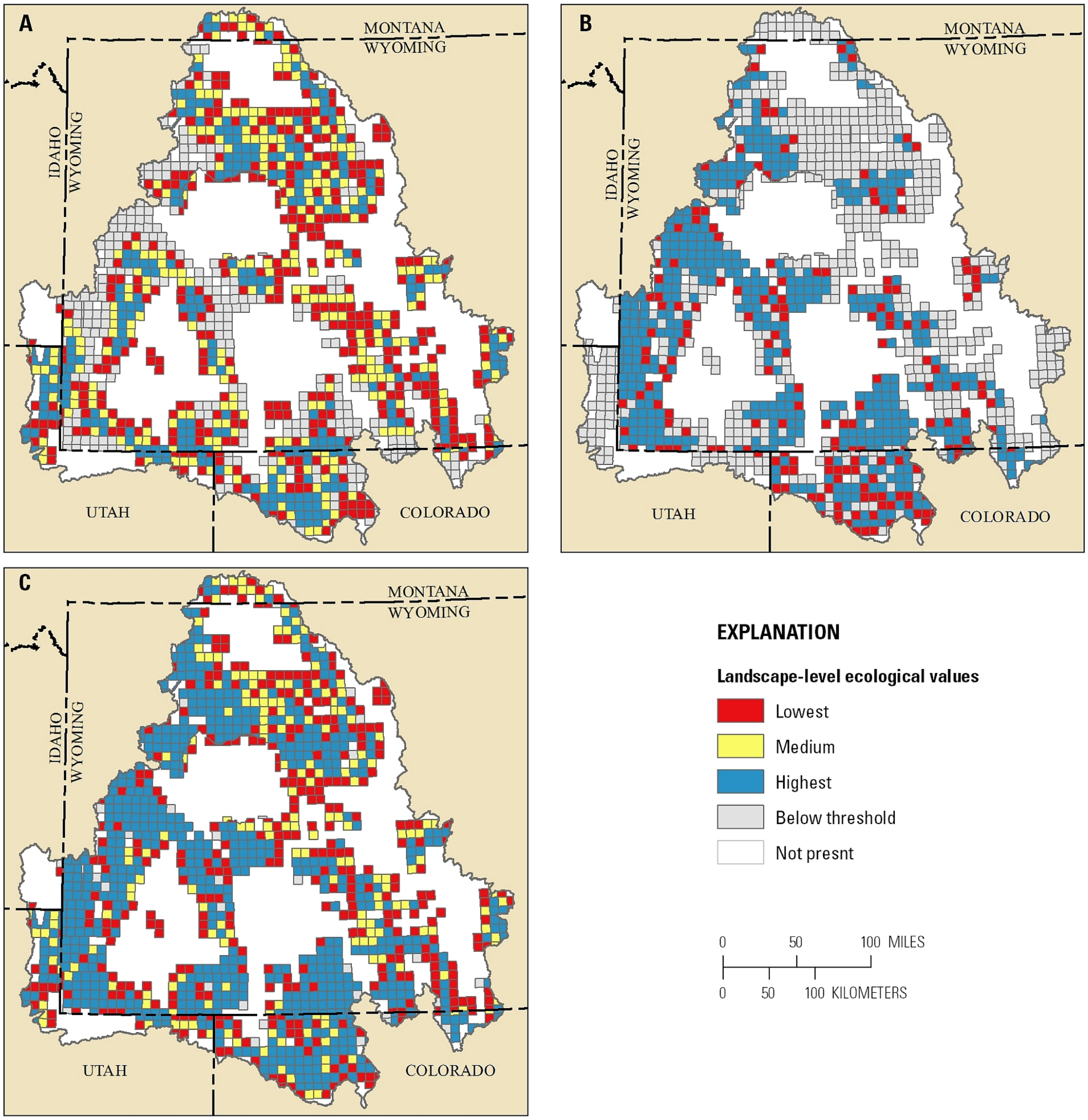

Figure 28–16. Ranks of landscape-level ecological values for mule deer habitat, summarized by township, in the Wyoming Basin Rapid Ecoregional Assessment project area. (*A*) Total area crucial winter range, (*B*) total length of migration corridors, and (*C*) overall.

Where are the townships with the greatest landscape-level risks (fig. 28–17)?

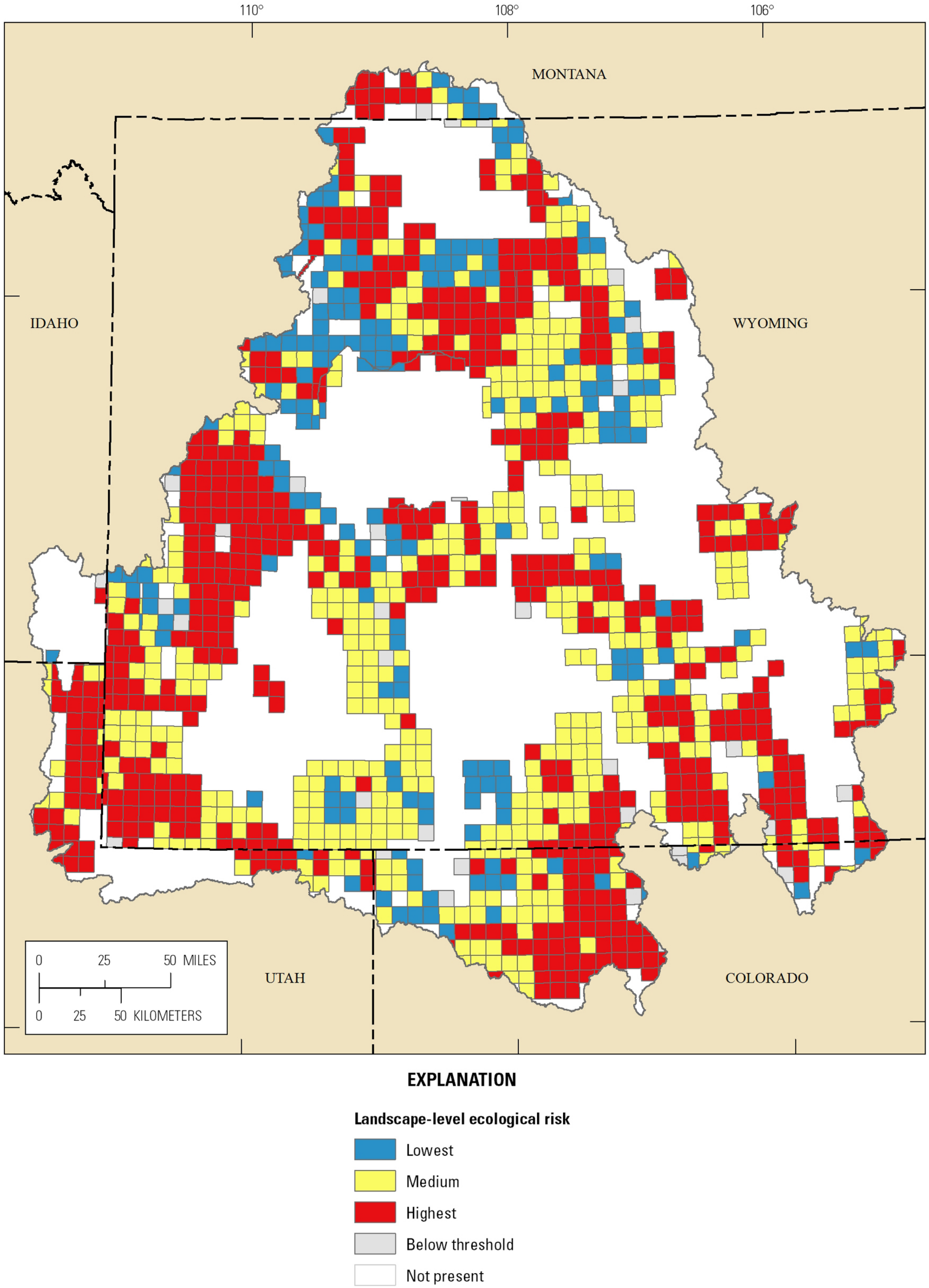

Figure 28–17. Ranks of landscape-level ecological risks based on the Terrestrial Development Index for mule deer habitat, summarized by township, in the Wyoming Basin Rapid Ecoregional Assessment project area (see table 28−4 for overview of methods).

Where are the townships with the greatest conservation potential (fig. 28–18)?

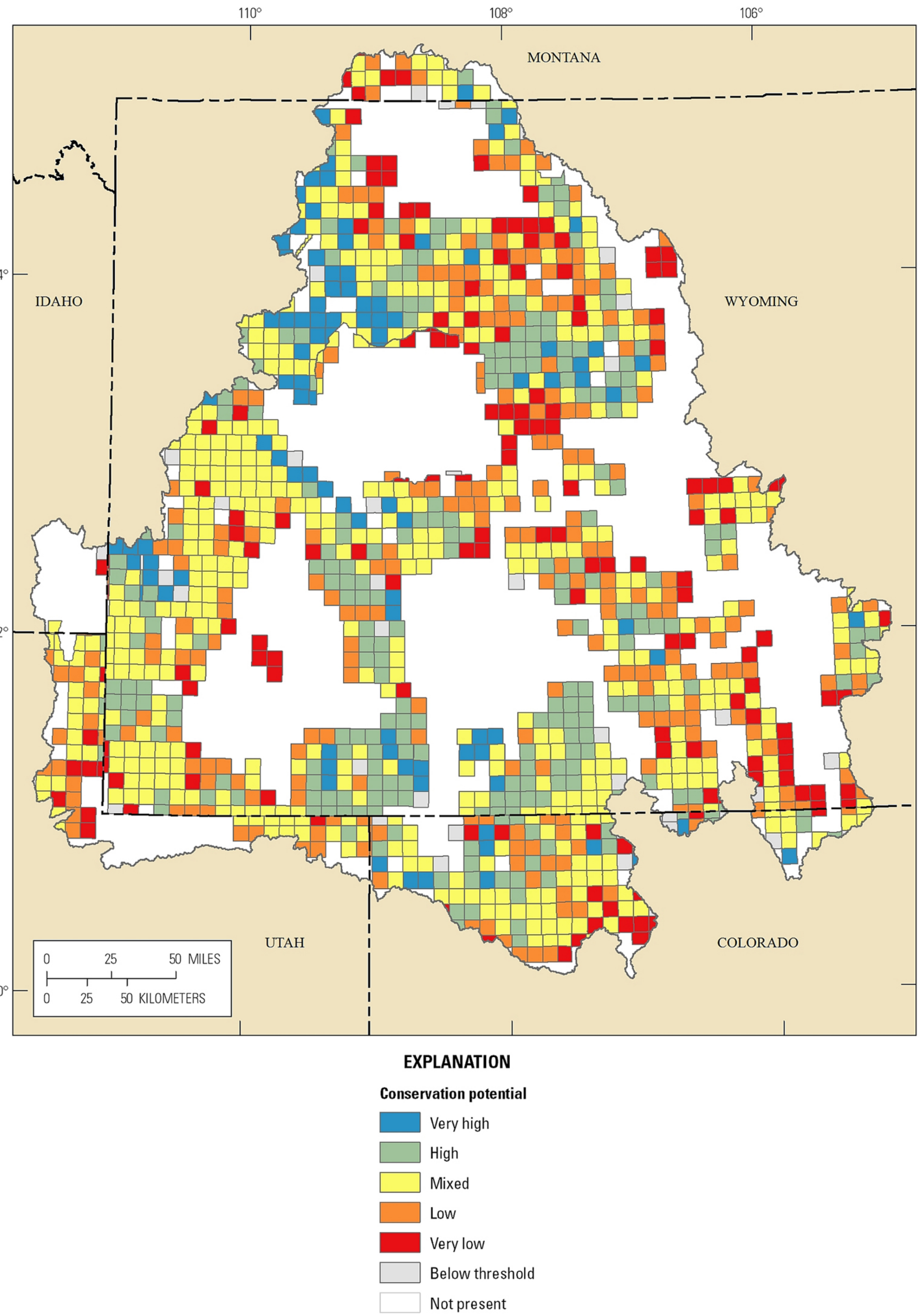

Figure 28–18. Conservation potential of mule deer crucial winter range and migration corridors, summarized by township, in the Wyoming Basin Rapid Ecoregional Assessment project area. Highest conservation potential identifies areas that have the highest landscape-level values and the lowest-level risks. Lowest conservation potential identifies areas that have the lowest landscape-level values and the highest-level 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

Mule deer crucial winter range occurs in approximately 16 percent of the Wyoming Basin, primarily at elevations between 1,400–1,700 meters (4,593–5,577 feet). The dominant vegetation type is sagebrush shrubland which is a major source of winter forage, but deciduous shrublands and riparian areas also provide valuable forage. Juniper provides thermal cover and concealment on crucial winter range and during migration, and management to control juniper could have negative effects on mule deer populations (Anderson and others, 2012). Agricultural lands have mixed effects on wintering mule deer. Winter wheat and alfalfa can provide forage, but most agricultural lands are located on formerly productive riparian areas and sagebrush shrublands (see Chapter 11—Sagebrush Steppe), and agricultural lands do not provide cover.

Relatively undeveloped areas may provide refuge from disturbance during vulnerable times, including winter, migration, and parturition. Development levels on crucial winter range and along migration corridors are very high in many areas. Of primary concern is the disturbance from roads and energy development, which have demonstrated negative effects on mule deer, as evidenced by their avoidance of infrastructure at moderate and high-development levels for migration corridors (Sawyer and Kauffman, 2011; Lendrum and others, 2012). Even low levels of development can cause the indirect loss of crucial winter range for mule deer as evidenced by their avoidance of well pads even when traffic volumes are limited (Sawyer and others, 2006, 2009). Direct and indirect loss of winter range may have greater population-level effects than the loss or alteration of other seasonal habitats, and disturbance from activities along roads and in energy fields could affect survival of overwintering mule deer (Webb, Dzialak, Kosciuch, and others, 2013).

Although we used the total surface disturbance footprint from development as an index of risk for mule deer, information on disturbance from human activities (vehicle traffic, well drilling activities) when available is a better predictor of avoidance behavior (Sawyer and others, 2009). The availability of concealment cover may diminish the disturbance effects of development (Anderson and others, 2012). This has important management implications, because traffic management, use of technology that reduces vehicle traffic, and management for concealment cover may help to minimize the indirect loss of mule deer habitat (Sawyer and others, 2009).

Most of the REA analyses centered on crucial winter range because of the availability of regionwide information and because of the vulnerability of wintering deer to development. There was limited availability of information on migration corridors and parturition areas, which are also vulnerable times for mule deer. Because year-round mule deer habitat is so widely distributed throughout the ecoregion, other chapters address vegetation types used by mule deer, including Chapter 11—Sagebrush Steppe, Chapter 13—Foothill Shrublands, Chapter 15—Aspen Forests and Woodlands, and Chapter 10—Riparian Forests.

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