Section III. Assessments of Communities

Chapter 14. Montane and Subalpine Forests and Alpine Zones

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Distribution and Ecology

Montane and subalpine forests (hereafter mountain forests) and alpine zones of the Wyoming Basin ecoregion are similar to those found throughout the northern Rocky Mountains. In general, mountain forests occur in major mountain ranges that define much of the Wyoming Basin ecoregion periphery, and all alpine zones occur outside the Wyoming Basin ecoregion proper, but within the project area buffer. Mountain forests that occur in relative isolation from the major mountain ranges may be found in the Owl Creek, Green, Shirley, Ferris, Seminoe, and South Big Horn Mountains, as well as the Little Mountain Ecosystem, Rattlesnake Range, and Commissary Ridge. Overall, the mountain forests are represented by five vegetation zones: lower and upper montane, subalpine, krumholtz, and alpine. Each zone typically occurs within a loosely defined elevational band that rises diagonally from lower elevations on northern aspects to higher elevations on southern aspects, although many local-to-regional factors may allow a given type to occur above or below its typical elevational band (Peet, 1988; Knight, 1994).

The lower montane forests generally occur at elevations of about 1,800–2,600 meters (m) (5,900–8,530 feet [ft]) and are characterized by a species-elevation gradient that shifts from ponderosa pine dominance in the foothills-montane ecotone to mixed ponderosa pine and Douglas-fir in middle elevations to Douglas-fir dominance at the higher elevations. At the foothills-montane ecotone, ponderosa pine savannah or woodland is typical, whereas at higher elevations, ponderosa pine forest may be found. Ponderosa pine seedlings are relatively cold sensitive, which limits them to warm, sunny sites, whereas Douglas-firs more typically occur at higher elevations and on shady slopes. Both species use water efficiently, but ponderosa pine requires more summer rainfall than Douglas-fir (Knight, 1994). Upper montane forests occur at elevations of 1,800–3,500 m (5,900–11,480 ft) and are dominated by the cold-tolerant lodgepole pine. This species also uses water efficiently, which can allow it to become established in areas that may be too dry for other species that characterize the upper montane (Knight, 1994). Subalpine forests occur at elevations of 2,350–3,500 m (7,710–11,480 ft) and are dominated by Englemann spruce and (or) subalpine fir (Knight, 1994). Both species are very cold-tolerant but limited primarily to mesic sites. They are also quite shade-tolerant (especially the firs), so they readily regenerate in the understory (Knight, 1994). At the upper subalpine, the forest diminishes into a zone of krummholz—patchy islands of stunted, wind-sculpted trees, including whitebark pines (Knight, 1994).

Some species span multiple zones. Throughout most of the montane elevations, especially the middle to upper montane, aspen may occur in pure or mixed aspen-conifer stands (see the Chapter 15—Aspen Forests and Woodlands). Mature aspen are relatively drought tolerant, but the seedlings are not (Knight, 1994), so aspen typically occur where soil moisture persists during the growing season (Knight, 1994). Limber and whitebark pines also may occur from the lower montane to treeline, typically in the drier, windswept areas that are unfavorable to other tree species (Knight, 1994) (see Chapter 16—Five-Needle Pine Forests and Woodlands).

The lower alpine zone typically occurs where mean July temperatures are <10 °C (50 °F), generally at elevations of 3,250 m (10,660 ft) in southern Wyoming and 3,000 m (9,840 ft) in the north (Knight, 1994). The alpine zone is characterized by alpine meadows in well-drained mesic sites with well-developed soils; by fellfields (rocky areas with scattered cushion plants) in dry, wind-swept sites; by patchy shrublands in drainages; by persistent snowfields leeward of ridges; by bogs in depressions; and by bare rock or talus on steep, unstable slopes. Most alpine plant species have morphological and physiological adaptations to maximize heat conservation and growth in alpine conditions, which favor perennial grasses, sedges, forbs, and low-growing (sometimes prostrate) shrubs. Common plants include timberline bluegrass, black alpine sedge, alpine avens, alpine bistort, alpine laurel, and willow species (both shrub and prostrate forms).

Landscape Structure and Dynamics

The major influences on mountain forest and alpine landscape structure are the elevational gradients in temperature and moisture availability (Peet, 1988). As elevation increases, temperatures decrease, whereas precipitation and duration of snow cover increase (that is, moisture also increases). However, concomitant increases in atmospheric pressure, solar and ultraviolet radiation, and wind velocity tend to counteract the effects of increasing moisture (Knight, 1994). Furthermore, these broad patterns are subject to localized effects of aspect, slope, and soil type; as well as to disturbance frequency, successional changes, and interactive effects of wildlife on plant life-history characteristics. For example, high-elevation species may occur at low elevations where cold-air drainage suppresses temperatures (Knight, 1994). Limestone- or dolomite-derived soils typically support Douglas-fir and Engelmann spruce, but the pines and subalpine fir typically occur on granitic, glacial, or volcanic soils (Knight, 1994). The distribution of limber and whitebark pines is strongly influenced by the seed-caching behavior of Clark's nutcrackers (see Chapter 16—Five-Needle Pine Forests and Woodlands) (Tomback and Linhart, 1990). Overall, tree species composition within and between forest types can range from pure stands of one species to more heterogeneous mixtures of two or more species.

Forest gaps created by disturbances, and larger parklands maintained by soil conditions and other factors unfavorable to tree growth, contribute to heterogeneity of montane forests. These gaps and parklands are characterized by grasses and forbs in drier sites and by sedges and shrubs in wetter sites (Knight, 1994). Common montane grasses, sedges, and shrubs include bluebunch wheatgrass, Idaho fescue, elk sedge, russet buffaloberry, Saskatoon serviceberry, shrubby cinquefoil, and willow species.

Insect outbreaks, fire, disease, wind-throw, drifting snow, and snow slides are the predominant disturbance types in mountain forests affecting forest type and stand structure (Peet, 1988; Knight, 1994). In the alpine zone, cryoturbation (soil disturbance and slumping due to frequent cycles of freezing and thawing) is the primary disturbance type (Knight, 1994). In general, the conditions that promote fire, including temperature, drought, and rapid build-ups of fine fuels, decrease with increasing elevation (Peet, 1988; Baker, 2009). Fire frequency, severity, and size, however, vary widely both spatially and temporally (for example, see Biondi and others [2011]). There is mounting evidence that fluctuations in vegetation communities and fire-activity levels are influenced primarily by climate, and fire regimes have varied accordingly throughout the Holocene (Whitlock and others, 2003; Baker, 2009).

Mixed burn severities in mountain forests result in patchy distributions of low- to high-severity burns, although low-severity burns are more typical where build-up of fine fuels can lead to more frequent fire, as observed in some ponderosa pine woodlands (Baker, 2009). Similarly, where conditions that promote fire occur less frequently, fuel buildups can be significant enough to support large canopy fires, as observed in all mountain forest types. Lower montane species have thick bark that insulates the larger trees from scorching during surface burns, which can promote an open woodland structure with relatively few small trees (Knight, 1994). Aspen, lodgepole pine, Engelmann spruce, and subalpine fir, however, have thin bark that affords little protection against scorching; thus, fire usually kills these trees (Knight, 1994), although aspen quickly resprouts from rootstock. For lodgepole pine, fire can create the conditions necessary for rapid, often dense reseeding from its serotinous cones, which insulate the seeds from fire but require fire to open the scales and release the seeds (Baker, 2009). The high-elevation conditions that reduce ignition probabilities in subalpine forests often allow these forests types to escape fire for centuries, which in turn promotes fuel build ups that may lead to broad-scale burns of mixed severity (Baker, 2009).

Outbreaks of insects, such as the endemic mountain pine beetle and western spruce budworm, occur cyclically throughout the mountain forest. When conditions allow insect populations to grow unchecked, however, widespread tree mortality may occur (Peet, 1988; Knight, 1994). Mature trees and forests are particularly susceptible, in part because the increasing competition for light, nutrients, and moisture in mature stands can stress the trees, which reduces their capacity to produce sap and chemical compounds that help to expel beetle larvae (Knight, 1994). Drought can further stress the trees and reduce their resistance to beetle attack.

Associated Species of Management Concern

Overall, mountain forests and alpine zones provide important habitat and other ecological resources for many of Wyoming's Species of Greatest Conservation Need, including American marten (Wyoming Department of Fish and Game, 2011). The forests also support whitebark pines and Canada lynx, both candidates for listing under the Endangered Species Act, grizzly bear (Federally listed as threatened), and wolverine (proposal to list as Federally endangered withdrawn in summer 2014). In September 2014, a large portion of the western Wyoming mountain forests in the Absaroka, Wind River, and Wyoming Ranges were designated as critical lynx habitat (see http://www.fws.gov/mountain-prairie/species/mammals/lynx/). Additionally, mountain forests provide cover for elk, mule deer, and moose (Wyoming Department of Fish and Game, 2011), and the forest gaps and parklands provide important summer grazing sites for these wild ungulates. For a given watershed, the greater snow accumulation that occurs in the smaller open areas often results in disproportionately more downslope water availability than an equal area of forest (Knight, 1994), which is an important influence on instream flow.

Change Agents

Development

Energy Development and Infrastructure

Energy development has not been a major Change Agent in mountain forests or alpine zones, but within the last decade, oil and gas development has been proposed in several areas that could affect mountain forests. Exurban development is largely restricted to private lands at the lower-to-mid elevations, but all forms of development increase when energy booms occur nearby, such as around the Green River Basin and the Atlantic Rim (Bowen and others, 2011). Development and upgrades of Wyoming's water-supply infrastructure are projected to continue in all major basins of the Wyoming Basin ecoregion, and some potential future reservoir sites are encompassed by the mountain forests (Wyoming Water Development Commission, 2007). Road development for logging, fire-fighting, and recreational off-highway vehicle use is an important driver of change in mountain forests and some alpine zones. Roads convert and fragment the forests (Reed and others, 1996) and damage vegetation, which can affect ecosystem processes, hydrological regimes, and erosion in particular (Knight, 1994; Luce and Wemple, 2001). Roads and trails also may function as corridors of invasion by exotic grasses and forbs (Wells and others, 2012).

Agricultural Activities

Agricultural activities in mountain forests and alpine zones include livestock grazing, timber harvest, and water impoundment (reservoirs) for irrigation. Grazing tends to concentrate in the parklands and forest gaps, where high stocking rates can interact with short growing seasons, leading to plant damage and changes in vegetation composition. High stocking rates also may result in water contamination, erosion, and downstream sedimentation. Historically, sheep grazing was a significant Change Agent on many alpine sites, which are very slow to recover, but since the early 1900s, sheep numbers have declined, and herding practices have changed (Thilenius, 1975). Timber harvest occurs in all mountain forest types, but ponderosa and lodgepole are the most commercially important species currently harvested in Wyoming (Brandt and others, 2009). Mechanical treatments, including logging and use of herbicides, as well as prescribed fire, are often used to manage stand structure of mountain forests for various agricultural, horticultural, and other purposes (Knight, 1994).

Altered Fire Regime

Generally, it has been assumed that fire suppression after Euro-American settlement reduced fire frequency in mountain forests, thereby facilitating the expansion of and increased stem density in conifer forests (Knight, 1994). Because fire suppression is a relatively recent phenomenon, however, it probably has had little effect on fire regimes except perhaps in some lower montane forests where fires were more frequent (Baker, 2009). Grazing interacts with fire suppression by decreasing fine fuels and allow increased establishment of tree seedlings by reducing competition from grasses and forbs (Knight, 1994); however, the degree to which livestock grazing has affected mountain forest tree densities and (or) overall fire regimes in the Wyoming Basin is unclear and likely has varied with species, soil types, and variations in climatic patterns.

Invasive Species, Insects, and Diseases

The primary invasive species of concern in mountain forests is a fungal disease that was introduced from Europe: the white pine blister rust (see Chapter 16—Five-Needle Pine Forests and Woodlands). Combined with the current outbreak of mountain pine beetle, whitebark pines are undergoing high rates of mortality (Bockino and Tinker, 2012). Although insect outbreaks are normal cyclic events in the mountain forests, warmer temperatures and drought can lead to greater amplitudes and durations of insect outbreaks (see Chapter 16—Five-Needle Pine).

Climate Change

Increasing temperatures have led to earlier onset of the growing season, upslope movement of mountain forests, and large-scale forest die-offs (Allen and others, 2010). In the San Juan Mountains of southwestern Colorado, where studies indicate that treeline has retreated and advanced with changes in climate throughout the Holocene, a rise in mean summer temperature of <1 ºC (1.8 ºF) resulted in treeline advancement of 80–140 m (262–459 ft) (Carrera and others, 1991). Moreover, the altitudinal and latitudinal advances of mountain forests could occur at the expense of alpine and taiga systems (Rehfeldt and others, 2012). Based on projected increasing temperatures, similar trends in the Wyoming Basin could occur, although rates of advancement and precise ranges of advancement will depend on the complex suite of regional and local factors that also affect changes in treeline (Holtmeier and Broll, 2005). Some alpine and subalpine species, such as American pika, reach the northern limit of their range in Bighorn Mountains, which may enhance connectivity if northward expansion occurs with changing climate.

Rapid Ecoregional Assessment Components Evaluated for Montane and Subalpine Forests and Alpine Zones

A generalized, conceptual model was used to highlight some of the key ecological attributes and Change Agents affecting mountain forests and alpine zones (fig. 14–1). Key ecological attributes addressed by the Rapid Ecoregional Assessment (REA) include (1) the distribution of mountain forests and alpine zones, (2) landscape structure (patch sizes and structural connectivity), and (3) landscape dynamics (fire and bark beetle occurrence and conifer-aspen dynamics) (table 14–1). The Change Agents evaluated include development, white pine blister rust, and climate change (table 14–2). Ecological values and risks used to assess the conservation potential of this community by township are summarized in table 14–3. Core and Integrated Management Questions and the associated summary maps and graphs are provided in table 14–4.

Methods Overview

To map the distribution of mountain and subalpine forests and alpine zones, we included Douglas-fir, ponderosa pine woodlands, lodgepole pine, spruce and fir, and all alpine LANDFIRE Existing Vegetation Types. Mountain slope aspen (see Chapter 15—Aspen Forests and Woodlands) and all grassland Existing Vegetation Types above 2,900 m (9,514 ft) also were included.

We assessed development levels in mountain forests using the Terrestrial Development Index (TDI) map, and used the resulting output to calculate patch size and structural connectivity metrics. We mapped structural connectivity of the baseline distribution at three interpatch distances derived from connectivity analysis for this community; local (0.36 kilometers [km]; 0.22 miles [mi]), landscape (1.44 km; 0.89 mi), and regional (2.43 km; 1.51 mi) levels. Areas that may function as barriers or corridors were derived from development levels and were identified by overlaying baseline patches on the TDI map. The perimeters of fires in mountain forests since 1980 and bark beetle mortality since 1997 were compiled from several data sources to assess fire frequency and extent (table 14–1).

We evaluated the potential changes in the distribution of montane forests and alpine zones separately, using the bioclimatic envelopes developed by Rehfeldt and others (2012) and climate scenario I, the Canadian Centre for Climate Modelling and Analysis Model version 3 (emissions scenario A2) in 2030. Current and projected bioclimatic envelopes were used to identify areas where mountain forests and alpine zones had the potential to increase, decline, or remain the same. We then overlaid the resulting maps with baseline maps to identify existing areas that have the potential to change for climate scenario I.

Landscape-level ecological values (area of mountain forests and alpine zones) and risks (TDI score) were compiled into an overall index of conservation potential for each township (table 14–3). See Chapter 2—Assessment Framework and the Appendix for additional details on the methods. 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.

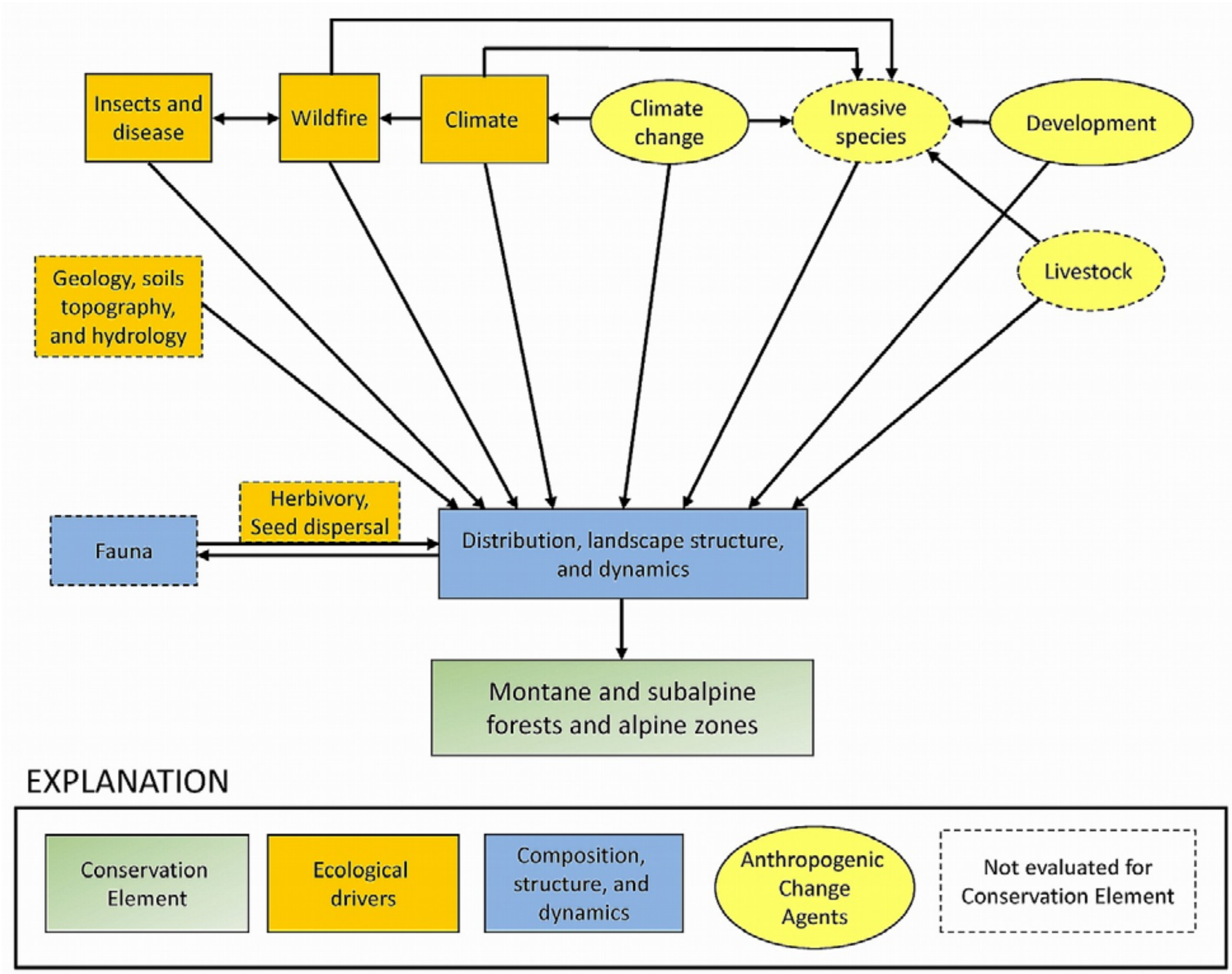

Figure 14-1. Generalized conceptual model for montane and subalpine forests and alpine zones for the Wyoming Basin Rapid Ecoregional Assessment (REA). Biophysical attributes and ecological processes regulating the occurrence, structure, and dynamics of montane and subalpine forests and alpine zones are 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 addressed for montane and subalpine forests and alpine zones due to the lack of regionwide data.

Table 14−1. Key ecological attributes and associated indicators of baseline montane and subalpine forests and alpine zones[1] for the Wyoming Basin Rapid Ecoregional Assessment.

[km, kilometer; mi, mile]

Attributes	Variables	Indicators
Amount and distribution	Total area	Distribution derived from LANDFIRE[1]
Landscape structure	Patch size	Patch-size frequency distribution
	Structural connectivity[2]	Interpatch distances that provide an index of structural connectivity for baseline patches at local (0.36 km; 0.22 mi), landscape (1.44 km; 0.89 mi), and regional (2.43 km; 1.51 mi) levels
Landscape dynamics	Fire and bark beetle occurrence[3]	Locations of fires (since 1980) and bark beetle outbreaks (sine 1987)

[1] Baseline conditions are used as a benchmark to evaluate changes in the total area and landscape structure of montane and subalpine forests and alpine zones due to Change Agents. Baseline conditions are defined as the potential current distribution of mountain forests and alpine derived from LANDFIRE Existing Vegetation Types without explicit inclusion of Change Agents (see Chapter 2—Assessment Framework and the Appendix).

[2] 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.

[3] See Wildland Fire section in the Appendix.

Table 14−2. Anthropogenic Change Agents and associated indicators influencing montane and subalpine forests and alpine zones 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 montane and subalpine forests and alpine zones in seven development classes using a 16-km^2 (6.18-mi^2) moving window
		Patch-size frequency distribution for montane and subalpine forests and alpine zones that are relatively undeveloped or have low development scores compared to baseline conditions
		Interpatch distances that provide an index of structural connectivity for relatively undeveloped patches at local (3.15 km; 1.96 mi), landscape (4.86 km; 3.02 mi), and regional (12.24 km; 7.61 mi) levels
Introduced species and disease	White pine blister rust	See Chapter 16—Five-Needle Pine Forests and Woodlands
Climate change	Projected temperature and precipitation	Potential distribution of montane and subalpine forests and alpine zones derived from the projected distribution of the bioclimatic envelope in 2030[2]

[1] See Chapter 2—Assessment Framework.

[2] Bioclimatic envelope represents the climatic conditions conducive for montane and subalpine forests and alpine zones, derived from Rehfeldt and others (2012) for climate scenario I (Canadian Centre for Climate Modelling and Analysis Model, ver. 3, emissions scenario A2).

Table 14−3. Landscape-level ecological values and risks for montane and subalpine forests and alpine zones. Ranks were combined into an index of conservation potential for the Wyoming Basin Rapid Ecoregional Assessment.

[>, greater than]

		Relative rank			
	Variables[1]	**Lowest**	**Medium**	**Highest**	**Description**[2]
Values	Area	<26	26–76	>76	Percent of township classified as mountain forests and alpine
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 each Conservation Element to minimize the effects of extremely small areas and put greater emphasis on conservation potential of large areas (see table A−19 in the Appendix for details on criteria for assigning ranks for values and risks and threshold levels).

[2] See tables 14–1 and 14–2 for description of variables.

Table 14−4. Management Questions addressed for montane and subalpine forests and alpine zones for the Wyoming Basin Rapid Ecoregional Assessment.

Core Management Questions	**Results**
Where are baseline mountain forests and alpine zones, and what is the total area?	Figure 14–2
Where does development pose the greatest threat to baseline mountain forests and alpine zones, and where are the relatively undeveloped areas?	Figures 14–3 and 14–4
How has development fragmented baseline mountain forests and alpine zones, and where are the large, relatively undeveloped patches?	Figures 14–5 and 14–6
How has development affected structural connectivity of mountain forests and alpine zones relative to baseline conditions?	Figure 14–7
Where are potential barriers and corridors that may affect animal movements among relatively undeveloped patches of mountain forests and alpine zones?	Figure 14–8
Where have mountain forests been disturbed by recent fires and bark beetle outbreaks, and what is the total area of forest affected by each disturbance?	Figures 14–9 and 14–10
What are the potential distributions of mountain forests and alpine zones in 2030?	Figures 14–11 and 14–12
Integrated Management Questions	**Results**
How does risk from development vary by land ownership or jurisdiction for mountain forests and alpine?	Table 14–5, Figure 14–13
Where are the townships with the greatest landscape-level ecological values?	Figure 14–14
Where are the townships with the greatest landscape-level risks?	Figure 14–14
Where are the townships with the greatest conservation potential?	Figure 14–15

Key Findings for Management Questions

Where are baseline montane and subalpine forests and alpine zones, and what is the total area (fig. 14–2)?

- The mountain forests and alpine zones comprise 24,903 square kilometers (km^2) (9,615 square miles [mi^2]) and cover approximately 14 percent of the project area, only 1.2 percent of which is in the ecoregion proper.
- The mountain forest and alpine zone occurs in the Absaroka, Wind River, Rattlesnake, Park, and Wyoming Ranges; the Big Horn, Ferris, Granite, Green, Laramie, Medicine Bow, Owl Creek, Seminoe, Shirley, Sierra Madre, South Big Horn, and Uinta Mountains; the Little Mountain Ecosystem; and Commissary Ridge (fig. 14–2).

Where does development pose the greatest threat to baseline montane and subalpine forests and alpine zones, and where are the relatively undeveloped areas (figs. 14–3 and 14–4)?

- Development levels are low in mountain forests and alpine zones within the Wyoming Basin; development is generally restricted to lower elevations (fig. 14–3). Large regions of the Absaroka, Bighorn, and Wind River Mountains have low levels of development.
- Compared to other communities in the ecoregion, development is lowest for mountain forests. Fifty-nine percent of this community is relatively undeveloped (TDI score $\leq$1 percent); only 4 percent has a TDI scores >5 percent, indicating high levels of development (fig. 14–4).

How has development fragmented baseline montane and subalpine forests and alpine zones, and where are the large, relatively undeveloped patches (figs. 14–5 and 14–6)?

- Baseline mountain forest and alpine patches are generally very large, with approximately 22 percent occurring in patches >5,000 km^2 (1,931 mi^2) and 64 percent occurring in patches >1,000 km^2 (386 mi^2) (fig. 14–5).
- Development has created pockets of disturbance at lower elevations, fragmenting the largest patches of mountain forest into smaller patches relative to baseline conditions. All relatively undeveloped mountain forests and alpine zones occur in patches <5,000 km^2 (1,930 mi^2).
- The largest relatively undeveloped patches occur in the Absaroka and Wind River Mountains (fig. 14–6).

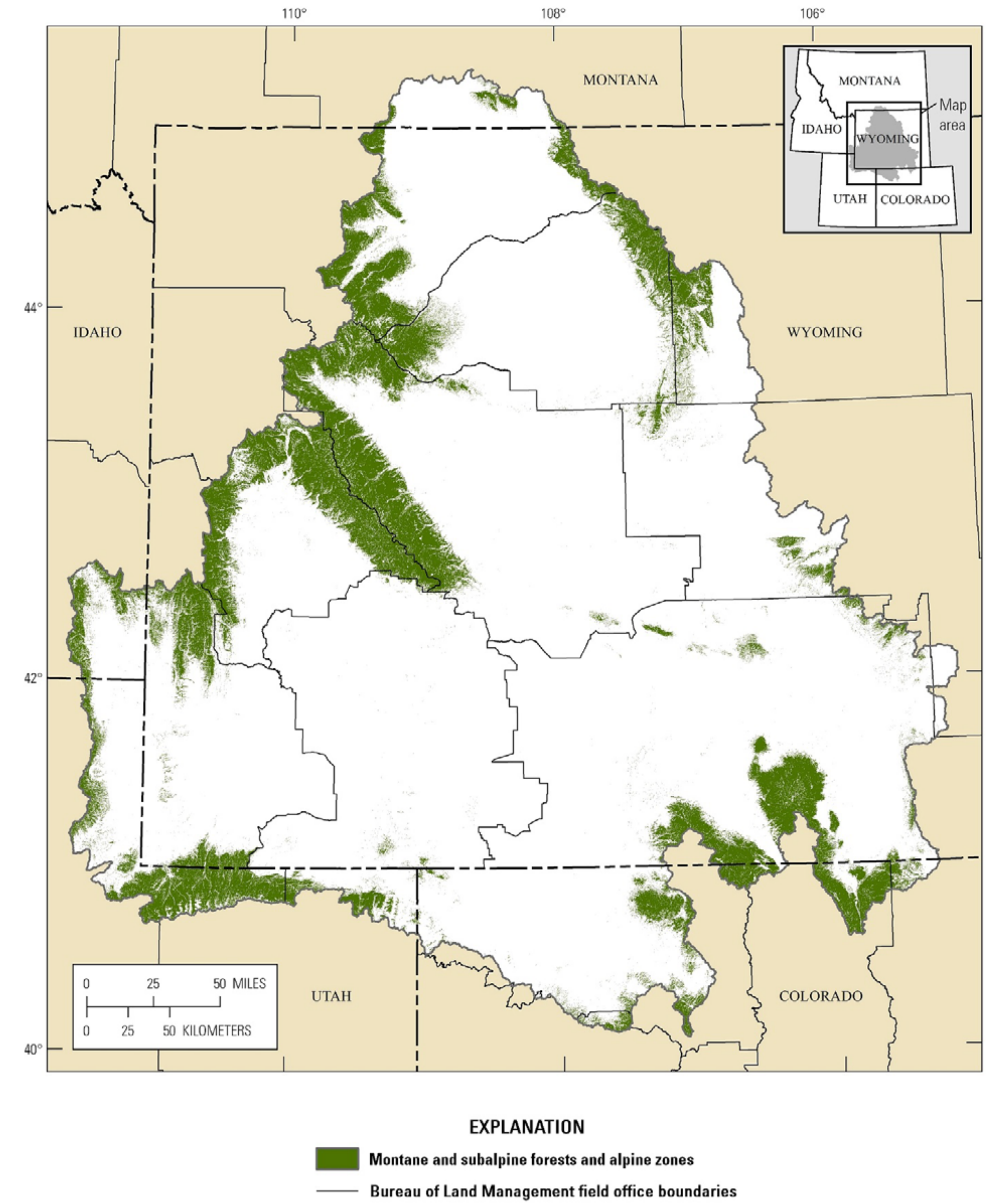

Figure 14-2. Distribution of baseline montane and subalpine forests and alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area.

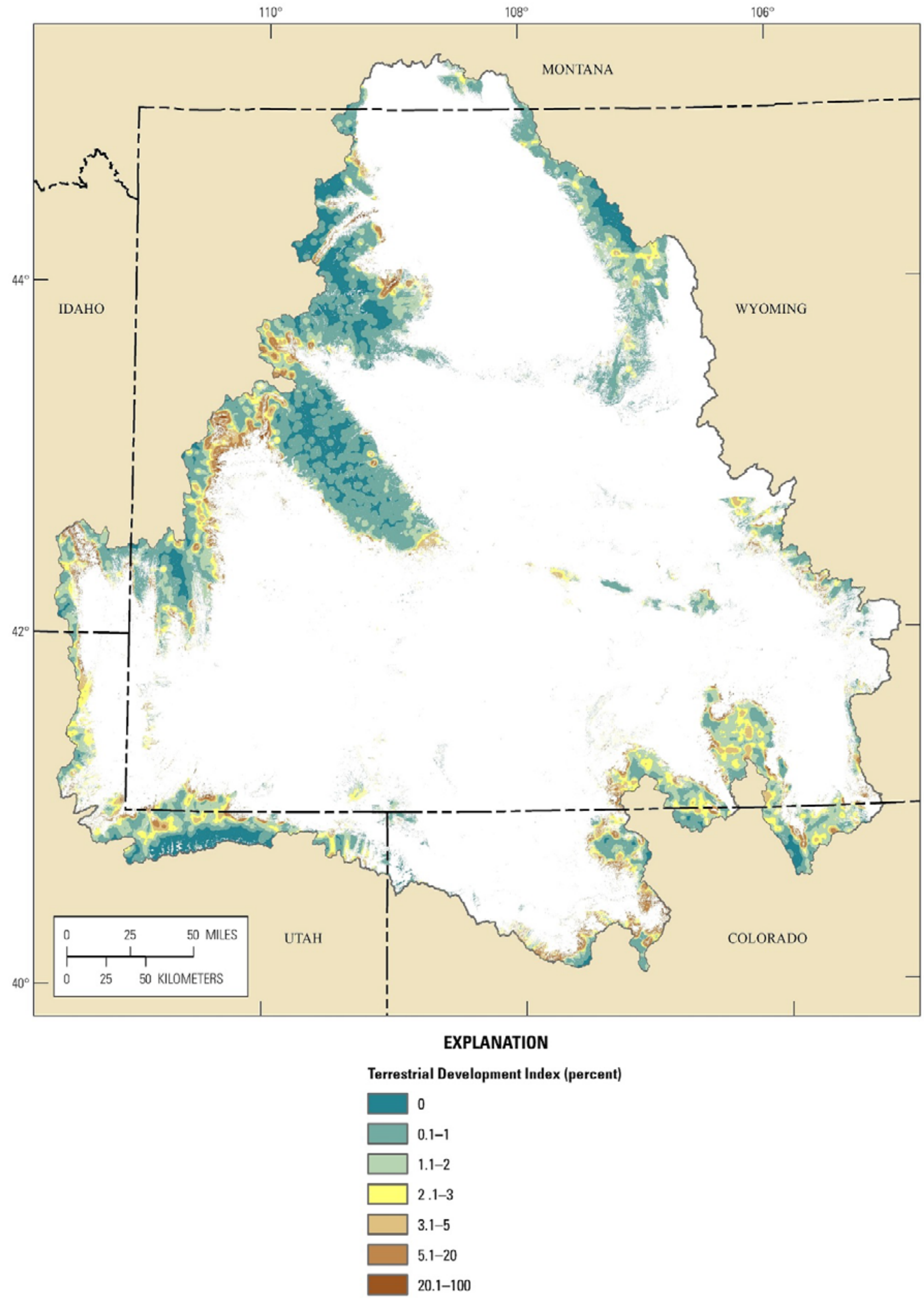

Figure 14-3. Terrestrial Development Index scores for montane and subalpine forests and alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area.

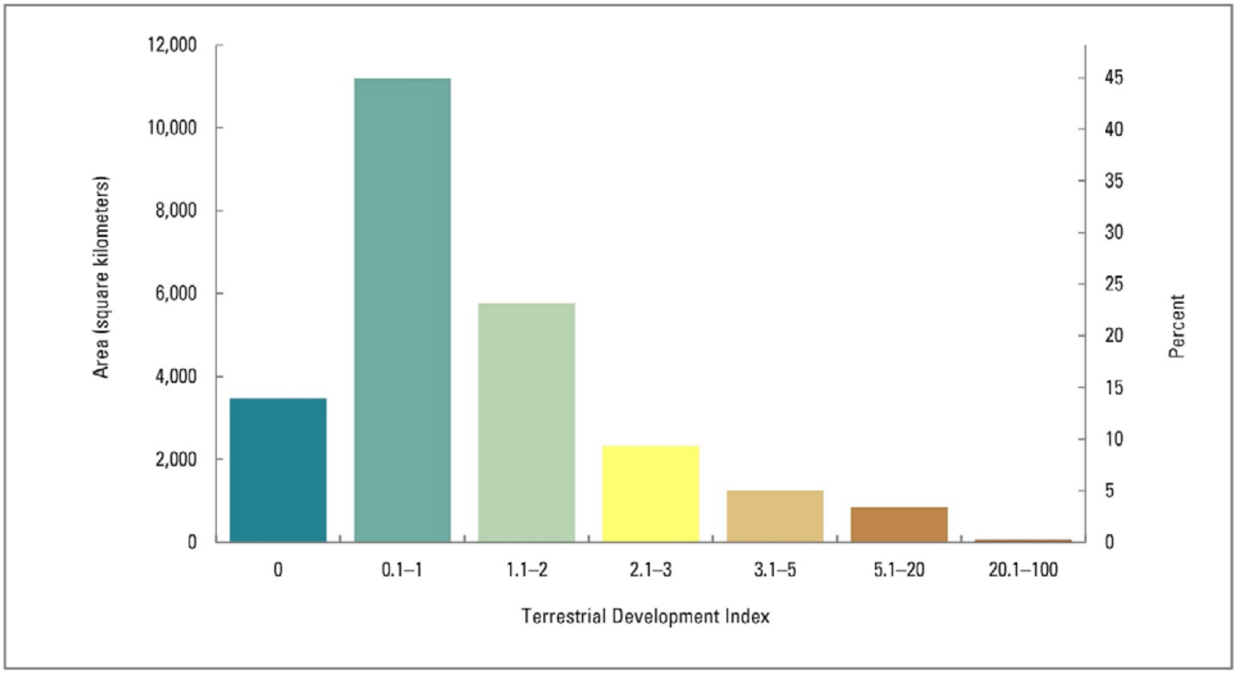

Figure 14-4. Area and percent of baseline montane and subalpine forests and alpine zones as a function of the Terrestrial Development Index in the Wyoming Basin Rapid Ecoregional Assessment project area.

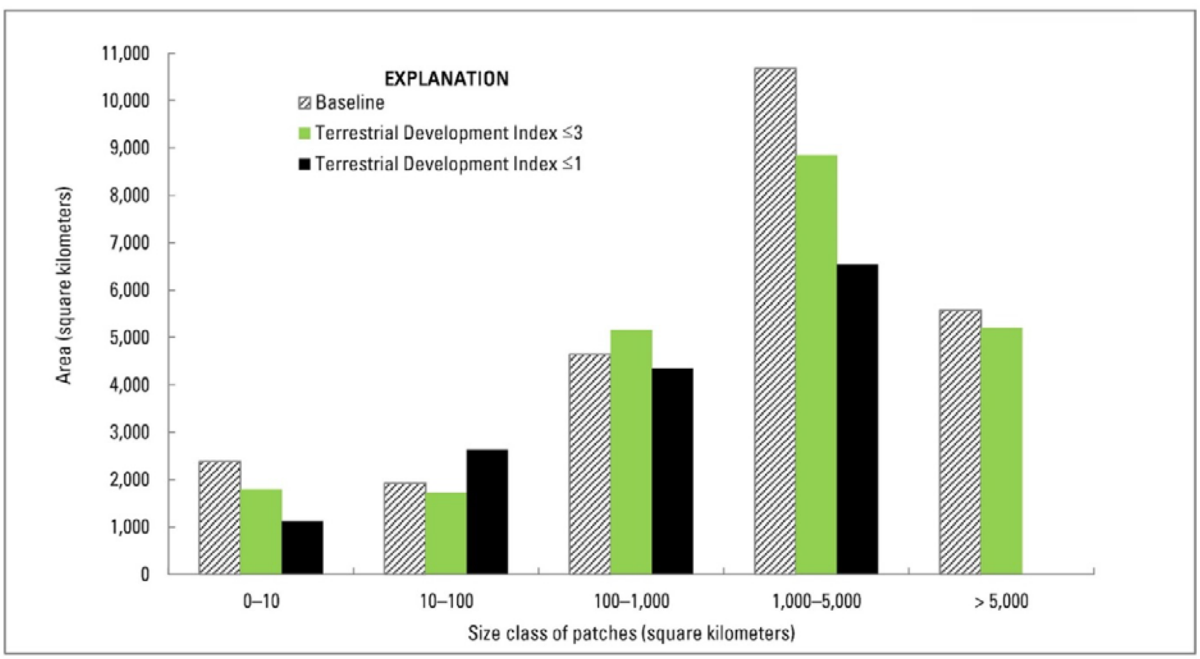

Figure 14-5. Area of montane and subalpine forests and alpine zones as a function patch size for baseline conditions and two development levels: (1) Terrestrial Development Index (TDI) score ≤3 percent, and (2) TDI score ≤1 percent (relatively undeveloped areas) in the Wyoming Basin Rapid Ecoregional Assessment project area.

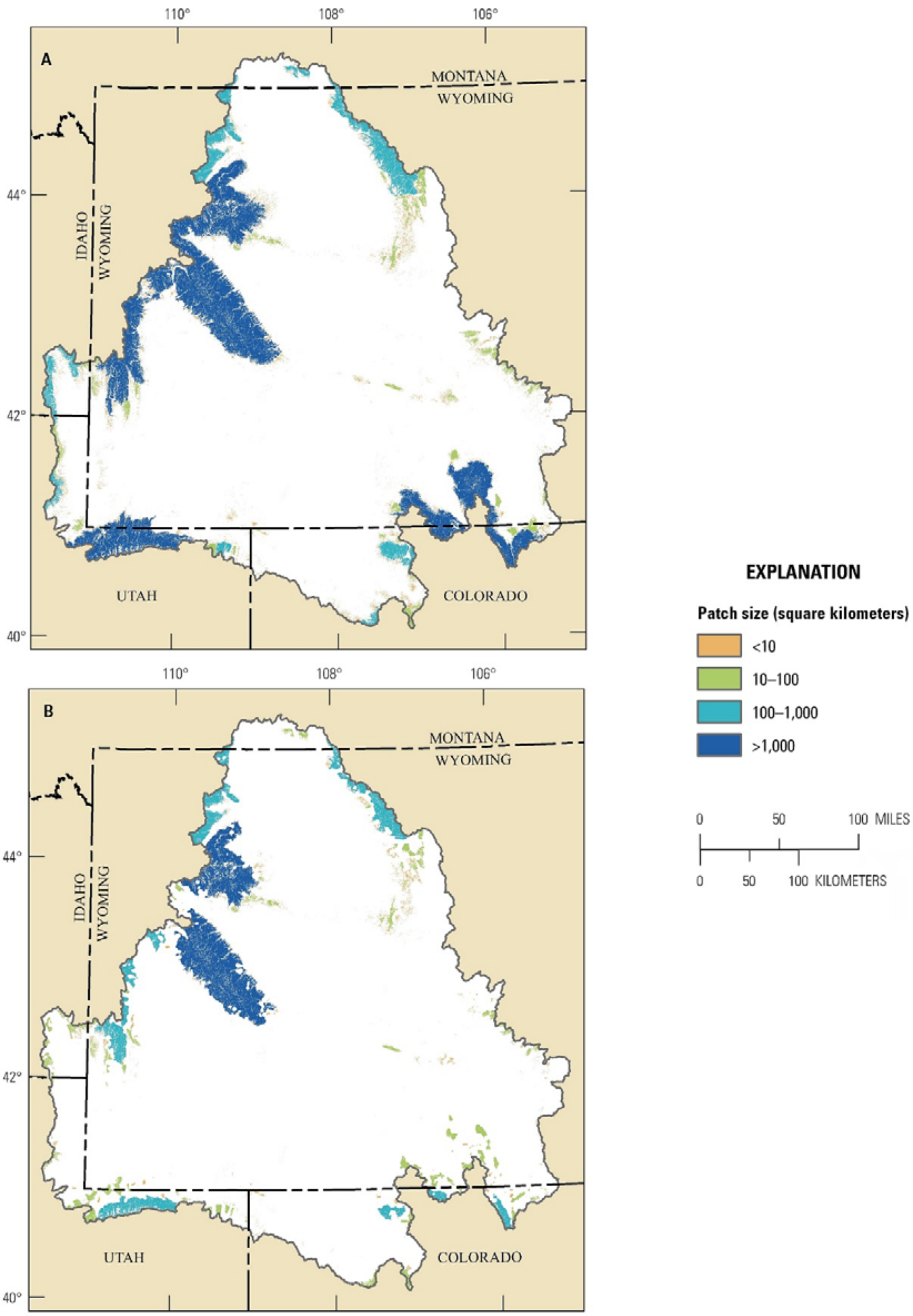

Figure 14-6. Patch sizes of montane and subalpine forests and alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area for (*A*) baseline conditions and (*B*) relatively undeveloped areas (Terrestrial Development Index score ≤1 percent).

How has development affected structural connectivity of montane and subalpine forests and alpine zones relative to baseline conditions (fig. 14–7)?

- The Wyoming Basin creates a natural discontinuity that separates the Northern and Southern Rocky Mountains. However, baseline mountain forests and alpine zones are highly connected at higher elevations within the larger mountain ranges in the project area buffer. Exceptions occur in the isolated mountain ranges, including the Owl Creek, Green, Shirley, Ferris, Seminoe, and South Big Horn Mountains, as well as the Little Mountain Ecosystem, Rattlesnake Range, and Commissary Ridge. Regional structural connectivity of baseline mountain forests occurs at an interpatch distance of 2.43 km (1.51 mi) (fig. 14–7).
- Development has diminished the structural connectivity of relatively undeveloped mountain forests and alpine zones, primarily at lower elevations. Connectivity of relatively undeveloped areas is 3.15 km (1.96 mi) at the local level, 4.86 km (3.02 mi) at the landscape level, and 12.24 km (7.61 mi) at the regional level.
- Patches of highly connected, relatively undeveloped areas (local, landscape, and regional connectivity) are associated with the large mountain ranges. Areas with high local and landscape connectivity may facilitate dispersal and seasonal movements, whereas lower-elevation and isolated mountains with only regional connectivity may have value as migratory bird stopovers across developed or otherwise unsuitable habitat.

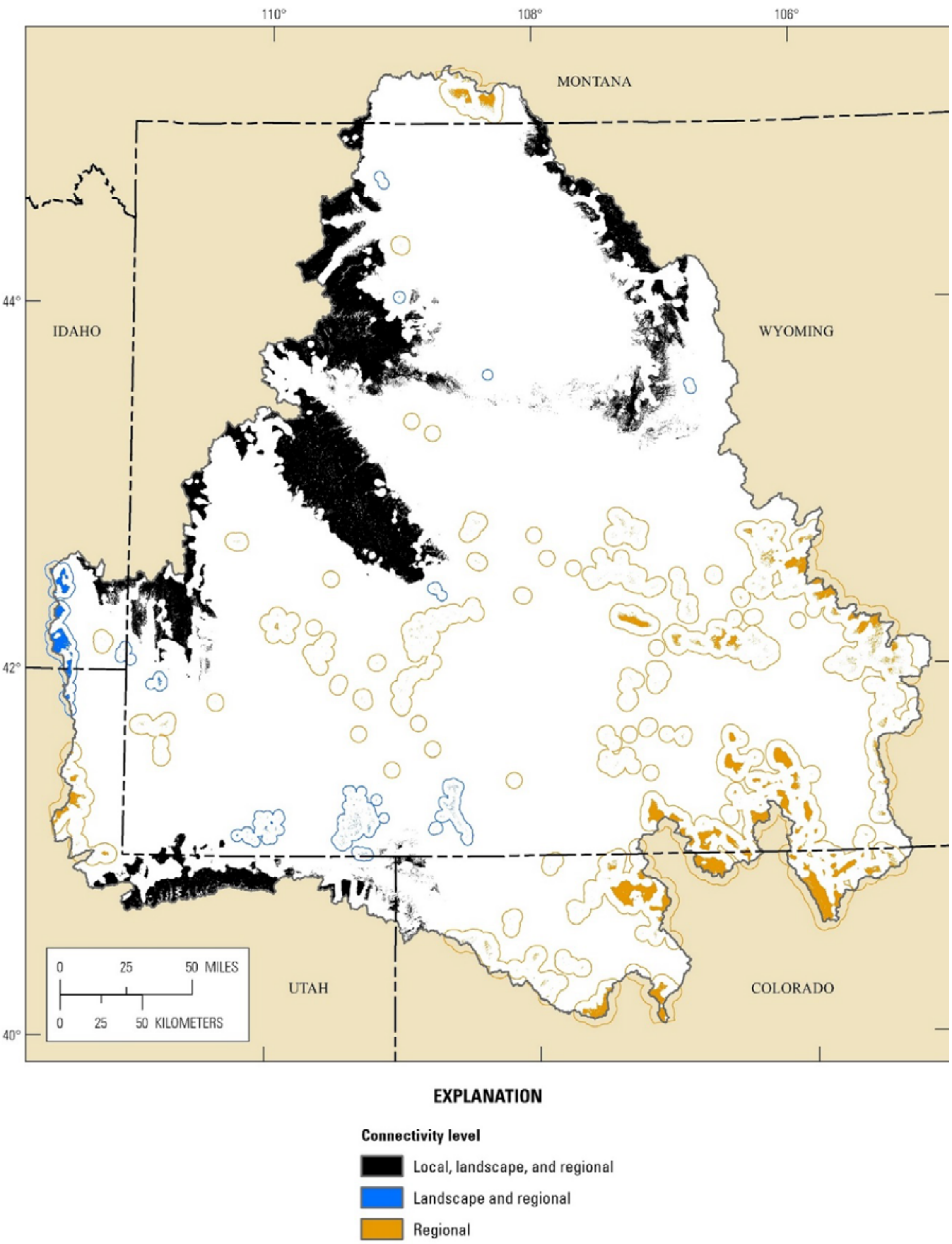

Figure 14-7. Structural connectivity of relatively undeveloped patches of montane and subalpine forests and alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area. Black polygons include large and highly connected patches. Blue polygons include patches that contribute to both landscape and regional connectivity. Orange polygons represent isolated clusters of patches surrounded by developed areas or other cover types.

Where are potential barriers and corridors that may affect animal movements among relatively undeveloped patches of mountain forests and alpine zones? (fig. 14–8)?

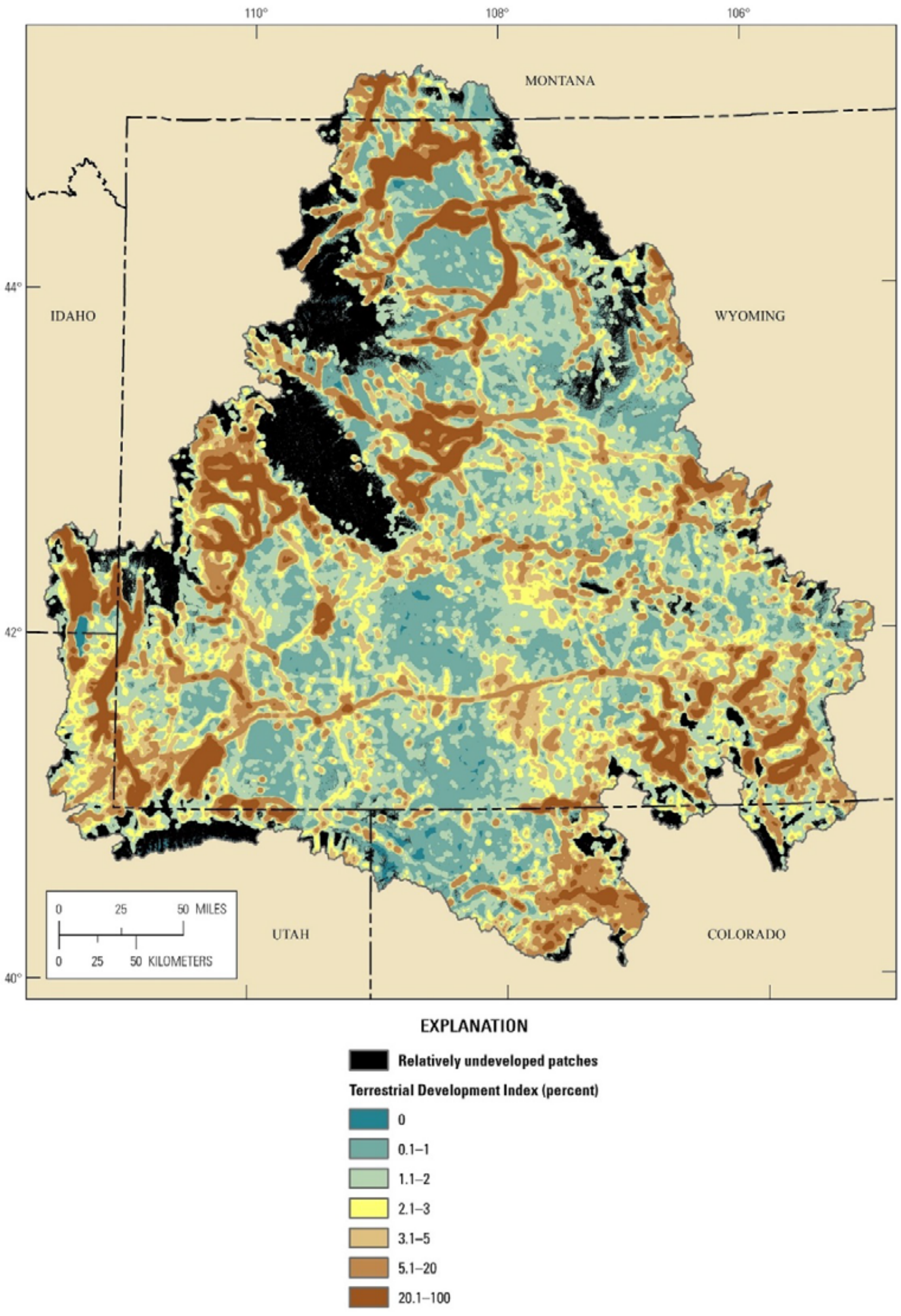

Figure 14-8. Potential barriers and corridors as a function of the Terrestrial Development Index (TDI) score for lands surrounding relatively undeveloped montane and subalpine forests and alpine zones. Higher TDI scores (for example, >5 percent) represent potential barriers to movement among relatively undeveloped patches. Lower TDI scores (for example, <2 percent) represent potential corridors for movements among patches.

Where have mountain forests been disturbed by recent fires and bark beetle outbreaks, and what is the total area of forest affected by each disturbance (figs. 14–9 and 14–10)?

- Typically, only a small fraction of mountain forest has burned each year since 1980. Cumulatively, the area that has burned since 1980 is 1,582 km^2 (983 mi^2) (6.3 percent).
- Most of the fires occurred after 2000, and a relatively large proportion of mountain forests (1.6 percent) burned in 2012 (fig. 14–9).
- Large fires have occurred since 1980 in mountain forests in all of the mountain ranges except the Granite, Laramie, Medicine Bow, and Sierra Madre Mountains (fig. 14–10).
- Approximately half of the mountain forest has been disturbed recently, primarily due to bark beetle outbreaks. The extent of forest mortality varies with disturbance severity.

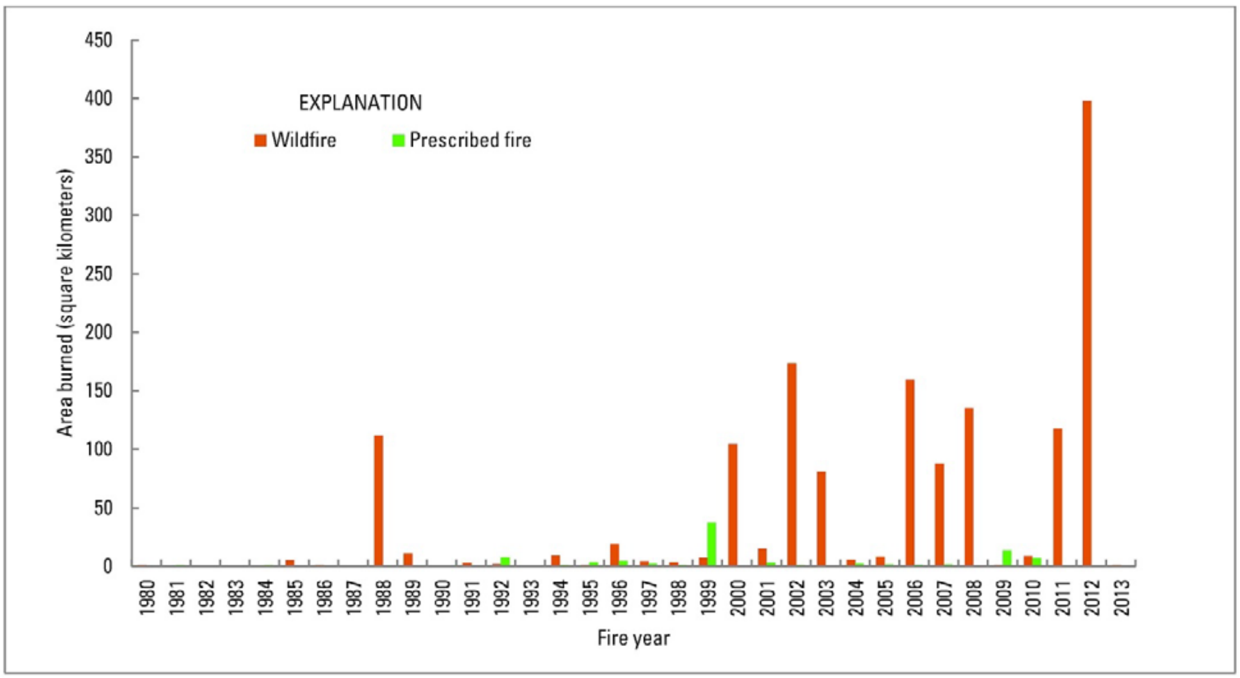

Figure 14-9. Annual area burned by wildfires and prescribed fires in baseline montane and subalpine forests and alpine zones since 1980 in the Wyoming Basin project area.

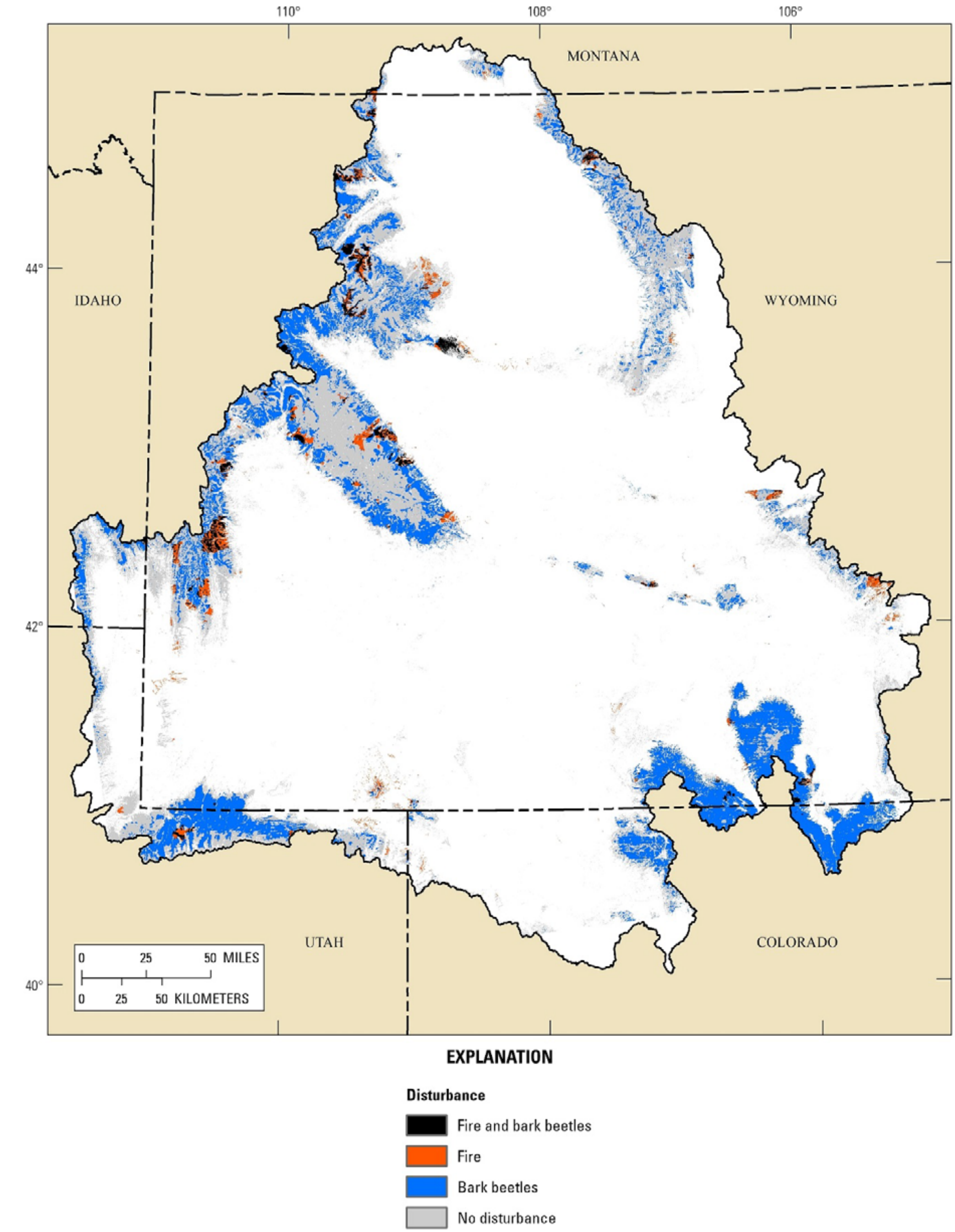

Figure 14-10. Locations of wildfires and prescribed fires (since 1980), and bark beetle outbreaks (since 1997) in baseline montane and subalpine forests and alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area.

What is the potential distribution of montane and subalpine forests and alpine zones in 2030 (figs. 14–11 and 14–12)?

- By 2030, the distribution of bioclimatic conditions conducive for mountain forests in the Wyoming Basin is projected to shift upslope for climate scenario I (fig. 14–11), and in the Granite Mountains, they are projected to be nearly absent (fig. 14–11).
- By 2030, the distribution of bioclimatic conditions conducive for alpine zones are projected to contract at lower elevations for climate scenario I (fig. 14–12).

How does risk from development vary by land ownership or jurisdiction for montane and subalpine forests and alpine zones (table 14–5, fig. 14–12)?

- The Forest Service and the BLM manage approximately 72 percent and 7.4 percent, respectively, of mountain forests and alpine zones in the Wyoming Basin (table 14–5).
- Federal and Tribal lands have much higher proportions of mountain forests and alpine zones with the lowest risk from development compared to other land owners (fig. 14–13).
- Nearly all mountain forests and alpine zones on Tribal land have low risk from development (fig. 14–13).

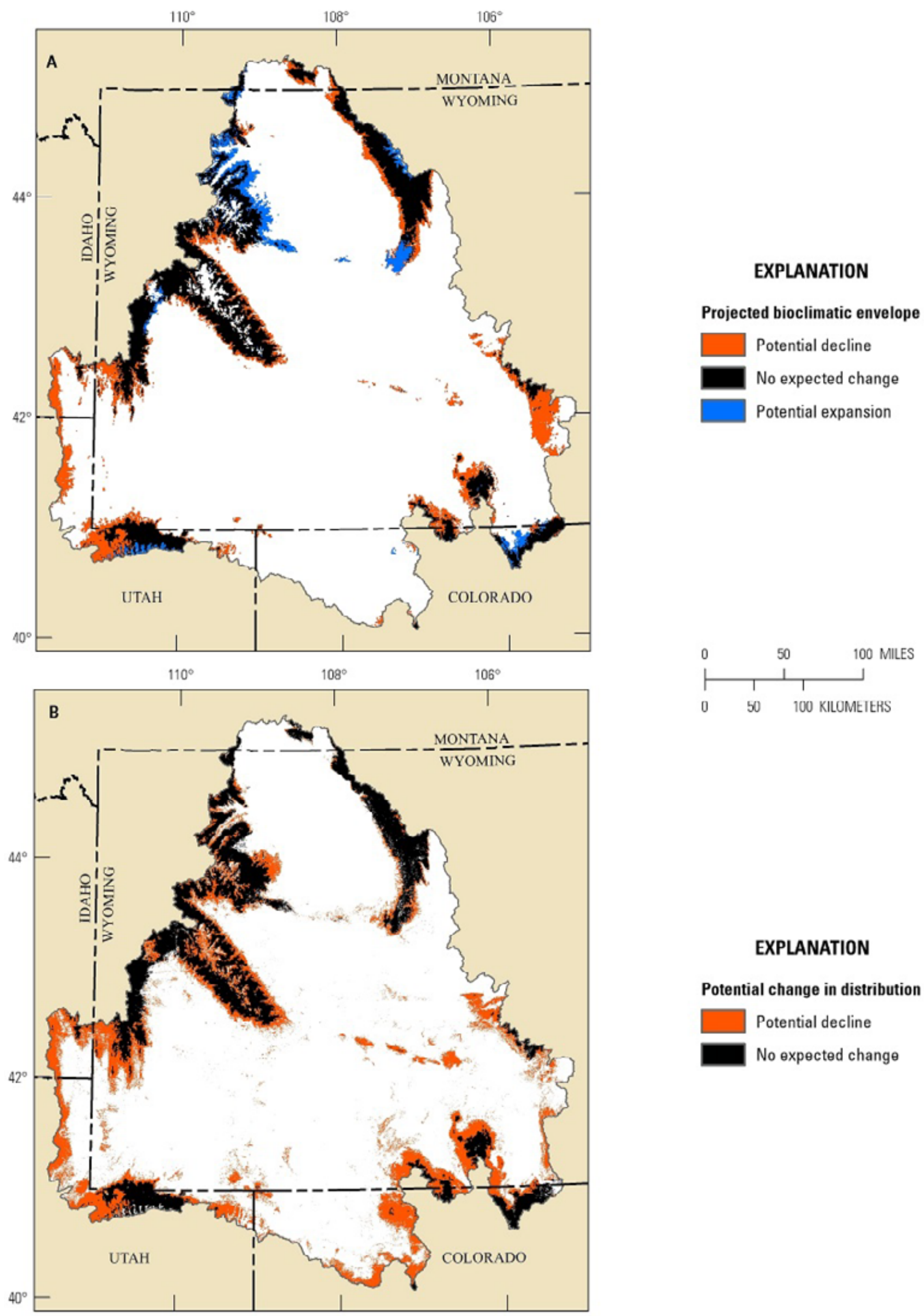

Figure 14-11. Potential effects of climate change on montane and subalpine forests in the Wyoming Basin Rapid Ecoregional Assessment project area. (*A*) Projected changes in the bioclimatic envelope for montane and subalpine forests derived from Rehfeldt and others (2012) for climate scenario I in 2030. Orange indicates areas with potential for decline because the current and projected envelope distributions do not coincide. Black indicates areas not expected to change because the current and projected envelope distributions overlap. Blue indicates potential for expansion into areas that are outside the current envelope distribution. (*B*) Potential changes in baseline montane and subalpine forests derived from overlap with the projected climate envelope distribution (as represented in *A*).

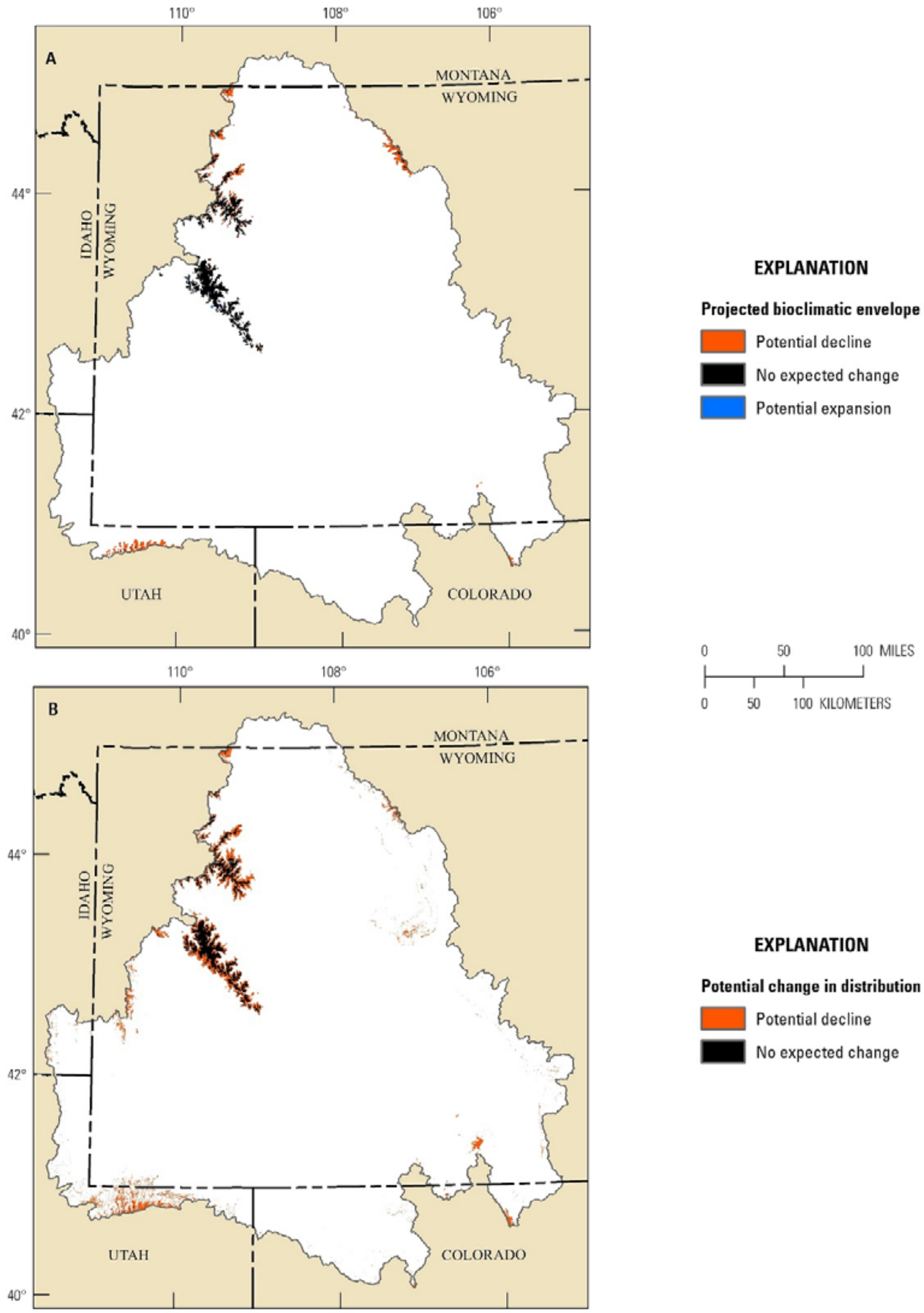

Figure 14-12. Potential effects of climate change on alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area. (*A*) Projected bioclimatic envelope for alpine zones derived from Rehfeldt and others (2012) for climate scenario I in 2030. Orange indicates areas with potential for decline because the current and projected envelope distributions do not coincide. Black indicates areas not expected to change because the current and projected envelope distributions overlap. Blue indicates potential for expansion into areas that are outside the current envelope distribution. (*B*) Potential changes in baseline alpine zones derived from overlap with the projected climate envelope distribution (as represented in *A*).

Table 14−5. Area and percent of montane and subalpine forests and alpine zones 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 of area
Forest Service[1]	17,912	72.0
Private	3,038	12.2
Bureau of Land Management	1,834	7.4
Tribal	1,338	5.4
State/County	570	2.3
Private conservation	109	0.4
Other Federal[2]	14	0.1

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

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

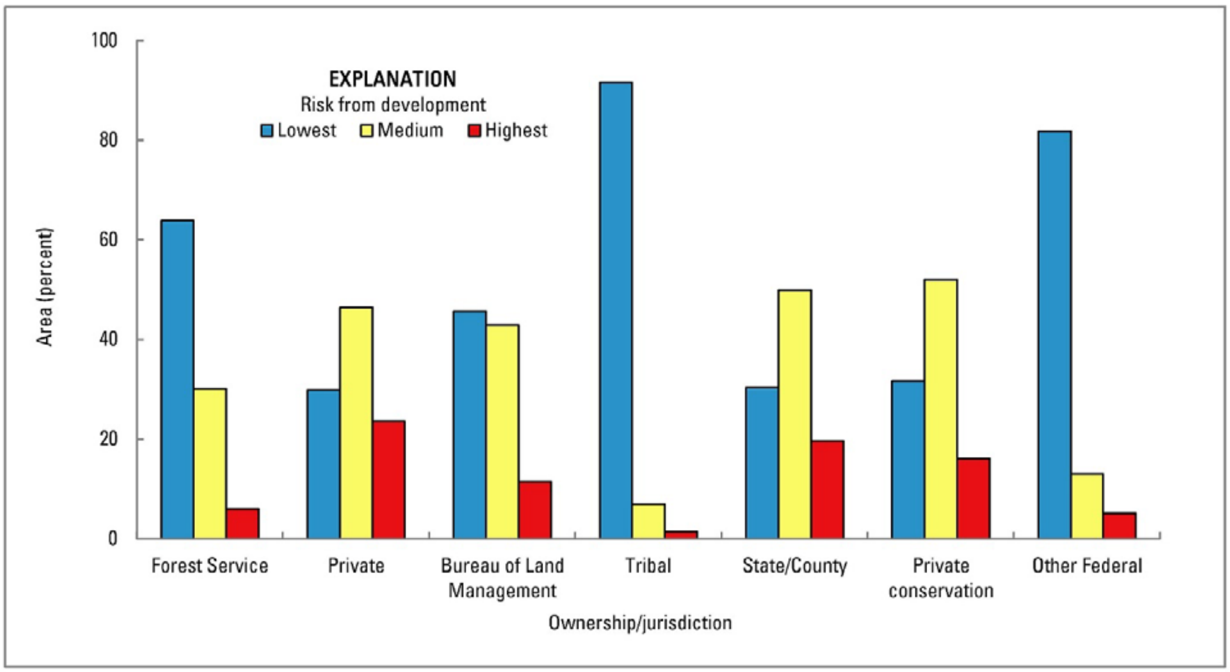

Figure 14-13. Relative ranks of risk from development, by land ownership or jurisdiction, for montane and subalpine forests and alpine zones in the Wyoming Basin Rapid Ecoregional Assessment project area. Rankings are lowest (Terrestrial Development Index [TDI] score <1 percent), medium (TDI score 1−3 percent), and highest (TDI score >3 percent).

Where are the townships with the greatest landscape-level ecological values, and where are the townships with the greatest landscape-level risks (fig. 14–14)?

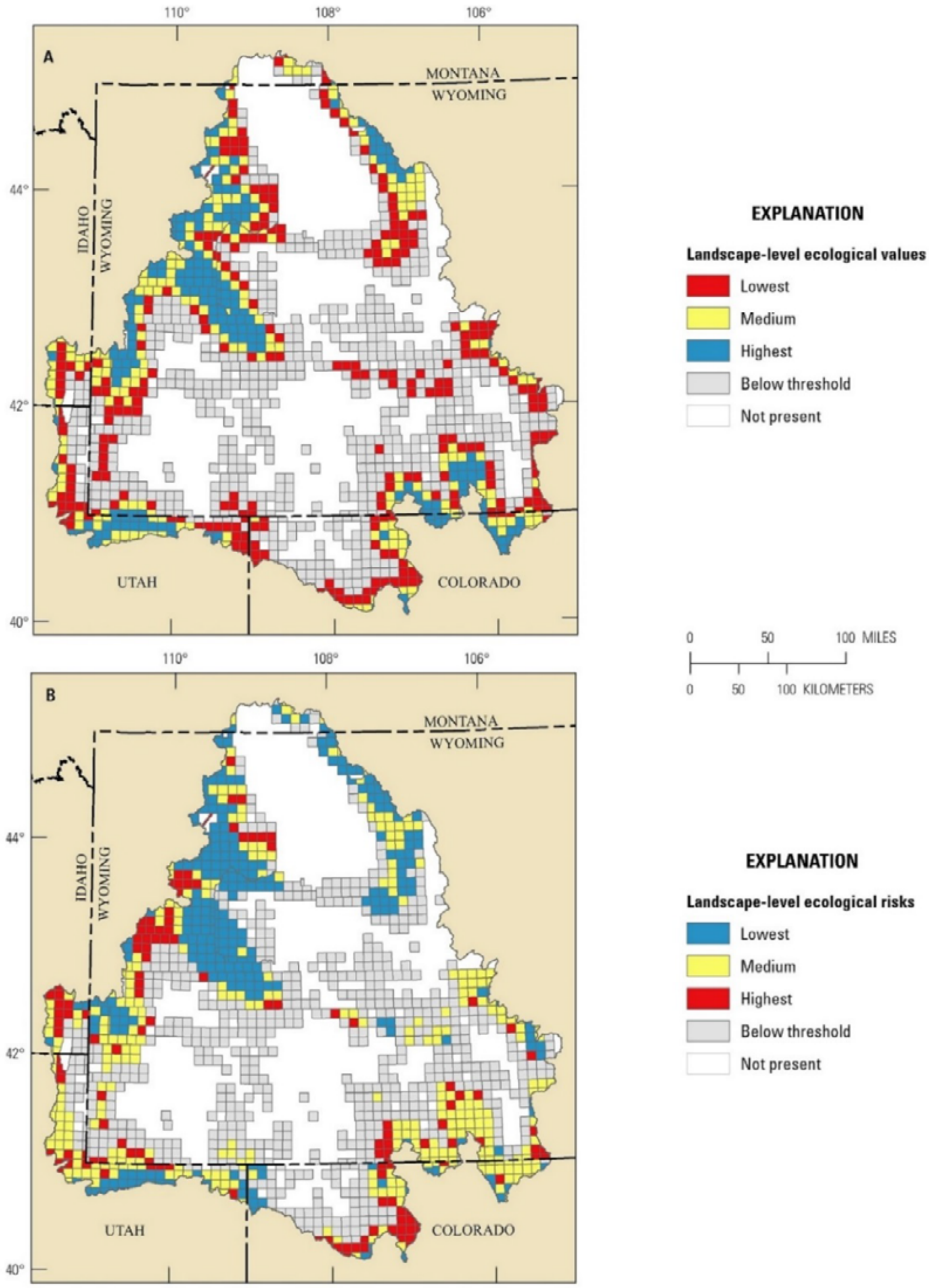

Figure 14-14. Ranks of landscape-level ecological values and risks for montane and subalpine forests and alpine zones, summarized by township, in the Wyoming Basin Rapid Ecoregional Assessment project area. (*A*) Landscape-level values based on area and (*B*) landscape-level risks based on Terrestrial Development Index (see table 14–3 for overview of methods).

Where are the townships with the greatest conservation potential (fig. 14–15)?

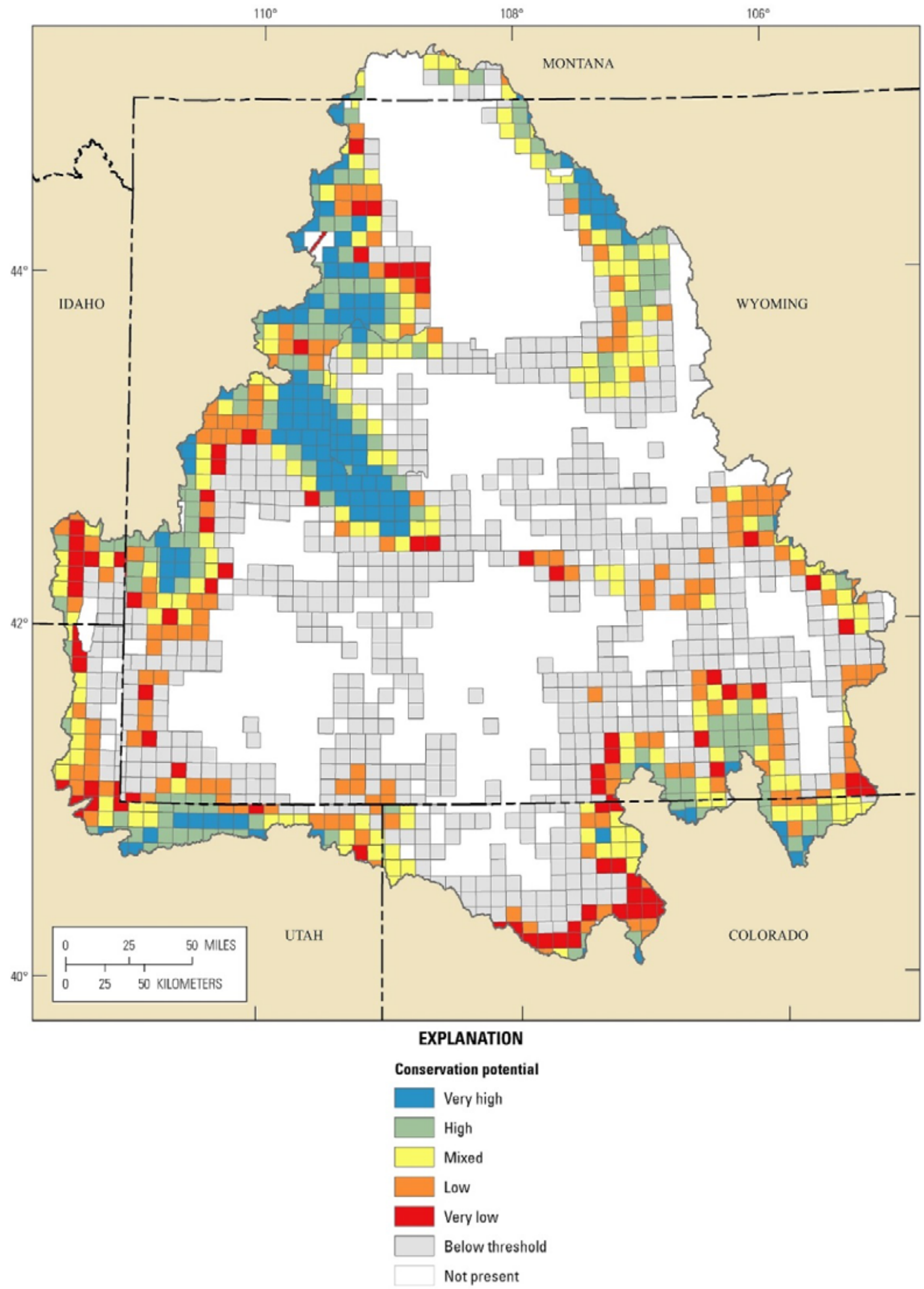

Figure 14-15. Conservation potential of montane and subalpine forests and alpine zones, summarized by township, in the Wyoming Basin Rapid Ecoregional Assessment project area. Highest conservation potential identifies areas that have the highest landscape-level values and the lowest risks. Lowest conservation 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

Mountain forests and alpine zones are patchily distributed in the Wyoming Basin and cover approximately 14 percent of the land area. The mountain forests and alpine zones are the least developed ecological community in the Wyoming Basin; only 4 percent of the area has Terrestrial Development Index (TDI) scores >5 percent. Nevertheless, development (including roads, energy, and agriculture) has fragmented and decreased the connectivity of mountain forests. All relatively undeveloped mountain forests and alpine zones (TDI score ≤1 percent) occur in patches <5,000 square kilometers(1,930 square miles). The largest relatively undeveloped patches occur in the Absaroka and Wind River Mountains.

Mountain forests and alpine zones are naturally discontinuous in the Wyoming Basin, but development has reduced connectivity further, especially at lower elevations. Patches of highly connected, relatively undeveloped areas are associated with the large mountain ranges, but relatively undeveloped areas in the Granite, Laramie, Medicine Bow, and Sierra Madre Mountains are not connected at the local level.

The recent bark beetle outbreak has affected nearly half of mountain forests in the Wyoming Basin. The time required for some mountain forest tree species to reach sexual maturity and the isolated nature of some mountain forests could result in long recovery times. In turn, wildlife species that depend on or have mutualistic relationships with tree species in mountain forest habitats could be negatively affected.

The distribution of bioclimatic conditions conducive for mountain forests is projected to shift upslope in most mountain ranges and become nearly absent in the Granite Mountains by 2030 for climate scenario I. Likewise, the distribution of bioclimatic conditions supporting alpine flora and fauna is projected to contract by 2030 for climate scenario I. Most high-value townships in the mountain forest and alpine zone co-occur with low risks. Overall, townships with the best conservation potential are at the higher elevations.

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