Section IV. Assessments of Species and Species Assemblages

Chapter 18. Cutthroat Trout

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Key Ecological Attributes

Distribution and Ecology

The cutthroat trout, a freshwater fish in the Salmonidae family, is native to western North America. Cutthroat trout were once widespread throughout cold water streams and lakes in the Wyoming Basin, but habitat loss has restricted them to a subset of their former range, and they now primarily occupy high-elevation streams in remote headwaters (Duff, 1996). Cutthroat trout occupy gravel-bottomed creeks, rivers, and lakes, and prefer cold, clear water and areas with good overhead or instream cover. They feed primarily on aquatic and terrestrial invertebrates but also can consume zooplankton and other fish.

There are 14 subspecies of cutthroat trout, four of which are present in the Wyoming Basin: the Bonneville, Colorado River, Yellowstone, and Snake River finespotted cutthroat trout. The Bonneville cutthroat trout is native to the Bear River drainage and is greatly restricted in numbers and distribution. It occupies approximately 35 percent of its historical habitat (Wyoming Game and Fish, 2010). The Colorado cutthroat trout was distributed throughout the upper Colorado River in Wyoming, Utah, and Colorado, but its distribution is severely restricted and it occupies <16 percent of its historical habitat (Hirsch and others, 2013). In 1999, the Colorado cutthroat trout was petitioned for listing on the basis of the Endangered Species Act, but it was determined that there was not enough information to warrant listing it at that time (Hirsch and others, 2006). The Yellowstone cutthroat trout is native to the Snake, Yellowstone, Bighorn-Wind, and Tongue River drainages. It occupies 42 percent of its historic range, but only 28 percent of populations are genetically unaltered (Gresswell, 2011). The Yellowstone cutthroat trout was petitioned for listing in 1998 and reviewed again in 2005 but still precluded from listing because there are multiple populations in headwater systems. In contrast, the Snake River finespotted cutthroat trout is still widely distributed throughout its historic range, which consists of the Snake River above Palisades Reservoir. The Wyoming Basin encompasses a small section of the Upper Snake River.

The Bonneville (May and Albeke, 2005), Colorado River (Hirsh and others, 2013), and Yellowstone (May and others, 2007) cutthroat trout have multistate conservation teams that manage and assess these populations. The teams focus on conservation populations, which are populations determined to be at least 90 percent genetically pure.

Landscape Structure and Dynamics

Potential cutthroat trout distribution is determined by river geomorphology and the flow and temperature regime (including groundwater inputs). Instream habitat features include gravel size, the presence of deeper pools, and temperature. The appropriate gravel size is needed for spawning, and deep pools or beaver ponds serve as winter refugia (Harig and Fausch, 2002). Cutthroat trout are coldwater fish, with a thermal maximum of 25–30 degrees Celsius (°C) (77–86 degrees Fahrenheit [(°F]) (Underwood and others, 2012). Low temperatures, however, can be a concern as well; for example, summer temperatures below 7.8 °C (46.04 °F) (using mean daily July temperatures) can delay spawning and egg development, resulting in decreased winter survival of fry (Harig and Fausch, 2002).

Cutthroat trout populations exhibit several migratory strategies including stream resident, fluvial (migrating between larger and smaller streams), and adfluvial (migrating between lakes and streams). Cutthroat trout also may migrate to spawn, which takes place in early summer after peak spring snowmelt flows. Migration may be limited by natural barriers, such as beaver dams, and anthropogenic barriers, such as water diversions and dams.

Cutthroat trout are subjected to a natural disturbance regime which includes floods, droughts, and wildfires. Droughts can lead to decreased population abundances from reduced streamflow, reduced resource availability, and increased stream temperatures, while floods can directly kill trout and destroy redds (fish nests). Wildfires also lead to increased stream temperatures and increase the potential for postfire flooding and debris flows which can decimate fish populations (Dunham and others, 2007). Cutthroat trout density has been shown to decline after fire, but recovery can occur within two years (Sestrich and others, 2011).

Change Agents

Cutthroat trout have experienced substantial population declines. Historically, overfishing and habitat degradation from mining, agriculture, and water development, were the main causes for declines. Currently, the three major threats include habitat degradation due to development, presence of nonnative species, and potential climate change.

Development

Habitat loss due to dams and diversions has led to extensive fragmentation with most cutthroat trout populations restricted to short stream segments in headwater streams. For example, in the North Fork Little Snake River drainage, Colorado River cutthroat trout are restricted to 0.8–6- kilometer (km) (0.5–3.73-mile [mi]) stream segments (Cook and others, 2010). An analysis of the Upper Colorado River Basin indicated that only 37 percent of Colorado River cutthroat trout populations are predicted to have a >90 percent chance of persistence for 70 years due to fragmentation (Roberts and others, 2013). Populations in the smallest stream segments, <7 km (4.35 mi) in length, are at the greatest risk of extirpation (Roberts and others, 2013). Habitat fragmentation and degradation is primarily the result of roads, energy development, and irrigation diversions and impoundments.

Energy and Infrastructure

There is limited research on how energy development affects cutthroat trout, but studies of brook trout in the Marcellus Shale suggest three main pathways through which energy development could affect trout populations: hydrological (water withdrawal), physical (surface disturbance), and chemical (water contamination) (Weltman-Fahs and Taylor, 2013). Reduced streamflow as a result of water withdrawal can affect habitat availability and quality, resulting in decreased densities and recruitment of trout. Surface disturbance can increase sedimentation in streams reducing the amount of spawning gravel available, while water contamination can have toxic or chronic sublethal effects.

Agriculture Activities

Livestock can substantially alter riparian habitat quality, water quality, and sediment transport by trampling stream banks and the riparian zone. Streams with extensive grazing show increased water temperatures, decreased cover, increased bank erosion, and loss of preferred spawning substrate due to a higher proportion of fine sediment (Armour and others, 1991). Grazing exclosures around riparian habitats can increase cutthroat trout density and biomass

(Binns and Remmick, 1994). Additionally, the negative effects of grazing can be mitigated by a shift to rotational grazing. In some northern Colorado streams, for example, a shift to a rotational grazing management scheme resulted in more riparian vegetation, greater inputs of terrestrial invertebrates, increased importance of terrestrial invertebrate prey in trout diets, and increased trout growth (Saunders and Fausch, 2012).

Water diversion for irrigation can alter flow regimes, entrain fish, and decrease structural connectivity. Diversions may form complete barriers or be partial barriers, only blocking access when the diversions are in use or streamflow is low. Connectivity is crucial for fluvial cutthroat trout that move between different habitats to spawn (Carlson and Rahel, 2010). Diversions are especially of concern when they entrain fish in irrigation canals, as most entrained fish die in the canal (Roberts and Rahel, 2008). Estimates for the proportion of Bonneville cutthroat trout entrained by irrigation diversions in the Bear River drainage range from 9 to 23 percent (Schrank and Rahel, 2004; Carlson and Rahel, 2010).

Altered Fire Regimes

At higher elevations, where most cutthroat populations remain, fire regimes have not been greatly affected by fire suppression (see Chapter 14−Montane and Subalpine Forests and Alpine Zones). Climate change has the potential to increase wildfire risk in western North America (Westerling and others, 2006; Haak and others, 2010). Although fire can have positive effects on cutthroat trout populations, an increase in fire occurrence, especially where small, fragmented cutthroat populations occur, could lead to local population declines due to isolation from downstream refugia and the inability of other populations to recolonize the area (Roberts and others, 2013).

Invasive Species

Nonnative trout species, such as rainbow, lake, brown, and brook trout, are contributing to cutthroat trout declines through hybridization, predation, competition for habitat, or competition for food and spawning sites. In rivers and streams, rainbow, brown, and brook trout are all competitors to cutthroat trout (Wenger and others, 2011). The coldwater thermal preferences of brook trout and cutthroat trout are the most similar; consequently, brook trout probably pose the biggest threat to headwater populations owing to resource competition and direct predation of young cutthroat trout (Peterson and Fausch, 2003; Peterson and others, 2004). In Yellowstone Lake, predation by introduced lake trout has resulted in declines of cutthroat trout (Tronstad and others, 2010).

Rainbow trout can interbreed with cutthroat trout and reduce the genetic integrity of populations (Muhfeld and others, 2009). The loss of genetic purity is a concern and provides the basis for determining which populations will be considered conservation populations. A 1996 assessment determined that only 26 percent of remaining Colorado River cutthroat trout populations can be considered to be genetically pure (Young and others, 1996). One management strategy is to build barriers to keep nonnative fish out, but the barriers restrict cutthroat trout to isolated headwater stream segments (Novinger and Rahel, 2003; Peterson and others, 2008; Fausch and others, 2009). As a result, there are complex tradeoffs with this type of management strategy, because barriers can increase vulnerability to reduced genetic variability (Peterson and others, 2008; Fausch and others, 2009).

Disease

Diseases posing threats to cutthroat trout include but are not limited to whirling disease, furunculosis, and infectious pancreatic necrosis virus (Hirsch and others, 2013). The nonnative parasite that causes whirling disease (*Myxobolus cerebralis*) has led to major declines in cutthroat populations across its range (McGinnis and Kerans, 2013).

Climate Change

Climate change is a growing concern due to projected (1) increased summer temperatures, (2) increased winter flooding, (3) increased wildfire risk, and (4) protracted drought (Haak and others, 2010). Over their entire range, projected climate change has the potential to decrease cutthroat trout habitat by 58 percent (Wenger and others, 2011), because of increased water temperatures and negative biotic interactions. Low-elevation populations are especially susceptible to temperature increases, which may exceed the thermal tolerance limits of native trout. In contrast, high-elevation populations could experience increased recruitment and population densities in response to higher water temperatures. Many cutthroat trout populations in the Basin are located in headwater reaches, and these populations are less at risk from increases in water temperature (Roberts and others, 2013).

Climate change could increase winter flooding if precipitation shifts from snow to rain. A decreased snowpack also could lead to protracted drought periods in the summer. Cutthroat trout occurrence shows a weak negative relationship with increased winter floods, but as spring spawners, cutthroat trout are less susceptible to winter flooding than other salmonids (Wenger and others, 2011). Protracted drought could have substantial negative effects on persistence and recruitment in cutthroat trout populations (Haak and others, 2010). In streams from which large amounts of water are diverted, cutthroat trout populations are likely to be especially susceptible to reduced streamflow from drought, and diversions can restrict access to deeper pools that can serve as refugia during periods of low streamflow.

The degree of susceptibility to climate change varies among subspecies. Seventy-three percent of the habitat occupied by Bonneville cutthroat trout is at risk from increasing temperatures, wildfire occurrence, and winter flooding, but only 29 percent of the habitat occupied by Colorado River cutthroat trout is similarly at risk (Williams and others, 2009). This is because Colorado River cutthroat are restricted to higher-elevation habitats, whereas Bonneville cutthroat still use lower-elevation habitats. Bonneville cutthroat populations exhibit fluvial migration, where overwintering populations remain in lower-elevation, main-stem habitats and spawning occurs in headwater tributaries. Nearly 100 percent of the Bear River watershed main-stem migration corridors are projected to be at risk from climate change (Williams and others, 2009).

Rapid Ecoregional Assessment Components Evaluated for Cutthroat Trout

A generalized, conceptual model was used to highlight some of the key ecological attributes and Change Agents affecting cutthroat trout (fig. 18–1). Key ecological attributes addressed by the REA include (1) the distribution of cutthroat trout habitat, (2) landscape structure (patch size and connectivity), and (3) landscape dynamics (fire occurrence, stream temperature, and hydrologic regime) (table 18–1). Change Agents evaluated include development; competition, predation, and hybridization risk from nonnative fishes; disease; and climate change (table 18–2). Ecological values and risks used to assess the conservation potential for cutthroat trout by fifth-level watershed are summarized in table 18–3. Core and Integrated Management Questions and the number of the associated summary maps and graphs are provided in table 18–4.

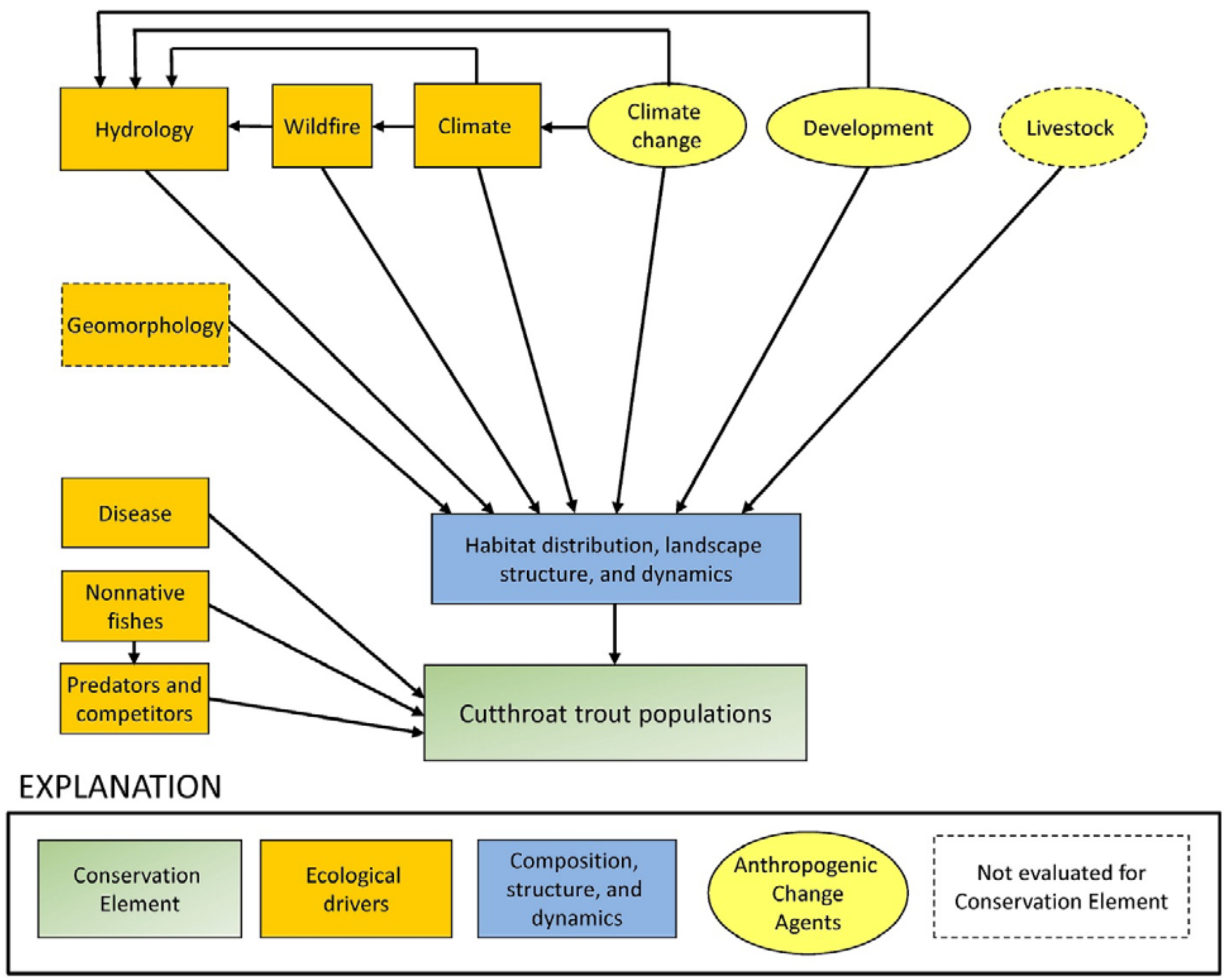

Figure 18–1. Generalized conceptual model of cutthroat trout habitat for the Wyoming Basin Rapid Ecoregional Assessment (REA). Biophysical attributes and ecological processes regulating the occurrence, structure, and dynamics of cutthroat trout populations and habitat are shown in orange rectangles; additional ecological attributes are shown in blue rectangles; and key anthropogenic Change Agents that affect key ecological attributes are shown in yellow ovals. The dashed lines indicate components not addressed by the REA. Livestock is a Change Agent that was not evaluated because there is a lack of regionwide data.

Table 18–1. Key ecological attributes and associated indicators of baseline cutthroat trout habitat[1] for the Wyoming Basin Rapid Ecoregional Assessment.

Attributes	Variables	Indicators
Amount and distribution	Stream length and area of lakes occupied	Distribution map derived from occurrence data[2]
Landscape structure	Patch size[3]	Stream-segment length frequency distribution
Landscape dynamics	Fire occurrence	See Chapter 8—Streams and Rivers
	Temperature regime	Probability of occurrence using mean July temperature[4, 5]
	Hydrologic regime	Mean summer flow and center time of mass stream flow[5]

[1] Baseline conditions are used as a benchmark to evaluate changes in the amount and landscape structure/dynamics of cutthroat trout habitat due to Change Agents. Baseline conditions are defined as the current distribution of cutthroat habitat derived from occurrence surveys (see Chapter 2—Assessment Framework), but existing dams have already altered conditions and increased isolated populations.

[2] Data provided by Wyoming Game and Fish Department, Montana Fish, Wildlife & Parks, and Trout Unlimited.

[3] National Hydrography Dataset, National Inventory of Dams.

[4] Probability of occurrence using a temperature threshold model developed by Haak and others (2010).

[5] U.S. Department of Agriculture Forest Service; http://www.fs.fed.us/rm/boise/AWAE/projects/modeled_stream_flow_metrics.shtml (Wenger and others, 2010).

Table 18–2. Anthropogenic Change Agents and associated indicators influencing cutthroat trout habitat for the Wyoming Basin Rapid Ecoregional Assessment.

[m, meter]

Change Agents	Variables	Indicators
Development	Aquatic Development Index (ADI)	Percent of cutthroat trout habitat in seven development classes[1]
		Frequency distribution of stream-segment lengths that are relatively undeveloped or have a low development score compared to baseline habitat[2]
	Barriers to movement	Number of potential barriers (points of diversion within 30 m, and stream-road crossings) [3]
Invasive species	Competition and predation with nonnative trout species	Co-occurrence of cutthroat trout with rainbow, brown, brook, and lake trout distributions[4]
	Genetic purity	Hybridization status of cutthroat trout populations by subspecies[5]
	Hybridization risk	Co-occurrence of cutthroat trout with rainbow trout[4]
Disease	Whirling disease risk	Co-occurrence of cutthroat trout and whirling disease[6]
Climate change	Temperature change	Change in the probability of occurrence using the projected distribution of the bioclimatic envelope in 2030[7]
	Hydrologic regime change	Projected mean summer flow and center time of mass streamflow in 2040[8]

[1] See Chapter 2—Assessment Framework.

[2] Relatively undeveloped stream segments using ADI scores <20.

[3] See Chapter 2—Assessment Framework for ADI datasets used for diversions and roads.

[4] Data on nonnative salmonids from Wyoming Game and Fish Department, and Montana Fish, Wildlife & Parks.

[5] Hybridization status data from Trout Unlimited.

[6] Data on whirling disease occurrence data from Wyoming Game and Fish Department.

[7] Probability of occurrence using temperature threshold models developed by Wenger and others (2011); projected temperature using climate scenario II (National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory Climate Model, ver. 2.1; emissions scenario A2) derived from Maurer and others (2007).

[8] U.S. Department of Agriculture Forest Service (using climate models Geophysical Fluid Dynamics Laboratory Climate Model, ver. 2.1; and European Center Hamburg Model, ver. 5) (http://www.fs.fed.us/rm/boise/AWAE/projects/modeled_stream_flow_metrics.shtml [see Wenger and others, 2010]).

Table 18–3. Landscape-level ecological values and risks for cutthroat trout habitat. Ranks were combined into an index of conservation potential for the Wyoming Basin Rapid Ecoregional Assessment.

[km, kilometer]

	Variables[1]	Relative rank: Lowest	Medium	Highest	Description[3]
Values[3]	Amount of habitat	<17	17–40	>40	Mean length (km) of stream segments occupied by cutthroat trout by watershed
	Number of populations	0	1–3	>3	Number of stream segments occupied by cutthroat trout by watershed
		0	1	>1	Number of lakes occupied by cutthroat trout by watershed
Risks	Aquatic Development Index (ADI)	<20	20–40	>40	Mean ADI score by watershed
	Amount of stream segments at risk of very low summer flow	0	0–0.041	>0.041	Number of occupied stream segments with zero mean summer flow, standardized by total length of occupied stream segments, by watershed
	Hybridization status and risk index	1	1.5–2.5	>2.5	Derived from genetic purity and presence of rainbow trout by watershed

[1] Fifth-level watershed was used as the analysis unit unit for conservation potential on the basis of input from Bureau of Land Management (ee table A–19 in the Appendix).

[2] See tables 18–1 and 18–2 for description of variables.

[3] Amount of habitat was valued in three ways: (1) length of stream segment, (2) number of stream segments (populations), and (3) number of lakes. Watersheds with longer stream segments and (or) greater number of populations (occupied stream segments and lakes) receive the highest rank for ecological values.

Table 18–4. Management questions evaluated for cutthroat trout for Wyoming Basin Rapid Ecoregional Assessment.

Core Management Questions	Results
Where is occupied baseline cutthroat trout habitat, and what is the total amount occupied by native/introduced populations and by each subspecies?	Figures 18–2 and 18–3
Where does development pose the greatest threat to baseline cutthroat trout habitat, and where are the large, relatively undeveloped habitats?	Figures 18–4 and 18–7
Where do diversions and road crossings pose potential barriers to cutthroat trout movements, and where are watersheds with the highest structural connectivity?	Figure 18–8
Where are genetically pure populations of cutthroat trout, and where are populations at risk from hybridization?	Figure 18–9
Where are cutthroat trout populations at risk of competition and predation by nonnative salmonid species?	Figure 18–10
Where are cutthroat trout populations at risk from whirling disease?	Figure 18–11
Where are cutthroat trout populations currently at risk from low summer flows?	Figure 18–12
Where could cutthroat trout populations be at risk from projected shifts in hydrological regime and temperature increases in 2040?	Figures 18–13 to 18–15
Integrated Management Questions	**Results**
How does risk from development vary by land ownership or jurisdiction for cutthroat trout habitat?	Table 18–5, Figure 18–16
Where are the watersheds with the greatest landscape-level ecological values?	Figure 18–17
Where are the watersheds with the greatest landscape-level risks?	Figure 18–18
Where are the watersheds with the greatest conservation potential?	Figure 18–19

Methods Overview

To map the distribution of cutthroat trout, we compiled data on mapped occurrences for each subspecies from state game and fish agencies (see table 18–1 for data sources). The resulting distribution map was used to quantify baseline conditions for cutthroat trout overall and for the four subspecies (fig. 18–2). Key ecological attributes were evaluated for baseline conditions and compared with overlays of Change Agents. The Aquatic Development Index (ADI) scores were derived from catchments coincident with cutthroat habitat. We used the length of occupied stream segments (classified in source data) as an index of habitat patch size (Roberts and others, 2013). Stream segments were derived from natural and anthropogenic barriers (dams) that restrict bidirectional movements among cutthroat trout populations (Roberts and others, 2013). To incorporate additional potential barriers, we summarized the number of diversion points within 30 meters (m) and stream-road crossings within 10 m (32.8 feet [ft]) of occupied stream segments, by sixth-level watershed.

Potential competition, predation, and hybridization risk were derived from occurrence data for rainbow, brown, brook, and lake trout compiled from state game and fish agencies (see table 18–2 for data sources). Competition and predation risk was derived from the number of nonnative salmonid species present in the stream segment. Hybridization risk was assumed high if rainbow trout were present in the stream segment. Genetic purity was derived from data and hybridization classes provided by Trout Unlimited. Whirling disease occurrence information was summarized from data provided by the Wyoming Game and Fish Department.

To evaluate potential effects of current and projected temperature and hydrological regimes, we relied on data derived from existing models. Probability of cutthroat trout occurrence using mean daily July temperature was derived from a model developed by Haak and others (2010). To evaluate potential effects of current and projected hydrological regimes, we relied on data derived from existing macroscale hydrological Variable Infiltration Capacity (VIC) models. Wenger and others (2010) demonstrated that the VIC model can be used to simulate recent (1978-1997) hydrological characteristics (such as mean summer flow and center time of mass streamflow) for streams and larger rivers. The center time of mass streamflow (referred to herein as center time) is defined as the time when 50 percent of the annual streamflow has occurred and serves as an index of the recent climatic conditions that govern the timing of runoff (Stewart and others, 2004). The VIC models also are used with climate model projections to evaluate potential changes in hydrological characteristics for future climate scenarios. To our knowledge, however, model calibration has not been performed for a semiarid environment such as the Wyoming Basin, which is dominated by intermittent and ephemeral stream types. These modeled streamflow characteristics, therefore, should be interpreted and used with caution and an understanding that these variables have a high level of uncertainty. Mean summer flow and center time were derived from U.S. Department of Agriculture Forest Service data for sixth-level watersheds (climate projections were available only for 2040; table 18–1); the summarized flow data for each watershed were assigned to occupied stream segments. Occupied stream segments predicted to have a mean summer flow near or at 0 cubic foot per second were considered at risk for loss of cutthroat trout due to low flow (calculated for the period beginning the first day after June 1 when flow falls below the mean annual flow through September 30). To evaluate potential effects of projected climate change on cutthroat trout populations, we used results from climate change scenario II (National Oceanic and Atmospheric Administration Geophysical Fluid Dynamics Laboratory Model 2.1 [GFDL2.1], emissions scenario A2) because of the availability of relevant climatic variables.

Landscape-level ecological values (amount of cutthroat trout habitat) and risk (ADI score, risk of low streamflow in summer, and hybridization risk) were compiled into an overall index of conservation potential for each fifth-level watershed (table 18–3). To account for different spatial patterns of habitats (mainstems, headwaters, and lakes), we combined area ranks using stream-segment length and number of populations (derived from counts of occupied stream segments and lakes) into an overall area rank (table 18–3). Conservation potential for cutthroat trout was summarized by fifth-level watershed derived from overall landscape-level values and risks. 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 is occupied baseline cutthroat trout habitat, and what is the total amount occupied by native/introduced populations and occupied by each subspecies (figs. 18–2 and 18–3)?

- Cutthroat trout occupy 10,252 km (6,370.3 mi) of streams and rivers and 706 square kilometers (km^2) (257.53 square miles [mi^2]) of lakes and ponds. Within the Wyoming Basin, 50 percent of rivers and streams and 51 percent of lakes and ponds support conservation populations (only native subspecies are present), whereas the remaining habitat constitutes streams occupied by a subspecies outside its native range as a consequence of stocking. These include areas in which none of the existing subspecies are native for example the North Platte Basin, and areas where a nonnative (to that basin) and native subspecies co-occur, for example Bonneville cutthroat in the Colorado River Basin (figs. 18–2 and 18–3). There are introduced cutthroat trout in the New Fork drainage in the western Wind River Range, whereas the eastern Wind River drainage has native Yellowstone cutthroat trout. Mountains in the western Absaroka Range support native Yellowstone cutthroat trout, whereas the eastern side has a mixture of native Yellowstone cutthroat trout and introduced Snake River cutthroat trout in the Greybull River drainage.
- There are four subspecies of cutthroat trout present in the Wyoming Basin. The Bonneville cutthroat trout accounts for 25 percent of occupied streams and rivers and 45 percent of occupied lakes and ponds. The Colorado River cutthroat trout accounts for 13 percent of streams and rivers and 1 percent of lakes and ponds. The Snake River cutthroat accounts for 24 percent of streams and rivers and 31 percent of lakes and ponds. The Yellowstone accounts for 14 percent of streams and rivers and 8 percent of lakes and ponds. For 24 percent of streams and 15 percent of lakes, the subspecies of cutthroat trout is not specified (fig. 18–3).

Where does development pose the greatest threat to baseline cutthroat trout habitat, and where are the large, relatively undeveloped habitats (figs. 18–4 to 18–7)?

- Relatively undeveloped areas are primarily found in headwater streams. The Wind River and Absaroka Ranges have the greatest amount of relatively undeveloped habitat (fig. 18–4).
- Approximately 26 percent of streams and rivers and 15 percent of lakes and ponds occupied by cutthroat trout are classified as relatively undeveloped (ADI score <20) (fig. 18–5).
- Approximately 24 percent of streams and rivers and 20 percent of lakes and ponds inhabited by cutthroat trout had very high development levels, as indicated by ADI score >50 (fig. 18–5). Development scores were highest for mainstem river habitats. The Colorado River, Bear River, and North Platte Basins all had high levels of development (fig. 18–4).
- All stream segments in relatively undeveloped areas are <500 km (310.67 mi) in length and are primarily found in headwater reaches (figs. 18–6 and 18–7).
- Most of the longer stream segments (>100 km [62.2 mi]) include mainstem rivers that flow through developed areas. The Smiths Fork and Bear River are the only two areas which still contain some longer stream segments that are relatively undeveloped (fig. 18–7).

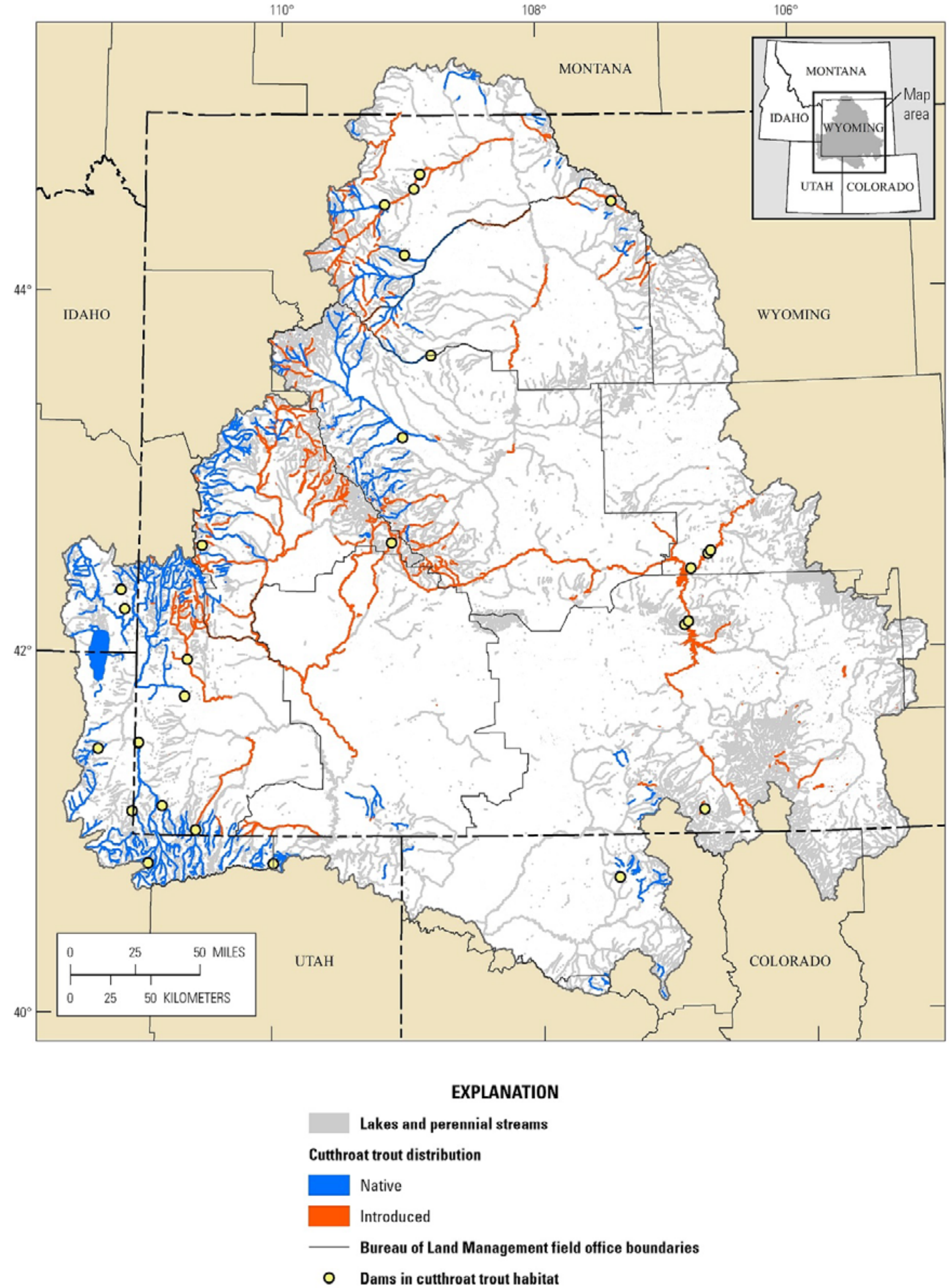

Figure 18–2. Distribution of baseline cutthroat trout in the Wyoming Basin Rapid Ecoregional Assessment project area. Native populations represent locations where only native subspecies are present. Introduced populations represent locations where cutthroat trout did not occur historically or where nonnative subspecies are present.

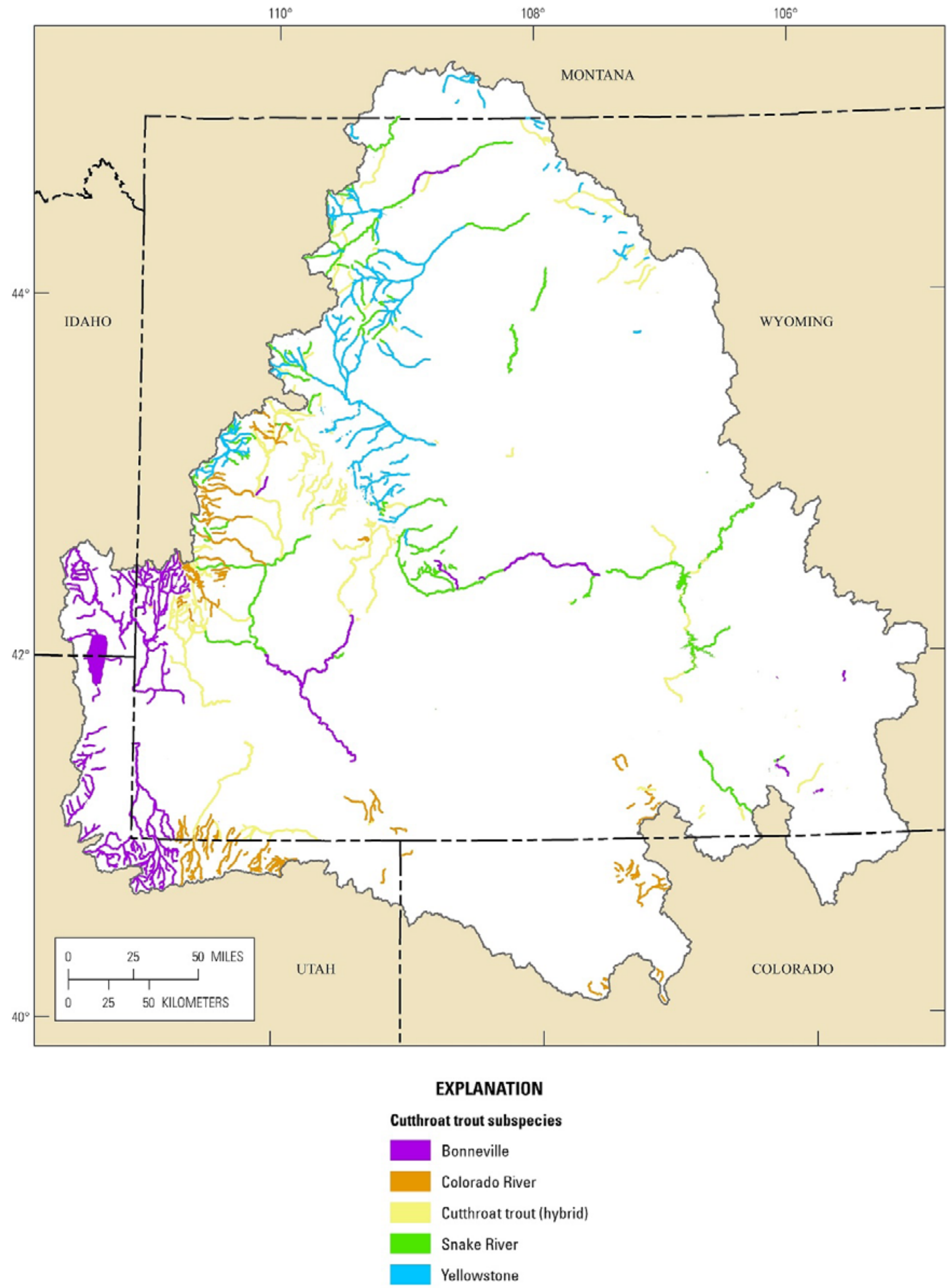

Figure 18–3. Distribution of cutthroat trout subspecies in the Wyoming Basin Rapid Ecoregional Assessment project area.

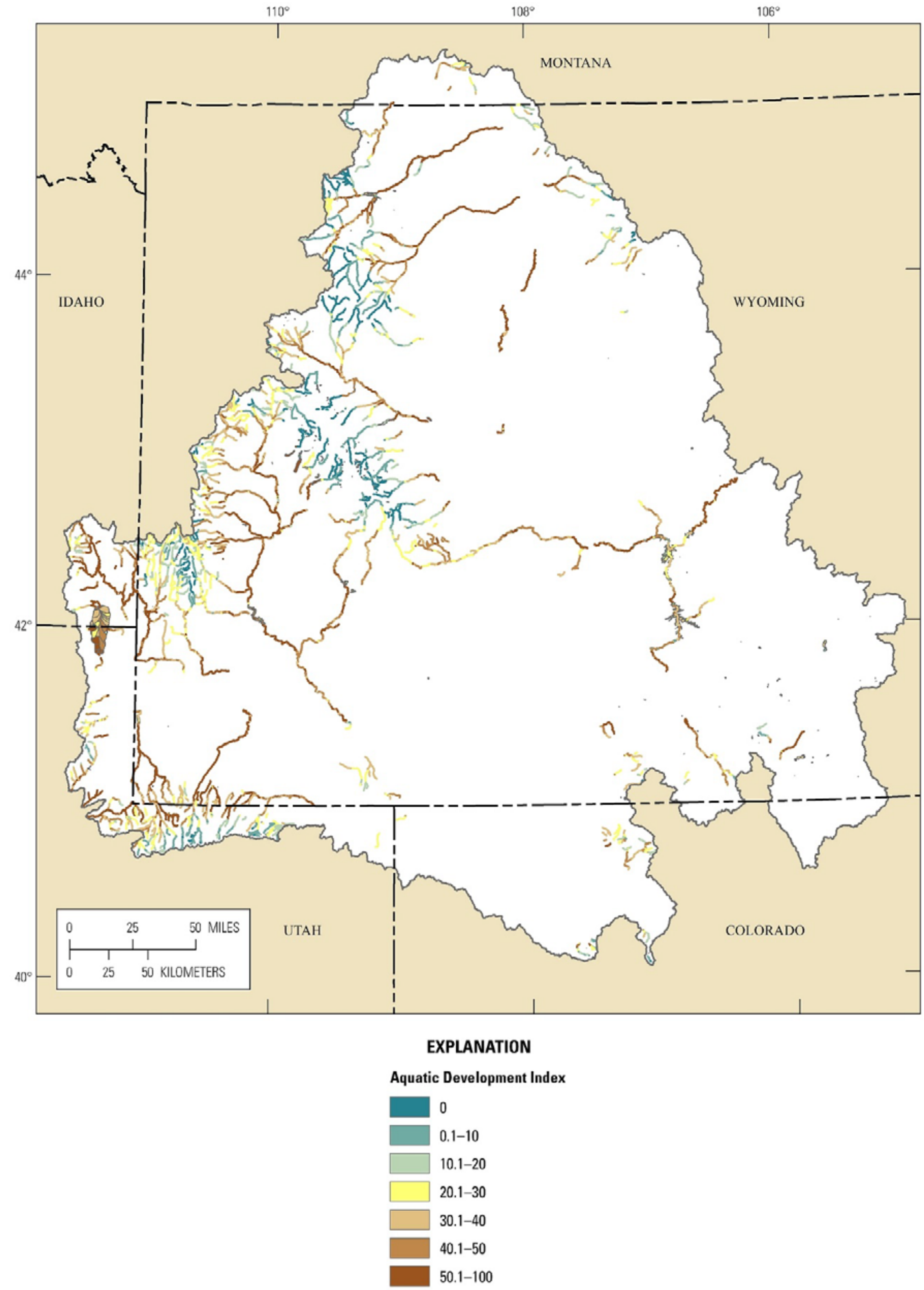

Figure 18–4. Aquatic Development Index scores for cutthroat trout habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.

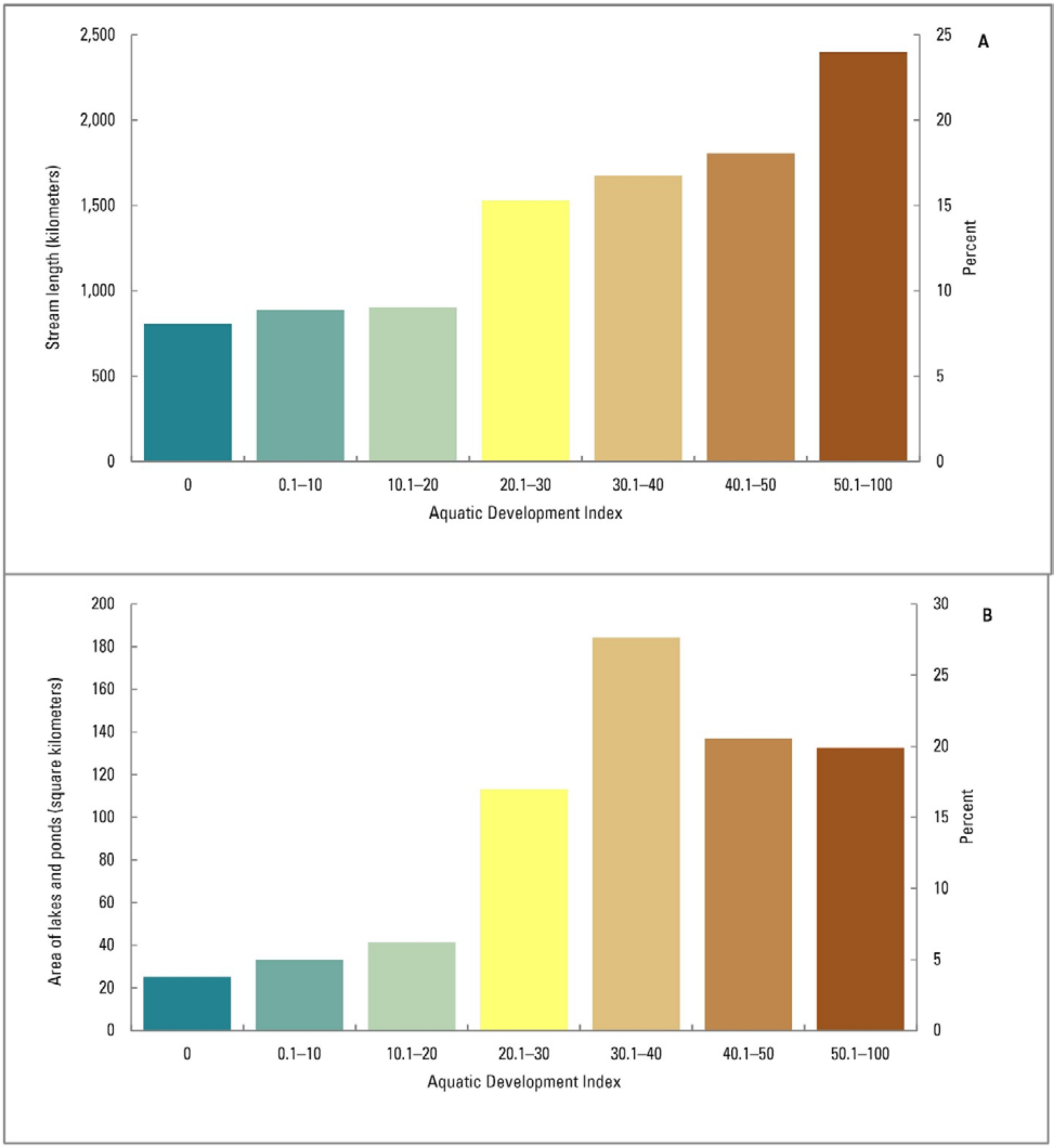

Figure 18–5. Cutthroat trout habitat as a function of the Aquatic Development Index in the Wyoming Basin Rapid Ecoregional Assessment project area for (*A*) streams and (*B*) lakes and ponds occupied by cutthroat trout.

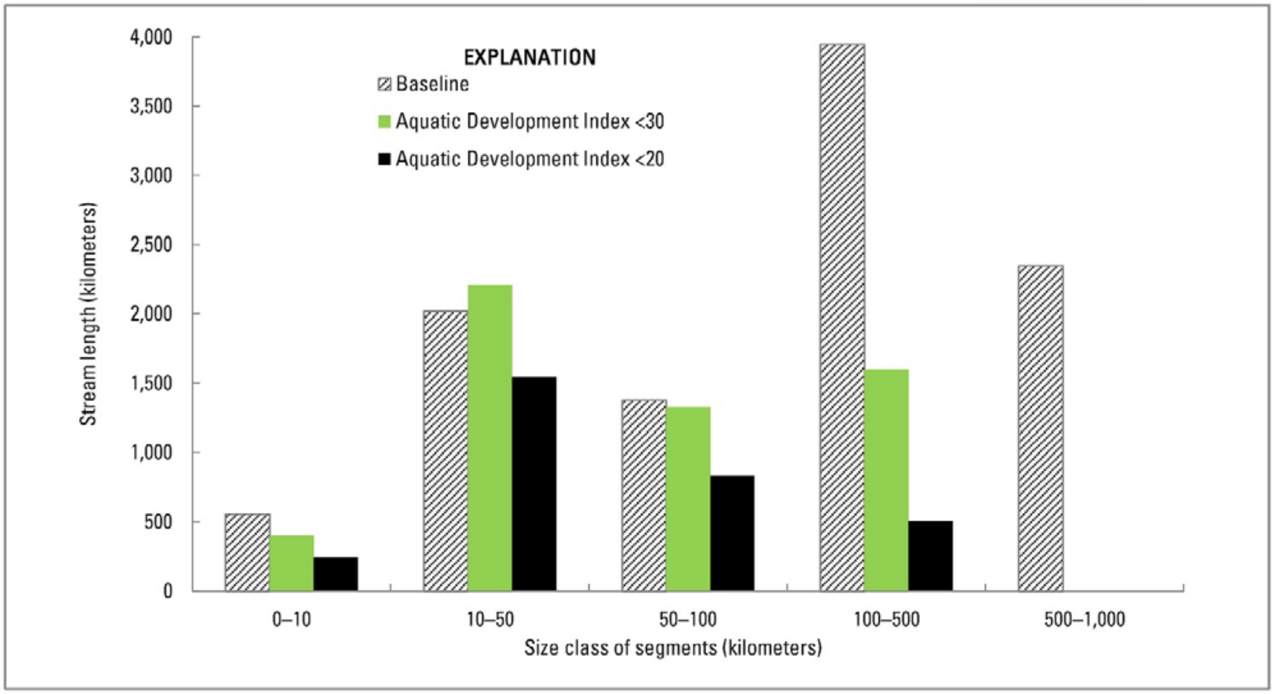

Figure 18–6. Amount of cutthroat trout habitat as a function of stream-segment size for baseline conditions and two development levels: (1) Aquatic Development Index (ADI) score <30, and (2) ADI score <20 (relatively undeveloped habitat) in the Wyoming Basin Rapid Ecoregional Assessment project area.

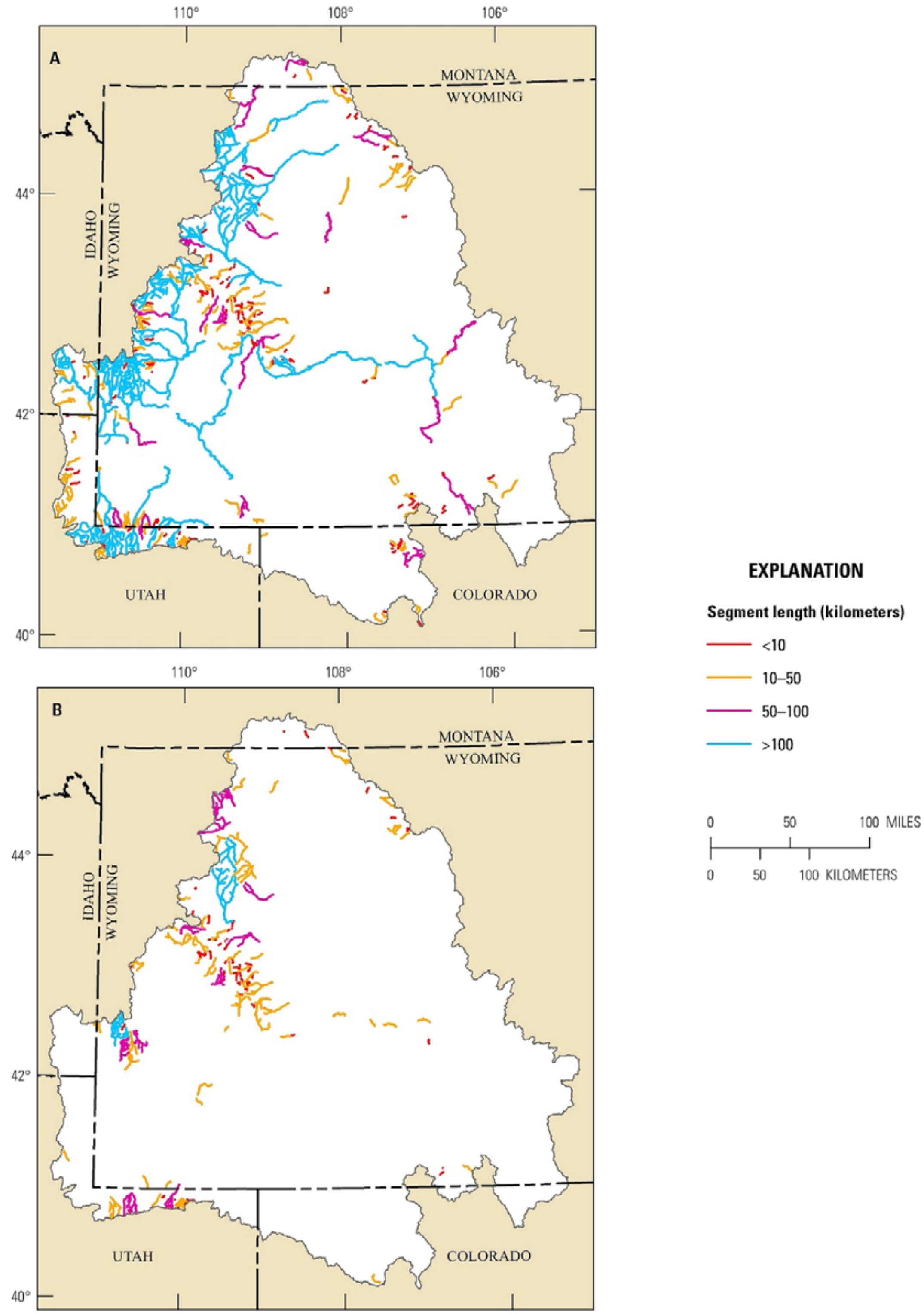

Figure 18–7. Stream-segment lengths of cutthroat trout habitat in the Wyoming Basin Rapid Ecoregional Assessment project area for (*A*) baseline conditions and (*B*) relatively undeveloped areas (Aquatic Development Index score <20).

Where do diversions and road crossings pose potential barriers to cutthroat trout movements, and where are watersheds with the highest structural connectivity (fig. 18–8)?

- Large barriers to movements created by dams and smaller potential barriers, such as water diversion structures and road crossings that can block or impede movements, reduce structural connectivity of cutthroat trout populations. Almost all sixth-level watersheds contain ≥1 potential barrier, but many contain >20.
- The Upper Green watershed, parts of the Bear River Basin, and the areas around Cody contain a large number of watersheds with >20 potential barriers (fig. 18–8).

Where are genetically pure populations of cutthroat trout, and where are populations at risk from hybridization (fig. 18–9)?

- Twenty-one percent of rivers and streams occupied by cutthroat trout contain genetically unaltered populations, including pure Bonneville, Colorado River, and Yellowstone cutthroat trout populations. Snake River cutthroat populations have not been genetically tested so their genetic purity is unknown. Forty-one percent of lakes and ponds occupied by cutthroat trout contain genetically unaltered populations, primarily Bonneville cutthroat trout.
- Genetically pure populations are primarily found in headwater stream systems. The Bear River Basin in the southwest portion of the Wyoming Basin has many populations with high genetic purity, as do some populations in the Upper Green and Little Snake watersheds. Many of the mainstem rivers are classified as unknown (fig. 18–9), because genetic testing has not occurred where cutthroat were introduced or where native cutthroat subspecies are known to be absent (fig. 18–2).
- Forty-five percent of rivers and streams and 95 percent of lakes and ponds with cutthroat trout also contain rainbow trout. Most genetically pure cutthroat trout populations are in areas where hybridization risk is low because of the lack of rainbow trout (fig. 18–9).

Where are cutthroat trout populations at risk of competition and predation by nonnative salmonid species (fig. 18–10)?

- Of the four species of nonnative salmonids (lake, brown, rainbow, and brook trout), most cutthroat trout populations coexist with at least one nonnative species. In the North and South Fork of the Shoshone River, upstream of Cody, there are four nonnative salmonids present.
- Only 28 percent of streams and rivers and 3 percent of lakes and ponds are free of nonnative salmonids. Areas with fewer nonnative salmonids present include the Greybull River, south of Cody, the Wind River mountains, the Upper Green watershed, and the Bear River Basin (fig. 18–10).

Where are cutthroat trout populations at risk from whirling disease (fig. 18–11)?

- The data for whirling disease is limited to point detections and demonstrate that whirling disease has been detected throughout the Basin, with the exception of the headwaters to the Bear River and the Greybull River (fig. 18–11).

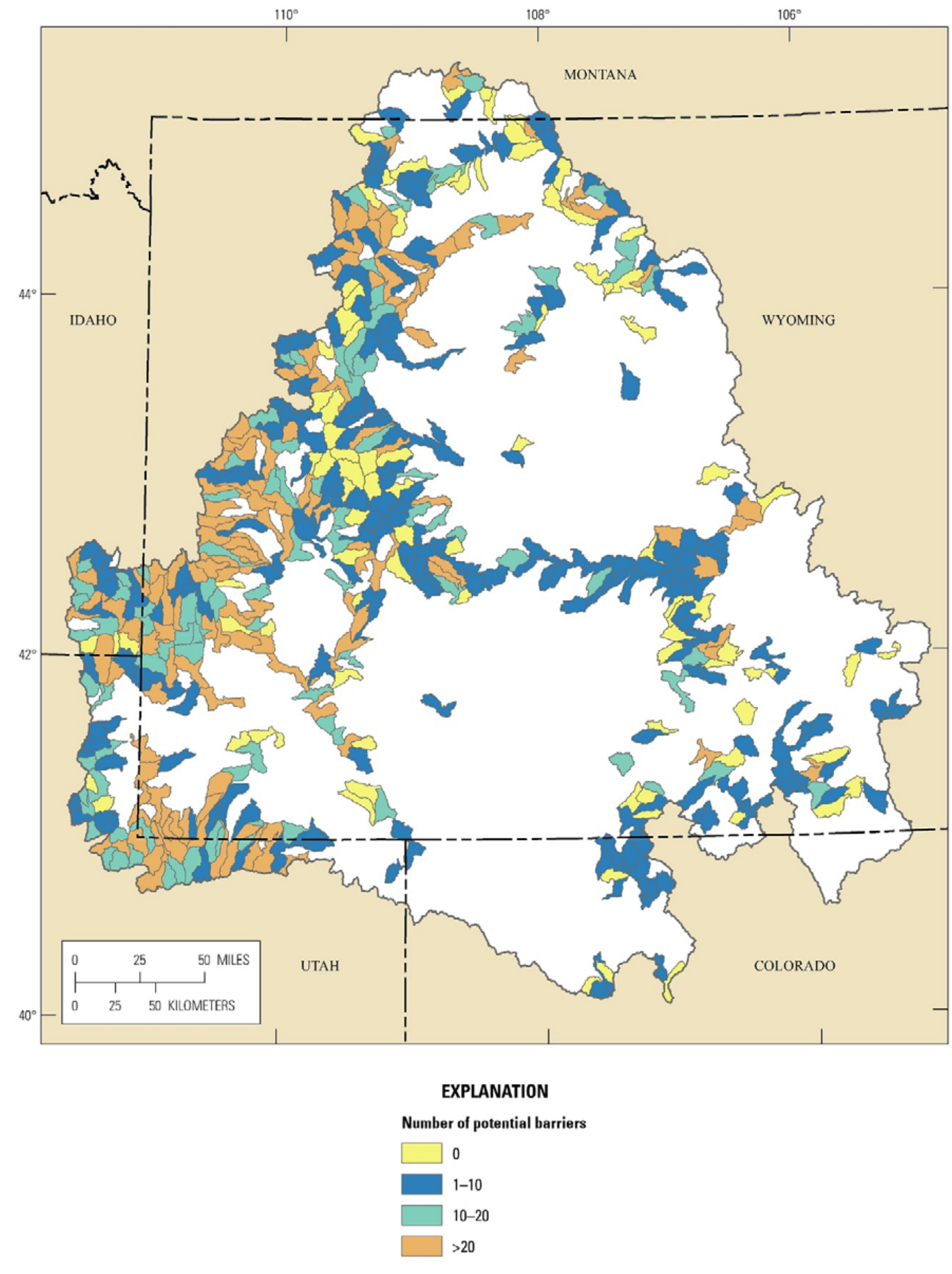

Figure 18–8. Potential barriers to cutthroat trout movements summarized by sixth-level watershed in the Wyoming Basin Ecoregional Assessment project area. Number of potential barriers includes points of diversion and stream-road crossings in occupied streams.

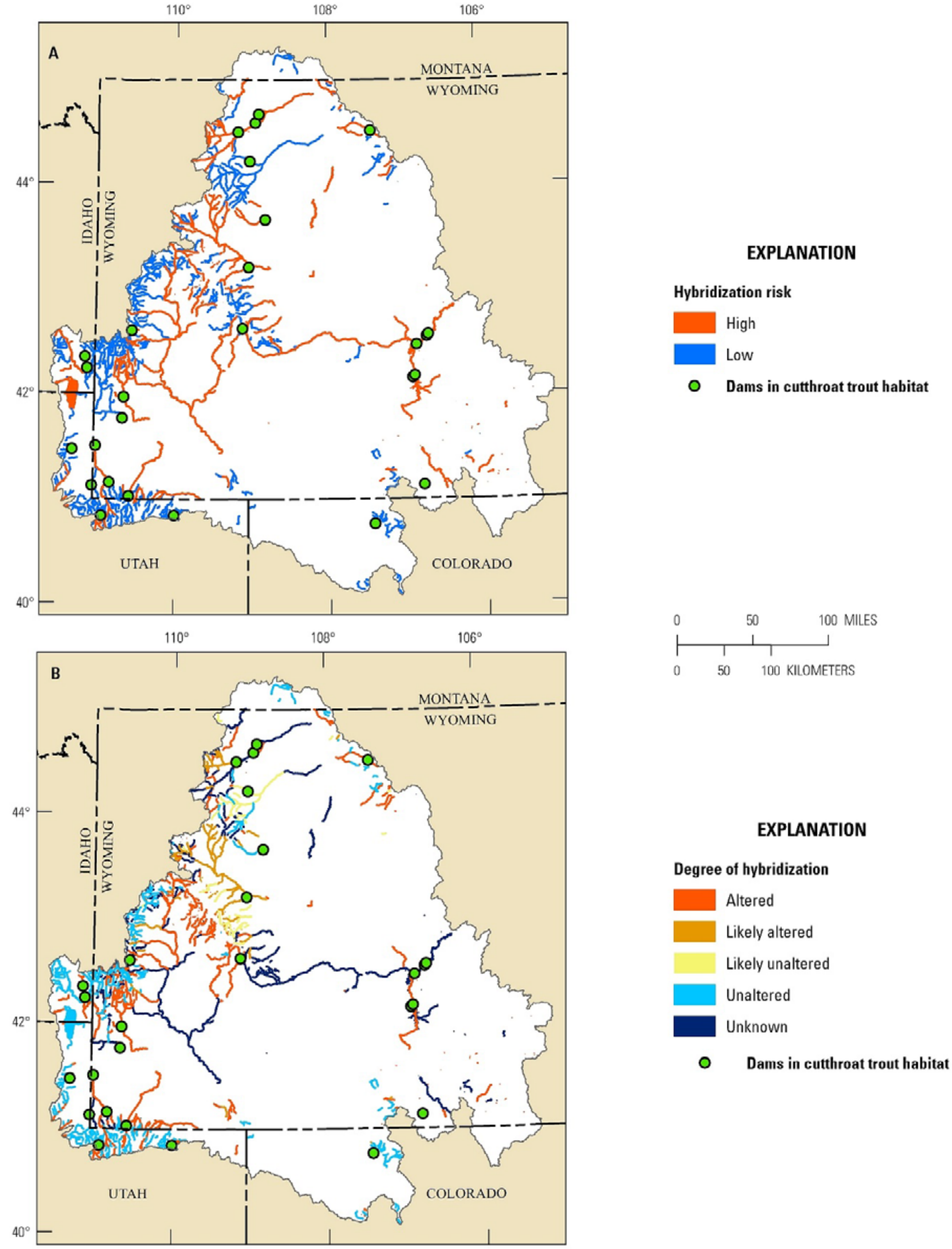

Figure 18–9. Hybridization risk (*A*) and degree of hybridization (*B*) of cutthroat trout populations with rainbow trout in the Wyoming Basin Rapid Ecoregional Assessment project area. Hybridization risk is assumed to be high if rainbow trout are present and low if they are absent.

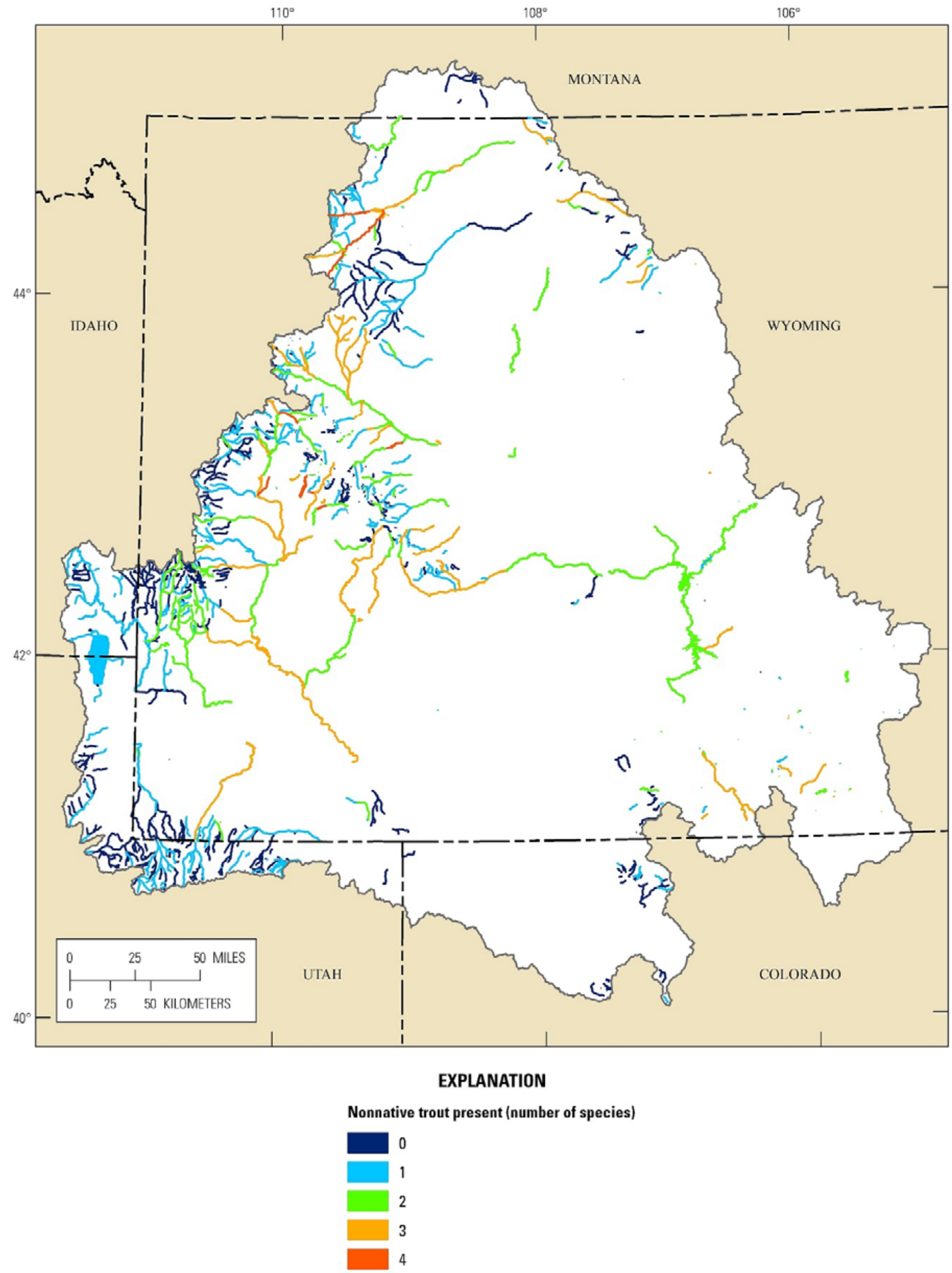

Figure 18–10. Competition and predation risk to cutthroat trout in the Wyoming Basin Rapid Ecoregional Assessment project area as a function of the number of other trout species present including rainbow, lake, brown, and brook trout.

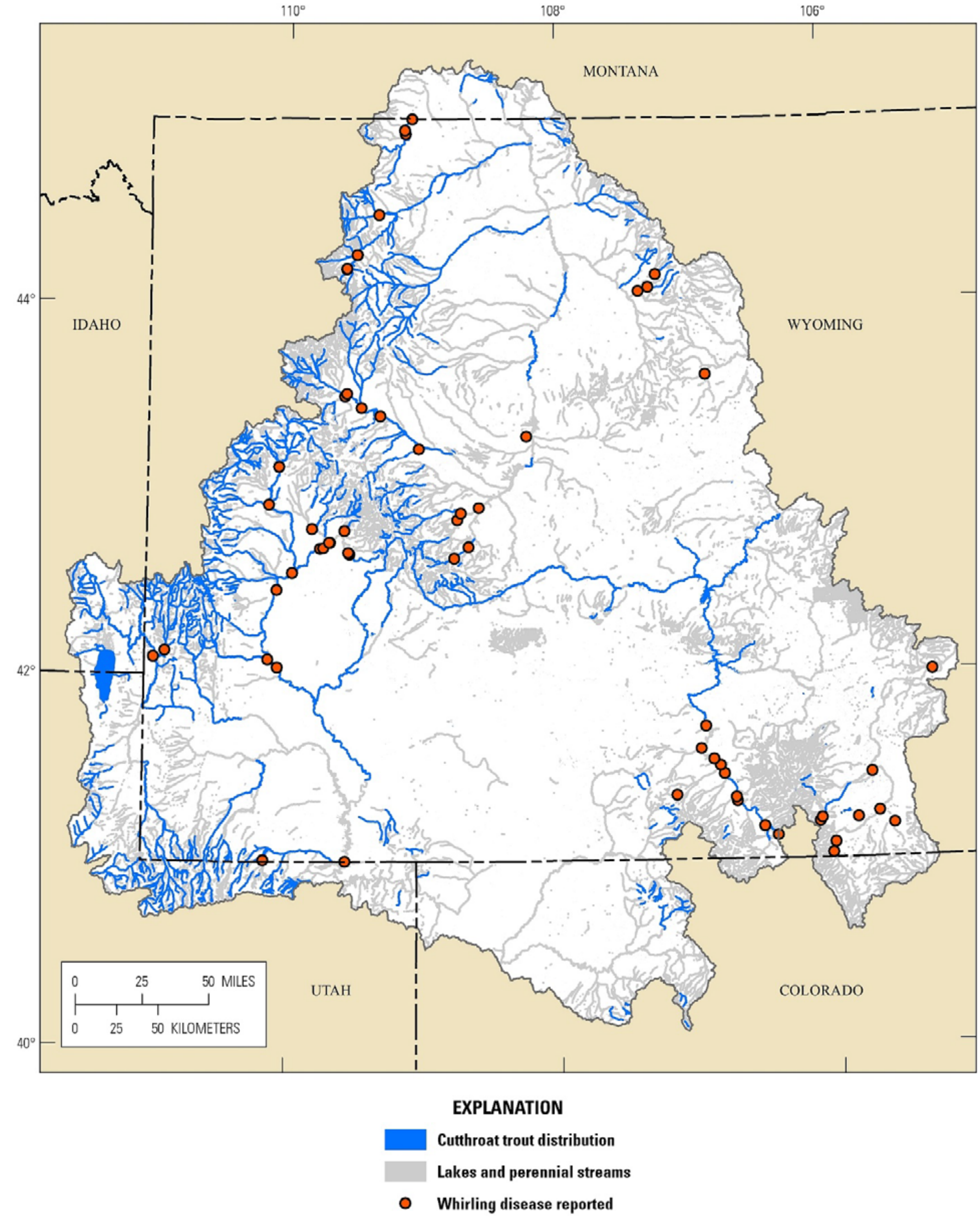

Figure 18–11. Occurrence of whirling disease within cutthroat trout habitat in the Wyoming Basin Rapid Ecoregional Assessment project area.

Where are cutthroat trout populations currently at risk from low summer flows? (fig. 18–12)

- Cutthroat trout populations exist in streams with mean summer flow ranging from 0 ft^3/s to >10 ft^3/s (fig. 18–12).
- Populations existing in streams with mean summer flow at or near 0 ft^3/s indicate the potential for dry reaches, which can decrease structural connectivity among remaining pools and increase mortality of trapped cutthroat trout, especially during drought years.

Where could cutthroat trout populations be at risk from projected shifts in hydrological regime and temperature increases in 2040 (figs. 18−13 to 18−15)?

- There is little difference between current and projected mean summer flow in 2040; thus, the models did not identify particular areas that may be at increased risk for drought in the scenarios we evaluated.
- The timing of spring runoff (as measured by center time of streamflow), however, is projected to occur earlier in many watersheds (figs. 18−13 to 18−14).
- Projected 2030 temperature increases could result in range expansion to higher-elevation sites in the Wind River and Absaroka Ranges where lower temperatures may currently constrain the upper limit of cutthroat populations (fig. 18–15).
- Lower-elevation populations in the North Platte River and Wind River/Bighorn drainages may be at greatest risk from projected increases in temperature (fig. 18–15).
- Because of uncertainty associated with potential changes to hydrologic regimes derived from projected climate scenarios, these patterns are best used to identify regional vulnerabilities.

How does risk from development vary by land ownership or jurisdiction for cutthroat trout habitat (table 18–5, fig. 18–16)?

- The two major types of land ownership or jurisdiction associated with cutthroat trout habitat are private (40 percent) and U.S. Department of Agriculture Forest Service (38 percent) (table 18–5). The private land has primarily moderate and high development levels, whereas the U.S. Department of Agriculture Forest Service land has primarily low development levels (fig. 18–16).

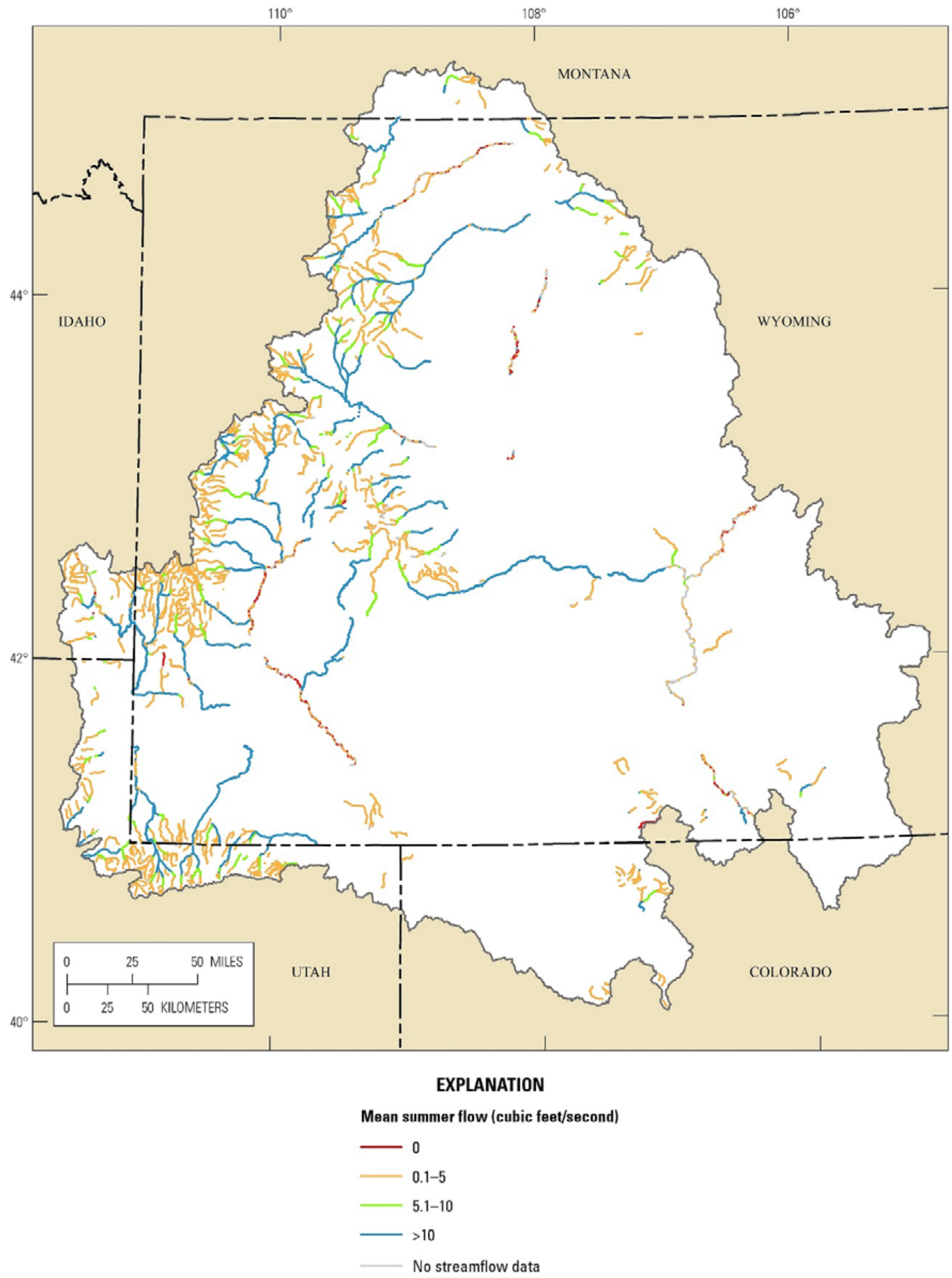

Figure 18–12. Mean summer flow (cubic foot per second) in cutthroat trout habitat for current conditions in the Wyoming Basin Rapid Ecoregional Assessment project area. Mean summer flow near or at zero indicates potential for reaches to dry out during summer months.

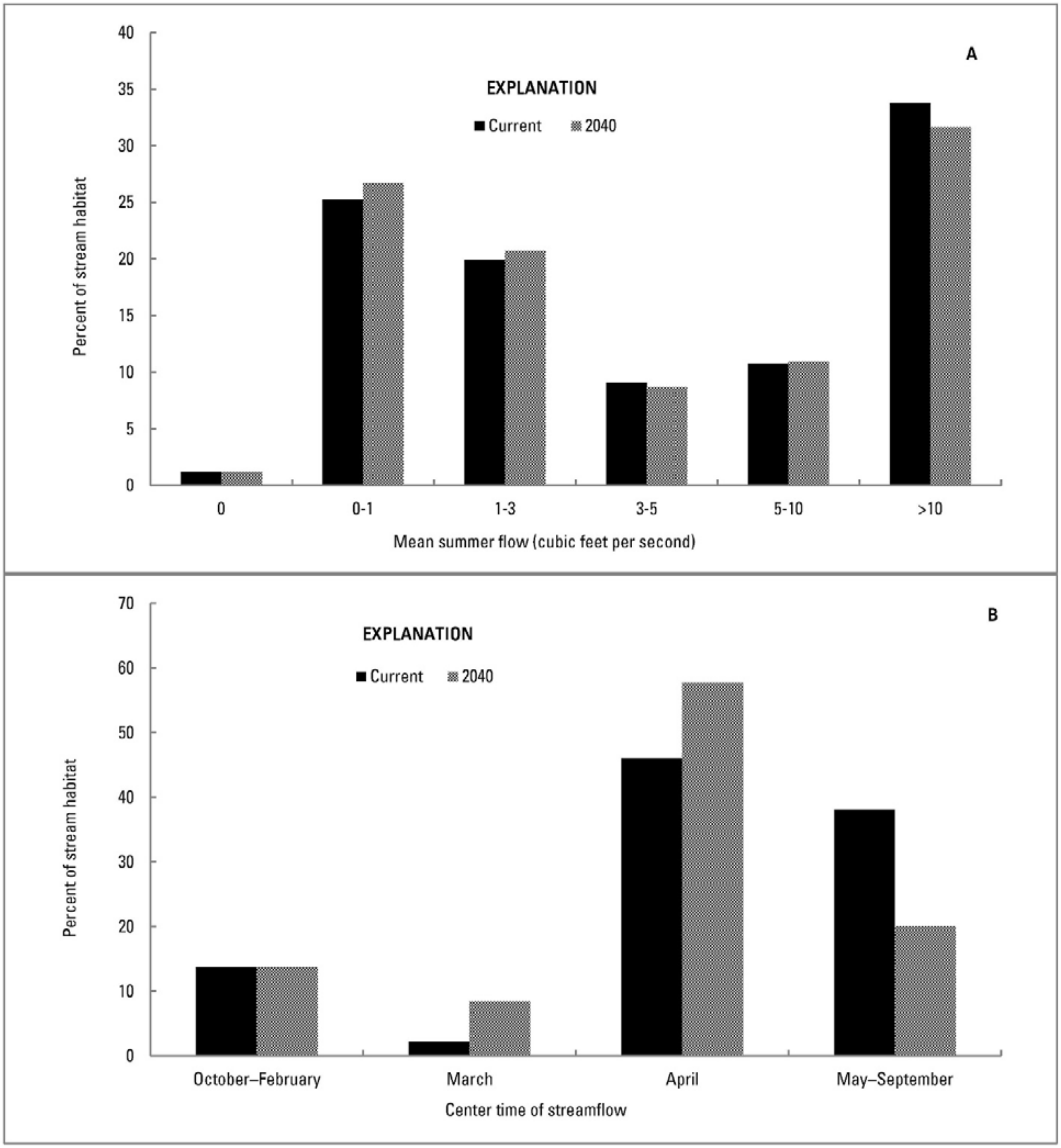

Figure 18–13. Potential effects of climate change on hydrological regime for cutthroat trout stream habitat for current conditions and projected for 2040 in the Wyoming Basin Rapid Ecoregional Assessment project area; (*A*) mean summer flow and (*B*) center time of mass streamflow (the time when 50 percent of the annual flow has occurred) (derived from figs. 18–12 and 18–14). Y-axis values represent percent of combined total (kilometers) of all stream segments in the Wyoming Basin Rapid Ecological Assessment Project Area known to be inhabited by cutthroat trout.

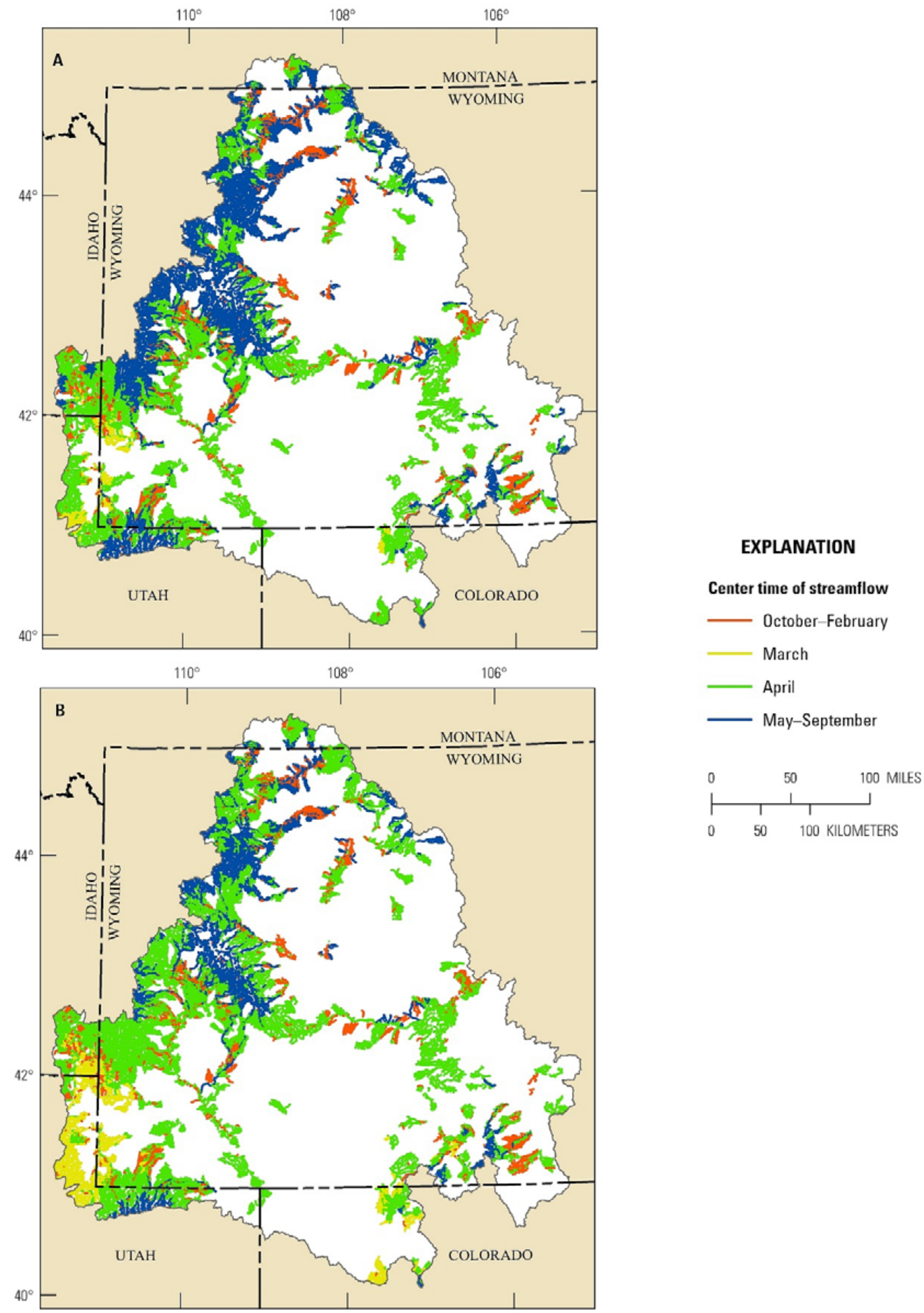

Figure 18–14. Center time of mass streamflow: (*A*) current and (*B*) projected in 2040 in the Wyoming Basin Rapid Ecoregional Assessment project area.

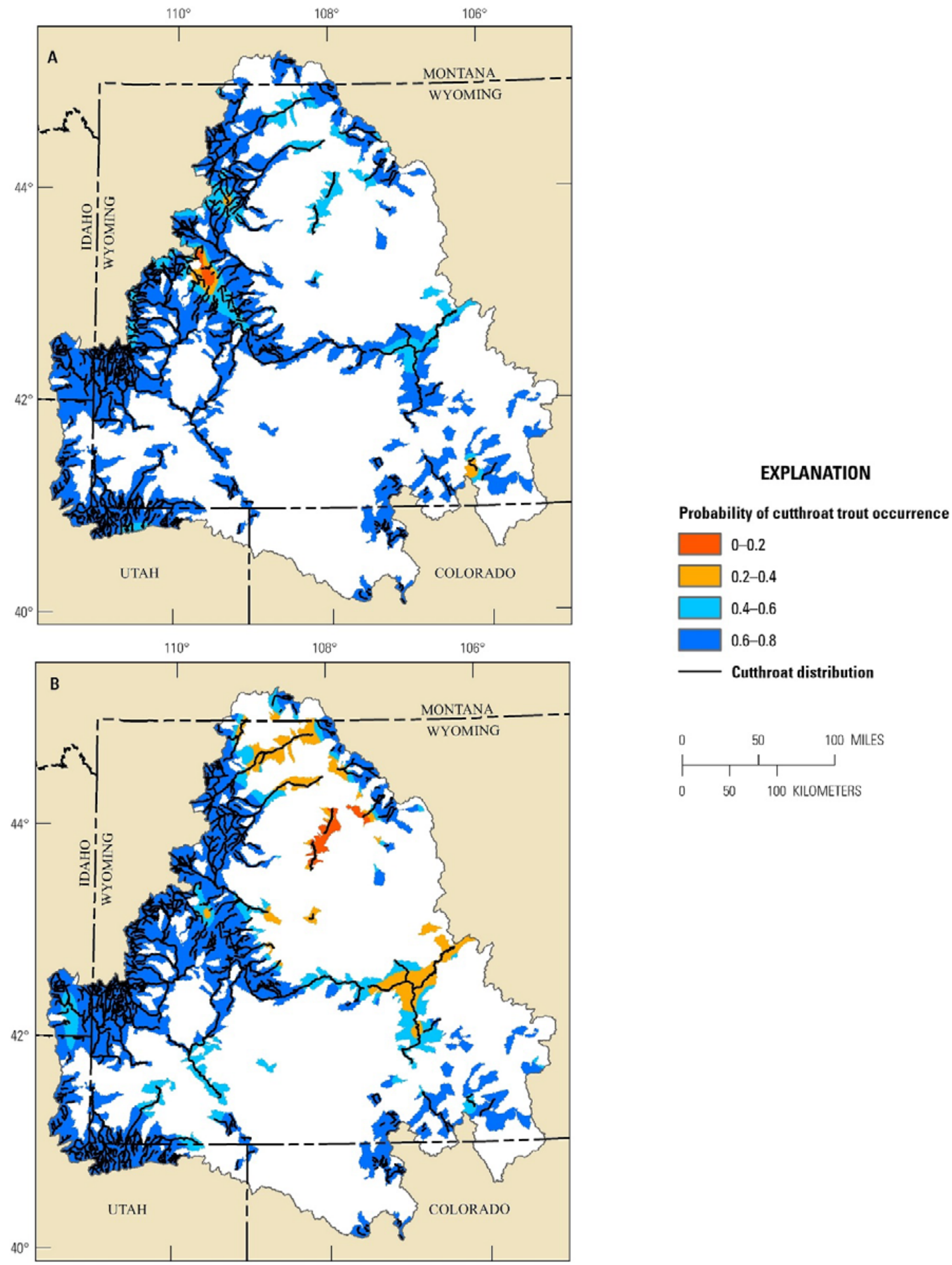

Figure 18–15. Probability of occurrence of cutthroat trout: (*A*) current and (*B*) projected in 2030 using mean daily July temperature in the Wyoming Basin Rapid Ecoregional Assessment project area.

Table 18–5. Length and percent of cutthroat trout habitat by land ownership or jurisdiction in the Wyoming Basin Rapid Ecoregional Assessment project area.

[km, kilometer]

Ownership or jurisdiction	Stream length (km)	Percent of habitat
Private	4,092	39.82
Forest Service[1]	3,858	37.55
Bureau of Land Management	787	7.66
State/County	545	5.31
Tribal	405	3.95
Other Federal[2]	318	3.10
Private conservation	179	1.74
Other	90	0.88

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

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

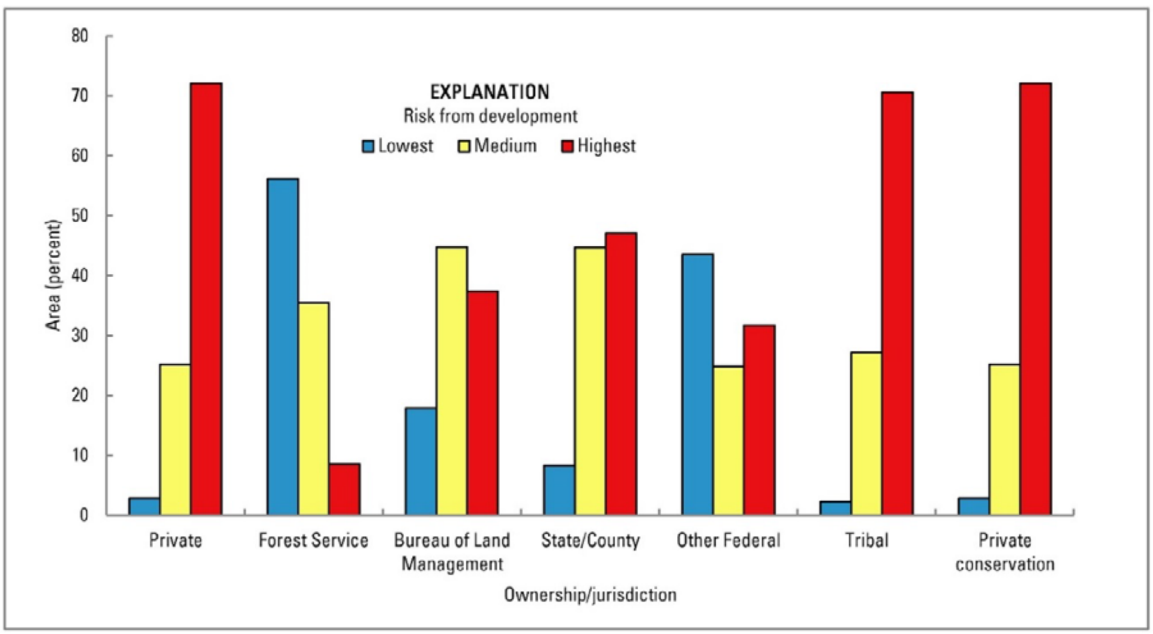

Figure 18–16. Relative ranks of risk from development by land ownership or jurisdiction for cutthroat trout habitat in the Wyoming Basin Rapid Ecoregional Assessment project area. Rankings are lowest (Aquatic Development Index [ADI] score <20), medium (ADI score 20−40), and highest (ADI score >40). [Forest Service, U.S. Department of Agriculture Forest Service]

Where are the fifth-level watersheds with the greatest landscape-level ecological values (fig. 18–17)?

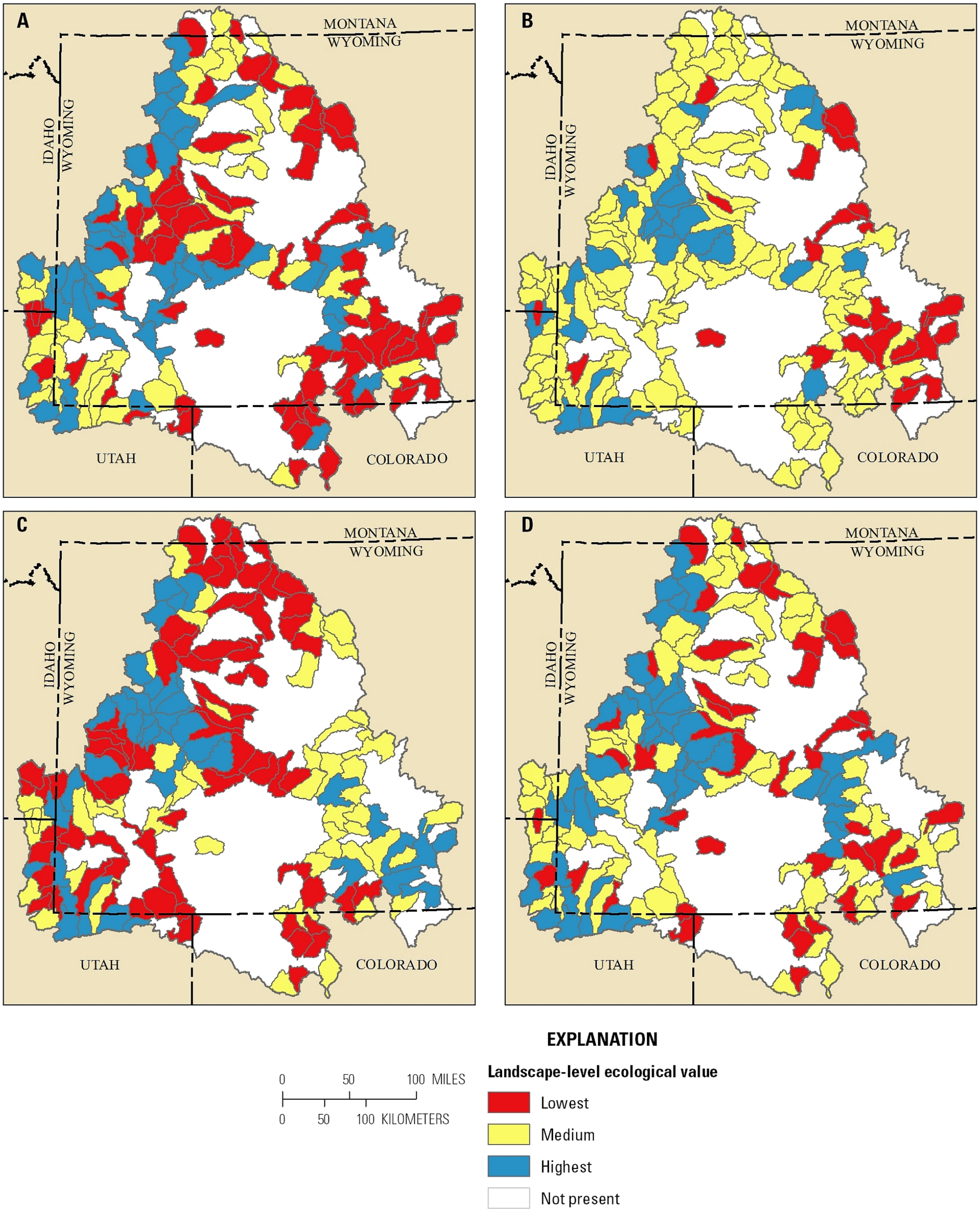

Figure 18–17. Ranks of landscape-level ecological values for cutthroat trout habitat, summarized by fifth-level watershed, in the Wyoming Basin Rapid Ecoregional Assessment project area. Landscape-level values based on (*A*) mean occupied stream-segment length (kilometers), (*B*) stream-segment count, (*C*) lake count, and (*D*) overall values (see table 18−3 for overview of methods).

Where are the fifth-level watersheds with the greatest landscape-level risks (fig. 18–18)?

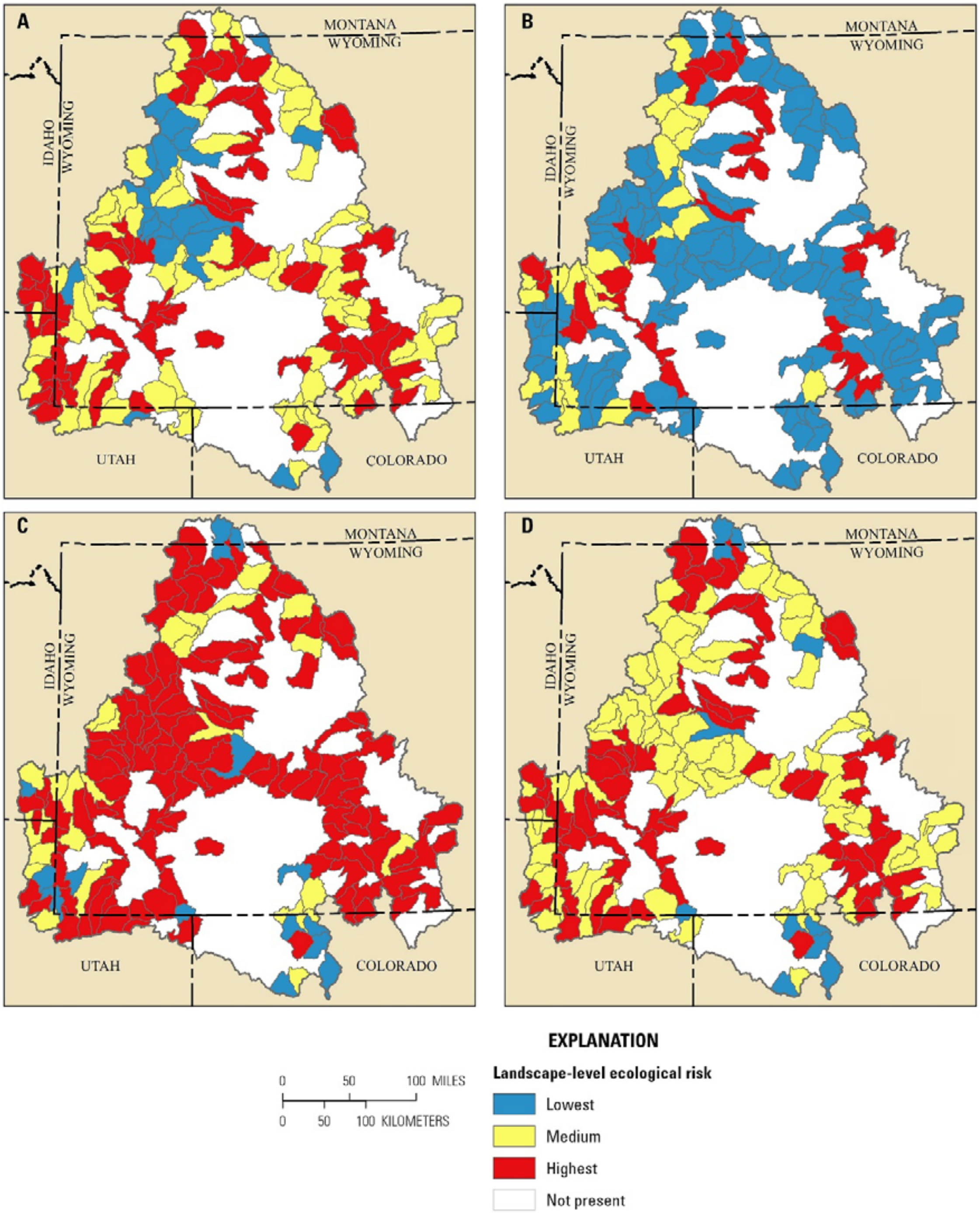

Figure 18–18. Ranks of landscape-level ecological risks for cutthroat trout habitat, summarized by fifth-level watershed, in the Wyoming Basin Rapid Ecoregional Assessment project area. Landscape-level risks based on (*A*) Aquatic Development Index, (*B*) number of cutthroat occupied stream segments with a mean-summer flow of 0 cubic foot per second divided by total length of cutthroat occupied stream segments per watershed, (*C*) hybridization status and risk index, and (*D*) overall risks (see table 18−3 for overview of methods).

Where are the fifth-level watersheds with the greatest conservation potential (fig. 18–19)?

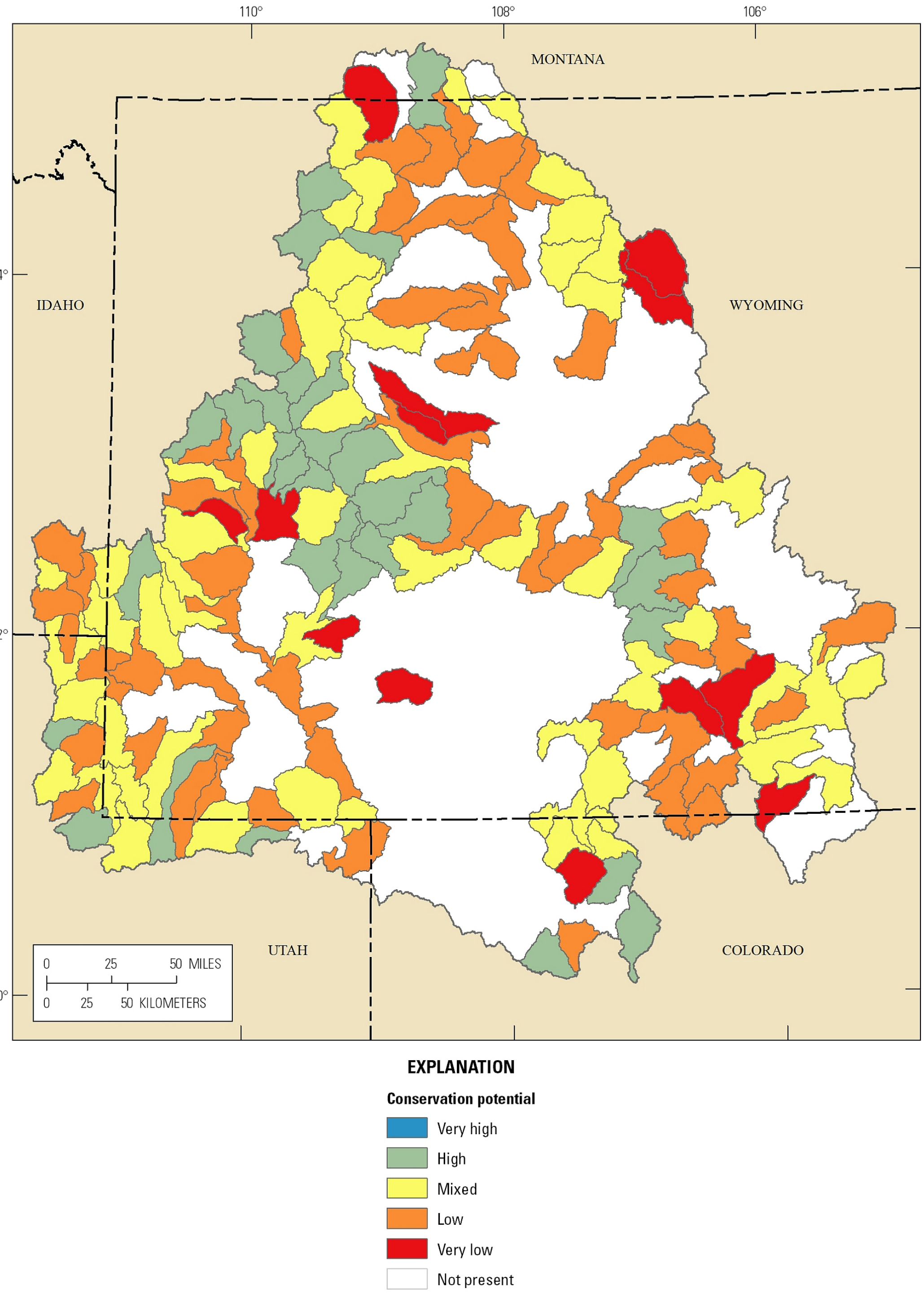

Figure 18–19. Conservation potential of cutthroat trout habitat, summarized by fifth-level watershed, in the Wyoming Basin Rapid Ecoregional Assessment project area. Highest conservation potential identifies watersheds that have the highest landscape-level values and the lowest risks. Lowest conservation potential identifies watersheds with relatively low landscape-level values and the highest risks. No watersheds ranked very high for cutthroat trout, because there are no watersheds ranked with the highest values that also were ranked with the lowest 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

Cutthroat trout are present primarily in the western portion of the Wyoming Basin, with the larger native populations occurring in the Greybull River (Yellowstone cutthroat), Wind River (Yellowstone cutthroat), Bear River (Bonneville cutthroat), Upper Green River (Colorado River cutthroat), and Little Snake River (Colorado River cutthroat) drainages. Cutthroat trout have been introduced extensively in the North Platte River and Lower Green River drainages. Both native and introduced populations experience some degree of stocking. Cutthroat trout occur primarily in stream and river habitat but are also found in some lakes and ponds.

Cutthroat habitat has been fragmented by dams, especially for mainstem river populations. However, our estimates of patch size derived from stream-segment length likely underestimate habitat fragmentation, as only major natural and anthropogenic barriers were used to define stream segments in the source data. Our analysis of potential barriers (water diversions, and stream/road crossings) included many additional potential barriers that reduce connectivity and increase habitat fragmentation (fig. 18–8). More detailed local studies are needed to quantify the loss of connectivity posed by potential barriers than can be evaluated with broad-scale data. For example, our analysis identified stream-segment lengths >100 kilometers (km) (62.1 miles [mi]) in the upper Colorado River Basin, but a local study found that most cutthroat trout populations in the Colorado River Basin occurred in stream segments <30 km (18.6 mi) (Roberts and others, 2013). Although barriers are generally believed to have negative effects on cutthroat trout, many of these barriers can be beneficial in isolating genetically pure cutthroat populations from rainbow trout, and barriers have been installed for this purpose.

Most of the habitat occupied by cutthroat trout was highly developed as a consequence of roads and agricultural activities. The largest areas with relatively undeveloped habitat are in the Wind River and Absaroka Mountains. The Bear River and Green River drainages are highly developed with the exception of headwater cutthroat trout habitat, which is relatively undeveloped. The Bear River drainage, in particular, had high development scores resulting from extensive agriculture, numerous water diversions, and high densities of roads. Nevertheless, long stream segments supporting genetically pure native Bonneville cutthroat trout remain, including mainstem habitat, which may enhance resistance to natural and anthropogenic disturbances. In contrast, genetically pure Colorado River cutthroat trout populations in small upstream headwater stream segments may be more susceptible to population declines following severe disturbances due to their isolation from downstream populations by barriers (Roberts and others, 2013).

The majority of cutthroat trout populations are not genetically pure. The genetically pure populations were primarily located in areas with low hybridization risk due to the absence of rainbow trout. There are a few areas such as Bear Lake, however, with genetically unaltered cutthroat trout and high hybridization risk due to rainbow trout presence.

Although flow projections did not indicate the potential for large decreases in mean summer flow in 2040, potential shifts to earlier timing of spring peak flow could lead to protracted periods of low summer flows during the summer. Risk from decreased flow would be exacerbated by the extensive network of water diversions present throughout cutthroat trout habitat. In addition, susceptibility to climate change is likely to vary by subspecies. Bonneville cutthroat trout are still present in mainstem habitat in the Bear River where increased temperatures and shifts in streamflow timing are more likely to occur, whereas Colorado River cutthroat trout are primarily present in headwater habitat, which is expected to be at lower risk of projected temperature increases and associated shifts in streamflow (Williams and others, 2009).

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

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