

## Section II. Change Agents—Current and Future

### Chapter 4. Development

By Natasha B. Carr, Kirk R. Sherrill, Michael O'Donnell, Steven L. Garman, Annika W. Walters, and Jeffrey Wesner

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## Introduction

The major types of development (including industrial, agriculture, and residential) identified as priorities for the Rapid Ecoregional Assessment (REA) are discussed in Chapter 1—Introduction and Overview. Although grazing and off-highway vehicles were also identified as priority Change Agents, sufficient regional data were not available for evaluation as part of the REA. To effectively analyze the impacts of grazing and off-highway vehicles, “step-down” (localized) data can be used to account for the multiple, complex factors involved. Here, we identify the relevant Management Questions, and associated maps, regarding the regional effects of current development and the potential implications of future development scenarios.

## Current Development

Because land uses can affect terrestrial and aquatic ecosystems differently, we evaluated terrestrial and aquatic systems separately. We used the Terrestrial Development Index (TDI) and Aquatic Development Index (ADI) to quantify the cumulative landscape-level effects of development on individual species or assemblages, ecological communities, and the entire Wyoming Basin Ecoregion. The TDI and ADI quantify levels of development intensity and provide a standardized framework for comparing the potential risks from development across species and communities. The methods for quantifying the TDI and ADI are described in Chapter 2—Assessment Framework.

Although species vary in their sensitivity to the direct and indirect effects of development, the TDI and ADI nevertheless provide a useful method for summarizing levels in development intensity across large landscapes (tables 4–1 and 4–2). Thus, the overall development index provides a standardized basis for comparing the landscape-level effects of development across species and communities. The risks from development are summarized in the chapters for each Conservation Element (Section III—Communities and Section IV—Species) and for the entire ecoregion (Chapter 29—Landscape Intactness). The Management Questions for development are provided in table 4–3.

## Potential for Future Energy Development

We evaluated the potential for future energy development for two types of energy: fossil fuels (oil and gas) and wind. Future oil and gas development used projections developed by Copeland and others (2009). Management Questions related to future energy development are provided in table 4–3. Potential oil and gas development was only evaluated at the ecoregion level and was not used to assess future risks for individual species and communities. The results of the potential wind energy were used for evaluating risk for golden eagle and ferruginous hawks. These raptors are especially vulnerable to direct mortality from wind turbines (Chapter 24—Golden Eagle and Chapter 25—Ferruginous Hawk). We also evaluated the potential for future energy development in areas currently disturbed by existing development (“brown fields”)

**Table 4–1.** Change Agent table for the Terrestrial Development Index. Classes of development and metrics, data sources, and analysis units are provided. See Chapter 2—Assessment Framework for additional details.

Change Agent	Variable class	Variable	Metric
Development	Transportation	Roads, railroads	Total surface area
	Energy and minerals	Oil and gas wells, wind turbines, mines	Total surface area
	Transmission structures	Communication towers, transmission lines	Total surface area
	Agriculture <sup>2</sup>	Pasture, cropland	Total surface area
	Urban	Urban classes of Existing Vegetation Type	Total surface area

**Table 4–2.** Change Agent table for the Aquatic Development Index. Classes of development and metrics, data sources, and analysis units are provided. See Chapter 2—Assessment Framework for additional details.

Change Agent	Variable class	Variable	Metric
Development	Transportation	Roads, railroads	Total surface area, number of road, crossings per stream km
	Energy & minerals	Oil and gas wells, wind turbines, mines	Number of oil and gas wells, number of wind turbines, number of mines
	Water	Dams, diversions, streams under section 303D of the Clean Water Act	Number of dams, number of diversions, kilometers of stream length
	Agriculture <sup>3</sup>	Pasture, cropland	Total surface area
	Urban	Urban classes of Existing Vegetation Type	Total surface area

## Management Questions

**Table 4–3. Management Questions addressed for terrestrial and aquatic development for the Wyoming Basin Rapid Ecoregional Assessment.**

Current development	Results
Where does development pose the greatest threat to terrestrial systems in the ecoregion, and where are the large, relatively undeveloped patches?	Figures 4–1 and 4–2
How do terrestrial development levels vary by transportation, energy and minerals, agriculture, and urban development classes?	Figure 4–3
Where does development pose the greatest threat to aquatic systems in the ecoregion, and where are the relatively undeveloped catchments and watersheds?	Figures 4–4 and 4–5
How do aquatic development levels vary by transportation, energy and minerals, dams and diversions, and agriculture and urban development classes?	Figure 4–6
Future energy development	Results
Where are areas with high potential for future oil and gas development in relation to current oil and gas development?	Figure 4–7
Where are the relatively undeveloped areas that have high potential for future oil and gas development?	Figure 4–8
Where are areas with high potential for future wind-energy development, and where are areas with existing development and relatively undeveloped areas that have high potential for future wind-energy development?	Figure 4–9

To map wind-energy potential, we used siting potential derived from wind-energy classes developed by the National Renewable Energy Laboratory (NREL), economic factors, and areas that are excluded from development. Siting criteria included wind speeds >6.5 meters per second (m/sec) (NREL class 3 and higher); distances of >500 m from forests and >400 m from water bodies; and locations within 10 kilometers (km) (6.2 miles [mi]) of primary roads, 80 km (50 mi) of cities with populations >20,000, or within 10 km (6.2 mi) of major transmission lines. Areas excluded from development were masked from the siting-potential map: Bureau of Land Management (BLM) areas designated as “no surface occupancy” and protected areas (PADUS Gap Status 1 or 2), including wilderness study areas and visual-resource-management areas, state wildlife- or habitat-management areas, state parks, National Wildlife Refuges, National Parks and Monuments, Department of Defense lands, surface mines and other activities that conflict with harvesting wind, slopes >15 degrees, and existing wind-energy facilities. To mask existing wind-energy facilities, turbine point locations were buffered by a radius equal to eight times the rotor diameter to create a minimum convex polygon for the existing wind-energy facility.

To evaluate where future oil and gas development potential is high in relation to existing development, we overlaid existing oil and gas well-pad locations and existing BLM leases on the oil and gas potential map. For wind energy, we mapped areas with high wind-energy development potential (that also had a TDI score > 5 percent) to identify areas with high levels of existing development. We also mapped relatively undeveloped areas (TDI score <1 percent) with high wind-energy development potential to evaluate potential risk to these areas from future energy development.

Where does development pose the greatest threat to terrestrial systems in the ecoregion, and where are the large, relatively undeveloped patches (figs. 4–1 and 4–2)?

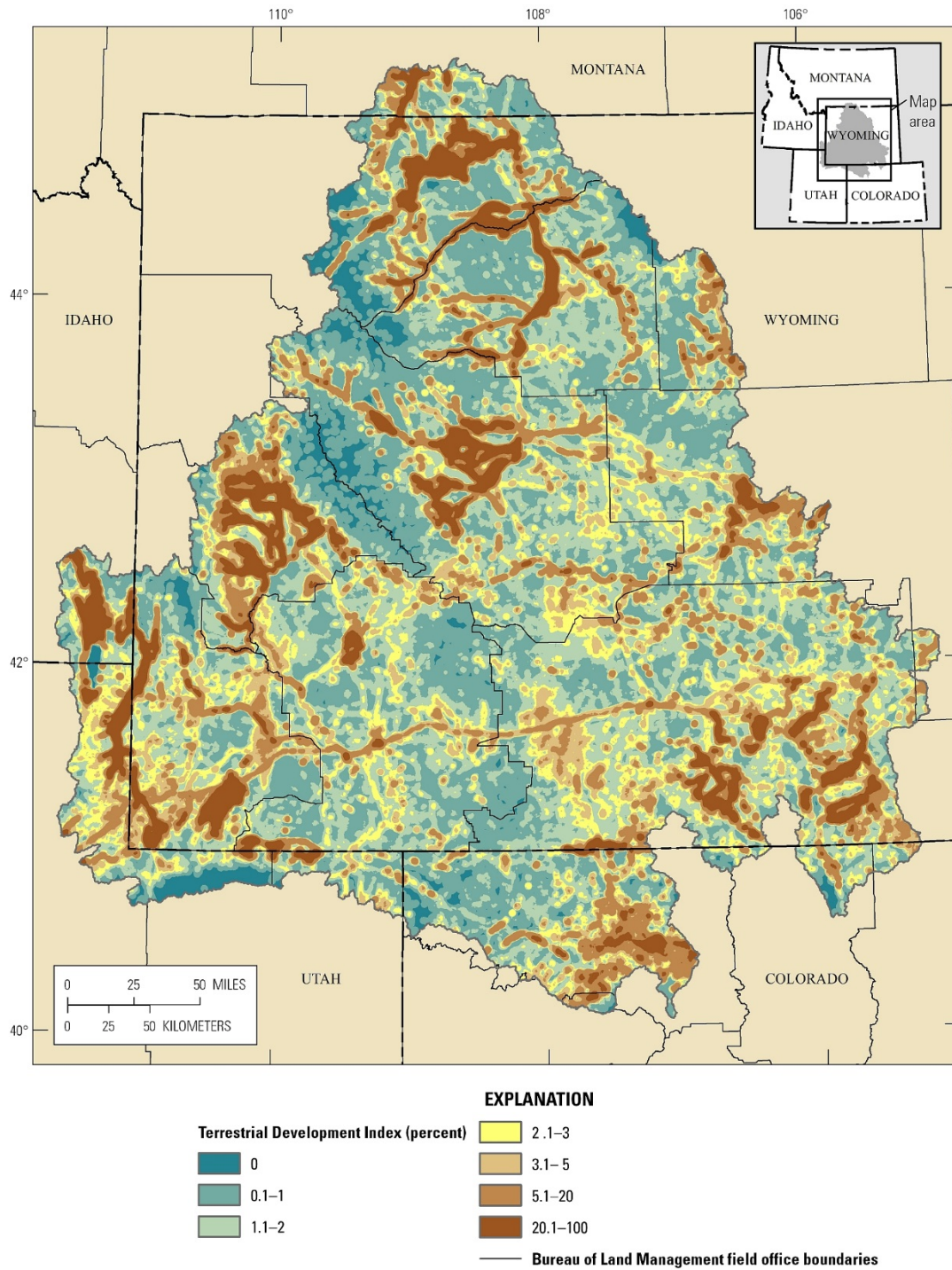


Figure 4–1. Terrestrial Development Index (TDI) in the Wyoming Basin Rapid Ecoregional Assessment project area. Relatively undeveloped areas are defined as TDI scores  $\leq 1$  percent.

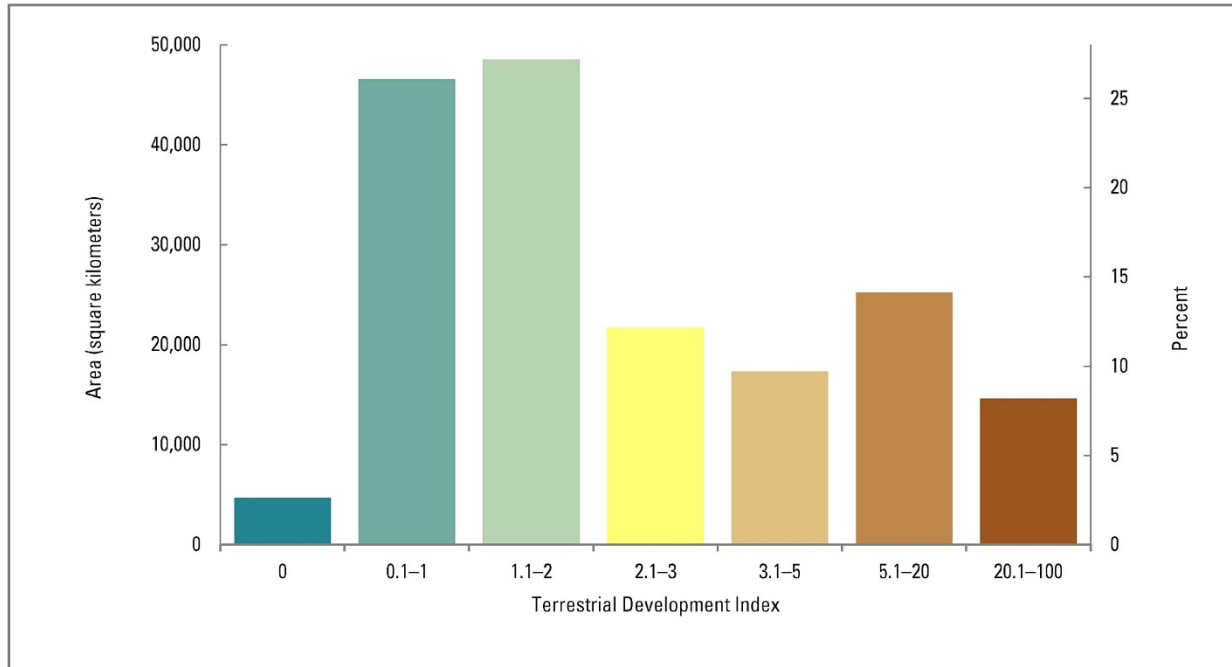


Figure 4-2. Percent of area by development level as a function of the Terrestrial Development Index in the Wyoming Basin Rapid Ecoregional Assessment project area.

How do terrestrial development levels vary for transportation, energy and minerals, agriculture, and urban development classes (fig. 4-3)?

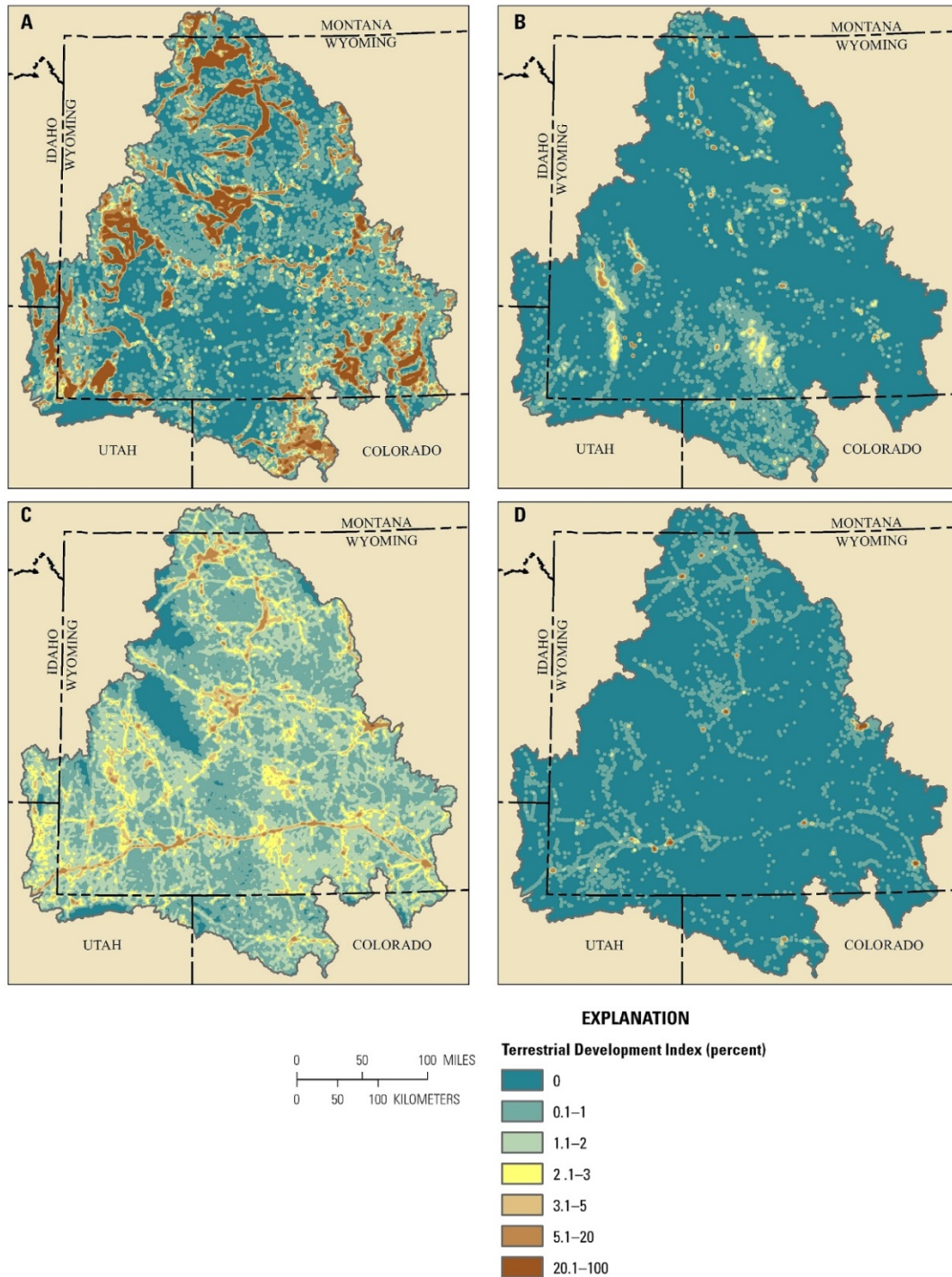


Figure 4-3. Percent surface area for four of the variables compiled in the Terrestrial Development Index (table 41): (A) agriculture; (B) energy and mineral development excluding roads; (C) all transportation; and (D) urban development.



Where does development pose the greatest threat to aquatic systems in the ecoregion, and where are the relatively undeveloped catchments and watersheds (figs. 4–4 and 4–5)?

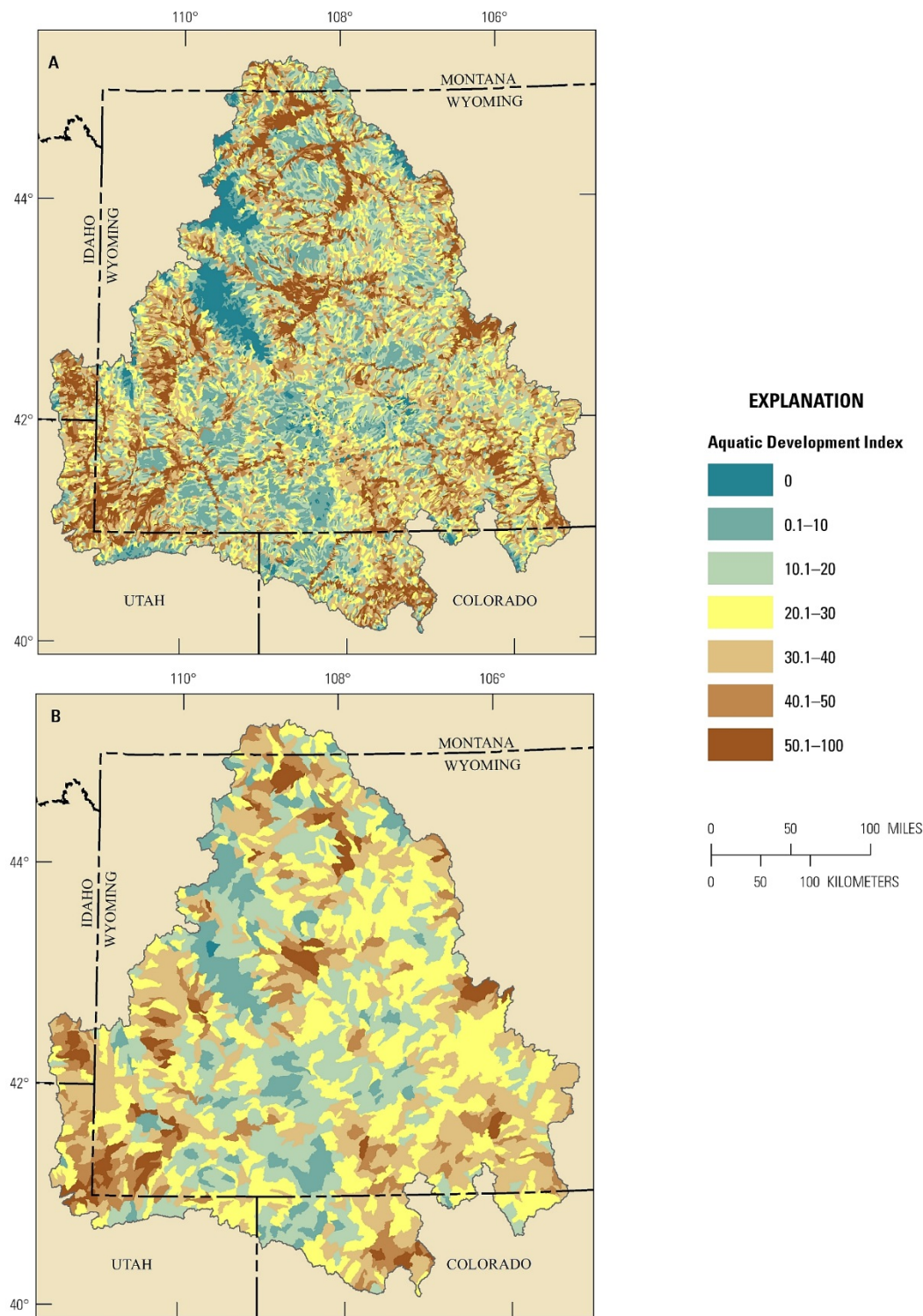


Figure 4–4. The Aquatic Development Index in the Wyoming Basin Rapid Ecoregional Assessment project area, summarized by (A) catchment (native resolution of index) and (B) sixth-level watershed.

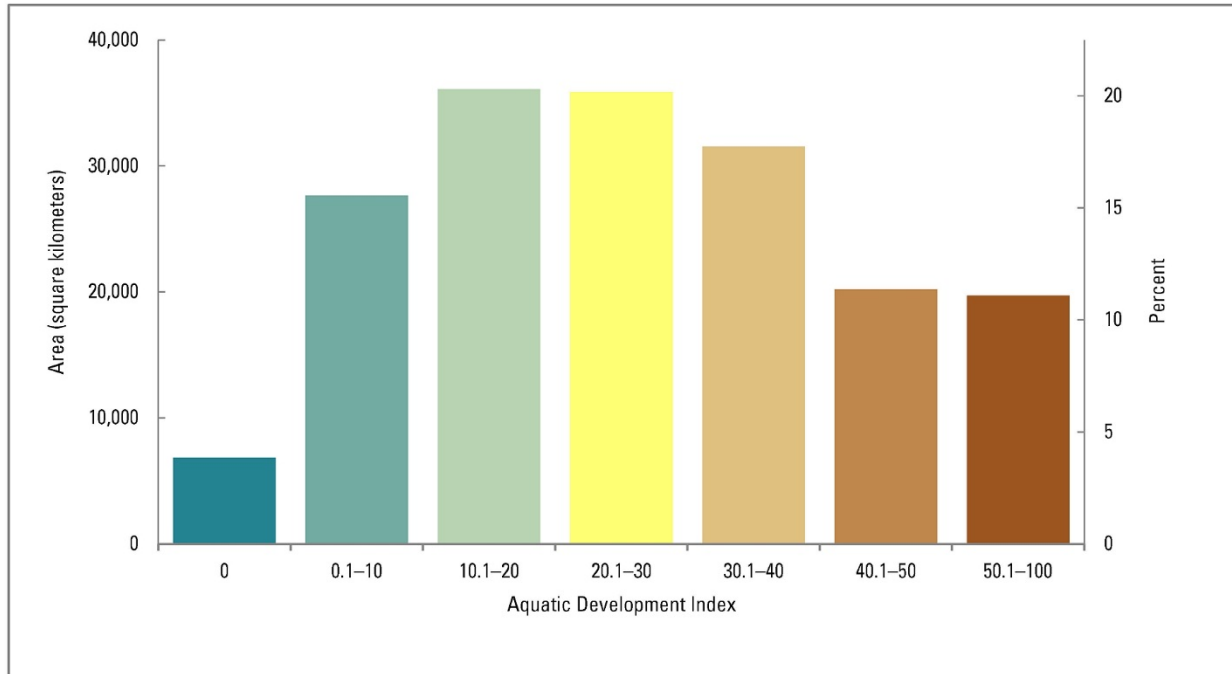


Figure 4-5. Percent of area by development level as a function of the Regional Aquatic Development Index in the Wyoming Basin Rapid Ecoregional Assessment project area.

How do aquatic development levels vary by transportation, energy and minerals, dams and diversions, and agriculture and urban development classes (fig. 4–6)?

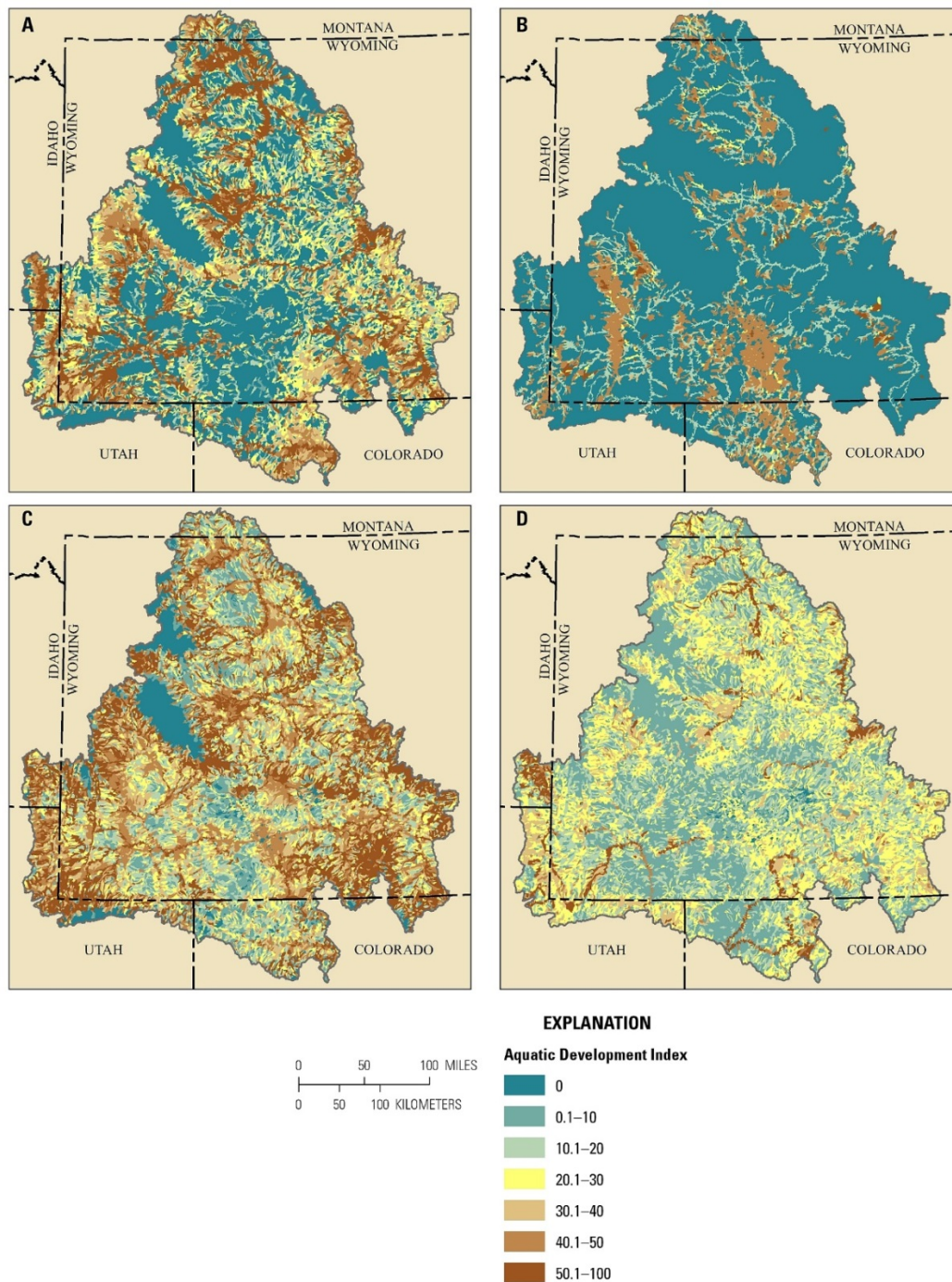


Figure 4–6. Aquatic Development Index for four classes of development, summarized by catchment: (A) agriculture and urban development; (B) energy and minerals; (C) roads and railroads; and (D) dams and diversions.



Where are areas with high potential for future oil and gas development in relation to current oil and gas development (fig. 4–7)?

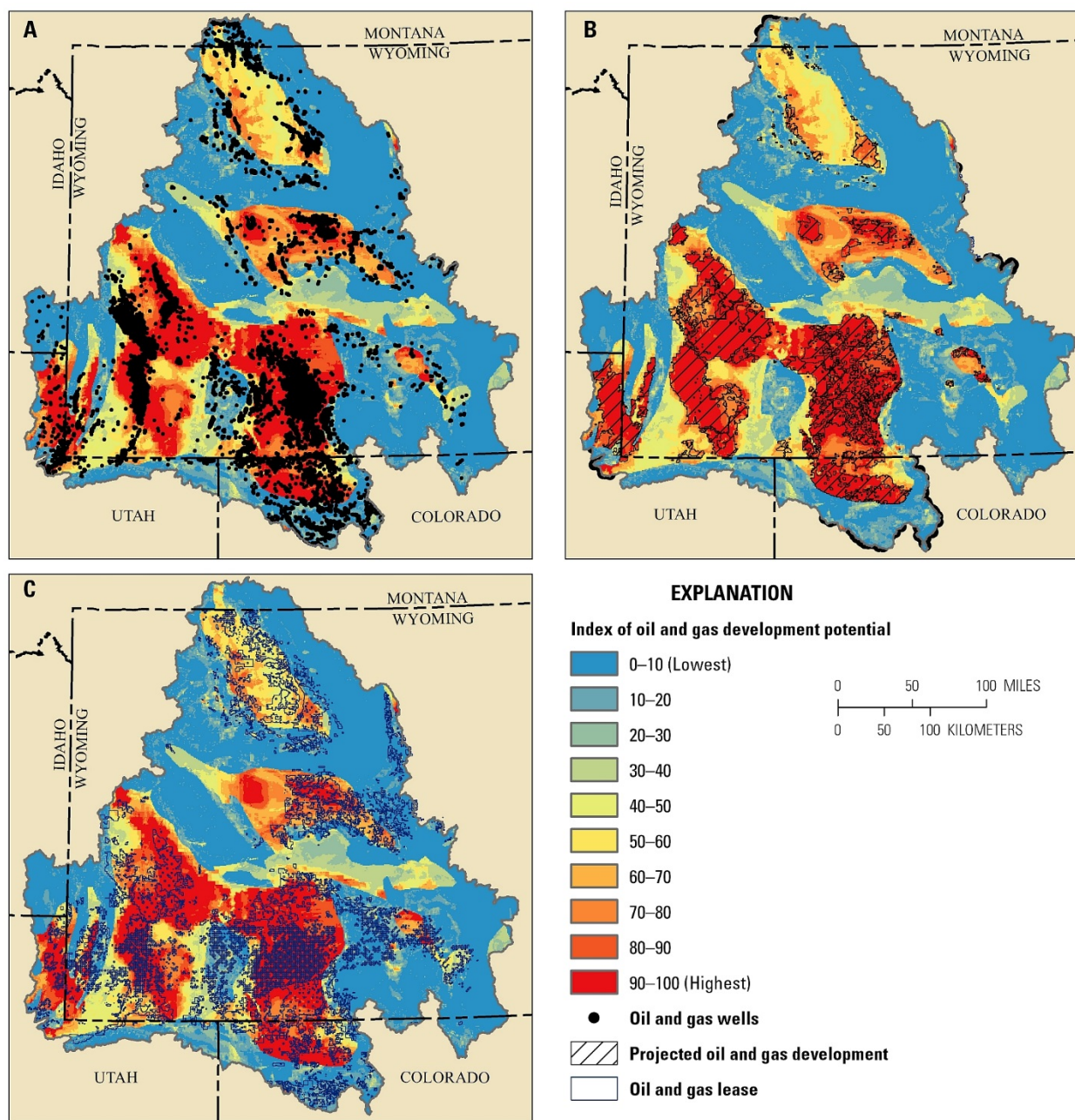


Figure 4–7. Relative potential for oil and gas development (Copeland and others, 2009) in the Wyoming Basin Rapid Ecoregional Assessment project area in relationship to (A) existing oil and gas well pads; (B) projected oil and gas development (Copeland and others, 2009); and (C) existing oil and gas leases.

Where are the relatively undeveloped areas that have high potential for future oil and gas development (fig. 4–8)?

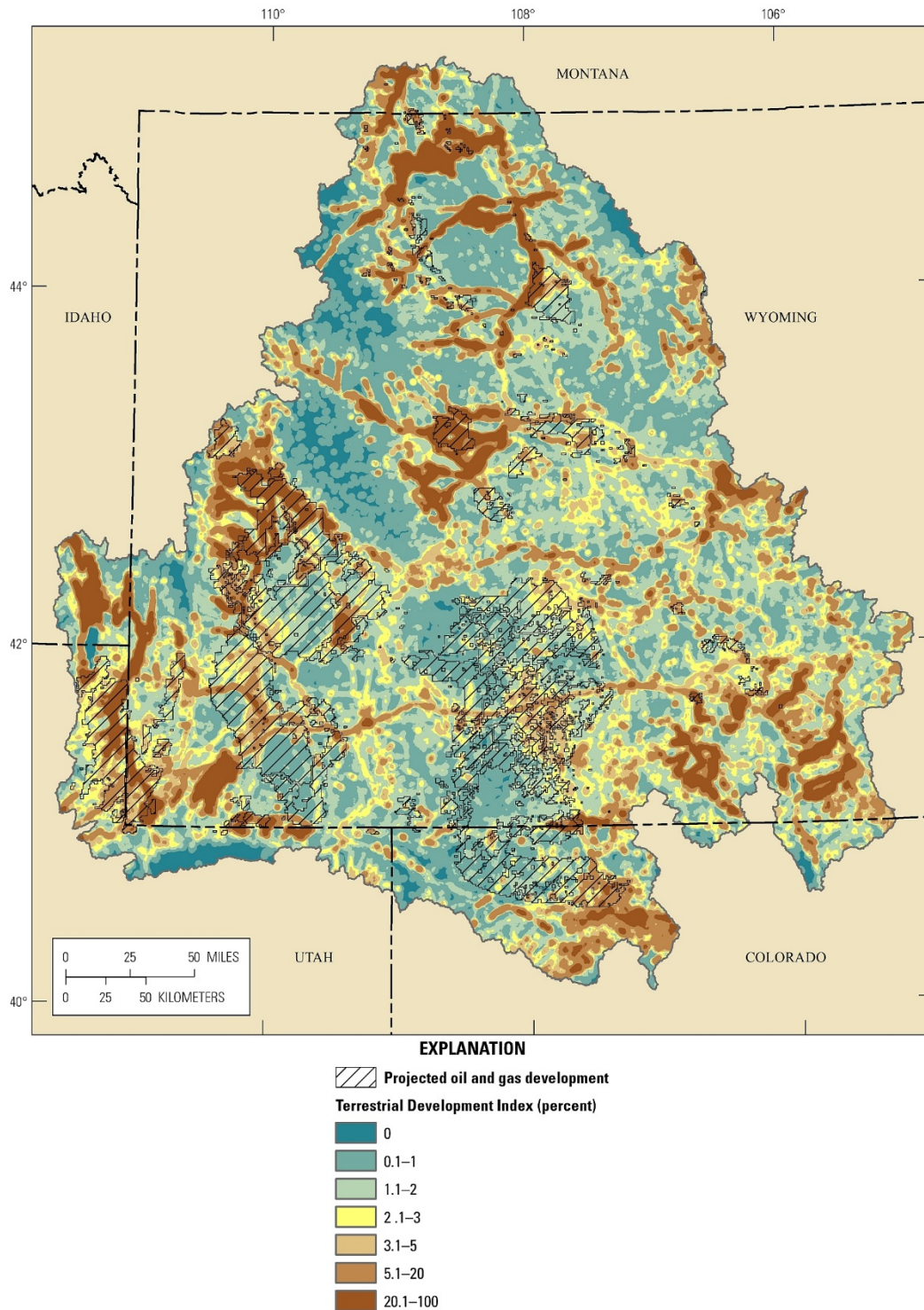


Figure 4–8. Projected potential for oil and gas development (Copeland and others, 2009) in relationship to the Terrestrial Development Index (TDI) in the Wyoming Basin Rapid Ecoregional Assessment project area. TDI scores  $\leq 1$  represent relatively undeveloped areas, and TDI scores  $> 5$  represent areas that currently have high levels of development.

Where are areas with high potential for future wind-energy development, and where are areas with existing development and relatively undeveloped areas that have high potential for future wind-energy development (fig. 4–9)?

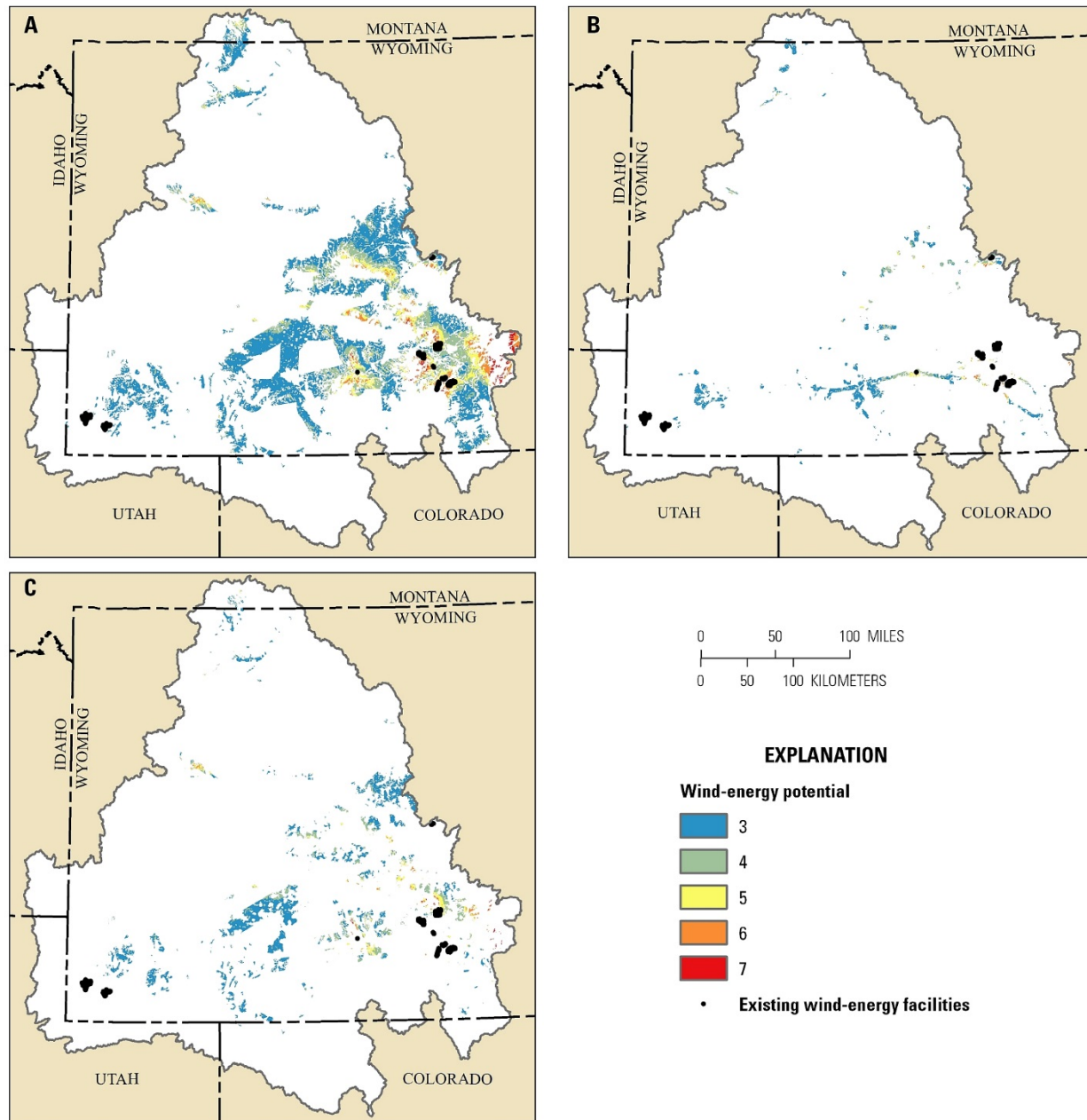


Figure 4–9. Distribution of existing wind-energy facilities and wind-energy potential in the Wyoming Basin Rapid Ecoregional Assessment project area. Maps show areas of relatively high potential for wind-energy development in (A) entire project area; (B) areas of high terrestrial development (Terrestrial Development Index [TDI] scores >5 percent); and (C) relatively undeveloped areas (TDI scores ≤1 percent).



## Reference Cited

Copeland, H.E., Doherty, K.E., Naugle, D.E., Pocewicz, A., and Kiesecker, J.M., 2009, Mapping oil and gas development potential in the US Intermountain West and estimating impacts to species: PLoS ONE, v. 4, no. 10, e7400.