Wind Power in Wyoming:

Doing it Smart from the Start

Biodiversity Conservation Alliance
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Front Cover Photographs: Wind towers near Medicine Bow, Biodiversity Conservation Alliance photo
Recreationist at Joe Hay Rim, Jack Morrow Hills by Biodiversity Conservation Alliance
Sage Grouse U.S. Geological Survey Image, Elk by Steve Torbit

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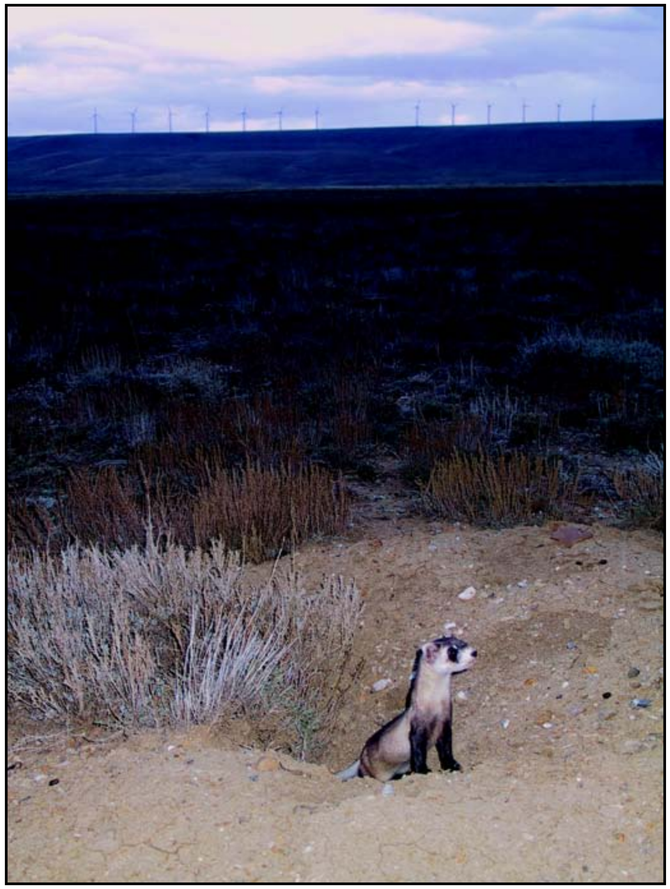
Executive Summary

Wyoming has world-class wildlife and wildland values that deserve protection, with some of the last intact and functioning ecosystems in the United States. At the same time, it has outstanding wind power resources that need to be developed so we can reduce our fossil fuel consumption. This generation has the opportunity to do wind energy development smart from the start, and the key to successful development will be siting wind power in areas capable of sustaining wind farms.

Wind power development offers a clean, renewable source of electricity that could help to replace fossil fuels, which contribute air pollution and exacerbate the problem of global climate change. As interest in constructing utility-scale wind power facilities increases, siting decisions that allow wind power development in such a way that protects special landscapes and sensitive wildlife is to the mutual benefit of wind power companies, government entities, local communities, and the larger public.

This report maps the location of sensitive wildlife habitats and landscapes sensitive to wind developments. Some of these categories of land are sufficiently sensitive to merit the exclusion of wind energy development, while other categories would permit wind energy development if certain best practices are implemented. By overlaying the various sensitive land types, a picture emerges showing where wind power development should be avoided (marked in red on the maps), where it could proceed with caution (mapped in yellow), and the areas lacking land use conflicts where it should be encouraged (marked in green).



Reintroduced black-footed ferret near the Foote Creek Rim wind power facility. BCA photo.

Considerations for Wildlife

Many types of wildlife are expected to be sensitive to wind power development. The propensity for wind turbines to kill birds (particularly raptors) and bats through collisions with spinning blades is well known, and thus turbines sited in areas where bird and bat activity is not concentrated are preferable. Turbine arrays can also lead to habitat fragmentation and displacement of wildlife from preferred habitats, especially for sage grouse and mountain plover. Potential impacts on big game in their crucial seasonal ranges and on burrowing small mammals remain poorly understood and more study is needed to reach definitive conclusions, but wind power facilities may be compatible with the habitat needs of these species if development is done carefully. Birds and small mammals will be sensitive to the placement of overhead power lines, and burying transmission lines through sensitive habitats could avoid significant impacts.

Sensitive Landscapes

Wyoming is known throughout the world for its iconic western landscapes. Many of these, like national parks, wilderness areas, and wilderness study areas, have been placed off-limits to industrial activities by federal law or regulation. Others, such as roadless areas and BLM Areas of Critical Environmental Concern, have limited protective designations which would tend to frustrate the timely development of wind projects and might preclude them in some cases. There is a third category of lands which may be unprotected at present but have a high public profile and strong scenic values, and wind power generation would face stiff opposition in these areas. Historical and cultural sites and historic trails are typically protected by federal law which requires that the sites as well as their historic settings be protected. Wind power developments near towns would profit from masking wind turbines for view or, if this is impossible, in gaining public buy-in to wind projects. Overall, open spaces in Wyoming are highly valued, which means that projects that do not impair prominent viewsheds are less likely to face opposition. By steering wind projects away from lands where industrial development would be prohibited or controversial, wind power generators can reap the benefits of speedier approval processes and strong public support.

Prioritizing Wind Power Development in Wyoming

When sensitive resources are overlaid with wind power potential on a map of Wyoming, it becomes apparent that some areas are unlikely prospects for wind energy (either due to a lack of wind power or multiple environmental sensitivities), while other areas have strong wind resources and few, if any, resource conflicts. These latter areas are the places where large-scale wind power generation should start, and in cases where transmission lines are limiting, these are the areas where transmission capacity should be built first. There are about 5 million acres of these "green" areas, more than 4 million acres of which have commercial wind power potential — more than enough space for commercial wind power development in the near future. Wind power development should start by developing in these "green zones" to the greatest extent possible, and transmission projects to support wind development should focus on providing service to these areas. Much of the area most favorable for wind energy development is private land, and the property rights of landowners will have to to be respected because unlike oil and gas development, wind power development always requires the consent of the landowner. By presenting areas of environmental sensitivity as well as the location of promising wind resource areas with few environmental conflicts, we foresee an ability for the wind industry, private landowners, and government officials to use incentives to steer wind development in Wyoming into areas that are noncontroversial and where impacts on lands and wildlife are minimal. Thus, the environmental benefits of switching away from fossil fuels can be maximized while Wyoming's outstanding landscapes and fully functioning ecosystems are protected.

Wind turbines near Medicine Bow
BCA photo

Summary of Key Siting Recommendations

Conduct demonstration studies to show no impacts before proceeding further	Big game crucial winter and parturition ranges, big game migration corridors.
Get local buy-in, site turbines out of sight when possible	Within 5 miles of municipalities.
Small wind facilities in low-value habitats	Ecoregional core areas, linkages, and portfolio sites; Bird Habitat Conservation Areas
Exclude from wind power siting consideration	National Parks, Monuments, and Wildlife Refuges; USFS Roadless Areas; citizens'proposed wilderness; BLM ACECs; raptor nesting concentration areas; nesting and wintering habitats of sage grouse, Columbian sharp-tailed grouse, and mountain plover.
Site wind power in areas hidden from view by topography	Within 5 miles of historic trails and sites, Continental Divide Trail, municipalities, and key overlooks in national parks, wilderness, and other high-value recreation areas.
Monitor bats/birds and avoid high-use areas; avoid forest fragmentation	Woodland and forest habitats.
Bury powerlines	Within half mile of prairie dog towns, grouse habitats, and black-footed ferret recovery areas.

Introduction

Across Wyoming, there is an unprecedented surge in wind energy development proposals. County, state, and federal agencies are inundated with proposals. The U.S. Department of Agriculture (n.d.) listed the Medicine Bow and Shoshone National Forests and Thunder Basin National Grassland among the National Forest system lands with the highest wind energy potential in the nation. Wind potential is even greater on private lands as well as public lands managed by the Bureau of Land Management in Wyoming's desert and grassland basins. While several wind power projects have been constructed during the past decade, there is currently a major "wind rush" in applications for rights of way and permits to set up utility-scale wind energy facilities in many parts of Wyoming.

The recent boom in oil and gas development was a painful experience in which Wyoming suffered the degradation of special landscapes, reduction or losses of wildlife populations, pollution problems, and disruption of community function. With the onset of large-scale wind energy development, Wyoming should develop wind energy in a way that protects open spaces and native ecosystems and is an asset to local communities rather than a disruption. Thoughtful siting of wind energy facilities and the adoption of Best Practices can ensure that wind energy is a net asset to the state and help the wind industry prevent unwanted conflicts with land and wildlife advocates or local communities. It is important for the wind industry to learn from the mistakes of the oil and gas industry, and not repeat them.

Pronghorn Photo courtesy BLM

This report provides a blueprint for doing wind smart from the start, by identifying areas where wind should be developed, where its shouldn't be attempted, and areas where wind development could be developed carefully with concessions to sensitive resources that allow wind power to be compatible with maintaining other values.

Smart from the Start is designed to be used by multiple audiences. The wind power industry can use this report to identify areas where wind power potential is greatest and the wildlife and social conflicts are smallest and earmark these areas to be developed first, while avoiding areas of high resource conflict. State, federal, and local regulators can use this report to guide how and where wind power facilities are permitted. And conservation groups and local citizens can use this report to prioritize the areas most important for protection while also recognizing areas where environmental conflicts are least significant.

It is our intent that this report will guide wind power planning on a statewide scale so that wind power generation can be expedited and fostered in areas of least conflict, while ill-advised forays into the state's most sensitive landscapes will be avoided. If wind power development is pursued in this manner, controversy and protracted conflicts can be avoided to the mutual benefit of the industry, our lands and wildlife, and the people of Wyoming.

Wind Power and the Solution to Global Climate Change

Wind power generation is seen as part of a solution to the problem of global climate change. Global climate change is driven by the production of carbon dioxide (CO_2) and other "greenhouse gases" according to the Intergovernmental Panel on Climate Change (IPCC 2007), and coal-fired electricity generation is a major part of the problem. Global climate change is a serious environmental crisis in its own right, causing rising sea levels, disappearance of certain habitats and displacement of others, changes in patterns of droughts and floods, and serious losses in biodiversity worldwide. To the extent that wind power displaces forms of electrical generation that emit greenhouse gases, it can be part of the solution to global climate change.

While the coal industry touts the potential of "clean coal," all coal-fired electrical generation in the U.S. at the present time is "dirty" from the perspective of carbon dioxide emissions, because there is presently no commercial coal-fired power plant in the United States that is sequestering its carbon dioxide to prevent emissions of CO_2 that trap heat in the atmosphere causing the "greenhouse effect." In 2005, electrical power generation produced 39% of all CO_2 emissions in the United States (National Research Council 2007). Demand for electricity continues to escalate in the United States, and the increase in wind power development may not keep pace with the overall increase in demand. As a result, the increase in wind energy may not result in an overall decrease in carbon dioxide and other pollutants due to a projected escalation demand for energy (National Research Council 2007).

Wind energy holds the promise to become a significant part of a clean energy portfolio in the United States. As a society, we have the choice of developing clean energy sources today and replacing dirty fossil fuel sources to reap the benefits of reduced greenhouse gas production, or we can put off developing clean energy solutions until we run out of fossil fuels and face the double crisis of accelerated climate change and ultimately an interruption in the energy supply that fuels our society. It is clear that it is in the best interests of Americans to replace fossil fuels with clean, sustainable energy sources; it is equally clear that Wyoming residents have a strong interest in ensuring that a major increase in industrial wind energy is done smart from the start, siting wind farms in areas that can sustain the presence of wind turbines.

The American Wind Energy Association (2000) projected that if all economically feasible land sites for wind energy development were installed with wind turbines, the resulting generation would supply approximately 20% of the nation's electricity needs. This new source could potentially displace a corresponding quantity of electricity from fossil fuels. Certainly, not all sites that are economically feasible are suitable for wind power development from an environmental or social perspective, so it is likely that wind energy will ultimately become a somewhat smaller percentage of overall electricity production in the United States. But wind energy does represent a potentially important part of a clean energy future in which it is complemented by a number of other renewable energy sources.

In the United States, coal-fired power plants currently supply the vast majority of "baseload power," or the electricity that is being generated constantly regardless of consumption to meet basic power demands. Most of the "peak load" electricity generated to supply spikes in demand (such as heat waves that increase air conditioner use) is generated "on the margin" by natural gas-fired power plants that can easily be turned on and off in response to fluctuating demand. Both of these types of power generation are major emitters of greenhouse gases. Even though the wind in Wyoming is fairly consistent, the wind does not blow all the time, and skeptics have argued that the inconsistent nature of wind power generation precludes its use to replace coal as baseload power. Others (e.g., Deisendorf 2007), argue that conventional coal-fired baseload power stations are not completely reliable either, and when they experience a failure, they can be down for months. Archer and Jacobson (2007) found that by interconnecting a number of wind farms in different areas, differences in wind power output can be dampened and up to 47 percent of yearly averaged wind power could be relied upon to supply baseload electricity demand.

When considering the benefits of placing fossil fuels with wind energy in the context of global climate change, it is also instructive to consider the collateral effects of wind farm construction on natural carbon sinks. Hall (2006) found that the "carbon payback" period was longer for wind farms built in areas that function as carbon sinks such as forests and peat bogs because the wind facilities displaced carbon-sequestering natural systems. Thus, in Wyoming wind turbine arrays sited in grassland and desert areas would have a greater net carbon benefit, while those constructed in forests would have a somewhat reduced benefit in dampening the effects of global climate change.

Overall, it is apparent that the development of wind energy nationwide can be a part of the solution to the global climate change problem. But it is apparent that wind power will need to be supplemented with other types of clean, renewable energy in order to completely satisfy our nation's energy appetite.

The Economic Advantages of Wind Power

Wyoming has been wracked by a series of energy booms and busts. These have stretched local communities and infrastructure to the breaking point during boom years while leaving economies on the rocks during the bust periods. Wind power generation, by contrast, creates steady income streams and highly skilled jobs that make it a sustainable asset to local communities in contrast to the massive influx of temporary workers and boom-and-bust income pattern of the oil and gas industry. For local economies, wind power creates more economic input per kilowatt than either coal- or gas-fired electricity generation (Tegen 2006). Wind power is a different type of energy industry that promises to employ well-paid professionals who will become long-term members of local communities and yield long-lasting and steady streams of income to local economies. Thus, wind power development is much more economically sustainable than oil and gas development.

A Blueprint for Doing Wind Smart from the Start

The key to doing wind smart from the start is pairing intelligent siting choices with sensible methods of development that minimize conflicts between utility-scale wind power projects and sensitive wildlife and landscapes. The potential for wind turbines to kill birds and bats is well-known, and this potential can be minimized by siting turbine facilities away from areas where birds and bats concentrate their flying activities, such as nesting sites, roosting areas, and migration flyways. Because wind power facilities are industrial developments, they have the potential to fragment habitats and displace sensitive wildlife to other areas. The wind industry and land and wildlife managers will need to develop an understanding of which species are most affected by wind projects and avoid the most sensitive areas. Finally, there is a social element to where, how fast, and how much wind energy development is appropriate. Wind energy development should avoid the most treasured landscapes and areas, get buy-in from local communities before constructing facilities next door, and modulate the pace and scale of wind development so that the open spaces and untamed character of the Wyoming landscape are not threatened and local residents are satisfied with the outcomes of development.

This report is based on Global Information System (GIS) mapping to show where sensitive resources and the best wind power potential are located. Each sensitive resource is mapped, and accompanying text outlines the nature of potential conflicts with wind energy development as well as Best Practices to minimize these efforts. Lands that should be avoided entirely are marked as red zones on the maps, while areas where wind energy could be developed if certain measures are taken to reduce impacts are marked in yellow. For these yellow zones, the requisite mitigation measures vary according to the nature of the conflict they are designed to resolve – in some cases, the "fix" will be relatively simple and easy to implement, while in other areas siting wind turbine facilities may be complex or difficult. At the end of the report, the red and yellow zones are overlaid against wind power potential, and "green zones" are identified where conflicts are minimal and wind energy development is encouraged.

This report is also designed to be a review of the scientific literature on wind power and its impacts, as a resource for industry, planners, and the public. We lean heavily in this report on studies that have been conducted across the nation on impacts of wind energy and the properties of sensitive wildlife in formulating our recommendations. Large-scale wind energy development is a relatively new phenomenon, and we rely on peer-reviewed science whenever it is available and supplemented it with unpublished studies and monitoring reports that are more widely available. Tested scientific hypotheses are used preferentially to the opinions and recommendations of experts in all cases.

Special Landscapes

There are certain special landscapes which, due to their iconic qualities, pristine nature, or recreational values are not compatible with industrial use. Many of these lands have received official designations of one sort or another, while others have not yet been recognized by agencies as special places. Historic and cultural areas are covered in a later section, but this section will address landscapes that enjoy special designations that preclude wind energy development by law or regulation, or where wind energy development is likely to be frustrated because these areas have been designated for other land use priorities.

National Parks and Monuments

Units of the National Park system (including National Parks and National Monuments) are managed under a strong legal mandate which directs the federal government to "protect and preserve" these lands and their natural resources "for the use and enjoyment of the public." National Park units are precluded from industrial development (although commercial development for tourism is permitted. Wind energy development would not be allowed by law in these units regardless of their wind energy potential, and key viewsheds visible from park overlooks should be protected from visible wind energy development as well.

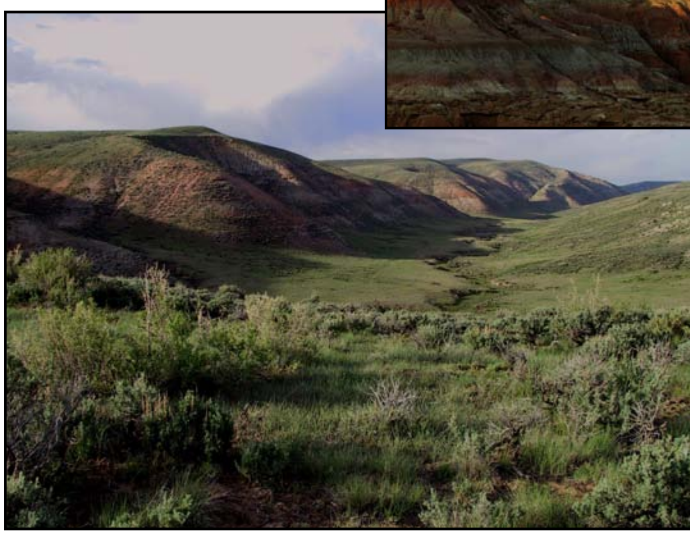
Designated Wilderness

Certain lands in Wyoming have been designated by Congress as Wilderness under the Wilderness Act. Although lands managed by all federal agencies are eligible for wilderness designation, in Wyoming only National Forest lands have been granted wilderness designation so far. By law, wilderness areas are a place "where the Earth and its community of life are untrammeled by man;" which generally appears to be affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable; and "where man himself is a visitor who does not remain." In addition to the backcountry recreation values present in wilderness, these areas can also possess superior habitat features in the absence of significant human disturbance. For example, Kershner et al. (1997) found that adult density, size, and habitat quality were greater for Colorado River cutthroat trout in wilderness areas compared to adjacent roaded forest lands.

Developments such as roads and wind turbines are not permitted by law in wilderness areas, and thus these areas are not worth considering for wind power development regardless of their potential. Viewsheds visible from key overlooks within wilderness areas also should be kept free of wind turbines by hiding turbine arrays behind intervening topography.

Wilderness Study Areas and Citizens' Proposed Wilderness

In 1976, the Bureau of Land Management was directed by Congress to inventory its lands for wilderness qualities and establish Wilderness Study Areas ("WSAs") for congressional consideration under the Federal Land Policy and Management Act. Some 63 of these units have been established in Wyoming, managed under the BLM's Interim Management Policy. For all proposed projects and activities in Wilderness Study Areas, BLM has the responsibility to "Review the proposal to determine whether, in a specific case, the activities will be nonimpairing and to ensure that the approval of such activities will not create a situation in which the cumulative effect of existing activities and the new proposed activities would impair wilderness suitability." BLM Handbook H-8550-1, p. 13. All Wilderness Study Areas in Wyoming are also classified as Visual Resource Management Class I, in which the goal is "to preserve the existing character of the land-

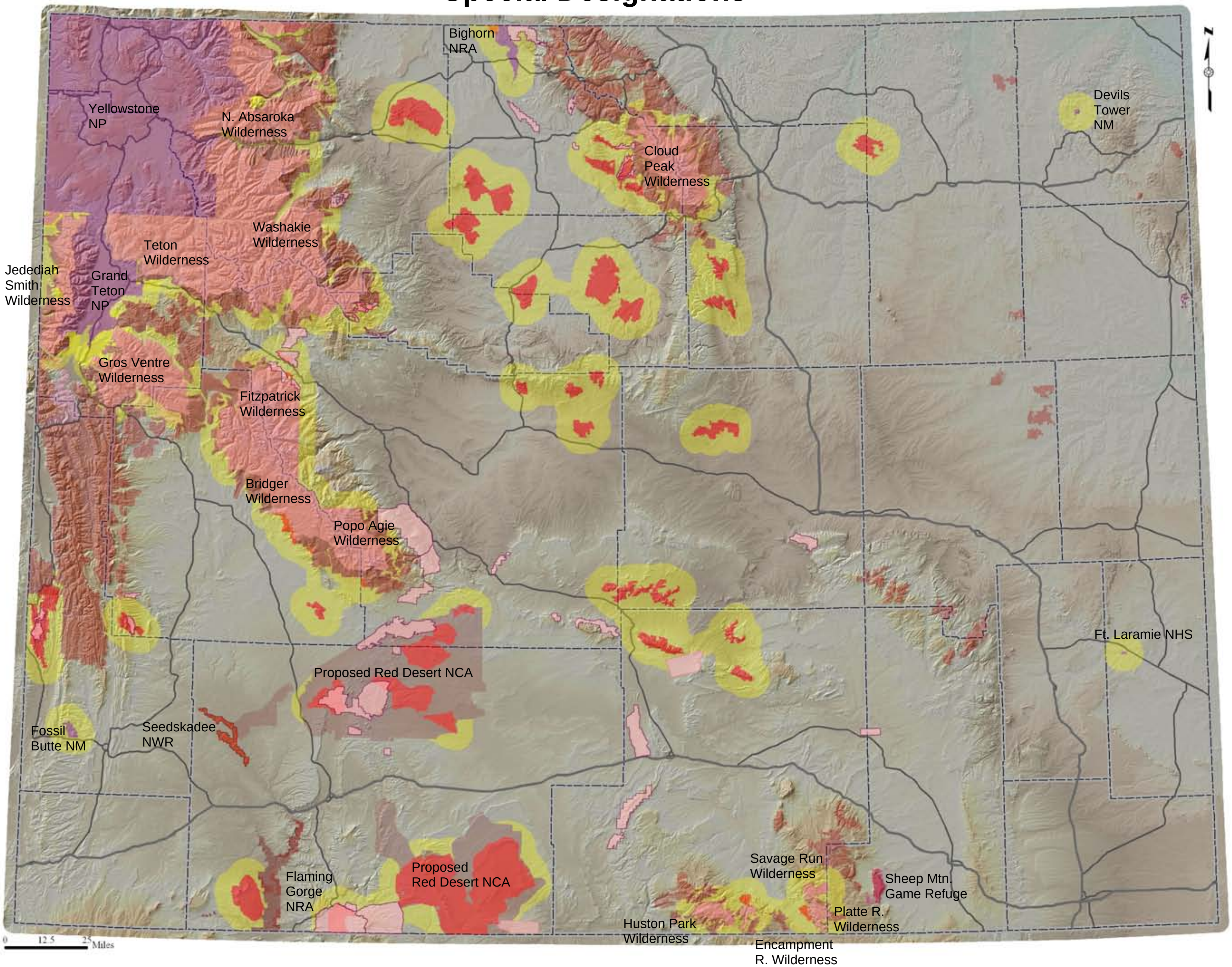


***Above:** Honeycomb Buttes WSA , Ken Driese photo*
***Left:** Wild Cow Creek citizens' proposed wilderness, BCA photo*

Map Legend

- Nat'l Paks and Monuments
- Nat'l Recreation Area
- BLM ACECs
- Nat'l Wildlife Refuge
- Nat'l Game Refuge
- Designated Wilderness
- Proposed ACECs
- USFS Roadless Areas
- Citizens' Proposed Wilderness
- Proposed National Conservation Area

Special Designations



scape." BLM Handbook H-8410-1. These lands are therefore unavailable for wind energy development under BLM regulations.

Citizens' proposed wilderness areas in Wyoming have been field inventoried and found to possess wilderness characteristics that would make them suitable for formal designation under the Wilderness Act. These areas, typically on Bureau of Land Management Lands, may have been excluded from the initial round of Wilderness Study Area designations in the late 1970s due to faulty initial inventories, failures by BLM to examine the areas in question as potential wilderness, or changes in conditions on the ground in which human intrusions which formerly would have excluded an area from wilderness consideration have disappeared. Citizens' proposed wilderness areas represent Wyoming's most pristine and outstanding examples of unprotected public lands, and as such are treated as exclusion areas for wind power development for the purposes of this report.

Forest Service Roadless Areas

The Forest Service has undertaken three rounds of intensive national inventories to determine which of its lands remain roadless and wild. These culminated in the Roadless Area Conservation Rule, established in 2000, which set these areas aside and prevented road-building, oil and gas leasing, and most other industrial uses.

The Roadless Rule has been embroiled in litigation since its inception. The Bush administration canceled the protections of the Roadless Rule in 2003, but litigation followed and the courts reinstated it in 2006. In 2008, a different court blocked the protections of the Roadless Rule, and this ruling is currently being challenged in a higher appeals court. Throughout the legal wrangling surrounding the Roadless Rule, the Forest Service has been very cautious and has proposed very few projects that do not comply, even during periods where it has been blocked from taking effect.

A number of species require large expanses of habitat free from the intrusions of resource extraction and high-intensity recreation, and these species have benefited from Roadless Area protection. This is particularly true for top carnivores. Many top predators, such as the wolf, grizzly bear, lynx, and wolverine, already have been driven extinct by past human incursions. Van Dyke et al. (1986) stated that "areas where there is continuing, concentrated human presence or residence are essentially lost to the [mountain] lion population, even if there is little impact on the habitat itself."

Above: *Southern Wyoming Range Roadless Area. Erik Molvar photo.*

At Right: *Duck Creek Roadless Area, Thunder Basin National Grassland.*

Other large predators as well as game animals such as elk are threatened by the disappearance of large, roadless tracts of habitat that serve as security areas. Edge and Marcum (1991) found that elk use was reduced within 1.5 km of roads, except where there was topographic cover. Gratson and Whitman (2000) found that hunter success was higher in roadless areas than in heavily roaded areas, and that closing roads increased hunter success rates. Cole et al. (1997) found that reducing open road densities led to smaller elk home ranges, fewer movements, and higher survival rates. Thus, roadless areas have come to provide important security habitat for elk.

In addition, many wildlife species are interior forest obligates that require large tracts of mature forest typically found only in roadless areas as a result of forest fragmentation due to half a century of clearcutting in other parts of our national forests. Examples include the northern goshawk (Reynolds et al. 1982, Squires and Ruggiero 1996, Graham et al. 1999), red-breasted nuthatch (Keller and Anderson 1992, Carter and Gillihan 2000, Ruefenacht and Knight 2000, Hansen and Rotella 2000), brown creeper (Keller and Anderson 1992, Crompton 1994, Hansen and Rotella 2000, Carter and Gillihan 2000), yellow-rumped warbler (Keller and Anderson 1992, Crompton 1994, Carter and Gillihan 2000), mountain chickadee (Keller and Anderson 1992, Carter and Gillihan 2000), hermit thrush (Keller and Anderson 1992, Evans and Finch 1993, Carter and Gillihan 2000), ruby-crowned kinglet (Carter and Gillihan 2000, Ruefenacht and Knight 2000), American marten (Buskirk 1992, Romme et al. 1992), red-backed vole (Romme et al. 1992), red squirrel (Romme et al 1992), and wood frog (deMaynardier and Hunter 1998). These species are vulnerable to forest fragmentation, and roadless forests are the core habitat that maintains reservoirs of these declining species.

Roadless areas contain some of the most outstanding trout habitat that remains (USFS et al. 1993, Henjum et al. 1994, Wissmar et al. 1994, Rhodes et al. 1994, Huntington 1998, Rhodes and Huntington 2000). Plans for the protection and restoration of declining salmonids have repeatedly called for the complete protection of all roadless areas larger than 1,000 acres (Henjum et al. 1994, Rhodes et al. 1994, Espinosa et al. 1997). Huntington (1998) noted that native cutthroat trout were larger and more numerous in the unroaded areas.

As a result of the elevated habitat values found in roadless areas and their importance to backcountry recreation, roadless areas have consistently been among the most contentious areas to site an industrial development project. Wyoming conservation groups have fought harder to protect roadless lands from intrusion than for any other land category that is managed by the Forest Service, and these groups have succeeded in blocking a number of projects, from timber sales to oil and gas seismic projects and drilling, proposed for roadless lands. It is likely that these lands will ultimately receive regulatory protection that would preclude wind area development. But even if this turns out not to be the case, wind energy developers would be wise to treat roadless areas as “no go” zones to avoid conflicts easily resolved by siting projects elsewhere.

Areas of Critical Environmental Concern

Federal law directs the Bureau of Land Management to establish Areas of Critical Environmental Concern (“ACECs”) and to protect the sensitive resources for which these lands were designated. Over the years, a number of ACECs have been established under the land use planning process, and still others have been proposed for plans currently being revised. The designation of ACECs does not confer a uniform set of protection measures; instead each ACEC has its own mandatory set of rules and regulations. While most ACECs do not address wind energy development directly (indeed, most were designated before wind power was recognized as a possibility in Wyoming), wind energy development in these areas is likely to pose difficult challenges and require longer and more expensive permitting processes. In addition, two key proposed ACECs, covering the Ferris Dunes and Powder Rim, have also been included due to their environmental sensitivity. Because it will be difficult to show that utility-scale wind power development will be consistent with the protection of resources for which the ACECs were designated, we recommend that ACECs be viewed as avoidance areas by the wind industry. The single exception is an ACEC designated in the Salt Creek oilfield which was established to recognize the toxic waste dumps in this heavily impacted area.

Proposed National Conservation Area and Other Congressional Designations

Wyoming has three crown jewel landscapes of national importance which currently do not receive sufficiently strong protection but which are top priorities for conservation: Adobe Town and the Jack Morrow Hills area in the Red Desert, and the Wyoming Range. These areas have been proposed for conservation action by Act of Congress.

Conservation groups have proposed a Red Desert National Conservation Area that would encompass some of the area’s most spectacular landscapes and most important wildlife habitats. It has two separate units, a northern unit encompassing the Jack Morrow Hills planning area and a southern unit encompassing Adobe Town and the Kinney Rim. Pristine wilderness and prime hunting and recreation areas are among the key features of these units. During planning processes, the prospect of industrial development in these special places raised a wave of public furor and controversy throughout the state: Over 64,000 people demanded that oil and gas drilling be excluded from the Jack Morrow Hills, and over 88,000 people commented in favor of protecting Adobe Town during the Great Divide plan revision. Both totals set new records for public participation in any federal plan or project. Due to the highly controversial nature of industrial use in these areas, they should be treated as avoidance areas for the purposes of wind energy development.

The Wyoming Range has also been a flashpoint for controversy over oil and gas drilling, and a bill is currently under consideration that would withdraw 1.2 million acres of the Bridger-Teton National Forest from consideration for future leasing (although oil and gas development may occur on existing leases, and perhaps a limited area for future leasing). Wind projects in this area could face stiff opposition depending on which part of the area is under consideration; we recommend avoiding wind development in the Wyoming Range proper and proceeding only with great caution with strong public support in the rest of this area.

Best Practices for Special Landscapes

Special landscapes in these categories should be exempted from consideration for wind power development in order to preserve the attributes for which these lands have received special designations. For national parks, wilderness areas, and BLM citizen’s proposed wilderness, we also recommend a 5-mile viewshed buffer within which wind power projects could proceed if they are not visible from prominent overlooks.

Above: *Oregon Buttes in the Northern Unit, Proposed Red Desert NCA. Pat Sullivan photo.*
Below: *Adobe Town in the Southern Unit, Proposed Red Desert NCA. BCA photo.*

Ecoregional Conservation Plans

Most conservation plans focus on a single species or a small subset of species, typically those which are unusually charismatic or a species that is the subject of hunting or fishing. The designation of lands in protected areas such as national parks and wilderness also contains biases, over-representing certain habitat types (such as alpine meadows) while other habitat types (like playas and sand dunes) tend to be underrepresented (Merrill et al. 1996). When considering the conservation of entire ecosystems and the wide array of plants and wildlife they support, however, it is preferable to take an ecoregional approach, because the distribution of plants and wildlife rarely respects arbitrary political designations like state lines and field office boundaries. In Wyoming, several ecoregional plans provide a framework for conservation of ecosystems on a large scale, and core habitats and connecting corridors identified in these plans warrant extra caution when planning and siting wind power facilities.

The Heart of the West Conservation Plan

The Heart of the West Conservation Plan was developed for the Wyoming Basins Ecoregion, which covers the western two-thirds of Wyoming as well as parts of Colorado, Montana, Idaho, and Utah (Jones et al. 2004). This plan is based on the identification of core areas and connecting corridors; cores were identified using SITES modeling and focusing on the habitat needs of 20 focal species as well as maximizing representation of a broad diversity of habitat types and capturing rare species occurrences. The result is an interconnected network of core areas and linkages prioritized for conservation protection and/or restoration, in a matrix of Sustainable Use Areas where industrial use is appropriate where pursued on a scale and in a fashion that is not destructive to other values.

An irreplaceability and vulnerability analysis was then performed on these core areas to determine which core areas should be of greatest conservation concern (Jones et al. 2006). Five of the eight core areas that scored highest in these two categories are located in Wyoming: the Upper Red Desert, Medicine Bow, Upper Green River, Absaroka Front, and Adobe/Vermillion core areas. These core areas merit the highest degree of conservation attention and protection.

The Northern Plains Conservation Network

In contrast to the Heart of the West Conservation Plan, the Northern Plains Conservation Network (NPCN) was formed as a coalition of conservation groups that formed to conduct a scientific inventory of this region's wildlife and habitats with the goal of identifying areas with excellent opportunities for large-scale wildlife restoration. This conservation inventory focused on portfolio sites rather than a core-and-linkage approach that conserves habitat and connectivity on a regional scale (Forrest et al. 2004). While conservation across the entire region is important, NPCN found that these sites offer the greatest promise for the re-creation of a fully functioning grassland ecosystem.

Two of the portfolio sites identified by NPCN cover significant extents of land in Wyoming, while a small portion of the Slim Buttes area overlaps the northeast part of the state (*see* Forrest et al. 2004). The Hole in the Wall unit was selected due to significant mountain plover habitat, significant acreage of prairie dog colonies, relatively intact grasslands, and large contiguous land area under BLM management. The Thunder Basin – Oglala Grasslands area was selected for its abundance of pronghorn and prairie dog colonies and high potential for the reintroduction of the Endangered black-footed ferret. To date, black-footted ferrets have been reintroduced to the Conata Basin in the Oglala National Grassland and to Badlands National Park, both in South Dakota, and a reintroduction effort is planned for the Thunder Basin National Grassland in Wyoming.

Best Practices for Identified Core and Linkage Areas

We recommend that great caution be exercised when siting wind projects in core areas and linkages and should be limited to small-scale projects in low-habitat-value areas. In the Wyoming Basins ecoregion, utility scale wind projects would be better suited to Sustainable Use Areas identified in the Heart of the West plan.

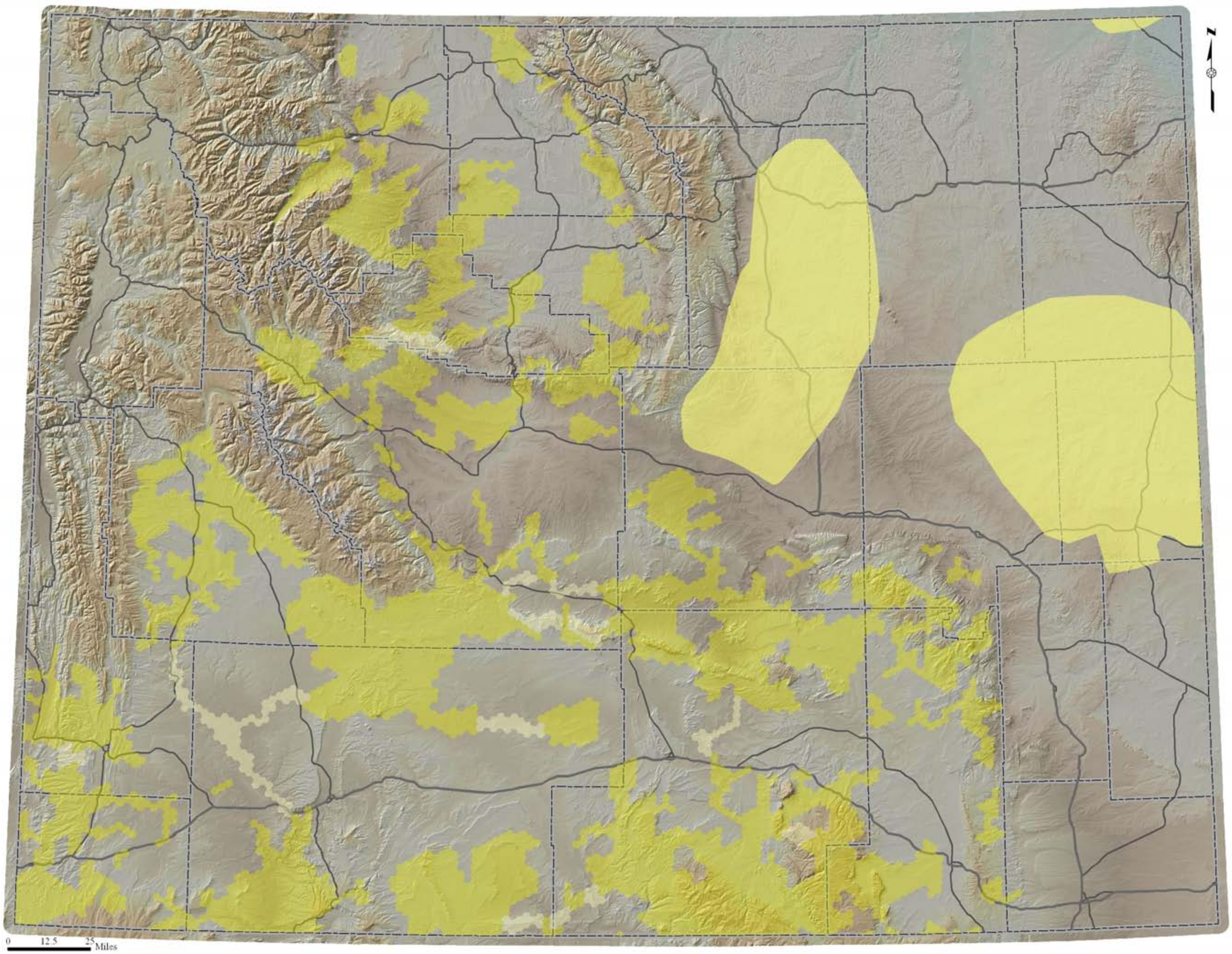
Map Legend

Heart of the West Core Areas

Northern Plains Conservation Network Core Areas

Heart of the West Linkages

Ecoregional Conservation Plans



Protecting Birds of Prey

One of the first large-scale wind energy facilities was sited at Altamont Pass in the foothills east of San Francisco Bay. Altamont Pass is a raptor nesting concentration area that also served as a flyway for winter migrations (Thelander and Rugge 2000). As a result of the high concentration of birds in this area, the level of fatalities for golden eagles and other birds struck by turbine blades rose so high that the facility became famous as "the bird blender." Most of the wind power facilities that followed had much lower rates of bird fatalities, but the reputation of wind turbines as killers of birds has been a difficult one for the industry to escape from. The lesson to be learned is siting the facility in an area of high bird concentrations, particularly for golden eagles and other raptors, created a major ecological problem that has made it more difficult for other projects to get started nationwide. This report seeks to identify key raptor habitats so that this problematic chain of events can be avoided in Wyoming.


Ferruginous hawk, a BLM Sensitive Species. Mark Chappell photo.

Birds of prey are simultaneously among the most visible and charismatic birds (and thus are a public favorite), and are more vulnerable to wind turbine fatalities than other types of birds. At Tehachapi Pass in California, Anderson et al. (2004) found that red-tailed hawks, American kestrels, and great horned owls showed the greatest risk of collision of all bird species. At Altamont Pass, Thelander and Rugge (2000) reported that golden eagles, red-tailed hawks, and American kestrels were killed with greatest frequency. In Minnesota, Osborn et al (2008) reported that the American kestrel was at highest risk of wind turbine mortality, spending 31% of flying time at heights within the blade-swept area of wind turbines. Smallwood and Thelander (2005) found that burrowing owls were also highly susceptible to turbine-related mortality, and estimated 181 to 457 burrowing owls were killed per year at the Altamont Pass facility.

Smallwood and Thelander (2005) were able to determine that bird species that spent the most time flying through turbine-swept areas had the highest mortality rates. At the Foote Creek Rim facility, birds that spent the greatest proportion of time flying through rotor-swept heights included raptors and waterfowl (Johnson et al. 2000). These bird groups were found to have the highest risk of turbine collision in California (Osborn et al. 2008).

Wind turbine mortalities can potentially result in population declines in raptors most heavily impacted by turbine strikes. Hunt et al. (1998) found that the golden eagle population was declining, and wind turbine strikes accounted for 38% of mortalities. Even if projects kill primarily non-territorial "floater" birds rather that territorial breeders, population declines can result because stable populations of breeders rely on an abundant supply of floaters to replace birds lost to other sources of mortality (Hunt 1998).

It does not appear that raptors make behavioral adjustments to wind power facilities that reduce fatality rates over time. Indeed, Smallwood and Thelander (2005) found that per-capita risk of raptor fatalities for individual birds actually increased over the 15 years of study, even as raptor densities decreased.

The position of turbines within a tower array does not appear to have a consistent correlation with raptor mortality. For example, Anderson et al. (2004) reported that turbines at center of strings experienced higher raptor fatality rates. Meanwhile, the Predatory Bird Research Group (1995) found that end-row turbines produced greater fatality totals at Altamont Pass. Thelander and Rugge (2000) found no relationship between fatality rates and edge or center of array at the same Altamont Pass location.

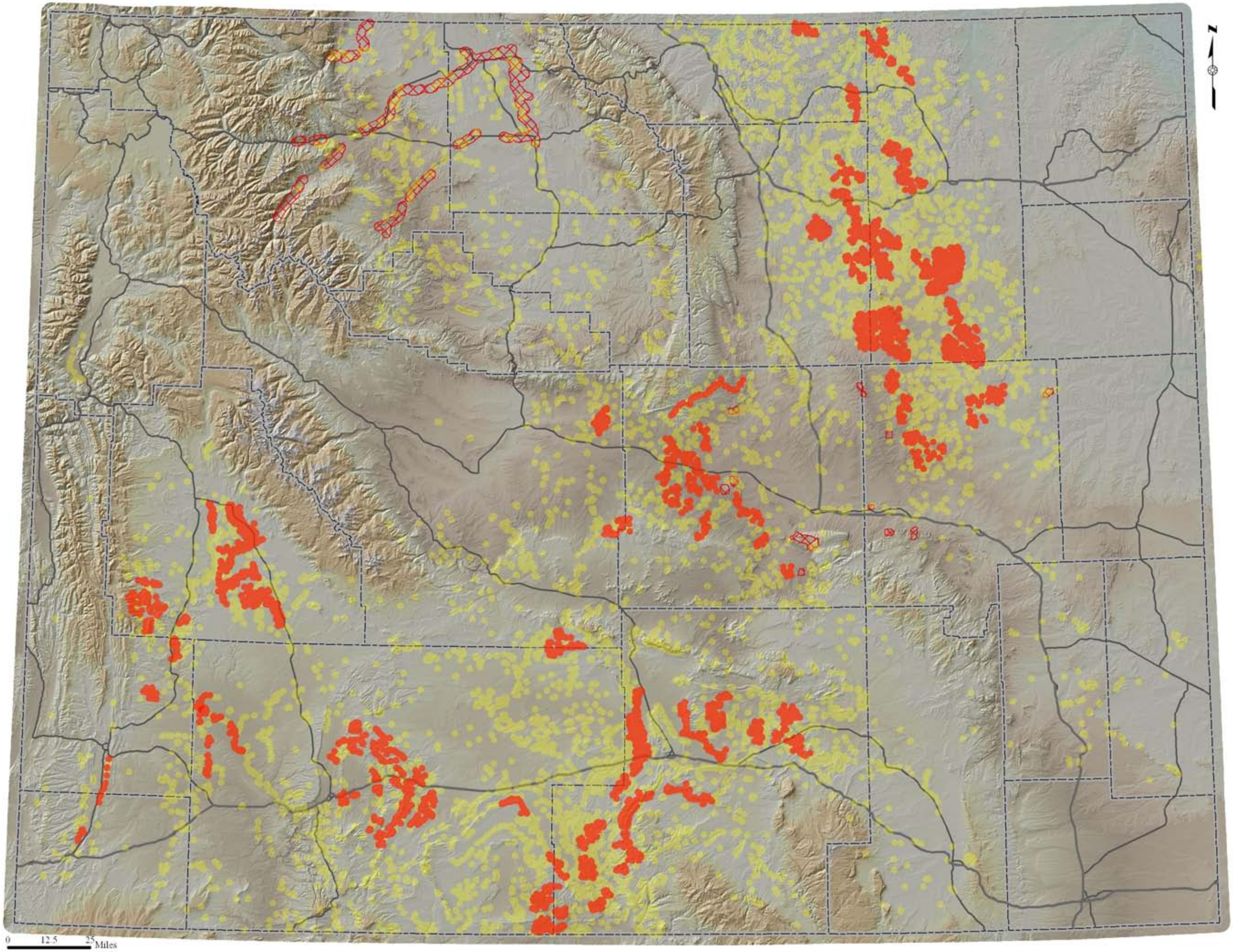
The type of wind turbine also does not have a clear relationship to rates of raptor mortality. According to the Predatory Bird Research Group (1995), both red-tailed hawks and golden eagles were recorded perching on lattice-type wind generation towers at Altamont Pass. Both species avoided perching on tubular towers but red-tailed hawks were occasionally recorded perching on the catwalks and ladders of such towers in this study. Thelander and Rugge (2000) later found no difference between raptor fatality rates at lattice towers versus tubular towers at Altamont Pass, and Smallwood and Thelander (2005) even found that raptor fatalities at Altamont Pass were greater for tubular towers and larger-rotor turbines. Anderson et al. (2004) found that vertical axis turbines of the FloWind type used at Tehachapi Pass had similar bird fatality rates to horizontal-axis (propeller-style) turbines. Thus, it appears that more modern wind turbines offer no particular advantage in reducing raptor mortality.

It is unclear whether a high density of wind turbines increases or decreases raptor mortalities. Dense clusters of turbines and "wind wall" configurations (parallel rows of wind turbines closely aligned to each other but with alternating tower heights) killed fewer raptors than scattered turbines (Smallwood and The-

Map Legend

- Raptor Nesting Concentration Areas, one-mile nest buffer
- Identified bald eagle roost areas, one-mile buffer
- Other identified raptor nest sites, one-mile nest buffer

Birds of Prey



lander 2005). However, fatality results at Tehachapi Pass suggest that high density sites cause greater fatality rates than low density (1 turbine per 100 meters) density of turbines, but this difference was not statistically significant (Anderson et al. 2004). More study is needed to determine whether advantages can be gained by altering the density of turbine arrays.

The National Research Council (2007) reported that raptor mortality rates in California per megawatt of installed capacity have been much higher than at other wind facilities across the nation. But Smallwood and Thelander (2005) pointed out that rates of bird fatalities per unit bird/time at Altamont Pass were similar to other turbine facilities, but the much greater bird densities at Altamont Pass drives the high level of fatalities there. According to these researchers,

> "To assert that the APWRA [Altamont Pass Wind Resource Area] is anomalous in its bird mortality may be misleading when comparing it to other wind energy facilities. While a relatively large number of raptors are killed per annum in the APWRA, the ratio of the number killed to the number seen during behavior observations is similar among wind farms where both rates of observation have been reported. It appears, based on the research reports reviewed for this project, that when comparing wind energy facilities birds tend to be killed at rates that are proportional to their relative abundance among wind farms."

This points out the critical importance of avoiding raptor concentration areas when siting wind energy facilities. In areas where there are concentrated raptor nest sites, there will be elevated raptor activity as at Altamont Pass, with higher raptor mortality rates. This is of particular concern in cases where raptor nests may be upwind of nest sites, and strong prevailing wind would have the tendency to carry fledgling raptors with underdeveloped flight skills straight into turbine swept areas.

The Altamont Pass wind facility was built in a golden eagle nest concentration area, and became highliy controversial as a result of raptor fatalities. Dan Chusid photo.

Raptors can function as keystone species (National Research Council 2007), potentially controlling populations of prey species and inducing trophic cascades. Thus, impacts to these classes of species could result in collateral impacts at the ecosystem level. A certain level of avian mortality is virtually unavoidable with wind power projects, but intelligent siting of turbine arrays should minimize the level of mortality from the project. Such impacts should be minimized by taking the following steps in the siting and operation of wind power facilities.

For the purposes of this report, GIS data for known nest locations was used to develop raptor nest concentration areas, which should be avoided, to be distinguished from scattered raptor nest locations, which are marked in yellow for caution. It is important to note that some areas (like the Powder River Basin) have experienced heavy raptor nest monitoring activity, while other areas have had lighter search effort. Also notable is the fact that the Newcastle BLM Field Office was unable to provide GIS data of any kind for this report, which explains the absence of raptor nest locations in the far northeastern corner of Wyoming.

Best Practices for Birds of Prey

Avoid Siting Turbines Near Raptor Concentration Areas

The Buffalo Ridge wind project showed low bird mortality rates (0.33 to 0.66 fatalities per turbine per year), likely due to its siting in a lower bird density area (Osborn et al. 2000). These researchers admonished that even a well-sited facility will kill some birds, but siting considerations can be employed to minimize raptor mortalities. At Wyoming's Foote Creek Rim wind facility, only eight percent of bird mortalities between 1998 and 2002 were raptors (Young et al. 2003). This has been attributed to several factors, including low density of raptor nest sites. By avoiding raptor nest concentration areas and migration flyways, raptor fatalities can be minimized.

Avoid Siting Wind Farms in Canyons, Passes, and Other Migration Pathways

Siting turbines in canyons and passes increases the risk of fatalities for migrating birds. In Montana, Harmata et al. (2000) found that more migrating birds passed over valleys and swales than over high points; while migrating birds tended to avoid passing over high points during headwinds, low passes received greatest use by migrating birds overall. Smallwood and Thelander (2005) found that golden eagles at the Altamont Pass facility were killed disproportionately by turbines sited in canyons. Thayer (2007) recommended, "Don't site wind turbines in canyons" to prevent excessive golden eagle fatalities. We concur with this recommendation, and it should be implemented as a best management practice for wind projects.

Engage in Pre-siting Surveys and Monitoring

Pre-siting surveys of bird habitat use and migration pathways should be undertaken prior to the determination of tower locations and arrays. In addition, pre-siting surveys of raptor and mountain plover nesting areas should be undertaken and these areas should be avoided for wind turbine siting. According to Morrisson (2006), "Such pre-siting surveys are needed to appropriately locate wind farms and minimize the impacts to birds." According to Mabee and Cooper (2004:45), "Seasonal patterns of noc turnal migration are critical to identify when collisions with wind turbines may be most expected." Analysis of bird migration data allowed the company to position its turbines to minimize mortality in the Stateline project of southeastern Washington (id.). Migration patterns should be analyzed prior to the initiation of project construction, and turbines should be sited to avoid them.

Require Setbacks from Windward Rims

At Altamont Pass, Hoover and Morrisson (2005) reported that kiting behavior was most frequently observed on steep windward slopes, and selected for the tallest peaked slopes; slopes where this behavior occurred had a disproportionate amount of red-tailed hawk mortality. In the context of the Foote Creek Rim project, Johnson et al. (2000) also reported higher than expected raptor use of rim edge habitats, and for this project SeaWest implemented a setback of at least 50 meters from the rim for wind turbines to reduce raptor mortality; 100 m setbacks would be better.

Fledglings like these young ferruginous hawks may be particularly vulnerable to rotor collisions. Mike McClure photo.

Vertical-axis wind-turbines of the FloWind type have been found to have similar rates of raptor deaths as conventional propeller-style turbines (Anderson et al. 2004). Symscape photo.

Bald eagle in flight. USFWS photo.

Minimizing Impacts to Bats

Initially, bird mortality was perceived as the most important impact of wind energy projects, but more recently it has come to light that wind turbine facilities can be a major source of bat fatalities as well. Kunz et al. (2007b) reported that bat fatalities at wind power facilities ranged from 0.8 to 53.3 bats per megawatt per year, with the highest mortality rates in forested areas. Taller towers with greater rotor-swept area showed greater bat mortality rates than smaller wind turbines in the same region (Arnett et al. 2008). As the trend within the industry is toward taller wind turbines with larger propellers, it is expected that risk to bats will increase further over time.

Bats may be more vulnerable to mortality at wind power facilities than birds because bats seem to be attracted to operating turbines. Arnett (2005) hypothesized that hoary bats may confuse turbine movements for flying insects and be drawn toward operating turbine blades. Johnson et al. (2004) also hypothesized that turbines attracted foraging bats in the agricultural lands of southwestern Minnesota. The attraction of bats to wind turbines during feeding was validated experimentally by Horn et al. (2008), with foraging bats approaching and pursuing moving turbine blades and then being trapped by their vortices of air. Bats sustain potentially fatal injuries not only from turbine strikes but also from potentially deadly decompression associated with air pressure gradients cased by spinning turbines (Arnett et al. 2008).

Bats have long lifespans and low reproduction rates and thus are more susceptible to population declines (GAO 2005, National Research Council 2007). According to the North American Symposium in Bat Research (2008), “Because bats have exceptionally low reproductive rates, making them susceptible to population declines and local extinctions, bat fatalities at wind facilities could pose biologically significant cumulative impacts for some species of bats unless solutions are found.” In cases where bat populations are suffering from other population or habitat stressors, wind turbine siting in key bat habitats can have decisive impacts on the population. Bats can function as keystone species (National Research Council 2007), potentially controlling populations of insects and inducing trophic cascades. Thus, projects that cause major impacts to bat populations could also destabilize ecosystem function.

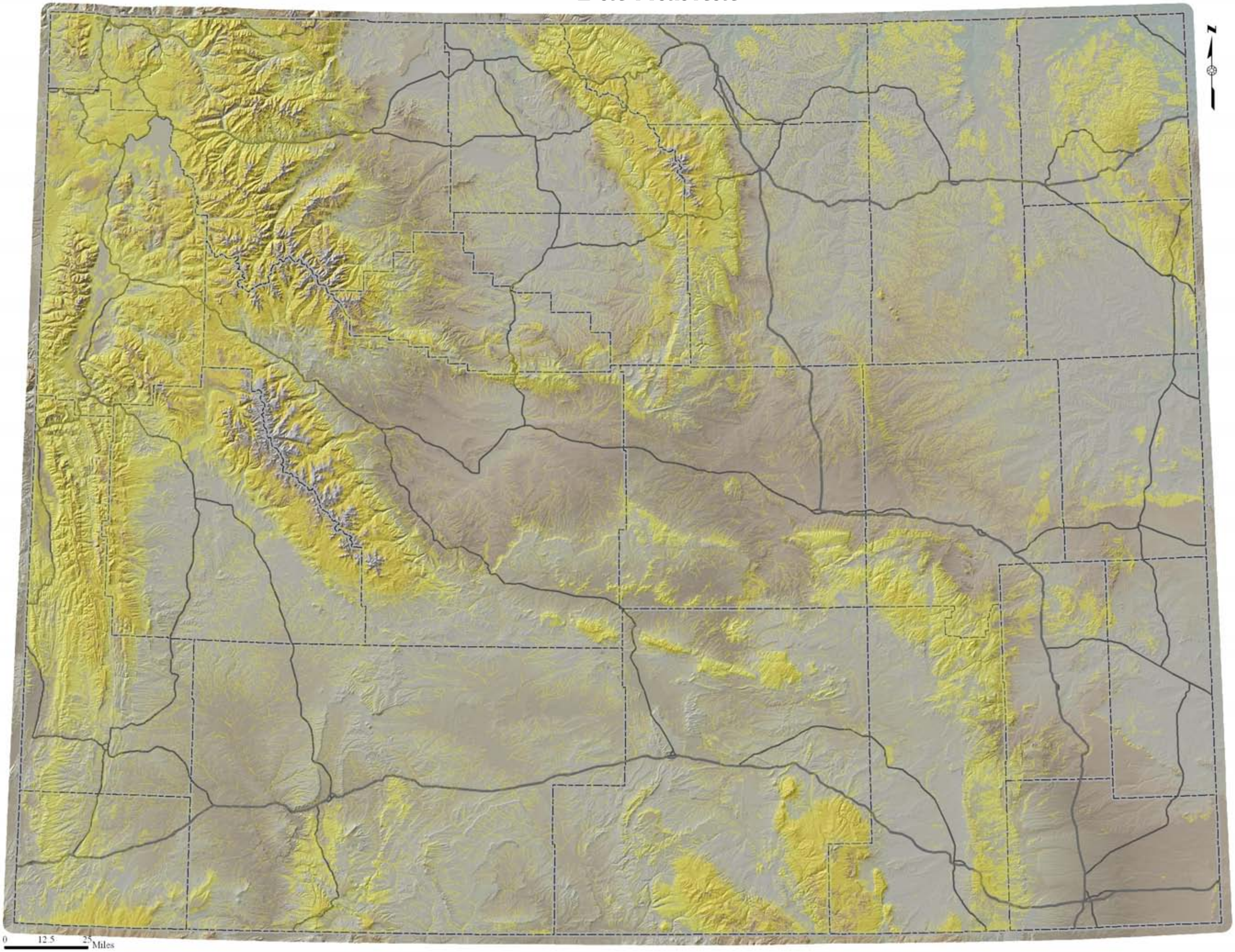
Hoary bats in Flight. Photo by J. Scott Altenbach

Almost 75% of all bats killed by wind turbines nationwide are made up of three species of tree-roosting, migratory Lasiurids: the foliage-roosting eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), and tree cavity-dwelling silver-haired bat (*Lasionycteris noctivagans*) (Kunz et al. 2007a, Arnett et al. 2008). Hoary and silver-haired bats dominated bat mortalities at wind facilities sited in open steppe habitats of the interior Columbia Basin (Johnson et al. 2003, Erickson et al. 2003). Johnson et al. (2004) found that hoary bats dominated wind turbine fatalities at the Buffalo Ridge wind facility in agricultural lands of southwest Minnesota, even though big brown bats were the most numerous resident population. In the Rocky Mountains, 89% of wind turbine bat mortalities are hoary bats (Kunz et al. 2007a). Of the tree-roosting bat species, the hoary bat and silver-haired bat are native to Wyoming and are found throughout the state.

Key habitats for tree-roosting bats and other bat species are poorly understood, and maps are not currently available designating critical habitats. According to the U.S. Forest Service (no date), “Hoary bats rely on deciduous woodlands (e.g., aspen stands and cottonwood stands) for roosting sites in the Rocky Mountains, and seem to rely somewhat on cottonwood riparian corridors in the non-forested and coniferous areas of their range.” According to the Wyoming Game and Fish Department, the hoary bat is associated not only with cottonwood gallery forests but also coniferous forests and juniper woodlands. Everette et al. (2001) documented hoary bat use of cottonwood groves for roosting on the Rocky Mountain Arsenal near Denver. According to the Wyoming Game and Fish Department’s Comprehensive Wildlife Conservation Strategy, the silver-haired bat is uncommon in Wyoming and prefers the following habitats:

> “The silver-haired bat inhabits coniferous and mixed deciduous-coniferous forests and woodlands, including juniper, subalpine fir, Engelmann spruce, limber pine, Douglas-fir, aspen, cottonwood, and willow. It is most commonly associated with forested and montane habitats adjacent to lakes, ponds, and streams; occurs most frequently in stands of late-successional forest; and may be reliant on older forests for roost trees. It roosts almost exclusively in trees, usually in cavities in live trees or snags, but also under loose bark or within tree cracks or crevices.”

Bat Habitat



Woodlands with Potential Bat Habitat

In Saskatchewan, Willis and Brigham (2005) found that hoary bats selected as roost trees conifers of similar size to the overall forest canopy that were protected from the wind. Because these species roost in woodlands of all types, bat roosting habitat is indexed by woodland cover types for the purposes of this report.

Wind projects planned in or near woodlands will thus have a greater likelihood of high bat mortality rates. Some of the highest levels of bat mortality were recorded at the Mountaineer wind power facility in the forested mountains of West Virginia, where an estimated 21 bats per night were struck (Horn et al. 2008). Nicholson (2003) reported an estimated 28.5 bats per turbine per year killed at the Buffalo Mountain wind farm in Tennessee. Fiedler (2004) reported that bat fatalities in 2004 at a wind power facility in mixed hardwood forest in eastern Tennessee were an order of magnitude greater than at 8 other facilities in the region, and blamed siting on a prominent ridgeline surrounded by forests with rocky outcrops for the higher bat mortality at this site and the Mountaineer wind farm. The National Research Council (2007) found that bat fatalities are higher for eastern sites on forested ridges, although similarly high fatality rates have been shown for croplands in Iowa and southwestern Alberta. Johnson et al. (2004) found that turbines located near woodlands also experienced higher levels of bat activity at the Buffalo Ridge facility in southwestern Minnesota. Arnett (2005) hypothesized that hoary bats may confuse turbine movements for flying insects and be drawn toward operating turbine blades, and that foraging areas such as forests may be particularly problematic in this regard.

Arnett (2005) found that bat fatalities were concentrated at both the ends and centers of turbine strings. Numerous studies have found that bat fatalities at turbines lit by red FAA lights and unlit turbines were similar (see, e.g., Johnson et al. 2004, Arnett 2005, Horn et al. 2008).

Silver-haired bat.
J. Scott Altenbach photo.

Best Practices for Bats

Siting Turbines in Open Habitats Rather Than Woodlands

Placement of wind power facilities in woodlands should be undertaken with great caution, and old-growth forests should be avoided entirely. Wind turbines sited at least 1 mile from woodland habitats, whether they be cottonwood, conifer, or aspen, will have lower probability of high bat mortality rates. Acoustic, radar, and/or thermal imaging surveys for bats should be undertaken to determine population sizes and occupied habitats for hoary and silver-haired bats in and near the project area prior to site selection, and foraging habitats and migration pathways used by these species. Turbine arrays should be designed to avoid identified areas of concentrated bat use.

Bat Mortality Monitoring

Bat mortality monitoring should be a standard protocol for wind turbine operations. Arnett (2005) reported that weekly carcass searches underestimated fatality rates due to high scavenger removal rates, and this researcher recommended carcass searches rotating through a subset of the turbines, so that there are some carcass data coming in each day.

Shutdowns to Avoid Bat Migrations

Johnson et al. (2004) found that bat mortalities are highest in late summer and early fall, coincident with migration periods. If turbines are sited across migration routes or between roosting and feeding areas, then these turbines should have seasonal shutdowns during the migration season(s) or periods.

Gearing Turbines to Cut In a 6 Meters per Second

In low-wind conditions, bats may not detect turbine blades in time to avoid collisions (Kunz et al. 2007a). Arnett (2005) found that bat fatalities occurred more often on low-wind nights when turbines were still operating, and fatalities increased just before and after the passage of storm fronts. In a later study, Arnett et al. (2008) reported elevated bat mortality from turbine collisions when wind speeds are light (<6 km/hr) and before and after the passage of storm fronts. Cryan (2008) recommended increasing blade ‘cut-in’ speed to wind velocities greater than 6 meters per second and mandatory shutdown during high-risk periods or seasons. Thus, turbines should be set to have a minimum ‘cut-in’ speed of 6 meters per second to avoid the increased mortality risk to bats at slow turbine speeds.

Conservation of Sage Grouse and Sharp-tailed Grouse

Sage grouse and sharp-tailed grouse may be negatively impacted by wind energy development, not so much from the standpoint of direct mortality from collisions but from displacement from favored habitats due to behavioral avoidance of tall structures. Much of what is known about the tolerance of sage grouse to industrial development derives from studies on oil, gas, and coalbed methane development. Sage grouse have lost the vast majority of their original population numbers and are sensitive to human disturbance; the same can be said of the Columbian sharp-tailed grouse, which has a small population in Wyoming in the foothills of the Sierra Madre Range. To the extent that wind power development also involves habitat fragmentation, road construction, and human activity and vehicle traffic associated with maintenance, some of the impacts recorded in the context of oil and gas development may apply to varying degrees to wind power developments.

The area within 2 or 3 miles of a sage grouse lek is crucial to both the breeding activities and nesting success of local sage grouse populations. One scientist described the lek site as "the hub from which nesting occurs" (Autenreith 1985). Grouse exhibit strong fidelity to individual lek sites from year to year (Dunn and Braun 1986). During the spring period, male habitat use is concentrated within 2 km of lek site (Benson et al. 1991). A Montana study found that no male sage grouse traveled farther than 1.8 km from a lek during the breeding season Wallestad and Schladweiler 1974). Other researchers found that 10 of 13 hens nested within 1.9 miles of the lek site during the first year of their southern Idaho study, with an average distance of 1.7 miles from the lek site; 100% of hens nested within 2 miles of the lek site during the second year of this study, with an average distance from lek of 0.5 mile (Hulet et al. 1986). In Montana, Wallestad and Pyrah (1974) found that 73% of nests were built within 2 miles of the lek, but only one nest occurred within 0.5 mile of the lek site. Holloran (2005 found that 64% of sage grouse nested within 3.1 miles of a lek in western Wyoming, and Walker et al. (2007) found that sage grouse habitat within 4 miles of a lek site was important to the persistence of the lek. Because leks sites are used traditionally year after year and represent selection for optimal breeding and nesting habitat, it is crucially important to protect the area surrounding lek sites from impacts.

Male sage grouse in breeding display. Jim Laybourn photo.

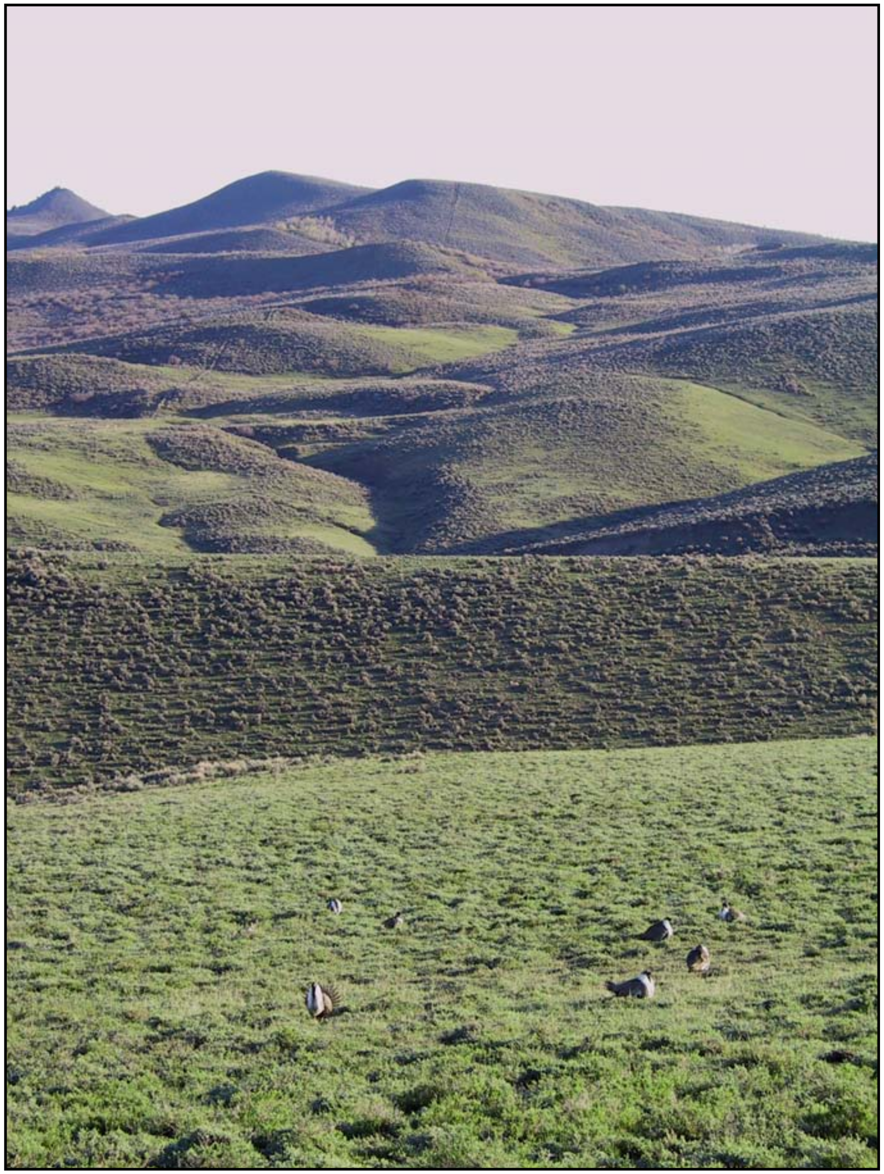
Sharp-tailed grouse concentrate nesting activity even closer to the lek site, and areas within one mile of lek sites are of disproportionate importance as nesting habitat. Nielsen and Yde (1982) found that sharp-tailed grouse concentrate their use within one mile of lek sites during spring, summer, and fall, and wintered in coulees where hardwood shrubs were prevalent. In another study, all grouse nest sites were within 1.1 km of a lek site (Marks and Marks 1987). Geisen and Connelly (1993) reported that a 2 km buffer around a lek forms a 95% probability ellipse for relocating sharp-tailed grouse. Nielsen and Yde (1982) recommended protecting both wintering areas and areas within a mile of lek sites from heavy cattle concentrations, and to locate reservoirs at least a mile away from draws with abundant woody vegetation. According to Saab and Marks (1992: 172), "Protecting habitats within 2.5 km of dancing grounds is critical for maintenance of summer habitat."

Although the impacts of wind energy development remain poorly understood, the impacts of oil and gas development on sage grouse have been well-studied. Like oil and gas development, wind energy development involves the construction of facilities and road networks, resulting in a level of habitat fragmentation that is similar to full-field oil and gas development. Wind turbines are very tall structures, and are therefore expected to trigger avoidance behaviors in grouse that may not come fully into play with oil and gas development except during the drilling stage. On the other hand, vehicle traffic may be less heavy in wind power facilities than in oil and gas fields, and thus the avoidance of wind farms due to vehicle traffic may be less than for oil and gas fields. Given the absence of rigorous scientific study of the impacts of wind farms on sage grouse, known impacts of oil and gas development may be instructive.

In August of 2008, the State of Wyoming adopted a new policy regarding the protection of sage grouse core areas across the state. Wyoming Executive Order 2008-2. This policy identifies specific core areas, shown on the map in blue outline, that include many of the largest sage grouse leks and the nesting habitat that surrounds them. According to this policy, "New development or land uses should be authorized or conducted only when it can be demonstrated by the state agency that the activity will not cause declines in Greater Sage-Grouse populations." As it cannot be determined that construction of wind turbines within five miles of an active lek will not cause population declines, these portions of the core areas have been labeled as red zones, whereas other parts of core areas have been noted as yellow zones where construction might be possible if great care and caution are exercised.

Lessons to be Learned from Oil and Gas Development

In a study near Pinedale, sage grouse from disturbed leks where gas development occurred within 3 km of the lek site showed lower nesting rates (and hence lower reproduction), traveled farther to nest, and selected greater shrub cover than grouse from undisturbed leks (Lyon 2000). According to this study,



Sage grouse strutting at a lek site, Little Snake River valley. BCA photo.

Map Legend

- 5-mile sage grouse lek buffers including 65% of state grouse populations
- Sage grouse 5 mile lek buffers, 70% pop.
- Sage grouse 5-mile lek buffers, 75% pop.
- Sage grouse 5-mile lek buffers, 80% pop.
- Sage grouse 5-mile lek buffers, 85% pop.
- Sage grouse 5-mile lek buffers, 100% pop.
- Sharp-tailed grouse lek
- Plains sharp-tailed grouse 5-mile lek buffers
- Columbian sharp-tailed grouse leks and 5-mile buffer

impacts of oil and gas development to sage grouse include (1) direct habitat loss from new construction, (2) increased human activity and pumping noise causing displacement, (3) increased legal and illegal harvest, (4) direct mortality associated with reserve pits, and (5) lowered water tables resulting in herbaceous vegetation loss. Pump and compressor noise from oil and gas development may reduce the effective range of grouse vocalizations; low-frequency noise from wind turbines could have a similar effect. A consortium of eminent sage grouse biologists recommended, “Energy-related facilities should be located >3.2 km from active leks.” And Dr. Clait Braun, the world’s most eminent expert on sage grouse, has recommended even larger NSO buffers of 3 miles from lek sites, based on the uncertainty of protecting sage grouse nesting habitat with smaller buffers.

Walker et al. (2007) found that coalbed methane development within 2 miles of a sage grouse lek had negative effects on lek attendance. Holloran (2005) found that active drilling within 3.1 miles of a lek reduced breeding populations, while wells already constructed and drilled within 1.9 miles of the lek reduced breeding populations. Both Holloran (2005) and Walker et al. (2007) documented the extirpation of breeding populations at active leks as a result of oil and gas development in the Upper Green River Valley and Powder River Basin, respectively. Road construction related to energy development is a primary impact on sage grouse habitat from habitat fragmentation and direct disturbance perspectives. Rowland et al. (2006: 5-10) modeled sage grouse distribution, and reached the following conclusions:

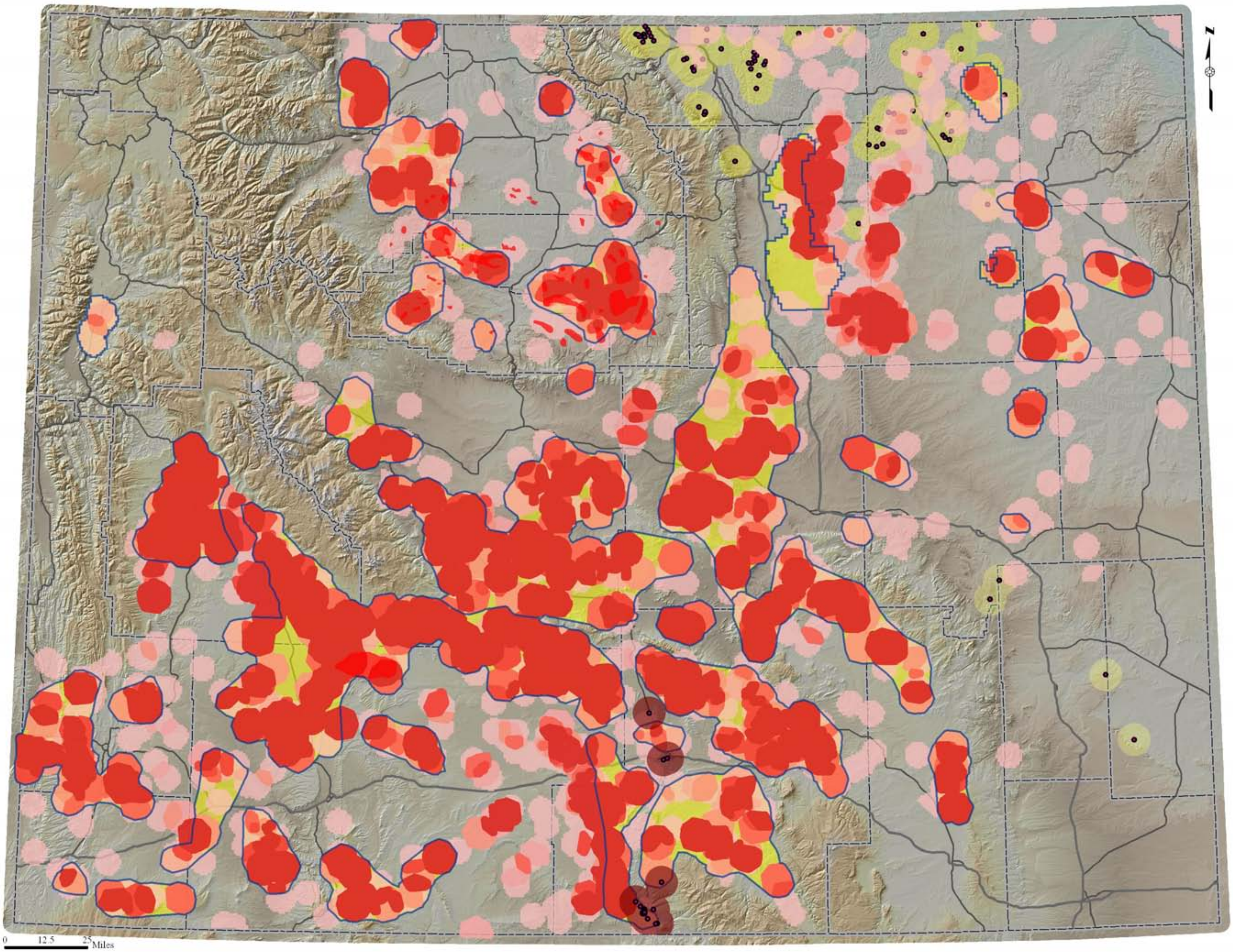
> “The secondary road network is a highly significant factor influencing processes in this landscape and is being developed and expanded rapidly across much of the WBEA. Secondary roads are being built as part of the infrastructure to support non-renewable energy extraction. For example, within the Jonah Field in the Upper Green River Valley, >95% of the area had road densities >2 mi/mi^2.”

(Internal citations omitted). Furthermore,

> “The dominant feature affecting output of the sage-grouse disturbance model was secondary roads, which occupy nearly 8% of the study area (Table 5.2) and are presumed to negatively influence an even larger extent.”

Pp. 6-15 through 16. Holloran (2005) found significant impacts of road traffic on sage grouse habitat use in the Pinedale Anticline gas field, concluding that habitat effectiveness declined in areas adjacent to roads with increasing vehicle traffic, documenting the secondary effect referenced by Rowland et al (2006).

Sage Grouse and Sharp-Tailed Grouse



Anemometer Towers and Sage Grouse: A Case Study

Even the erection of anemometer towers to test for wind energy potential can cause abandonment of key sage grouse habitats, as exemplified by the Cotterel Mountain wind project in Idaho. Windland Incorporated was granted rights-of-way by BLM to construct 7 meteorological towers, 30 to 150 feet in height and topped with anemometers to measure wind velocity for a commercial wind power feasibility study, along the length of Cotterel Mountain, Idaho in July of 2001 (BLM 2001). Anemometers went into operation the same year (Windland Inc. 2005). In October of 2003, permission to construct an eighth tower was granted (BLM 2003). As of 2003, there were 9 known sage grouse leks on Cotterel Mountain, five of which were newly identified that year (Reynolds 2004). On average, 21.5 birds were observed on the leks as a whole, and five leks were used consistently by breeding birds, with a population estimated at less than 50 breeding males (Id.). Overall population estimates were 64 to 72 individuals in 2004 and 59 to 66 individuals in 2005 (Reynolds and Hinckley 2005). In spring 2006, the population of sage grouse on Cotterel Mountain had declined to and estimated 16 individuals and seven of nine leks were unoccupied, while sage grouse populations elsewhere in the county exhibited steady population trends in 2004 and 2005 and only a very slight dip in 2006 (Collins and Reynolds 2006). It is instructive that the Cotterel Mountain sage grouse population crashed following installation of anemometer towers across the crest of Cotterel Mountain, while populations elsewhere in Cassia County held relatively steady.

Juvenile sage grouse near Baggs, Wyoming. BCA photo.

Best Practices for Grouse

Avoiding Turbine Construction in Breeding, Nesting, and Winter Habitats

Because wind turbines represent tall structures which sage grouse are believed to avoid behaviorally, the erection of a wind power facility in or adjacent to sage grouse habitat potentially leads to the abandonment of that habitat by grouse. For this reason, the USFWS (2003, *and see* Manville 2004) recommends siting wind turbine facilities at least 5 miles away from the leks of prairie grouse, which include the sage grouse and sharp-tailed grouse. We support these recommendations and the precautionary approach they adopt in the absence of firm evidence that utility-scale wind power generation is compatible with maintaining sage grouse habitat function. The same caution should apply to known wintering habitats. Areas within 5 miles of sage grouse leks and Columbian sharp-tailed grouse leks are shown as avoidance areas on the accompanying map, while Plains sharp-tailed grouse leks are buffered by yellow caution areas in which scientific study should be conducted for the first wind power facility within 5 miles of a lek and subsequent construction in such habitat should occur contingent on a finding that impacts on sharp-tailed grouse are negligible. We also recommend avoiding the erection of anemometer stations within 5 miles of active sage grouse leks.

Burying Powerlines in Grouse Breeding, Nesting, and Winter Habitats

Transmission towers serve as perches for hunting raptors (as discussed in the section on Wind Power Potential and Siting Considerations) in addition to potentially causing abandonment of sage grouse habitats through behavioral avoidance. An unpublished study found that sage grouse habitat use increased with distance (up to 600 meters) from powerlines (Braun, unpublished data, in Strickland 2004). All transmission lines (including high-voltage DC lines) sited within 5 miles of a grouse lek, within ½ mile of winter habitat, or through Core Areas identified by the recent Wyoming Executive Order should be buried. We recommend avoiding active sage grouse and Columbian sharp-tailed grouse leks by not less than 5 miles from sage grouse leks unless the turbines would be masked from view of the lek by intervening topography. Plains sharp-tailed grouse are not considered to be rare, and thus we recommend caution within 5 miles of lek sites, and providing monitoring studies to determine effects when wind power facilities are sited this close.

Big Game

There have been no scientifically rigorous hypothesis tests concerning the impacts of wind energy development on big game. There is some anecdotal information that pronghorn and even elk may continue to use the Foote Creek Rim wind power site, but this area has not been subjected to rigorous scientific study. According to NWCC (2002:27), "Wind farms also may disrupt wildlife movements, particularly during migrations. For example, herd animals such as elk, deer and pronghorn can be affected if rows of turbines are placed along migration paths between winter and summer ranges or in calving areas." It is widely agreed that construction-related activities are likely to displace wildlife from their native ranges. The impacts of energy development on elk and (to a lesser extent) mule deer have been studied, but for other big game animals, it will be necessary to infer potential impacts using the studied species until more specific scientific research can be conducted.

A number of studies have shown that elk avoid open roads (Grover and Thompson 1986, Rowland et al. 2000). Edge and Marcum (1991) found that elk use was reduced within 1.5 km of roads, except where there was topographic cover. Gratson and Whitman (2000) found that hunter success was higher in roadless areas than in heavily roaded areas, and that closing roads increased hunter success rates. On the Black Hills, elk chose their day bedding sites to avoid tertiary roads and even horse trails (Cooper and Millspaugh 1999). Cole et al. (1997) found that reducing open road densities led to smaller elk home ranges, fewer movements, and higher survival rates. Road networks associated with wind development would be expected to displace elk, and thus wind power facilities should avoid the most sensitive habitats and migration corridors.

Pronghorns near Delaney Rim. Ron Marquart photo.

On winter ranges, elk are highly susceptible to disturbance. They are so sensitive to human disturbance that even cross-country skiers can cause significant stress to wintering animals (Cassirer et al. 1992). Ferguson and Keith (1982) found that while cross-country skiers did not influence overall elk distribution on the landscape, elk avoided heavily-used ski trails. Disturbance during this time of year can be particularly costly, since the metabolic costs of locomotion are up to five times as great when snows are deep (Parker et al. 1984). To the degree that wind power facilities involve human presence in crucial ranges during the most sensitive time periods, these developments may tend to displace elk from their preferred habitats into marginal ranges, where habitat conditions may be poor or where they may be forced to compete with resident animals already at or near their carrying capacity.

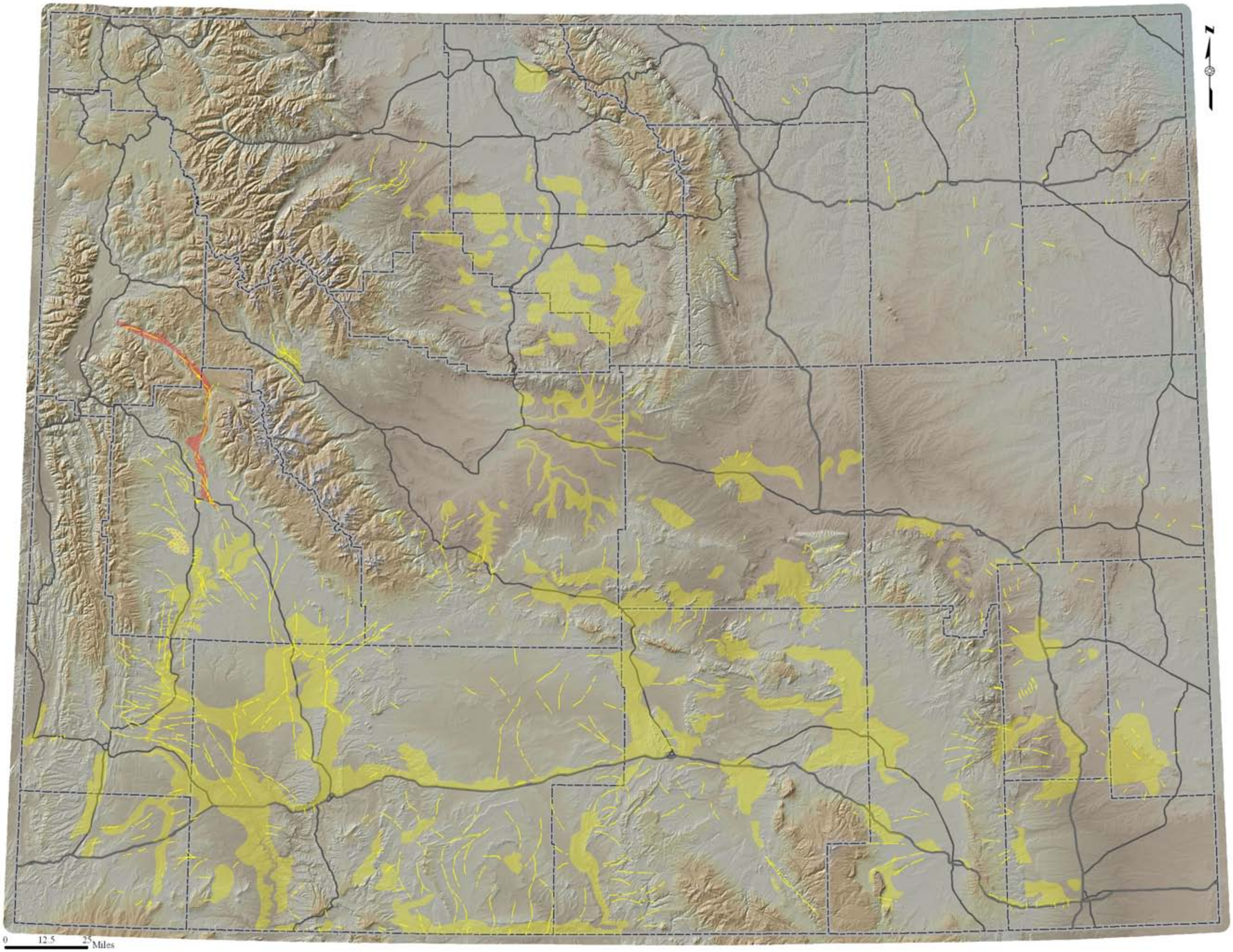
Several studies have shown that elk abandon calving and winter ranges in response to oilfield development, with potential implications for utility-scale wind power development. In mountainous habitats, the construction of a small number of oil or gas wells caused displacement of elk from substantial portions of their winter range (Johnson and Wollrab 1987, Van Dyke and Klein 1996). Drilling in the mountains of the Wyoming Range displaced elk from their traditional calving range (Johnson and Lockman 1979, Johnson and Wollrab 1987). Powell (2003) found that elk avoid lands within 1.5 kilometers of roads and gas well sites in summer and within 0.6 mile in winter in the sagebrush habitats of the Red Desert, and Sawyer and Neilson (2005) found the same results for response to roads for their subsequent investigation in the same area.

For mule deer, Sawyer et al. (2005) found that in the Pinedale area, wellfield development caused abandonment of mule deer crucial winter ranges for years at a time, and ultimately resulted in a 46% decline in mule deer populations, while herds in undeveloped areas showed a much smaller decline over the same period; the affected population has yet to recover to predisturbance levels.

Migration corridors may in some cases be equally important to large mammals and are potentially susceptible to impacts from wind energy development. Our maps show migration corridors designated by the Wyoming Game and Fish Department, but in a few cases more detailed migration corridor locations have been generated by studies using Global Positioning System tracking collars that take reading via satellite (e.g., Berger et al. 2007, Sawyer 2007). In the context of oil and gas development, the Piney Front Elk Study demonstrated that oil and gas development could pose a barrier to elk migration, denying herds access to crucial winter ranges (F.W. Lindzey, pers. comm.). The Western Governor's Association (2008) has adopted a Wildlife Corridors Intiative that specifically addresses the conservation of migration corridors in the context of renewable energy development:

> "In particular, WGA, in coordination with the WWHC [Western Wildlife Habitat Council], should ensure that development of the renewable energy zones 1) includes identification of relevant wildlife corridors and crucial habitat from the relevant state DSS [Decision Support System], and 2)

Antelope Crucial Ranges and Migration Corridors



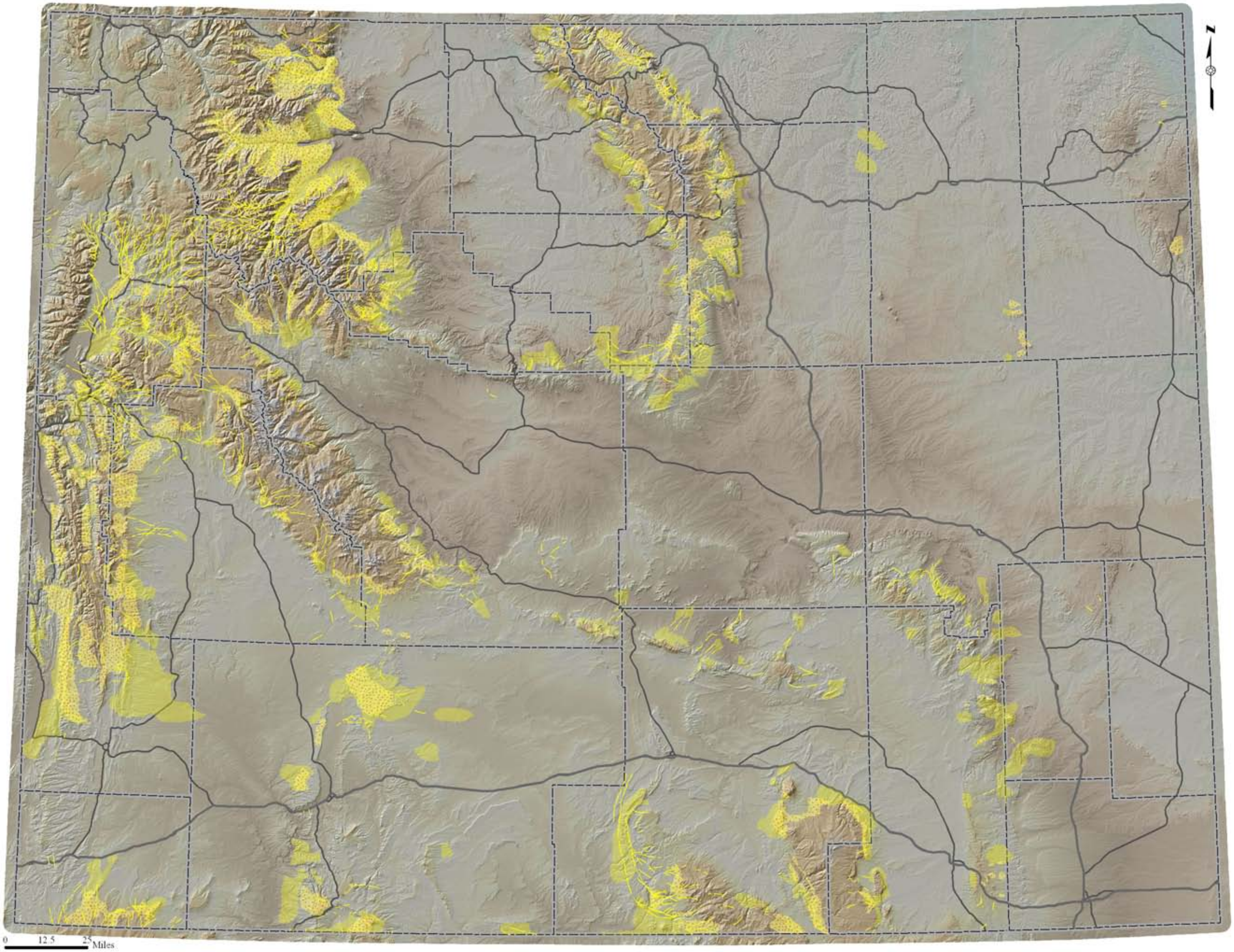
Antelope Parturition Habitats

Antelope crucial winter range

Antelope migration corridors

Northern portion, Grand Teton antelope migration corridor

Elk Crucial Ranges and Migration Corridors



Elk calving areas

Elk crucial winter range

Elk migration corridors

considers appropriate policies and actions to avoid, minimize, or mitigate impacts in these sensitive areas."

With this in mind, we have labeled identified big game migration bottlenecks identified for the Upper Green River Basin as avoidance areas and recommend caution when siting wind energy facilities, and migration routes should be accorded similar level of conservation as winter and parturition ranges.

Best Practices for Big Game Crucial Ranges and Migration Corridors

Test Initial Projects before Approving Additional Development in Crucial Habitats

The first projects to be constructed within big game crucial ranges or migration corridors should be accompanied by rigorous scientific studies to determine the level of tolerance of big game for wind power facilities. These studies should test the null hypotheses that construction activities have no effect on wildlife habitat selection and describe the area of avoidance if displacement occurs; test the same hypothesis for operation activities; determine population-levels effects, if any; and determine how long it takes for animals to resume using the wind power facility site. Such studies should use Before-After-Control formats for maximum scientific rigor. If these studies indicate that displacement of big game by wind power development from a type of sensitive range or migration corridor is negligible, then other wind power projects should be free to proceed in that type of range or migration corridor.

Perform Construction Activity Outside the Sensitive Season

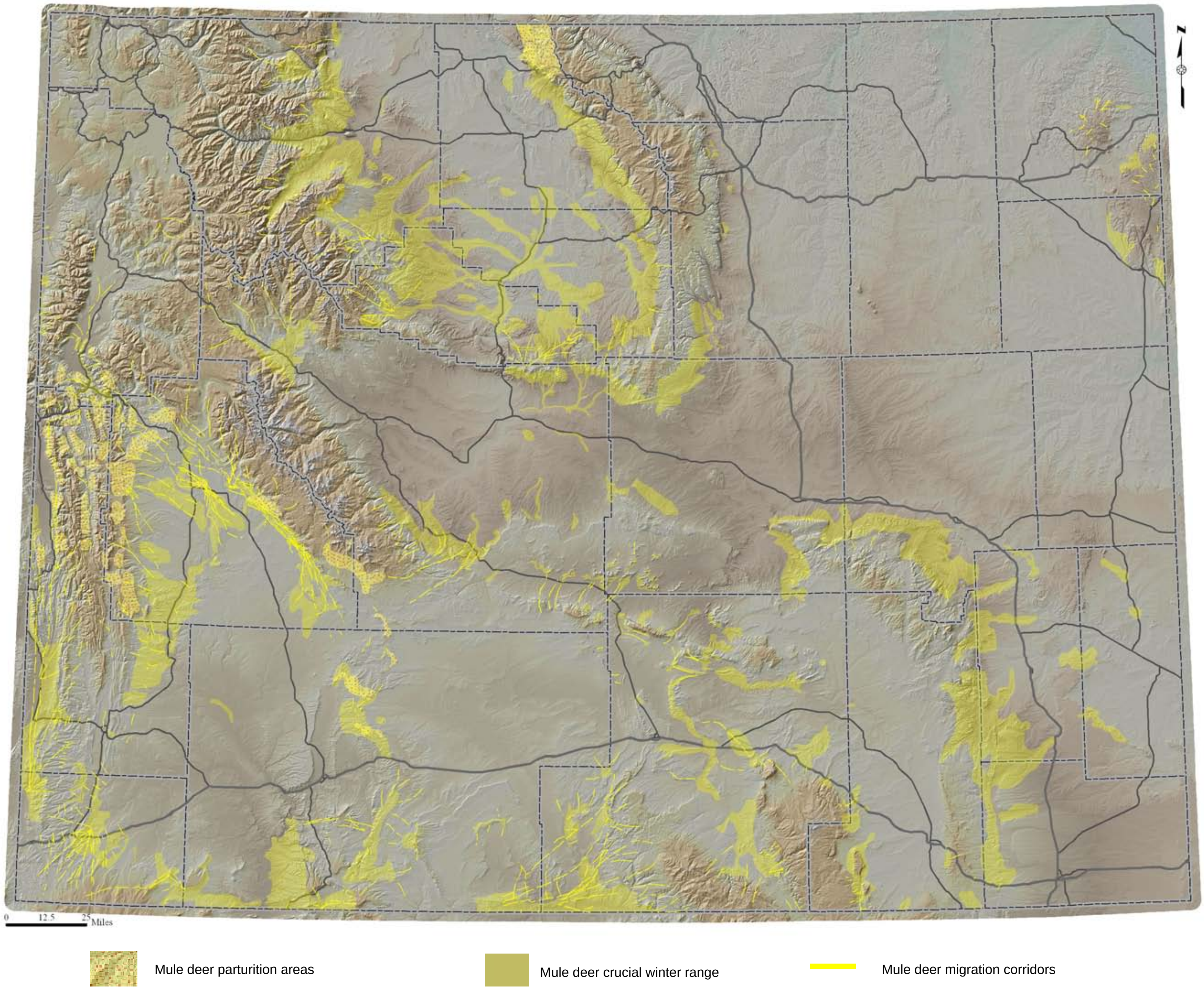
Within 2 miles of crucial ranges or migration corridors, wind power facility construction activities should occur outside their period of use by wildlife.

Seasonally Restrict Vehicles and Human Presence

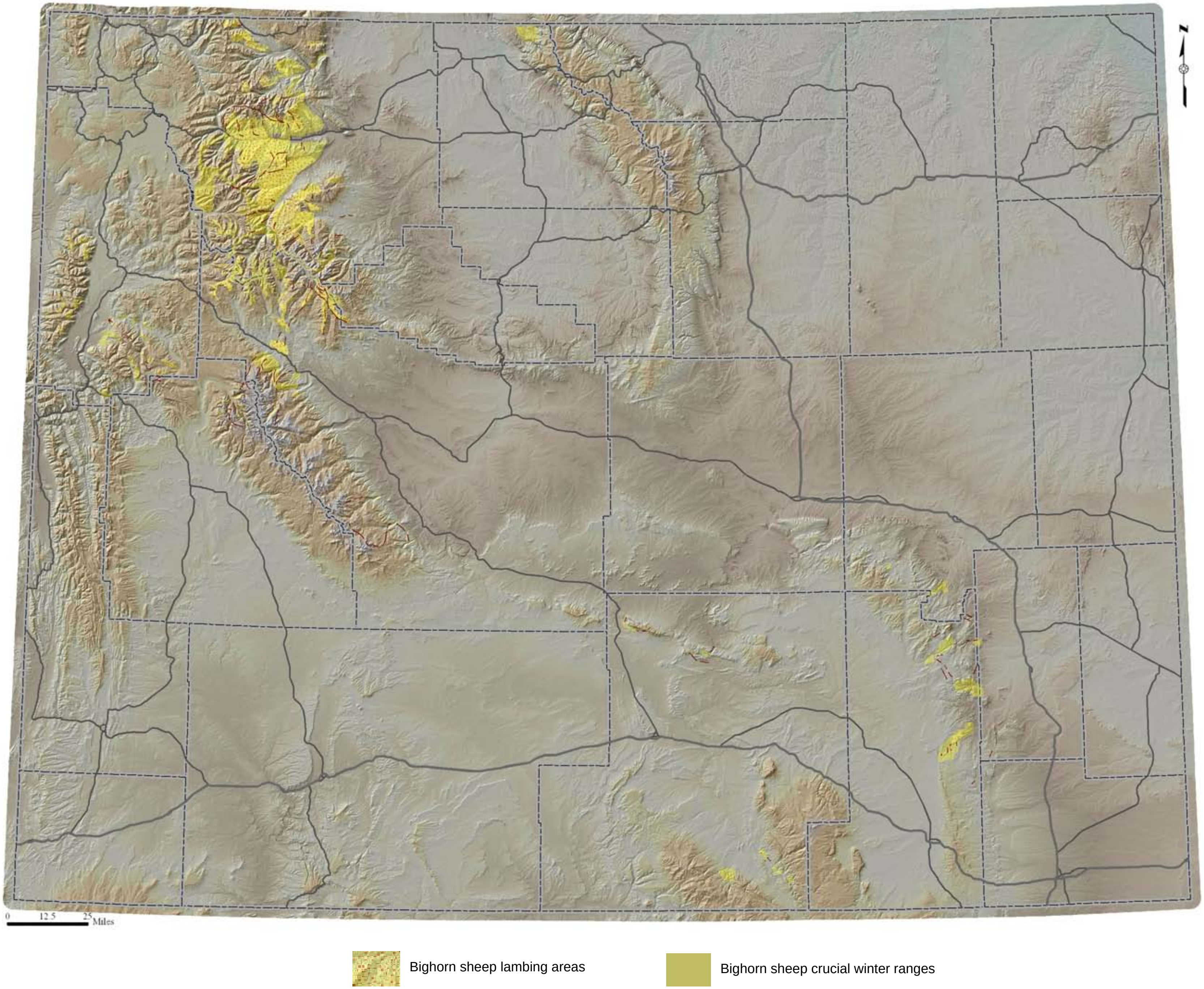
Portions of the wind energy facility inside crucial winter ranges or migration corridors should be closed to vehicle use (and human presence must be minimized) during their period of use by wildlife.

Above: *Elk along Parnell Creek, Jack Morrow Hills. BCA photo.*
Below: *Pronghorn near the Shirley Mountains. George Weurthner photo.*

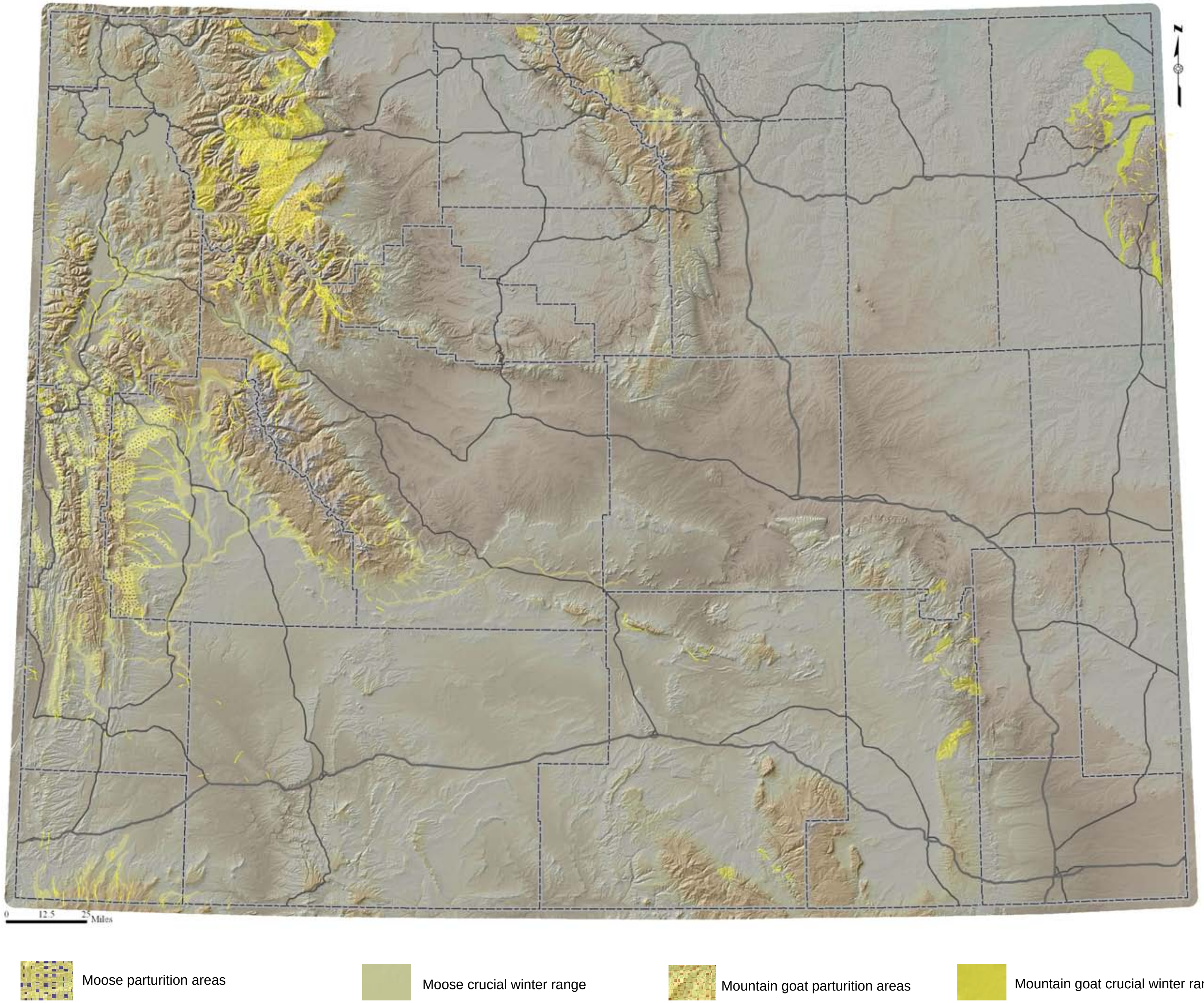
Mule Deer Crucial Ranges and Migration Corridors



Bighorn Sheep Crucial Ranges and Migration Corridors



Other Big Game Crucial Ranges and Migration Corridors



Stewardship for Other Sensitive Wildlife

Wind power projects can affect sensitive wildlife through direct mortality, habitat loss and fragmentation, and displacement of wildlife from preferred habitats due to disturbance. The key to minimizing these impacts is to site wind power facilities in areas of relatively low habitat importance and low likelihood of conflict.

Direct Mortality of Migratory Birds

Wind turbines arrays have the potential to be major sources of migratory bird mortality. Birds have relatively poor hearing, and human ears can detect wind turbines at roughly twice the distance as birds can (Dooling 2002). McCrary et al. (1983, 1984) estimated that 6,800 birds were killed annually at the San Gorgonio wind facility in California. Erickson et al. (2001) reported than in a California study, 78% of mortalities were songbirds protected by the Migratory Bird Treaty Act, while only 3.3% of bird mortalities were unprotected, non-native species such as rock doves or starlings. At Wyoming's Foote Creek Rim wind facility, 92% of bird mortality between 1998 and 2002 was comprised of passerines, or small songbirds (Young et al. 2003).

Kerns and Kerlinger (2004) reported the largest single bird mortality event at the Mountaineer facility in West Virginia in 2003. The mortality event was associated with a brightly lit substation in foggy conditions; the lights were subsequently turned off and no further large mortality events were reported for the site.

The sage thrasher (above) and green-tailed towhee (at right) are two songbird species considered sensitive to habitat fragmentation. US Fish and Wildlife Service photos.

While it is correct to point out that many other types of human activities have killed substantially more birds than have wind turbines to date, fatalities from turbine collisions are additive to all other stressors of bird populations, which may already be imperiled by other human-caused factors. The National Research Council (2007) points out that while turbine fatalities are a small portion of human-caused bird mortalities nationwide, but locally these mortalities can have important impacts on bird populations.

Woodlands may have greater sensitivity from the perspective of songbird mortality. The National Research Council (2007:53) found that "Total bird fatalities per turbine and per MW [megawatt] are similar for all regions examined in these studies, although data from the two sites evaluated in the eastern United States suggest that more birds may be killed at wind-energy facilities on forested ridge tops than in other regions." This is not always the case, however: not one dead bird was found by Keppinger (2002) during mortality monitoring at a Vermont turbine facility sited in rolling forested country.

Nocturnal migrations of songbirds should be identified as part of the baseline analysis for wind power projects. Bird migrations often occur at night (Mabee et al. 2006). The highest percentage of fatalities attributable to nocturnal migrants was 48% at Wyoming's Foote Creek Rim wind power facility (Erickson et al. 2001). Wind turbines extend into the lowest strata of bird migration; most migrating birds fly at heights above turbine facilities (Kerlinger 2002). Birds may maintain altitude after crossing ridgetops (Mabee et al. 2006), suggesting that wind turbine arrays with the tops of blades positioned lower than nearby ridgetops could result in lower rates of mortality for migratory birds.

Accurate mortality monitoring and before-and-after habitat use studies should be a basic part of all wind facility operations, and have been for many wind power programs to date. Estimates of bird mortality can be biased by the efficiency of searchers to locate dead birds and by the rates at which scavengers remove the carcasses. Both of these factors vary widely among wind power sites (Morrisson 2002). Searcher efficiency at the Foote Creek Rim was estimated at 90% for medium and large birds and 60% for small birds based on experimental trials (Young et al. 2003). Arnett (2006) found that trained dogs had a much higher efficiency of finding bird mortalities (71-81%) versus human searchers (14-40%) in the eastern US.

Habitat Impacts for Birds

Wind turbine arrays are likely to result in habitat fragmentation and the displacement of sensitive wildlife away from developed areas. Leddy et al. (1999) found that the Buffalo Ridge wind project area had a density of grassland passerines four times lower than surrounding habitats, indicating that songbirds avoid wind turbine arrays in their habitat selection. In Wyoming, Sensitive Species such as the sage sparrow, Brewer's sparrow, and sage thrasher, and site the project in such a way that impacts can be minimized.

Fragmentation of shrubsteppe habitats has a particularly strong negative impact on birds. Knick and Rotenberry (1995:1059) found that sage sparrows and sage thrashers decreased with decreasing patch size and percent sagebrush cover, and reached the following conclusion:

> Our results demonstrate that fragmentation of shrubsteppe significantly influenced the presence of shrub-obligate species. Because of restoration difficulties, the disturbance of semiarid shrubsteppe may cause irreversible loss of habitat and significant long-term consequences for the conservation of shrub-obligate birds.

Kerley (1994) found that small patches had fewer shrub-nesting species than large patches, and the green-tailed towhee, an interior sagebrush species, was entirely absent from small patches.

Wind turbine facilities sited in forested locations can contribute to forest fragmentation, potentially displacing interior forest species. The Searsburg facility in Vermont showed a decline in interior forest birds and an increase in edge-adapted birds such as robins and jays using the area, likely associated with the clearings constructed for turbine towers and roads (Kerlinger 2002).

Morrisson (2006) summed up habitat impacts as follows: "For wind developments, issues of habitat involve (1) outright loss because of development, (2) indirect impacts because of disturbance (i.e., the animal will no longer reside near the development), and (3) disruption in animal passage through or over the development because of the addition of towers and turbines." The American Society of Mammalogists (2008) has recognized that wind power projects lead to habitat fragmentation and wildlife displacement. Many of these impacts are avoidable through proper siting, according to the National Research Council (2007): "To the extent that we understand how, when, and where wind-energy development most adversely affects organisms and their habitat, it will be possible to mitigate future impacts through careful siting decisions." Another important factor is indirect habitat loss as a result of increased human presence, noise, or motion of operating turbines, according to the National Wind Coordinating Council (NWCC 2002).

Above: *Nesting mountain plover. Fritz Knopf photo.*

At right: *Black-tailed prairie dogs. Rich Reading photo.*

Beginning in 1994, federal and state agencies began to partner with bird conservation organizations under the Intermountain West Joint Venture, and together these stakeholders identified a number of Bird Habitat Conservation Areas that became priorities for federal funding (Intermountain West Joint Venture 2005). These areas were established to focus conservation efforts on priority birds and habitats. The Wyoming conservation plan incorporates the Audubon Society's Important Bird Areas, a smaller subset of the Bird Habitat Conservation Areas (id.). The Bird Habitat Conservation Areas are marked in yellow on the map as areas where wind power projects should be implemented with special sensitivity to bird conservation.

The Mountain Plover: A Species of Special Concern

The project area should be thoroughly surveyed for mountain plover nesting habitat, and identified nesting areas should be excluded from the project. On the nearby Foote Creek Rim facility, wind turbine development along the southern part of the rim caused the area to be abandoned as nesting habitat by mountain plovers. Johnson et al. (2000) showed a steady decline in estimated population of breeding mountain plovers along the Foote Creek Rim from 60 in 1995 to 18 in 1999. Plover nesting activity also appeared to be displaced from areas where construction activity was underway (id.). According to this study,

> Reduced use of the southern portion of Foote Creek Rim by mountain plovers may be related to behavioral avoidance of operating turbines and/or construction and maintenance activities, reduced habitat effectiveness caused by the presence of roads, turbine pads, and other ground disturbance, or a combination of the above (Johnson et al. 2000: 31).

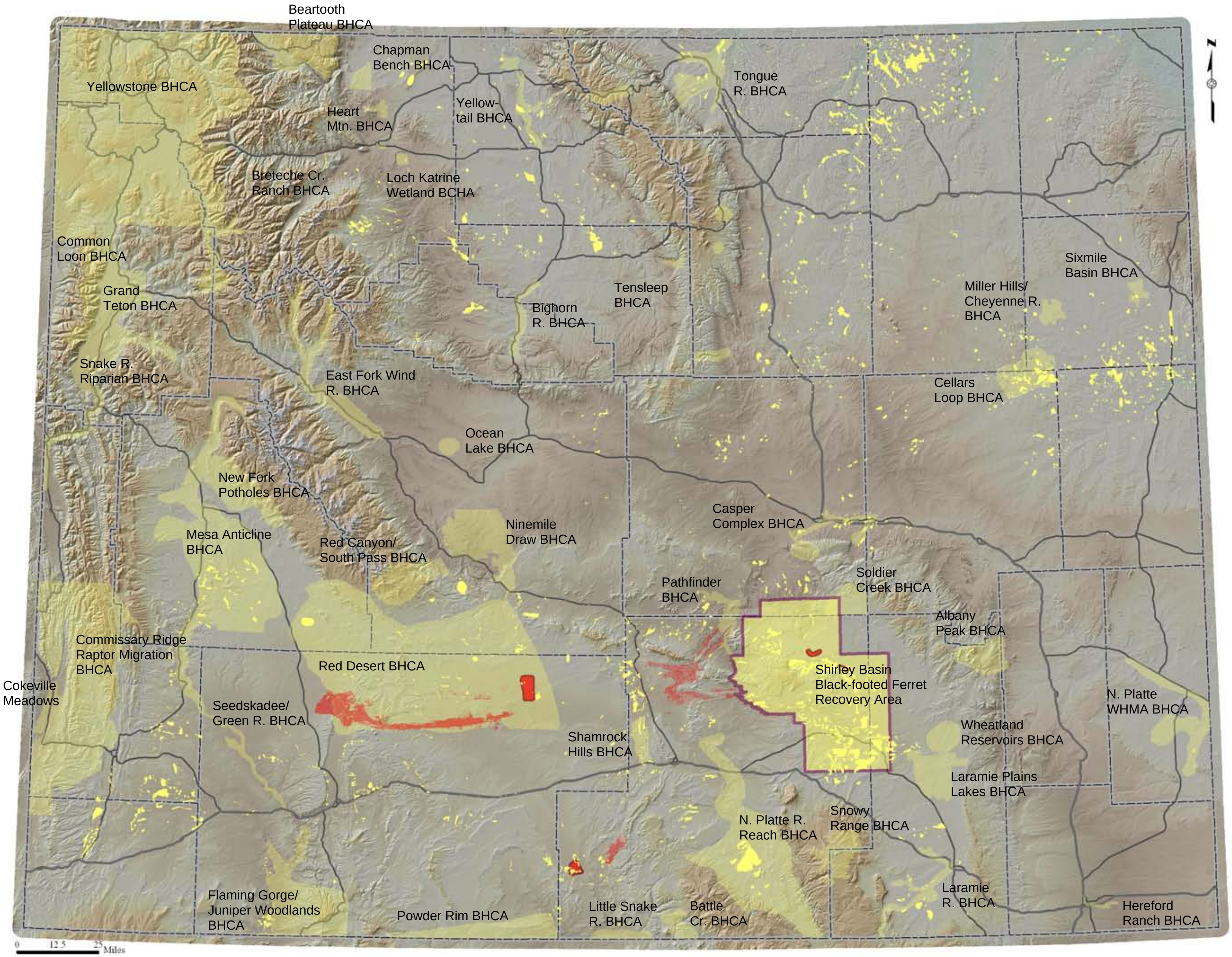
Rates of nest success also declined over this period, compounding the impacts of fewer nesting pairs (*id*.). Identification of key nesting habitats and siting turbine facilities to avoid them will be key to minimizing impacts to this species.

Small Mammals

Impacts of wind power projects to burrowing rodents are uncertain. Some studies indicate that wind power development can be compatible with burrowing mammals. At Altamont Pass, some species of burrowing rodents and rabbits clustered around turbine towers, attracting foraging raptors (Smallwood and Thelander 2005). Johnson et al. (2000) found that populations of prairie dogs and ground squirrels showed no apparent decline in response to wind turbine construction and operation at Foote Creek Rim.

On the other hand, fragmenting small mammal habitat can have negative consequences. Katzner (2004) noted that habitat fragmentation can reduce the size, stability and success of pygmy rabbit populations because these animals are reluctant to cross open habitats. Roads and wellpads clearly fall into this category. Purcell (2006: 34) noted, "the conversion of big sagebrush communities to energy production sites within southwestern and southcentral Wyoming creates a concern for pygmy rabbits in these regions."

Sensitive Wildlife Habitats



In Wyoming, the Wyoming pocket gopher, pygmy rabbit, and white-tailed prairie dog are of particular concern, as is the Endangered black-footed ferret, which depends virtually entirely on prairie dog colonies for habitat and prey.

Sand Dunes and their Unique Residents

Sand dune habitats are very rare features that typically support a unique assemblage of plants and animals that may be found in no other habitat. Bury and Luckenback (1983: 218) observed, "Dunes often lack adjacent or nearby colonization sources and much of the biota may be endemic," and made the following recommendations for the conservation of sand dune communities:

> "A paradigm for the management of desert dune systems should follow the recommendations of Whitcomb et al. (1976), who urge that ecological preserves be kept as large as possible because (1) large areas have low extinction rates and high immigration rates; (2) some taxa require very large areas for survival; (3) preservation of entire ecological communities, with all trophic levels represented, requires large areas; (4) large preserves are a better buffer against human disturbance; (5) large areas are necessary to minimize the predation, parasitism, and competition exerted by species abundant in the disturbed area surrounding reserves; (6) the failures of small reserves have been adequately documented; and (7) because fragmentation is irreversible, a conservative preservation strategy needs to be adopted."

According to the US Geological Survey (1996), "The highest priority should be given to protecting vegetated dunes, active sand dunes, forest-dominated riparian, shrub-dominated riparian and grass-dominated wetlands and riparian areas because their current protection is minimal and because they are potentially the most vulnerable to ongoing land management practices."

In Wyoming, the blowout penstemon, listed under the Endangered Species Act, is found only in active sand dune habitats bordering the Ferris Mountains. The lemon scurfpea – big sagebrush association is a rare plant community restricted to open dune habitats, and is found in the Killpecker Dune Field (BLM 2003). In Wyoming, Maxell (1973) found that scurfpea and ricegrass communities in the sand dunes contained the greatest kangaroo rat concentrations, and drew the following conclusion: "Kangaroo rats were almost exclusively restricted to the sand dunes and adjacent areas in the Basin" (p. 86). The vegetated sand dunes, active sand dunes, and graminoid-dominated "vernal pond" wetlands in this area all are rated "highest priority" for conservation by the Wyoming Gap study (USGS 1996). Thus, the conservation of actively migrating sand dune habitats is an important issue in Wyoming's cold deserts.

Map Legend

Joint Ventures Bird Habitat Conservation Areas

Mountain plover nesting concentration areas

USFWS Black-footed Ferret Recovery Area

Active prairie dog colonies

Best Practices for Other Sensitive Species

Conduct Pre-siting Wildlife Surveys to Determine Optimum Siting

Morrisson (2006) is one of many researchers that have conducted studies of bird habitat utilization and migration patterns in advance of wind energy development. By determining the habitat use on the project scale, turbines can be sited away from high-value bird habitats. This researcher concluded, "Such pre-siting surveys are needed to appropriately locate wind farms and minimize the impacts to birds." Such surveys should be applied generally, and will be particularly important for projects sited in Bird Habitat Conservation Areas.

Avoid Rodent Control Programs to Mitigate Raptor Mortalities

Rodent control programs to reduce prey availability have been ineffective in reducing raptor mortality at Altamont Pass (Smallwood and Thelander 2005, GAO 2005). Given the potential sensitivity of the rodent populations themselves in Wyoming, programs to reduce or eliminate rodent populations to reduce mortality rates of hunting raptors result in a net environmental loss.

Protecting Sand Dune Habitats

Wind power development in areas of actively migrating sand dunes has the potential to slow or alter wind patterns, resulting in the conversion of open dune habitats to dunes stabilized by vegetation. Keith et al. (2004) reported that large amounts of wind power can produce changes in climate at the continental scale

The Killpecker Sand Dunes in the heart of the Red Desert are the nation's largest actively migrating dune field. Ron Marquart photo.

by extracting kinetic energy and altering turbulent transport in the atmospheric boundary layer, with the result of slower wind speeds and greater turbulence near the surface. Roy et al. (2004) modeled the effects of wind farms in the Great Plains region and found that the wind farm significantly slows down the wind at the turbine hub-height level, and that turbulence generated by rotors creates eddies downwind of turbine arrays. In order to ensure that a reduction in wind velocity does not result in the stabilization of actively migrating dunes and the loss of open dune habitats, wind power projects should not be sited in or immediately upwind of areas of actively migrating dunes, marked in red on the accompanying map.

Requiring Unguyed Meteorological Towers

Meteorological towers associated with wind power facilities also can be a major source of avian and bat mortality. Guyed meteorological towers show a 3 times higher fatality rate than turbines themselves at Wyoming's Foote Creek Rim facility, with collisions with guy wires primarily responsible for bird deaths (Young et al. 2003). The Nine Canyon wind project in Washington used an unguyed meteorological tower, which resulted in no recorded bird or bat fatalities (Erickson et al. 2003). Meteorological towers should be of the free-standing, unguyed variety to minimize additional avian and bat mortality.

Avoiding Wyoming Pocket Gopher Habitat

The Stateline wind project in eastern Washington and Oregon was moved to avoid habitat for the Washington ground squirrel, which was on the state endangered species list (NWCC 2002). The Wyoming pocket gopher is similar in its rarity and unknown compatibility with wind power projects. Keinath and Beauvais (2006) point out that soil compaction and habitat fragmentation associated with oil and gas development are a principal threat, stating, "A more likely threat is soil disturbance and compaction due to increased petroleum exploration and extraction. In this context, increased road density that accompanies petroleum development may be more of a threat than the construction of well pads and pipelines, since it would fragment habitat, which could impede population persistence." These researchers further recommend that "compaction of soils, in areas of known occupation will be detrimental to gophers and should be avoided;" that roads should not be permitted to bisect occupied areas; and that man-made raptor perches such as power poles, tanks, and fence poles should not be located near occupied habitat. Due to the rarity of the Wyoming pocket gopher and its sensitivity to habitat fragmentation and soil compaction, ground surveys should be conducted for projects in potential habitat for this species, and wind power plans should be adjusted to avoid occupied habitats.

Avoiding Mountain Plover Habitats

Occupied mountain plover nesting habitats should be avoided for the purposes of wind tower and powerline siting. For the purposes of this report, identified mountain plover nest concentration areas are identified as red "no go" zones for wind power development, and in other areas of potential plover nesting habitat, nesting season surveys should be undertaken and siting adjustments made to leave nesting areas undisturbed.

Protecting Prairie Dog Colonies and Black-Footed Ferrets from Overhead Powerlines

Because prairie dogs are particularly vulnerable to an increase in raptor predation when overhead powerlines are sited across or near colonies, powerlines should be buried within ½ mile of active prairie dog towns. Prairie dog colonies are marked on the map in yellow, indicating this caution regarding powerlines (without implying siting requirements for wind turbines themselves). Similar measures should apply to the Black-footed Ferret Recovery Area in the Shirley Basin, because depression of prairie dog populations through increased predation is a threat to this ferret population, perhaps the healthiest and most secure black-footed ferret population in America.

Minimizing Fragmentation in Forests and Bird Habitat Conservation Areas

Because bird habitats in both shrub steppe and woodland settings are vulnerable to fragmentation and because migratory birds are vulnerable to turbine-strike mortality, the Joint Ventures Bird Habitat Conservation Areas have been delineated on the map in yellow, indicating that caution should be exercised when siting utility-scale turbine arrays. Such arrays should be small and compact, and sited away from key bird habitats within these zones. For woodland areas (identified in yellow on the bat conservation map), wind power facilities should be sited in areas already heavily fragmented, and should avoid areas of continuous mature forest or connecting corridors that provide linkages for interior forest wildlife.

Overhead powerlines like these in the Thunder Basin National Grassland, with perching golden eagle (left) and near the town of Medicine Bow (below) pose problems for small mammals and sage grouse because raptors use them for perches. BCA photos.

Aesthetic Values and the Human Element

Bisbee (2005) remarked that "Popular visual aesthetic preferences are the primary obstacle to obtaining the emission reductions and other benefits wind power offers." Historically, concerns about visual impacts, particularly in the vicinity of towns, have sparked high levels of concern. According to Gipe (2005),

> "Opinion surveys show that wind has high public support, but a worrisome NIMBY ["Not In My Back Yard"] factor. This support erodes once specific projects are proposed. Because support is fragile and can be squandered by ill-conceived projects, the industry must do everything it can to insure that wind turbines and wind power plants become good neighbors. One means for maximizing acceptance is to incorporate aesthetic guidelines into the design of wind turbines and wind power plants."

San Gorgonio wind power facility. Photo © Michael J. Slezak.

According to Cownover (2007), "The size, number, scale, motion and visual prominence of wind turbines makes visual mitigation nearly impossible and communities are faced with challenges in embracing green technology while protecting landscape views they value." In a Riverside County (California) survey regarding the San Gorgonio wind facility, most residents were ambivalent about whether wind energy development was worth the aesthetic cost, while the remainder were evenly split between supporters and opponents of the wind facility (Gipe 2005).

It is critically important for the proponents to implement this project in a way that engenders local support rather than backlash, both to ease acceptance of this project and to ensure that future wind projects do not engender immediate resistance due to a controversial process in Rawlins. According to Pasqualetti (2000:392),

> "If developers are to cultivate the promise of wind power, they should not intrude on favored (or even conspicuous) landscapes, regardless of the technical temptations these spots may offer. Had this been an accepted admonition twenty years ago, the potential of the San Gorgonio Pass might have carried with it the threat of public backlash sufficient to cause more far-sighted developers to hesitate. This argues for a more careful melding of land use, scenic values, public opinion, and environmental regulations with the technical considerations of each site."

Pasqualetti added, "Such spatial realities, even if amplified by only a few vocal objectors, can rob momentum and dull enthusiasm for renewable energy." With this in mind, Anschutz may want to consider scaling back wind power development so that it is neither dense nor obtrusive within the viewshed of Rawlins, and/or phase the construction of the windfarms so that viewshed areas are impacted last.

In New York state, the Town of Warren (2006) established lands within 5 miles and lands within 8 miles of turbine sighting as the area of visual impact analysis. Sterzinger et al. (2003) also used a 5-mile viewshed radius, while the National Research Council (2007) recommended a 10-mile radius for examining viewshed impacts of wind projects and a 15-mile viewshed analysis for particularly important overlooks.

Sterzinger et al. (2003) determined that while it is commonly assumed that wind power development will lower property values for neighboring residents, the empirical evidence shows no reduction in property values for wind energy zones versus areas unaffected by wind development. Hoen (2006) found no property value impacts of wind energy facility construction at a small town in upstate New York, and argued that property values are an independent index of aesthetic quality.

The scale of the project, particularly if that scale is highly visible, is a critical aesthetic factor. National Research Council (2007:105) admonished, "A project that dominates views throughout a region is more likely to have aesthetic impacts judged unacceptable than one that permits other scenic or natural views to remain unimpaired throughout the region." The Danish wind power program has gained broad acceptance, in part because it is based on a number of small (1 to 30 turbine) projects (id.). The National Wind Coordinating Council (2002:28) admonished, "Fewer and wider-spaced turbines may present a more pleasing appearance than tightly-packed arrays."

Among the recommendations of Gipe (2005) are maintaining aesthetic uniformity within an array (utilizing the same number of blades, similar turbine shapes), avoiding dense turbine spacing, and using low-contrast paint schemes to make the turbines less obtrusive. According to Pasqualetti (2000:391),

> "industry must strive to intelligently and carefully integrate turbines within individual landscapes in which they work.

Several generic steps can be taken, including attention to scale, symmetry of design, careful road construction and site preparation, and equipment maintenance."

The impacts of the proposed project on open space, which is valued by the public in its own right, need to be considered in any wind power development project. According to Pasqualetti (2000:390), "Open space remains the West's greatest attribute and attraction, the inalienable right of all those with the luck to have been born there or—as some believe—the sense to have moved there." Visibility of wind turbines increased annoyance levels in survey respondents (van den Berg et al. 2008). Perception is reality where aesthetic impacts are concerned, and in cases where the local perception is that the project will be a sustainable economic benefit to the community without the downside of being perceived as an eyesore. Interestingly, even large wind power projects such as those in northeastern Colorado can be noncontroversial when they are sited in remote areas lacking special landscapes and are distant from highways.

The National Research Council (2007:102) has outlined a process for evaluating the conditions under which the aesthetic impacts of a proposed wind project might become unacceptable or "undue" in regulatory terms, considering the following factors:

- Has the applicant provided sufficient information with which to make a decision? These would include detailed information about the visibility of the proposed project and simulations (photomontages) from sensitive viewing areas. ...
- Are scenic resources of local, statewide or national significance located on or near the project site? Is the surrounding landscape unique in any way? What landscape characteristics are important to the experience and visual integrity of these scenic features?
- Would these scenic resources be significantly degraded by the construction of the proposed project?
- Would the scale of the project interfere with the general enjoyment of scenic landscape features throughout the region? Would the project appear as a dominant feature throughout the region or study area?
- Has the applicant employed reasonable mitigation measures in the overall design and layout of the proposed project so that it fits reasonably well into the character of the area?
- Would the project violate a clear, written community standard intended to protect the scenic or natural beauty of the area? Such standards can be developed at the community, county, region, or state level.

Project proponents who can answer these questions to the satisfaction of local residents will not only be better able to clear regulatory hurdles but also will be better able to gain local support for wind power projects. In addition, wind energy producers who provide electricity free or at reduced rates to local communities might experience less opposition and controversy surrounding wind projects on locations visible from town.

Historical and Cultural Resources

The National Historic Preservation Act's regulations state that an "adverse effect" to hisotric properties results from the "[p]hysical destruction of or damage to all or part of the Property," "[a]lteration of a property, including restoration, rehabilitation, repair, maintenance, stabilization, hazardous material remediation, and provision of handicapped access, that is not consistent with the Secretary's standards for the treatment of historic properties (36 CFR part 68) and applicable guidelines" or the "[c]hange of the character of the property's use or of physical features within the property's setting that contribute to its historic significance." 36 C.F.R. § 800.5(a)(2)(i-ii, iv). Wind power facilities can cause significant impacts to the settings of historical and cultural sites listed on or eligible for the National Register of Historic Places. Wind facilities are seen by the viewer as symbols of technological development (Gipe 2005), and thus are in-

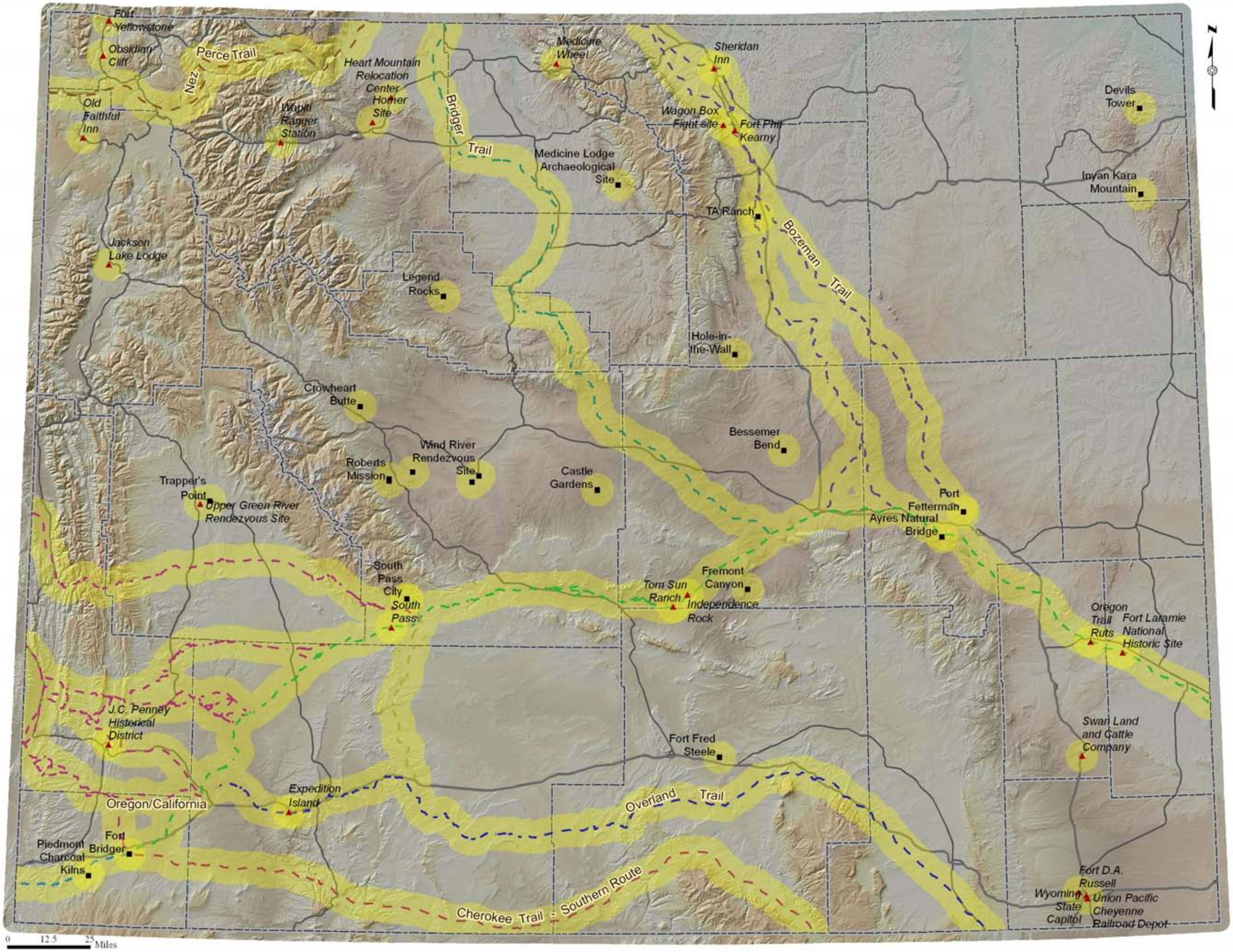
Map Legend

- ▲ NPS National Historic Landmarks
- ■ Other important historic sites
- 5-mile viewshed buffer
- Historic Trails

At Right: *A register rock carved with the names of pioneers along the Overland Trail in the Red Desert. BCA photo.*

Historic Sites and Trails

5-mile viewshed buffers shown



Stable ruins, Point of Rocks Stage Station along the Overland Trail. BCA photo.

compatible with historic settings. It would be very difficult to minimize or mitigate the impacts of a wind power array on the setting of a historic property. The best way to avoid this thorny issue is to site wind facilities in such a way that intervening topography masks them from view from historic trails and sites.

Visual Resources Management

In its long-term land-use plans, the Bureau of Land Management typically outlines areas where maintaining visual resources is a management priority. In Wyoming, wind power development would be precluded by regulation in Visual Resource Management Class I areas, "preserve the existing character of the landscape," and in any case all areas in this class are Wilderness Study Areas which must be managed to maintain their wilderness qualities. It would be very difficult for a utility-scale wind project to meet the requirements of Visual Resource Management Class II as well. These requirements state:

> The objective of this class is to retain the existing character of the landscape. The level of change to the characteristic landscape should be low. Management activities may be seen, but should not attract the attention of the casual observer. Any changes must repeat the basic elements of form, line, color, and texture found in the predominant natural features of the characteristic landscape.

BLM Manual H-8410-1. It is apparent that wind power facilities would not be able to meet these standards. These administrative requirements pose an additional constraint on wind power development.

Best Practices for Protecting Aesthetic, Historic Values

Getting Local Buy-In for Projects within 5 Miles of a Town

An open and inclusive public process benefits wind energy development by allowing public concerns to be addressed and gaining buy-in from neighboring communities. Hasty permitting projects with accelerated timelines result in trouble for wind power projects, according to the National Wind Coordinating Council (2002); this body pointed out that making enemies can result in lawsuits and ordinances that slow or prevent wind projects near communities. For lands within 5 miles of established towns, we recommend siting wind facilities in areas screened from view by intervening topography, and where this is not possible, getting formal buy-in from the local community via resolutions of approval from elected town bodies.

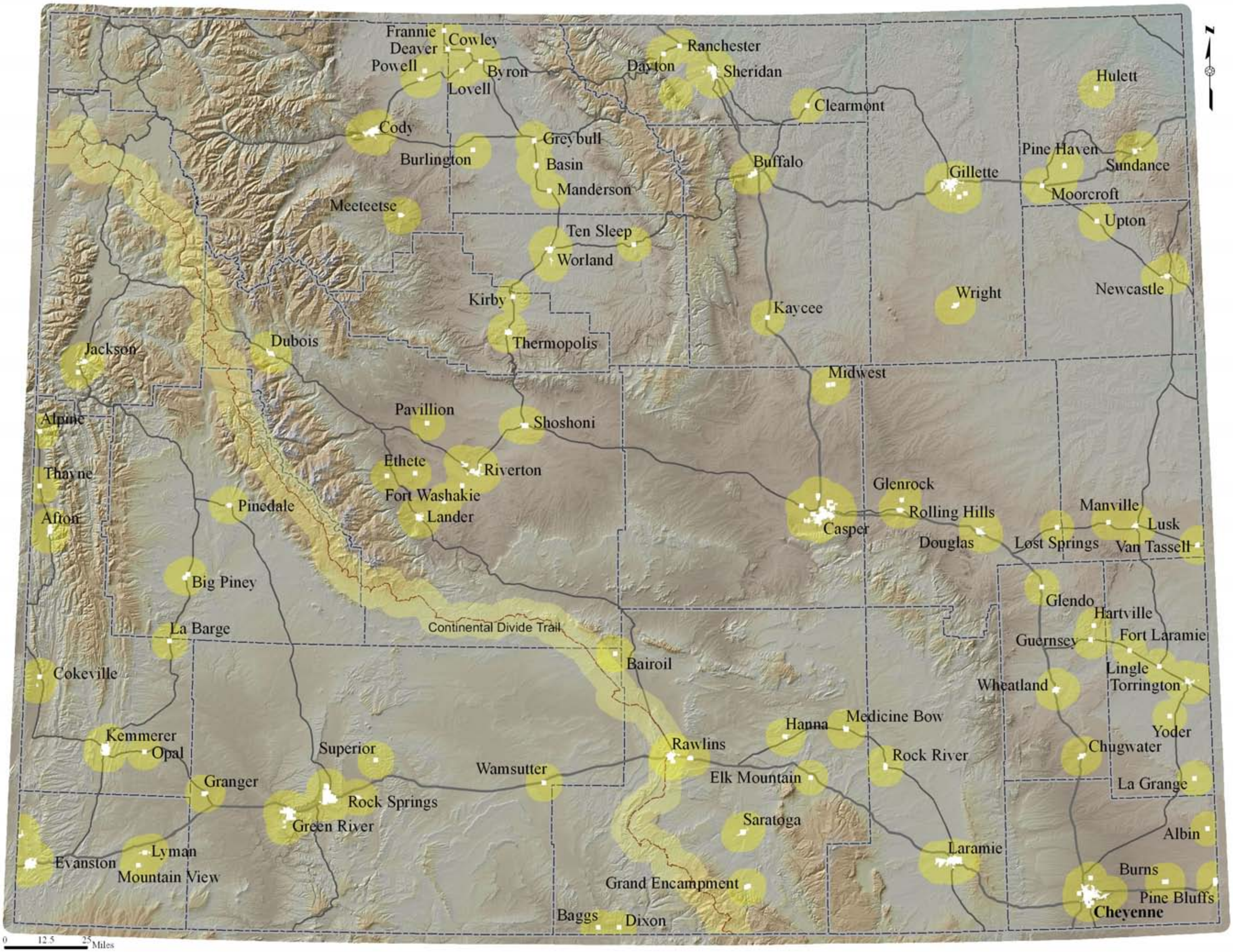
Minimizing the Impacts of Noise and Shadow Flicker near Dwellings

Impacts of turbine noise and shadow flicker should also be considered, particularly in cases where residents live very close to the proposed turbine array. Turbine noise is generally a factor only within 0.5 mile of the turbine site (National Research Council 2007). In a Netherlands study, van den Berg et al. (2008) found that when noise increased from 30 dBA to 45 dBA, respondents showed increased annoyance. Noise and shadow flicker have been identified as issues in Europe (National Research Council 2007), and shadow flicker has been recognized as a distraction to drivers and a potential safety hazard in some countries (MSU 2004). For projects sited away from primary access roads and human dwellings, these impacts should be of minor concern.

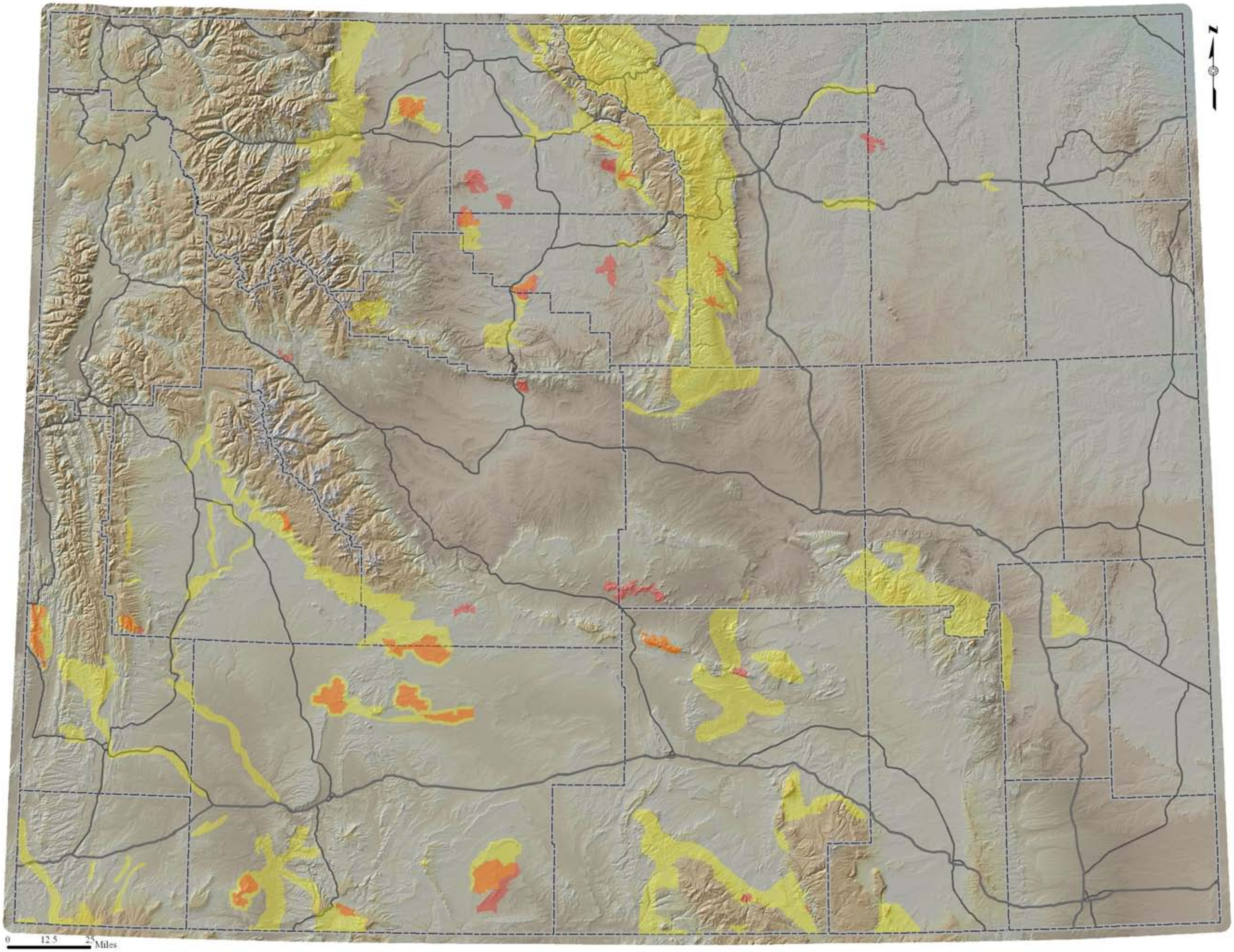
Wind turbines near Grover, Colorado. Erik Molvar photo

Municipalities and the Continental Divide Trail

5-mile viewshed buffers shown



BLM Visual Resource Management Classes



Visual Resource Management Class I

Visual Resource Management Class II

Shielding the Viewsheds of Historic Properties from Wind Turbines

Within 5 miles of important historic sites and trails, we recommend using great caution by siting wind power facilities only in areas that are visually screened from view from the historic property.

Consulting with Tribes on Traditional Cultural Properties

Wind energy companies should undertake formal consultation with Native American tribes to identify Traditional Cultural Properties, and these should be accorded a similar level of respect and protection as historic trails and sites.

At right: Red Desert petroglyphs. BCA photo.

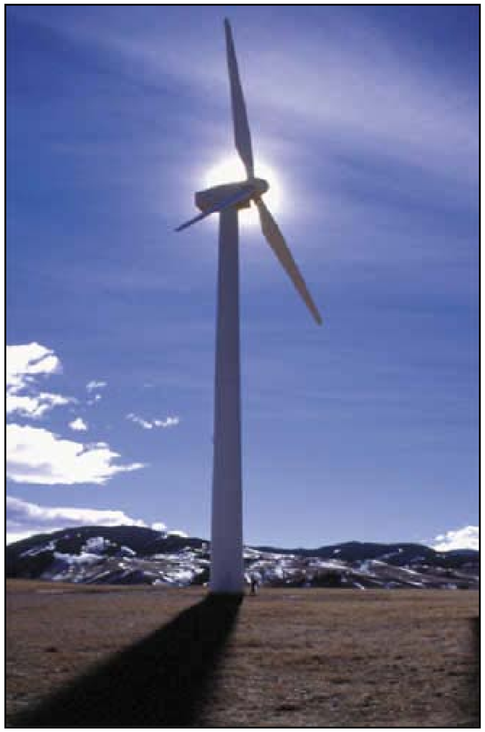
Below: *Transmission lines can also be an aesthetic issue. Erik Molvar photo*

*From a distance of 10 miles, Wyoming's Foote Creek Rim facility (**above**) is almost imperceptible. Wind power developments near Grover, Colorado (**below and below left**) are remote from towns and highways, and thus have not been controversial.*

Wind Power Potential and Siting Considerations

To date, the wind power potential of a site has been the principle (and often the only) consideration driving the siting of wind turbine arrays in Wyoming. While the velocity of wind and how consistently it blows are primary considerations, other factors also contribute to a site's wind power potential. The density of the air interacts with velocity to determine the power output that can be harvested, so for wind farms operating at similar windspeeds, low elevation facilities yield greater power than high-elevation turbine arrays working in thinner air. In addition, areas with a smooth, laminar flow of wind will provide more efficient wind power generation than areas where the wind is gusty or turbulent; for this reason, areas with broken topography are often less preferred for wind power siting even if they experience strong, consistent winds. We recommend that in the future, wind power siting be selected on the basis of both wind power potential and environmental considerations, and that the areas with strong wind potential that are in areas with few or no environmental conflicts should be the first to be developed for utility-scale wind energy generation.

The accompanying map shown on page 43 displays the wind power potential of Wyoming on a coarse scale, as mapped by the National Renewable Energy Laboratory. The higher the numerical rating, the stronger the potential is estimated to be for wind energy generation. At present all areas showing a rating of Class 4 or higher are considered to have commercial wind power potential, but areas rated at Class 3 are expected to become commercially viable in the near future due to improvements in wind turbine efficiency.



The wind farm at Foote Creek Rim had low raptor fatality rates because it was sited away from nesting concentration areas. Bonneville Power Administration photo.

The Value of Siting Wind Power in Areas of Few Environmental Conflicts

When all of the sensitive wildlife habitats and high-value landscapes are factored in, Wyoming offers a great deal of wind power potential without building turbines in areas that entail heavy impacts or social conflicts. The map at right shows areas that should not be considered for wind power development in red, areas where wind power development could occur once resource concerns are successfully addressed in yellow, and areas with negligible resource concerns in green. Areas with multiple cautions are marked in yellow, indicating that several different sensitive resources are present, and while solutions may present themselves for resolving these concerns and siting wind turbines successfully, the process is likely to be more complex. We recommend prioritizing the green zones with high wind power potential as areas where utility-scale wind power generation should start, with yellow areas also meriting consideration as long as the Best Practices for the sensitive resources in question are followed. In addition, large extents of green zone are the best candidates for bringing in additional electrical transmission capacity to support the growth of the wind power industry.

Based on our recommendations, about half of the state would be suitable for wind power development under varying levels of caution, while the other half is recommended as exclusion areas (some of which are already off-limits to any kind of industrial development by law or regulation). Sage grouse habitats are the primary driver of recommended exclusions. Special landscape designations also contribute, while raptor nest concentration areas appear to be fairly easy to work around for the purposes of wind farm siting. A substantial amount of the state is outlined in yellow, indicating that wind power projects could proceed once resource concerns were addressed.

Green zones, lacking major conflicts identified in the report, are recommended as priority areas for wind energy development. The largest of these zones is in southeastern Wyoming east of the Laramie Range, on both the north and south sides of the Platter River valley. By happy coincidence, this area also has the largest extent of high wind potential in the state. Other areas with concentrations of green zone corresponding with strong wind power potential include parts of the High Plains northeast of Casper and the southern tail of the Big Horn Mountains. Green areas on the Wind River Indian Reservation and in the northern part of the Powder River Basin also merit consideration, but have lower wind power potential.

Adding Value by Siting Wind Energy in Impacted Areas

The first screens in determining where wind energy should be sited should be wind energy potential and avoidance of sensitive habitats and landscapes.

Map Legend

Wind power exclusion area

Wind power caution area - single resource concern

Wind power promotion area

Wind power caution area - multiple resource concerns

Environmental Considerations for Wind Development

Once this first screen has been analyzed, the impacts of wind energy development can be further reduced by siting turbine arrays on lands that have already been heavily impacted by another form of industrial use. Thus, if wind energy must be sited in an area where cautions are indicated, siting facilities in industrialized areas will reduce the chances of resource conflicts. And in the "green zones" where conflicts are already minimal, siting wind towers in areas that are already impacted helps to protect open space, which is a legitimate value even in areas where habitat values are low and aesthetic concerns are not preeminent.

Oil, Gas, and Coalbed Methane Fields

Oil and gas development causes habitat fragmentation on a massive scale as well as essentially eliminating the value of wildlife habitat for species sensitive to vehicle traffic and other types of human disturbance. In theory, conventional oil and gas fields are typically designed to have a life of 30 to 50 years, after which they would be fully reclaimed and wildlife would be able to return. In practice, the large companies who typically develop major fields often sell off their interests to smaller independents as production begins to decline, and these wells are often sold as "stripper wells" to holding companies and individuals who keep them running to one degree or another for many years past their projected lifespan. In Wyoming, there has never been a major oil and gas field that has ever been returned to a natural state, to become fully functioning wildlife habitat once again.

Nonetheless, adding a wind farm (which is a much longer-term development, perhaps permanent) to an oil and gas field forecloses the opportunity of final reclamation for energy development and assures that the area will remain developed even after the oil and gas runs out. With these considerations in mind, siting in oil and gas fields is a major asset only in cases where the sensitive wildlife are entirely gone, and the prospect for ultimate reclamation is remote. Coalbed methane fields typically run out of product within 10 to 20 years, and it is not useful to view them as long-term sacrifice zones for the purposes of wind farm siting, even though their habitat value may be essentially zero during the life of coalbed methane production operations.

Reclaimed Mine Sites and Landfills

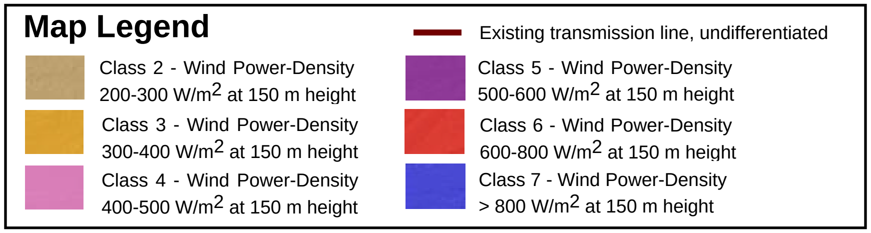
Landfills and reclaimed strip mines offer potential sites for wind power facilities that have less to lose from a habitat standpoint than native habitats. Strip mines for coal and bentonite are present in various parts of the state, and surface facilities for trona mines and processing plants are present in southwest Wyoming and, due to the level of human activity, might be attractive areas for co-locating wind farms. Coal mines are required under federal law to reclaim strip mine areas; these reclamation efforts have enjoyed a variable level of success, with grasses much easier to re-establish than trees and shrubs. As a result, reclaimed coal mine lands are likely to return to some level of habitat function, but are often not as productive for native wildlife as undisturbed lands. Landfill areas are in a similar situation but receive lower reclamation effort, and wind power facilities may be sited in landfill areas even while they are actively in use

Wind power facility in the dry-land crop fields in eastern Oregon, a compatible use that reduces environmental conflicts. Scott Smith photo.

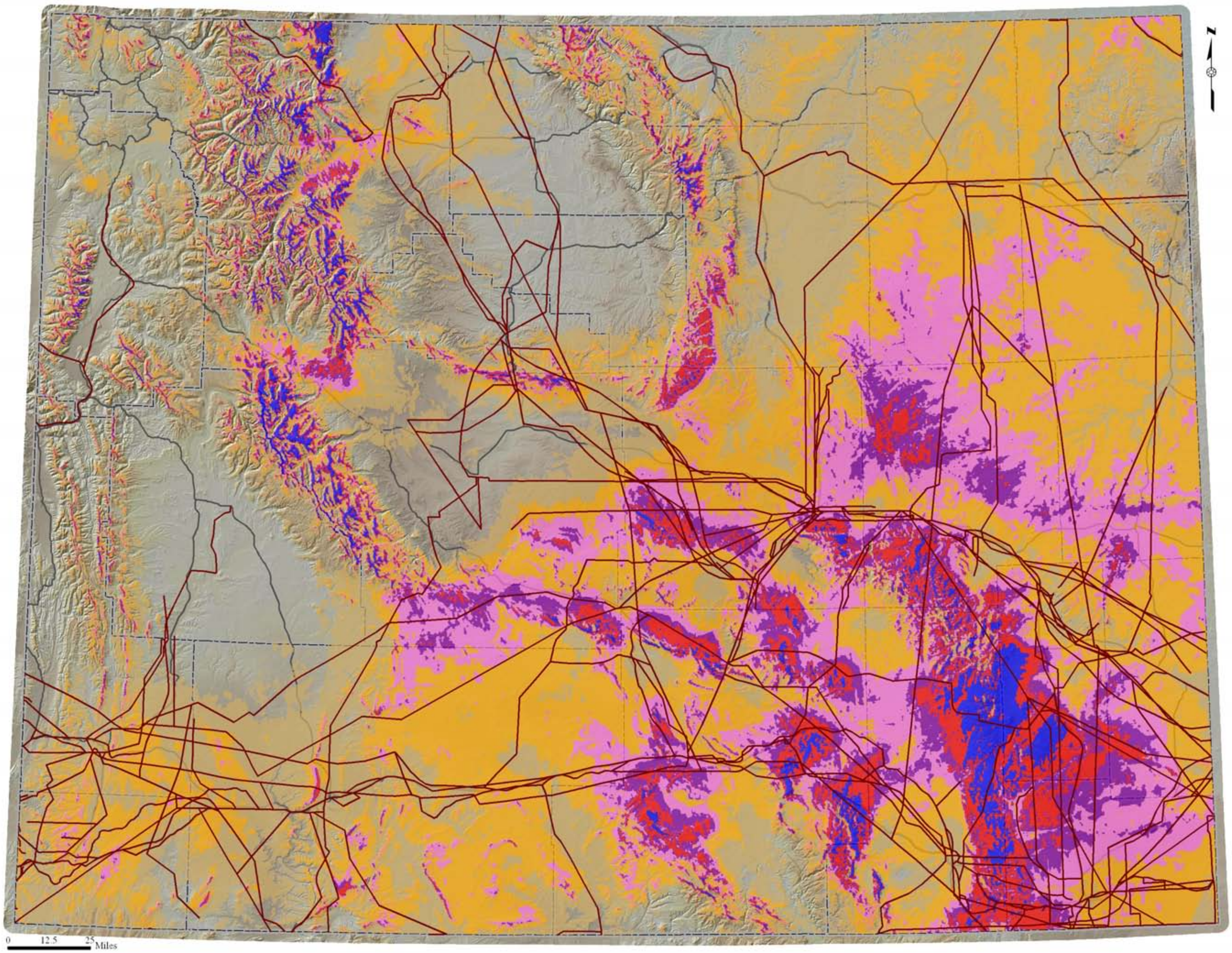
(unlike open pit mine sites, where blasting activity would typically preclude the siting of wind turbines until after reclamation is underway). While there have been instances where reclaimed mine sites in high bat use areas have had wind farms that experienced very high levels of bat mortality (see, e.g., Fiedler 2004), reclaimed surface mines, mine-related facilities, and landfills make attractive candidates for wind power siting due to their lower habitat value.

Agricultural Lands

Wind energy is compatible with farming and livestock grazing (Elliott and Schwartz 1993), and the National Wind Coordinating Council (2002: 23) considers agriculture as "a wind-compatible resource." Because wind developments typically take less that 2% of the land out of agricultural production and yield additional sources of revenue, they may be especially attractive to private agricultural landowners (Gordon 2004). In a Netherlands study, van den Berg (2008) found that respondents with direct economic benefits were more accepting of wind turbines from visual and noise perspectives. This suggests that siting



Wind Power Potential and Electrical Transmission



turbines on private lands may entail greater acceptance as landowners realize direct benefits while the public does not perceive direct compensation for the development of utility-scale wind projects on public lands. Thayer (2007) asserted, "Wind energy development on scenic public lands is less appropriate than wind farming on private rangeland because wind power provides more of a boost for productive farm/ranch management with less controversy over resource/aesthetic controls."

In particular, crop fields support a monoculture of non-native vegetation tend to provide ecologically impoverished fauna and low biodiversity. This is particularly true of dry-land farming of the type used in southeastern Wyoming and the Bighorn Basin. Leddy et al. (1999) recommended siting wind turbines in crop fields, which already have reduced densities of grassland birds. In general, bird fatalities at sites located in agricultural croplands have been at the lower end of the spectrum. At the Nine Canyon site, built in wheatfields and grazing lands of central Washington, Erickson et al. (2003) estimated 3.59 bird fatalities per turbine per year and 3.21 bat fatalities per turbine per year, for a total of 133 birds and 119 bats per year for the entire facility. We recommend crop fields as priority areas for wind turbine siting in the context of

Private grazing lands typically retain a much greater native habitat value and should not be considered sacrifice zones for the purposes of priority wind farm siting. Leddy et al. (1999) observed that the siting of wind turbines on Conservation Reserve Program lands may cancel out the habitat value of these lands for songbirds. However, feed lots would definitely qualify as areas where wind turbine siting would add minimal additional impact and could be priority sites for wind development.

General Best Management Practices

Transmission Lines

Wind power development is also more economical when sited close to existing transmission lines, particularly for smaller projects. Larger wind projects may generate sufficient electricity to require (and justify) long spur lines of their own. In Wyoming, most long-distance transmission lines are already heavily committed to coal-fired generation, leaving little capacity to carry wind power to distant markets. Transmission lines are shown on the accompanying map, but the current GIS data lacks the detail to discriminate the capacity of each line, so it is impossible to tell large-capacity power lines from smaller ones. Thus, the construction of major new electrical transmission lines will be necessary to accommodate any major increase in wind power development. Major new transmission projects sited in areas of high wind power potential are likely to stimulate the construction of new wind power projects nearby (a sort of "if you build it, they will come" effect). With this in mind, we encourage the construction of major new lines dedicated to wind power transmission into areas of low wildlife and cultural sensitivity, and avoiding the siting of major new lines through zones where wind power development would cause major resource conflicts.

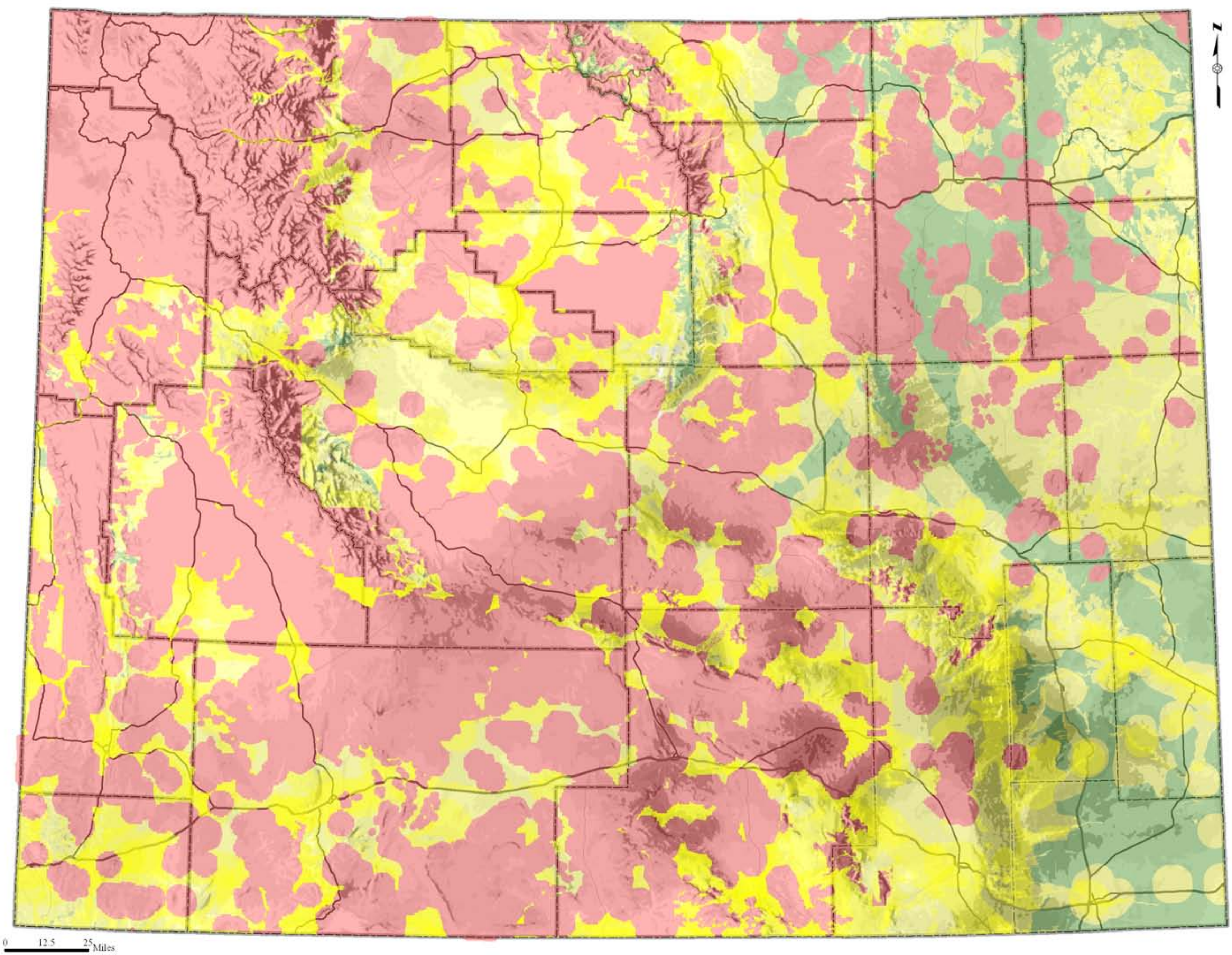
Transmission lines leading away from the Dave Johnson coal-fired power plant near Wheatland. Erik Molvar photo.

Powerline towers are likely to concentrate raptor nesting and perching activities, to the potential detriment of prey species. Transmission towers may be particularly attractive as nest sites for ravens, and Steenhof et al. (1993) reported that 133 pairs of ravens had colonized transmission towers on a single stretch of powerline in Idaho during its first 10 years of existence. Gilmer and Wiehe (1977) found that nest success for ferruginous hawks was slightly lower for transmission towers than other nest sites, and noted that high winds sometimes blew tower nests away. Steenhof et al. (1993) also found that transmission tower nests tended to be blown down, but found that nest success was not lower on

Map Legend

Class 2 - Wind Power-Density 200-300 W/m^2 at 150 m height	Class 7 - Wind Power-Density > 800 W/m^2 at 150 m height
Class 3 - Wind Power-Density 300-400 W/m^2 at 150 m height	Wind power exclusion area
Class 4 - Wind Power-Density 400-500 W/m^2 at 150 m height	Wind power caution area - single resource concern
Class 5 - Wind Power-Density 500-600 W/m^2 at 150 m height	Wind power caution area - multiple resource concerns
Class 6 - Wind Power-Density 600-800 W/m^2 at 150 m height	Wind power promotion area - lacking identified resource concerns

Wind Power Potential Overlay with Environmental Considerations



Acreage of Land by Wind Potential and Environmental Sensitivity

Wind Power-Density Class	Acreage in Green Zones (% of Power-Density Class)	Acreage in Yellow Zones (% of Power-Density Class)	Acreage in Green or Yellow Zones (% of Power-Density Class)	Acreage in Red Zones (% of Power-Density Class)	Total Acreage in Power-Density Class (% of Statewide Total)
Class 1	109,153 (0.70%)	4,987,687 (31.85%)	5,096,840 (32.55%)	10,561,059 (67.45%)	15,657,899 (25.13%)
Class 2	866,887 (5.77%)	6,044,410 (40.26%)	6,911,297 (46.03%)	8,101,934 (53.97%)	15,013,231 (24.09)
Class 3	1,843,786 (11.56%)	5,655,140 (35.45%)	7,498,926 (47.00%)	8,454,852 (53.00%)	15,953,778 (25.60%)
Class 4	1,322,415 (16.23%)	3,134,657 (38.48%)	4,457,072 (54.71%)	3,689,367 (45.29%)	8,146,439 (13.07%)
Class 5	524,054 (14.87%)	1,518,049 (43.08%)	2,042,103 (57.96%)	1,481,348 (42.04%)	3,523,451 (5.65%)
Class 6	199,024 (7.47%)	1,465,368 (55.04%)	1,664,392 (62.51%)	998,182 (37.49%)	2,662,574 (4.27%)
Class 7	61,407 (4.52%)	761,182 (55.97%)	822,589 (60.49%)	537,374 (39.51%)	1,359,963 (2.18%)
Totals (% of Statewide Acreage in Zone Class)	4,926,726 (7.91%)	23,566,493 (37.82%)	282,493,219 (45.72%)	33,824,116 (54.28%)	

towers for ferruginous hawks and was significantly higher on towers for golden eagles. In North Dakota, Gilmer and Stewart (1983) found that ferruginous hawk nest success was highest for powerline towers and lowest for nests in hardwood trees. Thus, although powerlines can be designed to minimize impacts to raptors, these corridors should be sited more than 2 miles away from prairie dog colonies and sage grouse leks to prevent major impacts to these sensitive prey species.

In order to encourage wind energy development, it would be helpful to build powerlines into areas of high wind potential and low environmental conflict to facilitate wind energy development. The siting of these powerlines should avoid sensitive areas outlined in this report. In particular, powerline corridors should be sited more than 1 mile away from prairie dog colonies and avoid sage grouse nesting and wintering habitats to prevent major impacts to these sensitive prey species. When avoidance is not feasible, burial of the powerlines provides an option that avoids most of the impacts inherent to overhead power lines.

Avoiding Impacts to Sensitive Soils

Depending upon siting, soil erosion could become a concern. According to the National Research Council (2007:49), "The construction and maintenance of wind-energy facilities alter ecosystem structure, through vegetation clearing, soil disruption and potential for erosion, and this is particularly problematic in areas that are difficult to reclaim, such as desert, shrub-steppe, and forested areas." We recommend siting wind turbine facilities and access routes away from steep (greater than 25 degrees) or unstable slopes or areas with high erosion potential.

Lower-Impact Access Routes

Improved gravel roads have been used in some cases for access to wind turbines in wind farm settings, while in other cases (particularly in croplands) jeep trails, or no access route at all, are the rule. In most cases, gravel access roads will not only be unnecessary but will also increase the level of project impacts (from dust pollution to wildlife disturbance). We recommend the use jeep trails or no access routes at all to individual turbine towers within a facility development. Vehicle traffic within the turbine array can be further minimized by siting control stations and other related facilities at the near edge of the development to minimize unnecessary vehicle traffic through the turbine arrays.

Conclusions

By following the recommendations in this report, decisionmakers and the wind industry can minimize conflicts with sensitive resources and minimize the potential for controversy. In this way, Wyoming wind energy can enjoy the broadest popular support possible, making approvals for future projects faster and easier. Doing wind power "smart from the start" provides immediate and obvious benefits by protecting sensitive wildlife and key landscapes, but also benefits the wind industry by streamlining clean wind energy projects.

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Data Sources for Maps

Map	Coverage or Shapefile	Description	Data Source
Special Designations	WY_ACECs.shp	Designated BLM ACECs	BLM
	nca_north.shp	Proposed Red Desert NCA, north units	BCA
	nca_south.shp	Proposed Red Desert NCA, south units	BCA
	Proposed_Acec.shp	Proposed ACECs, Rawlins BLM Field Office	BCA
	wcwp_nad83.shp	Citizens' proposed wilderness areas	BCA
	kr_north.bnd	Kinney Rim North citizens' proposed wilderness	BCA
	kr_south.bnd	Kinney Rim South citizens' proposed wilderness	BCA
	flaming_gorge.shp	Flaming Gorge National Recreation Area	USFS
	Roadless_Areas.shp	Inventoried Roadless Areas	USFS
	nps.boundary.shp	National Park and Monument units	NPS
	wilderness_areas.shp	Congressionally designated wilderness	USFS
	McCulloughFinal.shp	McCullough Peaks citizens' proposed wilderness	BCA
	SouthForkPowder3.shp	S. Fork of the Powder citizens' proposed wilderness	BCA
	skde.shp	Seedskadee Natl. Wildlife Refuge	USFWS
	special_desg.shp	Designated Wild and Scenic Rivers	USFS
Ecoregional Conservation Plans	conservation_opportunities.shp	Northern Plains Conservation Network Core Areas	WWF
	Heart of the West coverage files	Heart of West Conservation Plan Cores/Linkages	WUP
Birds of Prey	WFORaptors.shp	Raptor nest sites, Worland Field Office	BLM
	RSFOraptor_points.shp	Raptor nest sites, Rock Springs F.O.	BLM
	RFORaptors.shp	Raptor nest sites, Rawlins F.O.	BLM
	PFORaptor.shp	Raptor nest sites, Pinedale F.O.	BLM
	LFORaptors_1283.shp	Raptor nest sites, Lander F.O.	BLM
	KFO_raptor_nests_july04.shp	Raptor nest sites, Kemmerer F.O.	BLM
	CYFObald eagle roosting areas 1 mile buffer.shp	Bald eagle roosts, Cody F.O.	BLM
	CFORaptors.shp	Raptor nest sites, Casper F.O.	BLM
	BFOgdbRaptor.mdb	Raptor nest sites, Buffalo F.O.	BLM
	CYFO raptor coverage files	Raptor nest sites, Cody Field Office	BLM
Bat Habitat	Northwest ReGap Zones 21, 22, 29	Woodland cover types as potential bat habitat	NW ReGAP

Map	Coverage or Shapefile	Description	Data Source
Sage Grouse and Sharp-Tailed Grouse	co_sagegrouse_wyndd.shp	Columbian sharp-tailed grouse lek sites	WYNDD
	Sharptail_Grouse_Lek_points.shp	Plains sharp-tailed grouse leks	BLM
	65perctbreak.shp	Sage grouse leks w/65% of state population	WGFD
	70perctbreak.shp	Addl. sage grouse leks for 70% of state population	WGFD
	75perctbreak.shp	Addl. sage grouse leks for 75% of state population	WGFD
	80perctbreak.shp	Addl. sage grouse leks for 80% of state population	WGFD
	85perctbreak.shp	Addl. sage grouse leks for 85% of state population	WGFD
	100perctbreak.shp	Addl. sage grouse leks for 100% of state population	WGFD
Antelope Crucial Ranges and Migration Corridors	ant08mr.shp	Pronghorn migration routes	WGFD
	ant99pa	Pronghorn parturition areas	WGFD
	ant06sr.shp	Pronghorn crucial winter and seasonal ranges	WGFD
Elk Crucial Ranges and Migration Corridors	elk05sr.shp	Elk crucial winter and seasonal ranges	WGFD
	elk05pa.shp	Elk parturition areas	WGFD
	elk08mr.shp	Elk migration routes	WGFD
Mule Deer Crucial Ranges and Migration Corridors	mdr06sr.shp	Mule deer crucial winter and seasonal ranges	WGFD
	mdr04pa.shp	Mule deer parturition areas	WGFD
	mdr08mr.shp	Mule deer migration routes	WGFD
Bighorn Sheep Crucial Ranges and Migration Corridors	bhs06sr.shp	Bighorn sheep seasonal and crucial winter ranges	WGFD
	bhs02pa.shp	Bighorn sheep parturition areas	WGFD
	bhs08mr.shp	Bighorn sheep migration routes	WGFD
Other Big Game Crucial Ranges and Migration Corridors	moo06mr.shp	Moose migration routes	WGFD
	moo04pa.shp	Moose parturition areas	WGFD
	moo05sr.shp	Moose seasonal ranges and crucial winter ranges	WGFD
	rmg99pa	Mountain goat parturition areas	WGFD
	rmg99sr	Mountain goat seasonal and crucial winter ranges	WGFD
Sensitive Wildlife Habitats	bffma.shp	Black-footed ferret recovery area	WGFD
	Plover_Acec.shp	Mountain plover nesting concentration areas	BCA
	WY_pdogcombinedgeo83.shp	Occupied prairie dog colonies	WGFD
	WY_BHCAs.shp	Joint Venture Bird Habitat Conservation Areas	ABC
	Northwest ReGap Zones 22, 29	Active and stabilized dunes	NW ReGAP

Map	Coverage or Shapefile	Description	Data Source
Historic Sites and Trails	hist_sites_natnl.shp	NPS National Historic Landmarks	BCA
	hist_sites_other.shp	Other historic Sites, Alliance Historic Wyoming	BCA
	pioneer_trails.shp	Historic trails	BLM
Municipalities and the Continental Divide Trail	CDNST_WY_Roads.shp	Continental Divide Trail road segments	CDTA
	CDNST_WY_Trail.shp	Continental Divide Trail trail segments	CDTA
	Municipalities.shp	Boundaries of Wyoming municipalities	WYGISC
	Counties.shp	County boundaries	WYGISC
	Roads100k.shp	TIGER roads and highways	WYGISC
BLM Visual Resource Management Classes	WYVRMClass2.shp	BLM designated VRM Class 2 lands	BLM
	WYWildernessStudyAreas.shp	BLM designated WSAs	BLM
Wind Power Potential And Electrical Transmission	powerlines_WUS_CAN_sgca.shp	Electrical transmission lines, undifferentiated	USGS
	PNW_50mwindouma.shp	Wind power potential, power-density at 50m	NREL

Data Source Definitions

ABC - American Bird Conservancy, Kalispell, MT
BCA - Data digitized by Biodiversity Conservation Alliance, Laramie, WY
BLM - Bureau of Land Management, U.S. Dept. Of Interior, Wyoming State Office, Cheyenne, WY
CDTA - Continental Divide Trail Association, Pine, CO
NREL - National Renewable Energy Lab, Golden, CO
NPS - National Park Service, Denver, CO
NW ReGAP - Northwest ReGAP Project, U.S. Geological Survey, Moscow, ID
USFS - USDA Forest Service
USFWS - U.S. Fish and Wildlife Service
USGS - U.S. Geological Survey
WGFD - Wyoming Game and Fish Department, Cheyenne, WY
WUP - Wild Utah Project
WYGISC - Wyoming GIS Science Center, University of Wyoming
WYNDD - Wyoming Natural Diversity Database