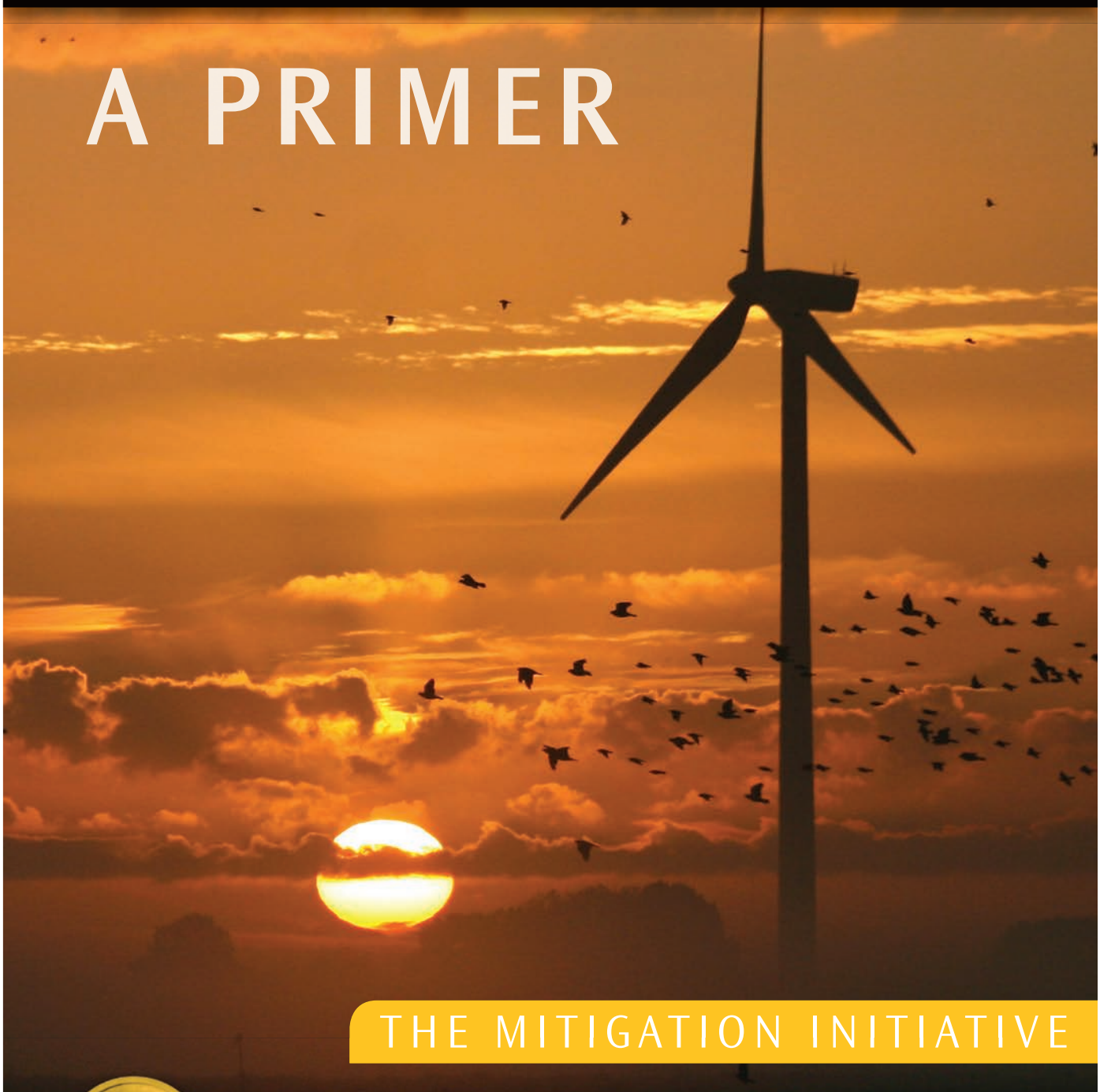
Wind Development and Wildlife Mitigation in Wyoming

A PRIMER



THE MITIGATION INITIATIVE

UNIVERSITY OF WYOMING
RUCKELSHAUS INSTITUTE OF ENVIRONMENT AND NATURAL RESOURCES

Our Mission Statement

The Haub School of Environment and Natural Resources advances the understanding and resolution of complex environment and natural resources challenges through education, research, and collaborative decision making.

- Our academic programs educate undergraduate and graduate students through innovative and interdisciplinary teaching;
- The Ruckelshaus Institute communicates relevant research and promotes collaborative decision making to support stakeholder-driven solutions to environmental challenges; and
- The Biodiversity Institute provides research, education, and outreach to support biodiversity conservation and management.

The Ruckelshaus Institute of Environment and Natural Resources is dedicated to maintaining the highest standards of objectivity in its support of informed, effective, interdisciplinary solutions to natural resource challenges. To this end, we submit our publications to rigorous expert review.

Suggested Citation: Jakle, A. 2012. Wind Development and Wildlife Mitigation in Wyoming: A Primer. Laramie, Wyoming: Ruckelshaus Institute of Environment and Natural Resources.

Wind Development and Wildlife Mitigation in Wyoming: A Primer

Figures

Tables

Note

This guide complements the Ruckelshaus Institute primer on natural gas mitigation (Ref. 1), which details mitigation terminology, metrics, and emerging approaches in natural gas development and wildlife mitigation in Wyoming. Refer to the *Natural Gas Development and Wildlife Mitigation in Wyoming: A Primer* for additional information and a more detailed explanation of mitigation terminology and metrics.

Executive Summary

Wind energy is one of the fastest-growing forms of electricity development in the United States, and installed wind energy capacity in Wyoming has increased fifteen-fold in the past decade. Wind is regarded as a "green energy" resource because it does not directly produce carbon dioxide emissions or other air pollutants, uses minimal amounts of water, and is renewable. However, like other forms of industrial development it is not without potential impacts to habitats and wildlife populations. Wind facilities, with their associated human activity and infrastructure—including access roads, meteorological towers, transmission lines, and power substations—can affect wildlife directly through habitat loss and turbine collisions. They also can impact wildlife indirectly by causing displacement or avoidance of habitat.

As more wind facilities are constructed in Wyoming and across the nation, site-specific and cumulative impacts to wildlife are increasingly a concern. Wildlife mitigation is the sequential process of (1) avoiding impacts when possible, (2) minimizing remaining impacts, and (3) compensating for unavoidable impacts. Mitigation for impacts to wildlife and habitat is an emerging field for the wind industry and is not well defined. This primer draws from scientific, working, and statutory knowledge to provide a survey of current wildlife mitigation practices for wind energy projects—both in Wyoming and outside the state—and explore what might be next for wildlife mitigation and wind as development moves increasingly to federal lands and may be subject to increased permitting and mitigation requirements.

As the wind industry is relatively young, there is little known about how wind facilities impact most species of wildlife other than birds and bats that are at risk of turbine collision. This, in turn, has led regulators and industry to focus on implementing avoidance and minimization measures to prevent or lessen direct impacts to avian species and bats. Careful siting, turbine design, and not developing in sensitive habitats are common avoidance measures, while seasonal restrictions, lighting decisions, use of wildlife deterrents, and curtailment can help minimize impacts.

Even with the use of comprehensive avoidance and minimization measures, impacts to wildlife can still occur, and the last step of the mitigation hierarchy is to compensate for these impacts. Compensatory mitigation is relatively rare for wind developments, primarily because there is little regulatory structure requiring or guiding compensation for wind–wildlife impacts. Projects across the country that have engaged in this third stage of mitigation have done so primarily through voluntarily purchases of replacement habitat via conservation easements or providing in-lieu fees to fund compensatory mitigation projects.

A possible next step in wind–wildlife mitigation is to engage in landscape-scale planning to strategically outline priority mitigation activities and address cumulative impacts from wind development. Developing meaningful metrics to both determine the amount of mitigation needed and measure if mitigation activities are meeting goals may help regulators and industry move toward effective wind–wildlife mitigation practices. Wyoming—with its abundant wind energy and wildlife resources—has the potential to be a leader in this field.

I. Introduction

Wind energy is one of the fastest-growing forms of electricity development in the United States, and installed wind energy capacity in Wyoming has increased fifteen-fold in the past decade (Figure 1; Table 1).[2] Wyoming currently ranks eleventh in the nation for overall installed wind capacity and has the eighth highest potential wind energy resources.[3,4] National drivers such as a production tax credit* and the Department of Energy "20% Wind Energy by 2030" goal, combined with state renewable portfolio targets, have advanced the wind energy market and its pace of development.

Wind is regarded as a "green energy" resource because it does not directly produce carbon dioxide or other air pollutants, uses minimal amounts of water, and is renewable. However, like other forms of industrial development, it is not without potential impacts to habitats and wildlife populations. Wind facilities, with their associated human activity and infrastructure—including access roads, meteorological towers, transmission lines, and power substations—can affect wildlife directly through habitat loss and turbine collisions and indirectly through habitat displacement or avoidance.[24] In Wyoming, excellent wind resources often coincide with sagebrush steppe and mixed- and short-grass prairies that provide habitat to a number of species, including those of conservation concern, such as the greater sage-grouse, black-footed ferret, pygmy rabbit, and mountain plover, and important game species, including pronghorn, mule deer, and elk.[52]

Approximately 10 percent of Wyoming's wind resources with development potential has been utilized.[72] Consistent, strong wind continues to attract wind energy developers to

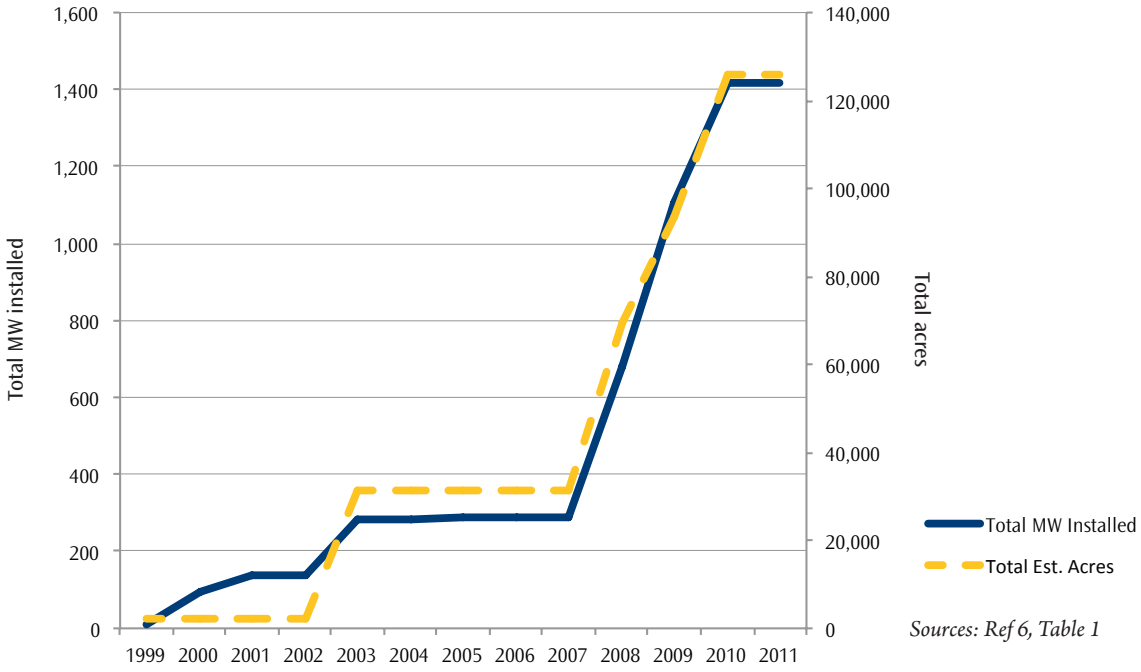


Figure 1. Wind Energy Capacity Growth in Wyoming (cumulative megawatts and acreage; 1999–2011). Development is slowing due to a lack of transmission capacity, restrictions within Sage-Grouse Core Areas, and uncertainty surrounding federal tax credits.

* The wind energy production tax credit of $0.022 per kilowatt-hour is set to expire at the end of 2012; if Congress does not renew the tax credit, the pace of wind development will likely slow.

Table 1. Existing Wind Projects in Wyoming, 2012 (> 5 turbines).

Project (Developer)	Year Online	County	Land Type	Size (MW)	Project Area (Acres)
Top of the World (Duke Energy)	2010	Converse	State/ private	200	18,090
Wyoming Wind Energy Center (Orion Energy)	2003	Uinta	State/ private	144	28,800
Mountain Wind I and II (Edison Mission Group)	2008	Uinta	Private	140	Unknown
High Plains & McFadden Ridge (PacifiCorp)	2009	Albany & Carbon	State/ private	128	11,000
Seven Mile Hill I and II (PacifiCorp)	2008	Carbon	State/ private	119	14,000
Dunlap I (PacifiCorp)	2010	Carbon	State/ private	111	14,600 (Stages I and II)
Campbell Hill (Three Buttes Windpower)	2009	Converse	Private	99	10,500
Rolling Hills (PacifiCorp)	2009	Converse	Private	99	Same land as Glenrock
Glenrock (PacifiCorp)	2008	Converse	Private	99	14,000
Foote Creek Rim I and III (SeaWest)	1999	Carbon	BLM/state/ private	66	2,090+
Rock River (SeaWest)	2001	Albany	Private	50	Unknown
Silver Sage (Duke Energy)	2009	Laramie	Private	42	1,600
Glenrock III (PacifiCorp)	2009	Converse	Private	39	Same land as Glenrock
Happy Jack (Duke Energy)	2008	Laramie	City (Cheyenne)	29	750
Foote Creek Rim IV (SeaWest)	2000	Carbon	BLM/state/ private	17	Unknown
Casper Wind Farm (Chevron Global Power)	2009	Natrona	Private	17	880
Totals				**1,400**	**116,300+**

Sources: Refs. 7–15, 69–70

Wyoming. Up to 8,500 megawatts (MW) of wind development—or roughly six times the state's 2011 installed capacity—are in various planning stages in the state.†

These proposed projects could span over 550,000 acres, or 860 square miles (Table 2). While previous wind energy development in Wyoming has occurred primarily on private and state lands, the majority of all proposed projects include federal lands managed by the Bureau of Land Management (BLM; Figure 2).

It is important to note that the actual facilities and associated infrastructure will be located on smaller footprints within the total project areas given in Tables 1 and 2.[22] Research done by the National Renewable Energy Laboratory found that direct impacts to land from turbines, access roads to turbines, substations, and transmission associated with wind facilities ranged from 0.15 acres/MW to almost 6.0 acres/MW, with over 80 percent of projects assessed directly impacting < 1.0 acre/MW. The majority of these direct impacts are from roads;[73] the study did not calculate indirect impacts.

As more wind projects are constructed, the effects wind facilities may have on wildlife are increasingly a concern. Mitigation for impacts to wildlife and habitat from wind development is an emerging field and is not well defined. This primer draws from scientific, working and statutory knowledge to provide a survey of current mitigation practices for wind energy projects—both in Wyoming and outside the state—and explore what might be next for wildlife mitigation and wind.

---

† However, in addition to the uncertainties surrounding the federal production tax credit, a need for transmission expansion and relatively recent Wyoming policies that include the Sage Grouse Core Areas and a wind-energy generation tax, may mean that some of these projects are not built in the near-term, if ever (Ref. 3).

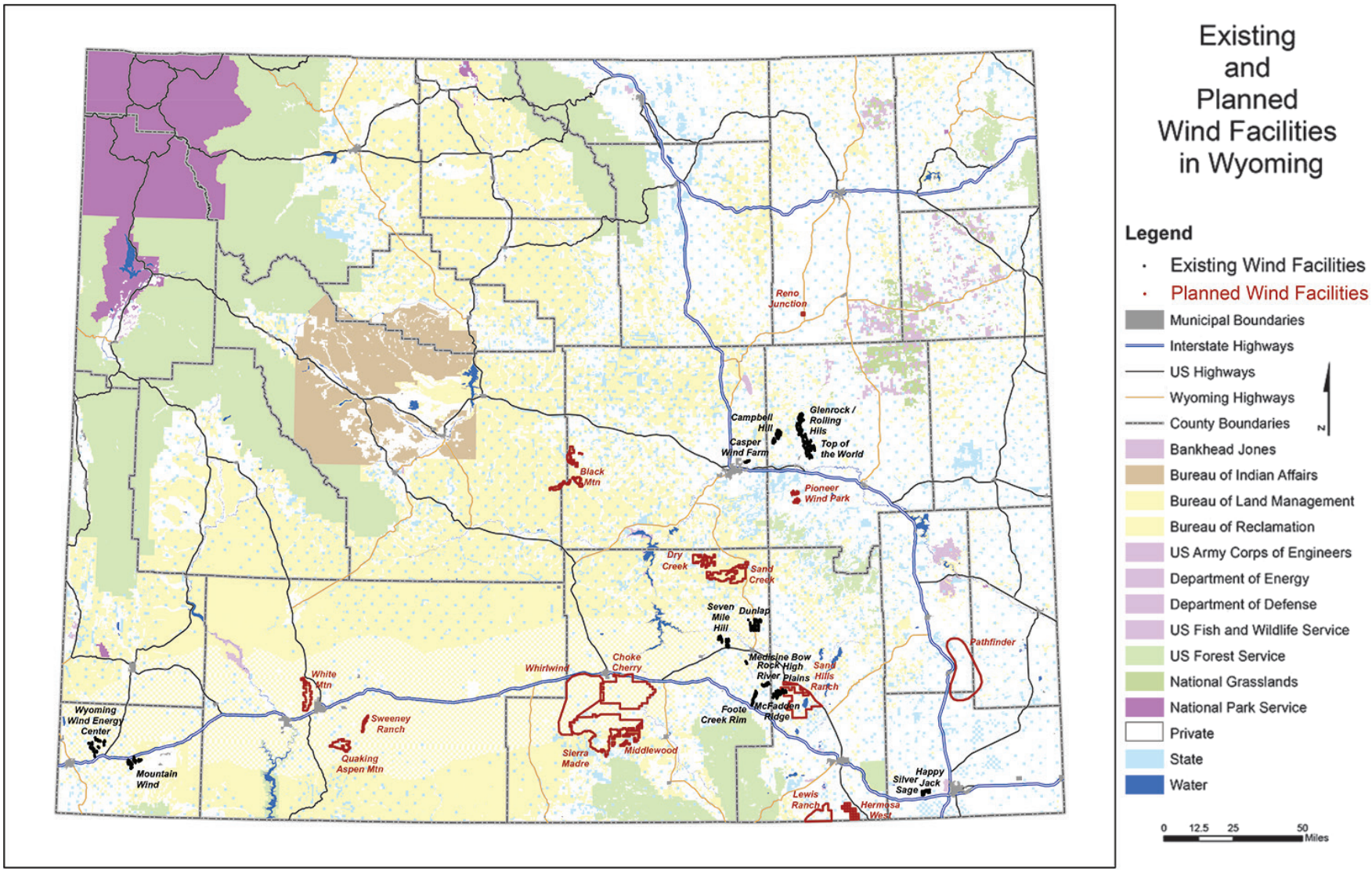
Table 2. Proposed Wind Projects in Wyoming, August 2012.

Project (Developer)	County	Land Type	Size (MW)	Project Area (Acres)
Sierra Madre/ Chokecherry Wind Farm Project (Power Company of Wyoming)	Carbon	BLM/state/ private	2,000–3,000	215,000
Sand Creek Wind Project (Big Wind Power Co.)	Carbon	Mostly BLM	1,000	Unknown
Whirlwind I (Pathfinder and Wold Companies)	Carbon	BLM/state/ private	400–700	65,000
Wheatland Wind Project (GreenHunter Energy Inc.)	Platte	BLM	600	20,000
Middlewood Wind Power Project (Eurus Middlewood Wind)	Carbon	BLM/state/ private	530	30,000
Chugwater Flats Energy Project I and II (Novelution Wind)	Platte/ Goshen	Private	440	8,040
White Mountain Wind Farm (Teton Wind)	Sweetwater	BLM/state/ private	360	13,150
Dry Creek Wind Power Project (Eurus Dry Creek)	Carbon	BLM	350	3,530
Hermosa West Wind Energy Project (Shell Wind Energy)	Albany	State/ private	300	11,125
Sweeney Ranch Wind Park (Wasatch Wind Development)	Sweetwater	BLM/private	270	9,700
Lewis Ranch Wind Energy Project (Ridgeline Energy)	Albany	State/ private	200	22,850
Dunlap II (PacifiCorp)	Carbon	State/ private	189	See Table 1 Dunlap I
Black Mountain Wind Energy Facility (Black Mountain Wind Park)	Natrona	BLM/state/ private	100–150	3,990
Reno Junction Wind Energy Project (Third Plant Windpower)	Campbell	State/ Private	150	Unknown
Quaking Aspen Wind Energy Project (Evergreen Wind Power Partners)	Sweetwater	BLM/state/ private	100	7,650
Pioneer Wind Park I and II (Wasatch Wind)	Converse	State/ private	99	31,370
Sand Hills Ranch Wind Energy Project (Shell Wind Energy)	Albany	BLM/private	50	4,700
Pathfinder I (Pathfinder Renewable Wind Energy)	Platte	State/ private	Unknown	90,000
Totals			**6,190*–8,490+**	**510,505*–550,205+**

* Lower end of range excludes the projects currently on hold.

Note: Shaded rows indicate that the project is on hold.

Sources: Refs. 5, 16–23, 80–82, 93–96, M. Fraley, pers. comm.



Sources: Ref. 6, Table 1

Map made by Scott Lieske of the Wyoming Geographic and Information Science Center and University of the Sunshine Coast, Australia.

Figure 2. Existing and Planned Wind Projects in Wyoming (2012).

II. Wind and Wildlife

As the wind industry is relatively young, there are few data regarding the impacts of facility construction and operation on most species of wildlife besides birds and bats. Studies to date have primarily focused on effects on raptors, songbirds, and bats, particularly their risk of turbine collision.[24,25,87,100] For other animals, such as large game species, small mammals, ground-nesting birds, amphibians, reptiles, and insects, studies of wind facility impacts are in their infancy. Indirect impacts, such as the implications of habitat fragmentation and disturbance from wind development, have also received little study. There are, however, studies underway in Wyoming on sage-grouse, pronghorn antelope, elk, and invertebrates, that seek to fill in some of the gaps in understanding.[82,83]

Direct Impacts

Wind turbines directly impact wildlife primarily through collisions.[100] Collision risks for birds and bats depend on a variety of factors, including a facility's location (e.g., its relationship to migratory pathways or ridgelines), turbine layout (e.g., alignment), turbine characteristics (e.g., size and rotor speed), lighting (e.g., level of attraction for nocturnal migrants), weather (e.g., visibility and wind speed), the types of species and numbers using a site, and use characteristics (e.g., diurnal or seasonal behavior).[26] Given these considerations, direct impacts from wind facilities are site and region specific.

Research has shown that songbirds, in particular nocturnal migrants, suffer the highest mortality from wind turbine collision and account for approximately 60 percent of all bird deaths from wind facilities.[15,24,27] Deaths tend to spike during migratory seasons, typically spring and fall.

Despite higher mortality rates for songbirds, wind facilities have not been found responsible for any population-level declines of songbird populations.[98] Songbird mortality from wind turbine collisions is thought to be far less than mortality from other sources of impact, such as buildings and windows, house cats, and high-tension lines.[74] Raptor collisions, though not as numerous as songbird collisions, may have greater population-level effects, as raptors are longer-lived species with lower reproductive potential and cannot recover from population decreases as quickly.[24]

Recent research has revealed that more bats may collide with wind turbines than birds, particularly at wind facilities near forested ridges.[27] Bats may also experience trauma from the rapid air pressure changes of rotating wind blades, which may cause internal organ damage, termed barotrauma.[101] Most bat fatalities occur at night during late summer and early fall migrations and among tree-roosting species.[28] Bat fatalities also occur more on nights with low wind speeds (< 6 meters/second) and before and after storm fronts move through an area.[28] Like raptors, bats are long-lived species that have a low reproductive rate, making them more susceptible to population-scale impacts from mortality increases.[28]

Indirect Impacts

Wind facilities, including their associated infrastructure and human activity, can also cause indirect impacts, which are later in time or farther removed in distance than the impact.[71] Examples of indirect impacts to wildlife include avoidance of an area, reduced nesting/breeding density, habitat abandonment, and other behavioral effects.[25] Indirect impacts

from wind facilities are poorly understood, though the adverse impacts to wildlife from construction and road traffic are well documented (see, for example, Refs. 75 and 90).

Indirect impacts are of most concern for ground-nesting birds like the greater sage-grouse, which are known to avoid tall structures and be sensitive to human presence.[91,92] Though specific effects of wind energy on sage grouse are not fully studied, the birds are known to react negatively to anthropogenic disturbance.[24,26,90] Data from the first study undertaken to evaluate the short-term impacts to greater sage-grouse distribution from wind energy development in southeast Wyoming suggest that sage-grouse did not avoid wind turbines during nesting and brood-rearing periods, and that the birds occupied habitats closer to turbines during the summer at the study site.[79,82] It is possible this is because of the high site fidelity sage-grouse exhibit—similar studies have shown disturbance to manifest itself in greater sage-grouse populations two to ten years after oil and gas development began.[29] In addition to displacement, the first Wyoming sage-grouse study monitored fitness and survival and found increased risk of sage-grouse nest and brood failure at locations closest to wind turbines, particularly within 1 kilometer of a turbine pad.[82] It will be important to conduct additional studies at wind facilities that span multiple generations of grouse to discern long-term trends.[29]

Uncertainties

There are a number of unknowns surrounding how wildlife species react to the presence of wind infrastructure—scientific studies on wind–wildlife impacts are sparse and evolving. Impacts on small mammals, ungulates, and other non-avian species are little studied, nor are there comprehensive studies on possible cumulative impacts of wind facilities on wildlife.[25] Even within some of the better-studied taxa, such as birds and bats, population-level effects of fatalities are poorly understood.[25] As science advances understanding of how wildlife responds to the presence of wind turbines, study results will continue to inform mitigation strategies.

III. The Mitigation Hierarchy and Wind Energy Development

Mitigation is generally defined as: (1) avoiding impacts when possible; (2) minimizing remaining impacts; and (3) compensating for unavoidable impacts.[1,30,31] This definition represents a hierarchy for mitigation activities: first seek to avoid and minimize impacts, and then compensate for impacts that do occur (Figure 3). Regulators and wind developers across the United States have thus far focused on implementing avoidance and minimization measures to prevent or lessen impacts to wildlife and have less experience in the area of compensatory mitigation. The U.S. Fish and Wildlife Service (USFWS) prioritizes on-site mitigation (within the project planning area) over off-site mitigation activities, and off-site activities near the project area and within the same ecological region are prioritized over those farther away.[33] The USFWS does recognize, however, that there are some off-site projects that could result in a greater net benefit to a target species, and it recommends that wind energy developers consult with the Service on a case-by-case basis to determine appropriate mitigation activities.[33]

Avoidance

Altamont Pass in California is an example of how poor siting of wind facilities can adversely impact wildlife, particularly birds. Constructed in the mid-1980s, before any industry best practices were outlined,[33,52,61] this wind facility is responsible for between 1,770 and 4,720 bird deaths each year, of which between 880 and 1,300 are raptors.[32] Altamont Pass helped illuminate that proper siting and facility design are the most effective ways to avoid and reduce impacts to wildlife, lessening the need for additional mitigation (see Appendix I for example avoidance measures).

Siting

For most projects, site characterizations are undertaken prior to permitting and construction. Ideally, data collected during this development stage inform a project design that optimizes exposure to wind resources while avoiding significant impacts to birds, bats,

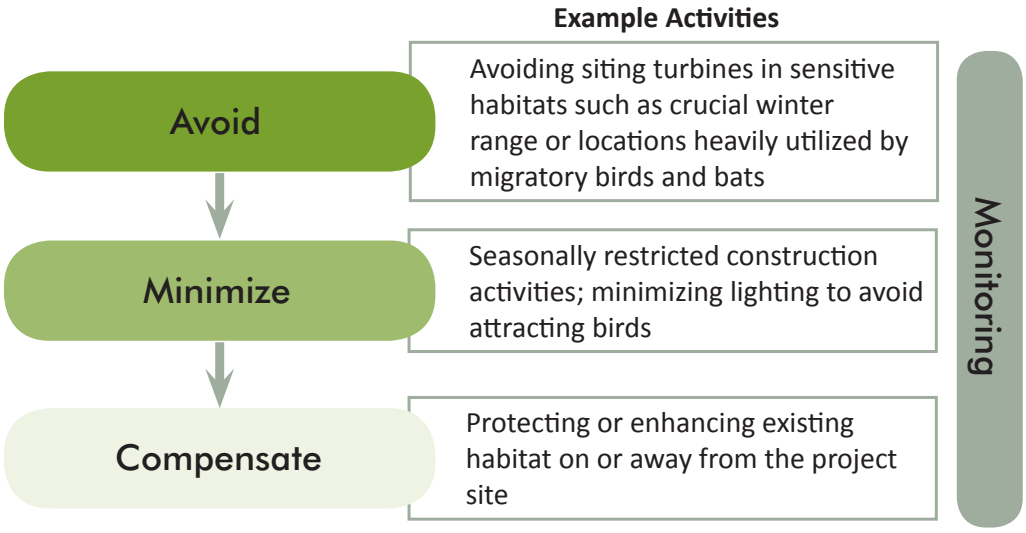
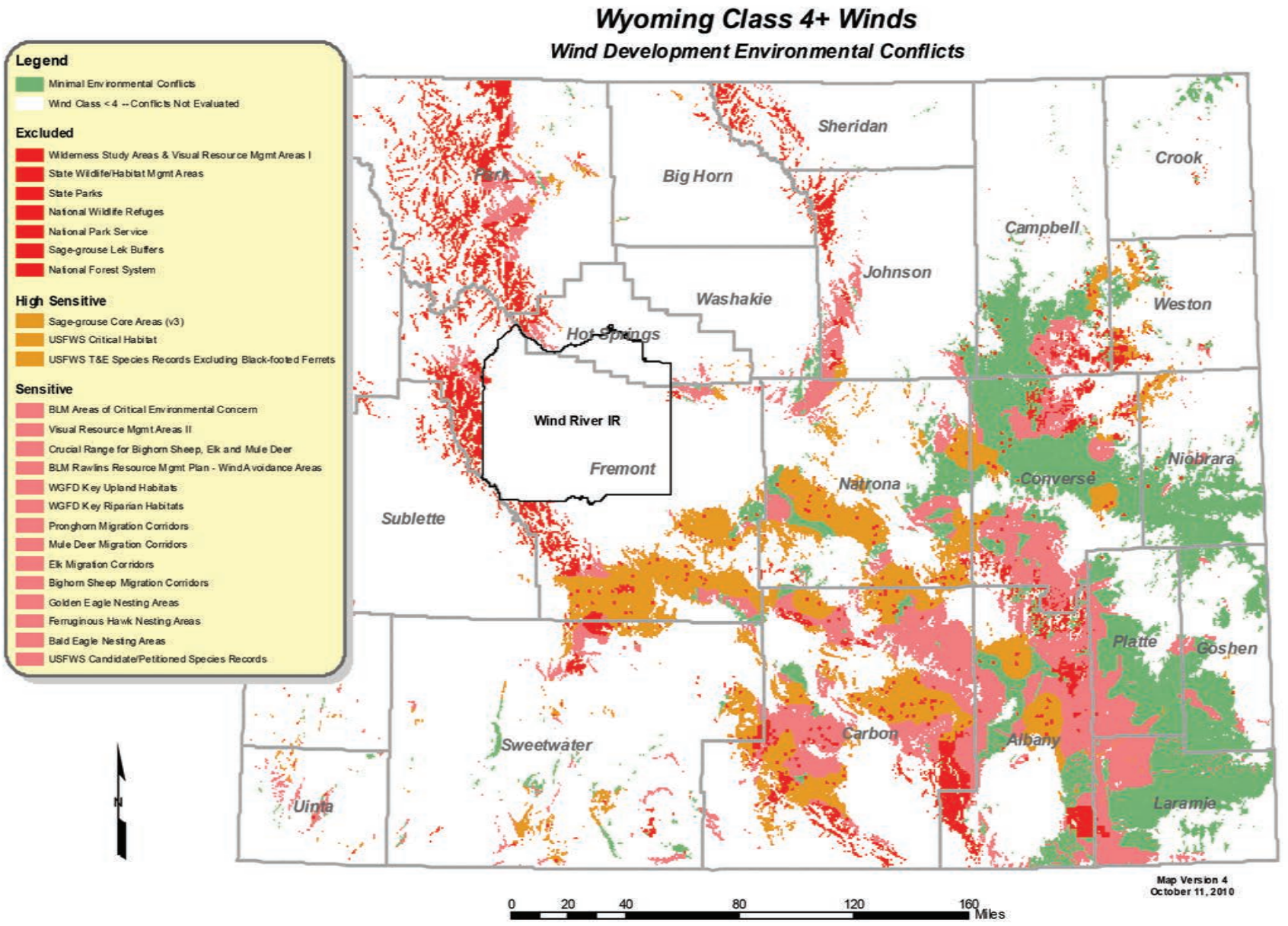


Figure 3. The Mitigation Hierarchy.



Source: Ref. 103

Figure 4. Wind Energy and Sensitive Habitats in Wyoming (2010 data).

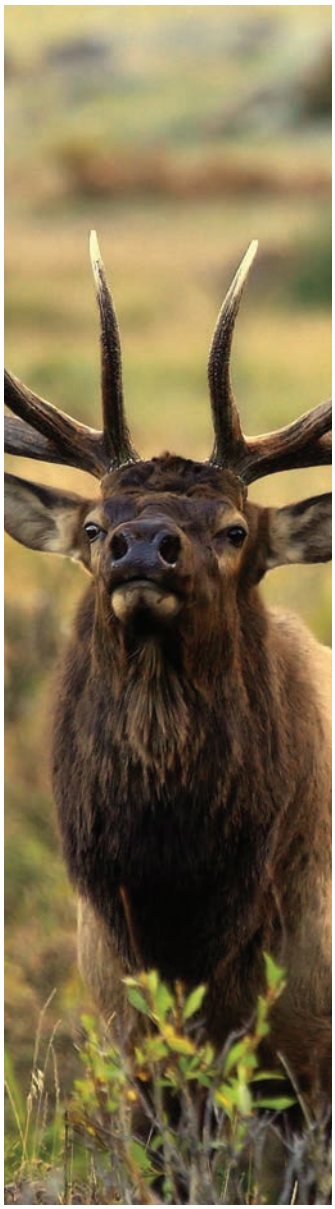
and other wildlife.[33] Macro-level siting considerations include avoiding flyways and wildlife migration corridors; features that attract raptors or other birds, such as ridgelines and an abundant prey base; and targeting previously disturbed or agricultural lands.[34,65] Micro-level siting can include creating buffer zones for special habitats located in the project area or placing individual turbines in ways that avoid specific areas of high bird and bat use.[35]

Though federal and/or state permit applications often do not explicitly require baseline data collection of bird and bat presence and crucial habitat areas, such as winter range for big game animals, the USFWS and Wyoming Game and Fish Department (WGFD) recommend that project developers undertake baseline studies and provide permitting authorities with projected site-specific and cumulative impacts to wildlife and measures to reduce or mitigate impacts. The WGFD, for example, requests two years of pre-construction data followed by three years of post-construction data for birds, bats, raptors, and some sensitive species and big game if vital habitat is involved (such as winter range).[52]

Placing Areas Off-Limits to Development

Making rare, unique, or sensitive habitats off-limits for development is also an avoidance measure. The State of Wyoming, for example, has established Sage Grouse Core Areas where wind energy development is "not recommended."[37] Though the state's Core Area policy is not legally enforceable outside of state lands, it may be difficult if not impossible to get a permit from state or county authorities for a facility in a Core Area unless there is "clear demonstration from the project proponent that the activity will not cause a decline in sage grouse populations."[77] Approximately 28 percent of developable wind resources in Wyoming are located in Sage Grouse Core Areas,[38] and all projects proposed in designated Core Areas have been put on hold.[18]

Wind developers also may want to avoid other ecologically rare or intact habitats that are not formally protected, such as Audubon Important Bird Areas, vital and/or irreplaceable habitats identified in the WGFD's Mitigation Policy, or sensitive landscapes identified in the Biodiversity Conservation Alliance's wind energy siting guide (Figure 4).[33,39,65] Federal agencies also recognize that there are unique areas where wind energy may not belong, and the BLM discourages wind project siting on or near "Areas of Critical Environmental Concern," including Wilderness Study Areas, Wild and Scenic Rivers, and National Historic and Scenic Trails.[40]

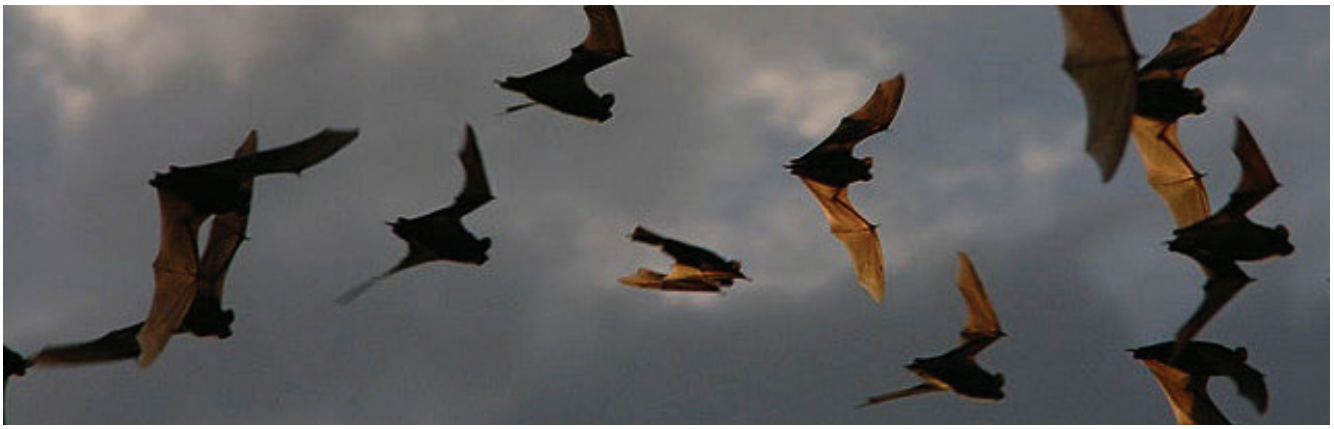


Minimization

After avoiding impacts, the next step of the mitigation hierarchy is minimizing impacts to wildlife. This can occur through seasonal construction restrictions, lighting decisions, use of wildlife deterrents, and other practices (see Appendix I for specific examples). In extreme cases, when other mitigation activities are ineffective and do not reduce fatalities, removing problem turbines or seasonal curtailment are last resort minimization measures, though these practices have not yet occurred in Wyoming.[35]

Seasonal Stipulations

Seasonal restrictions on construction activities are a common practice for minimizing the impacts to wildlife from industrial-scale development. These stipulations seek to lessen impacts to wildlife during sensitive times of the year, such as breeding season or winter. Seasonal stipulations come from a number of sources, including state wildlife agencies, federal management agencies, and from voluntary efforts. Seasonal restrictions generally apply only to construction activities and not during the operational phase of a wind facility, meaning their efficacy is limited compared to other avoidance or minimization measures that are in place throughout the lifetime of the wind facility.



Turbine Design

Turbine design can also help minimize impacts to wildlife. First-generation turbines often had lattice tower structures that attracted perching birds and were smaller and therefore sited close together. Newer wind turbines are set on tubular towers that provide little to no perching or nesting structures. Turbines are also increasingly larger and therefore rotor revolutions have decreased, though the tip speed of blades are similar to past speeds, averaging 135–180 miles per hour. These larger turbines are spaced farther apart, possibly giving birds more opportunities to avoid them. However, their wider and longer blades may have a greater impact on bats, because they create more air turbulence and vortices.[25] It is unclear how much turbine design advances—rather than improved siting practices—have been responsible for reductions in bird collisions.[36]

Curtailment

If an unanticipated and significant number of fatalities are detected at an operating wind facility, one way to minimize impacts is to curtail wind production during times of high bird or bat occurrence (e.g., seasonal migration). Bat fatalities occur most often during migration seasons and on nights with low wind speeds, so increasing the lowest speed at which turbines begin rotating (the "cut-in" speed) during bat migrations has been shown to significantly decrease mortality. [41,42]

The wind industry is just beginning to experiment with curtailment, and a wind facility in Texas was the first in the United States to begin real-time monitoring of bird migration to inform turbine shutdown. The facility has an avian-detection radar system that searches for large flocks of migratory birds, and the turbines are set to automatically shut down if the radar system detects a significant level of birds during low-visibility weather conditions.[33] Other facilities in California also plan to experiment with avian detection systems, and developers of the Ocotillo Wind Energy Facility have even proposed having a biologist onsite in a specially designed observation tower 24 hours a day to provide an additional layer of detection for migrating birds.[85,97,99]

Compensation

Thus far, regulators and the wind industry have focused on the first two aspects of the mitigation hierarchy—avoiding and minimizing impacts to wildlife—and have not often addressed compensation for impacts that do occur. It is possible that this is because there is little regulatory structure requiring or guiding compensation for wind–wildlife impacts. Some wind projects across the country have engaged voluntarily in offsetting impacts to

wildlife (Table 3), though this has not yet occurred in Wyoming.

Table 3. Wind Projects With Compensatory Mitigation (2012).

Project (Developer)	Location	Compensatory Mitigation
Shiloh Wind Plant Project (enXco)	California	• Purchased $1.4 M in conservation bank credits
Meridian Way Wind Farm (Horizon)	Kansas	• Funding provided for 20,000 acres of grassland habitat restoration, with 13,000 acres put under conservation easement
Horse Creek Wind Farm (Iberdrola)	New York	• Project plans include restoration of 249 acres of grassland habitat and working with local landowners to maintain grassland habitat through annual late season mowing regimes
OU Spirit Wind Energy Project (OG&E)	Oklahoma	• Paid $3.75 M to OK Department of Wildlife Conservation for lesser prairie-chicken habitat development
Elkhorn Valley Wind Power Project (Horizon)	Oregon	• Improved range and installed wildlife-friendly fencing around 300 acres of big game habitat immediately adjacent to project area • Replaced shrub-steppe and riparian habitat at a 2:1 replacement to disturbance ratio
Rattlesnake Road Wind Power Project (Horizon)	Oregon	• Purchased 120 acres of conservation easement off-site
Wheat Field Wind Power Project (Horizon)	Oregon	• Purchased 80 acres of conservation easement off-site
West Butte Wind Project (West Butte Wind LLC)	Oregon	• Operators upgrading 11 power poles per year within a 10-mile radius of the wind facility to reduce avian mortality • Provided funding for the restoration and enhancement of 9,000 acres of sage grouse habitat on BLM-administered public lands • Provided funds to the county for conservation easement purchases for sage grouse management
Kingdom Community Wind Project (Green Mountain Power)	Vermont	• Purchased 2,700 acres of conservation easement
Read Oak Knob/Tamarack Ridge Wind Facility (Highland New Wind)	Virginia	• Pre-established replacement costs for each individual of a species killed (e.g., $1,000/northern harrier) • Compensatory mitigation costs capped at $50,000, or 0.85% of prior year's total revenue
Big Horn Wind Power Project (Iberdrola)	Washington	• Established 455-acre conservation site south of wind development
Wild Horse Wind Power Project (Horizon)	Washington	• Established 600-acre parcel within the project site for habitat restoration • Followed Washington Department and Fish and Wildlife mitigation replacement ratios of 1:1 for grasslands and 2:1 for shrub-steppe habitat • Helped fund conservation easement

Sources: Refs. 43–46, 85

DEFINITIONS

Mitigation bank: A site, or suite of sites, where resources (e.g., wetlands, streams, riparian areas) are restored, established, enhanced, and/or preserved for the purpose of providing compensatory mitigation for impacts authorized by Army Corps of Engineers permits. In general, a mitigation bank sells compensatory mitigation credits to permittees who have an obligation to provide compensatory mitigation.

Conservation bank: A conservation bank is a parcel of land containing natural resource values that are conserved and managed in perpetuity, through a conservation easement held by an entity responsible for enforcing the terms of the easement, for specified [Endangered Species Act] listed species and used to offset impacts occurring elsewhere to the same resource values on non-bank lands.

Refs. 47 and 76

Replacement Habitat and Habitat Restoration

The most common form of compensatory mitigation for wind energy development is purchasing replacement habitat—outright or through conservation easement—to offset impacts to damaged habitats or species. This form of off-site mitigation can target areas such as nesting and breeding areas, foraging habitat, roosting or wintering areas, migratory rest areas, and habitat corridors and linkages.[35] Habitat can also be restored or enhanced on- or off-site to compensate for impacts. Ideally, protected sites should have a biological value equal to or higher than the impacted acreage.[35] Often, this type of mitigation occurs in a replacement to disturbed habitat ratio, that is, a certain number of acres are protected or restored for every one that is disturbed. The BLM, for example, applies a 3:1 (mitigation to disturbance) acreage ratio for some of its natural gas projects in Wyoming.[84]

Mitigation/Conservation Banks

In addition, mitigation or conservation banks are another form of compensatory mitigation. Mitigation banks have been used to comply with Section 404 of the Clean Water Act, which requires compensation for impacts to wetlands. Under this system, wetlands are restored, established, enhanced, and/or preserved, generating credits that can be purchased to compensate for unavoidable impacts to other wetlands.[47] Clean Water Act guidelines stipulate that developers can only purchase credits from a site within the same watershed.

Conservation banks utilize the same fundamental principles of a mitigation bank, but seek to offset unavoidable impacts to habitats of threatened or endangered species.[76] Habitats for species at risk of being listed as threatened or endangered under the Endangered Species Act are also eligible to be part of a conservation bank.[43] Like mitigation banks, units for conservation banks are most often acres of habitat. The USFWS determines the geographic area that conservation bank credits may include on a case-by-case basis through considering the transferability of physical and ecological systems and species/population distributions, among other criteria.[43,48]

A unique feature of the mitigation/conservation banking approach is that the ecological benefits of an offset have already occurred, or are "in the bank"; other compensatory mitigation activities, such as conservation easement purchases, do not necessarily have to document or quantify ecological benefits. Guidance for the appropriate use of species or habitat banking in the context of wind energy development is needed, however, for these tools to be effective for the wind industry. Specifically, it is unclear how banking systems would apply to impacted species that are not subject to special protections, and there are few metrics to help determine the biological suitability of a mitigation credit for a species or habitat impacted by wind development (see Box 1).[35]

In-lieu Fees

In-lieu fees are a method used to fund compensatory mitigation. Under this model, developers pay a fee to a government agency or non-profit that uses the funds to engage in activities that offset project impacts.[43] The State of Washington and Oklahoma Department of Fish and Wildlife currently have in-lieu fee programs for wind energy developers in place (Table 5).[43,50] The funds of the Jonah Interagency Office (JIO) and Pinedale Anticline Project Office (PAPO), which organize mitigation activities and monitoring for natural gas development in western Wyoming, are accrued through in-lieu fees.

Photo by Rob Wallace

BOX 1: PATHFINDER MITIGATION BANK

In May 2012, the Sweetwater River Conservancy submitted an umbrella agreement prospectus to the U.S. Army Corps of Engineers (USACE) that outlines plans to create mitigation and conservation banks on 99,145 deeded acres of central Wyoming's Pathfinder Ranch and neighboring properties in Natrona and Carbon Counties. These would be the first mitigation and conservation banks in Wyoming.

To create mitigation and conservation bank credits, the ranch owners plan to improve riparian areas and wildlife habitat. The USACE would then document the wetland and riparian habitat improvements and make those credits available for purchase by other developers responsible for impacts in the same Geographic Service Area (dictated by watershed boundaries). The U.S. Fish and Wildlife Service (USFWS) would be responsible for documenting and administering conservation bank credits for habitat or species of conservation concern. The developers state that habitat for threatened, endangered, or candidate species occurs within the proposed conservation bank areas, including for the greater sage-grouse, black-footed ferret, blowout penstemon, Canada lynx, and Ute ladies' tresses. The Geographic Service Areas for the conservation banks would be determined on a case-by-case basis, and guidelines are less clear than for wetland banks for how these would be established.

The conservation and mitigation bank proponents plan to sell credits to other energy developers and use them to cover impacts from proposed wind farms they are planning in Platte and Carbon Counties. While the wind development sites and offset sites are both technically in the same North Platte River watershed, some have questioned the transferability between impacts that would occur in Platte County and offsets that would occur, for example, at different elevations and habitats on the opposite side of the Laramie Range—a location approximately 140 miles away. Ultimately, if the conservation and mitigation banks are approved, it will be up to the USACE and USFWS to determine the geographic area to which offsets apply.

The Sweetwater River Conservancy plans represent a first attempt at compensatory mitigation banking in Wyoming, and it is likely that this project will set a precedent for what kind of off-site and compensatory mitigation measures will be available in the state for years to come.

Source: Refs. 49, 86, M. Fraley, pers. comm.

Monitoring

Wind operators are often required to undertake studies to assess a facility's impacts on wildlife, primarily those on birds and bats. The USFWS recommends searching periodically for carcasses beneath turbines for at least one year, and often for two to three more years, particularly if projects are located near endangered species or bald or golden eagle habitats.[33] Wind projects in Wyoming undertake sage-grouse monitoring for two years prior to construction and three years after operation begins.[52] Monitoring data then can be benchmarked against baseline data gathered during site characterization to determine impacts. Adaptive management strategies ideally allow for operators to respond if monitoring shows unintended impacts and additional mitigation measures are needed.[33]

In the past, experimental design and data collection protocols for baseline studies and monitoring of wind projects have been inconsistent, making it difficult to compare results across projects and aggregate impacts.[24] Before-and-after control-impact (BACI) studies that incorporate pre-and post-construction data as well as control sites are considered the most rigorous method for assessing wind farm impacts, and comprehensive studies also include sampling protocols that address scavenging and searcher efficiency biases.[24] As the industry gains more experience, best practice guidelines for wind–wildlife monitoring design continue to be refined.[33,50,51]

IV. Triggers and Guidelines for Wind Mitigation Activities in Wyoming

Mitigation Triggers

While oil and gas projects almost always involve federal minerals and/or federal surface lands, all wind development in Wyoming other than one project[+] has occurred on private or state lands. Therefore, permits (and mitigation requirements) have been issued on a state or county level. The wind industry is starting to move toward siting facilities on federal lands, however, where they may be required to engage in more widespread mitigation activities.

Federal Mitigation Triggers

Of all new commercial wind energy projects proposed in Wyoming, nearly 70 percent include federal lands (Table 2). Any wind development sited on federal lands or connecting to federal transmission must go through the National Environmental Policy Act (NEPA) Environmental Assessment (EA)/Environmental Impact Statement (EIS) process. The EA or the Record of Decision from the EIS identifies avoidance, minimization, and compensation measures the developer plans to undertake (Table 4).

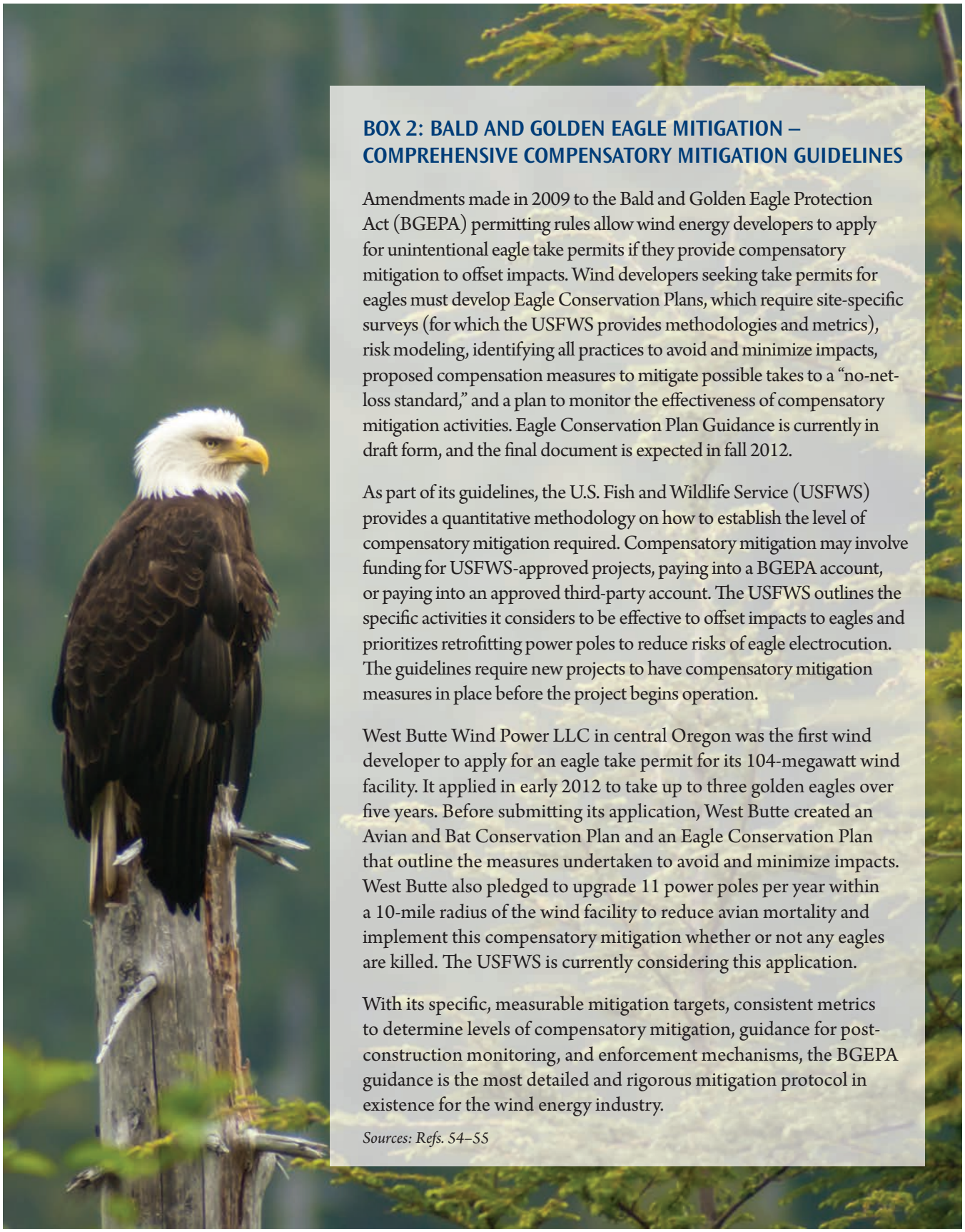
The BLM manages all federal lands in Wyoming currently under consideration for wind energy development. For wind development, the BLM requires a right-of-way (ROW) permit application. Part of the application, the Plan of Development, must include "design criteria" mitigation measures that protect natural resources, including wildlife.[40,53] In its wind energy development guidance memorandum, the BLM references compensatory mitigation and notes that it may be necessary for some wind energy projects, but as with oil and gas development, it is not required.[40]

Mitigation can be required under the Endangered Species Act (ESA) or Clean Water Act, if the project affects endangered species or wetlands. Some developers are seeking to address Section 9 of the ESA, which makes it unlawful to "take" an endangered species, through regional Habitat Conservation Plans (HCPs) that provide for conservation of threatened or endangered species while allowing some degree of "incidental take." One such HCP covers Great Plains states from North Dakota to Texas and addresses wind energy development's impacts to multiple species, including whooping cranes and lesser prairie chickens.[88]

The Bald and Golden Eagle Protection Act (BGEPA) is another federal statute that triggers wind project mitigation activities, and recent amendments to its permitting rules allow for compensatory mitigation after all avoidance and minimization measures are undertaken. The USFWS Draft Eagle Conservation Plan Guidance[31] outlines quantitative methodology to assess whether there is a need for mitigation and/or the amount of mitigation required. The guidelines represent perhaps the most rigorous existing mitigation protocol in the United States (see Box 2).

Though the Migratory Bird Treaty Act (MBTA) does not explicitly require mitigation, it often motivates significant avoidance and minimization measures, including the creation of Avian Protection Plans (see Box 3). This act prohibits any "takes," or the killing, harassing, or disturbing, of migratory birds.[43] The MBTA does not have any permitting requirements, but developers who follow the USFWS Land-Based Wind Energy Development Guidelines are less likely to be prosecuted under the act.[33,43] As of yet, no wind operators have been prosecuted under the act.

+ Foote Creek Rim facility, which was built in 1999.



BOX 2: BALD AND GOLDEN EAGLE MITIGATION – COMPREHENSIVE COMPENSATORY MITIGATION GUIDELINES

Amendments made in 2009 to the Bald and Golden Eagle Protection Act (BGEPA) permitting rules allow wind energy developers to apply for unintentional eagle take permits if they provide compensatory mitigation to offset impacts. Wind developers seeking take permits for eagles must develop Eagle Conservation Plans, which require site-specific surveys (for which the USFWS provides methodologies and metrics), risk modeling, identifying all practices to avoid and minimize impacts, proposed compensation measures to mitigate possible takes to a "no-net-loss standard," and a plan to monitor the effectiveness of compensatory mitigation activities. Eagle Conservation Plan Guidance is currently in draft form, and the final document is expected in fall 2012.

As part of its guidelines, the U.S. Fish and Wildlife Service (USFWS) provides a quantitative methodology on how to establish the level of compensatory mitigation required. Compensatory mitigation may involve funding for USFWS-approved projects, paying into a BGEPA account, or paying into an approved third-party account. The USFWS outlines the specific activities it considers to be effective to offset impacts to eagles and prioritizes retrofitting power poles to reduce risks of eagle electrocution. The guidelines require new projects to have compensatory mitigation measures in place before the project begins operation.

West Butte Wind Power LLC in central Oregon was the first wind developer to apply for an eagle take permit for its 104-megawatt wind facility. It applied in early 2012 to take up to three golden eagles over five years. Before submitting its application, West Butte created an Avian and Bat Conservation Plan and an Eagle Conservation Plan that outline the measures undertaken to avoid and minimize impacts. West Butte also pledged to upgrade 11 power poles per year within a 10-mile radius of the wind facility to reduce avian mortality and implement this compensatory mitigation whether or not any eagles are killed. The USFWS is currently considering this application.

With its specific, measurable mitigation targets, consistent metrics to determine levels of compensatory mitigation, guidance for post-construction monitoring, and enforcement mechanisms, the BGEPA guidance is the most detailed and rigorous mitigation protocol in existence for the wind energy industry.

Sources: Refs. 54–55

Table 4. Federal Mitigation Triggers for Wind Energy Development.

Clean Water Act (CWA)	Authority is designated under Section 404 of CWA to mitigate for impacts to wetlands. This process uses a watershed approach for mitigation site selection.
Endangered Species Act (ESA)	Section 7 of the ESA requires the USFWS to consider one-time and cumulative effects of federal agency actions on threatened and endangered species and their habitats, and authorizes the imposition of requirements to minimize the impacts of authorized takes; Section 10 authorizes "taking" of threatened or endangered species if a Habitat Conservation Plan is developed that will minimize *and mitigate* impacts of the taking. [emphasis added]
Federal Land Policy and Management Act (FLPMA) Right-of-Way (ROW) Permitting	A Plan of Development, which accompanies a ROW permit application to the Bureau of Land Management (BLM), must include "design criteria" mitigation measures that protect natural resources, including wildlife. This information is used for the NEPA analysis.
National Environmental Policy Act (NEPA)	Environmental impact statements or environmental assessments generated under the NEPA process must identify potential measures to mitigate identified impacts. NEPA offers pathways both for the permitting agency to identify mitigation measures and for the project developer to offer mitigation measures. Wind projects on federal lands or connecting to federal transmission must undertake a NEPA assessment.
Bald and Golden Eagle Protection Act (BGEPA)	Wind developers can now apply for eagle take permits, which require development of Eagle Conservation Plans in which an applicant outlines avoidance and minimization measures. Recent amendments to permitting rules allow for compensatory mitigation after all avoidance and minimization measures are undertaken.
Migratory Bird Treaty Act (MBTA)	Though this law does not require mitigation activities, to avoid prosecution under the MBTA wind energy developers often implement a number of avoidance and minimization measures to reduce potential for collisions, including creating Avian Protection Plans.

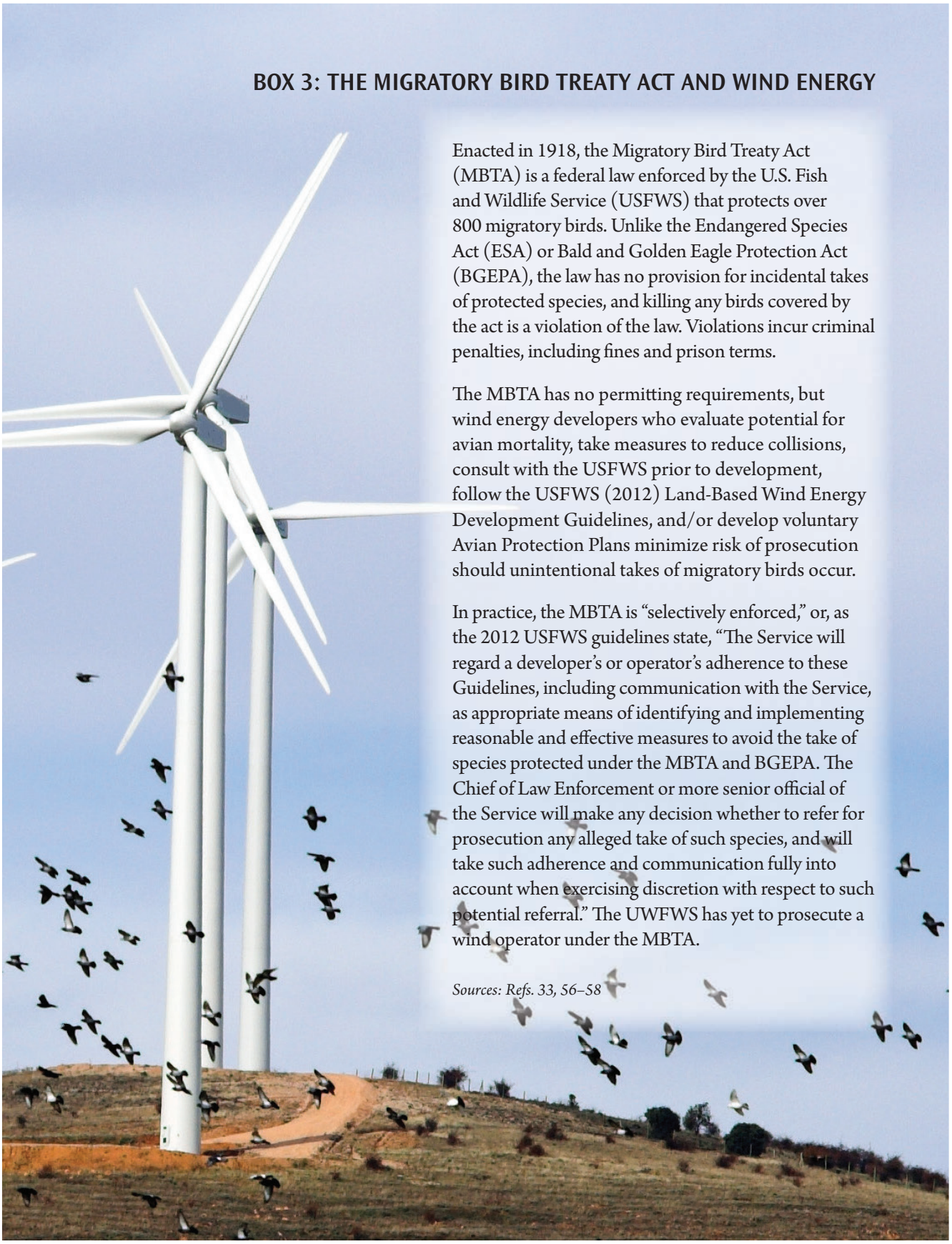
Sources: Refs. 1, 31, 40, 53

State-Level Mitigation Triggers

In Wyoming, if a wind facility is ≥ 30 turbines and occurs on private and/or state lands, wildlife mitigation activities are outlined in the project's permit from the Department of Environmental Quality (DEQ) Industrial Siting Division. State regulations require wind project developers to evaluate terrestrial, aerial, and aquatic impacts to wildlife. Project developers also are highly encouraged to consult with the WGFD prior to submitting permits. WGFD provides monitoring protocols for wildlife species and siting considerations through its Wildlife Protection Recommendations for Wind Energy Development in Wyoming.[52]

Rule I § 7(k)(i) of the DEQ Industrial Siting permitting guidance, "Controls and Mitigation Measures," states that project applicants must explain ways they will try to avoid endangering wildlife and any controls or mitigation measures they are planning that would alleviate adverse effects. However, the guidance provides no information on acceptable levels of impact or how the amount of mitigation should be determined. For wind facilities on private land permitted through the DEQ, a Technical Advisory Committee is formed, which

BOX 3: THE MIGRATORY BIRD TREATY ACT AND WIND ENERGY



Enacted in 1918, the Migratory Bird Treaty Act (MBTA) is a federal law enforced by the U.S. Fish and Wildlife Service (USFWS) that protects over 800 migratory birds. Unlike the Endangered Species Act (ESA) or Bald and Golden Eagle Protection Act (BGEPA), the law has no provision for incidental takes of protected species, and killing any birds covered by the act is a violation of the law. Violations incur criminal penalties, including fines and prison terms.

The MBTA has no permitting requirements, but wind energy developers who evaluate potential for avian mortality, take measures to reduce collisions, consult with the USFWS prior to development, follow the USFWS (2012) Land-Based Wind Energy Development Guidelines, and/or develop voluntary Avian Protection Plans minimize risk of prosecution should unintentional takes of migratory birds occur.

In practice, the MBTA is "selectively enforced," or, as the 2012 USFWS guidelines state, "The Service will regard a developer's or operator's adherence to these Guidelines, including communication with the Service, as appropriate means of identifying and implementing reasonable and effective measures to avoid the take of species protected under the MBTA and BGEPA. The Chief of Law Enforcement or more senior official of the Service will make any decision whether to refer for prosecution any alleged take of such species, and will take such adherence and communication fully into account when exercising discretion with respect to such potential referral." The UWFWS has yet to prosecute a wind operator under the MBTA.

Sources: Refs. 33, 56–58

includes members from the Industrial Siting Division, the developer, WGFD, USFWS, consultants, and landowners. The committee typically convenes once a year to provide ongoing review of the project and discuss impacts. If needed, the committee develops mitigation options that may apply to various phases of the project lifecycle, including operation, future phases of construction, and decommissioning. In addition, if a project is on private land, WGFD has a process for creating Landowner Conservation Plans where the affected landowner(s), WGFD, and the developer establish a cooperative plan to minimize wildlife impacts while protecting landowner interests.[52]

County-Level Mitigation Triggers

For wind energy projects with < 30 turbines on private and state lands in Wyoming, permitting occurs at the county level. The Wyoming Wind Facilities Act establishes minimum standards for wind permitting in Wyoming's counties. The act requires project developers to, "provide a detailed summary of any significant adverse environmental…effects that the proposed wind energy facility may have together with any preliminary plans developed to alleviate any of the adverse effects." If county commissioners feel they do not have the expertise to address environmental issues that the project poses, the act also authorizes them to refer permitting for the wind facility to the DEQ Industrial Siting Council.

Nine counties in Wyoming have commercial wind energy permitting requirements written into land-use plans or zoning regulations that go beyond those in the Wyoming Wind Facilities Act.* While most of these county-level plans do not address mitigation directly, some allow county commissioners to require mitigation measures where necessary, determined on a case-by-case basis. Only Lincoln and Sweetwater Counties explicitly require a mitigation plan that addresses impacts to wildlife.[59,60]

Guidelines for Mitigation Activities

Relative to oil and gas development, there are few standard mitigation practices for wind energy development. As the industry matures and expands, best management practices and guidelines will continue to be developed.

Federal Guidelines

Federal guidelines available for wind developers in Wyoming include:

- *U.S. Fish and Wildlife Service (USFWS) Land-Based Wind Energy Guidelines*[33]: Voluntary guidelines that primarily focus on avoidance, minimization, and monitoring. Applies to all commercial wind energy projects. Though the guidelines are voluntary, the USFWS states that, "If a violation occurs the Service will consider a developer's documented efforts to communicate with the Service and adhere to the Guidelines."
- *BLM Final Programmatic EIS on Wind Energy Development on BLM-Administered Land in the Western United States*[61]: Analyzes mitigation measures, but only considers avoidance and minimization. Applies to projects on BLM lands.
- *BLM Best Management Practices for Wind Developers*[40]: Provides similar avoidance and minimization measures that are outlined in the Programmatic EIS. Applies to projects on BLM lands.

* These are: Albany, Carbon, Converse, Laramie, Lincoln, Natrona, Park, Platte, and Sweetwater Counties. For links to these wind energy regulations, visit: http://wyomingrenewables.org/index.php/renewable-energy/wind/utility-scale-wind/landownerwindguide/#county%20level%20regs.

- *Wyoming BLM Standard Mitigation Guidelines for All Surface Disturbing and Disruptive Activities*[62]: Provides Wyoming-specific avoidance and minimization measures (e.g., avoidance of 25 percent slopes, construction prohibited when soil is frozen or saturated) for all development on BLM lands. Applies to projects on BLM lands in Wyoming.

- *BLM Resource Management Plans:* Dictate any mitigation measures specific to a BLM region (e.g., the Rawlins Field Office Resource Management Plan outlines wind energy exclusion and avoidance areas and other region-specific avoidance and minimization measures that apply to surface development). Apply to projects on BLM lands.

State Guidelines

At the state level, the WGFD "Wildlife Protection Recommendations for Wind Energy Development in Wyoming" provide site selection, seasonal restriction, and monitoring recommendations for wind energy developers.[52] However, the recommendations say little about offsetting impacts of wind facilities, or compensatory mitigation, stating, "current research is inadequate to determine the level of impact by wind energy development for most species of wildlife."[52] The guidelines do state that if monitoring of wind facilities constructed in "vital" habitats (those that contain species of greatest conservation need, big game crucial habitat, wetlands, and blue ribbon streams) detects population declines, WGFD will recommend a mitigation plan that outlines an appropriate mitigation strategy, which may include compensatory mitigation.[52]

Other state-level siting or mitigation guidelines may provide insights for future wind energy mitigation activities in Wyoming (Table 5).

Other Voluntary Guidelines

Some non-governmental organizations offer mitigation guidelines for wind facilities that project developers in Wyoming can reference. These mostly focus on avoidance (siting) and minimization measures:

- *Wind Power in Wyoming: Doing it Smart from the Start*[65]: Biodiversity Conservation Alliance publication that outlines Wyoming-specific considerations for siting and development and identifies priority areas for development; includes maps of areas with special land designations, ecoregional conservation plans, sensitive habitats, high concentrations of birds of prey, bat habitat, sage grouse and sharp-tailed grouse habitat, and big game ranges and migration corridors.

- *Wind Energy: Doing it Right in Wyoming*[89]: Recommended best management practices for wind energy development in Wyoming from the Wyoming Outdoor Council that covers measures for avoidance, siting, pre-and post-construction surveys, and minimization.

- *National Wind Coordinating Council Toolbox*[36]: Compilation of mitigation policies, guidelines, and research for direct and indirect impacts on wildlife caused by wind power facilities.

- *Southern Plains Wind and Wildlife Planner*[66]: Set of voluntary best-management practices to be used in siting and building wind farms in Colorado and New Mexico.

- *Natural Resources Defense Council Clean Energy in the Western U.S. Google Earth Application*[102]: A mapping tool that shows boundaries for protected areas that development should avoid and important bird areas.

Table 5. Wind Mitigation Activities in Other States.

State	Author	Title	Description
Arizona	Arizona Game and Fish Department	Guidelines for Reducing Impacts to Wildlife from Wind Energy Development in Arizona	• Primarily details how to assess potential impacts to wildlife • References National Wind Coordinating Collaborative avoidance and minimization measures as go-to best practices (Ref. 36) • Outlines acceptable compensatory mitigation practices, including funding wildlife studies, off-site conservation of essential habitat, and off-site habitat restoration or enhancement • States that "mitigation is site- and species-specific, and must be formulated for each individual project"
California	California Energy Commission & California Department of Fish and Game	Guidelines for reducing Bird and Bat Impacts from Wind Energy Development	• Provides suggestions for site selection, turbine layout, and developing facility infrastructure • Offers operation-stage mitigation measures • Like AZ, states that "compensation amount and metrics are site- and species-specific and must be formulated for each individual project" • Provides list of off-site (compensatory) mitigation measures to consider, including off-site conservation of essential habitat and off-site habitat restoration or enhancement
Kansas	Kansas Renewable Energy Working Group	Siting Guidelines for Windpower Projects in Kansas	• Primarily provides guidance on siting • Establishes that if significant ecological damage results from siting, developers should consider mitigation for habitat loss, including ecological restoration, long-term management agreements, and conservation easements
Oklahoma	Oklahoma Department of Wildlife Conservation	Lesser Prairie-Chicken Spatial Planning Tool	• Quantifies value of each acre of habitat in the lesser prairie-chicken's range • Determines areas where development would least impact prairie chickens • Provides estimate for voluntary in-lieu fee when wind projects impact prairie-chickens • Identifies priority areas for mitigation efforts
Oregon	Oregon Department of Fish and Wildlife	Wildlife Habitat Mitigation Policy	• Categorizes habitat on a scale of 1–6, with 1 being "irreplaceable, essential and limited," and 6 being habitat that has "low potential to become essential or important habitat" • Establishes mitigation goals for each category of habitat and preferred strategies to avoid or mitigate impacts • Applies to all large development projects, not just wind energy • Note: this policy only applies to wind energy projects that are >104 MW; all smaller projects are permitted through local-level siting processes

Table 5. Wind Mitigation Activities in Other States (continued).

State	Author	Title	Description
Washington	Washington Department of Fish and Wildlife	Wind Power Guidelines	• Stipulates that developers should target disturbed lands and use existing transmission corridors and roads • Establishes compensatory mitigation ratios for categories of habitat differentiated by quality • Defines characteristics of replacement habitat • Distinguishes between temporary and permanent impacts • Includes in-lieu fee option for developers to pay a negotiated amount that will be put into state-determined mitigation projects • Prioritizes supporting stewardship of "high-value" habitat in the same ecological region as the project for in-lieu fee

Sources: Refs. 35–36, 43, 50, 52, 63–64

V. Future Approaches to Compensatory Mitigation for Wind Energy

Development by Design

Researchers at The Nature Conservancy have generated a landscape-scale approach to mitigation that maps the state's energy resources against high-quality habitat and determines what areas developers may choose to avoid to minimize impacts, as well as areas that can be developed with least impact. This model, "Development by Design," represents methodical conservation planning that considers the possible cumulative impacts of wind development while allowing for mitigation activities to target species or habitats of concern.[67]

Researchers applied this methodology to wind energy development in Kansas, looking at the overlap between wind resources and high-priority conservation targets, identified as key habitats, umbrella species, imperiled species, and congregation areas for wildlife that may be at risk from wind facilities. They then calculated the ecological footprint of wind turbines for specific sites and quantified impacts that would need to be offset. They were also able to calculate the amount of offsets needed and associated costs of offsets based on the type of habitat impacted, and input the information into a model that establishes priority sites for compensatory mitigation activities.[68]

Species-Specific Conservation

In 2010, the Oklahoma Department of Wildlife Conservation developed the Oklahoma Lesser Prairie-Chicken Spatial Planning Tool, which maps areas of high wind potential against lesser prairie-chicken habitat and quantifies the value of each acre of habitat. In addition to helping determine suitability of a site's development, the tool can help wind developers calculate the appropriate level for voluntary contributions (in-lieu fees) to the Lesser Prairie-Chicken Habitat Conservation Fund and identify priority sites for restoration and recovery efforts. These funds can be used to buy land, purchase conservation easements,

or fund conservation practices such as fence removal, tree removal, planting native grasses, or prescribed burning. The prairie-chicken planning tool is an example of species-specific mitigation planning that first seeks to avoid and minimize impacts and then provides clear guidelines for compensatory mitigation.[64]

VI. Conclusion

The renewable energy industry—often operating on a smaller scale than other forms of energy development and on private lands—has less experience with mitigation activities relative to more mature energy industries. Though some best practice avoidance and minimization mitigation measures have been developed, there are few studies that assess the effectiveness of wind mitigation practices, and fewer still that address appropriate metrics and options for compensatory mitigation or when compensatory mitigation is or is not appropriate. Wildlife mitigation experiences in other sectors, such as the natural gas industry, can help inform wind energy mitigation practices, as fragmentation and disturbance are common to both industries; other wildlife mitigation practices will be specific to the wind industry.

With its abundant wildlife populations and strong wind resources, Wyoming is ideal territory to explore the effectiveness of wildlife mitigation measures both on- and off-site for a number of species. Landscape-scale planning to strategically outline areas where development should be avoided, prioritize mitigation activities, and address cumulative impacts from wind development also likely will be crucial for working toward mitigating impacts from wind facilities on wildlife.

References

1. A. Jakle, 2012, *Natural Gas Development and Wildlife Mitigation in Wyoming: A Primer* (Laramie, Wyoming: Ruckelshaus Institute of Environment and Natural Resources).

2. American Wind Energy Association (AWEA), 2011, Industry statistics, available at: http://www.awea.org/learnabout/industry_stats/index.cfm.

3. AWEA, 2012, Wind energy facts: Wyoming (January), available at: http://www.awea.org/_cs_upload/learnabout/publications/6425_4.pdf.

4. National Renewable Energy Laboratory (NREL), 2010, Estimates of windy land area and wind energy potential by state for areas – 30 percent capacity factor at 80 m, available at: http://www.windpoweringamerica.gov/docs/wind_potential_80m_30percent.xls.

5. Bureau of Land Management (BLM), 2011a, Environmental Assessment: Sand Hills Wind Energy Facility, Albany County, Wyoming, available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/rfodocs/sandhills-wind.Par.78999.File.dat/EA.pdf.

6. U.S. Energy Information Administration (EIA), 2011, Table 4: Electric power industry capability by primary energy source, 1990 through 2010 (megawatts), available at: http://www.eia.gov/electricity/state/wyoming.

7. AWEA, 2010, U.S. Wind Energy Projects – Wyoming, available at: http://archive.awea.org/projects/Projects.aspx?s=Wyoming.

8. CH2M Hill, 2007a, Wyoming Industrial Development Information and Siting Act, Section 109 permit application, Glenrock Wind Energy Project and Rolling Hills Wind Energy Project (November), available at: http://deq.state.wy.us/isd/downloads/Glenrock%20ISA%20Final_11-25-07.pdf.

9. CH2M Hill, 2007b, Wyoming Industrial Development Information and Siting Act, Section 109 permit application, Seven Mile Hill Wind Energy Project (November), available at: http://deq.state.wy.us/isd/downloads/Seven_Mile_Hill_%20ISA_FINAL_11-16-07.pdf.

10. CH2M Hill, 2008, Wyoming Industrial Development Information and Siting Act, Section 109 permit application, High Plains and McFadden Ridge Wind Energy Project (July), available at: http://deq.state.wy.us/out/downloads/High_Plains_ISA_All_Sections_(070708).pdf.

11. CH2M Hill, 2009a, Wyoming Industrial Development Information and Siting Act Section 109 Permit Application, Dunlap Wind Energy Project, available at: http://deq.state.wy.us/isd/downloads/Dunlap_ISA_FINAL.pdf.

12. CH2M Hill, 2009b, Wyoming Industrial Development Information and Siting Act Section 109 Permit Application, Top of the World Wind Project, available at: http://deq.state.wy.us/isd/downloads/ToWorld%20Application%209-21-09.pdf.

13. Duke Energy, 2012, Duke Energy renewables – wind energy, available at: http://www.duke-energy.com/commercial-renewables/wind-energy.asp.

14. Rocky Mountain Power, 2010, Rocky Mountain Power Wyoming wind projects (October), available at: http://www.rockymountainpower.net/content/dam/rocky_mountain_power/doc/About_Us/Newsroom/2190-14_RMP_WYWindProjects_Flyer_v2.pdf.

15. Western EcoSystems Technology, Inc. (WEST, Inc.), 2003, Final report: Avian and bat mortality associated with the initial phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming (10 January).

16. BLM, 2011b, Notice of Intent to Prepare an Environmental Impact Statement for the Quaking Aspen Wind Energy Project, Wyoming, and Notice of Segregation of Public Lands, *Federal Register* 76: 69279–69281.

17. BLM, 2011c, Draft EIS, Chokecherry and Sierra Madres Wind Energy Project, Appendix C: Summary of BLM environmental constraints, applicant committed measures, applicant committed best management practices, and proposed mitigation measures, available at: http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/Chokecherry.html.

18. BLM, 2011d, NEPA Hotsheet: BLM Wyoming land use planning and projects (December), available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA.Par.24843.File.dat/hot_sheet.pdf.

19. BLM, 2010a, Environmental Assessment for the White Mountain Wind Energy Project, Sweetwater County, Wyoming (February), available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/rsfodocs/whitemtn-wind/ea.Par.93226.File.dat/02EA.pdf.

20. BLM, 2010b, Scoping notice: Sweeny Ranch Wind Park, available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/rsfodocs/sweeney-wind.Par.53282.File.dat/scoping_notice.pdf.

21. Wyoming State Lands Board, 2011, Consideration of wind energy lease application, available at: http://slf-web.state.wy.us/osli/BoardMatters/2011/0811/D-12.pdf.

22. Wasatch Wind, 2011, Wyoming Industrial Development Information and Siting Act Section 109 permit application: Pioneer Wind Park I and Pioneer Wind Park II (January), available at: http://deq.state.wy.us/isd/downloads/Permit%20Application%20Wasatch.pdf.

23. Novelution Wind, 2010, Projects: Chugwater Flats Energy Project (CREP), available at: http://www.novelutionwind.com/chugwater_flats.html.

24. W.P. Kuvlesky, Jr., L.A. Brennan, M.L. Morrison, K.K. Boydston, B.M. Ballard, and F.C. Bryant, 2007, Wind energy development and wildlife conservation: challenges and opportunities, *Journal for Wildlife Management* 71: 2487–2498.

25. National Wind Coordinating Committee (NWCC), 2010, Wind turbine interactions with birds, bats, and their habitats: A summary of research results and priority questions, available at: www.nationalwind.org.

26. A.L. Drewitt and R.H.W. Langston, 2006, Assessing the impacts of wind farms on birds, *Ibis* 148: 29–42.

27. D.E. Naugle, 2011, *Energy Development and Wildlife Conservation in Western North America* (Washington, DC: Island Press).

28. E.B. Arnett and 13 others, 2008, Patterns of bat fatalities at wind energy facilities in North America, *Journal of Wildlife Management* 72(1): 61–78.

29. G. Johnson and M. Holloran, 2010, Greater sage-grouse and wind energy development: A review of the issues (14 April).

30. U.S. Environmental Protection Agency (EPA) and U.S. Army Corps of Engineers (USACE), 1990, Memorandum of agreement between the Department of the Army and the Environmental Protection Agency: The determination of mitigation under the Clean Water Act Section 404(b)(1) guidelines, available at: http://water.epa.gov/lawsregs/guidance/wetlands/mitigate.cfm.

31. U.S. Fish and Wildlife Service (USFWS), 2011a, Draft Eagle Conservation Plan guidance (January), available at: http://www.fws.gov/windenergy/docs/ECP_draft_guidance_2_10_final_clean_omb.pdf.

32. K.S. Smallwood, and C.G. Thelander, 2004, Developing methods to reduce bird mortality in the Altamont Pass Wind Resource Area, Final Report by BioResource Consultants to the California Energy Commission, Contract No. 500-01-019, 363 p.

33. USFWS, 2012a, U.S. Fish and Wildlife Service land-based wind energy guidelines (23 March), available at: http://www.fws.gov/windenergy/docs/WEG_final.pdf.

34. J.M. Kiesecker and eight others, 2011, Win-win for wind and wildlife: A vision to facilitate sustainable development, *PLoS ONE* 6(4): e17566.

35. California Energy Commission (CEC), 2007, California guidelines for reducing impacts to birds and bats from wind energy development (October), available at: http://www.energy.ca.gov/windguidelines/index.html.

36. NWCC, 2007, Mitigation toolbox (May), available at: http://www.nationalwind.org/assets/publications/Mitigation_Toolbox.pdf.

37. State of Wyoming, 2011, Sage Grouse Core Area Executive Order, available at: http://www-wsl.state.wy.us/sis/wydocs/EO2011-05.pdf.

38. D. Strickland, 2009, Current Sage Grouse Research, presentation at the Wyoming Wind Symposium, Laramie, Wyoming, 13 August.

39. Wyoming Game and Fish Department (WGFD), 2008, Mitigation (17 November), available at: http://gf.state.wy.us/web2011/Departments/Wildlife/pdfs/WGFC_MITIGATION_POLICY0001532.pdf.

40. BLM, 2008a, Instructional Memorandum 2009-043: Wind energy development policy, available at: http://www.blm.gov/wo/st/en/info/regulations/Instruction_Memos_and_Bulletins/national_instruction/2009/IM_2009-043.print.html.

41. E.F. Baerwald, J. Edworthy, M. Holder, and R.M.R. Barclay, 2009, A large-scale mitigation experiment to reduce bat fatalities at wind energy facilities, *Journal of Wildlife Management* 73: 1077–1081.

42. E.B. Arnett, M.M.P. Huso, M.R. Schirmacher, and J.P. Hayes, 2010, Altering turbine speed reduces bat mortality at wind-energy facilities, *Frontiers in Ecology and the Environment* 9(4): 209–214.

43. A. Davis, T. Weis, K. Halsey, and D. Patrick, 2009, Enabling progress: compensatory mitigation scenarios for wind energy projects in the U.S., Report prepared for the American Wind Wildlife Institute (AWWI), 17 September.

44. Horizon Wind Energy, n.d., Horizon habitat mitigation projects, available at: http://www.horizonwindfarms.com/western-region/documents/under-dev/antelope-ridge/asc/attachments/D3%20Habitat%20Mitigation%20Projects.pdf.

45. BLM, 2011e, West Butte Wind Power Project fact sheet, available at: http://www.blm.gov/pgdata/etc/medialib/blm/wo/MINERALS__REALTY__AND_RESOURCE_PROTECTION_/energy/priority_projects.Par.2571.File.dat/West_Butte_fact_sheet.pdf.

46. D. Staples, 2011, Wind power project generates clashes, *Rutland Herald* (25 December), available at: http://energizevermont.org/2011/12/rutland-herald-wind-power-project-generates-clashes.

47. USACE and EPA, 2008, Compensatory mitigation for losses of aquatic resources; Final Rule, *Federal Register* (10 April), available at: http://www.epa.gov/owow/wetlands/pdf/wetlands_mitigation_final_rule_4_10_08.pdf.

48. USFWS, 2011b, Conservation banking: incentives for stewardship, available at: http://www.fws.gov/endangered/esa-library/pdf/conservation_banking.pdf.

49. G. Nickerson, 2011, Banking on the environment: Pathfinder developers hope to offset impacts of energy development, *WyoFile* (30 August), available at: http://wyofile.com/2011/08/banking-on-the-environment-pathfinder-developers-hope-to-offset-impacts-of-energy-development.

50. Washington Department of Fish and Wildlife (WDFW), 2009, Washington Department of Fish and Wildlife wind power guidelines (April), available at: http://wdfw.wa.gov/publications/00294/wdfw00294.pdf.

51. NWCC, 2011, Comprehensive guide to studying wind energy/wildlife interactions, available at: http://www.nationalwind.org//publications/comprehensiveguide.aspx.

52. WGFD, 2010, Wildlife protection recommendations for wind energy development in Wyoming, available at: http://gf.state.wy.us/downloads/pdf/April%2023%202010%20Commission%20Approved%20Wind%20Recommendations.pdf.

53. BLM, 2008b, Wind energy plan of development, available at: http://www.blm.gov/pgdata/etc/medialib/blm/wo/Information_Resources_Management/policy/im_attachments/2009.Par.10750.File.dat/IM2009-043_att2.pdf.

54. USFWS, 2012b, Permit request considered for West Butte Wind Project, available at: http://us.vocuspr.com/Newsroom/Query.aspx?SiteName=FWS&Entity=PRAsset&SF_PRAsset_PRAssetID_EQ=129243&XSL=PressRelease&Cache=True.

55. 50 CFR 22.26.

56. USFWS, 2003a, Service interim guidance on avoiding and minimizing wildlife impacts from wind turbines (13 May), available at: http://www.fws.gov/habitatconservation/wind.pdf.

57. J.A. McKinsey, 2007, Regulating avian impacts under the Migratory Bird Treaty Act and other laws: the wind industry collides with one of its own, the environmental protection movement, *Energy Law Journal* 78: 71–92.

58. M.B. Lilley and J. Firestone, 2008, Wind power, wildlife, and the Migratory Bird Treaty Act: a way forward, *Environmental Law* 38: 1167–1214.

59. Lincoln County Government, 2011, Land use regulations, Chapter 6: Development Standards, available at: http://www.lcwy.org/departments/planning/documents/index.php.

60. Sweetwater County Government, 2006, Resolution 06-07-PZ-01: Sweetwater County wind farm zoning regulations, available at: http://www.sweet.wy.us/pz/Language_Amendments/Adopted_Wind_Farm_Regulations.pdf.

61. BLM, 2006, Wind energy final programmatic Environmental Impact Statement (EIS), available at: http://windeis.anl.gov/documents/fpeis/index.cfm.

62. BLM, n.d., Wyoming BLM standard mitigation guidelines for all surface disturbing and disruptive activities, available at: www.blm.gov/pgdata/etc/medialib/blm/wy/wildlife/baldeagle.Par.4022.File.dat/be-appa.pdf.

63. Arizona Game and Fish Department, 2009, Guidelines for reducing impacts to wildlife from wind energy development in Arizona (May), available at: http://www.azgfd.gov/hgis/documents/FinalAZWindGuidelinesMay2009.pdf.

64. Oklahoma Department of Wildlife Conservation (ODWC), 2010, A spatially-based planning tool designed to reduce negative effects of development on the lesser prairie-chicken in Oklahoma (March), available at: http://www.wildlifedepartment.com/spatial_planning/OK_LEPC_Model_Description_02222010.pdf.

65. Biodiversity Conservation Alliance, 2008, Wind power in Wyoming: Doing it smart from the start (November), available at: http://www.worldwildlife.org/what/wherewework/ngp/WWFBinaryitem11026.pdf.

66. Colorado Renewable and Conservation Collaborative (CRCC), 2012, Southern Plains wind and wildlife planner, available at: http://www.pljv.org/windandwildlife/index.php.

67. J.M. Kiesecker, H.E. Copeland, A. Pocewicz, and BA McKenney, 2010, Development by design: Blending landscape-level planning with the mitigation hierarchy, *Frontiers of Ecology and the Environment* 8: 261–266.

68. B. Obermeyer, R. Manes, J. Kiesecker, J. Fargione, and K. Sochi, 2011, Development by design: mitigating wind development's impacts on wildlife in Kansas, *PLoS ONE* 6(10): e26698.

69. Chevron, n.d., Casper Wind Power Project Frequently Asked Questions, available at: http://www.chevron.com/documents/pdf/casperwindfaq.pdf.

70. D. Anderton, 2003, Wyoming's new day: wind power – Utah planning to promote similar electricity source, *Deseret Morning News* (7 November).

71. 40 CFR 1508.

72. Wyoming Wind Collector and Transmission Task Force, 2009, Report to the Legislative Task Force on Wind Energy Transmission Sub-Committee (9 October).

73. P. Denholm, M. Hand, M. Jackson, and S. Ong, 2009, Land-use requirements of modern wind power plants in the United States, Technical report of the National Renewable Energy Laboratory (August), available at: http://www.nrel.gov/docs/fy09osti/45834.pdf.

74. W.P. Erickson, G.D. Johnson, M.D. Strickland, D.P. Young Jr., K. Sernka, and R. Good, 2001, Avian collisions with wind turbines: A summary of existing studies and comparisons to other sources of avian collision mortality in the United States (Washington, DC: Resolve, Inc.).

75. R.T. Forman, and L.E. Alexander, 1998, Roads and their major ecological effects, *Annual Review of Ecology and Systematics* 29: 207–231.

76. USFWS, 2003b, Guidance for the establishment, use and operation of conservation banks (2 May), available at: http://www.fws.gov/endangered/esa-library/pdf/Conservation_Banking_Guidance.pdf.

77. WGFD, 2009, Wyoming Game and Fish Commission position on Sage Grouse Core Areas and wind farm siting (9 August), available at: http://wgfd.wyo.gov/web2011/Departments/Wildlife/pdfs/WINDENERGY_SGCOREAREAS0000705.pdf.

78. BLM, 2010c, BLM Wyoming 2010 Annual Report, available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/annualreports.Par.59860.File.dat/2010anrpt.pdf.

79. G.D. Johnson, C.W. LeBeau, R. Nielsen, T. Rintz, J. Eddy, and M. Holloran, 2012, Greater sage-grouse habitat use and population demographics at the Simpson Ridge Wind Resources Area, Carbon County, Wyoming, Report prepared for EDF Renewables (17 April), available at: http://www.osti.gov/bridge/servlets/purl/1037739/1037739.pdf.

80. BLM, 2012, NEPA hotsheet, Spring quarter 2012, available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA.Par.24843.File.dat/hot_sheet.pdf.

81. TetraTech, Inc., n.d., Project description (Hermosa West Wind Energy Project), available at: http://ww2.wapa.gov/sites/western/transmission/interconn/Documents/hermosawest/ProjectDescription.pdf.

82. C. LeBeau, 2012, Evaluation of Greater Sage-Grouse Reproductive Habitat and Response to Wind Energy Development in South-Central, Wyoming, Masters Thesis, University of Wyoming (August).

83. C. Peterson, 2012, Wyoming researchers study impact of wind farms on antelope, elk, *Casper Star Tribune* (8 January).

84. BLM, 2008c, Record of Decision—Final Supplemental Environmental Impact Statement for the Pinedale Anticline Oil and Gas Exploration and Development Project (September).

85. Iberdrola Renewables, Inc., 2011, Avian and Bat Protection Plan: 2010 annual report (4 April), Portland, Oregon: Iberdrola Renewables.

86. Trout Headwaters, Inc., 2012, Sweetwater River Conservancy Conservation and Mitigation Bank Umbrella Agreement Prospectus (May 1), available at: http://www.nwo.usace.army.mil/html/od-rwy/pn/SRCumbrella.pdf.

87. NREL, n.d., Wind–Wildlife Impacts Literature Database WILD, available at: http://www.nrel.gov/wind/wild.html.

88. USFWS, 2012c, Final Scoping Document, Habitat Conservation Plan for Commercial Wind Energy Developments Within Nine States (16 February), available at: http://www.fws.gov/southwest/es/Documents/R2ES/Wind/USFWS_GPWE_ScopingReport_FINAL_16Feb2012.pdf.

89. Wyoming Outdoor Council, n.d., Wind energy: Doing it right in Wyoming, available at: http://wyomingoutdoorcouncil.org/html/what_we_do/energy/pdfs/WindBMPs-for%20web.pdf.

90. J.L. Blickley, D. Blackwood, and G.L. Patricelli, 2012, Experimental evidence for the effects of chronic anthropogenic noise on abundance of greater sage-grouse at leks, *Conservation Biology* 26(3): 461471.

91. C.L. Pruett, M.A. Patten, and D.H. Wolfe, 2009a, Avoidance behavior by prairie grouse: Implications for development of wind energy, *Conservation Biology* 23: 1253–1259.

92. C.L. Pruett, M.A. Patten, and D.H. Wolfe, 2009b, It's not easy being green: wind energy and a declining grassland bird, *Conservation Biology* 59: 257–262.

93. T. Parfitt, 2012, Renewable Energy Coordination Committee Overview (31 January), available at: http://wyia.org/wp-content/uploads/2012/02/todd-parfitt.pdf.

94. Staff, 2008, Wheatland wind project sold, *Wyoming Business Report* (17 July), available at: http://www.wyomingbusinessreport.com/article.asp?id=94945.

95. T. Mast, 2012, Pathfinder, Wold plan to develop large wind farm, *Casper Star Tribune* (29 January), available at: http://trib.com/business/pathfinder-wold-plan-to-develop-large-wind-farm/article_91b4e68a-facf-5ded-b7ab-695a81aa155c.html.

96. Carbon County Commissioners, 2012, Meeting Notes, May 1, 2012, available at: http://www.carbonwy.com/archives/61/12MIN0501%20-%20Approved%20-%20Website.pdf.

97. L. Sahagun, 2012, Avian radar units in the wind, *Los Angeles Times* (28 May).

98. T.W. Arnold and R.M. Zink, 2011, Collision mortality has no discernible effect on population trends of North American songbirds, *PLoS ONE* 6(9): e24708.

99. Ocotillo Express LLC, 2012, Golden eagle conservation plan for the Ocotillo Wind Energy Facility (23 February), available at: http://www.blm.gov/pgdata/etc/medialib/blm/ca/pdf/elcentro/nepa/ocotilloexpress/feis.Par.48467.File.dat/AppL9.pdf.

100. National Academy of Sciences, 2007, Environmental impacts of wind energy projects (Washington, DC: National Academies Press).

101. E.F. Baerwald, G.H. D'Amours, B.J. Klug, and R.M.R. Barclay, 2008, Barotrauma is a significant cause of bat fatalities at wind turbines, *Current Biology* 18: R695–R696.

102. Natural Resources Defense Council, 2009, Clean energy in the Western U.S.: A Google Earth-based report from NRDC, available at: http://www.nrdc.org/land/sitingrenewables/default.asp.

103. Wyoming Game and Fish Department. 2010. Wind Development Environmental Conflicts. Available at: http://wgfd.wyo.gov/web2011/wildlife-1000453.aspx.

Appendix I: Example Wildlife Mitigation Activities for Wind Energy Development in Wyoming

Project		Mitigation Action
Avoidance		
Birds and Bats	All wind projects in WY	No wind energy development within Sage Grouse Core Areas.[7]
	White Mountain Wind Energy Project	50-m (164-ft) minimum setback from the ridgeline of White Mountain, as well as the edge of large drainages, to reduce impacts to avian species.[1]
	Chokecherry/Sierra Madre Wind Farm Project	Avoid well locations, roads, ancillary facilities, and other surface structures requiring a repeated human presence within 825 feet of active raptor nests (ferruginous hawks, 1,200 feet).[2]
	Dunlap Wind Project	PacifiCorp shall site all WTGs [wind turbine generators] greater than 1 mile from active ferruginous hawk nests.[4]
	Pioneer Wind Park I and II	Ridgelines and areas with the highest observed raptor concentrations (10 or more observations of all raptor species, four or more observations of Golden Eagles) at flight heights approximating the proposed rotor-swept zone have been excluded from consideration for WTG [wind turbine generator] locations.[8]
	Chokecherry/Sierra Madre Wind Farm Project	No construction within 0.25 mile of an occupied or undetermined Columbian sharp-tailed grouse lek; high-profile structures (e.g., buildings, storage tanks, overhead power lines, wind turbines, towers, and windmills) authorized on a case-by-case basis.[2]
	Chokecherry/Sierra Madre Wind Farm Project	Outside Greater Sage-Grouse Core Areas: 0.25 mile no surface use (NSU) from lek perimeter (includes occupied and undetermined leks); greater-sage grouse surface disturbing activities or surface occupancy is prohibited or restricted; Inside Core Areas: 0.60 mile NSU from lek perimeter (includes occupied and undetermined leks).[2]
	Pioneer Wind Park I and II	Except for improvements to Mormon Canyon Road and two other existing dirt access roads, there will be no construction activities within a quarter mile of the Mormon Canyon [sage grouse] Lek, located in the PWP I project site. Similarly, the only construction activity to take place within a quarter-mile of the New Lek, located in the PWP II site, will be construction of an unpaved road to access the easternmost turbine array at that site.[8]
	White Mountain Wind Energy Project	Use of solid tubular towers to eliminate perch locations and slow-rotating blades for increased visibility.[1]
	Top of the World	TOTW will site the transmission line greater than 0.25 mile from all raptor nest sites identified during surveys, regardless of occupancy status.[9]

Other Wildlife	Chokecherry/Sierra Madre Wind Farm Project	No development within Red Rim-Grizzly Wildlife Habitat Management Area (WHMA).[2]
	White Mountain Wind Energy Project	If pygmy rabbits are found during presence/absence surveys undertaken prior to construction, Teton [the developer] would work with the BLM to modify turbine placement to avoid habitat to the extent possible.[1]
	Pioneer Wind Park I and II	None of the proposed facilities will be located within one-quarter mile of Willow Creek; consequently, potential impacts to breeding habitat for the northern leopard frog and other amphibians along this perennial stream will be avoided.[8]
	Wind Projects in Carbon County	Minimum one-quarter mile (0.25 mile) setback from state parks and wildlife refuges.[10]
Surface Disturbance	All projects on BLM lands in WY	No surface disturbance on slopes >25%, on identified 100-year floodplains, or within 500 feet of perennial waters, springs, and wetland and riparian areas.[6]
	All projects on BLM lands in WY	No surface occupancy will be allowed in special management areas (e.g., known threatened or endangered species habitat, areas suitable for consideration for wild and scenic rivers designation).[6]
	Pioneer Wind Park I and II	Prior to initiating construction, the existing culverts at Lone Tree Creek, Willow Creek, Gross Creek, and Virden Creek road crossings will be reset or redesigned and replaced in order to improve stream flows and minimize erosion and sedimentation.[8]
	Top of the World	To protect aquatic systems, TOTW avoided all perennial streams and wetlands.[9]
Minimization		
Seasonal Stipulations	Sandhills Ranch Wind Energy Project	Surface disturbing and disruptive activities located in potential mountain plover habitat are prohibited during the reproductive period of April 10 to July 10 for the protection of breeding and nesting mountain plover.[3]
	White Mountain Wind Energy Project	No project-related activities within antelope crucial/yearlong range from November 15 to April 30 to minimize potential impacts to pronghorn antelope in crucial winter ranges.[1]
	Dunlap Wind Project	No construction will take place within 1 mile of active ferruginous hawk nests from April 1 to August 1.[4]
	Dunlap Wind Project	Construction activities shall be limited in pronghorn crucial winter ranges to areas and times designated by the WY Game and Fish Department.[4]
	All projects on BLM lands in WY	Surface disturbing and disruptive activities will not be allowed during the period of November 15 to April 30 to reduce disturbance to big game crucial winter range; disruptive activities will require the use of BMPs [best management practices] designed to reduce the amount of human presence and activity during the winter months.[6]
	All projects on BLM lands in WY	No surface disturbance or disruptive activities in big game parturition areas from May 1–June 30.[6]

Birds and Bats	White Mountain Wind Energy Project	To minimize potential impacts to bats during the operations and maintenance phase of the project, Teton [the project developer] will work with the BLM to develop and implement an operational protocol to modify the cut-in speeds of wind turbines within the project area. These protocols would be implemented during a portion of evening and nighttime hours of operation during the peak bat migration season.[1]
	Chokecherry/Sierra Madre Wind Farm Project	If measured bat mortality is determined to be above levels of concern for the project (as presented in the wildlife and fisheries section), turbine curtailment would be implemented during low wind speed nights when bats are migrating through the Application Area (August to September).[2]
	White Mountain Wind Energy Project	To minimize potential impacts to passerine and other small birds, the removal of natural vegetation (grassland and shrub communities) would be minimized to the extent possible during construction.[1]
	Chokecherry/Sierra Madre Wind Farm Project	In Sage Grouse Core Areas: Limit development to one disturbance location per 640 acres; cumulative value of one location and existing disturbance to not exceed 5% of sagebrush habitat within 640 acres.[2]
	Dunlap Wind Project	The overhead distribution transmission line will be constructed in accordance with the recommendations of the Avian Power Line Interaction Committee for raptor protection on power lines, as well as PacifiCorp's Avian Protection Plan.[4]
	Top of the World	Flight diverters will be installed in areas that span Sand Creek, where raptor use would be expected to occur at greater frequency than in upland areas.[9]
Other Wildlife	All projects on BLM lands in WY	Removal and disturbance of vegetation will be kept to a minimum through construction site management (e.g., using previously disturbed areas and existing easements, limiting equipment/materials storage yard and staging area sizes, etc.).[6]
	Pioneer Wind Park I and II	Following construction, approximately 222 acres of temporary use areas will be reclaimed and revegetated, providing high quality forage for big game moving through and foraging in the area.[8]
Roads and Fences	White Mountain Wind Energy Project	Upgrade as many of the existing access and two-track roads as possible so the least number of new roads are constructed.[1]
	White Mountain Wind Energy Project	Posted speed limit signs would be installed on project roads in cooperation with Sweetwater County officials to minimize traffic collisions with wildlife.[1]
	Chokecherry/Sierra Madre Wind Farm Project	Design road crossings to simulate natural stream processes for water bodies that potentially support fish for a portion of the year.[2]
Lighting	White Mountain Wind Energy Project	To minimize potential impacts to birds flying at night, Teton will utilize flashing lights on any wind turbines or met towers that require FAA lighting.[1]

Compensation (On- or Off-site)		
In-lieu Fee	White Mountain Wind Energy Project	To mitigate potential impacts of the project on endangered fish species found in the upper Colorado River Basin, Teton will provide a financial contribution to the Colorado River Recovery Program as determined by the USFWS for water depletion exceeding 100 acre-ft.[1]
Habitat Improvement	Pathfinder Wind Energy Project	Improvement of riparian areas and increase of wildlife populations, including sage grouse, at off-site ranch.[5]

[1] Bureau of Land Management (BLM), 2010, Environmental Assessment for the White Mountain Wind Energy Project, Sweetwater County, Wyoming (February), available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/rsfodocs/whitemtn-wind/ea.Par.93226.File.dat/02EA.pdf.

[2] BLM, 2011a, Draft EIS, Chokecherry and Sierra Madre Wind Energy Project, Appendix C: Summary of BLM Environmental Constraints, Applicant Committed Measures, Applicant Committed Best Management Practices, and Proposed Mitigation Measures, available at: http://www.blm.gov/wy/st/en/info/NEPA/documents/rfo/Chokecherry.html.

[3] BLM, 2011b, Environmental Assessment: Sand Hills Wind Energy Facility, Albany County, Wyoming, available at: http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/rfodocs/sandhills-wind.Par.78999.File.dat/EA.pdf.

[4] CH2M Hill, 2009a, Wyoming Industrial Development Information and Siting Act: Section 109 Permit Application, Dunlap Wind Energy Project (15 June), available at: http://deq.state.wy.us/isd/downloads/Dunlap_ISA_FINAL.pdf.

[5] G. Nickerson, 2011, Banking on the environment: Pathfinder developers hope to offset impacts of energy development, *WyoFile* (30 August), available at: http://wyofile.com/2011/08/banking-on-the-environment-pathfinder-developers-hope-to-offset-impacts-of-energy-development.

[6] BLM, n.d., Wyoming BLM standard mitigation guidelines for all surface disturbing and disruptive activities, available at: www.blm.gov/pgdata/etc/medialib/blm/wy/wildlife/baldeagle.Par.4022.File.dat/be-appa.pdf.

[7] State of Wyoming, 2011, Sage Grouse Core Area Executive Order, http://www-wsl.state.wy.us/sis/wydocs/EO2011-05.pdf.

[8] Wasatch Wind, 2011, Section 109 Permit Application, Pioneer Wind Park I, LCC and Pioneer Wind Park II, LLC (January), available at: http://deq.state.wy.us/isd/downloads/Permit%20Application%20Wasatch.pdf.

[9] CH2M Hill, 2009b, Wyoming Industrial Development Information and Siting Act: Section 109 Permit Application, Top of the World Windpower Project (21 September), available at: http://deq.state.wy.us/isd/downloads/ToWorld%20Application%209-21-09.pdf.

[10] Carbon County, 2011, Carbon County Section 5.11 – Wind energy overlay-district regulations (5 April), available at: http://www.carbonwy.com/DocumentView.aspx?DID=537.