NATIONAL WIND COORDINATING COLLABORATIVE

MITIGATION TOOLBOX

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Executive Summary

Human disturbances to the landscape have often led to increased fatality rates for wildlife. Mitigation techniques have been applied in an effort to reduce or eliminate the harmful effects of human disturbance. This “mitigation toolbox” was created to provide direction for future wind development projects by presenting an assortment of mitigation measures that can be used to minimize or eliminate the negative impacts to wildlife that result from the design, construction, and operation of wind farms. However, there are relatively few instances where research has been done to validate whether mitigation strategies have reduced impacts as expected, specifically in relation to wind development. The following ‘mitigation toolbox’ is a compilation of mitigation policies, guidelines, and research that are either directly or indirectly applicable to the wind industry.

The information in this toolbox was obtained through Internet, library, and database searches; literature reviews; and interviews of experts in the field. Although there is considerable research on mitigation, and there are many tools that might be applied in the context of wind power, few scientifically proven mitigation strategies are currently available to the wind industry. Numerous mitigation strategies are proving to be successful in certain situations in the field, however, and a significant amount of promising research is currently underway that could result in new techniques.

Intended to improve current and future mitigation efforts, this toolbox is a living document that will grow and change as new information becomes available to fill in the gaps between existing policies or guidelines and current research, as well as within the research itself.

Introduction

U.S. wind development is expected to increase from about 10,000 MW in 2007 to 50,000 MW by 2020. As a result, government groups at all levels are beginning to publish wind turbine siting and mitigation policies and guidelines to minimize the effects of future wind power development on wildlife. Suggested mitigation techniques range from general strategies (e.g., avoid locations used heavily by migrating bats and birds) to specific ones (e.g., reduce motion smear by painting the blades). The development of mitigation policies and guidelines may be an important step for minimizing the impacts of development on wildlife; however, in order to be truly successful, the suggested strategies must work.

The Mitigation Toolbox

The National Wind Coordinating Committee's (NWCC) Mitigation Subgroup has compiled a number of mitigation strategies in this "mitigation toolbox." The toolbox provides guidance and direction for future wind development by describing various mitigation measures or tools that can be used in the decision-making process. For the purposes of the toolbox, 'tools' are defined as effective approaches to mitigating avian and bat fatalities, as well as habitat impacts, as proven through statistically significant research. Since differences in habitat, topography, and landscape among wind facilities often make it difficult to generalize findings from one geographic region to another, the toolbox is intended to house a wide variety of tools rather than a single, 'all-purpose' one. The toolbox is also intended to be a living document that will be periodically updated as new mitigation research and tools become available.

There are relatively few instances where research has been done to validate whether mitigation strategies have reduced impacts as expected, specifically in relation to wind development. As a result, the toolbox currently contains few verifiable tools. There are, however, numerous guidance documents that have been developed for the wind industry that incorporate a wide variety of mitigation strategies.

Information for Decision Makers

To help guide future decision making, this toolbox provides information about existing mitigation policies and guidelines, as well as on whether strategies are based on sound scientific research. It indicates the effectiveness of various methods of avoiding, minimizing, or compensating for direct and indirect impacts on wildlife caused by wind power facilities (recognizing, however, that avoiding wildlife mortality completely is probably not possible).

The toolbox contains four main sections:

- A comparison of existing mitigation policies and guidelines from the United States, Canada, Europe, and Australia that examines policies at both local and federal levels
- An Annotated Bibliography that includes research on wind development mitigation, as well as general habitat mitigation studies that could be applicable to wind sites
- Case studies that focus on exceptional mitigation strategies and currently available tools
- A matrix illustrating gaps and overlaps between existing policies or guidelines and current research.

The information presented here is intended to improve overall mitigation efforts by illustrating the gaps between current policies and guidelines and the research supporting them. Identifying the gaps makes it possible to tailor future research and policies to better meet goals for both wildlife and development. However, since each type of habitat is different, the results of mitigation research in one area might not apply in another area.

Defining Mitigation

The NWCC Mitigation Subgroup acknowledges the definition of mitigation established by the United States Fish and Wildlife Service, for all resources:

> "The President's Council on Environmental Quality defined the term "mitigation" in the National Environmental Policy Act regulations to include:
> '(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; (e) compensating for the impact by replacing or providing substitute resources or environments.' [40 CFR Part 1508.20(a-e)].
>
> The Service supports and adopts this definition of mitigation and considers the specific elements to represent the desirable sequence of steps in the mitigation planning process."[1]

The toolbox exists in the context of this definition. However the emphasis is on the tools available to mitigate impacts after developers and decision makers determine that a wind power project will be built.

[1] U.S. Fish and Wildlife Service Mitigation Policy, FR 46 (15) Jan 81, 7656, at www.fws.gov/policy/A1501fw2.html.

Methods

Literature Review

The literature review included a general review of existing wind siting policies, guidelines, and research pertaining to wildlife mitigation both nationally and internationally. Information was acquired by conducting Internet searches, conducting library searches, contacting ornithological societies, interviewing experts in the field (see Appendix A) via phone and e-mail, and searching numerous databases. The National Wind Coordinating Committee (NWCC) provided an initial list of existing policies. Previous literature reviews—including those of Gerson and Klute (2006), Johnson and Arnett (2004), Kerlinger (2000), Manville (2005), Spellerberg (1998), and Herbert et al. (1995)—were also used (see the Annotated Bibliography).

Research methods included searching the National Renewable Energy Laboratory's (NREL) Avian Literature Database, the National Wind Technology Center's EBSCO Database, the Colorado State University (CSU) EBSCO Database, the CSU JSTOR Database, the CSU Web of Science Database, Google, and Google Scholar, as well as compiling citations in relevant review articles. Most published articles were acquired from the CSU library.

Research and Analysis

From a significant amount of existing literature, the studies reviewed were limited to those deemed relevant, i.e., that examined the effects of specific changes to wind farm characteristics on birds or bats as well as those that examined more general habitat mitigation efforts and their effects on wildlife, which may be applicable to wind power development. Relevant studies included research that examined the effectiveness of mitigation strategies on wildlife, certain avian or bat behavior studies conducted at wind sites, studies comparing the effects of wind site alterations on wildlife, studies that examined mitigation strategies suggested in policies or guidelines, and studies mentioned by experts in the field. Research was not included that focused on avian or bat ecology, searcher efficiency rates, scavenging rates, avian or bat mortality estimates, study design, or modeling.

The mitigation studies selected represented those reflecting the views of the scientific community overall but also numerous studies in which scientific opinions differed. Selections focused on recent literature (1995 and later), unless that was not possible. Some earlier literature was included if it was cited often in other studies because of its historical foundations. A number of interesting studies could not be obtained from either the NREL or CSU library, online, or in personal communications, and this was further complicated by cost and time limitations.

Reviews included determining the goals of the research, its location and habitat types, the length of the study, and the general methodology used. Also researched were any conclusions, results, and management suggestions that would mitigate negative effects on wildlife. Earlier literature reviews (e.g., by Orloff in Erickson et al. 1999) were used occasionally because of time constraints and difficulty in attaining original papers. They are footnoted in the Annotated Bibliography.

The studies were then divided into two matrixes. One matrix illustrates the type of review process used (peer, none, or unknown) and the other combines existing research with policies and guidelines on mitigation. Due to difficulties in ascertaining the difference between credible peer reviews and non-credible peer reviews, studies were divided into journals and reports under an umbrella section entitled 'Reviewed'. Further analysis is required to differentiate studies into more specific categories.

For the matrix comparing policy or guideline recommendations with research results, mitigation strategies were divided into nine general categories: lighting, siting, turbine type, turbine configuration, power lines, habitat enhancement, revegetation, disturbance during construction, and operation. Individual studies were then analyzed to determine whether or not they supported the mitigation strategies suggested within any of the categories.

A Review of Existing Policies and Guidelines

The following is a compilation of existing policies and guidelines pertaining to wind power development, impacts on wildlife and habitats, and mitigation efforts. Guidelines are categorized according to their scope, i.e., Local, State, Federal, International, and Other. Within each category, guidelines are alphabetized by author and then organized into design-stage, construction-stage, and operational-stage mitigation efforts, when possible. A more comprehensive summary of policies and guidelines that allows for easier comparisons is in Appendix A. The information presented here is also in the Guidelines Spreadsheet, which allows for easier comparisons of guidelines among policies.

Local Policies and Guidelines

Washington Department of Fish and Wildlife: Wind Power Guidelines

Date Established: August 2003

Location: East of the Cascades

Contact: Dr. Jeff Koenings, Director of WDFW, 360-902-2200

See: http://wdfw.wa.gov/hab/engineer/windpower/wind_power_guidelines.pdf

General Principles for Siting and Mitigation

- Implementation of mitigation measures is presumed to fully mitigate for habitat losses for all species; state or federal *endangered* or federal *threatened* species may require additional mitigation efforts.
- Developers should be encouraged to place linear facilities[1] in or adjacent to existing disturbed corridors in order to minimize habitat fragmentation and degradation.
- Developers should be encouraged to site wind power projects on disturbed lands.
- Developers should be discouraged from using or degrading high-value habitat areas.
- Developers are responsible for acquiring replacement habitat under this proposal and for management of such lands for the life of the project,[2] unless otherwise indicated.

Conventional Mitigation Policies and Guidelines

Permanent Habitat Impacts

A. No mitigation required for cropland, developed or disturbed areas
B. All other areas require the acquisition of replacement habitat that is:
   - Like-kind (e.g., shrub-steppe for shrub-steppe; grassland for grassland) and/or of equal or higher habitat value than the impacted areas (alternative ratio may be negotiated)
   - Given legal protection
   - Protected from degradation for the life of the project
   - In the same geographical region as the impacted habitat
   - Jointly agreed upon by the wind developer and WDFW

Ratios: Replacement Habitat Subject to Imminent Development – 1:1

[1] Examples include collector cable routes, transmission line routes, or access roads.
[2] "Life of project" is defined as beginning at the end of the first year of commercial operation and ending with implementation of the project decommissioning plan.

Grassland, CRP Replacement Habitat – 1:1
Shrub-Steppe, or Other High-Value Replacement Habitat[3] – 2:1

Temporary Habitat Impacts (anticipated to end when construction is complete and land has been restored)

A. No mitigation required for cropland, developed, or disturbed areas
B. Mitigation options for other land types include:
    - Implementing a WDFW-approved restoration plan for the impacted area, including site preparation, reseeding with appropriate vegetation, noxious weed control, and protection from degradation.
    - Acquiring suitable replacement habitat for every acre temporarily impacted by the project (see ratios below).
    - A good faith effort to restore the impacted area. However, long-term performance targets should not be imposed since temporal losses and the possibility of restoration failure are incorporated into the acquisition and improvement of replacement habitat.
    - WDFW and a wind developer may agree on other 'customized' or 'alternative' ratios and terms where doing so is mutually beneficial, and accepted methodologies are used, such as a natural resource damage assessment (NRDA) or an alternative mitigation option.

Ratios: Acquisition of Grassland, CRP Replacement Habitat – 0.1:1
Acquisition of Shrub-Steppe Habitat – 0.5:1

<u>Alternative Mitigation Policies and Guidelines</u>

The goal of the Wind Power Alternative Mitigation Pilot Program is to provide an optional and streamlined approach to mitigation that results in better habitat value and is more attractive to wind developers than conventional on-site mitigation.

Alternative: Applicant will pay an annual fee[4] for the life of the project,[5] which is based on an alternative mitigation fee rate of $55/acre/year for each acre of replacement habitat that would be owed using the ratios and analysis discussed in the section titled Conventional Mitigation Policies and Guidelines.

General Provisions:

- The fee is based on habitat in average condition and can be increased or decreased by 25% to account for differences in habitat quality.
- The applicant is required to implement an approved restoration plan for temporarily impacted areas.
- In cases in which the project impacts a mixture of habitat types, the fee schedule will be applied accordingly (to the nearest acre).
- The annual fee will be used primarily to support stewardship of high-value habitat in the same ecological region as the project.
- If the applicant and the WDFW cannot agree on a mutually advantageous package under the alternative mitigation program, conventional mitigation guidance will be applied to the project.

[3] Habitat considered to be in excellent condition will require developers to engage in additional consultation with WDFW regarding suitable mitigation requirements.
[4] The fee will be reviewed annually and adjusted as necessary by WDFW.

State Policies and Guidelines

California Energy Commission & California Department of Fish and Game: ***DRAFT*** Guidelines for Reducing Wildlife Impacts from Wind Energy Development

Date Established: Draft released December 2006; Final expected June 2007.

Location: State of California

Contact: Rick York, California Energy Commission, 916-654-3945, ryork@energy.state.ca.us

See[6]: www.energy.ca.gov/2006publications/CEC-700-2006-013/CEC-700-2006-013-SD.PDF

Every wind energy project site is unique, and no one recommendation will apply to all prepermitting site selection and layout planning. The following elements, however, should be considered in site selection, in turbine layout, and in developing infrastructure for the facility.

Design-Stage Mitigation

- Good macro-siting decisions are essential for choosing an acceptable site or portion of a site.
- Once a site is selected, micro-siting efforts can avoid or reduce potential impacts to birds, bats and other biological resources.
- Minimize fragmentation and habitat disturbance.
- Establish buffer zones around areas of high bird or bat use in which no disturbance is allowed in order to minimize the risk of collisions.
- Avoid guy wires.
- Reduce impacts with appropriate turbine layout based on micro-siting decisions.
- Place power lines underground, unless burial would result in greater impacts to biological resources.
- Ensure that all above-ground lines, transformers, or conductors comply with Avian Power Line Interaction Committee (APLIC) standards, including the use of deterrents.

Operation-Stage Mitigation

- Decommission nonoperational turbines so they no longer present a collision hazard to birds and bats. Developers should submit a decommissioning and reclamation plan that describes the expected actions when some or all of the turbines at a wind site are nonoperational as part of the permitting application. Decommissioning typically involves removal of turbine foundations to 1 meter below ground level and removing access roads and unnecessary fencing and ancillary structures.
- Avoid lighting that attracts birds. Until more is known, lights with short flash durations that emit no light during the "off phase" should be used—those that have the minimum number of flashes per minute and the briefest flash duration allowable.
- Use lights on auxiliary buildings near turbines and meteorological (met) towers that are motion-sensitive rather than steady burning; they should be downcast.
- Limited and periodic feathering during low-wind nights may help avoid impacts to bats.

[6] Since the drafting of this document, the California Energy Commission released a second draft staff report on April 2007, it can be viewed at at http://www.energy.ca.gov/renewables/06-OII-1/documents/index.html#041607.

- Note that high fatality levels may require removal of problem turbines or seasonal shutdowns of turbines.
- Apply adaptive management and effectiveness monitoring processes to better achieve management objectives.
- Modify habitat to make the site less attractive to at-risk species.

Off-Site Activities

- Provide for long-term conservation of the target species and its habitat.
- Ensure that the site is large enough to be ecologically self-sustaining and/or part of a larger conservation strategy.
- Before the property is sold or credits are sold at a mitigation bank, have a resource management plan approved by all appropriate agencies or nongovernment organizations involved in property management.
- Protect the site permanently through a fee title and/or a conservation easement.
- Provide for long-term management of the property after the project is completed or after all mitigation credits have been awarded for the mitigation bank.
- Ensure the implementation of the resource management plan in the event of nonperformance by the owner of the property or nonperformance by the mitigation bank owner and/or owner.
- Provide a sufficient level of funding with acceptable guarantees to fully ensure the operation and maintenance of the property, as may be required.
- Provide for monitoring and reporting on the identified species/habitat management objectives, with an adaptive management/effectiveness monitoring loop to modify management objectives as needed.

The Kansas Renewable Energy Working Group: Siting Guidelines for Windpower Projects in Kansas

Date Established: January 22, 2003

Location: State of Kansas

Contact: Jim Plogger, Kansas Corporation Commission, j.ploger@kcc.state.ks.us

See: www.krewg.org/reports/KREWGSitingGuidelines.pdf

The Environmental and Siting Committee of the Kansas Renewable Energy Working Group (KREWG) has drafted these guidelines for wind power project stakeholders to use as they consider potential project sites in the State of Kansas. Wind energy siting and permitting requirements vary from county to county, depending largely on whether or not a county is zoned. Currently, statewide regulations for siting wind projects do not exist.

Design-Stage Mitigation

- Use biological and environmental experts to conduct preliminary reconnaissance of the prospective site area. If a site has a large potential for biological and/or environmental conflicts, it may not be worth the time and cost of conducting detailed wind resource evaluation work.
- Involve local environmental/natural resource groups as soon as practical.
- Use landscape-level examinations of key wildlife habitats, migration corridors, staging/concentration areas, and breeding and brood-rearing areas to develop general siting strategies.
- Situate turbines in a way that does not interfere with important wildlife movement corridors and staging areas.

- Do not allow any perches on the nacelles of turbines. Towers should not utilize lattice-type construction or other designs that provide perches.
- In regions where grassland burning is practiced, make sure that the infrastructure is able to withstand periodic burning of vegetation.
- Consider potential cumulative regional impacts from multiple wind energy projects when making environmental assessments and mitigation decisions.
- Take care to avoid damage to unfragmented landscapes and high-quality remnants in the Sandsage, Mixed Grass, and Shortgrass prairies in central and western Kansas. Allowing for an undeveloped buffer adjacent to intact prairies is desirable.
- When feasible, locate wind energy development on already altered landscapes.

Construction-Stage Mitigation

- Bury power lines, when feasible.
- Minimize roads and fences, and take care to avoid sensitive habitats.
- Ideally, implement construction and maintenance when the ground is frozen or when soils are dry and native vegetation is dormant.

Operational-Stage Mitigation

- Address potential adverse affects of turbine warning lights on migrating birds.
- If significant ecological damage results from siting, consider mitigation for habitat loss, including ecological restoration, long-term management agreements, and conservation easements to enhance or protect sites with an ecological quality that is similar to or higher than that of the developed site.
- Use native vegetation of local ecotypes to reseed disturbed areas.
- Consider wildlife and plant composition in determining the frequency and timing of mowing near turbines.

Wind Energy Technical Advisory Group: ***DRAFT*** Siting Guidelines to Mitigate Avian and Bat Risks from Windpower Projects

Date Established: July 6, 2006

Location: State of Maryland

Contact: Michael Dean, 410-767-8149; mdean@psc.state.md.us

Applicants should consult with the Department of Natural Resources Power Plant Research Program (PPRP) well in advance of filing an application with the Public Service Commission; failure to do so may result in project delays. Applicants are required to consult with Department of Natural Resources Natural Heritage Program (NHP) biologists to ensure that construction is scheduled to avoid or minimize disruptions to bird and bat breeding seasons, as well as to determine the boundaries of allowed physical disturbance during construction. Applicants are then required to submit a request for environmental review from the state's Wildlife and Heritage Service, which includes the project site and boundaries, results from 1 year of monitoring on the proposed site for impacts to bats and birds, an assessment of potential bat habitat on the site, the results of a Phase 1 avian risk assessment, and breeding bird survey results. The PPRP will establish a peer review group composed of relevant experts to assess monitoring plans and data, and the applicant undertakes a post-construction study of mortality rates for at least 3 years. Any mitigation plans should be graded in their implementation so as to reasonably reflect the level of the observed impact and the probability of successful mitigation.

Design-Stage Mitigation

- Use tubular towers, as opposed to lattice towers.

- Construct no permanent towers, including met towers, that are supported by guy wires.
- Avoid locations that have been identified to have potentially high risk to birds or bats, have unique habitat features, or are occupied by species of particular concern (as determined by the applicant or the state).

Construction-Stage Mitigation

- Bury on-site electrical collector cables when possible.
- Avoid or minimize disruptions during bird and bat breeding seasons.
- Reestablish any disturbed nesting/maternity areas, as feasible.

Operational-Stage Mitigation

- Minimize lighting of turbines by lighting the fewest possible number of turbines, synchronizing the flashing cycles of all strobes, installing red strobes (as opposed to white strobes) with the longest possible cycle, and not installing high-intensity lamps for area lighting (e.g., sodium vapor lamps).
- In the event that a larger-than-expected number of fatalities occurs, contact the NHP as soon as possible, at least within 24 hours. If the impacts to bird or bat populations are considered adverse, the state will seek corrective actions from the applicant to avoid, minimize, or mitigate the adverse impact. Mitigation plans may involve either on-site or off-site activities, or both.

Massachusetts Executive Office of Environmental Affairs: ***DRAFT*** Guidance on the Siting of Wind Turbines

Date Established: In progress; expected to be released by end of 2006

Location: State of Massachusetts

Contact: Josh Bagnato, MA Executive Office of Environmental Affairs, 617-626-1041; Josh.Bagnato@state.ma.us

State of Michigan Department of Labor & Economic Growth: Michigan Siting Guidelines for Wind Energy Systems

Date Established: December 14, 2005

Location: Rural areas; not meant for On-Site Use or Utility Grid

Contact: John Sarver, Energy Office, 517-241-6280

See: www.michigan.gov/documents/Wind_and_Solar_Siting_Guidlines_Draft_5_96872_7.pdf

(1) The applicant shall have a third-party, qualified professional conduct an analysis to identify and assess any potential impacts on the natural environment or wildlife and endangered species.

(2) The applicant shall take appropriate measures to minimize, eliminate, or mitigate adverse impacts identified in the analysis.

(3) The applicant shall identify and evaluate the significance of any net effects or concerns that will remain after mitigation efforts.

(4) Sites requiring special scrutiny include wildlife refuges, other areas where birds are highly concentrated, bat hibernacula, wooded ridge tops that attract wildlife, sites that are frequented by federally and/or state-listed endangered species of birds and bats, significant bird migration pathways, and areas that have landscape features known to attract large numbers of raptors.

(5) The analysis shall include a thorough review of existing information regarding species and habitats, as well as the potential effects on species listed under the federal Endangered Species Act and Michigan's Endangered Species Protection Law.

(6) The analysis shall indicate whether a post-construction wildlife mortality study will be conducted and, if not, the reasons why such a study does not need to be conducted.

(7) Power lines should be placed underground, when feasible, to prevent avian collisions and electrocutions. All above-ground lines, transformers, or conductors should comply with APLIC published standards.

(8) The applicant shall be responsible for making repairs to any public roads damaged by the construction of the utility grid wind energy system.

Montana Department of Fish and Wildlife

Date Established: N/A

Location: State of Montana

Contact: T.O. Smith, 406-444-3889; TOSmith@mt.gov

There is no regulatory authority over wind development in Montana; however, Montana Environmental Protection Agency requires developers on public and state lands to obtain input from the Montana Department of Fish and Wildlife (MDFW). MDFW has established an internal draft strategy for working with wind development on private lands to minimize environmental impacts to the extent possible. While the draft strategy has not yet been released to the public, the main points pertain to the following:

1. Coordination with county commissioners
2. Location of transmission lines
3. Staff education
4. Research
5. Coordination with the wind industry
6. Working with environmental assessments and environmental impact statements

In addition, the MDFW advocates locating turbines near transmission lines and in areas that are not visible from critical recreation areas, as close as possible to where the power will be used, and in areas that are not composed of native shortgrass prairie. The MDFW also advocates minimizing road traffic to and from sites, minimizing the loss of topsoil, replanting disturbed areas with native seeds, conducting preassessment surveys for impacts to bats and birds, and avoiding major migratory routes (waterbird, waterfowl, and raptor).

New York State Department of Agriculture and Markets: Guidelines for Agriculture Mitigation for Windpower Projects

Date Established: March 25, 2003

Location: Construction areas in county-adopted, state-certified agricultural districts.

See: http://www.agmkt.state.ny.us/AP/agservices/constructWind.html

Operational-Stage Mitigation
The following actions are to occur following construction until October 1. For areas to be restored after that date, provision should be made to restore any eroded areas in the springtime.

- All disturbed agricultural areas will be decompacted to a depth of 18 inches with a deep ripper or heavy-duty chisel plow.[7]
- All rocks 4 inches and larger will be removed before and after the replacement of topsoil.
- Topsoil will be replaced to original depth and original contours will be reestablished where possible.
- Access roads will be regraded, and original surface drainage patterns will be restored.
- Restored agricultural areas will be seeded with the seed mix specified by the landowner.
- All construction debris will be removed from the site.

Monitoring and Remediation
The Project Sponsor will provide a monitoring and remediation period of no less than two years immediately following the completion of initial restoration. General conditions to be monitored include topsoil thickness, relative content of rock and large stones, trench settling, crop production, and drainage and repair of severed fences.

- Topsoil deficiency and trench settling shall be mitigated with imported topsoil that is consistent with the quality of the topsoil on the affected site.
- Excess rocks and large stones will be removed and disposed of by the project sponsor.
- Appropriate rehabilitation measures will be determined and implemented when subsequent crop productivity within the affected area is less than that of the adjacent unaffected agricultural land.
- Where representative subsoil density of the affected area exceeds the representative subsoil density of the unaffected area, shattering of the soil profile will be performed. Deep shattering will be applied during periods of relatively low soil moisture, and any oversized stone or rock material will be removed that was uplifted to the surface.

Oregon Department of Fish and Wildlife: Fish and Wildlife Habitat Mitigation Policy For Siting Non-Nuclear Energy Facilities (635-415-0000)

Date Established: September 1, 2000

Location: State of Oregon

Contact: 503-947-6000

See: http://www.dfw.state.or.us/OARs/415.pdf

[7] In areas where the topsoil was stripped, soil decompaction shall be conducted prior to topsoil replacement.

The fish and wildlife habitat mitigation policy of the Oregon Department of Fish and Wildlife requires or recommends mitigation for losses of fish and wildlife habitat resulting from development actions. Whether it is a requirement or a recommendation depends on the habitat protection and mitigation opportunities provided by specific statutes. Priority for mitigation actions is given to habitat for native fish and wildlife species. Mitigation actions for nonnative fish and wildlife species may not adversely affect habitat for native fish and wildlife.

- Departmental recommendations or requirements for mitigation are based on the following:
  - The location, physical and operational characteristics, and duration of the proposed development action.
  - The alternatives to the proposed development action.
  - The fish and wildlife species and habitats that will be affected by the proposed development action.
  - The nature, extent, and duration of impacts expected to result from the proposed development action.
- The Department may recommend or require the posting of a bond, or other financial instrument acceptable to the Department, to cover the cost of mitigation actions based on the nature, extent, and duration of the impact and/or the risk of the mitigation plan not achieving mitigation goals.
  - The Department may only use mitigation banks and payment to provide mitigation for habitat categories 2-6 (see below).
  - The amount of payment to provide mitigation will include, at a minimum, the cost of property acquisition, mitigation actions, maintenance, monitoring, and any other actions needed for the long-term protection and management of the mitigation site.
- The Department requires the submission of a mitigation plan, which includes:
  - Protocols and methods, and a reporting schedule for monitoring the effectiveness of mitigation measures. Performance measures include success criteria and long-term protection and management provisions
- The project proponent is responsible for the expenses of developing, evaluating, and implementing the mitigation plan and monitoring the mitigation site.

To issue a site certificate, the Council must find that the design, construction, operation and retirement of the facility, taking into account mitigation, are consistent with the fish and wildlife habitat mitigation goals and standards.

All Habitat Category mitigation strategies must first seek to avoid impacts through alternatives to the proposed development action. If that does not work, then the following mitigation strategies will be pursued:

<u>Habitat Category 1</u>: Irreplaceable, essential habitat for a fish or wildlife species, population, or a unique assemblage of species and is limited on either a physiographic province or site-specific basis, depending on the individual species, population or unique assemblage.

MITIGATION = no loss of either habitat quantity or quality, requiring:

- No authorization of the proposed development action if impacts cannot be avoided.

<u>Habitat Category 2</u>: Essential habitat for a fish or wildlife species, population, or a unique assemblage of species and is limited on either a physiographic province or site-specific basis, depending on the individual species, population, or unique assemblage.

MITIGATION = no net loss of either habitat quantity or quality, and the provision of a net benefit of habitat quantity or quality, requiring:

- In-kind, in-proximity habitat mitigation to achieve no net loss of either predevelopment habitat quantity or quality. In addition, a net benefit of habitat quantity or quality must be provided.

- If neither of the above can be achieved, the Department shall recommend against or shall not authorize the proposed development action.

Habitat Category 3: Essential habitat for fish and wildlife, or important habitat for fish and wildlife that is limited either on a physiographic province or site-specific basis, depending on the individual species or population.

Habitat Category 4: Important habitat for fish and wildlife species.
MITIGATION = no net loss of either habitat quantity or quality.

- In-kind, in-proximity habitat mitigation to achieve no net loss of either predevelopment habitat quantity or quality. Habitat Category 4 also includes out-of-kind and off-proximity habitats.
- If neither of the above can be achieved, the Department shall recommend against or shall not authorize the proposed development action.

Habitat Category 5: Habitat for fish and wildlife having high potential to become either essential or important.
MITIGATION = provide a net benefit in habitat quality or quantity.

- Actions that contribute to essential or important habitat.
- If neither of the above can be achieved, the Department shall recommend against or shall not authorize the proposed development action.

Habitat Category 6: Habitat has low potential to become essential or important for fish and wildlife.
MITIGATION = to minimize impacts.

- The Department shall recommend or require actions that minimize direct habitat loss and avoid impacts to off-site habitat.

South Dakota Bat Working Group & South Dakota Game, Fish and Parks: Siting Guidelines for Wind Power Projects in South Dakota

Date Established:

Location: Entire state

Contact: Alyssa Kiesow, 605-773-2742

See: http://www.sdgfp.info/wildlife/Diversity/windpower.htm

The guidelines outlined in this document are neither mandates nor regulations. They have been compiled and developed to encourage developers to select potential wind sites using a process that is acceptable to all stakeholders, to protect South Dakota's rare and unique areas, to minimize deleterious effects to wildlife, to help provide information to all involved and interested parties, and to promote a responsible, guided, uniform approach to the siting of wind power projects in South Dakota.

Design-Stage Mitigation

- Use biological and environmental experts to conduct a preliminary biological reconnaissance of the likely site area.
- Involve wildlife agency personnel, universities, and local environmental and natural resource groups and agencies; their involvement will provide resource information as well as minimize potential conflicts.
- Situate turbines so they do not interfere with important wildlife movement corridors and staging areas.
- Avoid large, intact areas of native vegetation.

- Avoid lattice-designed towers or other designs providing perches for avian predators.
- Develop a stringent plan for preventing the introduction or establishment of nonnative or invasive flora.
- Consider turbine designs.

Construction-Stage Mitigation

- Bury power lines and/or place turbines near existing transmission lines and substations.
- Minimize the number of roads and fences.
- Consider the timing of construction and maintenance activities (including mowing). Avoid construction and maintenance activities during breeding season (April to July) and, if possible, during migrations (April to June and August to October).

Operational-Stage Mitigation

- Mitigate for habitat loss through ecological restoration, long-term management agreements, conservation easements, or fee title acquisitions.
- Address potential adverse affects of turbine warning lights on migrating birds and bats.

Vermont Fish and Wildlife Department: ***DRAFT*** Guidelines for the Evaluation and Mitigation of Impacts to Wildlife Associated with Wind Energy Development in Vermont

Date Established: April 20, 2006

Location: Entire state

Contact: Julie Moore, 802-241-3687

See: http://www.energy.ca.gov/renewables/06-OII-1/documents/other_guidelines/VERMONT_GUIDELINES_2006-04.PDF

In general, habitat disturbance should be minimized, as well as the risk of collision mortality for both resident and migratory bird and bat species. In addition, permittees should be required to establish an escrow fund to support the necessary post-construction monitoring.

Design-Stage Mitigation

- The applicant should establish the presence or absence of different wildlife species and significant habitats, well in advance of any construction activities, so that appropriate mitigation and avoidance practices can be used.
- Studies need to be completed during breeding and migratory seasons.
- The Department will review all survey results to determine if the project will result in undue adverse impacts,[8] and may seek revisions to the project.

Construction-Stage Mitigation

- Construction activities should be scheduled to avoid important periods of wildlife courtship, breeding, and nesting.
    - o Any clearing of montane spruce-fir must take place outside the breeding period for Bicknell's Thrush.

[8] Fatality rate exceeds the national average (2.3 birds/turbine/year and 3.4 bats/turbine/year) or some of the species affected are considered threatened or endangered by the state or federal government.

    - Construction activities within ¼ mile of significant black bear hard mast habitat or spring feeding areas should take place outside the feeding periods September 1–November 21 and May 1–July 15.
- Noise-reduction devices should be maintained in good working order on vehicles and construction equipment.

Operation-Stage Mitigation

- Habitat restoration activities should be initiated as soon as possible after construction is complete.
- A minimum of three years of rigorous post-construction bird and bat mortality surveys are necessary for any utility-scale wind project in Vermont.
    - Monitoring is to be conducted from April 15 to October 31.
- If a project is considered to have undue adverse impacts, mitigation measures will be required that may include the following:
    - Modified Operations – additional monitoring or research, technological improvements, adjustment of operations during periods of highest risk, or suspension of operation during periods of highest risk.
    - Modified Lighting – alternative aircraft warning lighting, reduction in number of lit turbines, altering the arrangement of lights, using LED fixtures, or providing baffling around the lights.
    - On-site Habitat Management – modifying the type or extent of vegetation cover, forest openings, perching and nesting sites, or cover for prey species.
    - Habitat Protection – compensatory mitigation measures such as protection or enhancement of wildlife habitat.

Wisconsin Department of Natural Resources: Wind Farm Siting Guidance

Date Established: August 31, 2005

Contact: Steve Ugoretz, 608-266-6673

See: http://www.dnr.state.wi.us/org/es/science/energy/wind/studies.htm

A baseline wildlife evaluation should be conducted for each site under serious consideration for wind farm development. To allow comparison with other studies, this evaluation should follow accepted standard protocols for wind farm evaluations (such as the NWCC study guidelines). If the U.S. Fish and Wildlife Service guidelines are used, they should also incorporate Wisconsin Department of Natural Resources (DNR) considerations.

Design-Stage Mitigation

- Bird and bat use and interactions with wind turbines and supporting facilities should be monitored for an adequate period (at least two years is recommended) after installation, using accepted standard methods. This should be done for the first wind farms in any ecological region of the state.
    - If no problems are determined by the DNR's evaluation of the results, it is likely that later installations with similar characteristics will not require as much detailed study as the initial wind farms.
- Mitigation measures proven to minimize collisions and mortality should be designed into the wind farm.
- An adaptive management approach to planning, design, construction, and operations is highly recommended.

Construction-Stage Mitigation

- Placing electric lines underground is highly recommended.
- The use of perch guards on above-ground poles and other APLIC-endorsed technologies is recommended.

Federal Policies and Guidelines

Bureau of Land Management – Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western United States

Date Established: June 2005

Location: All wind energy development projects on BLM-administered lands

See: https://www.eh.doe.gov/nepa/otheragency/fes0511/index.html

The BLM proposes the following best management practices (BMPs) be applied to all wind energy development projects:

Design-Stage Mitigation

- The area disturbed by installation of met towers shall be kept to a minimum.
- Individual towers shall not be located in sensitive habitats or in areas where ecological resources known to be sensitive to human activities are present.
- Installation of towers shall be scheduled to avoid disruption of wildlife reproductive activities or other important behaviors.
- Existing roads shall be used to the maximum extent feasible.
- Avian and bat use of the project area should be evaluated using rigorous survey methods.
- Turbines shall be configured to avoid landscape features known to attract raptors.
- Disturbance to any population of federally listed plant species is prohibited.
- A habitat restoration plan shall be developed to avoid, minimize, or mitigate negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species, including revegetation, soil stabilization, and erosion-reduction measures.
- Procedures shall be developed to mitigate potential impacts to special status species.
- Locations heavily utilized by migratory birds and bats should be avoided, especially migration corridors or known flight paths, raptor nest sites, and areas used by bats as colonial hibernation, breeding, and maternity/nursery colonies, if studies show that they would pose a high risk to species of concern.
- Facilities shall be designed to discourage their use as perching or nesting substrates for birds.
- Operators shall develop a plan to control noxious weeds and invasive species.
- Habitat disturbance should be minimized by locating facilities in previously disturbed areas.
- Projects should not be located in areas with a high incidence of fog and mist.
- The use of sodium vapor lights should be minimized or avoided.

Construction-Stage Mitigation

- The area disturbed by construction and operation will be kept to a minimum.
- Topsoil from all excavations and construction activities shall be salvaged and reapplied during reclamation, along with weed-free native grasses, forbs, and shrubs.
- Guy wires on permanent towers shall be avoided.
- Habitat restoration will begin as soon as possible after the completion of construction.

- Access roads should be located to follow natural contours of the topography and minimize side hill cuts, and they should minimize stream crossings.
- The creation of, or increase in, the amount of edge habitat between natural habitats and disturbed lands should be minimized.
- Stream crossing should be designed to provide in-stream conditions that allow for and maintain the uninterrupted movement and safe passage of fish.
- Construction activities should be scheduled to avoid important periods of wildlife courtship, breeding, nesting, lambing, or calving.
- Buffer zones should be established around raptor nests, bat roosts, and biota and habitats of concern, if facilities are believed to pose a significant risk to avian or bat species of concern.
- Noise-reduction devices should be maintained in good working order on vehicles and construction equipment.
- Explosives should be used only within specified times and at specified distances from sensitive wildlife or surface waters.
- Dust abatement techniques should be used on unpaved, unvegetated surfaces.
- Construction materials and stockpiled soil should be covered if they are a source of fugitive dust.
- Refueling should occur in a designated fueling area that includes a temporary berm to limit the spread of any spill.
- Drip pans should be used.
- Construction equipment should be visually inspected to identify and remove seeds that may be adhering to tires and other surfaces.
- Fill materials that originate from areas with known invasive vegetation problems should not be used.
- Certified weed-free mulch should be used when stabilizing areas of disturbed soil.
- Pesticide use should be limited to nonpersistent, immobile pesticides.

Operation-Stage Mitigation

- Measures to reduce raptors' use of the project site shall be considered, including minimization of road cuts and maintenance of either no vegetation or nonattractive plant species around the turbines.
- All unnecessary lighting should be turned off at night to limit attracting migratory birds.
- Higher-height vegetation should be encouraged along transmission corridors to minimize foraging in these areas by raptors, to the extent that local conditions will support this vegetation.

Federal Aviation Administration Advisory Circular: Obstruction Marking and Lighting, Chapter 13

Date Established: February 1, 2007

Location: Any terrestrial location within the United States

Contact: Scott Larwood, 503-752-7479; smlarwood@ucdavis.edu

Wind turbine farms are defined as a wind turbine development that contains more than three turbines that measure more than 200 feet high above ground level. The recommended marking and lighting of wind turbines is intended to provide day and night conspicuity and to assist pilots in identifying and avoiding these structures. There was no mention of the effects of these guidelines on wildlife, and no sign of plans to research this topic in the future.

Operational-Stage Lighting Requirements

- Maximum separation gap between lights along a row $\leq$0.5 miles.

- Omission of lighting within clusters (unless turbines are taller than peripheral units); lighting of end turbines or end rows necessary.
- Synchronization of lights for entire project.
- No daytime lighting necessary if white or light off-white paint is used. Daytime lighting should be used if darker paint is used.
- Omit steady burning lights; use of Federal Aviation Administration (FAA) L-864 aviation red-colored flashing lights is recommended for nighttime lighting (and found to be most effective); however, white strobe fixtures (FAA L-865) may be used in lieu of L-864 lights if they are used alone without any red lights and positioned in the same manner as red flashing lights would be.
- Light fixtures should be placed as high as possible on the turbine's nacelle, so as to be visible from 360 degrees.
- Turbines that protrude from the general limits of the turbine farm should be lit.
- High concentrations of lights should be avoided.

United States Fish and Wildlife Service: Service Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines

Date Established:	July 10, 2003
Location:	Any terrestrial location within the United States
Contact:	For general use of guidance, and contacts with Ecological Services Field Offices, contact: David Stout, Chief, Division of Habitat and Resource Conservation, 703-358-2555 For avian-wind issues, research protocols, and technical issues contact: Robert Blohm, Chief, Division of Migratory Bird Management, 703-358-1714
See:	http://www.fws.gov/habitatconservation/wind.pdf

The Potential Impact Index (PII) represents a first-cut analysis of the suitability of a site proposed for development by estimating wildlife species' use of the site. The PII is derived from the results of three checklists: physical attributes, species occurrence and status, and ecological attractiveness. The PII ranking is intended to guide developers by estimating the level of impact that may be expected if a site is developed.

Design-Stage Mitigation

- Predevelopment evaluations should be conducted by a team that includes federal and/or state agency wildlife professionals with no vested interest (e.g., monetary or personal business gain) in the sites selected. Teams may also include academic and industry wildlife professionals, as available. Any site evaluations conducted by teams that do not include federal and/or state agency wildlife professionals will not be considered valid evaluations by the Service.
- Avoid placing turbines or towers in documented locations of any species of wildlife, fish, or plant protected under the Federal Endangered Species Act, or where species reside that are sensitive to human disturbance (e.g., prairie grouse).
- Avoid locating turbines or towers in known local bird and bat migration pathways or in areas where birds and bats are highly concentrated, unless the mortality risk is low.
- Avoid known daily movement flyways and areas with a high incidence of fog, mist, low cloud ceilings, and low visibility.
- Configure turbines to avoid potential avian mortality where feasible (e.g., group turbines rather than spreading them out widely, orient rows of turbines parallel to known bird movements).
- Avoid fragmenting large contiguous tracts of wildlife habitat.
- Where practical, place turbines on disturbed habitats.

- Reduce the availability of carrion by practicing responsible animal husbandry.
- Develop a habitat restoration plan for the proposed site that avoids or minimizes negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species.
- Collocate the communications equipment on an existing communication tower or other structure. If this is not feasible, construct towers no more than 199 feet above ground level, using construction techniques that do not require guy wires (e.g., monopole), if possible.

Construction-Stage Monitoring

- Road access and fencing should be minimized
- If significant numbers of breeding, feeding, or roosting birds are known to habitually use the proposed tower construction area, relocation to an alternate site should be recommended. If this is not an option, seasonal restrictions on construction may be advisable to avoid disturbance during periods of high activity among birds.
- Minimize roads, fences, and other infrastructure. Infrastructure should be capable of withstanding periodic burning of vegetation.

Operational-Stage Monitoring

- The Service recommends that all sites be monitored for impacts on wildlife after construction is completed; monitoring is not expected to exceed 3 years.
- Where feasible, turbines should be shut down at times when birds are highly concentrated.
- Daytime visual markers should be on any guy wires used to support towers that are located in known raptor or waterbird concentration areas or daily movement routes, or in major diurnal migratory bird movement routes or stopover sites.
- Where feasible, power lines should be underground or if on the surface, should be insulated, shielded wire.
- The minimum amount of pilot warning and obstruction avoidance lighting required by the FAA should be used.
    - The use of solid red or pulsating red warning lights at night should be avoided.
    - White strobe lights should be used at night; the minimum number, minimum intensity, and minimum number of flashes per minute allowable by FAA.
    - Security lighting for on-ground facilities and equipment should be down-shielded to keep light within the boundaries of the site.
- When the height of the rotor-swept area poses a high risk for wildlife, the tower height should be adjusted, where feasible.
- Older turbines that have been shown to cause high rates of mortality should be retrofitted or relocated.

A Federal Advisory Committee Act (FACA) process and call for committee nominations were published in the Federal Register on March 13, 2007, with the receipt of nominations accepted through April 12, 2007. A FACA committee intended to review the Service's interim guidelines is anticipated to begin meeting later in 2007.

United States Forest Service: ***DRAFT*** 36 CFR 251, Special Use Permits

Date Established:	Currently being drafted; expected release date is fall 2006
Location:	Any development taking place on Forest Service land
Contact:	Kristen Nelson, (202) 205-1406, kristennelson@fs.fed.us

- The proposed land use must be consistent with standards and guidelines in the applicable forest land and resource management plan prepared under the National Forest Management Act (NFMA) and 36 CFR part 219: National Forest System Land and Resource Management Planning (219.20, ecological sustainability, is below).
    - The planning process must include the development and analysis of information regarding ecological components at a variety of spatial and temporal scales, as determined by the responsible official.
    - Plan decisions affecting ecosystem or species diversity must provide for maintenance or restoration of the characteristics of ecosystem compositions and structure within the range of variability that would be expected to occur under natural disturbance regimes in accordance with paragraphs (b)(1)(i) through (v) of this section.
- The proposed activity cannot materially impact the characteristics or functions of the environmentally sensitive resources or lands identified in Forest Service Handbook 1909.15, chapter 30.

Note: To date, only two wind power projects have occurred on forest service lands—one in Vermont, the other in Michigan. The Forest Service is in the process of revising current permitting guidelines to include issues specific to wind power. The updated guidelines were not available as of 2/15/07.

International Policies and Guidelines

Australian Wind Energy Association: Best Practice Guidelines for Wind Energy Projects

Date Established: March 2002

Location: Australia

See: www.auswea.com.au

Developers must submit to development approval authorities documentation demonstrating how the design has taken into account the need to mitigate potential impacts, and how mitigation measures will be implemented during construction and operation. The development application must include details of impact mitigation measures incorporated into the design, construction, and operation of the development to address regulatory or legislative requirements and to meet general best practice environmental management targets.

Design-Stage Mitigation

- Avoid development sites and turbine sites with high bird usage.[9]
- Locate turbines and roads well away from wetlands and other bird-rich habitats
- Consider widening the spacing between turbines to permit movement of birds around and between the turbines.
- Design roads and tracks to avoid changes to surface water runoff and to not cause erosion.
- Route power cable to avoid the need to remove native vegetation and habitat
- Ensure that power cables are not placed across regular bird flight paths.
- Locate the switchyard to avoid areas of native vegetation or habitat.

Construction-Stage Mitigation

[9] A radius of up to 30 km from the potential site should be used when gathering information on flora and fauna present within the site.

- Monitor for any downslope deposition of material from construction areas, and ensure that weeds are controlled and areas are revegetated.
- Implement strict speed limits where tracks are within 200 meters of wetlands or other habitats where birds could be disturbed.
- Locate storage areas and vehicle standing areas away from native vegetation and habitat and at least 200 meters from wetlands.
- Avoid building roads and placing turbines on areas of native vegetation and fauna habitat
- Avoid construction during the most sensitive times of the year, and/or stage construction work to ensure adequate distances between work and sensitive habitats.

Operation-Stage Mitigation

- Avoid human disturbances to any wetlands or other habitats that hold bird groups potentially vulnerable to collision.
- Undertake an extensive rabbit control program to minimize the attractiveness of the site to birds of prey.
- Clear away sheep and cattle carcasses rapidly.
- Provide alternative habitat off site to attract at-risk birds from near turbines.
- Monitor and repair any erosion and reduce surface water pooling or concentration of runoff.
- Do not illuminate wind turbines as this can attract insects and confuse night-flying birds.
- Bird and bat utilization studies should be continued for at least 2 years after operation begins.

Environment Canada, Canadian Wildlife Service: Wind Turbines and Birds – A Guidance Document for Environmental Assessment

Date Established: July 2005

Location: Canada

Contact: 819-997-1095; cws-scf@ec.gc.ca,

See[10]: http://www.energy.ca.gov/renewables/06-OII-1/documents/other_guidelines/CANADIAN_GUIDELINES_2005.PDF

These guidelines are intended to be used in consultation with regional Canadian Wildlife Service biologists and Environment Canada (EA) experts. The guide should not be regarded as exhaustive or restrictive, and should serve as the starting point for discussions with EA staff on each project.

These guidelines include a level of concern matrix (low to very high) based on site sensitivity and facility size: very high concern (2+ years of baseline data and 3+ years of follow-up required), high concern (comprehensive surveys to gather baseline and 2+ years of follow-up), medium concern (basic baseline information surveys and 2-year basic follow-up), and low concern (minimum amount of baseline information and 1-year follow-up).

Design-Stage Mitigation

- Preliminary information must be gathered to determine site sensitivity.
- Any turbine taller than 150 meters in height should be subject to closer scrutiny, especially for sites close to arrival and departure sites of nocturnal migrants, on mountain tops or in foggy areas.

[10] Since the drafting of this document, Environment Canada and the Canadian Wildlife Service finalized their guidance document in April 2007. The April 2007 version can be downloaded at http://www.cws-scf.ec.gc.ca/publications/eval/index_e.cfm.

- A smaller number of larger turbines may pose less of a risk to birds than a larger number of smaller turbines.
- Tubular and met towers without guy wires are recommended in commercial wind energy projects.
- Configuration should avoid creating barriers to bird movement. Spacing between the turbines should be greater than 200 meters to avoid inhibiting movement.
- Perching opportunities such as lattice towers, guy wires, hydro poles or other structures should be reduced or removed whenever possible.

Construction-Stage Mitigation

- Focus intense construction outside the core breeding and migration seasons to reduce disturbance to birds.
- Keep the number of access roads constructed to a minimum. When roads need to be constructed, minimize habitat destruction, fragmentation, and disturbance of breeding and wintering grounds as much as possible.
- Bury all lines, when possible. When that is not possible, consider the following mitigation techniques:
    - Line visibility should be increased by using bird flappers or other bird flight diverters and by increasing the size of the wire
    - Lines should not be built over water or other areas with high concentrations of birds.
    - Small lightning shield wires should be eliminated where lines cross wetlands and migration routes.
    - Lines should be made parallel to the direction of prevailing winds.
    - Place lines crossing rivers at oblique rather than right angles.
    - Place lines as close to trees as practical and below the level of tree tops, wherever possible.
- All wastes should be collected and disposed of.

Operation-Stage Mitigation

- Access roads that are not used after construction should be allowed to revegetate (with native and not invasive plant species).
- Lighting should be used only where required by Transport Canada regulations. Use strobe lights only, with the minimum number of flashes per minute and the briefest flash duration allowable. Avoid steady-burning or other bright lights such as sodium vapor or spotlights on turbines and other structures.
- Take measures to minimize motion smear.
- If a moving blade appears to be causing high bird mortality along a particular flight path, the turbine can be shut down, which may reduce the number of direct hits.
- If mortality is due to attraction to lights, other lighting options may need to be considered. It may be possible to reduce the amount of lighting, or even to turn lights off during periods of high risk.
- If there are high densities of raptors in the area, implement a prey control program and/or remove other raptor food sources at the site.
- In agricultural sites, the area under the turbines can be planted in a crop that is less attractive to birds.
- If grassland birds are being killed during aerial displays, it may be possible to offset losses in productivity if hay cutting can be delayed at adjacent sites.

When wind farms are found to cause an unacceptable number of bird kills, and various mitigation strategies prove unsuccessful, other options should be considered, such as encouraging the proponent to purchase and then protect a parcel of land of similar size and habitat type. Other “last-resort” methods include decommissioning or moving problem turbines to a new location.

Department for Environment, Food and Rural Affairs: Nature Conservation Guidance on Offshore Windfarm Development (Version 1.9)

Date Established: March 2005

Location: England

See: http://www.defra.gov.uk/WILDLIFE-COUNTRYSIDE/ewd/windfarms/windfarmguidance.pdf

This document has been produced by the Department for Environment, Food and Rural Affairs to provide developers with a greater understanding of the potential nature conservation impacts of offshore wind farms and the steps they are legally obliged to follow to comply with the requirements of the European Commission's Habitats and Wild Birds Directives, including steps to avoid harming the Natura 2000 network.

Design-Level Mitigation

- The whole wind farm area plus surrounding buffer of 1-2 kilometers should be surveyed; observers should be trained by ornithologists.
- Survey data from at least 2 years are necessary, and more survey data (preferably 3 years) will be required in circumstances where important concentrations of birds occur.
- Avoid areas with concentrations of important conservation species or important migratory paths.
- Ensure that siting and design are appropriate in terms of orientation, spacing, and location:
    - Allow wide corridors between clusters of turbines, with a line formation parallel to the main flight direction.
    - Lines of turbines should be broken up.
- Construction of larger turbines may provide greater visibility.

Construction-Level Mitigation

- Time construction work and methods to avoid critical periods such as molting.
- Use high contrast patterns on turbine blades to reduce motion smear.
- Postpone maintenance of turbine(s) during critical periods.
- Employ methods of chemical use that minimize the release of polluting materials into the water column and use only chemicals selected from the List of Notified Chemicals.
- Do not undertake construction between December 16 and March, to minimize impacts on the over-wintering common scoter.
- Cable laying along the beach from October to April should avoid the sensitive period 2 hours either side of high water for over-wintering wader species. Cable laying should also occur outside of the molting period for the common scoter (July to September).
- Piling work for turbine foundations should only be carried out between high tide minus 3 hours and high water plus 3 hours to minimize disturbance to little terns.
- No work should be carried out near nesting and breeding areas between May 1 and August 1.

Operation-Stage Mitigation

- Use intermittent rather than continuous navigation lighting, particularly strobing lights. Clusters of turbines will reduce the single point source and provide a more diffuse light distribution. Avoid floodlighting of turbines, particularly in periods of bad weather. White lights are preferable to red.
- Surveys should be carried out for at least 3 years following construction, and some monitoring may be required for the lifetime of the development.

Other Policies and Guidelines

American Birding Conservancy: Wind Energy Policy

Date Established: October 12, 2004

See: http://www.abcbirds.org/policy/windpolicy.htm

The American Birding Conservancy (ABC) supports alternative energy sources, including wind power. However, ABC emphasizes that before approval and construction of new wind energy projects proceeds, potential risks to birds and bats should be evaluated through site analyses, including assessments of the abundance of birds and bats, the timing and magnitude of migrations, and habitat use patterns. Wind energy project location, design, operation, and lighting should be carefully evaluated to prevent, or at least minimize, bird and bat mortality and adverse impacts through habitat fragmentation, disturbance, and site avoidance.

Design-Stage Mitigation

- Compile a minimum of 1 year of monitoring data; 2 years of data are suggested. Seasonal observations and detailed evaluation of the site should be conducted by qualified professionals with no vested interest in the project.
- Wind energy project location, design, operation, and lighting should be carefully evaluated to prevent, or at least minimize, bird and bat mortality and adverse impacts through habitat fragmentation, disturbance, and site avoidance.
- Sites requiring special scrutiny include those that are frequented by federally listed endangered species of birds and bats, are in known bird migration pathways, have high concentrations of birds, and have landscape features known to attract large numbers of raptors.
- Wind turbines, associated communication towers, and permanent met towers should be monopoles, not of lattice construction, and use no guy wires.

Construction-Stage Mitigation

- All connecting power transmission lines should be underground; if above-ground lines are required, the lines and poles should comply with APLIC standards.
- When disturbance is temporary, such as from construction impacts, disturbed areas should be fully reclaimed to approximate the same habitat functions for wildlife that existed before the disturbance.

Operational-Stage Mitigation

- The number of turbines that are lit should be minimized.
- Lit turbines should use only simultaneously pulsing white or red strobes, preferably at 20 pulses per minute.
- If significant mortality rates cannot be resolved, then turbines should be shut down during periods of peak risk to birds or bats.
- Two years of monitoring data should be collected after construction is complete. If legitimate mortality concerns arise, then studies should continue until monitoring demonstrates that concerns have been resolved.

Audubon Washington: Wind Power Policy for Washington State

Date Established: September 23, 2002

Location: State of Washington

Contact: Nina Carter, Executive Director Audubon Washington, 360-786-8020 x208

See: http://www.audubon.org/chapter/wa/wa/DOCs/Sept2002_WindPowerPolicy_ExecSummary.doc

The following policy statement applies to the siting, development, operation, and monitoring of wind power generation facilities. Although wind power generation generally has less detrimental impact than other forms have, this focus on wind power results from recent, high-profile developments in Washington. Furthermore, because the construction and operation of wind turbines has immediate, quantifiable impacts on birds, the public looks to Audubon for guidance on reducing or mitigating these impacts. This policy on wind power facilities is part of a more comprehensive energy policy, the remainder of which will be developed at a later date.

Design-Stage Mitigation

- At least 2 years of baseline monitoring of bird use of the project area and a surrounding buffer zone need to be completed. This requirement may be reduced to 1 year if monitoring is conducted using radar systems such as BIRDRAD.
    - Monitoring activities should span all seasons and be carried out during the night as well as during daylight hours, be conducted by professional ornithologists, and follow standard protocols.[11]
- Designs need to include technologies that are known to reduce detrimental impacts on birds (e.g., tubular towers, absence of guy wires, absence of lights that may attract night-migrating birds).
- A contingency plan must be established to be implemented when operational monitoring shows detrimental effects to birds and/or bird habitat.
- Wind power developers should encourage the involvement of local Audubon chapters and the environmental community during the initial project development phase.

Operational-Stage Mitigation

- Maximum speed of turbines is less than 30 rpm.
- Environmental monitoring must be conducted to assess the level of bird mortality caused by collisions, and it must follow standard protocols.
- Monitoring reports and data must be submitted quarterly to the Washington State Energy Facility Site Evaluation Council and the Washington Department of Fish and Wildlife for the first 2 years following commencement of operations and annually thereafter.

Clean Energy States Alliance: Model State Guidance Document Governing Avian and Bat Impacts from Wind Facilities

Date Established: October 2006

Location: State and federal agencies

[11] If the environmental impact study, site ranking process, or adaptive management results reveal areas with low bird density or use, or areas where substantial detrimental impacts to birds would not likely occur, these requirements could be reduced or waived.

Contact: Mark Sinclair, Deputy Director, Clean Energy States Alliance, 802-223-2554; msinclair@cleanegroup.org

The following "model" guidelines are recommendations for consideration by state and federal agencies to use in avoiding or minimizing impacts to avian and bat species from the construction and operation of wind-energy facilities. The purpose of the proposed guidelines is to outline the types and extent of the information needed to adequately identify, assess, mitigate, and monitor the potential adverse effects of wind energy projects on birds and bats. These guidelines are intended to be used in consultation with state wildlife biologists. A technical advisory committee should be established to review monitoring results and make suggestions to the permitting agency regarding the need to adjust mitigation and monitoring requirements.

Design-Stage Mitigation

- At least 1 year of preassessment monitoring should be conducted for micrositing (and more in areas with particularly high uncertainty about level of impacts and/or high site sensitivity). Survey methods used should be based on the objectives of the study, the species of interest, and the landscape. Studies should be conducted as seasonally and spatially appropriate; the intensity and frequency of monitoring is determined in consultation with the state wildlife agency.
- Avoid locations identified to have the potential for high risk to birds or bats or that are occupied by species of particular concern.
- Site projects on disturbed lands where possible.
- Avoid using or degrading high habitat areas.
- Avoid areas with high concentrations of birds through micrositing alternatives.
- Use tubular towers (as opposed to lattice towers) or best available technology to reduce the ability of birds to perch and the risk of collision.
- Turbine configurations should avoid creating barriers to bird movement, to the extent possible.
- Constraint mapping should be undertaken to assess where roads should or should not be located.

Construction-Stage Mitigation

- Minimize road cuts and the number of access roads.
- Power lines in open or high-elevation exposed locations should be buried, where possible. Overhead lines may be acceptable if they follow tree lines or are otherwise screened from potential collisions.
- Habitat destruction and fragmentation and disturbance of breeding, staging, and wintering birds should be minimized, to the extent possible.

Operational-Stage Mitigation

- Use the minimum number of pilot warnings and obstruction avoidance lighting recommended by the FAA. No high-intensity lighting should be permanently installed. Site lighting generally should be turned off unless needed for specific tasks.
- A decommissioning condition should be established for wind projects that require the creation of a plan and fund for the removal of the turbines and infrastructure when they cease operation, and for restoration of the site to approximate preproject conditions.
- Postconstruction operations monitoring is recommended at sites that support high densities of native breeding birds, concentrations of migrating birds, or threatened and endangered species. When the risk of fatalities is of concern, or considered likely for a species of concern, mortality surveys should be recommended for 1-2 years (and more if significant mortality concerns are identified) at a fairly modest level of sampling and intensity to determine possible effects.
- Determinations of carcass losses, scavenging trails, and searcher efficiency trials should be conducted in order to assess fatality rates as accurately as possible.

Annotated Bibliography

The literature included in this section was selected for its relevance to this mitigation study. Selections were limited to studies that examine the effects of specific changes to wind farm characteristics on birds and bats, as well as those on general habitat mitigation that appeared applicable to wind development. Studies were deemed relevant that examined one of several areas:

- The effectiveness of mitigation strategies on wildlife
- Avian/bat behavior studies conducted at wind sites along with management suggestions
- Studies comparing the effects of wind site alterations on birds or bats
- Studies that examined mitigation strategies suggested in policies and guidelines
- Studies mentioned by experts in the field.

Research was not included that focused on avian or bat ecology, searcher efficiency rates, scavenging rates, avian or bat mortality estimates, study design, classes of wildlife other than birds or bats, and modeling.

Referenced mitigation studies were representative of the current body of literature, and when scientific opinions differed, numerous studies were included. In general, selections were made from recent literature (published since 1995), but in some cases this was not possible. Some earlier literature was included if it was cited repeatedly within other studies because of its historical foundations. Previously conducted literature reviews (e.g., Appendix G by Orloff in Erickson et al. 1999) were used occasionally because of time constraints and difficulties in obtaining original papers; these are marked by a footnote within the annotated bibliography.

The literature is categorized according to the primary topic of the mitigation effort and research (e.g., location of the turbine on the site vs. habitat alterations). The bold type at the end of each citation indicates the type of publication (e.g., report, journal) as well as whether or not a peer review process was used (based on information gathered from the Acknowledgements section). Remaining categories include literature reviews and current research that has not yet been published. See also Appendixes B and C.

Turbine Location / Turbine Type

1. Anderson, R., N. Neuman, et al. (2004). *Avian Monitoring and Risk Assessment at the Tehachapi Pass Wind Resource Area.* Prepared for National Renewable Energy Laboratory: 1-102.

    This study was conducted to examine bird utilization, fatality rates, and collision risk indices between bird species, turbine types and turbine locations within the Tehachapi Pass WRA. Research was conducted between October 1996 and May 1998. Results indicated very few differences in the effects of turbine characteristics. There was a pattern of higher fatality rates at larger turbines, but when the fatality rates and collision risks were adjusted by rotor swept area (RSA) or turbine density, those differences were reduced, and in some cases the fatality rates for smaller turbines were higher than those for the larger turbines, on an RSA equivalence basis. Tubular towers were found to have lower estimated fatality rates than lattice towers in general, but the true cause of the difference cannot be determined because the two types of turbines were in different geographic locations. Results from this study and others conducted at the Altamont suggest that tower type is not likely to be related to collision risk where perch sites are abundant; however, the data indicate a higher rate of perching behavior on small and large lattice turbines, and on small tubular turbines compared with tall tubular turbines. Most perching occurs on turbines that are not operating. Structures such as lattice turbines and overhead lines that provide perches could lead to higher mortality because of an increase in the use of sites. Recommendations include higher search frequencies (e.g., monthly or twice monthly, at a minimum), a larger sample size (N=127, with 75 found on search plots), and searching entire turbine strings as opposed to individual ones when turbines within strings are closer together than two times the fatality plot search radius. **Report; review process used.**

2. Barrios, L., and A. Rodriguez (2004). "Behavioral and environmental correlates of soaring-bird mortality at on-shore wind turbines." *Journal of Applied Ecology* **41**: 72-81.

This study measured bird mortality, analyzed the factors that led birds to fly close to turbines, and proposed mitigation measures at two wind farms installed in the Straits of Gibraltar. Research was conducted between December 1993 and December 1994 at the wind farms, E3 and PESUR, which are located on hills and ridges composed of scrubland, rangeland, and forest habitat. Bird vulnerability and mortality were found to reflect a combination of site-specific, species-specific, and seasonal factors. Mortality was found to be much lower at E3 than at PESUR, as were risk indices (0.059 vs. 0.198, respectively). The frequency of risk situations at PESUR varied significantly with wind speed; the risk index was 0.343 between 4.6-8.5 m/s winds and decreased with increasing wind speed (0.037 in strong winds). Risk was observed to increase in autumn and winter. Mortality caused by turbines was higher than that caused by power lines, but it was not significantly associated with either structural attributes of wind farms (lattice vs. tubular) or visibility. The absence of thermals is believed to cause birds (specifically vultures) to use slopes for lift, and this could be a prominent factor in the high mortality rates observed. All species affected by the turbines were listed as threatened or vulnerable in Spain; thus, mitigation measures are necessary. Results indicate the most sensible approach is to suspend the operation of the small number of turbines that cause most deaths only under the wind speeds that lead to risk situations. A more general recommendation is that all new wind power facility projects should include a detailed study of bird behavior at the proposed construction site. **Journal; no mention of review process.**

3. Brown, W. M., R. C. Drewien, et al. (1985). *Mortality of Cranes and Waterfowl from Power Line Collisions in the San Luis Valley, Colorado*. 4th Crane Workshop, Grand Island, Nebraska, Platte River Whooping Crane Habitat Maintenance Trust.

The authors recommend that no new transmission lines be placed within two kilometers of traditional roost or feeding sites. The static wire (the nonconducting topmost wire on a power line used to minimize power outages from lightning strikes) is normally smaller than the conductors and appears to be the wire most often struck by birds in flight. Static wire removal is recommended whenever possible, but modification or better marking are preferred methods. **Unable to relocate study for review information.**

4. Erickson, W. P., G. D. Johnson, et al. (1999). *Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington.* Prepared for the National Renewable Energy Laboratory**:** 1-75.

This report summarizes the avian research conducted at the Columbia Wind Farm #1 in Klickitat County, Washington. This report documents only the preconstruction data collected because development of the site was indefinitely postponed and the field surveys were suspended at the end of one year. After one year of data collection, spatial use data indicated that avian use of the CARES study area tends to be concentrated near the rim edge, indicating that risk may be reduced by placing turbines away from the rim edge. High use of rim edges by raptors has also been documented at other sites. **Report; review process used.**

5. Hoover, S. (2002). *The Response of Red-tailed Hawks and Golden Eagles to Topographical Features, Weather, and Abundance of a Dominant Prey Species at the Altamont Pass Wind Resource Area, California*. Prepared for the National Renewable Energy Laboratory: 1-64.

The goals of this study were to determine which characteristics of the landscape influence hawk and eagle habitat selection within the Altamont Pass Wind Resource Area (WRA). The study period was June 9, 1999, to June 20, 2000; observations were conducted weekly. The variables showing the strongest relationship for red-tailed hawks (RTHA) were wind speed, wind direction, and slope aspect. There was a significant relationship between kiting or gliding activity and elevation; 90% of RTHA kiting occurred on only 3 of the 24 slopes in the steepest incline category and 14% of all mortalities found on 4% of the slopes. Kiting behavior was found to be used in high winds and was seen significantly more often at 11-50 m from the ground, the height of the rotating turbine blades. RTHA flight activity did not increase in areas with progressively higher squirrel density, suggesting that favorable wind currents have a stronger appeal because they make foraging more energy efficient. Golden eagles were noted as using narrow corridors that transect large hills, specifically ones that are oriented east to west with steep (>23% average grade) and tall (peak elevations of 170-205 m) hills located on the north and south sides. All 7 eagle fatalities occurred where these 'canyons' opened up onto the valley floor (Rugge 2001). Closing down the turbines that are constructed on valley plateaus or along the rim where the plateau meets the sloping hillsides is recommended. It is also recommended that turbines be powered down atop hazardous slopes (RTHA) and where high winds are perpendicular to the slope. This well-done study illustrates numerous significant relationships to support recommendations. **Report; review process used.**

6. Hoover, S. L., and M. L. Morrison (2005). "Behavior of red-tailed hawks in a wind turbine development." *Journal of Wildlife Management* **69**(1): 150-159.

Between June 1999 and June 2000, the flight behaviors of RTHA were recorded in relation to characteristics of the topography (e.g., slope aspect, elevation, and inclination) and to various weather variables (e.g., wind speed and direction). RTHA behavior and their use of slope aspect was found to differ according to wind speed; hawks perched or soared more often in low winds and showed kiting behavior in strong winds. Results indicate that red-tailed hawk behavior is strongly influenced by a combination of wind conditions and topography. Strong winds from the south-southwest resulted in kiting behavior on south-southwestern facing slopes with inclines greater than 20% and peak elevations greater than adjacent slopes. Because topographical features and weather variables have been shown to predict the strength and location of deflection updrafts necessary for kiting behavior, it is essential that a detailed site assessment and behavioral study be conducted to identify locations where the topographical/weather interaction may produce dangerous conditions for foraging RTHA and other raptors. Mitigation measures to decrease fatalities should be directed specifically to these areas and others fitting the general model. It is suggested that turbines be powered down at the top of these hazardous slopes when they pose the greatest danger, i.e., strong winds facing perpendicularly to the slope. No significant relationships were specifically mentioned within results to support management considerations. **Journal; review process used.**

7. Hunt, W.G. (2002). *Golden Eagles in a Perilous Landscape: Predicting the Effects of Mitigation for Wind Turbine Blade-Strike Mortality*. Prepared for the California Energy Commission**:** 1-72.

This study was initiated in June 1998 to provide information to the California Energy Commission's Public Interest Energy Research (PIER) Program before an extensive repowering project was carried out to replace approximately 1300 Type-12 turbines with larger turbines on tubular towers at a ratio of 7:1. The objectives of this study were to increase the number of radio-tagged eagles and to continue monitoring them to further understand demographics, track the net result of repowering, and explore other mitigation measures to reduce golden eagle mortality rates. Density comparisons of eagle relocations and fatalities in the two northern polygons, both of which contained relatively high numbers of relocations, suggested that the one containing Type-13 turbines was more lethal (19 mortalities) than that containing Type-28 turbines (2 mortalities). Reducing the number of Type-13s as part of the repowering would very likely benefit eagles, especially in areas where they concentrate. The turbines that caused lower mortality rates had blades higher off the ground, towers that were spread apart more widely, and tubular towers that offered little opportunity for perching. Other suggestions include reducing ground squirrel density around the turbines through live-trapping and relocation, a recommendation based on surveys indicating golden eagles use of high-density squirrel areas over low ones at a ratio of 7:1. **Report; reviewed by four referees (incl. Erickson, Strickland, and Manly).**

8. Johnson, G. D., M. K. Perlik, et al. (2004). "Bat activity, composition, and collision mortality at a large wind plant in Minnesota." *Wildlife Society Bulletin* **32**(4): 1278-1288.

Bat activity levels, species composition, and collision mortality were examined at a large wind plant in southwest Minnesota from June 15-September 15, 2001, and again in that period in 2002. Peak bat activity at turbines followed the same trend as bat mortality, occurring from mid-July through the end of August. It is believed that most bat mortality (151 individuals) involved migrating bats, because of the species involved in collision fatalities (hoary, eastern red, and silver-haired bats). There was no significant relationship between bat activity at turbines and the presence of lights or number of fatalities at turbines. Bat activity decreased with increasing distance from woodlands; however, this relationship may reflect only the high bat activity (>10 bat passes/night) recorded at a small number of turbines within 100 m of woodlands rather than a true relationship between bat activity as a function of distance from woodlands. **Journal; two reviewers (incl. R. Osborn).**

9. Osborn, R. G., C. D. Dieter, et al. (1998). "Bird flight characteristics near wind turbines in Minnesota." *American Midland Naturalist* **139**(1): 29-38.

This study was conducted at Buffalo Ridge Wind Resource Area (BRWRA), where the habitat consists of agricultural and CRP fields. Data suggests that birds avoid flying in areas with wind turbines. Most birds observed (75% in 1994; 70.2% in 1995) flew below blade height, with only 16% (1994) and 17.5% (1995) seen flying between 21-51 m. Birds seen flying through tower string often adjusted their flight patterns when turbine blades were rotating and often made no adjustments when turbine blades were not rotating, suggesting that birds could detect blade movement either by sight or sound (80% in 1994 & 74.8% in 1995 seen flying 31 m or further from turbine at time of sighting). The absence of raptor mortality at the site is believed to be the result of the small number of raptors frequenting the area and the tubular tower design which discourages perching and nesting on turbines. The availability of alternative perching sites is also believed to have reduced the attractiveness of wind turbines as perching sites for raptors at this location. 75% of passerine mortality occurred during migration periods. Baseline data noted as being essential for establishing initial abundance, migration patterns, identifying species of concern, and evaluating post-construction effects of turbines on bird populations. It is unclear how tower design conclusions were reached based on study design. **Journal; no mention of review process.**

10. Osborn, R. G., K. F. Higgins, et al. (2000). "Bird mortality associated with wind turbines at the Buffalo Ridge Wind Resource Area, Minnesota." *The American Midland Naturalist* **143**(1): 41-52.

The purpose of this research was to determine the degree of avian mortality resulting from collisions with wind turbines and to assess the influence of biases affecting our ability to detect avian mortality at Buffalo Ridge in Minnesota. Research occurred in 1994 and 1995 (1994 considered a pilot year & methodologies modified in 1995), and turbines were located in agricultural and Conservation Reserve Program (CRP) fields. Because of the small number of dead birds found (12l), it was not possible to determine if any particular species or group of birds is more susceptible to collisions with turbines. Observer efficiency was found not to differ by year or cover type, but to be influenced by the size of the bird. Consideration of potential impacts on avian communities before designing and siting of a facility may be a best first step to reduce mortality at wind power resource projects involving wind turbines (citing Nelson and Curry 1995). The recommendation is to avoid building wind plants near areas with large concentrations of birds (e.g., high-density breeding or wintering areas), known migration corridors, or refuges until further research is done. Recommendations also include conducting mortality searches on a 2- to 3-day-rotation to minimize the impacts of scavenging and decomposition on recovery numbers; however, biases affecting bird recovery are expected to be unique for each wind plant, so bias assessments must be made on a site-by-site basis. Unable to find definitive information within paper pertaining to significance of results or if recommendations are supported by research. Also, very small sample size. **Journal; reviewed by six referees (incl. S. Ugoretz, J. Schladweiler, S. Cooper).**

11. Orloff, S., and A. Flannery. (1992). *Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas Tiburon, California.* Prepared for the Planning Departments of Alameda, Contra Costa, and Solano Counties and the California Energy Commission.

This study was conducted at the Altamont Pass WRA over six seasons between 1989 and 1991 to determine the relationships among bird use, fatalities, turbine characteristics, and physical variables associated with the site. Of 182 bird carcasses found, 119 (65%) were raptors (55% killed by turbines, 8% electrocuted, 11% collided with wires, and 26% unknown). Lattice turbine types were associated with a higher mortality rate than all other turbine types combined; however, mortality rates at tubular towers were found to increase 12.5% when located in end rows and close to a canyon. A discriminate analysis indicated three turbine characteristics were significantly associated with raptor mortality: end-row turbines, turbines close to canyons, and the number of steep-sided slopes (0-4). Using the same analysis, these characteristics were not found to have a significant association with raptor mortality: first turbine row, degree of slope, slope aspect, length of turbine row, position on slope, and ground squirrel density. Elevation was also deemed significant, although the authors question the biological significance because (1) mean elevation difference was only 157 ft, (2) distribution of elevations between killing and nonkilling turbines was similar, and (3) elevation was associated with canyon proximity and number of steep slopes, which were related to mortality. None of the characteristics were found to be significant for nonraptors, but the authors note this may have been caused by the low sample size. Mortality did not appear related to abundance. **Report; review process used.**

12. Smallwood, K.S., and C.G. Thelander. (2004). *Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area.* Prepared for the California Energy Commission: 1-363.

This study involved a five-year research effort to better understand bird mortality at the Altamont WRA. Bird behaviors, raptor prey availability, wind turbine and tower design, interturbine distribution, landscape attributes, and range management practices were studied to explain variations in bird mortality. Researchers recommended the following mitigation measures: relocate selected, highly dangerous wind turbines; move rock piles away from wind turbines (prey cover for kit fox); retrofit tower pads to prevent burrowing by small mammals; remove broken and nonoperating wind turbines; implement means to effectively monitor the output of each turbine; and retrofit noncompliant power poles to minimum Avian Power Line Interaction Committee (APLIC) guidelines. Researchers recommend the following measures be abandoned because of their ineffectiveness in reducing avian mortality rates: rodent control program, installation of perch guards, provision of alternative perches, and barricading of rotor blades. The following mitigation measures are unproven but believed to be highly effective: exclude cattle from around wind turbines through fencing (decreasing cattle pats and associated grasshopper populations may decrease Burrowing Owl population because of perching preference); install flight diverters (poles placed 5-10 m apart and just beyond the rotor plane of the wind turbine at end of string); paint blades using scheme of Hodos et al.; reduce vertical and lateral edge in slope cuts and nearby roads (to decrease pocket gopher population); and use devices to identify when to operate problem wind turbines with the least effect on birds (accelerometers). Turbine strings were found to be most dangerous when some turbines are on and others off; wind turbines at the ends of strings and at the edges of clusters were found to kill disproportionately more birds. Access roads should be minimized, along with buried pipelines near wind turbines. Also, the APWRA could be repowered with fewer wind turbines mounted on taller towers with larger individual output capacities (turbines should have blades no closer to the ground than 29 m). Researchers found that at least 3 years of carcass searches are needed before the sample of wind turbines sufficiently stabilizes. **Report; review process used (five referees).**

13. Smallwood, K.S. (2006). *Biological Effects of Repowering a Portion of the Altamont Pass Wind Resource Area, California: The Diablo Winds Energy Project*.

This paper provides a review of the WEST, Inc. (2006) report on the Diablo Wind Energy Project, in which 169 vertical-axis wind turbines were replaced with 31 larger horizontal-axis wind turbines in the Altamont Pass WRA. The author found WEST, Inc., to have inappropriately analyzed bird mortality rates because the study area was increased (800-m radius) compared with the initial smaller area (300-m radius). Adjusted mortality estimates from 1 year of monitoring data indicated a 70% reduction in overall bird mortality, a 62% reduction in raptor mortality, and an 85% reduction in burrowing owl mortality. RTHA mortality, however, was shown to have increased nearly 300%, and some mortalities were not recorded during prereplacement studies (e.g., golden eagles and bats). Analysis of utilization and mortality indicated a decline in utilization over the past 8 years and a decrease in mortality since repowering. Mortality adjustments include uncertainties and potential statistical bias. Several years of monitoring will be needed more accurately compare mortality before and after the project. **No review process.**

14. Thelander, C. G., and L. Rugge. (2000). *Avian Risk Behavior and Fatalities at the Altamont Wind Resource Area*. Prepared for the National Renewable Energy Laboratory: 1-22.

In this progress report, mortality data were collected during an 11-month period to meet these objectives: (1) to relate bird flight and perching behaviors to mortality risk, and (2) to identify any relationships between these behaviors and turbine or tower type, weather, topography, habitat features, and other factors that may predict high degrees of risk to birds, especially raptors. Findings indicated that there may be no significant difference between the frequency of fatalities associated with turbines at the ends of turbine strings when compared with those within turbine strings (contrary to Orloff and Flannery 1996). Findings also indicated that, to date, 57% of all bird fatalities had been associated with tubular towers (50% of all turbines included in fatality searches were on tubular towers). This is significant because it implies that tubular towers may represent as significant a risk to birds as do horizontal-lattice turbine towers (contrary to Orloff and Flannery 1992). This paper also pointed out the difficulty of finding a universal management solution when underlying risk factors vary greatly from species to species. **Report; review process used.**

Lighting

15. Erickson, W. P., J. Jeffrey, et al. (2004). *Stateline Wind Project Wildlife Monitoring Final Report, July 2001-December 2003.* Prepared for FPL Energy, the Oregon Energy Facility Siting Council, and the Stateline Technical Advisory Committee**:** 1**-**105.

Nocturnal migrant and bat fatality rates for lit turbines, turbines adjacent to lit turbines, and other unlit turbines were collected and compared from July 2001-December 2003. Observed fatality rates at lit turbines were slightly higher than at unlit turbines, although none of the differences were statistically significant ($p > 0.10$). This suggests that lights on Stateline turbines did not attract large numbers of bats or birds during the study (supported by Erickson et al. 2003b and Johnson et al. 2002). One factor that may cause this lack of association is the height of turbines and rotors (74 m [242 ft]), which is significantly lower than tall communication towers associated with large fatality events. Light type (solid, flashing, strobe), color (red, white), and intensity (low, medium, high) may be important factors in attracting birds, but these factors are not well understood. Nearly all bat fatalities were found in late summer and fall, at times when silver-haired and hoary bats are migrating; these two species comprised 96.1% of fatalities. A common resident of the area, the horned lark, had the largest fatality rate (40%), but the next most abundant fatality rate was for the golden-crowned kinglet, not a local breeder but believed to have been affected while migrating through the area at night. Fatality estimates per turbine may be lower for smaller turbines than for larger ones, but could be misleading since it takes more small turbines to generate the same amount of electricity. The true cause of death is unknown for most of the 2002-2003 fatalities; several are believed to be caused by vehicles (e.g., maintenance personnel) and not wind turbines, given the location of the finds. Preliminary results suggest a relatively small-scale impact on nesting birds; the majority is due to direct loss of habitat from pads and roads. Grassland bird displacement studies, fatality monitoring, raptor nest monitoring, and the Wildlife Reporting and Response System (WRRS) components of this study will be continued. **Report; five reviewers (J. White, T. Meehan, M. Kirsch, K. Blakley, G. McEwen)**

16. Howell, J. A., J. Noone, et al. (1991). *Visual Experiment to Reduce Avian Mortality Related to Wind Turbine Operations.* Prepared for Altamont U.S. Windpower, Inc.: 1-25.

Three hypotheses about bird collisions and wind turbines in the Altamont Pass were tested from August 1988 to August 1989: birds cannot see the blades under specific conditions, collisions tend to occur at ends of turbine strings, and collisions tend to occur at swales or hill shoulders. During the study, 10 dead birds were found beneath turbines. Increasing turbine blade visibility (alternating patterns of red and white) appeared to reduce the number of collisions, since only one bird was recovered under a painted tower. It was not clearly determined that specific locations in the turbine string are foci for mortality, although site-specific variation did exist. No significant differences were found as a result of the three studies; however, the authors say that lower p-values for the paint experiment may suggest a significant effect would be detected if the sample size were larger. **Report; unsure of review process.**

17. Johnson, G. D., W. P. Erickson, et al. (2003). "Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota." *American Midland Naturalist* **150**: 332-342.

This study was conducted from 1996-1999 to assess the effects of wind power development on wildlife. A total of 184 bat collision fatalities were documented (97% of carcasses found $\leq$ 20 m from a turbine); hoary and eastern red bats constituted most of the fatalities. There was a near absence of mortality in June and early July when resident bats are breeding, indicating that resident populations are not being impacted by the wind plant. The timing of mortalities, among other factors, suggests that most mortality involves migrant rather than resident breeding bats. Lighting on turbines did not increase the number of bat collision fatalities at the Buffalo Ridge wind plant. The potential for wind plants to impact bat populations should be addressed when siting new facilities, especially in areas where threatened or endangered bat species may be found. **Journal; no mention of peer review.**

18. Kerlinger, P., and J. Kerns (2004). *A Study of Bird and Bat Collision Fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003*. Prepared for FPL Energy and Mountaineer Wind Energy Center Technical Review Committee**:** 1-39.

A postconstruction bird and bat fatality study was conducted between April 4 and November 11, 2003, at the Mountaineer Wind Energy Center (MWEC) in Tucker County, West Virginia. A total of 69 avian carcasses representing 24 known species were found; the majority were nocturnal migrant songbirds or songbird-like species (70.8%). Of the 69 fatalities, 33 (47.8%) were found on May 23, 2003, and determined to have been caused by the combination of heavy fog and several sodium vapor lights at a substation located near turbine 23. No avian fatality events occurred at the site after the sodium vapor lights were extinguished. A total of 475 bat carcasses representing 7 species were detected, mostly between August 18 and September 30, 2003 (92.5%). Correlation between weather during fall migration and new bat fatalities reveal no strong relation between fatalities and wind speed, wind direction, temperature, or fog/precipitation at the site. Bats killed at the MWEC might have collided with the turbine itself rather than the blades. No difference in numbers of birds or bat fatalities was found at lit versus unlit turbines. This suggests that FAA lighting (L-864 red strobes) did not attract nocturnal migrants, unlike the lighting on communication towers (which include steady-burning red, L-810 lights). Recommendations include conducting weekly searches of turbines in the eastern United States, particularly during avian/bat migration periods. Ideally, daily searches of all turbines or a random subset during fall migration should be conducted to examine correlations between weather conditions and bat fatalities. **No review process; statistical reviews by Erickson and Shoenfeld.**

19. Larwood, S. (2005). *FAA Obstruction Lighting Standards for Wind Energy Plants*. Prepared for the California Wind Energy Collaborative, sponsored by the California Energy Commission Public Interest Energy Research (PIER) program.

This project report established lighting standards for wind turbine sites as an issue of pilot safety. Proposed guidelines include establishing a maximum separation gap of 0.5 mile between lights along a row; omitting lights within clusters; no daytime lighting; synchronizing lights for entire project; using red or white flashing lights if possible; omitting steady-burning lights; lighting end row turbines; and using a single light mounted above the hub radius. No research was conducted on the effects of this lighting scheme on wildlife. These guidelines are based on the outcomes of airplane flight evaluations conducted by J. Patterson (2004). **Report; no review process**.

20. U.S. Fish and Wildlife Service. (2007). *"Effects of Communication Towers on Migratory Birds."* Comments of the U.S. Fish and Wildlife Service submitted electronically to the FCC on 47 CFR Parts 1 and 17, WT Docket No. 03-187, FCC 06-164, Notice of Proposed Rulemaking: 32, 12-18.

These comments and recommendations assess a compilation of past and very recent (through 2006) peer-reviewed studies conducted most recently in Michigan and New York on the impacts of various lighting regimes (i.e., steady-burning red [L-810] and white lights, white strobe lights [L-865], red strobe lights [L-864 red strobes], and red blinking incandescent lights [L-864 flashing beacons]) on night-migrating avifauna. Where steady-burning L-810 lights were completely extinguished in the Michigan study (Gehring et al. 2007), avian collision injury and mortality with the communication towers were reduced by 71%. USFWS also provisionally recommended use of red strobe and/or red blinking lighting regimes as a secondary option if white strobes cannot be used. This recommendation is predicated on the use of no steady-burning lights. The results from these communication tower studies are also applicable to lighting regimes on wind turbine facilities. Recommendations to the Federal Communications Commission based on peer-review of the Michigan research protocol (2 independent reviewers), and independent peer review of the preliminary research results; peer review of the New York study to be published in North American Birds independently peer-reviewed by anonymous professionals.

Visual Blades

21. Hodos, W. (2003). *Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines*. Prepared for the National Renewable Energy Laboratory**:** 1-43.

This study evaluated the pattern electroretinogram (PERG) visibility of 7 blade velocities from 36-144 rpm. To reduce motion smear, eight blade patterns, a serious of blade tip devices, and various chromatic and achromatic single blade types were devised and tested. Thin, staggered black stripes were found to have a visibility approximately 4x greater than blank blades at 130 degrees of visual angle per second (dva/sec). At 170 dva/s, all the patterns had about the same visibility. By 240 dva/s, all the patterns essentially had no visibility as individual blades appeared blurry or transparent. No data suggest the optimum ratio of black to white stripe thickness. Tests using a 20-m diameter turbine rotating at 45 rpm against a neutral background found that blank blades, thin-stripe blades, and thick-stripe blades would all be visible at a distance of 21 m; thin-striped blades were the most visible. By 19 m, the anti-motion-smear patterns lost advantage over blank blades; by 17 m, visibility for all three blade types was close to zero. A combination of blade diameter, rotation rate, and viewing distance resulting in velocities of the retinal-image of the blade tip exceeding 130 dva/s will result in motion smear. No data illustrate how these stimuli retain their improved visibility under suboptimal viewing conditions (e.g., mist, rain). A single, solid-black blade or a thin-striped blade paired with two blank blades would probably be the most visible visual deterrent. Colored blades are not recommended because of cost and possible problems with background contrast. Data showed that two-tip devices were superior to blades with no devices, but single and three-tip devices were found to be ineffective. However, two-tip devices became less visible against naturalistic backgrounds, thereby making the results rather ambiguous. The size of tip devices was arbitrary. This study has not been field-tested; results are based on lab data to date. **Report; review process used**.

22. Young, D. P., W. P. Erickson, et al. (2003). *Comparison of Avian Responses to UV-Light-Reflective Paint on Wind Turbines*. Prepared for the National Renewable Energy Laboratory: 1-67.

This study examined the effects on bird use and mortality of painting wind turbine blades with UV-reflective gel at Foote Creek Rim Wind Plant in Carbon County, Wyoming. Data were collected from six permanent stations within the study area (33 conventionally painted turbines and 72 turbines painted with UV-reflective paint) using avian point count surveys and carcass searches. A total of 3,501 bird observations were made between July 1, 1999, and December 31, 2000. Passerine use was similar between the two areas; raptor use was significantly higher in the UV area. Of 84 fatalities found within the search plots, 57 (68%) were found at the UV turbines, 13 (15%) at the non-UV turbines, and 14 (17%) at the 7 meteorological (met) towers. Although other studies (Hurlbert 1984, Morrison et al. 2001) found significant differences between UV and non-UV turbines, this study found no significant difference between bird mortality, use, or risk between turbine blades painted with a UV-light-reflective paint and those with conventional paint. Although two times more passerine fatalities were found at the UV-painted turbines, statistical inferences are limited because of the low level of avian mortality observed and the lack of a controlled experimental design. Better spatial representation, accomplished by providing a larger sample size of turbines and more observations, would have improved this study. **Report; review process used.**

Microwaves

23. Kreithen, M.L. (1996). "Development of a pulsed microwave warning system to reduce avian collisions with obstacles." *Second International Conference on Raptors*. Urbino, Italy.

In this study, 20 homing pigeons were tested for their ability to detect pulsed microwaves. For 707 trials, 84.3% of the birds responded to pulsed microwaves, and 17.1% responded to control trials. Study results should not be used to make statistical inferences for species of birds other than homing pigeons.[1]

Sound

24. Dooling, R. (2002). *Avian Hearing and the Avoidance of Wind Turbines*. Prepared for the National Renewable Energy Laboratory: 1-17.

This report describes hearing measurement in birds, the effects of noise on hearing, and the relationship between avian hearing and the general noise levels around wind turbines. A review of the literature on the ability of birds to hear in noisy (windy) conditions suggests that birds cannot hear the noise from wind turbine blades as well as humans can (humans can hear blades 2x further away). Because some blades whistle as a result of blade defects, minor modifications to the acoustic signature of a blade might make them more audible to birds (between 1 and 5 kHz) while making no measurable contribution to overall noise. The hypothesis that louder blade noises (to birds) results in fewer fatalities remains untested. **Report; review process used.**

Marking Power Lines

25. Alonso, J.C., J.A. Alonso, and R. Munoz-Pulido. (1994). "Mitigation of bird collisions with transmission lines through groundwire marking." *Biological Conservation* **67**: 129-134.

This study was conducted in southwestern Spain during two winters (1990 and 1991) to evaluate the effectiveness of groundwire marking in reducing bird collisions with transmission lines. The habitat studied included agricultural lands alternating with oak forests, and markers were placed at sites frequently crossed by birds of several species during daily flights between roosting and feeding areas. A significant decrease in collision frequency ($p = 0.029$) was found between spans marked with red PVC spirals (18 birds found) compared with the same spans before marking (45 birds found). Bird mortality at unmarked spans increased (19 to 25 birds), but this change was found to be insignificant ($p = 0.461$). The percentage of birds flying between the cables decreased, and those flying above the cables increased, suggesting that the birds saw the groundwire markers. **Journal; reviewed by three referees (incl. E. Duffey).**

26. Brown, W. M., and R. C. Drewien (1995). "Evaluation of two power line markers to reduce crane and waterfowl collision mortality." *Wildlife Society Bulletin* **23**(2): 217-217.

This study evaluated two power line markers for reducing crane and waterfowl mortality in the San Luis Valley, Colorado, and examined factors contributing to collisions and marker effectiveness. Collision mortality rates at 8 segments (about 0.8 km each) of power lines marked with either yellow spiral vibration dampers or yellow fiberglass swinging plates were compared with 8 adjoining unmarked segments. During 3 spring and 3 fall migration periods (1988-1991), estimated mortality on study segments was 706, affecting 35 species or more. Waterfowl and cranes constituted >80% of mortality. Both marker types reduced mortality ($P < 0.005$). Birds reacted to marked lines at greater distances and increased their altitude compared with unmarked lines ($P < 0.0001$). Factors affecting collisions or marker effectiveness included wind, nocturnal flights and disturbance, and age of sandhill cranes. Neither marker performed better in all study seasons; each may have had unique benefits.

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[1] Cited by Sue Orloff in Erickson et al. (2002). *Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington*. Prepared for the National Renewable Energy Laboratory: 1-75.

Plates damaged distribution lines, precluding their continued use; however, a new marker from Europe that incorporates the benefits of both plates and dampers should be evaluated, because it may protect best against collision losses.[2] **Journal; no mention of review.**

27. Janss, G. F. E., and M. Ferrer (1997). "Rate of bird collision with power lines: effects of conductor-marking and static wire-marking." *Journal of Field Ornithology* **69**(1): 8-17.

This study tested the ability of different markers to reduce bird collisions by comparing marked spans with unmarked spans along three different power line types in west-central Spain. The study consisted of two periods over 4 years. The first period (1991-1993) had no markers; the second (1993-1995) had markers in some of the study spans. No statistical differences were detected among the three power lines in collision frequency per survey ($P = 0.86$). The spiral marker was found to significantly reduce collisions for all birds by 81% ($P = 0.0198$). Black crossed bands were also found to be effective, resulting in a decrease in collisions of 76% for all birds. However, when the vulnerable great bustard is included in the analysis, markers were found to have no effect ($P = 0.080$). The third marker, consisting of thin black strips, showed no significant reduction in mortality ($P = 0.052$). Overall reduction in mortality for both the spiral and the crossed bands was more than 75% (excluding the great bustard), deemed an encouraging result compared with other studies where reductions in mortality are about 50%. **Journal; no mention of review.**

28. Morkill, A. E., and S. H. Anderson (1991). "Effectiveness of marking power lines to reduce sandhill crane collisions." *Wildlife Society Bulletin* **19**(4): 1-8.

This study was conducted near the Platte River in portions of Dawson, Buffalo, and Kearney Counties in south-central Nebraska to evaluate the effectiveness of marking power lines to reduce collisions with sandhill cranes. Nine segments of static wires were divided into spans that were either marked or unmarked with yellow aviation balls containing vertical black stripes. Of the 36 carcasses, 25 had died from collisions with unmarked spans. No significant difference between the number of birds flying over marked and unmarked transmission lines was found, but significantly more cranes were killed in collisions with unmarked spans because cranes reacted sooner to marked spans. Although this study was deemed appropriate and strong (see Orloff in Erickson et al. 1999), it is unclear how the segments or spans were selected. **Journal; reviewed by six referees (W. Hubert, E. Williams, F. Lindzey, M. Czaplewski, J. Lewis, C. Faanes)**.

29. Organ, C. A., M. Timewell, et al. (2003). *Bird Surveys along the Proposed Musselroe Wind Farm Transmission Line - Ringarooma Ramsar Area, North-east Tasmania*. Prepared for Hydro-Electric Corporation**:** 1**-**62.

This study is a preassessment for a proposed transmission line easement. Surveys were conducted in areas up to 300 m from the proposed easement and occurred over two seasons, one day during winter and several days in spring 2002. Overall, potential impacts on birds are expected to be low, as the route selected largely avoids areas of high bird activity. Bird flight diverters where transmission lines cross the Ringarooma River and the Marsh Creek Dam are recommended. The study also recommended that the power line be kept high where it crosses the Marsh Creek Dam to minimize the potential for collisions with birds taking off or landing. **No mention of review.**

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[2] Cited by Sue Orloff in Erickson et al. (2002). *Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington*, Prepared for the National Renewable Energy Laboratory: 1-75.

Perch Guards

30. Nelson, H. K., and R. C. Curry (1995). "Assessing avian interactions with wind plant development and operations." *61st North American Wildlife and Natural Resources Conference*. Washington, D.C.

    This study was conducted to assess whether perch guards reduced the number of birds perching on turbines at Altamont Pass, California. Wires or wire screens were installed to prevent perching and nesting on 50 turbines. A 54% reduction in perching was estimated; however, no power analyses were conducted to evaluate sample size and no confidence intervals were calculated.[3] **Unsure of review process.**

Curtail Turbines

31. Huppop, O., J. Dierschke, et al. (2006). "Bird migration studies and potential collision risk with offshore wind turbines." *Ibis* **148**: 90-109.

    This study was begun in 2003 to investigate year-round bird migration over the North Sea in Germany to determine avian behavior in regard to wind farms (flight distances, evasive movements, influence of lights, collision risk). Data were collected from a platform holding a 100-m mast located at the proposed construction site. Results show weather severely impacting variations in intensity, time, altitude, and species of migration. Most offshore bird migration was confined to a few nights, when tailwinds were above a certain strength. More than half of the cadavers were collected in two nights; most birds clearly collided with the tower rather than died from starvation. Terrestrial birds, especially passerines, were attracted by illuminated offshore obstacles, especially in poor visibility conditions. Disoriented birds flew around the platform repeatedly, increasing the risk of collision and energy consumption. Inland findings are not believed applicable to offshore ones because birds tend to migrate at lower altitudes over sea than land, particularly night migrants on dark nights, in headwinds, or when there is precipitation. The study suggests that turbines be turned off and rotor blades adjusted during the few nights in which numerous bird strikes are expected (e.g., in adverse weather conditions with high migration intensities). It also recommends that turbines not be placed in dense migratory zones or between resting and foraging grounds, that they be aligned in rows parallel to the main migratory direction, and that do not feature large-scale continuous illumination. This research was conducted before the establishment of an actual wind farm, so it cannot be directly applied to offshore wind farms. Recommendations need to be field-tested. **Journal; three reviewers (R. Langston, K. Huppop, S.A. Gauthreaux, Jr.)**

Habitat

Habitat Alterations

32. Grindal, S.D., and R.M. Brigham. (1998). "Short-term effects of small-scale habitat disturbance on activity by insectivorous bats." *Journal of Wildlife Management* **62**(3): 996-1003.

    This study examined the effect of small-scale disturbances (creation of small cutblocks) and an access road in a forest setting on bats' habitat use. This before-after control impact (BACI) study occurred in a low-elevation forest in the southern interior of British Columbia, Canada, in 1993 and 1994. Forest harvesting was found to have a significant effect on bat activity but not on insect availability. Bat activity increased in cutblocks after harvesting

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[3] Cited by Sue Orloff in Erickson et al. (2002). *Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington*. Prepared for the National Renewable Energy Laboratory: 1-75.

(activity tended to decrease with increasing cutblock size, although not significantly). Bat activity was increased after road construction. However, data were pooled for different cutblock sizes because of the small sample size (no N located in this study). Small-scale habitat disturbance may provide commuting and foraging areas for bats, but larger scale disturbances on bat ecology are still unclear. **Journal; reviewed by three referees (C.I. Stephan, P. Bradshaw, M.A. Setterington).**

33. Herzog, F., S. Dreier, et al. (2005). "Effect of ecological compensations areas on floristic and breeding bird diversity in Swiss agricultural landscapes." *Agriculture, Ecosystems and Environment* **108**: 189-204.

Vegetative and avian surveys were conducted in 56 study regions between 1998 and 2001 to assess whether ecological compensation areas (ECAs) in Switzerland enhance biodiversity, as stated in policy goals. ECAs make up approximately 13% of the utilized Swiss agricultural area (UAA). ECA grasslands occurred more frequently up to 50 m from the forest edge; they were much more often located in steeper areas. There were very few Red List plant species found within ECAs, suggesting that the ECA program is hardly contributing to the preservation of endangered species, as the policy states. The quality of vegetation of 51%-87% of the ECA meadows did not correspond to traditional hay meadows, and they generally did not enhance populations of meadow birds. Most ECA litter meadows achieved target vegetation compositions; breeding birds used them more frequently than they did other ECA types. Approximately 50% of the hedgerows in the ECA program had good ecological quality and were advantageous for birds, and traditional orchards reflected prior intensive utilization with little contribution to floral diversity. The study recommended that meadow programs be eliminated, litter meadow and hedgerow programs be expanded, and extension activities be concentrated on traditional orchards. Results are limited to the Swiss plateau and cannot be extrapolated to the whole of Switzerland. **Journal; reviewed by seven referees (S. Aviron, S. Birrer, P. Jeanneret, L. Kohli, D. Bailey, M. Kuusaari, G. Le Lay).**

34. Larsen, J.K., and J. Madsen. (2000). "Effects of wind turbines and other physical elements on field utilization by pink-footed geese (*Anser brachyrhynchus*): A landscape perspective." *Landscape Ecology* **15**: 755-764.

This study was carried out in spring 1998 to examine the effects of wind turbines and other physical landscape elements on field utilization by wintering pink-footed geese in farmlands in Denmark. Habitat loss per turbine was found to be higher in wind farms with turbines arranged in a large cluster than for those with turbines in small clusters or lines, with avoidance distances at 200 m and 100 m, respectively. This is believed to result from placing wind farms in small clusters or linear layouts generally close to roads or other 'avoidance zones,' whereas large clusters were placed in open farmland areas. The study notes, however, that the configuration with the fewest impacts in a given situation may be the result of factors other than habitat loss. A significant difference was determined between field utilization and the location of avoidance zones; geese were unlikely to use fields in which avoidance zones covered the centers (2 of 11 used) and more likely to use fields in which zones did not cover the centers (13 of 15 used). The synergistic avoidance effects of reducing field use was not taken into account and needs to be researched in the future. Overall, this study indicated that wind farm disturbance is relatively minor (<200 m) in relation to foraging pink-footed geese. **Journal; reviewed by numerous referees (incl. T. Fox).**

35. Leddy, K. L., K. F. Higgins, et al. (1999). "Effects of wind turbines on upland nesting birds in Conservation Reserve Program grasslands." *Wilson Bulletin* **111**(1): 100-104.

Conservation Reserve Program grasslands without turbines and areas located 180 m from turbines supported grassland birds at mean densities that were 4x higher than those found in grasslands closer to turbines. Although wind turbines may not cause mortality directly, the presence of turbines may affect local grassland bird populations indirectly by decreasing the area of grassland habitat available to area-sensitive breeding birds. In addition to human disturbance and noise, the physical movements of the turbines when they are operating may have disturbed nesting birds. Maintenance trails between turbines that are driven daily may have further decreased the availability of grassland habitat adjacent to turbines. The study recommended that wind turbines be placed within cropland habitats that support lower densities of grassland passerines than those found in CRP grasslands. The study was conducted for one only breeding season (May-July 1995), and data indicate a larger number of birds identified in the turbine area than in the nonturbine area (379 vs. 150, respectively). Species composition, however, varied between the two sites. **Journal; reviewed by numerous referees (incl. L.D. Flake, D.H. Johnson).**

Artificial Nests

36. Belthoff, J.R., and R.A. King. (2002). "Nest-site characteristics of burrowing owls (*Athene cunicularia*) in the Snake River Birds of Prey National Conservation Area, Idaho, and applications to artificial burrow installation." *Western North American Naturalist* **62**(1): 112-119.

This study observed 32 burrowing owl nests and 31 unused burrows to (1) measure physical, vegetative, and topographic characteristics of burrowing owl nest sites; (2) determine potentially important features for nest-site selection by burrowing owls; and (3) use this information to help guide future construction and placements of artificial burrows. A significant difference was found between nest and comparison burrows in relation to tunnel angle—a 17% reduction in odds of use with each 1-degree increase in the slope of the tunnel angle. This feature and productivity, however, were not found to be significantly related. A weak significant relationship was found between productivity and distance to the perch, and a stronger negative relationship was found between productivity and distance to irrigated agriculture. The most common vegetation surrounding burrowing owl nests included cheatgrass, tumble mustard, and annual wheatgrass; there was no significant difference in cover classes between nest and comparison burrows. Results suggest placing nest burrows near agriculture and open areas, in low shrub cover and short vegetation; however, there are concerns about the effects of pesticides and intensive agriculture on birds. The study also suggested that tunnel entrance angles be limited to gradual slopes (average of 27 degrees), although this suggestion has not been field-tested. **Journal; reviewed by five referees (L. Bond, A. Dufty, J. Munger, B. Smith, N. Woffinden).**

37. Smith, G.C., and G. Agnew. (2002). "The value of 'bat boxes' for attracting hollow-dependent fauna to farm forestry plantations in southeast Queensland." *Ecological Management & Restoration* **3**(1): 37-46.

This study was conducted to assess vertebrates' use of artificial nest or roost boxes, and their contribution toward enhancing biodiversity in plantation forests through the provision of habitat. Two sites were located in a relatively 'intact' forest landscape and two in a more 'fragmented' landscape, and each site was checked 5-9 times from April 1996 to November 2000. Fewer animals were recorded in boxes at the intact sites; the highest numbers of animals were recorded in boxes in forest plantations with variegated landscapes (five native mammal species). No vertebrates were found in boxes at the State Forest (the most intact) site. The maximum occupancy rate recorded was 40%. Data suggested no preference toward box aspect. No significant relationships were determined; the sample size was 50. Additionally, there are approximately 21 species of potentially hollow-roosting microbats in the area, but only 1 species was found to occupy the boxes (max. 25% at one site). **Journal; no mention of review process.**

38. Smith, M.D., C.J. Conway, et al. (2005). "Burrowing owl nesting productivity: a comparison between artificial and natural burrows on and off golf courses." *Wildlife Society Bulletin* **33**(2): 454-462.

This study was conducted on 8 golf courses in south-central Washington to examine whether burrowing owls would locate and occupy artificial burrows placed on golf courses, and if so, which course features influenced the probability that owls used an artificial burrow. The study also examined whether occupied artificial burrows were as successful as other types (natural on golf course, natural off-course, artificial off-course). About 175 natural burrows off golf courses, 14 natural burrows on courses, 86 artificial burrows off golf courses, and 130 artificial burrows on courses were monitored from February 1-August 21 during 2001 to 2004. Burrowing owls used a smaller proportion of artificial nests on golf courses (7% average) than off golf courses (18% average); golf course usage occurred primarily in nonmaintained areas (12.5% of burrows established were used) and only 1 burrow was used in maintained areas. Owls were additionally found to occupy 35% of the 23 burrows installed within 200 m of natural nest burrows. Analysis suggests that proximity to rough, fairway, sprinkler, and maintained areas (areas receiving turf maintenance) influenced the use of artificial burrows, as does proximity to natural burrows. Management suggestions include that burrowing owls preexist for artificial burrows to be successful, as well as the importance of maintaining burrows outside the owl's breeding season. No significant relationships were detected in the analysis; however, the information may prove useful in mitigation at wind turbine sites with burrowing owls in terms of maintenance requirements for burrows and sites. **Journal; reviewed by three referees (incl. D. Cristol, A. Rodewald).**

39. Trulio, L.A. (1995). "Passive relocation: A method to preserve burrowing owls on disturbed sites." *Journal of Field Ornithology* **66**(1): 99-106.

This study examined the belief that passive relocation is more likely to occur if artificial nest boxes are placed within 100 m of destroyed burrows, based on the observation that burrowing owls spend most daylight hours 50-100 m from their nests. Passive relocations using artificial burrows were conducted on six sites in northern California between 1988 and 1993. Burrowing owls moved into the artificial burrows in less than 1 month in all sites where boxes were placed within 75 m of the destroyed burrow; however, birds were not banded at 4 of the 5 sites, so it is unclear as to whether birds living in the boxes were the same ones that were evicted. The only site where birds did not occupy the artificial nest was the one in which the box was placed 165 m from the destroyed burrows. Passive relocation is believed to be a better alternative than active relocation of the owls, because birds generally disappear from a new, unfamiliar site within a season (Schulz 1993), and predation may increase for owls moved long distances in contrast to those living in familiar surroundings (Dyer 1987). While passive relocation is deemed a successful way to relocate birds, the study notes that it is not an adequate mitigation strategy if sufficient adjoining foraging habitat is not preserved. The sample size is unclear; Table 1 provides the number of birds evicted, but this doesn't match the number of artificial burrows or the occupation of burrows. Also, distances to new burrows tested was not consistent (75 m compared with 165 m; a question remains as to distances between those two). **Journal; reviewed by five referees (J. Barclay, P. Delevoryas, T. Schulz, L. Feeney, K. Bildstein).**

Relocation

40. Matthews, K.R. (2003). "Response of mountain yellow-legged frogs, *Rana muscosa*, to short distance translocation." *Journal of Herpetology* **37**(3): 621-626.

The purpose of this study was to determine the response of *R. muscosa* (a species being considered for federal listing) to short-distance (144-630 m) translocations in the upper Dusy Basin, Kings Canyon National Park, California. Twenty frogs were captured and outfitted with radio transmitters and passive integrated transponder (PIT) tags, and body masses were collected. The frogs were then moved distances ranging from 144-630 m from one water body to another. Patterns of movement for the translocated frogs were monitored from August 5-September 4, 1999 (the period is short because the transmitters work for only 30 days). Eighteen of the frogs were relocated at the end of the study, the radio transmitters were removed and body mass collected (the other 2 were found in summer 2000). Of the 20 translocated frogs, 7 returned to their original capture site, 4 moved in the direction of their capture site but had not returned by the end of the study, and 9 did not return and were found at the translocation site. All frog relocations were found closer to the capture site than to the release site. Translocated frogs exhibited a loss in body mass when weighed at the beginning and end of the study (n = 18, mean loss = –1.2 g). A control study that outfitted 14 frogs with radio transmitters but did not translocate them found the frogs exhibited a mean gain in body mass of 2.5 g (n=18). This study illustrates that translocation may not be an effective tool for some species because of increased stress levels and site fidelity. Further research is suggested to determine the effectiveness of relocating eggs or tadpoles. **Journal; no mention of review process**.

41. Roby, D., K. Collins, et al. (2002). "Effects of colony relocation on diet and productivity of Caspian terns." *Journal of Wildlife Management* **66**(3): 662-673.

This study investigated the efficacy of management agencies to reduce the impact of Caspian tern predation on the survival of juvenile salmonids in the Columbia River estuary by relocating approximately 9,000 pairs of terns from Rice Island to East Sand Island, 26k m away. Efforts to attract terns to nest on East Sand Island included the creation of nesting habitat, use of social attraction techniques (decoys and audio playback systems), and predator control (gulls), with concurrent efforts to discourage nesting on Rice Island (fencing, streamers, undesirable vegetation). All nesting Caspian terns shifted from Rice Island to East Sand Island during the 3-year period 1999-2001. Nesting success overall was found to be higher at East Sand Island than at Rice Island; 1.4 young were raised per breeding pair at East Sand Island after gull control attempts had terminated in 2001 (the highest Rice Island productivity was from 1998-2000—0.55 young per pair). Considerable information is provided concerning dietary alterations, but this does not appear to be relevant to current research. **Journal; reviewed by two referees (D. Duffy, C. Thompson).**

Cave Gating

42. Martin, K.W., D.M. Leslie, Jr., et al. (2003). "Internal cave gating for protection of colonies of the endangered gray bat (*Myotis grisescens*)." *Acta Chiropterologica* **5**(1): 1-8.

This study examined the effects of constructing gates inside cave passages on resident populations of the endangered gray bat in eastern Oklahoma, specifically (1) population trends before and after cave passages were gated and (2) initiation of emergence from protected and nonprotected caves. Six gated caves were examined to determine population trends before and after gating, and three gated and three nongated caves were examined to determine cave emergence. The total numbers of gray bats in all six caves was 60,130 in 1981 and 71,640 in 2001 (after gating); two caves harbored more bats after gating and three caves exhibited no change in population (cave 1 is not included because there was no pregate data to compare results with). Internal cave gate effects on bat flight were examined from mid-June to mid-July in 1999 and 2000. Cave gating was not found to impede or delay exit flights of colonies ($\leq$ 25,000) of gray bats. Additional research is suggested to determine the applicability of these findings to other species of bats, as well as to determine the effect of internal gates on larger colonies of gray bats. While these findings are positive, there was no mention of statistical significance. **Journal; reviewed by three referees (D.M. Engle, E.C. Hellgren, J.H. Shaw)**

Livestock Fencing/Grazing

43. Dobkin, D.S., A.C. Rich, et al. (1998). "Habitat and avifaunal recovery from livestock grazing in a riparian meadow system of the northwestern Great Basin." *Conservation Biology* **12**(1): 209-221.

This research was conducted to examine vegetation dynamics in riparian meadow systems in the absence of livestock and to relate these dynamics to avian species composition and relative abundance. The study was conducted from 1991-1994 in the Hart Mountain National Antelope Refuge in southeastern Oregon, commencing one year after livestock grazing was entirely eliminated from the refuge. Data were compared between areas that had been fenced off from livestock for many years and areas that had been subjected to regionally typical cattle grazing until the study began. Results indicated that the recovery of vegetation in riparian meadow systems does not follow a simple successional direction. Sedges and forbs were found to constitute significantly greater percentages of cover on exclosure plots than on open plots, while bare ground and litter were found to be significantly more extensive on open plots than on exclosure plots. Grass cover increased and litter and bare ground decreased on all plots during years of increased moisture. Forbs, rush, and cryptogamic cover increased on open plots, but not on enclosed ones. Avian species composition was markedly different on the two plots; wetland and riparian birds dominated exclosure plots, and upland grassland species dominated open plots. While avian species richness and relative abundance were greater on exclosure plots, it is not known how closely the restoration of the avian community composition will track vegetation recovery. Although this study indicates that habitat structure and avian populations change in response to livestock grazing (or lack thereof), it was conducted for only four years and many of its findings were not deemed significant. **Journal; reviewed by one referee (D. Pyke).**

44. Earnst, S.L., J.A. Ballard, et al. (2004). *Riparian Songbird Abundance a Decade after Cattle Removal on Hart Mountain and Sheldon National Wildlife Refuges*. U.S. Department of Agriculture Forest Service Gen. Tech. Rep. PSW-GTR-191: 9 pp.

This study compared songbird abundance in 2000-2001 to that in 1991-1993 on 69 permanent plots to determine the effects of cattle removal. It took place in the high desert riparian habitats of Hart Mountain and Sheldon National Wildlife Refuges located in south-central Oregon and northwestern Nevada, respectively. The plots featured 6 different cover types (meadow, riparian aspen, snow pocket aspen, willow, nonriparian shrub, and mixed deciduous), and each was surveyed three times from May 8-June 24, 2000, and from May 17-June 25, 2001. Survey data from 1991-1993 had been collected 3 times annually from May 7-July 11. Comparisons within this study were limited to passerines, doves, woodpeckers, and shorebirds that either primarily nest or forage in riparian habitat within the Hart-Sheldon landscape. Of 51 species for which detections were sufficient to calculate changes in abundance, 71% (36/51) exhibited a positive trend and 76% (16/21) that exhibited a significant change (either positive or negative) increased. Species associated with aspen and willow habitats exhibited a significant increase in detections/km^2, but species associated with meadows did not exhibit this change. Ground/low cup nesting species were found to increase more than either high cup or cavity nesting species; ground/understory foraging species increased significantly more than overstory or bark foraging species. Only meadow associates, cavity nesters, and bark gleaners did not increase significantly. Of the 26 riparian species of concern within the area, 7 exhibited significant increases on original plots after the removal of cattle (yellow warbler, white-crowned sparrow, dusky flycatcher, warbling vireo, MacGillivray's warbler, orange-crowned warbler, and mourning dove) and 3 exhibited significant declines (Bullock's oriole, ruby-crowned kinglet, and Wilson's warbler). For the 16 significantly increasing species identified in this study, patterns of change on breeding bird survey routes from 1980-1999 suggested that the changes were not merely a reflection of regional patterns. Another year of data collection was mentioned, but there is no evidence that this project continued past 2001. **Report; unknown review process**.

45. Manier, D.J., and N.T. Hobbs. (2006). "Large herbivores influence the composition and diversity of shrub-steppe communities in the Rocky Mountains, USA." *Oecologia* **146**: 641-651.

This study examined changes in plant cover and diversity at 17 sites in western Colorado where livestock and wild ungulate grazing had been excluded for 41-51 years from semi-arid shrub-steppe communities. Differences in species richness and evenness between protected treatments and surrounding grazed communities were small and not significant. Although mean species richness and diversity were similar between treatments, protected areas featured much higher dominance by fewer species, primarily sagebrush. Shrub cover was 2x times greater inside exclosures relative to adjacent areas outside exclosures (significant in protected Great Basin communities and sagebrush steppe sites), with no significant effects of grazing exclusion on cover or frequency of grasses, biotic crusts, or bare ground. Species evenness was positively correlated with richness in protected plots, while evenness and richness were inversely related in grazed plots. The exclusion of grazing appears to cause minor changes in cover and diversity of herbaceous plants, an increase in shrub cover, and an alteration in the relationship between evenness and richness. **Journal; no mention of review process.**

46. Maron, M., and A. Lill. (2005). "The influence of livestock grazing and weed invasion on habitat use by birds in grassy woodland remnants." *Biological Conservation* **124**: 439-450.

This study compared the intraspecific variation in bird foraging behavior and microhabitat selection of seven ground-foraging bird species among three site types of remnant woodland in southeastern Australia: heavily grazed with little to no ground vegetation (9 sites); weedy, ungrazed sites with a ground layer dominated by tall introduced grasses (9 sites); and a relatively intact ground layer dominated by native plant species (5 sites). Data were collected eight times from January 3 to November 6, 2003 (2 per season). Most bird species were present in similar proportions in each site type, but there was evidence of a negative impact of habitat degradation on all but two of the bird species studied. Observations suggest that weed invasion contributes to a reduction in habitat suitability by reducing the availability of foraging substrates, thereby forcing birds to forage in a subset of available microhabitats when foraging on the ground or inducing them to use more energy-costly foraging maneuvers. Cattle grazing decreases weed invasion, but can injure the development of the cryptogamic crust and result in low tree densities. The ideal management regime, therefore, is believed to be a combination of careful grazing to control weeds alternating with periods of no livestock grazing, during which regeneration can occur. Areas within remnants where the ground layer is in good condition (limited weeds and intact cryptogamic crust) could be fenced permanently, while other areas with heavy weed invasions could be managed through grazing or chemicals. **Journal; reviewed by three referees (incl. S. Attwood, R. Major).**

Wetland Creation

47. Balcombe, C.K., J.T. Anderson, et al. (2005). "Wildlife use of mitigation and reference wetlands in West Virginia." *Ecological Engineering* **25**: 85-99.

This study was conducted to evaluate the success of mitigation wetlands in West Virginia in supporting healthy wildlife communities by comparing 11 constructed and partially restored mitigation wetlands (4-21 years old) with four reference wetlands. All reference wetlands were classified as palustrine emergent or palustrine scrub-shrub and mitigation wetlands as palustrine emergent or palustrine unconsolidated bottom wetlands. All reference wetlands were located near mitigation sites within each area, usually within the same watershed. Avian communities were evaluated between May 5 and June 27 in 2001 and 2002. Mitigation wetlands were significantly different from reference sites in vegetation community structure, containing more open water (40.6% vs. 11.6%) and less emergent aquatic vegetation.

Despite differences in vegetation and invertebrate abundance, mean species richness, diversity, and abundance were similar between mitigation and reference wetlands. High avian numbers in mitigation wetlands appear to be the result of wetland size, landscape position, vegetative structure, and diversity and invertebrate community structure. The study notes that a diverse wetland community within mitigation wetlands does not mean that birds are successfully reproducing, and that future studies should correlate changes in vegetation and invertebrate communities to avian community structure and evaluate breeding success. Effects on anuran communities were also evaluated. Authors caution that it is premature to assess the outcome of mitigation efforts in West Virginia because this was only a 2-year study, that created wetlands often take more than a decade before functioning in a manner comparable to reference wetlands (5 sites were over 10), and that the data should not be extrapolated to other states. **Journal; reviewed by four referees (incl. W.J. Mitsch, J.S. Rentch, W.N. Grafton).**

48. Darnell, T.M., and E.H. Smith. (2004). "Avian use of natural and created salt marsh in Texas, USA." *Waterbirds* **27**(3): 355-361.

This study examined the "accuracy" of habitat creation as a means of mitigation by comparing avian use of three man-made sites of various ages with three natural marsh reference sites on the central Texas coast. Geomorphology of created sites differed substantially from the natural sites, affecting habitat development and avian use. In both natural and created sites, unvegetated, irregularly flooded habitat was used more consistently by a larger number of birds than any other habitat type (shorebirds, wading birds, and gulls or terns were associated significantly with unvegetated shallow water and exposed substrate). This zone of habitat, however, was compressed into a narrow band along the elevation gradient in created wetlands; more frequent inundation and decreased salinity occurred as a result of their smaller sizes. Results indicated that each of the created wetlands, especially the oldest one (4 years old vs. 2 years), became overgrown with vegetation in intertidal elevations over time, indicating that a habitat component was being lost. The oldest created wetland, which was the most overgrown, had significantly more perching birds than other sites and was rarely used by shorebirds. Management recommendations include a need for created marshes to provide unvegetated habitats, which may be accomplished through management (e.g., removal) of vegetation or through geomorphic design that attempts to mimic natural conditions producing unvegetated habitats. The length of this study was unclear. **Journal; reviewed by numerous referees**.

49. Federal Highway Administration. (1992). *Evaluation of Wetland Mitigation Measures*, Volume 1: Final Report: 1-353.

This study determined the level of success of 23 highway-related wetland mitigation projects (divided into enhancement, creation, restoration) in terms of goal attainment and replacement of wetland functions. Success or failure determinations were based on both informal goals, expectations of biologists, and model assessments of wetland functions and values. This study was conducted during summer 1989, and projects were located around the country. Of the 23 mitigation projects, only 3 (1 enhancement site and 2 creation sites) appeared fully successful in replacing all functions lost to construction. Mitigation type was not apparently a factor in determining mitigation effectiveness; level of planning effort, inclusion of certain design elements in detailed mitigation plans, and precision with which plans were implemented appeared to be the most important aspects of effectiveness. As to planning, firm mitigation objectives and detailed plans were found to be necessary to ensure that good ideas were communicated clearly to construction crews and that the sequencing of construction was correct. Design elements of primary importance to successful enhancement, creation, or restoration of wetlands included location in relation to surface water systems and other wetlands, slope and elevation, topdressing of some type of topsoil, and configuration of vegetation and open water. In determining whether spreading topsoil was more effective than planting marsh plants to protect soils, this study found that although spreading topsoil is significantly more expensive ($14,600/acre vs. $1,100/acre); it was significantly more successful than plantings due to herbivory, harvesting, and moisture/substrate problems. As to set mitigation ratios, the study found that most were not based on scientific study or monitoring of success rates for functional replacement, but rather were set subjectively on the basis of a few previous examples of mitigation successes or failures. The study notes that, if appropriately located and implemented, certain wetland functions can be replaced through out-of-kind mitigation efforts. It also suggests that postconstruction monitoring occur for at least 3-5 years to determine if specific goals have been met. **Report; unkown review process**.

Wildlife Corridors

50. Aresco, M.J. (2005). “Mitigation measures to reduce highway mortality of turtles and other herpetofauna at a north Florida lake.” *Journal of Wildlife Management* **69(2)**: 549-560.

The purpose of this study was to test the effectiveness of a drift fence and culvert system in reducing road mortality and facilitating the migration of turtles and other herpetofauna at Lake Jackson near Tallahassee, Florida. This study was conducted from 2000 to 2003 both during and following a severe 3-year drought (a 97.4 cm rainfall deficit in 1998-2000), and entailed a sampling period of 1,367 days and 5,664 total hours. Migration and death rates were attained before and after fence construction by monitoring a 700-m section of U.S. Highway 27N for live and dead animals and by observing the type and number of tracks along the roadside and culvert. A total of 10,229 reptiles and amphibians of 44 species were found either behind fences or on the highway. Road mortality rates for turtles were found to significantly decrease after the installation of fences (to 0.09 dead on road (DOR)/km/day from 11.9 DOR/km/day); less than 1% of turtles accessed the highway by climbing or penetrating the fences. Because all aquatic, semiaquatic, and terrestrial species are able to scale the temporary fences, only 74% of upland and semiaquatic species and 25% of aquatic species (excluding turtles) were prevented from reaching the highway. This study found vinyl erosion control fencing in combination with existing culverts to be an effective method of reducing road mortality. However, it states that attaining these results required frequent fence maintenance and daily monitoring to remove turtles from behind fences. A more effective long-term solution might be a permanent barrier with a smooth, vertical surface and an over-hanging, inward facing lip. Another potential issue of fencing is predation; 92/95 turtles were found dead behind fences as a result of mammalian predation after nightfall. **Journal; reviewed by six referees (incl. K. Dodd, F. James, M. Gunzburge, J. Travis, E. Walters).**

51. Cain, A.T., V.R. Tuovila, et al. (2003). “Effects of highway and mitigation projects on bobcats in southern Texas.” *Biological Conservation* **114**: 189-197.

This study identified habitats selected by bobcats, assessed landscape characteristics correlated with vehicle-caused mortalities, evaluated bobcats’ use of three types of highway crossing structures (bridges, modified culverts, and unmodified culverts), determined characteristics correlated with bobcats’ use of these structures, and tested the utility of 100-m wing fences to increase bobcats’ use of crossing structures. The study was conducted from July 9, 1997, to May 31, 1999, using radio collars to track 16 bobcats. Monthly crossing usage varied among structure types; bridges and modified culverts were used more often than unmodified culverts. Openness and cover were positively correlated with felid crossing use. Bobcats were photographed using the crossings at all times during diel periods; however, 41 of 54 complete crossings occurred in darkness. High-use crossing structure types were near dense thornscrub or drainages; regression analysis indicated cover was an important variable explaining bobcat crossing usage. Regression analysis also indicated that openness was significant in crossing usage, but the exact size of optimal culvert openings is not known. Erecting a fence to funnel wildlife toward culvert openings was found to have no significant effect on felid use of crossing structures; however, when culverts were little used were removed from the analysis, there was an indication that fences may increase bobcat use. During this study, 25 bobcats were hit while crossing the highway; mortality was more frequent on sections of the highway with large amounts of thornscrub (the preferred habitat type). Observations also indicate that catwalks may be important where standing water is likely to persist, and culverts that open into the median may reduce the tunnel effect and encourage usage. **Journal; reviewed by four referees (S.E. Henke, F. Hernandez, M.J. Chamberlain, T.J. Mallow).**

52. Dixon, J.D., M.K. Oli, et al. (2006). “Effectiveness of a regional corridor in connecting two Florida black bear populations.” *Conservation Biology* **20**(1): 155-162.

This study evaluated the effectiveness of the Osceola-Ocala corridor for the Florida black bear using genetic material (hair and tissue samples) and geographic information system (GIS) maps to characterize the dispersal of bears from the source populations. Data were collected from 1998-2003 within the Osceola-Ocala corridor, a patchwork of public and private lands within a matrix of roads and development. Bears were present in multiple locations in the corridor, indicating that some individuals may be corridor residents. Most bears sampled in the corridor were assigned to Ocala (28 of 31), indicating a predominantly unidirectional pattern of movement from Ocala into the corridor. The ratio of bears sampled in the corridor was 3 females to 31 males, suggesting that the corridor is used primarily for gender-based dispersal. All bears sampled in Ocala (N = 40) were of the same origin, while 5 of 41 bears in Osceola were genetically related to the Ocala population. The results indicate that the corridor is functional and provides genetic and demographic connectivity; however, increasing pressure for development may affect the functional connectivity of these populations if the corridor habitat is not protected. There is some question as to whether the genetic restructuring within the Osceola population is due to corridor migration or the relocation of nuisance bears from Ocala into Osceola (6 of 7 fates are known; 1 is unclear). **Journal; reviewed by one referee (M. Sunquist).**

53. Ng, S.J., J.W. Dole, et al. (2004). “Use of highway undercrossings by wildlife in southern California.” *Biological Conservation* **115**: 499-507.

This study sought quantitative data on the extent to which passages beneath highways (underpasses, livestock tunnels, and drainage culverts) in a fragmented landscape are used by wildlife and assessed characteristics of the passages most often frequented by species of concern. Fifteen potential wildlife passages were monitored, and each was observed for four consecutive days each month from July 1, 1999, to June 30, 2000. During the year of study, 2,723 detections were recorded as tracks and photos, of which 531 were native medium to large mammals, 1,640 were humans, 155 were domestic animals, and 397 were small mammals. Length was found to have a significant negative correlation with cross-sectional area. Coyote use showed a significant positive correlation with human activity and a significant negative correlation with development. Bobcat use showed a significant positive correlation between passage use and percentage of natural habitat; all three carnivores—bobcat, mountain lion, and coyote—showed a positive but not significant relationship between passage use and extent of natural habitat. Raccoon use correlated negatively with the extent of natural habitat and positively with the extent of developed habitat and passage length. No statistically significant relationships were found between passage attributes and activity of opossums or either of two skunk species, but passage length and use were positively correlated. Passage dimensions were found to significantly influence deer passage; mule deers’ use of passages correlated negatively with passage length and positively with cross-sectional area. No significant relationships were found between the use of passages by mule deer and habitat type; however, all sites used by deer were characterized by significant amounts of nearby natural habitat. Domestic animals’ use correlated negatively with passage length and positively with both cross-sectional area and the amount of human activity. This study offers some useful information pertaining to mammalian use of passageways under highways, but significant correlations were confusing and wind turbines are not likely to be close to highways. **Journal; reviewed by three referees (incl. M. Schwartz).**

Baseline Data

54. Erickson, W. P., G. D. Johnson, et al. (2002). *Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments*. Prepared for Bonneville Power Administration**:** 1-129.

To assist stakeholders in evaluating new projects, this report evaluates the ability to predict direct impacts on avian resources (primarily raptors and waterfowl and waterbirds) using less than a year of baseline avian use data. Data were collected for more than 30 study areas from 15 WRAs, including Foote Creek Rim (Wyo.), Stateline (Ore./Wash. State), Klondike (Ore.), and Buffalo Mountain (Tenn.). The amount and extent of baseline data should be determined on a case-by-case basis using information from this report; recent projects; existing project site data from agencies, groups, and individuals; public scoping; and results of vegetation and habitat mapping. Other factors that should be considered include the likelihood of sensitive species and expected impacts to those species, project size, and project layout. Baseline data on raptors collected during one season (spring, summer, or fall) appear to be adequate for making overall wind plant direct impact predictions (e.g., low, moderate, or high relative mortality), especially in agricultural settings. In areas where baseline data indicates a site has high levels of raptor use, the study recommends that data be collected for more than one season to refine predictions and micrositing decisions. Correlations are very low between fatalities and overall raptor nest density, but data on nests very close to turbines (within one-half mile) are currently inadequate to determine the level of impact. Wind plants with year-round waterfowl use have shown the highest waterfowl mortality; native landscape sites show very little waterfowl use except where significant water sources are available. Resident and migrant passerines constituted a large proportion of the fatalities at wind plants, but nocturnal migrant mortality appears very low compared with utilization rates. Bat collision mortality is virtually nonexistent during the breeding season; most mortalities involve migrant or dispersing bats in late summer and fall. Conclusions are based solely on a literature review; recommendations need to be field-tested. **Report; reviewed by nine referees (D. Malin, K. Kronner, A. Linehan, T. Meehan, G. McEwen, D. Mudd, J. Bernowitz, L. Sharp, Two Ravens Inc).**

55. Percival, S.M. (2003). *Birds and Wind Farms in Ireland: A Review of Potential Issues and Impact Assessment:* 1-25.

This document reviews current knowledge on the effects of wind farms on birds and provides a methodology for assessing those effects. In assessing wind turbine placement, it is not possible to have a fixed baseline survey requirement, so a phased approach (the level of detail required depends on the avian sensitivity of the site) is more useful. Phase 1 should include a collation of all existing information on the proposed site, as well as a bird survey of an area 500 m around the proposed site (or 300 m for breeding birds in less sensitive habitats such as farmland). These areas are based on the results of studies looking at the disturbance effects of wind farms on bird distribution (see Table 2). Phase 2 is completed if important bird species and populations may be affected (defined as those listed in Annex 1 of the European Union's Birds Directive, BirdWatch Ireland's red list, rare or vulnerable migratory species, or species occurring in regionally or nationally important numbers); this phase requires a more detailed assessment of the importance of the site to these species within an area of at least 1 km. An evaluation of potential collision risk and direct or indirect disturbance should also be conducted during this phase. Phase 3 is required where a significant potentially adverse effect (e.g., direct habitat loss, collision risk, or behavioral disturbance) is predicted, and includes a population analysis and options for reducing the risk. To determine the significance of a potential impact, a matrix combining impact magnitude and species sensitivity was established. To account for the inevitable degree of uncertainty in the predictions of wind farm impacts on birds, enhancement measures should be enacted that provide a benefit over and above the predicted adverse effect. This study also provides some useful tables listing bird mortality and habitat disturbance studies throughout Europe. **Report; no review process noted**.

56. Young, D.P., Jr., W. P. Erickson, et al. (2003). *Avian and Bat Mortality Associated with the Initial Phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming.* Prepared for Pacificorp, Inc., Bureau of Land Management and SeaWest Windpower, Inc.: 1-50.

This report presents results of more than 3 years of carcass search studies for Foote Creek Rim I, consisting of 69 towers and associated met towers. The large majority of wind-plant-related casualties (92%, N = 122) were passerines; slightly more than half of these, based on species and date found, were probably nocturnal migrants. The number of raptor casualties was very low during the study period despite high raptor use estimates for the site and a rotor swept area 5x larger than the average rotor swept area of turbines at Altamont. Although some studies have suggested that birds may be more at risk of collisions with wind turbines during inclement weather, this study found no strong correlations between avian or bat casualties and weather. Correlating fatalities to weather was difficult because the time of death was not known. More frequent casualty searches would be required to better determine time of death; however, in environments with low scavenging and high searcher efficiency, daily or weekly searches would not be necessary to estimate mortality accurately. **Report; no mention of review.**

Postconstruction Data

57. Arnett, E. B., W. P. Erickson, et al. (2005). *Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines*. Prepared for the Bats and Wind Energy Cooperative: 1-187.

This study investigated the relationships between bats and wind turbines at the Mountaineer Wind Energy Center in Tucker County, West Virginia, and the Meyerdale Wind Energy Center in Somerset County, Pennsylvania. Primary objectives were to compare results of daily versus weekly carcass searches, quantify bias corrections needed to more accurately estimate fatality, and recommend improved search protocols for bats. Bat fatalities were also correlated to previous nights' weather and turbine conditions, and their behavior was quantified when encountering moving and nonmoving blades at turbines with and without Federal Aviation Administration (FAA) approved lights. Estimates at the two locations were among the highest ever reported, supporting the contention that forested ridges pose especially high fatality risks to bats at wind facilities. Weekly searches at Mountaineer produced mortality estimates 3x lower than daily estimates because of high scavenging rates and the periodicity of fatalities. Weekly searches at Meyerdale, however, yielded similar but slightly higher (1.2x) results compared with daily searches because of low scavenging rates. A better design might be to search a portion of turbines each day for 4 days, rather than all turbines on 1 day. Considerably more adult male bat carcasses were found than those of adult females or juveniles of either sex. This may result from differential distribution among males and females within landscapes, especially during summer. Fatalities were distributed across all turbines at both sites, although higher than average numbers of bats were found at turbines near the end or center of a string (but no significant correlation supported a relationship). The only turbine with no fatalities was in a feathered (blades parallel to wind), "free-wheeling" (blades allowed to move freely) mode in which the blade essentially did not move unless winds were quite high (>15 m/s); this suggests that bats are not running into stationary blades or turbine masts. Lighting or ultrasounds do not appear to be significant attractions; however, other sources of ultrasonic emissions from turbines should be investigated further. The timing of all bat fatalities was highly correlated, suggesting broader landscape patterns dictated by weather and availability of prey. Thermal images indicated that bats are attracted to and investigate both moving and nonmoving blades; most bat activity occurs in the first 2 hours after sunset. The majority were killed on low-wind nights when power production appeared insubstantial but turbine blades were still moving, often at or close to full operational speed (17 rpm). Fatalities increased just before and after the passage of storm fronts. Turbines within forest openings and near edges may be misconstrued by bats as favorable roosting sites, as shown in observations of bats landing on turbine masts and stationary turbine blades. Modifications to wind farm landscapes (e.g., open spaces around turbines and access roads) may create favorable foraging habitats for both local and migratory bats. **Report; reviewed by numerous referees (incl. E. Gates, M. Huso, P. Jodice).**

No Effect

58. Lucas, M. D., G. F. E. Janss, et al. (2005). "Bird and small mammal BACI and IG design studies in a wind farm in Malpica (Spain)." *Biodiversity and Conservation* **14**: 3289-3303.

This study was carried out in northwestern Spain for 3 years during various periods of wind farm construction: preconstruction (June 1995), construction (June 1996), and postconstruction (June 1997). The turbines are in a mixed coastal shrub steppe and maritime woods habitat. The study analyzed (1) the possible impacts of the wind farm on nesting and nonnesting bird communities, (2) flight behaviors of both nesting and nonnesting birds affected by the presence of the wind farm, (3) possible impacts of wind farms on rodents. Wind farms were not found to clearly affect bird and small mammal populations, as there was no significant difference in avian abundance or density between study years or areas (wind farm vs. reference). Significant differences were detected in flight heights between study areas; soaring birds were observed to detect the turbines and change flight directions. Small mammals did not appear to be affected by the wind farm at all. Mortality studies were not conducted because the postconstruction period of study was only a few months. **International journal; not sure of review process.**

Offshore

59. Pettersson, J. (2005). *The Impact of Offshore Wind Farms on Bird Life in Southern Kalmar Sound, Sweden.* Prepared at the request of the Swedish Energy Agency**:** 1**-**128.

This study was conducted over four spring and four autumn seasons from 1999 to 2003 in the Kulmar Sound in Sweden. Migration patterns of waterfowl and flock reactions to wind turbines (7 in all) were studied and documented. Researchers found that spring migratory paths have shifted up to 2 km eastward, and that during both spring and fall migration, flocks avoid flying closer than 1 km to turbines. The proportion of flocks that made a change in flight path was about 30% in good visibility in spring and 15% in fall. Radar monitoring showed waterfowl migration in fog and mist to be limited, and indicated that nocturnal migrants reacted similarly to the turbines as daytime migrants did. Visits to turbines by wind farm service boat were found to disturb the long-tailed duck and common scooter, so that they abandoned their feeding areas in the vicinity of the turbines in the daytime. This study site included only 7 turbines, and only 1 death was recorded (Eider). **Report; reference group indicated.**

Literature Reviews

60. Drewitt, A.L., and R.H.W. Langston. (2006). "Assessing the impacts of wind farms on birds." *Ibis* 148: 29-42.

61. Erickson, W. P., G. D. Johnson, et al. (2001). *Avian Collisions with Wind Turbines: A Summary of Existing Studies and Comparisons to Other Sources of Avian Collision Mortality in the United States*. National Wind Coordinating Committee**:** 1-67.

This paper provides a detailed summary of mortality data collected at wind plants and puts avian collision mortality associated with wind power development into perspective in regard to other significant sources of avian collision mortality across the United States. A summary is provided of data collected at many U.S. wind plants and annual bird fatality estimates and projections for all U.S. wind turbines.

62. Gerson, J., and D. Klute. (2006, January). *Wind Power and Wildlife in Colorado: An Informational Resource Guide*. Prepared for the Colorado Division of Wildlife.

63. Herbert, E., E. Reese, and R. Anderson. (1995, October). *Avian Collision and Electrocution: An Annotated Bibliography.* Prepared by the California Energy Commission: 1-114.

64. Johnson, G.D. & E. Arnett. (2004, July 16). *A Bibliography of Bat Interactions with Wind Turbines.*

65. Kerlinger, P. (2000). *Avian Mortality at Communication Towers: A Review of Recent Literature, Research, and Methodology*. Prepared for the U.S. Fish and Wildlife Service Office of Migratory Bird Management.

66. Mabey, S. (2006, November). *Impact of Wind Energy and Related Human Activities on Grassland and Shrub Steppe Birds*. Prepared for the National Wind Coordinating Committee by the Ornithological Council: 1-128.

67. Manville, A. M. (2005). *Bird Strikes and Electrocutions at Power Lines, Communication Towers, and Wind Turbines: State of the Art and State of the Science—Next Steps Toward Mitigation*. U.S. Department of Agriculture Forest Service**:** 1051-1064.

68. Rowland, M.M., M.J. Wisdom, et al. (2005). "Effects of roads on elk: Implications for management in forested ecosystems." In M.J. Wisdom (technical editor), *The Starkey Project: A Synthesis of Long-term Studies of Elk and Mule Deer*. Reprinted from the 2004 *Transactions of the North American Wildlife and Natural Resources Conference*, Alliance Communications Group, Lawrence, Kansas: p.45-52.

This paper (1) describes current knowledge about the effects of roads on elk, emphasizing results of research conducted at Starkey; (2) describes an example in which a distance-band approach, rather than the traditional road density method, was used to evaluate habitat effectiveness (HE) for elk in relation to roads; and (3) discusses the broader implications of road-related policies and land management with regard to elk. Illustrated direct impacts of increased road density on elk include avoidance of areas near open roads (response varies with traffic rates, extent of forest canopy, topography, type of road, gender, and temporal and spatial scales); increased vulnerability to mortality from hunting; and increased stress and movement rates. The study suggests that road closures may have the following benefits: decreased energy expenditures and improved diet quality for elk, increased total amount of effective habitat, increased hunting opportunities on public lands, decreased damage to crop and haystacks by elk on private lands, and decreased vulnerability of elk during hunting

seasons. However, road closures alone may not be effective in eliminating the effects of roads and traffic on elk because of inadequate enforcement. Careful assessment of how roads are being used, rather than their official status, is suggested as necessary to credibly evaluate effects of roads on elk and other wildlife. Additional research is suggested to enhance our understanding of the effectiveness of road closures, as well as on the precise levels of disturbance from motorized traffic that elicits a response and the duration of that response. Much of what has been learned about elk and roads is from field studies that lacked experimental components; thus, there was no sound basis from which to infer cause-effect relationships. **Report in book; reviewed by three referees (J.G. Kie, G.J. Roloff, B.C. Wales)**.

69. Spellerberg, I.F. (1998). "Ecological effects of roads and traffic: A literature review." *Global Ecology and Biogeographical Letters* **7**(5): 317-333.

70. Trombulak, S.C., and C.A. Frissell. (2000). "Review of ecological effects of roads on terrestrial and aquatic communities." *Conservation Biology* **14**(1): 18-30.

This study involves a literature review of the ecological effects of roads. Road construction has been shown to cause soil compaction, sedimentation, and direct mortality of individual species. Wildlife collisions with vehicles have increased with traffic volume (Rosen and Lowe 1994, Fahrig et al. 1995); however, high-speed and medium-speed roads have both attracted various species of wildlife. Environmental characteristics that are altered by roads include soil density, temperature, soil water content, light, dust, surface-water flow, pattern of runoff, and sedimentation. In addition, the maintenance and use of roads contribute at least 5 different types of chemicals to the environment: heavy metals, salt, organic molecules, ozone, and nutrients. Heavy metal contamination has been shown to increase with vehicular traffic (Leharne et al. 1992, Dale and Freedman 1982). Accumulations of salts from chemicals used to control dust or deice roads can disrupt natural stratification patterns and thus potentially upset the ecological dynamics of meromictic lakes (Hoffman et al. 1981, Kjensmo 1997). Roads tend to disperse exotic species by stressing or removing native species and allowing easier movement by wild or human vectors. Overall, the specific mechanisms by which flora and fauna are affected by roads are often complicated and uncertain; thus, mitigation or treatment of specific effects can be costly and uncertain. In addition, the multiplicity of effects resulting from the construction of roads suggests it is unlikely that consequences will ever be completely mitigated or remediated. It is thus critical to retain remaining roadless or near-roadless areas in their natural state. **Journal; reviewed by two referees (incl. R. Noss).**

Current Studies

71. Lehn, K., and F. Bairlein. (2006). "Is mulching a suitable method for improving the nesting habitat of the northern lapwing?" *Journal of Ornithology* **147**(5).

This study was conducted from 2002 to 2004 in the Diepholzer Moorniederung in northwest Germany to determine if winter mulching could be used to improve pastures for northern lapwing nesting. Mulching is defined as cutting and leaving the shredded vegetation in situ. Five nature reserves comprising 100.6 ha were mulched during the winter; then, the distribution and breeding of northern lapwings were mapped during the breeding seasons. Vegetation in mulched areas was significantly shorter and less dense during the breeding season (April/May) than in control areas, but no significant difference was found in the density of lapwings between the two areas. Lapwings showed a preference for mulched areas over control areas, however, and more nests were found in mulched areas than within control areas. Mulched areas appear to provide suitable nest sites, presumably because litter is present and vegetative regeneration is delayed. Therefore, they offer a suitable management tool for improving lapwing nesting habitat.

72. Gregory, A., S.M. Wisely, and B.K. Sandercock. (In progress) The Genetic Consequences of Wind-power Development on Greater Prairie Chicken (Tympnuchus cupido) Leks in Eastern Kansas.

This study is using a BACI design to assess the possible genetic consequences of habitat loss and fragmentation due to wind-power development on greater prairie chickens in the Flint Hills region of eastern Kansas.

73. McNew, L.B., B.K. Sandercock, and S.M. Wisely. (In progress) Effects of Wind Power Development on the Demography of the Greater Prairie Chicken.

This study is examining the impacts of wind development on lek attendance, mating behavior, habitat use, dispersal, and demographic performance of greater prairie chickens. A BACI design with three replicates of paired study sites will be used to assess potential impacts of wind development on prairie-chicken demography. Focal population studies will occur at the Elk River II site in Butler County, Kansas, in Year 1, and expand to three sites in Years 2-4. Birds will be captured and radio-marked at leks during the 2006-2009 breeding seasons for this study. Treatment and reference sites will be monitored simultaneously during three phases of wind power development: predevelopment, construction, and operation.

74. PIER Energy-Related Environmental Research. (In progress) Range Management Practices to Reduce Wind Turbine Impacts on Burrowing Owls and Other Raptors in the East Bay Regional Parks. For information, see www.energy.ca.gov/pier/environmental/project_summaries/PS_500-01-032_DIDONATO.PDF.

This study is investigating land management practices in relation to raptor behavior and prey distributions, as well as raptor flight behavior and spatial distribution over land with and without wind turbines at the Altamont Pass WRA. The study seeks to understand how vegetation management practices (e.g., sheep grazing) in the APWRA can modify raptor foraging patterns by changing the distribution of prey. Three-dimensional GIS models will be used to characterize the influence of range management practices on raptor flight patterns, small mammal burrow distributions, burrowing owl nesting patterns, and turbine-induced avian mortality. A progress report detailing preliminary results is expected in January 2007.

75. Schroeder, M.A., C.E. Braun, and J.W. Connelly. (In progress) Effects of Wind Power Development on Sage Grouse.

This study is looking at the effect of sagebrush-steppe site developments on local sage grouse populations. The hypothesis is that the footprint of wind power generation in the sagebrush steppe is far larger than that presented by proponents because of the spread of noxious weeds, habitat loss and fragmentation, and mortality risk due to predation and collisions with turbines, power lines, fences, and vehicles. Researchers believe that site developments within this habitat-type will present major impediments to the retention of local sage-grouse populations.

76. Sherwell, J. (In progress) Developing a Mitigation Strategy for Bat Impacts from Windpower Development in Maryland.

This study presents a model that has been established to aid in the development of mitigation strategies for wind turbine developments in Maryland along the Appalachian Mountains. Two mitigation scenarios were investigated: one in which suboptimum tip speed ratios are explored, the other in which the rotation rate is managed from a low value up to a threshold value, above which the optimum tip speed ratio is established. Results indicate that both mitigation strategies significantly reduce cumulative risk of collisions relative to operation at maximum tip speed ratios.

77. Szewczak, J., and E.B. Arnett. (In progress) Evaluation of Acoustic Deterrents to Reduce Bat Fatality at Wind Facilities.

> This study seeks to determine if high-intensity ultrasounds will deter bats from wind developments. The hypothesis is that above some threshold, bats will exhibit avoidance because they cannot hear anything but the sound being emitted from the deterrence device.

78. Young, D.P. (In progress) Impacts of Wind Power Development on Mountain Plovers at Foote Creek Rim.

> This study showed mountain plover nesting success to be lowest during construction years, increasing in subsequent years. The sample size was small (n = 41), and it is difficult to separate potential disturbance or displacement effects from a broader decline in the mountain plover population. The results of this study indicate that mountain plovers appear to be compatible with wind projects over the long term.

Case Study 1

Arnett, E.B., technical editor. (2005*). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Bat Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines*. Final report submitted to the Bats and Wind Energy Cooperative. Bat Conservation International. Austin, Texas, USA.

Introduction

This study was conducted in 2004 to investigate the relationship between bats and wind turbines at the Mountaineer Wind Energy Center in West Virginia and the Meyersdale Wind Energy Center in Pennsylvania, because an abnormally high number of bat fatalities were discovered at Mountaineer in 2003. Numerous hypotheses were proposed about the mechanisms of bats' attraction to wind turbines or failure to detect them. However, there was little research on the relationships between bats and wind turbines.

In response to concerns about potential bat fatality issues and potentially inaccurate postconstruction monitoring protocols (an avian fatality protocol was used to study bats in Mountaineer), representatives from the American Wind Energy Association (AWEA), Bat Conservation International (BCI), the U.S. Department of Energy's National Renewable Energy Laboratory (NREL), and the U.S. Fish and Wildlife Service (USFWS) joined together to form the Bats and Wind Energy Cooperative (BWEC). The purpose of this collaborative was to conduct research needed to address issues and develop solutions surrounding wind energy development and bat fatalities.

This study describes the first field research undertaken by the BWEC. The primary objectives were to compare results of daily versus weekly carcass searches, quantify bias corrections needed to more accurately estimate fatalities, and recommend improved search protocols for bats. In addition, bat fatalities were correlated to previous nights' weather and turbine conditions, and their behavior was analyzed when bats encountered both moving and unmoving blades on turbines both with and without Federal Aviation Administration (FAA)-approved lights.

This case study summarizes the techniques used, data collection, and results described in each of three chapters in the report: "Bat and Bird Fatality at Wind Energy Facilities," "Timing of Nightly Bat Activity and Interaction with Turbine Blades," and "Use of Dogs to Recover Bat/Bird Fatalities**."**

Techniques Used

Bat and Bird Fatality at Wind Energy Facilities. Statistical techniques were used to develop estimators of fatality and compare these estimates from weekly and daily searches. The researchers also investigated the use of the program DISTANCE for developing estimates of bat fatalities. Associations between turbine and weather characteristics and recent bat fatalities were investigated using graphical methods, univariate association analyses, multiple regression, and logistic regression. For more, see the detailed description of statistical methods used in this study.

Timing of Nightly Bat Activity and Interaction with Turbine Blades. Thermal infrared imaging was used to observe the basic types of flight behavior around the rotor-swept zone of the turbines. This allowed researchers to observe bat and turbine blade interactions and establish the timing of nightly flight activity around operating turbines.

Use of Dogs to Recover Bat/Bird Fatalities. Using hand signals and whistle commands, researchers trained two Labrador retrievers to quarter within a 10-m wide area and to locate bat carcasses of different species and in different stages of decay. Dogs were trained using the fundamental principles employed to teach basic obedience, upland game bird hunting techniques, and blind-retrieve handling skills.

Data Collection

Bat and Bird Fatality at Wind Energy Facilities. Carcass searches were conducted for 6 weeks, from the beginning of August to mid-September. Half the turbines at each site were sampled daily for three weeks; the other half were sampled once a week (on the same day) for three weeks. The sampling protocols switched in the final three weeks to ensure that all turbines were sampled at both daily and weekly intervals.

Fatality studies were conducted by centering a rectangular plot measuring 130 m x 120 m on each turbine sampled. This distance was based on previous studies that indicated most bat fatalities are found within half the maximum distance from the tip height to the ground (the tip height for Mountaineer is 104.5 m and for Meyersdale, 115 m). Search plots at Mountaineer, however, were often irregularly shaped because of the proximity of the forest edge, and the distance from each turbine to its search plot boundary varied in all directions. Transect lines were established 10 m apart within each plot, and searchers walked each transect line and searched the area 5 m away on each side of the line.

Searcher efficiency and carcass removal trials were conducted using fresh and frozen or thawed bat carcasses found at each study site, by discreetly marking each specimen for later identification purposes. Fresh bat carcasses found each day were uniquely marked and either left in the field where found or redistributed to a predetermined randomly selected location. Carcasses were checked daily until removed or until the end of the 21-day trial period.

Information was also collected on whether bat fatalities occurred at lit or unlit turbines, and whether or not ultrasonic sounds were being emitted by digital anemometers at the turbine (anemometers were disabled at half the even-numbered turbines at each site). Finally, weather data were collected every 10 minutes from each meteorological tower and turbine by using a digital anemometer.

Timing of Nightly Bat Activity and Interaction with Turbine Blades. Data were collected between 2030 and 0530 hours from August 2 to 27, 2004, at the Mountaineer Wind Energy Center. Images were collected by using three FLIR Systems S60 uncooled microbolometer video cameras mounted on tripods and grouped together at a single observation station beneath a turbine. Data were captured at 30 frames per second, and the cameras were placed at randomly chosen lit and unlit turbines for five nonconsecutive nights. Terrain permitting, camera stations were located 30 m from the base of the turbine, directly upwind and perpendicular to the plane of rotation; each camera focused on a different part of the rotor-swept area. Each object observed was classified according to a set of qualitative criteria, a time stamp was recorded, and flight elevation and direction were estimated.

Use of Dogs to Recover Bat/Bird Fatalities. Dogs and their handlers and human searchers alone were tested regularly during searcher efficiency trials at both sites. Dog/handler searches were conducted both before and after humans conducted searches alone. The two Labradors alternated between each plot in order to reduce observer bias, evaluate differences in search efficiency between dogs, and allow rest to reduce fatigue and increase performance. Humans alone were restricted to the transect lines; dogs were allowed to quarter the entire 10-m-wide search area for each transect.

Results

Bat and Bird Fatality at Wind Energy Facilities. Searchers found 398 bat carcasses from six bat species at Mountaineer and 262 bat carcasses from seven species at Meyersdale; the most common species killed was the hoary bat. Bat fatalities were highly variable and periodic throughout the study. Fatalities were distributed across all turbines, although generally higher than average numbers of bats were found at turbines near an end or the center of the string at both sites. Of the 64 turbines studied, one (turbine 11 at Mountaineer) was not operational throughout the study period, and no fatalities were found near it.

The timing of all bat fatalities at Mountaineer and Meyersdale was highly correlated. Although more male than female bat fatalities were found, the timing by sex was similar at both sites. Additionally, timing of fatalities of hoary and eastern red bats was positively correlated at both sites. These temporal patterns suggest broader landscape, perhaps regional, patterns dictated by weather and prey abundance or availability or other factors. Ninety-three percent (Mountaineer) and 84% (Meyersdale) of fatalities were found ≤40 m from the turbine; there were more adults than juveniles and more male than female carcasses at both sites.

Fatalities per turbine averaged 10.6 at Mountaineer and 13.1 at Meyersdale. The only turbine with no fatalities operated in a 'feathered' mode (blades parallel to the wind) and 'free-wheeling' (blades allowed to move freely). At Mountaineer, 6.1 times more fatalities were found during daily searches than during weekly ones; at Meyersdale, daily searches yielded only 2.1 times more fatalities than weekly searches. Searcher detection probability was found to be 43.6% overall for all trials at Mountaineer and 25% at Meyersdale; detection probability decreased with distance from the transect line (5x lower >2.5-3 m from the transect, unless it was open habitat), with distance from the turbine (decreasing beyond 10 m), and in lower visibility habitat areas.

Carcass removal rates were found to differ substantially between the two study sites; 24% of the fresh bat carcasses left in place were removed within the first day at Mountaineer, and only 3% were removed within the first 24 hours at Meyersdale. Carcasses placed in high visibility habitats at Mountaineer were removed at approximately twice the rate of those placed in low to extremely low visibility habitats (47.7% vs. 12.5% and 29% respectively) within the first 24 hours, and fresh carcasses were removed more rapidly than those that had been previously frozen. Based on estimates derived from habitat visibility strata, daily searches yielded an estimated 38 bats killed per turbine, and a total of 1,364–1,980 bats were killed for the 6-week study at Mountaineer. An estimated 25 bats were killed per turbine, and a total of 400–660 bats were killed at Meyersdale during the 6-week study.

Bat fatalities were similar between turbines equipped with FAA lights and those that were unlit, and fatalities at turbines with anemometers turned off were slightly lower than at turbines with operating anemometers, but the differences were not statistically significant. Factors relating to wind speed were found to be significantly related; higher wind speeds were associated with lower fatality rates.

Timing of Nightly Bat Activity and Interaction with Turbine Blades. Although 4,572 objects (birds, bats, insects, etc.) were observed within the datasets collected, time constraints required that datasets be selected that were collected by one camera (Camera A) from 10 sample nights for the final analysis. A total of 2,398 observations were made at turbines during this 10-day period from Camera A: 998 bats (41%), 503 insects (20%), 37 birds (1%), and 860 unknown (35%). Flight elevation was highly variable, but 3x more bats were observed to fly within the medium-altitude band (within the upper and lower bounds of the blade swept area), than at 'low' or 'high' altitudes. The number of bats observed nightly was highly variable, and a significant correlation was found between insect passes or insect abundance and bat passes. Bat activity was highest 2 hours after sunset and in the early morning hours; a lull in activity occurred close to midnight. Aviation lighting did not appear to affect foraging around turbines, although it was observed to result in higher insect activity.

Thermal images indicated that bats are attracted to and investigate both moving and unmoving blades. Thermal images of bats attempting to land or actually landing on stationary blades and turbine masts suggest possible curiosity about potential roosts or use for gleaning insects. Images of bats chasing turbine blades rotating at slow speeds suggest possible attraction to movement out of curiosity. However, most of the observed collisions (7 of 8) were between bats and fast-moving (17 rpm) turbine blades.

Use of Dogs to Recover Bat/Bird Fatalities. Results varied between the male and female dogs at Mountaineer (80% and 60% efficiency, respectively), but were similar between dogs at Meyersdale (80% and 82% for the male and female, respectively). Dog/handler and human searchers' efficiency varied considerably between the two sites; the dog team found 71% of the carcasses at Mountaineer and 81% at Meyersdale, compared with 42% and 14% for the human searchers, respectively. Dog and human searchers' efficiency also varied considerably with distance from the turbine and visibility. Both teams found a high proportion of bats within 10 m of the turbine and in high-visibility habitats, but humans' efficiency declined beyond 10 m with declining visibility while the dog/handler team remained relatively consistent.

Implications For Wind Development

Although this study has improved our understanding of why and how bat collisions and fatalities occur, it marks the first attempt to observe and interpret bat behavior in the rotor-swept zone of operating turbines; as such, it presents numerous questions requiring further investigation. While statistical inferences are limited to the forested ridges in the Appalachian Mountains where the study areas were located, similar findings could be expected at wind facilities with comparable forest composition and topography. The following areas appear to be most promising for improving research and mitigating the effects of wind development in the future:

- Daily searches must be conducted at a portion of turbines in a wind farm to establish relationships between fatalities, weather patterns, and turbine characteristics. These relationships are critical in furthering our understanding of the predictability of fatalities.

- A pilot study on carcass removal rates would be useful in determining intervals for fatality searches. Fresh carcasses should be used to more accurately reflect realistic rates of scavenging.

- In areas where carcass removal rates are relatively low, infrequent searches can yield relatively accurate fatality estimates. However, removal rates should be expected to change over time, thus changing fatality estimates, as scavengers learn about a new food source. In areas where carcass removal rates are high, however, more frequent fatality searches should be conducted to avoid underestimating the fatality rate. Daily searches are advised in areas with high scavenger rates; however, weekly searches interspersed among days of the week rather than on one day should result in similar estimates. It is important to note that searchers' efficiency and scavenger removal differ by habitat type because different vegetative cover conditions influence observer detectability and scavenging rates. Thus, these statistics should not be extrapolated from one habitat type to another.

- Dog/handler teams have strong potential for increasing the precision of fatality estimates for at least some questions of interest. However, the results of this study are preliminary, and further research is necessary to better understand the efficacy of the use of dogs and determine any bias associated with that.

- FAA lighting and ultrasonic sounds were found to have little to no effect on bat fatality rates.

Potential mitigation strategies include the following:

- High wind speeds appeared to result in low levels of bat fatalities associated with wind turbines; low wind speeds were associated with high levels of fatalities. “Feathering” turbines on nights of low winds and relatively low levels of power production may reduce fatalities, but further study is required to evaluate the reductions relative to economic costs.

- Bats’ attraction to turbines appears to be influenced by several interacting factors. Extreme variations in nightly insect and bat activity suggests that dynamic variables (e.g., weather conditions) are at play rather than some fixed property of the turbines themselves. However, bats also were observed attempting to land on stationary blades and masts, supporting the roost-attraction hypothesis. These factors, combined with the fact that bats are most active during the first two hours after sunset, suggest that windows of high risk for collisions may be clearly identifiable with additional long-term studies. Curtailing turbines during these periods may significantly reduce bat fatality rates.

Case Study 2a

Young, D. P., W. P. Erickson, et al. (2003). *Comparison of Avian Responses to UV-Light-Reflective Paint on Wind Turbines.* Prepared for the National Renewable Energy Laboratory: 1-67

Introduction

The study was conducted to test the hypothesis that painting turbine blades to increase their visibility will reduce avian fatalities. Birds can visually detect wavelengths outside the range of human vision, including the ultraviolet (UV) spectrum; some research suggests that birds may be more sensitive to UV light than to visible light (Kreithen and Eisner 1978, Burkhard and Maier 199, Chen et al. 1984). UV light is defined within this study as light between 0 and 400 nm in wavelength.

The objectives of this study were to (1) review and critique published and unpublished information relevant to the study, (2) estimate the spatial and temporal behavior of birds near turbines with blades coated with UV-reflective paint vs. the behavior of birds near turbines coated with non-UV-reflective paint, and (3) compare the number of carcasses found near turbines with blades coated with UV-reflective gel vs. those found at turbines without the coating. The overall study format is quasi-experimental because the study design was based on U.S. Fish and Wildlife Service (USFSW) recommendations without control over the spatial distribution of turbines with UV-reflective blades.

Techniques Used

UV gel was applied by the blade manufacturers at the factory, and conformed to Mitsubishi Heavy Industries standards for spectral reflectance of light wavelengths. UV reflectance was approximately 60% in comparison to that of standard paint, which reflects approximately 10% of UV light and absorbs the rest. UV-reflective blades were installed during Phases I and II of the Foote Creek Rim Wind project in response to USFWS recommendations, but Phase III was constructed using conventionally painted turbine blades. Mean use estimates were calculated (using detections within 400 m of each point) by species and grouped by bird size.

Data Collection

Six permanent stations were established within the Foote Creek Rim (FCR) wind site. Two stations were placed in the section of the plant with conventional paint (FCR III, 33 turbines) and 4 stations were placed in the section in which UV-reflective gel had been applied to turbine blades (FCR I, II, 72 turbines). Avian use was estimated by conducting point count surveys once per week for 76 weeks from July 1, 1999, to December 31, 2000. Each survey consisted of visiting six plots 2x each survey day, once in the morning (0600-1200 hours) and once in the afternoon (1200-1800 hours). A survey consisted of 40-minute point counts at each station.

Data from fatality studies conducted in 1998 were used to estimate the number of fatalities associated with the FCR I turbines, and the protocol was expanded to cover FCR II (UV) and FCR III (non-UV). Fatality searches were conducted within plots that extended 60 m in all directions from the turbine, centered on a turbine by walking parallel transects. Transects were set approximately 8-10 m apart, and searches of all turbine strings were conducted every 28 days. Carcasses found at other times and places were recorded as incidental carcass discoveries. Carcass removal and searcher efficiency trials were conducted for statistical purposes.

Results

Golden eagles (GOEA) were the most abundant raptor species observed (0.238/survey). Overall raptor use was significantly higher on the UV area (0.778) than on the non-UV area (0.215); mainly because of the high estimates for GOEAs and red-tailed hawks (RTHA). The lowest raptor use occurred during winter (November-March). Raptor use by distance from turbine was not significantly different between the UV and non-UV areas. Overall passerine use was not different between the two areas, primarily because of the offset of use in the non-UV area caused by a greater abundance of horned lark (HOLA) in that area.

Eighty-four fatalities were found within the boundaries of the search plots, 57 of which occurred at the 72 UV turbines (68%), 13 at the 33 non-UV turbines (15%), and 14 at the 7 meteorological (met) towers (17%). The majority of casualties were passerines (78/84), most of which were HOLAs (26). No significant differences were noted between fatality rates for the UV and non-UV turbines, although overall passerine fatality rates at the UV turbines were 2x higher than at the non-UV turbines (primarily because of the higher number of HOLA casualties per turbine).

Overall mortality was estimated to be 1.49/turbine; raptor mortality was estimated to be 0.042. The risk index was found to be 3 times higher at the non-UV area compared with that of the UV area for raptors, but this was not statistically significant. Because there were only 6 raptor fatalities, the magnitude of the differences was probably not correctly estimated.

Implications for Wind Development

This study found no evidence to support the claim that turbine blades coated with a UV-light-reflective paint result in lower bird usage, mortality, or risk compared with those associated with blades coated with conventional paint. The low level of avian mortality observed and the uncontrolled experimental design, however, limit researchers' ability to make statistical inferences. The high level of use and fatalities observed for HOLAs suggest a correlation between avian use and mortality; however, relationships between raptor species use and mortality were not apparent. The high rate of passerine deaths at guyed met towers (4-5 times higher than those for either turbine type), support arguments that unguyed permanent met towers should be constructed to minimize avian mortality.

Case Study 2b

Hodos, W. (2003). *Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines.* Prepared for the National Renewable Energy Laboratory**:** 1-43.

Introduction

This study analyzed the causes of bird collisions with wind turbine blades and evaluated visual deterrents based on the results of the analysis. Although birds have excellent visual acuity (especially raptors), they still collide with turbines. The researcher's hypothesis was that a phenomenon known as "motion smear," "motion blur," or "motion transparency," in which an object becomes progressively blurred as it moves across the retina with increasing speed, may be part of the problem. The purpose of this study was to determine the ability of birds to see turbine blades at varying velocities, with varying patterns and colors and with and without lateral blade tip devices. The data collected were used to model the distances at which patterns maintain their visibility for different turbine diameters and rotation rates.

Techniques Used

A variable-speed motor was fitted with 32-cm-long rotor blades made from 5-mm white foamboard and placed against a background of white posterboard. Three tungsten halogen lamps were used for illumination, and positioned in a manner that minimized shadows. A pattern electroretinogram (PERG) was used to measure the visibility of the blades to birds using a variety of anti-motion-smear patterns and other patterns at various retinal-image velocities and against several types of stimulus backgrounds. The ENFANT visual electrophysiology system apparatus was used to present visual stimuli on a video display monitor and record, amplify, display and analyze electrical potentials. The rotation rate of the blades in rpm was measured by allowing the blades to interrupt a photocell light beam.

Data Collection

Fifteen American kestrels (AMKE) were used throughout this study, and a different number of individual subjects were used for each aspect of it. Individual birds were lightly anesthetized for testing purposes, and their heads were placed in a rigid metal head holder to eliminate movement. Vecuronium bromide was administered to the cornea over 20 to 30 minutes to paralyze accommodation. Platinum electrodes were inserted in each upper eyelid, and a third electrode was inserted in the skin of the scalp to serve as a ground. One eye was covered with a black patch (this electrode served as the reference).

Eight blade velocities, ranging from 36-144 rpm, were tested to determine the threshold visibility of a simulated turbine blade display. Blade visibility was measured by collecting data from seven recording sessions (three measurements were made per session at each velocity) from three AMKE using the following stimuli: (1) blank blades, (2) blades with thin stripes in a staggered, anti-motion-smear pattern, (3) blades with thick stripes in an anti-motion-smear staggered pattern, and (4) no stimulus (both eyes covered).

To evaluate a variety of blade patterns with anti-motion-smear properties, 6 pattern types were tested, as well as blank blades and a physiological noise condition (both eyes covered) on 6 AMKE. Presentation and recording methods were the same as in the velocity experiment, except that the blades were presented at 130 degrees of visual angle per second (dva/s) of retinal-image velocity, which is the retinal velocity at which the patterns are maximally visible. Three measurements were made of each pattern type during each recording session.

To determine the effectiveness of color on blade visibility, chromatic stimuli specified by the R-G-B color system were tested on seven AMKE. Stimuli were printed (solid and striped) using a Hewlett-Packard 2000, photo-quality, professional ink-jet printer. The rotation rate for the blades was 130 dva/s, at which achromatic patterns are maximally visible. Visibility of colored blades was tested against blank and colored backgrounds depicting wind-resource areas (three to five AMKE were used). A single-blade pattern composed of thin, silver, reflective stripes was also tested against the variegated naturalistic background.

The visibility of lateral blade stimuli against a neutral white background was also tested on four AMKE by attaching blade tip devices at right angles to the long axis of the blade. The devices attached were black squares that subtended 6.5 x 6.5 dva.

Results

The visibility of the thin stripes, as measured by the amplitude of the PERG in microvolts (μV), at 130 dva/s (4.2 μV) was significantly more visible than the noise, blank blades, and thick stripes; however, by 170 dva/s the visibility of the thin stripes dropped to 0.9 μV, and by about 240 dva/s it was close to zero. Although neither the thick stripes nor the blank blades were significantly different from the noise at 130 dva/s, at 170 dva/s the visibility of thick stripes was 1.0 μV and for blank blades it was 1.6 μV. By 200 dva/s and at all subsequent velocities, no differences between blades were significant, nor were any of the visibilities significantly different from noise (they were virtually invisible to the AMKE).

Of the 8 scenarios tested, the only blade patterns found to significantly differ from the blank blades at 130 dva/s were noise (both eyes covered), 1 blade painted with solid black and 2 left blank, and thin, staggered black stripes on all blades. Red, black, and green blade patterns were found to be significantly more visible than blank blades; however, when the blank background was changed to a colored scene, no statistically significant differences were found among the stimuli. Color and spatial patterning of the background played a major role in the visibility of a particular stimulus; the visibility of the blank blades increased considerably against this type of background.

The approach angle of a raptor toward the blades will vary the background considerably and could potentially have a major effect on blade visibility; the only color with a relatively consistent level of visibility was black. Results indicated that thin, black stripes on a single blade are the most visible against a variegated naturalistic background, but the small number of subjects tested (2) and recording sessions (4) were not significantly different than for blank blades.

No difference was found between laterally oriented blades with a single, black rectangle and those with no stimulus affixed to the tip with a neutral white background; however, 2-rectangle tip attachments significantly increased visibility when compared with results for blank blades. Three lateral tip devices offered no greater visibility benefit than did the single lateral tip device. When a variegated, naturalistic background was used, the difference between the two-tip device and the no-tip device diminished slightly, indicating that the devices may be less effective.

Implications for Wind Development

Data from this study suggest that a single, solid-black blade paired with two blank blades—or possibly a single, thin-striped blade paired with two blank blades—would be the most visible visual deterrent to birds in the field. Colored blades are not recommended because of their cost and possible problems with background contrast. The results from this study apply only to laboratory conditions that mimic some aspects of optimum viewing in the field, such as bright illumination and good viewing conditions; therefore, field tests need to be conducted. Suggestions for field testing design and implementation are included.

Case Study 3

Barrios, L., and A. Rodriguez (2004). "Behavioral and environmental correlates of soaring-bird mortality at on-shore wind turbines." *Journal of Applied Ecology* **41**: 72-81.

Introduction

This study analyzed the effect on birds of two wind energy farms, PESUR and E3, in the Campo de Gibraltar region, Cadiz province, Spain. The E3 farm consists of one row of 34 turbines and one of 32 turbines along a ridge of the Sierra de Enmedio (420-550 m above sea level). The PESUR farm has seven rows containing 190 turbines in all in the Dehesa de los Zorrillos hills (80-300 m above sea level). The Straits of Gibraltar are the main point of migratory passage for hundreds of thousands of soaring birds on their journeys between Europe and Africa, and this is also one of the four areas in Spain with the greatest potential for producing energy from the wind. Relief and wind are the two principal factors affecting both the behavior of soaring birds and the selection of wind sites. The specific aims of this study were to determine (1) the bird mortality rate associated with wind energy facilities; (2) the effect of these facilities on bird behavior and habitat use; (3) the factors that lead birds to approach turbines; and (4) mitigation measures that may reduce avian mortality.

Techniques Used

Bird corpses were surveyed along turbine lines and an associated power line to estimate mortality rates. The effects of location, weather, and flight behavior on risk situations (passes within 5 m of turbines) were analyzed using generalized linear modeling.

Data Collection

Mortality surveys were conducted between December 1993 and December 1994 at 15 randomly selected sampling sites, defined as groups of eight lattice towers or four tubular towers. Data were collected at a total of 87 wind turbines and seven lattice meteorological towers and lightning conductors. Searches were conducted twice a week within the turbine sampling areas and once a week at the power lines. A 100-m wide band along the entire length of both wind farms was also surveyed weekly for griffon vultures. Carcass removal and searcher efficiency trials were conducted for statistical purposes and to determine search frequency.

Behavioral observations were made from the edge of the ridges where the turbines were placed or from sampling areas of any soaring bird within 250 m of a turbine. Distance was estimated by using binoculars within 200 m of the turbines and using known distances between structures as a reference.

Data were also collected on type of flight, flight height, and wind speed for birds considered to be in a risk situation (passing within 5 m of the blades of an operating wind turbine). The frequency of risk situations was then used to create a risk index, the ratio between the number of birds observed within 5 m of the blades and the total number of passes or observations within 250 m of the turbine lines.

Results

Sixty-eight birds were found to collide with structures associated with the wind farms during this study, the majority of which (51) were from medium to large species. Large differences were found between the two wind farms in the frequency of casualties. The estimated number of bird losses and mortality rates per turbine were much lower at E3 than at PESUR (2 deaths and a 0.030 mortality rate vs. 68 deaths and a 0.360 mortality rate, respectively). Griffon vultures and common kestrels made up the most frequent fatalities (30 and 12, respectively); the highest concentration of fatalities occurred when species density was greatest (kestrels in summer, vultures in autumn/winter).

Vulture deaths were all found to occur between October and April (66.7% occurring between December and February), and more than half of the deaths occurred in two segments of PESUR (15% of turbines were responsible for 57% of collisions). Collisions rarely occurred in strong winds, and all deaths except one occurred on clear days. The absence of thermals in winter is believed to have forced vultures to use slopes for lift, the most likely mechanism influencing both their exposure to turbines and the risk of fatalities. Tower structure could be excluded as a factor, because the number of losses for each type of tower (85% lattice, 15% tubular) was not significantly different from their availability.

Common kestrel deaths were concentrated in the summer after the fledging period; 67% of fatalities occurred between July 15 and August 17, 1994. All common kestrel fatalities occurred at the PESUR wind farm. Fatalities were evenly distributed across the wind farm, and the distribution of collisions for lattice (75%) and tubular towers (25%) was not significant. The concentration of carcasses in open habitats around a single wind farm may indicate that risk is associated with hunting habitat preferences.

Of 14,524 bird passes near the wind farms, 4,809 (33%) were griffon vultures. Average annual sighting frequencies at PESUR (10 vultures/h) were higher than at E3 (6.5 vultures/h), as were the risk indices at the two locations (0.198 vs. 0.059, respectively). At wind speeds lower than 4.5 m/s, the turbine blades did not turn and there was no risk. When the turbine blades were rotating, the risk index was highest (0.343) at wind speeds from 4.6-8.5 m/s, and the risk decreased with increasing wind speed. The risk index was also higher when vultures circled (0.279) rather than when they were in straight or slope flights (0.131 and 0.032, respectively), as well as when the birds approached the turbines from below (0.259) rather than above (0.062).

Implications for Wind Development

This study indicates that avian vulnerability and fatalities at wind power facilities are the result of a combination of site-specific (wind-relief interactions), species-specific, and seasonal factors. Therefore, it is very important to conduct a detailed study of bird behavior at the precise location where construction is proposed in order to identify species that are particularly vulnerable, the sites that are used intensively, and thus the optimum turbine location. The results of this study lead the authors to believe that the most sensible approach to reducing avian mortality at PESUR and E3 would be to suspend operation of the small number of turbines that caused the most deaths during conditions that increase risk.

Case Study 4a

Alonso, J.C., J.A. Alonso, and R. Munoz-Pulido. (1994). "Mitigation of bird collisions with transmission lines through groundwire marking." *Biological Conservation* **67**: 129-134.

Introduction

Collisions with electric power transmission lines are known to cause fatalities among birds, and groundwires are especially problematic because they are thinner and more difficult for birds to see. While methods such as route planning, rerouting, and burying cables have proven effective in minimizing bird fatalities, these approaches are generally carried out before construction or are very expensive (e.g., burying cables). Removing or marking the groundwire can be done after lines have already been installed. The purpose of this study was to evaluate the effectiveness of groundwire marking as a method of reducing bird fatalities caused by collisions at a transmission line in southwestern Spain.

Techniques Used

Before the field study, the four most critical sectors of the power line were determined according to published or known information about local bird populations and collision data. The four sectors measured 4236 m, 7370 m, 8784 m, and 7811 m. Red-colored spirals made of polyvinyl chloride and measuring 1 m long and 30 cm diameter (maximum), were rolled around both groundwires at 10-m intervals in four sectors totaling 12,500 m.

Data Collection

Data were collected on line sectors from December 1989 to April 1990 and again during the same period in 1990 to 1991, before and after bird flight diverters were installed. Each power line sector was searched once weekly; observers walked in a zigzag pattern within the 50-m-wide search area. Full-day observations of bird flight intensity across two spans of the line (approximately 800 m) were conducted once monthly at each of the four line sections, for a total of 366 hours of observations. Flight intensity observations could not be made at unmarked spans during the second year, because the company decided to mark all spans previously selected for flight observation.

Fatality estimations did not take into account errors such as the disappearance of dead birds as a result of scavenging, birds undetected because of vegetation density, or birds seriously injured but not immediately killed by the collision. This is not believed to have affected the estimate of groundwire marking efficiency, however, as the possible bias in fatality estimates affected both study years, before and after the line was marked.

Results

A total of 7,456 individuals belonging to 59 species were observed during flight intensity observations; common cranes were the most numerous of the birds observed (33.6%). The mean daily numbers of birds observed flying across the power line decreased by 61% after the groundwire marking, and three of the four sectors exhibited significant decreases.

The mean number of individual birds of the same species seen flying across the power line decreased from 74.4 birds before groundwire marking to 29.3 birds after marking, but the difference was not significant. There were, however, significantly more species for which flight intensity decreased after groundwire marking than those for which flight intensity increased.

Fatality searches resulted in 107 dead birds belonging to 30 species; the most numerous species was wood pigeons (16.8%). The number and diversity of dead birds found in the marked sectors of the line significantly decreased, from 45 birds (19 species) to 18 birds (13 species) after groundwire marking. This increased from 19 birds (15 species) to 25 birds (15 species) in sectors left unmarked (not significant). The decrease in the number of dead birds found per span was significant in comparison to those found in the same span before marking. However, there was no significant change in the number of dead birds found in the sample of spans left unmarked (26/29 spans resulted in fewer or no change in dead birds).

Implications for Wind Development

This study illustrates the effectiveness of marking groundwires in order to reduce avian collisions with transmission lines. This technique may offer an appropriate solution for reducing avian impacts at wind farms where groundwires, transmission lines, and distribution lines are characterized by increased bird mortality rates.

Case Study 4b

Janss, G. F. E., and M. Ferrer (1997). "Rate of bird collision with power lines: Effects of conductor-marking and static wire-marking." *Journal of Field Ornithology* **69**(1): 8-17.

Introduction

Various marking schemes have been published over the years to address the issue of birds colliding with power lines. Although some studies have examined the effects of wire markers on distribution lines (Brown and Drewien 1995), there has been no comparison of fatalities at transmission lines to those at distribution lines. As a result, this study evaluated three different types of power lines in west-central Spain: one transmission line with static wires and two distribution lines without static wires. The purpose was to quantify the fatalities recorded for three different types of power lines and to evaluate the effect of three different types of markers.

Techniques Used

Line A was a 380-kV double-circuit transmission line with six duplex conductors forming three cable levels with two static wires overhead. Line A crossed a cultivated area in which 40-m-high towers were 500 m apart. Eight consecutive spans were studied (4.5 km) before and after white polypropylene spirals were rolled around the two static wires every 10 m and staggered between the static wires. The spirals were 1-m long with a maximum diameter of 30 cm.

Line B was a 132-kV simple-circuit distribution line without static wires, with three conductors on the same level. Line B crossed an extended cultivated area in which 20-m-high towers were 250 m apart. Fifteen consecutive spans were studied (3.9 km) before and after markers were installed every 20 m; the markers consisted of two neoprene black crossed bands (35 cm x 5 cm) and a phosphorescent stripe (5 cm x 4 cm) fixed on a plastic peg.

Line C was a 13-kV simple-circuit distribution line without static wires, with three conductors almost at the same level. Line C was located in a protected river delta, and consisted of 9-m towers placed 100 m apart. Ten consecutive spans (1.2 km) were examined before and after markers consisting of three thin plastic black stripes (70 cm x 0.8 cm) were hung every 12 m from the central conductor.

Markers were placed on alternating study spans, so that each marked span had an adjacent unmarked span.

Data Collection

Fatality searches were conducted over 4 years and consisted of two study periods. The first study period (1991-1993) took place before the installation of the markers. Surveys were conducted as follows: Line A – seven surveys from February 1992-February 1993, every 2 months; Line B – four surveys from August 1992-March 1993, every 2 months, and four surveys conducted monthly from July-October 1993; Line C – seven surveys conducted from August 1991-August 1992, every 2 months.

The second study period (1993-1995) took place after the line markers were installed in some of the study spans. Fatality searches were conducted monthly for at least 13 months at each line: Line A – February 1994-February 1995, 3 marked, 4 unmarked; Line B – December 1993-

December 1994, 7 marked, 8 unmarked; Line C – August 1993-November 1995, 4 marked, 4 unmarked.

Results

One hundred and fifty casualties of 26 species were found during this study, 64 during the first study period and 86 during the second period. Avian mortality was not found to differ between the three power lines studied. Gruiformes were the most common victims, with great bustards and little bustards representing 15.3% and 17.3%, respectively, of all bird remains.

The greatest frequency of collisions (2.95 birds/km) occurred at Line C, followed by Line A (0.96) and B (0.84). No statistical differences were detected between the three power lines in collision frequency per survey. The reductions in mortality for all birds when the white spirals were used (Line A) was 81%. The total number of birds under spans marks with crossed bands (Line B) was significantly smaller than those under unmarked spans (a 71% reduction); however, when the great bustard was included in the analysis, the markers were found to have no effect. There was no significant reduction in mortality as a result of using the black striped marker (Line C).

Implications for Wind Development

Although overall mortality rates were reduced by more than 75% using both the spiral and crossed-band markers, it is important to note that this excludes the great bustard, for which no effective marker could be found. This suggests that markers for transmission or distribution lines near wind farms, while effective overall, may not be effective for all species and should not be assumed to be an adequate mitigation strategy for some birds. This study also illustrates (through research and reference) that various markers can be effective in reducing avian mortality so that other factors, such as price and durability, should be considered. The effectiveness of these markers on wind turbines and meteorological towers supported by guyed wires has not yet been tested.

Case Study 5

Earnst, S.L., J.A. Ballard, and D.S. Dobkin. (2004). *Riparian Songbird Abundance a Decade after Cattle Removal on Hart Mountain and Sheldon National Wildlife Refuges*. U.S. Department of Agriculture Forest Service Gen. Rep. PSW-GTR-191.

Introduction

Concern has been growing about the health of riparian habitats in the arid West, because they support a higher diversity of breeding songbirds than any other habitat type but comprise only 1% of the landscape. In addition, they are being severely affected by agriculture, recreation, timber harvesting, water diversion, and, in particular, livestock grazing. Previous studies have indicated that ground or near-ground nesting species and shrub nesting species are more affected by cattle grazing than habitat generalists, canopy nesters, and cavity nesters because cattle have a greater effect on lower vegetation strata.

Within the Sheldon-Hart Mountain National Wildlife Refuge Complex in Oregon and Nevada, there are currently 26 riparian species of concern. They are defined in this study as riparian associates that had either (1) a significant declining trend on North American Breeding Bird Survey (BBS) routes within USFWS Region 1 (comprising Calif., Ore., Wash. State, Nev., Idaho); (2) a significant declining trend on BBS routes in the Columbia Plateau physiographic area; (3) a Partners in Flight score for the Columbia Basin of >20; or (4) an Oregon Management Index score of >10. The objectives of this study were to compare the abundance of riparian birds 1-3 years and 11-12 years after livestock removal occurred at the Sheldon and Hart Mountain National Wildlife Refuges.

Techniques Used

Survey data collected during this study was compared with survey data collected during May 7-July 11 from 1991 to 1993 (three times annually). Mean detections per visit were averaged among visits within a year and among years within a phase (i.e., 1991-1993 and 2000-2001). The mean difference across all plots was calculated for each species and a paired t-test was used to determine whether the difference for each species was significantly different from 0. Comparisons were limited to passerines, doves, woodpeckers, and shorebirds that either nested or foraged primarily in riparian habitat within the Hart-Sheldon landscape and that had an average of $\geq$ 0.02 detections per plot visit (n = 51 species). Species were assigned to primary habitats (aspen, willow, meadow), nesting guilds (ground/low cup, high cup, cavity) and foraging guilds (ground/understory, overstory, aerial, bark). Binomial tests, t-tests, and one-way analyses of variance within groups were used to test for differences among guilds over time (based on detections/km^2).

Data Collection

Data were collected from 69 permanent study plots within six different cover types (meadow, riparian aspen, snow pocket aspen, willow, nonriparian shrub, and mixed deciduous): five cover types in five drainages in Hart Mountain (n = 47) and four cover types in six drainages in Sheldon (n = 2). Each plot was 150 m long by 100 m wide, and most plots were at least 250 m apart. Each study plot was surveyed three times from May 8-June 24, 2000, and May 17-June 25, 2001, by an observer walking slowly along the center-line of the plot and recording the first occurrence of each individual seen or heard within the plot.

Results

Preliminary results one decade after cattle removal indicated that 71% (36/51) of riparian species exhibited positive trends and 76% (16/21) of species increased that had exhibited a significant change (either positive or negative). Species associated with aspen and willow habitats exhibited a significant increase in detections/km^2, but species associated with meadows did not exhibit this change. Ground/low cup nesting species were found to increase more than either high cup or cavity nesting species, and ground/understory foraging species increased significantly more than overstory or bark foraging species and marginally more than aerial foragers. Only meadow associates, cavity nesters, and bark gleaners did not increase significantly.

Of the 26 riparian species of concern for which there were sufficient detections, seven exhibited significant increases on original plots since the removal of cattle (yellow warbler, white-crowned sparrow, dusky flycatcher, warbling vireo, MacGillivray's warbler, orange-crowned warbler, and mourning dove) and three exhibited significant declines (Bullock's oriole, ruby-crowned kinglet, and Wilson's warbler). For the 16 significantly increasing species found within this study, patterns of change on BBS routes from 1980-1999 suggested that the changes found in this study were not merely a reflection of regional patterns.

Implications for Wind Development

Removing cattle from riparian habitats has been shown to significantly increase the abundance of certain species, specifically those that are open nesting, insectivorous, or neotropical migrants. Purchasing riparian habitat and enhancing it, or protecting riparian habitat near a wind farm, may prove to be a viable mitigation option. Wind development that occurs near riparian areas where livestock are located should consider installing fences to prevent cattle from decimating the habitat.

Case Study 6

Roby, D., K. Collins, et al. (2002). "Effects of colony relocation on diet and productivity of Caspian terns." *Journal of Wildlife Management* **66**(3): 662-673.

Introduction

This study addresses salmon fishery managers' concerns that colonial waterbirds were inhibiting the recovery of certain endangered and threatened salmon species in the Columbia River Basin. Initial research indicated that Caspian terns relied heavily on juvenile salmonids as a food source, especially the Rice Island colony, which is the largest of its kind in North America. Previous attempts to reduce avian predation of fish stocks along the Columbia River included lethal control, oiling eggs, harassing fish-eating birds, protecting fish, and changing rearing practices in hatcheries. While a number of these techniques had proven effective, the public often considered them unacceptable.

The objectives of this study, therefore, were to monitor and evaluate efforts to relocate the Caspian tern colony from Rice Island to East Sand Island (based on colony size and nest productivity). The study also aimed to test the efficacy of this approach for reducing the reliance of terns on juvenile salmonids as a food source (based on diet composition analyses). This approach was based on studies indicating the successful restoration of historical breeding colonies of terns along the northeastern shore of the United States and Canada, although these studies did not attempt to relocate an entire colony.

Techniques Used

To encourage the relocation of the tern colony, East Sand Island was altered to create a bare sand habitat similar to the one found on Rice Island. Caspian tern decoys and audio playback systems (recorded at the Rice Island colony) were installed throughout the bare sand area on East Sand Island and a limited number of glaucous-winged gulls were removed to encourage prospecting terns to settle and nest on the new island. Site treatments were undertaken again in 2000 and 2001 to reduce encroaching vegetation, and two 20- to 30-m-wide buffer strips were added on either end of the core colony area in 2001 to provide additional protection to the terns by discouraging nesting by glaucous-winged gulls. On Rice Island, suitable nesting habitat was reduced through plantings, silt fencing, and the placement of streamers and wire across the previous colony site. An area of 0.65 ha was left unaltered in the core of the colony in 1999 and was subsequently reduced each year after that to encourage the relocation of terns.

Data Collection

Colony size and productivity data were collected from aerial photographs and ground counts from observation blinds on both islands. Further details on the aerial photo census methods utilized are described in Collis et al. 2002. Diet composition data were collected through direct observation of adults as they returned to the colony with fish (bill-load observations). Prey items were identified as salmonid/nonsalmonid, and researchers were able to further distinguish nonsalmonid taxa, but not salmonid. In order to assess the relative proportion of various salmonid species in tern diets, an additional 10 bill-load fish/week were collected through shooting at each site when that activity was determined to not have a negative impact on the colony. Data on colony numbers, diet composition, and causes of nesting failure were collected daily.

Results

All nesting Caspian terns elected to move from the Rice Island colony to the East Sand Island colony during the 1999-2001 study period. In May 1999, about 550 of the 8,300 pairs of terns were nesting on East Sand Island, and by July 1999 this had more than doubled to 1,400 pairs. By 2000, 94% of the Caspian terns that nested in the Columbia River estuary were located on East Sand Island.

Nest productivity was found to be consistently higher for Caspian terns nesting on East Sand Island than for those nesting on Rice Island, reaching 1.4 young per pair in 2001. This was the highest productivity observed at either tern colony after 1996. Terns nesting on East Sand Island were also found to have significantly fewer salmonids in their diets than those nesting on Rice Island (42% to 83%, respectively); anchovies, herrings, and sardines were becoming the most prevalent prey types found in the East Sand Island terns' diets.

Implications for Wind Development

Although this study does not apply to wind development sites, it does show definitively that it is possible to relocate an entire colony of birds. The study focused on terns, but it may be a useful approach for other colonial nesting bird species, such as double-crested cormorants or great blue herons, which nest near freshwater lakes and wetlands. As wind development grows, there may be some interest in developing near inland water bodies. Thus, this approach may prove useful in minimizing or eliminating the risk to colonial nesting birds. In addition, this study was based on other efforts that successfully restored historical tern colonies along the eastern shore; this suggests that it may prove useful in the future as wind development expands to coastal areas.

Future Case Studies

McNew, L.B., et al. (In progress) Effects of Wind Power Development on the Demography of the Greater Prairie Chicken.

This study is examining the impacts of wind development on lek attendance, mating behavior, habitat use, dispersal, and demographic performance of Greater Prairie Chickens. A before-after control-impact, or BACI, design with three replicates of paired study sites will be used to assess potential impacts of wind development on prairie-chicken demography. Focal population studies will occur at the Elk River II site in Butler County, Kansas, in Year 1 and expand to three sites in Years 2-4. Birds will be captured and radio-marked at leks during the 2006-2009 breeding seasons for this study. Treatment and reference sites will be monitored simultaneously during three phases of wind power development: predevelopment, construction, and operation.

PIER Energy-Related Environmental Research. (In progress) Range Management Practices to Reduce Wind Turbine Impacts on Burrowing Owls and Other Raptors in the East Bay Regional Parks. For information, see http://www.energy.ca.gov/pier/environmental/project_summaries/PS_500-01-032_DIDONATO.PDF.

This study is investigating land management practices in relation to raptor behavior and prey distributions, as well as raptor flight behavior and spatial distribution over land with and without wind turbines at the Altamont Pass Wind Resource Area (APWRA). The study seeks to understand how vegetation management practices (e.g., sheep grazing) in the APWRA can modify raptor foraging patterns by changing the distribution of prey. Three-dimensional global information system models will be used to characterize the influence of range management practices on raptor flight patterns, small mammal burrow distributions, burrowing owl nesting patterns, and turbine-induced avian mortality. A progress report detailing preliminary results is expected in late 2007.

Schroeder, M.A., et al. (In progress) Effects of Wind Power Development on Sage Grouse.

This study is examining the effect of wind power generation on sagebrush steppe habitat, specifically that of the sage grouse. The hypothesis is that the 'footprint' of wind power generation in the sagebrush steppe is far larger than previously believed because of the spread of noxious weeds and exotic plants, habitat loss and fragmentation, and fatality risk due to predation and collision with turbines, powerlines, fences and vehicles. Additional disturbance and noise caused by wind farms is also of concern in relation to sage grouse populations.

Sherwell, J. (In progress) Developing a Mitigation Strategy for Bat Impacts from Windpower Development in Maryland.

This study presents a model that has been established to aid in the development of mitigation strategies for bats at wind farms in Maryland along the Appalachian Mountains. Two mitigation scenarios were investigated: one in which suboptimum tip speed ratios is explored, the other in which rotation rate is managed from a low value up to a threshold value, above which the optimum tip speed ratio is established. Results suggest that low wind speed curtailment can significantly reduce the risk of bat collisions. This study has been conducted, but results have not yet been published and economic consequences have not yet been explored.

Szewczak, J., and E.B. Arnett. (In progress) Evaluation of Acoustic Deterrents to Reduce Bat Fatality at Wind Facilities.

This study was based on earlier observations that bats avoided areas featuring high-intensity ultrasounds; it sought to determine whether high-intensity ultrasounds deterred bats from wind turbines. The hypothesis is that, above some threshold, bats will show avoidance because they can't hear anything but the sound emitting from the deterrence device. Only preliminary results from laboratory and field tests are currently available.

United States Fish and Wildlife Service (In progress; contact: Ron Reynolds [9/2006])

This study is being conducted to examine the effectiveness of a mitigation strategy to remedy problems for ruddy ducks on their wintering grounds resulting from an oil spill in the Patauxent River in Maryland. A Board of Trustees decided that mitigation for the spill required the organization to introduce new ruddy ducks into the population to make up for the ones that were lost. In order to do this, the USFSW Habitat and Population Evaluation Team is helping to restore or create new habitat on the breeding grounds in North Dakota. Evaluations of mitigation will begin as soon as the mitigation treatments are completed, and they will last for 10 years. Mitigation includes restoring the function of degraded wetlands or replacing drained wetlands, largely through conservation easements on agricultural lands. They are currently targeting areas with high ruddy duck breeding populations because they are already supportive landscapes.

Villegas-Patraca, Rafael et al. (In progress) Impact and Potential Conflicts of Wind Power Generation on Raptor Migration in Tehuantepec Isthmus, Mexico.

Several companies will be developing the largest wind-farm facilities in Latin-American over the next five years in the Isthmus of Tehuantepec in Oaxaca, Mexico. During three field work seasons, more than four million migratory raptors were found around the potential sites for the wind-farm. The majority of these birds were Turkey Vultures, Swainson Hawks and Broadwing Hawks flying at heights less than 120m. There is a potential high risk that birds will collide with the wind turbines within a range of 72-130m high in operation because this area is one of the most important bird migration routes in the world. This study will monitor the effects of a mitigation strategy to shut down the turbines for 3 weeks during Broad-winged Hawk, Mississippi Kite, and Swainson's Hawk migration on avian mortality and economic performance. This study hasn't begun yet.

WEST, Inc. (In progress; contact: Dale Strickland [11/2006])

WEST is conducting research at Altamont Pass in California to evaluate the effectiveness of seasonal wind turbine shut-downs, relocating or removing high-risk turbines, and replacing old turbines with newer, larger ones.

Summary of Existing Policies and Guidelines and Related Research Studies

This matrix combines existing policies and guidelines with existing mitigation research in order to identify gaps and overlaps between the two. The mitigation strategies listed in Column A are sorted by type of strategy (e.g., construction-stage, operational-stage) and are taken directly from existing policies or guidelines; the author is listed in Column B. Column C presents existing research related to the policy or guideline topic; where no research was found to support the policy or guideline, the field was left blank. Column D indicates whether research supports the mitigation strategy advocated in the policy or guidelines. The numbers next to Related Study authors correspond to the Annotated Bibliography, where detailed description of each study can be found. Finally, the Status of Supporting Studies column, Column E, offers anecdotal information pertaining to the research conducted.

GAPS/OVERLAPS MATRIX

A Mitigation Stated in Policies and Guidelines	B Whose Policy/Guideline?	C Related Studies	D Support Policy?	E Status of Supporting Studies & Notes
Design Stage				
Avoid lattice-type construction - use monopoles/tubular towers	ABC, WA Audubon, KS, MD, WA, CESA	Anderson et al. 2004 (1) Hunt 2002 (7) Orloff & Flannery 1992 (11) Thelander & Rugge 2000 (14)	Y Y Y N	research inconclusive . but, mortality rates at tubular towers increased when located on an end-row and close to canyon 57% bird fatalities at Altamont associated with tubular towers
Perching opportunities should be reduced or removed	Canada, KS, BLM	Osborn et al. 1998 (9) Smallwood & Thelander 2004 (12)	N Y	indent
Construct towers no more than 199 feet above ground level	USFWS			USFWS proposed to address 2 issues: (1) met towers should be unguyed, unlit, < 200 ft AGL, based on documented impacts from guy wires. (2) If wind turbine rotor swept area exceeds 199 ft AGL requiring turbine lighting, use minimum intensity, maximum off-phased white strobe, followed by red strobe, followed by red-blinking incandescent lighting, in decreasing order of priority. No L-810 lights should be used.
Larger turbines reduce mortality	England, Canada	Hunt 2002 (7) Smallwood 2006 (13)	N Y	Based on Diablo Wind Energy repowering project
Situate turbines in a way that does not interfere with wildlife movement corridors (turbine design)	ND, KS, CESA			
Group turbines rather than spreading them widely	England, USFWS	Larsen & Madsen 2000 (34)	N	Habitat loss for PFGO per turbine higher in farms with turbines arranged in a large cluster. USFWS policy supports minimizing overall footprint, reducing habitat fragmentation, disturbance and site avoidance esp. by grassland-sage-steppe-obligate songbirds and “prairie grouse.”
Orient rows of turbines parallel to known bird movements	England, USFWS			USFWS policy suggests; where known bird passageways (i.e., staging or migration) have been documented in historically compass-like directions, turbine orientation should minimize potential contacts. Been witnessed with seabird passage.
Spacing between turbines (should be greater than 200m)	Australia, England, (Canada)	Larsen & Madsen 2000 (34)	Y	Habitat loss for PFGO per turbine less in farms with turbines in small clusters or lines (no optimal distance suggested)
Lines of turbines should be broken up	England			
Avoid sensitive & large tracts of native habitat (don't fragment) /locate turbines on altered landscapes	England, USFWS, ND, Australia, WA, KS, CESA, CA	Larsen & Madsen 2000 (34) Leddy et al. 1999 (35)	Y Y	Wind farms placed close to roads or other 'avoidance zones' resulted in less impact to PFGO CRP grasslands 180+m from turbines found to support 4x more nesting birds USFWS policy recommends avoiding placing wind turbines within 5 miles of known leks. We now recognize that since recommending our 5-mile volunteer metric, separations will vary between species – least for Lesser and Greater Prairie-chickens (~3.75 mi), and greatest for migratory populations of Sage-grouse (~12.5 mi).
Avoid landscape features that attract raptors	BLM	Erickson et al. 1999 (4) Orloff & Flannery 1992 (11) Hoover 2002 (5) Hoover & Morrison 2005 (6)	Y Y Y	Rim edges should be avoided Rim edges should be avoided Avoid steep slopes(RTHA) & narrow E-W corridors that open up onto valley floor (GOEA)
Avoid areas heavily used by birds/bats	England, USFWS, Australia, MD, WA, CESA, CA	Osborn et al. 2000 (10) Huppop et al. 2006 (31)	Y Y	no supporting research for management suggestion turbines should not be placed in dense migratory zones between resting and foraging grounds While avoiding areas heavily used by birds and/or bats is intuitive, the premise of the USFWS's voluntary wind guidance is based on avoiding locations that are bird and/or bat unfriendly (i.e., heavily used for whatever purposes).

Do not locate projects in areas with high incidence of fog and mist	USFWS, BLM	Kerlinger & Kerns 2004 (18) Young et al. 2003 (22) Pettersson 2005 (59)	N N N	No correlation between wind speed, direction, temperature, or fog/precipitation and bat fatalities. No strong correlations found between avian/bat acualties and weather events Radar monitoring indicated waterfowl migration in fog and mist limited While weather has been well correlated with mass nighttime bird deaths at communication towers, power lines, building windows, and monuments, no mass mortality events have yet been documented at wind facilities. In an effort to avoid or at least minimize that problem, the USFWS suggested this guideline.
Locate turbines and roads away from wetlands	Australia			
Avoid known daily movement flyways	USFWS			While avoiding areas heavily used by birds and/or bats is intuitive, the premise of the USFWS's voluntary wind guidance is based on avoiding locations that are bird and/or bat unfriendly (i.e., heavily used for whatever purposes).
Create road siting plan (using constraint mapping)	CESA, WA			
Use existing transmission corridors	WA, MT, CA			
Route power cable to avoid need to remove native veg and habitat, and	Australia			
Establish buffer zones around turbines	CA			
Construction-Stage				
Perch guards and other APLIC endorsed technologies recommended	WI, WA	Smallwood & Thelander 2004 (12) Nelson & Curry 1995 (30)	N Y	54% reduction in perching estimated with perch guards, but no statistical support
Bury power lines underground	ABC, USFWS, SD, MI, KS, WI, Canada, MD, WA, CESA, CA			Mentioned by numerous studies as recommended management, but couldn't locate research testing this suggestion. USFWS policy suggests: Where risk of power-line strikes and electrocutions exists, bury lines to minimize injury and death, and reduce habitat fragmentation, esp. to "prairie grouse."
Guy wires should be avoided	ABC, WA Audubon, Canada, BLM, MD, WA, CA			
Follow APLIC standards	Wisconsin, ABC, CA			
Establish buffer zones around raptor nests, bat roosts, and biota if facilities pose significant concern	BLM			
Construction should be done when ground is frozen or soils are dry and native veg dormant	KS			
Minimize area disturbed by construction and operation	BLM, CESA			
Installation of towers should avoid disruption of important wildlife behaviors - seasonal restrictions on construction	England, USFWS, Canada, SD, VT, BLM, Australia, MD			USFWS policy suggests: Construction of access roads, drainage ditches, tower platforms, and the installation of towers and turbines can severely disrupt breeding, feeding, roosting, nesting, fledging, staging and resting birds; as well as breeding (maternity colony), feeding, and overwintering (hibernaculum) bats. By not constructing during these time periods, behavioral disruptions to birds and bats can be avoided.
Minimize roads & fences; those built should follow natural land contours and minimize stream crossings and side hill cuts	USFWS, SD, BLM, KS, Canada, WA, CESA	Smallwood & Thelander 2004 (12) Trombulak & Frissell 2000 (70)	Y Y	Access roads should be minimized - unsure of supporting research Unlikely the consequences of roads will be completely mitigated so critical to retain roadless areas in natural state USFWS policy suggests: Grassland-sage-steppe-obligate songbirds and "prairie grouse" have been shown to be especially susceptible to human disruption, including from road development and use, fences, and other "tall" structures. Efforts should be taken to minimize their presence, and where they are constructed to reduce their effects.
Noise-reduction devices should be maintaind in good working condition on vehicles and equipment	VT, BLM			
Dust abatement techniques should be used	BLM			
Develop plan to prevent intro of weeds/invasive flora	SD, Australia, WA			
Minimize creation of edge habitat	BLM	Arnett et al. 2005 (57)	Y	Turbine locations within forest openings and near edges may be miconstrued by bats as favorable roosting sites
Implement strict speed limits	Australia, WA			

Vehicle storage and standing areas should be away from native veg and habitat, and at least 200m from wetlands	Australia			
Monitor and repair erosion	Australia			
Minimize chemical use	England	Trombulak & Frissell 2004 (70)	Y	Accumulations of salts & heavy metals been shown to disrupt natural stratification patterns (other studies cited)
Operational-Stage				
Adjust tower height where rotor height area poses high risk for wildlife	USFWS			While it is infeasible to generally consider elevating rotor swept areas due to generation inefficiencies, where low flying avifauna such as “prairie grouse” occur USFWS suggests this policy to mitigate interactions.
Older turbines that cause high mortality should be moved or retrofitted	USFWS, CA			USFWS made this recommendation initially with Altamont Pass in mind, but it has applicability elsewhere such as at some of the older CA sites. The retrofit refers to a replacement of 1 new, larger turbine for every 7 older turbines.
Decompact disturbed agricultural areas to 18"	NY			
Reseeding with native vegetation	WA, KS, Canada, BLM			
Certified weed-free mulch should be used when stabilizing disturbed soils	BLM			
Higher height veg encouraged along transmission corridors to minimize foraging in these areas	BLM			
Re-vegetate access roads not used after construction	Canada			
Plant area under turbine with less attractive crop	Canada, BLM			
Disturbed lands fully reclaimed to habitat functions prior to construction	ABC			
Markers on guy wires	USFWS, Canada, WA, CA	Alonso et al. 1994 (25) Brown & Drewien 1995 (3) Janss & Ferrer 1997 (27) Morkill & Anderson 1991 (28)	Y Y Y Y	Significant decrease in collisions between spans marked with red PVC spirals and those without Both yellow spirals and yellow swinging plates reduced mortality 75% reduction in mortality seen with black spiral and black crossed band markers While USFWS recommended marking guy wires (both met tower and guyed turbines) where guys were shown to be necessary but could impact avifauna – e.g., Whooping Crane migratory corridor, Spectacled and Steller’s Eider pathways, because of the paucity of published literature in refereed journals, USFWS recommend only limited use of markers until more research can be shown to reduce collisions, especially for night-migrating songbirds in inclement weather
Use of sodium vapor lights should be minimized or avoided	WA Audubon, BLM, MD, CESA	Kerlinger & Kerns 2004 (18)	Y	
Avoid using solid red or pulsating red warning lights at night	England, USFWS	Kerlinger & Kerns 2004 (18)	N	FAA lighting (L-864 red strobes) did not appear to attract nocturnal migrants, but steady burning red, L-810 lights did USFWS policy suggests that solid/steady-burning L-810 lights should not be used on turbines or met towers. The Service provisionally recommended using minimum intensity red blinking/pulsating lights when minimum intensity, maximum off-phased white strobe lights could not be used.
Security lighting on ground should be down-shielded	USFWS, CA			USFWS policy suggests: Steady-burning sodium, halogen, quartz, or related ground-based security lighting have been implicated in moderate to high levels of bird mortality, especially during inclement weather at night. Security lighting was implicated in the largest yet recorded wind turbine kill in WV; when the lights were extinguished yet the fog continued, bird kills appeared to end.
Site lighting should be 'off' unless needed for specific tasks	CESA, CA			
Strobe lights only, min number of flashes and briefest flashes permintable	England, USFWS, Canada, CA			USFWS recommends as a first option, minimum intensity, maximum off-phased white strobe lights. When infeasible, minimum intensity, maximum off-phased red strobe lights are suggested – provided no steady-burning lights are used.
Minimize number of lit turbines	ABC, MD, WA, Australia, BLM, CESA	Johnson et al. 2003 (17) Erickson et al. 2004 (15) Huppop et al 2006 (31) Arnett et al. 2005 (57)	N N Y N	Presence of lighting did not affect number of bat collisions No statistically significant difference found between lit and unlit turbines and bat/bird mortality Large-scale continuous illumination should be avoided (research pre-construction - off-shore) Lighting does not appear to be a significant source of attraction to bats
Lit turbines should use simultaneously pulsing red or white strobes, 20 pulses per minute if possible	ABC			
Synchronization of lights	FAA, MD	Patterson 2004	Y	Study was conducted by FAA (Patterson) for purposes of pilot safety, not wildlife

Wildlife and plant composition needs to be considered when setting mowing schedule	KS			
Reduce availability of carrion	USFWS, Australia			While this was one of many USFWS recommendations focused on the somewhat unique situation at Altamont Pass, to avoid similar future scenarios, it was also recommended elsewhere.
Shut down turbines during certain periods of time	ABC, USFWS, Canada, CA	Barrios & Rodriquez 2004 (2) Hoover 2002 (5) Hoover & Morrison 2005 (6) Huppop et al. 2006 (31)	Y Y Y Y	Suspend turbines causing most deaths under wind speeds that are problematic Close down turbines where valley plateaus meet sloping hillsides and power down turbines located on steep slopes when there are high winds perpendicular Turn turbines off during few nights there is a combo of adverse weather and high migration USFWS suggests: While we still have only an N=1 of turbine samples feathered during bat migration (i.e., Backbone Mt., WV), other study results are pending and will be assessed with great interest. If bats are present and feeding during periods of minimal electrical generation, "feathering" may soon be scientifically validated as a "conservation measure" recommended to the industry as an option for use.
Limited and periodic feathering durin low wind nights	CA	Arnett et al. 2005 (57)		
Prey control program (extensive rabbit control, squirrel control)	Canada, Australia	Hunt 2002 (7) Smallwood & Thelander 2004 (12)	Y N	No supporting research for management suggestion
Use of rodenticides is discouraged around base of turbines	WA			
Reduce motion smear by painting blades	England, Canada	Smallwood & Thelander 2004 (12) Howell & Noone 1991 (16) Hodos 2003 (21) Young et al. 2003 (22)	Y Y Y N	Unproven, but believed to be highly effective (Hodos et al. scheme) Painting of blades (red/white) reduced collisions but not statistically significant Painting of blades (bk/wh) useful up to 19m, then patterns lose advantage - thin-bk stripes best UV painted blades not significantly different than non-painted
Maximum speed of turbines less than 30rpm	WA Audubon	Hodos 2003 (21) Arnett et al. 2005 (57)	N N	20-m diameter turbine rotating at 45rpm with painted blades was visible up to 21m Low wind nights (17rpm) found to result in highest amount of bat fatalities.
Any nesting/maternity areas disturbed shall be reestablished as feasible	MD			
Habitat modifications to make site less attractive	CA			
Other				
Posting of a bond, or other financial instrument, to cover the cost of mitigation actions	OR, WA			
Education and collaboration with county commissoiners, industry, and government	MT, CA			
Apply adaptive management and effectiveness monitoring processes to better achieve management objectives	CA			
Off-site Habitat Enhancement				
Acquisition of replacement habitat (conservation easement, wetland, etc)	SD, OR, VT, WA, KS, MD, CA, Canada	Smith et al. 2005 (38) Trulio 1995 (39) . Roby et al. 2002 (41) Balcombe et al. 2005 (47) Darnell & Smith 2004 (48)	Y/N Y/N . Y Y N	BUOW boxes positive mitigaiton, but must have preexisting BUOWs for artificial nests to succeed Passive relocaiton of BUOW effective mitigation, but cannot move long distances and must protect enough foraging habitat Example of successful CATE colony relocation project Despite differences in veg and invertebrates, mitigation and reference wetlands very similar Mitigation wetland had high salinity, inundation too frequent, and necessary habitat too narrow
Provide alternative habitat off-site to attract at-risk birds from near turbines	Australia			

Conclusions and Recommendations

The impacts of windpower on wildlife has generated a great deal of debate among windpower's advocates and its opponents, often generating a great deal of heat but little light. This Mitigation Toolbox is not directed at determining what the impacts are, nor does it comment on what level of significance those impacts might have. It does, however, take the general position that there are cost-effective opportunities to lessen wind's impacts where they may be determined to have significance. The purpose of the toolbox is to catalog existing mitigation measures and to further explore others, and bring them to light for discussion, research and innovation.

While numerous studies currently exist pertaining to wildlife management in general, there are few studies that specifically look at the effectiveness of mitigation techniques, and even fewer that focus on mitigation techniques in the context of wind turbines. As a result, there are few verified tools available for use in mitigating wildlife impacts from wind development at this time. However, it is clear from the research conducted for this report that the opportunities for mitigation in windpower have just begun to be explored. In addition to those tools or techniques discussed in this report, there are surely useful tools from other industries that could be applied in the windpower context, including those involving adaptive management or offsite mitigation. Industry, advocates and the scientific community should seek out these opportunities and bring them forward for discussion and evaluation. This report is intended to be the first installment of an ongoing process to highlight, in one document, mitigation strategies.

The process of researching for this report has raised a number of themes that need more attention, such as the straightforward preference for siting wind farms in already disturbed areas rather than in more pristine landscapes. However, this document is not intended to be a prescriptive set of best practices such are typically found in siting guidelines. Instead it is intended to be a discussion of the many mitigation opportunities that have either been tried or represent potential means of lowering wind projects' impacts on wildlife.

Siting guidelines building on the U.S. Fish & Wildlife Service's mitigation definition have tended to focus on avoiding impacts to begin with, which often means not building at all in the highest impact areas. This document picks up from that point, asking the follow-up question to "where shouldn't we build", which is the practical question of what we do to mitigate impacts when a decision has been made to build a wind project. It is accepted by many that avoiding all impacts is not a likely or perhaps even achievable goal. We also recognize that some mitigation techniques will prove to be too expensive to be practical, and others may offer the promise of achieving a given goal at a far lower cost. This toolbox may encourage a discussion of those techniques that can achieve goals at the lowest reasonable cost so that they can be broadly utilized and accepted by industry, advocates, regulators, and other interested parties.

With the expected growth of the wind industry over the next few decades, there is a need to address the existing gaps between what is on the research agenda for wind and the practice of planning, constructing and operating wind farms. This need includes research into the question of "where shouldn't we build", focusing on pre-construction studies to avoid the most problematic areas and examining whether pre construction studies can consistently predict post construction impacts to wildlife. Additionally, post-construction studies are needed to determine what impacts are occurring and methods to reduce those impacts in a cost-effective manner. Expanding the amount of research focused on mitigation strategies will not only improve our knowledge of wildlife management, but it will also help to guide policymakers, regulators, industry and the public in developing guidelines or policies that are beneficial for wildlife and cost-effective for development. Expanding the range and scope of mitigation techniques being utilized, including those that may not appear in this report, is also crucial to a vibrant investigation of the most effective ways of achieving the goal of lowering wind energy's impacts at a reasonable cost that encourages adoption by industry. This toolbox is intended to be a living document, adding new techniques as they are developed and applied.

The existing mitigation techniques described in this toolbox emphasize local mitigation methods to reduce impacts. There is a challenge in the need to create mitigation practices that focus on a landscape scale rather than generalized practices that are constrained by political boundaries. Landscape scale planning and offsite habitat evaluations may provide opportunities to enhance wildlife management. It is clear that many jurisdictions are reinventing the wheel again and again, because of a lack of comprehensive and accessible resources documenting current knowledge. This toolbox is a source of compiled information, which will be available to regulatory agencies and other stakeholders making real-time decisions. By integrating this valuable existing information database at the local and landscape scales, we can help to ensure that wind development occurs in a way that will not diminish sensitive migration corridors, breeding grounds, and wintering areas.

APPENDIX A: Comparison of existing policies and guidelines pertaining to wind development and mitigation efforts

	MONITORING		MITIGATION STRATEGIES				
	Pre-Construction	**Post-Construction**	**Design-Stage**	**Construction-Stage**	**Operational-Stage**	**Off-site**	**Other**
LOCAL							
Washington - east of Cascades Department of Fish and Wildlife *Wind Power Guidelines* August 2003 http://wdfw.wa.gov/hab/engineer/windpower/wind_power_guidelines.pdf . Dr.Jeff Koenings (360) 902-2200	Site-specific components and duration of assessment should depend on the size of project, availability and extent of exisgint data, habitats potentially affected, likelihood and timing of occurrence of sensitive species at site, and other factors such as issues and concerns identified during public scoping. At a minimum, 1 raptor nest survey during breeding season within 1-mile of site should be conducted At a minimum, 1 full season of avian use surveys (spring/summer) is recommended - additional seasonal data recommended if avian site use is high, there is little existing data on site, or project is especially large	Monitoring studies are required, but the duration and scope of the monitoring should depend on the size of the project and the availability of existing monitoring data at projects in comparable habitat types A Techincal Advisory Committee (TAC) is recommended to be responsible for reviewing results of monitoring data and making suggestions to the permitting agency regarding the need to adjust mitigation and monitoring requirements	Developers should be encouraged to site wind power projects on disturbed lands.		No mitigation is required for cropland, developed or disturbed areas Temporary habitat impact may implement a WDFW approved restoration plan for the impacted area, including: site preparation, reseeding with appropriate vegetation, noxious weed control, and protection from degradation	All permanent habitat impacts require the acquisition of replacement habitat that is: like kind, equal/higher habitat value, given legal protection, protected from degradation for the life of the project, in the same geographical region, and jointly agreed upon by developer and WDFW (imminent development, grassland, CRP 1:1; Shrub0Steppe or Other High Value 2:1) All temporary habitat impacts have option to acquire suitable replacement habitat for every acre temporarily impacted (grassland, CRP 0.1:1; Shrub-Steppe 0.5:1)	Annual Fee for life of project based on Alternative Mitigation Fee Rate of $55/acre/year for each acres of replacement habitat that would be owed (using ratios found in Off-Site section) The fee is based on habitat in 'average' condition and can be increased or decreased by 25% to account for differences in habitat quality
STATE							
California CA Energy Commission & CA Department of Fish and Game *DRAFT Guidelines for Reducing Wildlife Impacts from Wind Energy Development* December 2006 http://www.energy.ca.gov/2006publications/CEC-700-2006-013/CEC-700-2006-013-SD.PDF http://www.energy.ca.gov/renewables/06-OII-1/documents/index.html#041607 Rick York (916) 654-3945, ryork@energy.state.ca.us	Data and information gathering should be conducted early in process, be collaborative and include experts A scientific advisory committee of relevant experts should be established for life of project, ideally composed of a member from: the lead agency, CDFG, USFWS, developer and conservation organization Minimum of 1 year data collection for birds/bats - nightly acoustic monitoring for bats, weekly bird use counts (BUCs) for birds Small Bird Counts (SBC) may be required in special cases One year bird/bat carcass study to determine natural predation rates Raptor nest searches and bat roost searches conducted within 5 km of proposed site	2 years of carcass searches and bird/bat use surveys recommended, with carcass searches every 2 weeks More frequent searches necessary if pre-permitting studies indicated potential for impacts to bats or small birds Monitoring for repowering projects should use same methodology as for new projects Searcher efficiency trials and carcass removal trials to be conducted seasonally over 2 years More or less monitoring may be appropriate depending on project Science advisory committee and/or USFWS and CDFG should be consulted in determining study protocols and duration	Macro-siting, then micro-siting to maximize impact avoidance Minimize fragmentation and habitat disturbance. Reduce impacts with appropriate turbine layout. Establish buffer zones to minimize collision hazards. Avoid guy wires Power lines should be placed underground, unless burial would result in greater impacts to biological resources All aboveground lines, transformers, or conductors should comply with APLIC standards, including use of deterrents		Decommision non-operational turbines, which includes turbine foundations 3 ft below ground level, access roads, unnecessary fencing and auxillary structures Avoid lighting that attracts birds - use lights with short flash durations that emit no light during "off phase", with minimum number of flashes per minute and briefest flash duratino allowable Lights on auxilary buildings should use motion-sensitive lights and be downcast Limited and periodic feathering during low wind nights Removal of problem turbines Seasonal shutdowns of turbines Habitat modifications to make site less attractive	Mitigation site must provide for long-term conservation of target species and its habitat Site must be large enough to be ecologically self-sustaining Site must be permanently protected through fee title and/or conservation easement Resource managment plan should be approved and provisions made for implementation prior to sale of property/ easement or credits at mitigation bank Provisions for long-term management of property should be made Provisions should be made for monitoring/reporting on identified species and managment objectives	Post-construction monitoring may not be needed if findings from pre-contruction monitoring indicate low bird use and no special-status species or issues of concern, or if the site is near or adjacent to a recently well studies and comparable site with low fatality numbers.

Kansas Renewable Energy Working Group *Siting Guidelines for Windpower Projects in Kansas* January 22, 2003 http://www.krewg.org/reports/KREWGSitingGuidelines.pdf Jim Plogger (785) 271-3349, j.ploger@kcc.state.ks.us http://www.energy.ca.gov/renewables/06-OII-1/documents/index.html#041607	Biological and environmental experts should be used No time frame mentioned Landscape-level examinations should be used Detailed evaluation may not be worthwhile on sites with high potential for biological and environmental conflict		When feasible locate on altered landscapes Infrastructure should be able to withstand periodic burning of vegetation No perches allowed on nacelles Avoid lattice-type construction or other designs that provide perches Turbines should be situated in a way that does not interfere with important wildlife movement corridors and staging areas Avoid damage to unfragmented landscapes and high quality prairie remnants	Power lines underground when feasible Roads and fences should be minimized Avoid sensitive habitats Ideally, construction and maintenance should be done when the ground is frozen or when soils are dry and native vegetation is dormant	Native vegetation of local ecotype should be used to reseed disturbed areas Wildlife and plant composition should be considered in setting mowing schedule Potential adverse affects of warning lights should be addressed If there is significant ecological damage, mitigation for habitat loss should be considered, including: ecological restoration, long-term mangement agreements, conservation easements		
Maryland Wind Energy Technical Advisory Group *<u>DRAFT</u> Siting Guidelines to Mitigate Avian and Bat Risks from Windpower Projects* July 6, 2006 . Michael Dean (410) 767-8149, mdean@psc.state.md.us	Consult with DNR and NHP biologists Request Environmental Review be conducted - minimization or mitigation plans identified at this point will become part of conditions filed in CPCN proceeding Determine limits of physical construction disturbance with NHP biologist and clearly mark boundaries 1 year monitoring data for birds/bats (must be spatially and seasonally appropriate), assessment of potential bat habitat, results of Phase 1 avian risk assessment, and survey results of breeding birds required with CPCN application Additional monitoring may be required for rare, threatened and endangered species	Monitoring shall be conducted for minimum of 3 years Maryland PPRP will establish a peer review group external to State Agencies and comprising of relevant experts to assess monitoring plans and data Data shall be reported to NHP, PPRP, and external peer review group after each migration period (twice/year); and shall include species impacted and weather conditions Additional studies identified by State will not be responsibility of applicant	Avoid lattice-type construction or other designs that provide perches Construct no permanent towers supported by guy wires Avoid locations identified as high risk to birds/bats, have unique habitat features, or are occupied by species of concern	Bury onsite electrical collector cables when possible Avoid or minimize disruptions during bird/bat breeding seasons Any nesting/maternity areas distrubed shall be reestablished as feasible	Minimize lighting by lighting fewest number of turbines possible, synchronizing flashing cycles, installing red rather than white strobes, and avoiding high intensity lights (i.e. sodium vapor) Corrective actions will be sought by State if unforeseen adverse impacts occur	Mitigation plan may involve onsite and/or offsite activities, but offsite may be inappropriate for species of concern	Projects are exempt from CPCN process and guidelines only if the generated power is to remain onsite Mitigation actions should be graded in their implementation so as to reflect the level of the observed impact and the probability of successful mitigation, while defining and bounding the operational limitations or costs associated with the mitigation action
Massachusetts Executive Office of Environmental Affairs *<u>DRAFT</u> Guidance on the Siting of Wind Turbines* . Josh Bagnato (617) 626-1041, Josh.Bagnato@state.ma.us	Guidelines are in the final draft stage - they have been reviewed, but have not yet been released for public comment. Release expected by the end of 2006.						
Michigan Department of Labor & Economic Growth *Michigan Siting Guidelines for Wind Energy Systems* December 14, 2005 http://www.michigan.gov/documents/Wind_and_Solar_Siting_Guidlines_Draft_5_96872_7.pdf . John Sarver (517) 241-6280	3rd party analysis no time frame mentioned special scrutiny required for wildlife refuges, other areas where birds are highly concentrated, bat hibernacula, wooded ridge tops that attract wildlife, sites that are frequented by endangered species, signifant bird migration pathways, and areas that have landscape features known to attract large numbers of raptors	Analysis shall indicate whether a post construction wildlife mortality study will need to be conducted	The applicant will take appropriate measures to minimize, eliminate, or mitigate adverse impacts identified in analysis	Power lines underground when feasible	Applicant shall identify and evalutate the significance of any net effects or concerns that remain after mitigation efforts		
Minnesota Public Utilities Commission *Wind Turbine Siting Requirements* February 7, 2002 http://energyfacilities.puc.state.mn.us/wind.html . Alan Mitchell (651) 296-3714	An applicant for a site permit shall include with the application an analysis of the potential impacts of the project, proposed mitigative measures, and any adverse environmental effects that cannot be avoided, in the following areas: wildlife, rare and unique natural resources, wetlands, vegetation...						

New York Department of Agriculture and Markets *Guidelines for Agriculture Mitigation for Windpower Projects* March 25, 2003 http://www.agmkt.state.ny.us/AP/agservices/constructWind.html . Contact Unknown (800) 554-4501		2+ years of data needs to be collected			All disturbed agricultural areas will be decompacted to a depth of 18 inches with a deep ripper or heavy-duty chisel plow . All rocks 4 inches and larger will be removed prior to and after the replacement of topsoil. Topsoil will be replaced to original depth and the original contours will be reestablished where possible. Access roads will be regraded and original surface drainage patterns will be restored. Restored agricultural areas will be seeded with the seed mix specified by landowner. Topsoil deficiency and trench settling shall be mitigated with imported topsoil that is consistent with the quality of the topsoil on the affected site. Appropriate rehabilitation measures will be determined and implemented when subsequent crop productivity within the affected area is less than that of the adjacent unaffected agricultural land. Where representative subsoil density of the affected area exceeds the representative subsoil density of the unaffected area, shattering of the soil profile will be performed.		
New York Department of Environmental Conservation . Jack Nasca (518) 402-9172, janasca@gw.dec.state.ny.us	Guidelines are in the final draft stage - they have been reviewed, but have not yet been released for public comment. Release expected by the beginning of December 2006.						
Oregon Department of Fish and Wildlife *Fish and Wildlife Habitat Mitigation Policy for Siting Non-Nuclear Energy Facilities* September 1, 2000 http://www.dfw.state.or.us/OARs/415.pdf . Contact Unknown (503) 947-6000	Departmental recommendations or requirements for mitigation will be based on: location, physical characteristics, duration of action and its impacts, alternatives available, fish and wildlife species and habitats affected	Department requires submission of a mitigation plan, which includes protocols, methods, and a reporting schedule for monitoring the effectiveness of mitigation measures				Any habitat not considered irreplaceable (Habitat Category 1) that is damaged must be mitigated through the acquisition of in/out-of-kind, in/off-proximity habitat depending on the habitat category level.	The Department may require or recommend the posting of a bond, or other financial instrument, to cover the cost of mitigation actions based on the nature, extent, and duration of the impact and/or the risk of the mitigation plan not achieving mitigation goals.
Pennsylvania Pennsylvania Wind Farms and Wildlife Collaborative http://www.dcnr.state.pa.us/wind/index.aspx . Kerry Campbell (717) 772-5985, kcampbell@state.pa.us	Pennsylvania recently intitiated a collaborative approch to develop a set of Pennsylvania-specific principles, policies, best management practices, guidelines, and tools that can be used to assess risk to habitat and wildlife from wind power development, and to mitigate* for the impact of that development. This process is expected to be lengthy. PA does already have a process in place that developers must go through to ensure wildlife is protected entitled the Pennsylvania National Heritage Program. An index (PNDI) is used to evaluate any project that requires a permit from the PA Dept. of Environmenta Protection (DEP). Developers enter information about their project into an online review system (www.naturalheritage.state.pa.us) and are notified if there are any potential conflicts with the species or habitats of concern within the database. If they receive a "hit", they're directed to contact the appropriate jurisdictional agency, which will evaluate the project further. PGC evaluates projects that will impact birds and mammals; PFBC evaluates projects that impact fish, aquatic organisms, reptiles, and amphibians; DCNR evaluates plant impacts; and the US Fish and Wildlife Service evaluates impacts on federally listed species.						

South Dakota Bat Working Group & Game, Fish and Parks *Siting Guidelines for Wind Power Projects in South Dakota* http://www.sdgfp.info/Wildlife/Diversity/windpower.htm . Alyssa Kiesow (503) 947-6000	Prepare a monitoring and mitigation plan for protection of sensitive resources during construction and operation of the project Use biological and environmental experts to conduct a preliminary biological reconnaissance of the likley site area Communicate with personnel from wildlife agencies and universities		Situate turbines so they do not interfere with important wildlife movement corridors and staging areas Avoid large, intact areas of native vegetation Avoid lattice-designed towers or other designs providing perches Develop a stringent plan for preventing the introduction or establishment of non-native/invasive flora Consider turbine designs	Minimize the number of roads or fences Power lines underground and/or place turbine near existing transmission lines and substations Consider timing of construction and maintenance activities (including mowing). Avoid construction and maintenance activities during breeding season (April to July) and, if possible, during migration (April-June and August October)	Mitigate for habitat loss through: ecological restoration, long-term management agreements, conservation easements, or fee title acquisitions Address potential adverse affects of turbine warning lights on migrating birds and bats.		
Vermont Fish and Wildlife Department *<u>DRAFT</u> Guidelines for the Evaluation and Mitigation of Impacts to Wildlife Associated with Wind Energy Development in Vermont* April 20, 2006 http://www.energy.ca.gov/renewables/06-OII-1/documents/other_guidelines/VERMONT_GUIDELINES_2006-04.PDF . Julie Moore (802) 241-3687	The applicant should establish the presence or absence of different wildlife species and significant habitats so that appropriate mitigation and avoidance practices can be used. Studies need to be completed during breeding and migratory seasons The Department will review all survey results to determine if the project will result in undue adverse impacts, and may seek revisions to the project.	A minimum of 3 years of rigorous post-construction bird and bat mortality surveys are necessary for any utility-scale wind project in Vermont. Monitoring is to be conducted from April 15 to October 31	ANR reviews initial resource assessment with project layout and works with applicant to identify potential indirect and direct impacts and means of addressing them	Construction activities should be scheduled to avoid important periods of wildlife courtship, breeding and nesting Any clearing of montane spruce-fir must take place outside the breeding period for Bicknell's Thrush Construction activities within ¼ mile of significant black bear hard mast habitat or spring feeding areas should take place outside the feeding periods September 1 – November 21 and May 1 – July 15. Noise-reduction devices should be maintained in good working order on vehicles and construction equipment ANR may recommend the retention of an independent engineer to oversee construction	Habitat restoration activities should be initiated as soon as possible after construction is complete If a project is considered to have undue adverse impacts, mitigation measures will be required, which may include the following: modified operations, modified lighting, on-site habitat management, habitat protection		
Wisconsin Department of Natural Resources *Wind Farm Siting Guidance* August 31, 2005 http://www.dnr.state.wi.us/org/es/science/energy/wind/studies.htm . Steve Ugoretz (608) 266-6673, Steven.Ugoretz@dnr.state.wi.us	A baseline wildlife evaluation should be conducted for each site under serious consideration for windfarm development. To allow comparison with other studies, this evaluation should follow accepted standard protocols for windfarm evaluations (such as the NWCC study guidelines).	At least 2 years of monitoring recommended for the first wind farms in any ecological region in the state	Mitigation measures proved to minimize collisions and mortality should be designed into the windfarm An adaptive mangement approach is highly recommended	Power lines underground is highly recommended Perch guards and other APLIC endorsed technologies recommended			
FEDERAL							
BLM *Programmatic Environmental Impact Statement on Wind Energy Development on BLM-Administered Lands in the Western U.S.* June 2005 https://www.eh.doe.gov/nepa/otheragency/fes0511/index.html . Lee Otteni (505) 599-8911	Avian and bat use of the project area should be evaluated using rigorous survey methods Operators shall evaluate avian and bat use of the project area and design the project to minimize or mitigate the potential for bird and bat strikes Scientifically rigorous avian and bat use surveys shall be conducted - the amount and extent of ecological baseline data required shall be determined on a project basis.		Minimize area distubed by installation of tower Individual towers shall not be located in sensitive habitats or in areas with sensitive ecological resources Installation of towers shall be scheduled to avoid disruption of wildlife reproductive acitivities or other important behaviors Operators shall develop a plan for control of noxious weeds and invasive species Maximize use of existing roads Configure turbines to avoid landscape features known to attract raptors and desgin facilities to discourage perching and nesting Avoid locations heavily used by migratory birds and bats Minimize habitat disturbance by locating facilities in previously disturbed areas Projects should not be located in areas with high incidence of fog and mist	Noise-reduction devices should be maintained in good working order on vehicles and construction equipment Explosives should be used only within specified times and at specified distances from sensitive wildlife or surface waters Dust abatement techniques should be used Refueling should occur in a designated fueling area that includes a temporary berm to limit the spread of any spill Certified weed free mulch should be used when stabilizing areas of disturbed soil Fill materials that originate from areas with known invasive vegetation problems should not be used Minimize area disturbed by construction and operation	Measures to reduce raptor use at project site shall be considered, including: minimization of road cuts, and the maintenance of either no vegetation or non-attractive plant species around the turbines All unnecessary lighting should be turned off at night to limit attracting migratory birds Higher-height vegetation should be encouraged along transmission corridors to minimize foraging in these areas by raptors to the extent local conditions will support this vegetation The use of sodium vapor lights should be minimized or avoided		

				Topsoil from all excavations and construction activities shall be salvaged and reapplied during reclamation along with weed-free native grasses, forbs, and shrubs Guy wires on permanent towers shall be avoided Access roads should follow natural contours of topography and minimize side hill cuts and stream crossings Minimize the creation of, or increase in, the amount of edge habitat between natural and disturbed lands Construction activities should avoid important periods of wildlife behavior Stream crossings should be designed to provide in-stream conditions that allow for and maintain uninterrupted movment and safe passage of fish Establish buffer zones around raptor nests, bat roosts, and biota and habitats of concern, if facilities are beleived to pose a significant concern			
USFWS *Service Interim Guidance on Avoiding and Minimizing Wildlife Impacts from Wind Turbines* July 2003 http://www.fws.gov/habitatconservation/wind.pdf . For general use of guidance contact: David Stout, Chief, Division of Habitat and Resource Conservation, 703-358-2555 For technical issues contact: Robert Blohm, Chief, Division of Migratory Bird Management, 703-358-1714	Pre-development evaluations should be conducted by a team that includes Federal and/or State agency wildlife professionals with no vested interest (e.g., monetary or personal business gain) in the sites selected. Any site evaluations conducted by teams that do not include Federal and/or State agency wildlife professionals will not be considered valid evaluations by the Service Site evaluations are to be conducted using a series of checklists, which are them compiled to determine a ranking for the site	The Service recommends that all sites be monitored for impacts on wildlife after construction is completed – monitoring is not expected to exceed 3 years.	Avoid placing turbines or towers in documented locations of any species protected under the ESA, or where species reside that are sensitive to human disturbance Avoid locating turbines or towers in known local bird/bat migration pathways or in areas where birds/bats are highly concentrated, unless mortality risk is low. Avoid known daily movement flyways and areas with a high incidence of fog, mist, low cloud ceiling, and low visibility. Configure turbines to avoid potential avian mortality where feasible (i.e. group turbines rather than spreading them widely, orient rows of turbines parallel to known bird movements). Avoid fragmenting large contiguous tracts of wildlife habitat. Where practical, place turbines on disturbed habitats. Reduce availability of carrion Develop a habitat restoration plan for the proposed site that avoids or minimizes negative impacts on vulnerable wildlife while maintaining or enhancing habitat values for other species. Construct towers no more than 199 feet above ground level, using construction techniques that do no	Road access and fencing should be minimized If significant numbers of breeding, feedings or roosting birds are known to habitually use the proposed tower construction area, relocation to an alternate site should be recommended. If this is not an option, seasonal restrictions on construction may be advisable tin order to avoid disturbance during periods of high bird activity. Minimize roads, fences and other infrastructure. Infrastructure should be capable of withstanding periodic burning of vegetation.	Where feasible, turbines should be shut down during periods when birds are highly concentrated. Towers using guy wires for support which are proposed to be located in known raptor or waterbird concentration areas or daily movement routes, or in major diurnal migratory bird movement routes or stopover sites, should have daytime visual markers on the wires. Where feasible, power lines should be underground or on the surface as insulated, shielded wire. Where the height of the rotor-swept area produces a high risk for wildlife, adjust tower height where feasible. It is recommended that older turbines that have been shown to cause high mortality be retrofitted or relocated The use of solid red or pulsating red warning lights at night should be avoided. White strobe lights should be used at night – the minimum number, minimum intensity, and minimum number of flashes per minute allowable by FAA. Security lighting for on-ground facilities and equipment should be down-shielded		
USFS *<u>DRAFT</u> 36 CFR 251: Special Use Permits* . Kristin Nelson (202) 205-1406	The planning process must include the development and analysis of information regarding ecological components at a variety of spatial and temporal scales, as determined by the responsible official.		Plan decisions affecting ecosystem or species diversity must provide for maintenance or restoration of the characteristics of ecosystem compositions and structure within the range of variability that would be expected to occur under natural disturbance regimes in accordance with paragraphs (b)(1)(i) through (v) of 36 CFR 219.20				

FAA *FAA Advisory Circular: Obstruction Marking and Lighting, Ch.13* February 1, 2007 http://www.energy.ca.gov/2005publications/CEC-500-2005-180/CEC-500-2005-180.PDF . Scott Larwood (530) 752-7479, smlarwood@ucdavis.edu					Maximum separation gap between lights along a row to be 0.5 mi Omission of lighting within clusters (unless turbines are taller than perhiphery) Lighting of end turbines or end rows. Synchronization of lights for entire project. No daytime lighting necessary if white or off-white paint is used. Omit steady burning lights - Use of red (L-864) flashing lights recommended at night, or white(L-865) flashing lights possible if used alone without red lights and positioned in same manner as red flashing lights. Light fixtures should be placed as high as possible on the nacelle. Stray turbines should be lit High concentrations of lights should be avoided		
INTERNATIONAL							
Australia Wind Energy Association *Best Practice Guidelines for Wind Energy Projects* March 2002 www.auswea.com.au	A radius of up to 30km from the potential site should be used when gathering information on flora and fauna present within the site	Bird/bat utilization studies should be continued for at least 2 years after operation begins.	Avoid development sites and turbine sites with high bird usage Locate turbines and roads well away from wetlands and other bird-rich habitats Consider widening turbine spacing to permit movement of birds around and between turbines Design roads and tracks so that changes to surface water runoff are avoided and erosion is not initiated Route power cable to avoid the need to remove native vegetation and habitat Ensure power cables are not placed across regular bird flight paths Locate switchyard to avoid areas of native vegetation or habitat	Monitor for any downslope deposition of material from construction areas and ensure weeds are controlled and areas are revegetated. Implement strict speed limits where tracks are within 200m of wetlands or other habitats where birds could be disturbed. Locate storage areas and vehicle standing areas away from native vegetation and habitat and at least 200m from wetlands. Avoid building roads and placing turbines on areas of native vegetation and fauna habitat Avoid construction during the most sensitive times of year, and/or stage construction work to ensure adequate distance between works and sensitive habitats	Avoid human disturbance to any wetlands or other habitats that hold bird groups potentially vulnerable to collision Undertake an extensive rabbit control program to minimize the attractiveness of the site to birds of prey Clear away sheep and cattle carcasses rapidly Monitor and repair any erosion and reduce surface water pooling or concentration of runoff Do not illuminate wind turbines as this can attract insects, and confuse night-flying birds	Provide alternative habitat off-site to attract at-risk birds from near turbines	
Canada Environment Canada & Canadian Wildlife Service *A Guidance Document for Environmental Assessment* July 2005 http://www.energy.ca.gov/renewables/06-OII-1/documents/other_guidelines/CANADIAN_GUIDELINES_2005.PDF Final April 2007 Version: http://www.cws-scf.ec.gc.ca/publications/eval/index_e.cfm . Contact Unknown (819) 997-1095	Depends upon Level of Concern Matrix (Site Sensitivity + Facility Size): VERY HIGH CONCERN = 2+ years HIGH CONCERN = comprehensive survey MEDIUM = basic baseline surveys LOW = minimum amount of baseline information • Any turbine taller than 150m in height should be subject to closer scrutiny, especially for sites close to arrival and departure sites of nocturnal migrants, on mountain tops or in foggy areas.	Depends upon Level of Concern Matrix (Site Sensitivity + Facility Size): VERY HIGH CONCERN = 3+ years HIGH CONCERN = 2+ years MEDIUM = 2 years LOW = 1 year	A smaller number of larger turbines may pose less of a risk to birds than a larger number of smaller turbines. Tubular and meteorological towers without guy wires are recommended in commercial wind energy projects Configuration should avoid creating barriers to bird movement - spacing between the turbines should be greater than 200m in order to avoid inhibiting movement. Perching opportunities such as lattice towers, guy wires, hydro poles or other structures should be reduced or removed whenever possible.	Intense construction should be focused outside the core breeding and migration seasons to reduce disturbance to birds. Keep the number of access roads constructed to a minimum. When roads need to be constructed, habitat destruction, fragmentation and disturbance of breeding and wintering grounds should be minimized as much as possible. Power lines underground when possible. When above-ground lines, the following mitigation techniques should be considered: bird flappers or other flight diverters, increased size of wire, parallel to prevailing wind directions, removal of small lighting shield wires, placement close to trees and below tree tops, oblique rather than right angles when crossing rivers, avoidance of water crossings.	• Access roads that are not used after construction should be allowed to re-vegetate (with native not invasive plant species). • If grassland birds are being killed during aerial displays, consider delaying hay cutting If there are high densities of raptors in the area, implement a prey control program In agricultural sites, the areas under the turbines can be planted in a crop that is less attractive to birds Minimize or eliminate lighting. Use strobe lights only, with the minimum number of flashes per minute and the briefest flash duration allowable. Avoid steady-burning or other bright lights such as sodium vapor or spotlights on turbines and other structures. • Measures should be t	Encourage proponent to purchase and protect a parcel fo land of similar size and habitat Decommission or move problem turbines to a new location	

England Department for Environment, Food and Rural Affairs *Nature Conservation Guidance on Offshore Windfarm Development* March 2005 http://www.defra.gov.uk/WILDLIFE-COUNTRYSIDE/ewd/windfarms/windfarmguidance.pdf	Survey data from at least 2 years are necessary, with more survey data (preferably 3 years) will be required in circumstances where important concentrations of birds occur. Whole windfarm area plus surrounding buffer of 1-2 km should be surveyed – observers should be trained by ornithologists.	Surveys should be carried out for at least 3 years following construction and some monitoring may be required for the full lifetime of the development.	Avoid areas with concentrations of species of conservation importance or important migratory paths. Construction of larger turbines may provide greater visibility. Appropriate siting and design in terms of orientation, spacing and location should be used: allow wide corridors between clusters of turbines, with a line formation parallel to the main flight direction, and with the lines of turbines broken up.	Time construction works and construction methods should avoid critical times such as molting. Employ methods of chemical use that minimize release of polluting materials into the water column and only using chemicals selected from the List of Notified Chemicals. Construction works must not be undertaken between December 16 and March to minimize impacts on over-wintering Common Scoter. Cable laying along the beach from October to April should avoid the sensitive period 2 hours either side of high water for overwintering wader species. Cable laying should also occur outside of the molting period for the Common Scoter (July to September). Piling work for turbine foundations should only be carried out between high tide – 3 hours and high water +3 hours to minimize disturbance to Little Terns. No work should be carried out between May 1 and August 1 near to nesting/breeding areas.	Use intermittent rather than continuous navigation lighting, particularly strobing lights. Clusters of turbines will reduce the single point source and provide a more diffuse light distribution. Floodlighting of turbines should be avoided, particularly in times of bad weathers. White lights are preferable to red. High contrast patterns should be used on turbine blades to reduce motion smear		

OTHER							
American Birding Conservancy *Wind Energy Policy* October 12, 2004 http://www.abcbirds.org/policy/windpolicy.htm . Unknown Contact (540) 253-5782	1 year minimum, 2 years suggested Seasonal observations and detailed evaluation of site recommended, including surveys for noctrunal migrants Conducted by qualified professionals without a vested interest in the outcome	2 year minimum, statistically robust If legitimate mortality concerns, then studies should continue until monitoring demonstrates resolution of concerns	Location, design, operation, and lighting should be cafefully evaluated to prevent, or at least minimize, adverse impacts Towers and turbines should be monopoles, not of lattice construction, and have no guy wires	Power lines should be underground Above ground lines and poles should comply with Avian Power Line Interaction Committee (APLIC) standards Disturbed areas should be fully reclaimed to approximate the same habitat functions for wildlife that existed before the disturbance	The number of turbines tha are lit should be minimized Lit turbines should use simultaneously pulsing red or white strobes, suggested at 20 pulses per minute if possible If significant mortality rates cannot be resolved, then turbines should be shut down during periods of peak risk to birds or bats		
Audubon Washington *Wind Power Policy for Washington State* September 23, 2002 http://www.audubon.org/chapter/wa/wa/DOCs/Sept2002_WindPowerPolicy_ExecSummary.doc . Nina Carter (360) 786-8020	2+ years of baseline data of project area and surrounding buffer zone - potentially reduced to 1 year if use radar system such as BIRDRAD	Environmental monitoring must be conducted to assess the level of bird mortality caused by collisions, and must follow standard protocols. Monitoring reports and data must be submitted quarterly to EFSEC and WDFW for the first 2 years following commencement of operations, and annually thereafter.	Designs need to include technologies that are through to, or have been shown to reduce detrimental impacts on birds (i.e. tubular towers, absence of guy wires, absence of lights that may attract night-migrating birds) There must be a contingency plan established to be implemented when operational monitoring shows detrimental effects to birds and/or bird habitat		• Maximum speed of turbines less than 30rpm.		
CleanEnergy States Alliance *Model State Guidance Document Governing Avian and Bat Impacts from Wind Facilities* October 2006 . Mark Sinclar (802) 223-2554, msinclair@cleanegroup.org							

APPENDIX B: Wind Development and Wildlife Mitigation Studies Outline

The following collection is a compilation of literature on wind turbine mitigation efforts that has been separated according to the review process utilized (peer, none, or unknown). Within the 'Reviewed' section, documents are sorted into two primary categories (Journal or Report) and by the primary topic of the mitigation efforts and research (i.e., lighting alterations vs. location of turbines within site). The numbers located next to the citation correspond to the Annotated Bibliography, where detailed descriptions of each study can be found.

REVIEW PROCESS UTILIZED

Journals

Turbine Location/Turbine Type

2. Barrios, L. and A. Rodriguez (2004). "Behavioral and environmental correlates of soaring-bird mortality at on-shore wind turbines." Journal of Applied Ecology **41**: 72-81.
6. Hoover, S. L. & M. L. Morrison (2005). "Behavior of Red-Tailed Hawks in a Wind Turbine Development." Journal of Wildlife Management **69**(1):150-159.
8. Johnson, G. D., M. K. Perlik, et al. (2004). "Bat activity, composition, and collision mortality at a large wind plant in Minnesota." Wildlife Society Bulletin **32**(4): 1278-1288.
9. Osborn, R. G., C. D. Dieter, et al. (1998). "Bird Flight Characteristics Near Wind Turbines in Minnesota." American Midland Naturalist **139**(1): 29-38.
10. Osborn, R. G., K. F. Higgins, et al. (2000). "Bird Mortality Associated with Wind Turbines at the Buffalo Ridge Wind Resource Area, Minnesota." The American Midland Naturalist **143**(1): 41-52.

Lighting

17. Johnson, G. D., W. P. Erickson, et al. (2003). "Mortality of Bats at a Large-scale Wind Power Development at Buffalo Ridge, Minnesota." American Midland Naturalist **150**: 332-342.

Marking Power lines

24. Alonso, J.C., J.A. Alonso & R. Munoz-Pulido. (1994). Mitigation of Bird Collisions With Transmission Lines Through Groundwire Marking. Biological Conservation **67**: 129-134.
25. Brown, W. M. and R. C. Drewien (1995). "Evaluation of Two Power Line Markers to Reduce Crane and Waterfowl Collision Mortality." Wildlife Society Bulletin **23**(2): 217.
26. Janss, G. F. E. and M. Ferrer (1997). "Rate of Bird Collision with Power Lines: Effects of Conductor-Marking and Static Wire-Marking." Journal of Field Ornithology **69**(1): 8-17.
27. Morkill, A. E. and S. H. Anderson (1991). "Effectiveness of Marking Power Lines to Reduce Sandhill Crane Collisions." Wildlife Society Bulletin **19**(4): 442-449.

Curtail Turbines

30. Huppop, O., J. Dierschke, et al. (2006). "Bird migration studies and potential collision risk with offshore wind turbines." Ibis **148**: 90-109.

Reports

Turbine Location/Turbine Type

1. Anderson, R., N. Neuman, et al. (2004). Avian Monitoring and Risk Assessment at the Tehachapi Pass Wind Resource Area, Prepared for National Renewable Energy Lab: 1-102.
4. Erickson, W. P., G. D. Johnson, et al. (1999). Baseline Avian Use and Behavior at the CARES Wind Plant Site, Klickitat County, Washington, Prepared for the National Renewable Energy Lab: 1-75.

5. Hoover, S. (2002). The Response of Red-tailed Hawks and Golden Eagles to Topographical Features, Weather, and Abundance of a Dominant Prey Species at the Altamont Pass Wind Resource Area, California, Prepared for the National Renewable Energy Lab: 1-64.
7. Hunt, W. G. (2002). Golden eagles in a perilous landscape: Predicting the effects of mitigation for wind turbine blade-strike mortality, Prepared for the California Energy Commission**:** 1-72.
11. Orloff, S. & A. Flannery. (1992). Wind Turbine Effects on Avian Activity, Habitat Use, and Mortality in Altamont Pass and Solano County Wind Resource Areas Tiburon, California, Prepared for the Planning Departments of Alameda, Contra Costa and Solano Counties and the California Energy Commission.
12. Smallwood, K.S. & C.G. Thelander. (2004). Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area, Prepared for the California Energy Commission: 1-363.
14. Thelander, C. G. & L. Rugge. (2000). Avian Risk Behavior and Fatalities at the Altamont Wind Resource Area, Prepared for the National Renewable Energy Laboratory: 1-22.

Lighting

52. Arnett, E. B., W. P. Erickson, et al. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines, Prepared for the Bats and Wind Energy Cooperative**:** 1**-**187.
15. Erickson, W. P., J. Jeffrey, et al. (2004). Stateline Wind Project Wildlife Monitoring Final Report, July 2001 - December 2003, Prepared for FPL Energy, the Oregon Energy Facility Siting Council, and the Stateline Technical Advisory Committee**:** 1**-**105.
12. Smallwood, K.S. & C.G. Thelander. (2004). Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area, Prepared for the California Energy Commission: 1-363.

Visual Blades

20. Hodos, W. (2003). Minimization of Motion Smear: Reducing Avian Collisions with Wind Turbines, Prepared for the National Renewable Energy Laboratory**:** 1-43.
21. Young, D. P., W. P. Erickson, et al. (2003). Comparison of Avian Responses to UV-Light-Reflective Paint on Wind Turbines, Prepared for the National Renewable Energy Lab: 1-67.

Sound Devices

52. Arnett, E. B., W. P. Erickson, et al. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines, Prepared for the Bats and Wind Energy Cooperative**:** 1**-**187.
23. Dooling, R. (2002). Avian Hearing and the Avoidance of Wind Turbines, Prepared for the National Renewable Energy Lab: 1-17.

Perch Guards

12. Smallwood, K.S. & C.G. Thelander. (2004). Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area, Prepared for the California Energy Commission: 1-363.

Baseline Data

53. Erickson, W. P., G. D. Johnson, et al. (2002). Synthesis and Comparison of Baseline Avian and Bat Use, Raptor Nesting and Mortality Information from Proposed and Existing Wind Developments, Prepared for Bonneville Power Administration**:** 1-129.

Post Construction Data

56. Arnett, E. B., W. P. Erickson, et al. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines, Prepared for the Bats and Wind Energy Cooperative**:** 1**-**187.

Offshore

58. Pettersson, J. (2005). The Impact of Offshore Wind Farms on Bird Life in Southern Kalmar Sound, Sweden, at the request of the Swedish Energy Agency**:** 1**-**128.

Curtail Turbines

56. Arnett, E. B., W. P. Erickson, et al. (2005). Relationships between Bats and Wind Turbines in Pennsylvania and West Virginia: An Assessment of Fatality Search Protocols, Patterns of Fatality, and Behavioral Interactions with Wind Turbines, Prepared for the Bats and Wind Energy Cooperative**:** 1**-**187.

NOT PEER REVIEWED

Turbine Location/Turbine Type

13. Smallwood, K.S. (2006). Biological Effects of Repowering A Portion of the Altamont Pass Wind Resource Area, California: The Diablo Winds Energy Project.

Lighting

19. Larwood, S. (2005). FAA Obstruction Lighting Standards for Wind Energy Plants, Prepared for California Wind Energy Collaborative, sponsored by the California Energy Commission Public Interest Energy Research (PIER) program.

Marking Power lines

28. Organ, C. A., M. Timewell, et al. (2003). Bird Surveys along the proposed Musselroe Wind Farm Transmission Line - Ringarooma Ramsar area, north-east Tasmania, Prepared for Hydro-Electric Corporation**:** 1**-**62.

UNKNOWN REVIEW PROCESS

Turbine Location/Turbine Type

25. Brown, W. M., R. C. Drewien, et al. (1985). Mortality of cranes and waterfowl from power line collisions in the San Luis Valley, Colorado. 4th Crane Workshop, Grand Island, Nebraska, Platte River Whooping Crane Habitat Maintenance Trust.

Lighting

16. Howell, J. A., J. Noone, et al. (1991). Visual experiment to reduce avian mortality related to wind turbine operations, Prepared for Altamont U.S. Windpower, Inc.: 1-25.
18. Kerlinger, P. and J. Kerns (2004). A Study of Bird and Bat Collision Fatalities at the Mountaineer Wind Energy Center, Tucker County, West Virginia: Annual Report for 2003, Prepared for FPL Energy and Mountaineer Wind Energy Center Technical Review Committee**:** 1-39.

Visual Blades

1. Howell, J. A., J. Noone, et al. (1991). Visual experiment to reduce avian mortality related to wind turbine operations, Prepared for Altamont U.S. Windpower, Inc.: 1-25.

Microwaves

22. Kreithen, M. L. (1996). Development of a Pulsed Microwave Warning System to Reduce Avian Collisions with Obstacles. 2nd International Conference on Raptors. Urbino, Italy.

Sound Devices

76. Szewczak, J. & E.B. Arnett. (N/A). Evaluation of Acoustic Deterrents to Reduce Bat Fatality at Wind Facilities.

Perch Guards

29. Nelson, H. K. and R. C. Curry (1995). Assessing Avian Interactions with Wind Plant Development and Operations. 61st North American Wildlife and Natural Resources Conference. Washington, D.C.

Baseline Data

54. Percival, S.M. (2003). Birds and Wind Farms in Ireland: A Review of Potential Issues and Impact Assessment: 1-25.
55. Young, Jr., D.P, W. P. Erickson, et al. (2003). Avian and Bat Mortality Associated with the Initial Phase of the Foote Creek Rim Windpower Project, Carbon County, Wyoming, Prepared for Pacificorp, Inc., Bureau of Land Management and SeaWest Windpower, Inc.: 1-50.

Curtail Turbines

75. Sherwell, J. (N/A). Developing a mitigation strategy for bat impacts from windpower development in Maryland.

No Effect

57. Lucas, M. D., G. F. E. Janss, et al. (2005). "A bird and small mammal BACI and IG design studies in a wind farm in Malpica (Spain)." Biodiversity and Conservation **14**: 3289-3303.

APPENDIX C: Habitat Mitigation Studies Outline

The following is a compilation of literature on habitat mitigation efforts that has been separated according to the review process used (peer, none, or unknown). Within each section, documents are sorted by the primary topic of the mitigation effort and research (e.g., livestock fencing). The numbers located next to the citation correspond to the Annotated Bibliography, in which descriptions of each study can be found.

REVIEW PROCESS USED

Wetland Creation

46. Balcombe, C.K., J.T. Anderson, et al. (2005). "Wildlife Use of Mitigaiton and Reference Wetlands in West Virginia." Ecological Engineering **25**: 85-99.
47. Darnell, T.M. & E.H. Smith. (2004). "Avian Use of Natural and Created Salt Marsh in Texas, USA." Waterbirds **27**(3): 355-361.

Livestock Fencing

42. Dobkin, D.S., A.C. Rich, et al. (1998). "Habitat and Avifaunal Recovery from Livestock Grazing in a Riparian Meadow System of the Northwestern Great Basin." Conservation Biology **12**(1): 209-221.
45. Maron, M. and A. Lill. (2005). "The influence of livestock grazing and weed invasion on habitat use by birds in grassy woodland remnants." Biological Conservation **124**: 439-450.
12. Smallwood, K.S. & C.G. Thelander. (2004). Developing Methods to Reduce Bird Mortality in the Altamont Pass Wind Resource Area, Prepared for the California Energy Commission: 1-363.

Cave Gating

41. Martin, K.W., D.M. Leslie Jr., et al. (2003). "Internal Cave Gating for Protection of Colonies of the Endangered Gray Bat (*Myotis grisescens*)." Acta Chiropterologica **5**(1): 1-8.

Relocation

40. Roby, D., K. Collins, et al. (2002). "Effects of Colony Relocation on Diet and Productivity of Caspian Terns." Journal of Wildlife Management **66**(3): 662-673.

Artificial Nests

35. Belthoff, J.R. & R.A. King. (2002). "Nest-site Characteristics of Burrowing Owls (Athene Cunicularia) in the Snake River Birds of Prey National Conservation Area, Idaho, and Applications to Artificial Burrow Installation." Western North American Naturalist **62**(1): 112-119.
37. Smith, M.D. C.J. Conway, et al. (2005). "Burrowing owl nesting productivity: a comparison between artificial and natural burrows on and off golf courses." Wildlife Society Bulletin **33**(2): 454-462.
69. Trombulak, S.C. and C.A. Frissell. (2000). "Review of ecological effects of roads on terrestrial and aquatic communities." Conservation Biology **14**(1): 18-30.
38. Trulio, L.A. (1995). "Passive Relocation: A Method to Preserve Burrowing Owls on Disturbed Sites." Journal of Field Ornithology **66**(1): 99-106.

Habitat Alterations

31. Grindal, S.D. and R.M. Brigham. (1998). "Short-term Effects of Small-scale Habitat Disturbance on Activity by Insectivorous Bats." Journal of Wildlife Management **62**(3): 996-1003.
34. Leddy, K. L., K. F. Higgins, et al. (1999). "Effects of Wind Turbines on Upland Nesting Birds in Conservation Reserve Program Grasslands." Wilson Bulletin **111**(1): 100-104.

33. Larsen, J.K. & J. Madsen. (2000). “Effects of Wind Turbines and Other Physical Elements on Field Utilization by Pink-footed Geese (Anser Brachyrhynchus): A Landscape Perspective.” Landscape Ecology **15**: 755-764.
67. Rowland, M.M., M.J. Wisdom, et al. (2005). “Effects of Roads on Elk: Implications for Management in Forested Ecosystems.” In M.J. Wisdom (technical editor), The Starkey Project: a synthesis of long-term studies of elk and mule deer. Reprinted from the 2004 Transactions of the North American Wildlife and Natural Resources Conference, Alliance Communications Group, Lawrence, Kansas: p.45-52.
69. Trombulak, S.C. & C.A. Frissell. (2000). Review of Ecological Effects of Roads on Terrestrial and Aquatic Communities. Conservation Biology 14(1): 18-30.

Conservation Easements (CRPs, ECAs, etc)

32. Herzog, F., S. Dreier, et al. (2005). “Effect of ecological compensations areas on floristic and breeding bird diversity in Swiss agricultural landscapes.” Agriculture, Ecosystems and Environment **108**: 189-204.

Wildlife Corridors

49. Aresco, M.J. (2005). “Mitigation measures to reduce highway mortality of turtles and other herpetofauna at a north Florida lake.” Journal of Wildlife Management **69**(2): 549-560.
50. Cain, A.T., V.R. Tuovila, et al. (2003). “Effects of a Highway and Mitigation Projects on Bobcats in Southern Texas.” Biological Conservation **114**: 189-197.
51. Dixon, J.D., M.K. Oli, et al. (2006). “Effectiveness of a Regional Corridor in Connecting Two Florida Black Bear Populations.” Conservation Biology **20**(1): 155-162.
52. Ng, S.J., J.W. Dole, et al. (2004). “Use of highway undercrossings by wildlife in southern California.” Biological Conservation **115**: 499-507.

UNKNOWN REVIEW PROCESS

Wetland Creation

48. Federal Highway Administration. (1992). Evaluation of Wetland Mitigation Measures, Volume 1: Final Report: 1-353.

Livestock Fencing

43. Earnst, S.L., J.A. Ballard, et al. (2004). Riparian songbird abundance a decade after cattle removal on Hart Mountain and Sheldon National Wildlife Refuges. USDA Forest Service Gen. Tech. Rep. PSW-GTR-191: 9 pgs.
44. Manier, D.J. & N.T. Hobbs. (2006). “Large Herbivores Influence the Composition and Diversity of Shrub-Steppe Communities in the Rocky Mountains, USA.” Oecologia **146**: 641-651.

Relocation

39. Matthews, K.R. (2003). Response of Mountain Yellow-Legged Frogs, *Rana muscosa*, to Short Distance Translocation. Journal of Herpetology **37**(3): 621-626.

Artificial Nests

36. Smith, G.C. & G. Agnew. (2002). “ The Value of ‘Bat Boxes’ for Attracting Hollow-dependent Fauna to Farm Forestry Plantations in southeast Queensland.” Ecological Management & Restoration **3**(1): 37-46.

Habitat Alterations

73. McNew, L.B., B.K. Sandercock & S.M. Wisely. (N/A). Effects of Wind Power Development on the

Demography of the Greater Prairie-Chicken.
74. Schroeder, M.A., C.E. Braun & J.W. Connelly. (N/A). Effects of Wind Power Development on Sage-Grouse.

Habitat Enhancement

71. Lehn, K. & F. Bairlein. (2006). Is mulching a suitable method for improving the nesting habitat of the Northern Lapwing? Journal of Ornithology **147**(5): N/A. **(THIS STUDY HAS NOT YET BEEN PUBLISHED)**

APPENDIX D: Personal Interview Contacts and Responses

The following list includes individuals that were contacted via phone or e-mail in order to gather information about existing research pertaining to mitigation. A list of interview questions is in Appendix E.

TELEPHONE

1) **Wayne Walker, Director of Project Development, Horizon Wind Energy, 713-265-0247, wayne.walker@horizonwind.com;** He is "not aware of a plethora of mitigation studies." Horizon looking into conservation banks, but hasn't implemented any yet. Mentioned Wild Horse study as only example of conservation/development that Horizon is currently involved in – it was not set up for mitigation specifically. He also mentioned www.bambergerranch.org as an example of someone taking a heavily degraded habitat and returning it to pre-European levels. Includes a manmade cryptorium for free-tailed bats. I looked it up, but seems a little 'fluffy'. (Follow up with the WA Nature Conservancy pertaining to Wild Horse study still necessary) – L/M with Horizon WA office on 11/1/06 for more info, 509-962-1122; also spoke with Jeff Compton of TNC-WA, 206-343-4345.

2) **Ed Arnett, Conservation Scientist – Wind Energy, Bat Conservation International, 512-327-9721, earnett@batcon.org;** no studies/research to his knowledge concerning habitat enhancement and bats. Says most species killed by turbines live in trees, so mitigation of caves/mines does little for repairing damage. Said research on insects/bats at turbines and stopping blades needs to be further researched.

3) **Jill Shaffer, Ecologist, USGS Northern Prairie Wildlife Research Center, 701-253-5547, jshaffer@usgs.gov;** she spoke with a few people about the existence of research that directly examines the effectiveness of any mitigation techniques and "we have come up mostly blank." Mitigation can include creating new habitats as well as protecting what exists – "both are important avenues to consider because placing wind developments in already disturbed land might preclude needing mitigation for habitat impacts or displacement of animals at all." Suggested I contact Habitat and Population Evaluation Team, DOT, FHWA, and SD State University.

She also mentioned the 'Effects of Management Practices on Grassland Birds' research http://www.npwrc.usgs.gov/resource/literatr/grasbird/index.htm. I looked into management suggestions for the Ferruginous Hawk and Burrowing Owl to determine how well supported they were. The research cited is from before the mid-90s, so appears to be a bit dated. When I looked into some of the papers cited, the management suggestions didn't appear to be overwhelmingly supported statistically. Jill did mention that they were updating the publication and that I should contact her to send me the updated versions – I am currently awaiting response from her.

4) **Jim Lowe, Birds in Forested Landscapes, Cornell Ornithology Lab, 607-254-2413;** said they have not studied applied mitigation – just surveys. Suggested contacting Stefan Hames who is their 'wind guru'. Left him a message on 8/22, but have not received a response. Stefan contact is 607-254-2496, rsh5@cornell.edu.

5) **Gail Garber, NM Avian Protection Working Group, HawksAloft (?), 505-828-9455, gail@hawksaloft.org;** the organization has never looked at mitigation as a research project. They have set up nesting platforms, but no research was conducted on its effectiveness. They have done

some pre-site assessments for wind turbines to identify raptors in area and if potential site is in way of migratory pathway. She suggested I contact Wally Erickson and David Young.

6) **Sandy Vana-Miller, USFWS in Colorado (Energy aspect), 303-236-4748;** suggested I call Al Manville. No idea about research pertaining to mitigation or habitat enhancement.

7) **Nick Myatt**, **Access and Habitat Coordinator, Oregon Department of Fish and Wildlife, 503-947-6087;** he doesn't do anything pertaining to habitat enhancement studies himself, but sent word out to co-workers for help with the question. Received response from one woman, who was going to look into studies that have been conducted within her area and send contacts for more information. Nick also suggested looking at the Conservation Plan for OR at www.dfw.state.or.us which outlines how to manage wildlife. Like npwrc research, however, it focuses more on individual species of concern. I emailed him and the woman again this week to see if they had come up with anything or anyone for me to speak with, but I haven't heard back from them yet.

8) **Rob Manes, Director of Conservation, The Nature Conservancy, 620-672-5677, rmanes@tnc.org;** he said that "definitive studies are not out there" pertaining to mitigation and its effects on birds/bats. He did send me some information on a mitigation proposal that TNC has been working on in the Smokey Hills, as well as some studies pertaining to Prairie Chickens and mitigation in Kansas.

9) **John Sherwell, Power Plant Research Program, Maryland Department of Natural Resources, 410-260-8667, jsherwell@dnr.state.md.us;** I called him specifically about a study that he intends to present at the conference in November pertaining to wind turbine rotation speed and bat interactions. He stated that the study modeled risk at low wind speeds, finding that lower rpms significantly decreased the risk to bats. He is looking for comments on whether or not the risk model is reasonable presently.

10) **Paul Garrett & Lamar Smith, Federal Highway Administration;** left messages with both of them, not sure if they are the correct contacts at this department though. Spoke with John Fagan 8/23, who said he would look into the best contact but has yet to get back with me. Left message for Jeff Peterson with the CDOT on 11/1/06 – Jeff.Peterson@dot.state.co.us, 303-512-4959

11) **Al Manville, Wildlife Biologist, Division of Migratory Bird Management, USFWS, albert.manville@fws.gov;** "No one has any idea what is going on in relation to bird/bat mortality and mitigation." He said that it was very important to assess populations, and that post-construction monitoring was a big part of this. Mitigation strategies mentioned included blade-painting strategies (Strickland), Bat-Be-Gone (Arnett) which is currently being testing in the field in TX – acoustic deterrents that do not appear to be cost effective, and Lesser Prairie Chicken studies (Robell, USFWS recommends >5m buffer from leks, BLM recommends ¼ mile) – surrogate structures used to date, need to test at wind facilities. Europe is ahead of US in this department – British, German (Franz Bairlein).

An interesting study that he mentioned was one in Oaxaca, Mexico. They are currently in the process of constructing a very large wind power plant, but World Bank will not fund unless they agree to shut down the turbines for 3 weeks during Broad-winged Hawk, Mississippi Kite, and Swainson's Hawk migration. Monitoring program has been set up to see the effects of this mitigation strategy on avian mortality, as well as on economic performance of plant. Study hasn't begun yet.

12) **Mike Estey, Habitat Population and Evaluation Team, USFWS, 701-355-8540;** he suggested I speak with Ron Reynolds. Did mention that HAPET is currently identifying potential

problems with the siting of a wind power plant in ND (pertaining to wildlife migration); "the biggest problems are identifying any real problems."

13) **Ron Reynolds, Habitat Population and Evaluation Team, USFWS, 701-355-8535;** study currently being conducted to examine the effectiveness of a mitigation strategy to remedy problems caused to Ruddy Ducks on their wintering grounds as a result of an oil spill in the Patauxent River, MD. Board of Trustees decided that mitigation for spill required the organization to return new Ruddy Ducks into the population to make up for the ones that were lost. In order to do this, HAPET is helping organization to restore/create new habitat on the breeding grounds which are in ND. Evaluations of mitigation will begin as soon as the mitigation treatments are completed, and they will last for 10 years. Mitigation includes restoring the function of degraded wetlands or replacing drained wetlands, largely through conservation easements on agricultural lands. They are currently targeting areas with high RUDU breeding populations because they are already supportive landscapes.

14) **Karen Kronner, President, Northwest Wildlife Consultants Inc., 541-278-2987, kronner@oregontrail.net;** stated that there wind is relatively new compared to other types of mitigation, so mitigation approaches have largely been based on mitigation efforts from gas projects, transmission lines, oil pipes, highways, etc. Mitigation depends on the scale of the project, and NWC works directs with state to minimize impacts. She doesn't "believe something needs to be formerly researched if other studies have shown how a habitat/species responds to change." A lot of mitigation efforts are based on intuition which is developed by being in the field and "gaining a sense of things in the area." People don't know what to do – you can learn from other regions, but you will need to tailor strategies to local conditions. They keep asking for more certainty, but you "can study a site for three years and still not know everything." Mentioned BLM in Nevada is currently developing regional specific wind power guidelines that will include pre-construction, environmental, and fatality monitoring. Also mentioned Cotterall Mountain (sp??) project in Idaho, where she though Sage Grouse mitigation tools were developed (Lynn Sharp was mentioned as contact).

Stateline project is the largest in Oregon, and has the largest post-construction study done thus far, which includes grassland bird displacement studies, raptor studies, and recovery of temporary disturbed areas (grass seeding). Pre-construction monitoring was conducted, and gaps were left in saddles when placing turbines as a result. Report on post-construction monitoring is expected January 2007. Stateline was found to exceed the raptor kill threshold established by the state, however, and a three part mitigation plan was developed, including: 1) construction of artificial nest structures, 2) protection of riparian habitat (raptor habitat) through exclosures of riparian area and upland livestock, and 3) provision of financial support to wildlife rehabilitator to purchase food to rehabilitate raptors and chicks. Mitigation efforts are only ¾ completed at this point, and effectiveness monitoring with be conducted on platform usage but not on effects of fencing due to long time period required for effects to be evident.

15) **Sara McMahon, Wildlife Biologist, PPM Energy, 503-796-7000, Sara.McMahon@PPMEnergy.com;** a lot of mitigation not based on research, but based on recommendations and observations. Efforts follow more of a precautionary principle approach, such that "it wouldn't hurt to set the turbines back from the canyon edges." Studies like the Altamont are not useful for the NW because there are different biological characteristics there.

Andy Linnenhahn (??) has been involved with Arnett's study on acoustic deterrents, where high frequency noise generators are used to block the ability of bats to relocate. Initial field trials have been completed and the deterrents appear to be positive at this point. He is not sure how far effects will extend, and mentioned that the devices are still in prototype development.

16) **David Klute, All-bird Conservation Coordinator, Colorado Division of Wildlife, 303-291-7320;** left message, no response

17) **Gregory Johnson, Ecologist/Project Manager, WEST Inc, 307-634-1756;** left message, no response

18) **Jim Lindsey, Principal Biologist Florida Power and Light, 561-691-7032;** left message, no response

E-MAIL

1) **Bruce Johnson, Starkey Experimental Forest (Biologist), johnsobd@eou.edu;** brief initial correspondence, but no response to questions

2) **Franz Bairlein, Editor-In-Chief, Institute for Avian Research, franz.bairlein@ifv.terramare.de;** responded that he was at the International Ornithological Congress and would get back to me when he returned to Germany. Received an email from co-worker Ommo Hueppop, who stated that he didn't "know of any such studies where artificial modifications of habitats around windfarms" were used as a measure to mitigate wildlife interactions. He suggested I pose this question to the Yahoo-group on Wind-turbines and birds/bats, http://tech.groups.yahoo.com/group/wind turbines birds/ . He additionally sent me a paper on offshore-windfarms entitled "Bird migration studies and potential collision risk with offshore wind turbines".

3) **Ellen Paul, Executive Director, The Ornithological Council, ellen.paul@verizon.net;** stated that she isn't aware of what mitigation measures have been taken, and that people tend to make educated guesses about things that will work but that they don't do any studies to determine the outcome. "No one has ever determined if the site selection has reduced mortality." There has been work done with regard to the surrounding vegetation (contact Carl Thelander), and Ed Arnett was suggested as a good contact on bats. "It would be possible that you are looking for information that doesn't exist."

4) **Dave Cowan, VP Environmental Affairs, UPC Wind Management, 207-829-6055, dcowan@upc.wind;** HCP for Hawaii project includes a "very comprehensive mitigation component", but there is not any hard data or research as of yet that can be cited. The project came on-line in June, and mitigation provisions are just getting started. Study has made some headway on documenting behavioral avoidance of turbines by birds that regularly pass through the site, but again, the data is not ready to present as a research paper. Rigorous impact avoidance protocol was implemented during construction phase to "ensure that no birds were accidentally disturbed or killed by clearing, earthwork, or vehicles and heavy equipment moving around the site." HCP plan itself is largely based on uncertainties, so it contains a lot of contingencies. "Track 1 if A happens, but Track 2 if B happens – it's as much a protocol as a prescription." He sent me a copy of the HCP for review.

5) **Dr. Michael L. Rosenzweig, Professor of Ecology and Evolutionary Biology, University of Arizona, scarab@email.arizona.edu;** he had heard of dozens of mitigation cases, but does not keep a formal file of them and is too "freighted with commitments to accomplish this in any reasonable time-frame." He does state, however, that many of them appear in his book "Win-Win Ecology", and although they are not labeled 'mitigation' per se, the will have the fingerprint of mitigation all over them. Additional resources included:

- Rosenzweig, M.L. (2006). Beyond set-asides. In Goble, D., D. Scott, J. Michael, and F.W. Frank (eds), *The Endangered Species Act at Thirty: Renewing the Conservation Promise.* Island Press, Washington, D.C.: p.259-273.
- Rosenzweig, M.L. (2005). Avoiding mass extinction: basic and applied challenges. *American Midland Naturalist* 153: 195-208.

6) **Ryan Burnett, Terrestrial Ecologist, Point Reyes Bird Observatory**, 530-258-2414, **rdburnett@prbo.org;** he stated that "PRBO hasn't done too much work but I know we have at least looked into doing some work and done some research". He suggested I contact Katie Fehring, who does most of the raptor work for the organization. Katie stated that PRBO is currently conducting surveys at a proposed wind site in Marin, but that is all the organization has done with wind development thus far. Her contact info is 415-868-0655 x380, kfehring@prbo.org.

APPENDIX E: Personal Interview Questions

The National Wind Coordinating Committee's Wildlife Workgroup Mitigation Subgroup is collecting information about research that has been conducted to determine the effectiveness of wildlife mitigation strategies, especially as they might apply to wind turbine sites. This research will be presented as case studies that will be included in a mitigation toolbox being developed by the Subgroup.

Questions:

1. Are you familiar with any such studies that have been conducted/are being conducted within your company/organization?
2. If so:
   a. Can you describe the study to me?
   b. What have you learned from this research?
   c. Has it definitively shown certain mitigation strategies to be effective or ineffective?
   d. Can you send me any documentation of this research, especially approach, methodologies, and analyses/results?
3. If not:
   a. Are you familiar with any such research that might be useful to this study?
   b. Has your organization/company implemented any mitigation strategies? Did you find them to be effective/ineffective?
   c. Does your company/organization plan to do any such research in the future?

APPENDIX F: Economic Analysis

This matrix compares the economic costs of certain mitigation strategies with the estimated effect on mortality of that strategy. The mitigation strategies presented in Column A came from both mitigation research and existing policies and guidelines. Column B briefly describes what the mitigation strategy encompasses. Associated Research is presented in Column C and shows existing or current research that has tested the mitigation strategy; the results of that research (in terms of effectiveness) are presented in Column D. Finally, Column E presents the estimated costs of the mitigation strategy.

ECONOMIC ANALYSIS

Mitigation Strategy	Description	Associated Research	Estimated effect on mortality	Estimated Cost
Install beneficial turbine designs	Place turbines in locations that minimize the chances of negatively affecting wildlife - includes placing turbines away from rim edges, away from flyways, creating wind walls, etc.	Orloff & Flannery 1992, Thelander & Smallwood 2004	Estimate 4% decrease in bird/raptor mortality by creating wind wall; untested	Pre-assessment surveys
Avoid areas heavily used by birds/bats	This would include migration pathways and breeding grounds.		untested, but presumably significant	Pre-assessment surveys
Locate turbines on altered landscapes	This would include areas such as agricultural lands - avoid constructing turbines in sensitive or large tracts of native habitat			N/A
Reduce and minimize lateral edge	Cuts into hillsides for wind turbine lay-down areas and access roads should be minimized	Smallwood & Thelander 2004	Ground squirrels avoided zone, but pocket gophers were attracted to it; untested	
Establish buffer zones	Establish areas where there will be no construction or development occuring around areas of high bird/bat use			
Alter tower type	Tower type altered, but existing turbine blade not changed			
Paint blades	One blade painted black (or thinly striped black/white) and two painted white	Hodos et al. 2003	untested	
	Red and white stripes	Howell et al. 1992, Thelander & Smallwood 2004	90% reduction (n=10) according to Howell; 2-3% increase according to Thelander	
	Paint blades with UV gel	Young et al. 2003	52% more fatalities at UV turbines - not significant and nocturnal species; degeneration of gel	

Rodent control	Live-trapping and relocation of rodents.	Hunt 2002	Potential increase in mortality for species that depend upon burrows &/or prey; no compelling evidence that rodent control reduces bird mortality; potential bioaccumulation and biomagnification issues	
	Poisoning of rodents using bait of some form.	Thelander & Smallwood 2004		
Fence around turbines to exclude livestock	Livestock congregate around wind turbines (wind-breaks, shade?), which increases cow pats and subsequent insect numbers. 50-m exclusion area may suffice, but may be necessary to fence off groups of turbines in order to minimize length of fencing and perching opportunities.	Thelander & Smallwood 2004	Estimated 18-22% reduction in avian fatalities; untested	
Rock piles	Establish rock piles to create denning habitat for Kit Fox prey population			
	Move artificial rock piles as far away from wind turbines as possible	Thelander & Smallwood 2004	not believed to reduce mortality substantially by itself; untested	Low
Perch guards	Treatments designed to discourage perching by raptors on lattice-style turbines	Thelander & Smallwood 2004, Nelson & Curry 1995, Curry & Kerlinger 2001	Reduction in perching observed to be 0-54%; Increase in hawk mortality of 2% (Thelander & Smallwood)	
Repower turbines	Older turbines replaced within newer ones (e.g., lattice-style towers replaced with tubular towers).	Thelander & Smallwood 2004, Anderson et al. 2004, Hunt 2002, Orloff & Flannery 1992, Thelander & Rugge 2000, WEST (unpublished)	90% decrease (Hunt), Tubular towers associated with 6-35% increased mortality (Thelander); WEST currenlty testing in CA (Altamont)	
Mark power lines	Placement of various markers on groundwires or power lines to increase visibility.	Alonso et al. 1994, Brown & Drewien 1995, Janss & Ferrer 1997, Morkill & Anderson 1991	60% decrease (Alonso), 76-81% decrease (Janss); 56% decrease (Morkill)	
Install bird flight diverters	Benign pole structures placed beyond the ends of strings and edges of turbine clusters.	Thelander & Smallwood 2004	untested	

Provide alternative perches	Establishment of alternative perches in order to attract birds away from turbines.	Thelander & Smallwood 2004	untested	
Barricade the rotor plane	Erection of barriers to keep birds from flying into moving blades.	Thelander & Smallwood 2004	untested	believed to be overwhelmingly costly & impractical
Accoustic deterrents	Modifying the acoustic signatures of turbine blades in order to make them more audible to birds/bats.	Dooling 2002, Arnett et al. 2005, Szewczak & Arnett (unpublished)	acoustic signatures for birds untested; sonar "jamming" testing in progress	associated costs for decreasing bat fatalities believed high
Retrofit turbine-tower pads				
Reduce availability of carrion	Remove carcasses to discourage scavengers from approaching turbines		untested	
Minimize number of lit turbines		Johnson et al. 2003, Erickson et al. 2004, Huppop et al. 2006, Arnett et al. 2005	lighting did not appear to affect bats/birds (Johnson, Erickson, Arnett); lights observed to cause disorientation and be attractant - needs to be field tested (Huppop)	save $
Avoid sodium vapor lights		Kerlinger & Kerns 2004	47.8% decrease after lights were turned off	
Synchronize lighting	Lights on turbines should flash at same time.	Larwood 2005	untested (only looked at effects on pilots)	N/A
Relocate selected turbines	Dependent upon species/location. Relocation of turbines that cause disproportionately large numbers of fatalities (i.e. isolated turbines, turbines in canyons).	Hoover 2002, Hoover et al. 2005, Thelander & Smallwood 2004, WEST (unpublished)	2-5% decrease in bird/raptor mortality by removing isolated turbine (Thelander); 100% decrease in GOEA mortality from turbines by removing from canyon (Hoover); WEST currenlty testing in CA (Altamont)	
Coordinate timing of operational turbines				
Remove derelict and non-operating turbines	Evidence suggests raptors are killed disproportionately more often by turbines adjacent to broken ones.	Thelander & Smallwood 2004	5-9% increase in mortality at or next to derelict turbines	

Suspend operation during high risk periods	Dependent upon species/location. Includes combinations of adverse weather, high migration, high/low winds, and topography.	Arnett et al. 2005, Hoover 2002, Hoover et al. 2005, Barrios & Rodriquez 2004, Huppop et al. 2006, Sherwell (unpublished), Villegas-Patraca et al. (unpublished), WEST (unpublished)	Currently being tested by Sherwell in MD, WEST in CA (Altamont), and Villegas-Patraca in Mexico.	
Repower using turbines with high rotor planes	Rotor planes should be no lower than 29m above the ground.	Thelander & Smallwood 2004	untested	
Acquire off-site conservation easements	Improving habitat/wildlife population by purchasing/improving habitat in another location.	USFWS (Ron Reynolds contact) unpublished		
Reestablish nesting/maternity areas	Any bird/bat nesting/maternity areas that are disturbed by the construction/operation of the turbines should be reestablished.			