BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF THE JOINT APPLICATION FOR THE LOCATION APPROVAL OF THE CORONA WIND NORTH PROJECT AND FOR THE RIGHT-OF-WAY WIDTH APPROVAL PURSUANT TO THE PUBLIC UTILITY ACT, NMSA 1978, §62-9- 3	)	**Case No. 22-000___-UT**
DAHLIA WIND LLC, GALLINAS MOUNTAIN WIND LLC, PASTURA WIND LLC, AND PATTERN SC HOLDINGS LLC,	)	
JOINT APPLICANTS.	)	

DIRECT TESTIMONY OF ADAM CERNEA CLARK

I. INTRODUCTION AND QUALIFICATIONS

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Adam Cernea Clark. My business address is 1088 Sansome St., San Francisco, CA 94111.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by Pattern Energy Group LP ("Pattern Energy"). I hold the position of Senior Environmental and Natural Resources Manager of Pattern Energy. I am the project lead on environmental and permitting issues for the approximately 3,200 ("MW") of wind generation projects in New Mexico, including the 1,500 MW of wind generation that is the subject of this proceeding the ("Corona Wind North Generation") and the development and permitting of the 345-kilovolt ("kV") transmission system and associated transmission facilities (collectively, "Corona Wind North Gen-Tie System"). The location of the Corona Wind North Gen-Tie System and Corona Wind North Generation are the subject matter of this application for location control approval before the New Mexico Public Regulation Commission ("Commission") pursuant to NMSA 1978, §§62-9-3, 62-9-3.2 and Commission Rule 17.9.592 NMAC ("Joint Application").

Q. PLEASE DESCRIBE YOUR EDUCATIONAL AND WORK BACKGROUND.

A. I am a 2005 graduate of Kenyon College with a B.A. in English and an Integrated Program in Humane Studies concentration. I am also a 2014 graduate of both Northeastern University School of Law and Vermont Law School, where I earned a Juris Doctor and Master's Degree in Environmental Law and Policy, respectively. In 2015, I was admitted as an attorney to the New York State Bar but am not an actively practicing attorney. I have been working in the wind industry since 2015, when I joined Pattern Energy as an associate of environmental and natural resources. My previous work experience includes fellowships at an international development organization and a local legal aid service, as well as corporate transactional work at a law firm in Europe.

In the course of my employment with Pattern Energy, I am responsible for environmental, permitting, and non-permitting development issues related to the development of wind, solar, and transmission projects, as well as non-project-specific regulatory and policy matters. In my capacity as a representative of renewable projects such as the Corona Wind North Project, I am in charge of assessing and mitigating environmental impacts of Pattern Energy's projects and securing all requisite permits prior to project construction and financing. In this capacity, I work closely with federal regulatory and environmental agencies, such as the Bureau of Land Management, National Park Service, the U.S. Army Corps of Engineers ("USACE"), and the U.S. Fish and Wildlife Service ("USFWS"), as well as state and local officials in communities where Pattern Energy builds its projects.

I also engage with federal agencies, other renewable companies, and non-profit organizations as a representative of Pattern Energy more generally to advance progress in environmental policy and research.

Q. HAVE YOU PREVIOUSLY PROVIDED TESTIMONY BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION?

A. Yes. I have previously provided testimony in several location control proceedings relating to Pattern Energy wind projects in New Mexico. I am the project lead on environmental and permitting issues for the approximately 3,200 ("MW") of wind generation projects in New Mexico ("Corona Wind Project") and the development and permitting of the 345-kilovolt ("kV") transmission system and associated transmission facilities (collectively, "Corona Gen-Tie System"). The location of the Corona Gen-Tie System and Corona Wind Project were filed with the New Mexico Public Regulation Commission ("Commission") pursuant to NMSA 1978, §§62-9-3, 62-9-3.2 and Commission Rule 17.9.592 NMAC ("Joint Application") in the following proceedings: a) NMPRC Case No. 17-00221-UT; b) NMPRC Case No. 18-00065-UT; c) NMPRC Case No. 20-0008-UT; and NMPRC Case No. 21-00281-UT. With the exception of NMPRC Case No. 21-00281-UT, which is pending at this time, the Commission granted all the other location approvals sought. Together these proceedings are referred to in my testimony as the "Prior Corona Location Approval Proceedings".

Q. ON WHOSE BEHALF ARE YOU APPEARING IN THIS PROCEEDING?

A. I am appearing on behalf of Dahlia Wind LLC, El Corazon Wind LLC, Gallinas Mountain Wind LLC, Pastura Wind LLC, and Pattern SC Holdings LLC, (collectively referred to as the "Joint Applicants") in support of this Joint Application for approval of the Corona Wind North Project.

Q. WHAT ARE THE JOINT APPLICANTS SEEKING IN THIS PROCEEDING?

A. The Joint Application seeks the following approvals: a) locate wind turbines in areas designated herein and more specifically referred to as the "Corona Wind North Generation "; b) locate an associated Gen-Tie System and related transmission facilities, the "Corona Wind North Gen-Tie System", within the study area identified in this Joint Application ("Corona Wind North Gen-Tie System Study Corridor"); and, c) provide the necessary approval to the extent required by law, for the 180-foot right-of-way ("ROW") width for the Corona Wind North Gen-Tie System that is the subject of this Joint Application. The Corona Wind North Generation for which Commission approval is sought in this Joint Application is more specifically described in Exhibit JA-1, attached to the Joint Application. The Corona Wind North Gen-Tie System and associated Corona Wind North Gen-Tie System Study Corridor for which Commission approval is sought is more specifically described in Exhibits JA-2 and JA-3, attached to the Joint Application. Collectively, the Corona Wind North Generation and the Corona Wind North Gen-Tie System are referred to as the "Corona Wind North Project."

Q. ARE YOU SPONSORING ANY EXHIBITS WITH YOUR TESTIMONY?

A. Yes. I am sponsoring or co-sponsoring several exhibits in my testimony. However, the primary exhibit in support of the Joint Application is Exhibit NO-1, the Corona North Wind Environmental Report ("Environmental Report") which is attached to the testimony of Nathan Olday, the Department Manager within the Houston Environmental Services Group for Burns & McDonnell. The Environmental Report was prepared under the joint supervision of me and Mr. Olday. I was the primary contact on behalf of the Joint Applicants with the Burns & McDonnell team and have reviewed and am familiar with all of the work performed and the conclusions reached. The remaining exhibits are discussed later in my testimony in more detail.

Q. PLEASE PROVIDE A SUMMARY OF YOUR TESTIMONY.

A. I am submitting testimony in support of the location approvals sought in the Joint Application for the Corona Wind North Project. I describe the area where wind turbines might be located, the Corona Wind North Generation , and explain that this area and the location of these generation facilities therein is in compliance with all applicable laws and regulations in New Mexico, as well as the comprehensive environmental protections agreed upon by the Joint Applicants and Commission Staff and intervenors in the Prior Corona Location Approval Proceedings.

I further describe the areas where the Corona Wind North Gen-Tie System would be located and state that the Corona Wind North Gen-Tie System Study Corridor will comply with all the Commission requirements for location permit approval for a transmission system. Finally, I discuss how these new areas will implement the environmental protections agreed upon by the Joint Applicants and the Commission staff in the Prior Corona Location Approval Proceedings.

II. POTENTIAL ENVIRONMENTAL IMPACTS

A. ENVIRONMENTAL IMPACTS OF TRANSMISSION PROJECTS

Q. HOW WOULD YOU CHARACTERIZE THE ENVIRONMENTAL IMPACTS OF TRANSMISSION SYSTEMS GENERALLY?

A. In the United States there are over 200,000 miles of high-voltage transmission lines such as the proposed Corona Wind North Gen-Tie System, and over 5,000,000 miles of distribution lines. Electrical transmission lines have relatively few significant negative environmental impacts, largely because transmission projects have a small physical impact relative to other forms of development and do not require the ROW to be converted entirely to industrial use. The few environmental impacts consist primarily of habitat modification and impacts to birds. Transmission projects are typically able to microsite around sensitive site-specific resources, such as archaeological and historical resources or wetlands and streams.

Q. PLEASE DESCRIBE IN BRIEF TERMS HOW TRANSMISSION LINES CAN IMPACT LOCAL HABITATS?

A. Because transmission lines are long, linear projects, they will inevitably bisect different habitats even if actual direct habitat modification is limited to portions of the transmission ROW. Habitat modification is primarily the result of vegetative clearing of a transmission ROW to ensure that appropriate structure clearances are maintained pursuant to the standardized requirements of the North American Electric Reliability Corporation ("NERC"). NERC establishes minimum clearance distances from vegetation to ensure the reliability of the North American bulk power system. The effects of habitat modification as a result of transmission lines are multiple, nuanced, and will vary widely across differing circumstances. Habitat modification can result in the permanent direct loss of preexisting habitat types across a ROW. This may occur, for example, where a transmission line crosses a heavily forested habitat in the Northeastern United States which requires clearing of vegetation for the operations and maintenance of the line in compliance with NERC. Conversely, a transmission project in the desert Southwest is unlikely to require significant vegetative clearing within its ROW since habitat loss will largely consist of minimal areas for project structures, such as power poles. At the same time, vegetative restoration can be more challenging and take longer in arid environments. Transmission ROWs can also create valuable habitat for certain species utilizing edge habitat, such as pollinator insects and various passerine birds. In contrast, other species such as those utilizing more heavily forested habitat, which are not present within the wind project area, may see habitat modification remove useful habitat. Large-body predators may utilize cleared transmission ROWs for travel.

Like most large linear projects, transmission line ROWs can be sited to minimize impacts to sensitive habitats, such as playa lakes. Also, because the permanent physical footprint of a transmission project consists of power pole structures and aerial cables, power poles can further be micro-sited to avoid impacts to specific sensitive resources. This is true also of electrical substations. While avoidance of environmental impacts comes at an economic cost, careful siting can significantly reduce the already modest impacts caused by transmission projects.

Q. PLEASE DESCRIBE IN BRIEF TERMS HOW TRANSMISSION LINES CAN AFFECT AVIAN SPECIES?

A. I have discussed some of the potential issues relating to avian habitat. Birds can also be impacted by collision with or electrocution from powerlines. Electrocution risk can be managed in a variety of ways, and it is an increasingly common practice to utilize the Avian Powerline Interaction Committee ("APLIC") electrocution guidelines to implement measures to reduce this risk. However, the 345-kV systems that will be used in connection with the Corona Wind North Project are large enough to remove the risk of electrocution.

Risk of collision exists for both distribution and transmission lines. The majority of birds colliding with transmission lines are small passerine species with high fecundity rates and short lifespans that are more resilient to mortality at the population level. Risk factors are detailed in the APLIC collision guidelines, including proximity to agricultural fields, water resources, and parks. *See* Exhibit ACC-1 for the 2012 APLIC collision guideline, *Reducing Avian Collisions with Power Lines*.

I believe that the most effective measure for minimizing avian mortality at transmission lines, after a line has been sited, is the installation of bird diverters. Bird diverters are visual deterrents installed on transmission lines to make the lines stand out visually to flying birds. Bird diverters are installed in identified areas along a transmission project based on various risk factors detailed in the APLIC guidelines on transmission line conductors. They are designed to be visually conspicuous to birds. They can be very effective where used appropriately. Pattern Energy has implemented bird diverters at different sites around the country, including the Western Spirit Wind projects that are part of the Corona Wind Project and the project transmission associated with the Broadview and Grady wind projects in Curry County.

Q. HOW CAN TRANSMISSION LINES IMPACT CULTURAL RESOURCES?

A. Transmission lines can impact cultural resources through construction and placement of structures in close proximity to sensitive cultural resources, such as archaeological or historical sites. Transmission lines can generally be constructed to avoid archaeological and historical sites altogether through careful siting of a transmission ROW and subsequently by implementing the micro-siting of power pole structures to span, or avoid altogether, any impacts to a given resource.

B. EXISTING ENVIRONMENT OF THE CORONA WIND NORTH PROJECT

Q. PLEASE DESCRIBE THE CORONA WIND NORTH PROJECT.

A. In this proceeding, the Joint Applicants propose to expand the wind generation in New Mexico which is or will be owned and operated by Pattern Energy and the Joint Applicants. Collectively Pattern Energy and its related entities have constructed 1,511 MW of wind generation in the state of New Mexico, as well as associated gen-tie systems. The Corona Wind North Project will add up to 1,500 MW to the portfolio, located on over 327,895 acres of land, including 210, 419 acres of private land and 117, 476 acres of state land located in the Counties of Guadalupe, San Miguel, and Torrance. The Joint Applicants are also proposing to obtain location approval for the Corona Wind North Gen-Tie System which will have a linear length of 69.3 miles or 365, 904 linear feet, depending upon final alignment within the Corona Wind North Gen-Tie System Study Corridor. The Corona Wind North Gen-Tie System is shown on Exhibit JA-2 to the Joint Application. The Corona Wind North Gen-Tie System Study Corridor is generally 1-mile wide, although it is narrower in certain segments and wider in one segment, where it would pass through the existing El Cabo Wind Farm, as seen in Exhibit JA-2. The study corridor is wider within this facility in order to accommodate the existing wind generation facility's needs but does represent an added environmental benefit of consolidating renewable generation and transmission facilities on the landscape. Further discussion is available in the Prepared Direct Testimony of Jeremy Turner.

Q. IS THERE A REASON YOU DO NOT DESCRIBE THE LOCATION OF THE CORONA WIND NORTH GEN-TIE SYSTEM WITH MORE SPECIFICITY?

A. Actually, we have described and shown in maps our best approximation of the Corona Wind North Gen-Tie System route at this time. In Exhibit JA-3 to the Joint Application, which I am sponsoring, we provide very detailed mapping of the proposed Corona Wind North Gen-Tie System with satellite imagery that will provide the Commission extraordinary detail of the entire route. However, as noted previously in my testimony in the Prior Corona Location Approval Proceedings, the siting of wind projects' infrastructure is a data-driven process. While the Corona Wind North Gen-Tie System will ultimately be restricted to a specified approved ROW width, the Corona Wind North Project is still under active development. As part of the wind development process, we are constantly collecting data that is integrated into the design of our projects. Generally, the more flexibility a project has to integrate and adapt site-specific data into project design, the better a project will tend to be at the end of the day, both in terms of cost and impact minimization.

The exact location of the ROW may change within our study area either due to micro-siting of the alignment of the Corona Wind North Gen-Tie System itself, or through adjustments in the location of project turbines. These factors are sufficient to drive changes in the location of project substations, which subsequently can result in changes to the overall alignment of the Corona Wind North Gen-Tie System. Joint Applicants performed a comprehensive environmental analysis of the entire area encompassed by the Corona Wind North Project ("Corona Wind North Project Study Area"). This environmental analysis covered a region that is considerably larger than the generally one-mile corridor we previously utilized for purposes of the environmental analysis for other Corona Gen-Tie Systems and is consistent with our approach in the filing in NMPRC Case No. 21-00281-UT. The area included in this expanded environmental study is shown in the Environmental Report which is attached to the testimony of Nathan Olday as Exhibit NO-1 and is further reflected in Exhibits JA-1, JA-2 and JA-3 to the Joint Application.

Q. WHAT IS THE BENEFIT OF HAVING PERFORMED THE DETAILED ENVIRONMENTAL ANALYSIS OVER THE ENTIRE CORONA WIND NORTH PROJECT STUDY AREA?

A. The Corona Wind North Project Study Area has been studied holistically in the Environmental Report to analyze the potential impacts of the Corona Wind North Gen-Tie System anywhere within this area. As a result, the extensive environmental analysis performed for the Corona Wind North Project allows for micro-siting to occur later in the project development as final decisions are made after reviewing the data.

Q. WHEN IS THE CORONA WIND NORTH PROJECT EXPECTED TO BE IN SERVICE?

A. The Corona Wind North Project is expected to be in service by the end of 2026.

Q. WHAT IS THE EXISTING ENVIRONMENT OF THE CORONA WIND NORTH PROJECT?

A. As detailed in the testimony of Nathan Olday in Exhibit NO-1, the existing environment within the Corona Wind North Project largely consists of open savannah as well as pinon juniper habitat subject to ranching activities.

III. PATTERN ENERGY AND ITS APPROACH TO PROJECT DEVELOPMENT AND ENVIRONMENTAL ISSUES.

A. PATTERN ENERGY'S ENVIRONMENTAL VALUES IN PROJECT DEVELOPMENT

Q. PLEASE PROVIDE THE COMMISSION WITH SOME BACKGROUND ON PATTERN ENERGY IN TERMS OF THEIR ENVIRONMENTAL VALUES AND TRACK RECORD.

A. Pattern Energy has taken a leadership role in tackling the modest environmental impacts of the wind industry. We actively participate and provide funding in wind industry efforts to understand, study, and minimize the environmental impacts of wind energy and to advance the development of impact minimization technology and industry best management practices ("BMPs"). Pattern Energy personnel participated in the public-private collaboration that led to the development of the USFWS Land-Based Voluntary

Wind Energy Guidelines (“WEGs”). See Exhibit ACC-2. We have funded research into novel technologies for understanding and minimizing the environmental impacts of our projects. We are a founding and sustaining member of the American Wind Wildlife Institute, a coalition of wind industry companies and non-governmental organizations working to advance conservation values, scientific research, and wind energy development. We also routinely implement voluntary BMPs and mitigation strategies that further our environmental values.

For example, Pattern Energy plays a leadership role in the American Clean Power organization’s efforts to raise funding for scientific research for understanding the impacts of wind-wildlife interactions, supporting the implementation of bat mitigation measures during the autumn bat migration that have proven to substantially decrease bat mortality at the cost of reduced renewable energy generation, and working with leading environmental non-profit organizations to advance practical solutions to wildlife permitting that both promote renewable energy and wildlife conservation. Pattern Energy recently released our latest sustainability report that describes our management approach to developing our renewable energy projects in a safe and environmentally responsible manner and with respect for the communities and cultures where we have a presence. These practices have been and will continue to be implemented at the Corona Wind North Project to ensure that project development occurs in a way that is socially and environmentally responsible. In fact, the funding of pinyon-juniper management practices and potential impacts to sensitive birds that the Western Spirit Wind Projects made in early 2021 is referenced in our recent 2020 Sustainability Report published in September of 2021.

Q. DOES PATTERN ENERGY HAVE A FORMAL POLICY RELATING DIRECTLY TO THE PROTECTION OF THE ENVIRONMENT?

A. Yes. Pattern Energy developed and followed the Statement of Environmental Commitments that outlines an iterative process for identifying, avoiding, minimizing, and addressing potential environmental impacts of renewable energy development and operations. See the Pattern Energy Statements of Commitments, which includes our Statement of Environmental Commitments, in Exhibit ACC-3.

Q. PLEASE DESCRIBE HOW THE STATEMENT OF ENVIRONMENTAL COMMITMENTS AFFECTS HOW PATTERN ENERGY ADDRESSES THE ENVIRONMENTAL BENEFITS AND IMPACTS OF RENEWABLE ENERGY GENERATION AND TRANSMISSION DEVELOPMENT?

A. The Statement of Environmental Commitments outlines the following principles that guide our approach to environmental protection and renewable energy development:

- Identify and assess potential environmental impacts at all stages of the life cycle of our projects, incorporate them in our decision making, and explore creative mitigations to minimize any adverse impacts.
- Comply with all applicable environmental laws and regulations. Where there are limited regulations, we apply our more stringent standards.
- Engage relevant stakeholders, including community representatives and national resource agencies, during the planning process of our projects.
- Site and design projects in such a manner as to respect wildlife and their habitat.
- Construct and operate projects using best practices to prevent pollution and conserve natural resources.

- Work to continually improve overall environmental performance and ensure we are stewards of the environment.

Pattern Energy strives to fulfill these principles in the construction and operation of all our projects by implementing the Statement of Environmental Commitments as standard practice on how we address environmental impacts in the United States. This dynamic ensures that a long-term approach is implemented from the earliest stage of development for addressing potential environmental concerns arising in the course of project development, construction, and operation. *Building Wildlife-Friendly Wind,* an infographic, explains how Pattern implements this approach to develop and operate its projects in an environmentally responsible way. Exhibit ACC-4 illustrates this stepwise approach.

Q. PLEASE DESCRIBE HOW PATTERN ENERGY HAS IMPLEMENTED AND APPLIED THESE ENVIRONMENTAL VALUES IN NEW MEXICO, INCLUDING AT THE PORTIONS OF THE CORONA WIND NORTH PROJECT CURRENTLY UNDER CONSTRUCTION?

A. Pattern Energy has consistently sought to meet or exceed environmental BMPs and to go over and above legal requirements. Our New Mexico wind projects currently in operation and under construction exemplify this policy. At our Broadview and Grady wind projects in Curry County, New Mexico, we funded research into the interactions between the lesser-prairie chicken and wind energy facilities and committed substantial resources to in-perpetuity habitat conservation for the species on a voluntary basis. At the Clines Corners, Duran Mesa, Red Cloud Wind, and Tecolote Wind Projects, we successfully implemented BMPs developed in partnership with the New Mexico Public Regulation Commission

Staff, the New Mexico State Land Office and the Claunch-Pinto Soil and Water Conservation District that were committed to in previous filings. See Exhibit ACC-5. We have also partnered with the Audubon Society, Defenders of Wildlife, and the Nature Conservancy to provide substantial funding to the New Mexico Avian Conservation Partners and the Bird Conservancy of the Rockies to study the relationship between tree clearing practices in pinyon-juniper habitats and sensitive bird species. In the Corona Wind North Project, we will be partnering again with the New Mexico State Land Office and New Mexico State University to study the efficacy of different vegetative reclamation practices in the arid southwest to identify potential improvements to standard best practices in reclamation that are tailored to the environment where the wind projects are located.

Q. ARE THERE OTHER IMPORTANT VOLUNTARY GUIDELINES THAT EFFECT HOW PATTERN ENERGY ADDRESSES ENVIRONMENTAL PROTECTION AND STEWARDSHIP IN PROJECT DEVELOPMENT?

A. Yes. Pattern Energy also follows the WEGs (Exhibit ACC-2) at all its projects across the United States and integrates into powerline siting decisions the APLIC guidelines (Exhibit ACC-1) for reducing avian mortality from powerlines.

Q. WHAT ARE THE WEGS?

A. The WEGs follow a tiered approach identifying, understanding, and addressing potential impacts of wind energy projects to the surrounding environment. Tier One entails an initial landscape-level site characterization relying on satellite imagery and publicly available databases. Tier Two identifies species and habitats of potential concern and different habitat types within a prospective project area that could be impacted by project development. The Tier Two phase often corresponds to the initiation of informal consultation with the USFWS about the proposed project. In Tier Three, biological field studies are initiated and reviewed with USFWS and site-specific data is used to understand potential risks of impacts to sensitive species. These first three tiers of the WEGs cover the development and construction of a project. The subsequent tiers involve post-construction studies to understand potential and actual impacts of a project to be incorporated into project operations.

Q. HOW DO THE WEGS AFFECT THE WAY PATTERN ENERGY APPROACHES ENVIRONMENTAL ISSUES IN PROJECT DEVELOPMENT?

A. The WEGs' stepwise approach forms the basis of how we address environmental issues in renewable energy development, construction, and operations. Our Statement of Environmental Commitments, also structured around an iterative process, provides a natural complement to the WEGs and allows us to apply our own internal standards in addition to the industry-wide standards delineated in the WEGs.

Q. WHY ARE THE WEGS IMPORTANT TO UNDERSTANDING THE ENVIRONMENTAL IMPACTS OF TRANSMISSION LINES SPECIFICALLY?

A. The WEGs are important to the Corona Wind North Gen-Tie System insofar as our implementation of this environmental review process in our projects includes equally the siting, designing, and operating of project-specific transmission "gen-tie" lines and wind turbines. Pattern Energy has also migrated the lessons and methods learned through successfully implementing the WEGs in wind project development directly into our approach to developing of renewable generation and transmission projects.

Q. PLEASE EXPLAIN IN MORE DETAIL THE APLIC GUIDELINES?

A. The APLIC guidelines on electrocution and collision are voluntary guidance documents that are the result of industry, non-profits, and government agencies, such as USFWS, working together to create standardized processes for analyzing and minimizing risk of avian mortality as a result of collision with or electrocution by operating powerlines. These guidelines provide a stepwise methodology to assessing and minimizing impacts to birds from powerlines and are not associated with wind energy development per se.

Q. ARE THE APLIC COLLISION AND ELECTROCUTION GUIDELINES RELEVANT TO THE CORONA WIND NORTH GEN-TIE SYSTEM?

A. The APLIC electrocution guidelines are not material to the Corona Wind North Gen-Tie System. This is because the Corona Wind North Gen-Tie System consists entirely of 345-kV transmission lines which, because of the design and larger dimensions of 345-kV lines, do not pose a material risk of electrocution.

Q. WHY DID THE JOINT APPLICANTS DECIDE TO IMPLEMENT THE APLIC GUIDELINES?

A. The Joint Applicants have elected to implement the APLIC guidelines because these guidelines have long served as an effective tool developed with diverse stakeholder input for addressing potential impacts from powerlines to avian species.

Q. HOW DO THE APLIC GUIDELINES AFFECT POWERLINE SITING DECISIONS BY PATTERN ENERGY?

A. The APLIC collision guidelines, *Reducing Avian Collision with Power Lines*, are more significant in this instance and help direct our siting and risk assessment of project gen-ties. These guidelines help identify areas where the risk of avian collision is more or less likely.

Following the APLIC guidelines will result in the development of an Avian Protection Plan ("APP") that will be produced to assess specifically the risks of avian mortality. An APP is a BMPs document following APLIC and USFWS guidelines to investigate and address powerline impacts to birds. For wind projects following the WEGs, a Bird and Bat Conservation Strategy is instead developed and structured around the tiered approach of the WEGs and additionally augmented by reference to the APLIC guidelines. However, for the benefit of the Commission and considering the scale of these projects, a separate APP will be completed regarding the Corona Wind North Gen-Tie System ("Corona Wind North APP"). The Corona Wind North APP will be finalized to reflect the final alignment of the Corona Wind North Gen-Tie System through avian risk assessments which I will discuss in further detail in this testimony.

B. PATTERN ENERGY ENVIRONMENTAL VALUES IN DEVELOPMENT OF THE CORONA WIND NORTH PROJECT

Q. PLEASE DESCRIBE HOW PATTERN ENERGY HAS DEVELOPED AND DESIGNED THE CORONA WIND NORTH PROJECT AND, SPECIFICALLY, THE CORONA WIND NORTH GEN-TIE SYSTEM WITH RESPECT TO POTENTIAL IMPACTS TO THE ENVIRONMENT?

A. As discussed earlier, Pattern Energy has implemented its Statement of Environmental Commitments as well as the WEGS and the APLIC Collision Guidelines in developing the Corona Wind North Project. When we began work on the Corona Wind North Project, we also began an analysis of the project and engaged Western Ecosystem Technology, Inc.

("WEST") to complete initial site assessments. As land has been added to the Corona Wind North Project over the course of development, site assessment review has been extended to these new lands. These site assessments included surveys for cultural resources, wetlands and streams, and threatened and endangered species. Tier 1 and Tier 2 followed these initial studies in 2020 and thereafter. These studies allowed us to understand not only the existing environment and possible species of concern within the Corona Wind North Project Study Area, but also the likelihood of their presence or absence.

Avian Use Surveys in the broader Corona Wind North Project Study Area were conducted over the course of 2021 through today. Eagle and raptor nest surveys also are ongoing. General avian nest surveys have been conducted in the Corona Wind North Project Study Area and are ongoing. In certain portions of the Corona Wind North Project Study Area, avian use and raptor nest surveys began several years prior. Additionally, bat feature surveys in and around the areas of the Corona Wind North Project Study Area will be part of the overall survey effort. Overall, thousands of hours of biological field surveys have already occurred and are ongoing across the Corona Wind North Project Study Area.

We have consulted with both the USFWS and New Mexico Department of Game and Fish relating to our survey efforts and findings and will continue to do so through the course of project development. We have also commenced an initial phase of cultural resource surveys that are being used to microsite turbine locations and will be used to microsite the Corona Wind North Gen-Tie System as design is finalized.

The approach to identifying potential resources has been refined over time. This has included a combination of desktop and field surveys to identify potential occurrence of sensitive resources such as surface waters, cultural resources, and avian nests. The U.S.

Army Corps of Engineers has approved such an approach for identifying potentially jurisdictional waters and upland areas that requires field verification. We have elected to conduct this analysis across all project areas ahead of actual proposed infrastructure. We have taken a similar approach to cultural resources, not only on public lands but also on private lands. We are currently developing a similar approach for identifying potential occurrence of nesting bird sites. This allows us to identify potential resource conflicts before, during, and after designing project infrastructure to minimize impacts to the maximum extent practicable.

Q. PLEASE DESCRIBE THE CORONA WIND NORTH APP?

A. The Corona Wind North APP will be a project-specific third-party transmission line avian risk assessment. The Corona Wind North APP will analyze the risk posed to birds from collision with the Corona Wind North Gen-Tie System. The Corona Wind North APP will utilize three levels of risk to analyze segments of the Corona Wind North Gen-Tie System. Category One represents line spans with high habitat quality and/or high anticipated bird use. Category Two represents line spans with moderate habitat quality or high habitat quality and moderate anticipated bird use. Category Three represents line spans with disturbed areas, areas of high level of human influence, with areas of moderate to high anticipated bird use or moderate habitat quality with moderate anticipated bird use. We will take a similar approach to the Corona Wind North APP as we did with our Corona Wind Project, and expect to have approximately similar findings and resulting bird diverter installation plans for spans of moderate or higher risk.

Q. HOW DOES PATTERN ENERGY PLAN TO IMPLEMENT THE CORONA WIND NORTH APP INTO THE DESIGN AND OPERATIONS OF THE CORONA WIND NORTH GEN-TIE SYSTEM?

A. Pattern Energy will incorporate the recommendations of the Corona Wind North APP into our construction plans and integrate bird diverter installation into our construction contracting and planning. Consistent with the approach taken at the Corona Wind Project, we will at a minimum install bird diverters at all recommended areas.

Q. PLEASE SUMMARIZE THE GOVERNMENT CONSULTATION ON ENVIRONMENTAL ISSUES THAT YOU HAVE COMPLETED IN FURTHERANCE OF THE CORONA WIND NORTH GEN-TIE SYSTEM.

A. We have consulted extensively with the relevant government entities to apprise them of the environmental impacts of the Corona Wind North Gen-Tie System to obtain their input on how best to minimize our modest impacts. Please refer to Exhibit ACC-6 for a table of federal and state agencies with whom Pattern Energy has consulted to date. Consultation has been fruitful and positive and will be ongoing throughout the development of the Corona Wind North Project.

Q. DID ANY OF THE STATE AND FEDERAL AGENCIES WITH WHOM PATTERN ENERGY HAS CONSULTED RAISE CONCERNS OR PROVIDE RECOMMENDATIONS WITH RESPECT TO THE CORONA WIND NORTH PROJECT, INCLUDING THE CORONA WIND NORTH GEN-TIE SYSTEM?

A. No. The Corona Wind North Project is not expected to have significant adverse environmental impacts, and the potential environmental impacts of the Corona Wind North Gen-Tie System, as I will discuss subsequently, are expected to be *de minimus*.

Additionally, it is my belief that the siting practices and BMPs of Pattern Energy, adopted by the Joint Applicants, which were also discussed with some of these agencies, provide further indication that the Corona Wind North Gen-Tie System potential impacts are unlikely to raise concerns. In fact, as I previously discussed, many of the core project BMPs were developed in partnership with the New Mexico State Land Office, as well as with the Claunch-Pinto Soil and Water Conservation District. I hope to collaborate further with these agencies in the future.

IV. <u>REQUESTED COMMISSION APPROVALS</u>

Q. WHAT COMMISSION APPROVALS ARE THE JOINT APPLICANTS REQUESTING?

A. The Joint Applicants request that the Commission approve the location of the Corona Wind North Project, which includes the Corona Wind North Gen-Tie System pursuant to NMSA 1978, §62-9-3, ("Siting Statute") and Commission Rule 17.9.592 NMAC, ("Location Rule"). In addition, the Joint Applicants request that the Commission determine that a 180-foot ROW width for the Corona Wind North Gen-Tie System is needed pursuant to NMSA 1978, §62-9-3.2. Finally, the Joint Applicants are requesting that the Commission approve at this time any future siting adjustments to the Corona Wind North Gen-Tie System that may be located within the entire Corona Wind North Project Study Area.

Q. PLEASE EXPLAIN WHY PATTERN ENERGY PERFORMED AN EXTENSIVE ENVIRONMENTAL ANALYSIS OF THE ENTIRE CORONA WIND NORTH PROJECT STUDY AREA.

A. As I mentioned earlier in my testimony the common practice in project development of this nature is to adjust proposed locations for wind turbines and the associated Gen-Tie System as more information is obtained during site preparation and analysis phases of a project. In the past, when Pattern Energy determined that it was necessary to adjust a proposed route for a gen-tie system outside of the initial study corridor, it was necessary to perform a subsequent environmental analysis and seek another formal location approval through a proceeding before the Commission. To minimize the need for a time-consuming and costly later environmental study and regulatory review, Pattern Energy decided to expand its study area when performing the environmental analysis in connection with the proposed Corona Wind North Gen-Tie System. We performed a detailed analysis throughout the entire area where the Corona Wind North Project will be located. It is our hope and request that the Commission will recognize the benefit of this detailed level of environmental review over the entire region and allow the Joint Applicants to revise the siting of the Corona Wind North Gen-Tie System as necessary during the construction phase anywhere within the area that has been evaluated in the Environmental Report. Although we do not anticipate such changes, it is important to expedite the construction process as much as possible and avoid unnecessary regulatory delays. Of course, should any adjustments be made to the proposed route it will be reported to the Commission as part of the regular Quarterly Reports Pattern Energy files on the Corona Wind North Project.

A. <u>SITING STATUTE, NMSA 1978, §62-9-3</u>

Q. WHY DOES THE CORONA NORTH WIND PROJECT REQUIRE LOCATION APPROVAL?

A. My understanding is that New Mexico's Siting Statute, specifically NMSA 1978, §62-9-3(B) requires prior approval by the Commission for construction within New Mexico of any generating plant designed for or capable of operation at a capacity of 300 MW or more and for transmission lines and associated facilities designed for or capable of operations at a nominal voltage of 230-kV or more to be constructed in connection with said plant.

The Commission's location approval is required because the Corona Wind North Project generation facilities are collectively designed for or capable of operating up to 1,500 MW of wind generation. Although our wind turbines will be spread over a relatively large area, the Joint Applicants are not attempting to bypass Commission approval by characterizing these as numerous smaller projects, but have treated this as a single large, generating facility.

The Commission's approval is also required for the Corona Wind North Gen-Tie System since it will be designed for or capable of being operated at a nominal voltage of 345-kV and will be constructed in connection with, and to transmit electricity from, the Corona Wind North Project to the SunZia Project.

Q. PLEASE EXPLAIN YOUR UNDERSTANDING OF THE NEED TO COMPLY WITH STATE, COUNTY OR MUNICIPAL LAND USE.

A. I understand that NMSA 1978, §62-9-3(G) prohibits the Commission from approving a location control application that violates an existing state, county or municipal land use statutory or administrative regulation unless the Commission finds the regulation is unreasonably restrictive.

1. THE CORONA WIND NORTH PROJECT

Q. PLEASE EXPLAIN YOUR UNDERSTANDING OF THE STATUTORY REQUIREMENTS FOR LOCATION APPROVAL FOR THE CORONA WIND NORTH GENERATION.

A. My understanding is that NMSA 1978, §62-9-3(E) requires the Commission to approve an application for location of a generating plant unless the Commission finds that the operation of the facilities will not comply with all applicable air and water pollution control standards existing and established by the New Mexico agency having jurisdiction over a particular pollution source. I understand that the New Mexico Environment Department has jurisdiction over air and water pollution.

Q. DOES THE CORONA WIND NORTH GENERATION COMPLY WITH THE REQUIREMENTS OF THE SITING STATUTE?

A. Yes, the Joint Application and supporting testimony and exhibits demonstrate that the Corona Wind North Generation complies with these requirements. As the Joint Applicants' other witnesses and I explain in our testimonies, the Corona Wind North Generation will comply with all applicable air and water pollution control standards. Moreover, the existing state, county, and municipal land use statutory and administrative regulations allow for the installation of the Corona Wind North Generation.

2. THE CORONA WIND NORTH GEN-TIE SYSTEM

Q. WHY DOES THE CORONA WIND NORTH GEN-TIE SYSTEM REQUIRE LOCATION APPROVAL?

A. The Commission's approval is required for the Corona Wind North Gen-Tie System since it will be designed for or capable of being operated at a nominal voltage of 345-kV and will be constructed in connection with, and to transmit electricity from, the Corona Wind North Project.

Q. PLEASE EXPLAIN YOUR UNDERSTANDING OF THE STATUTORY REQUIREMENTS FOR LOCATION APPROVAL FOR THE CORONA WIND NORTH GEN-TIE SYSTEM.

A. My understanding is that NMSA 1978, §62-9-3(F) of the Siting Statute requires the Commission to approve an application for location of transmission lines unless it finds that the location will unduly impair important environmental values. In making that determination, NMSA 1978, §62-9-3(M) of the Siting Statute allows the Commission to consider the following factors:

(1) existing plans of the state, local government, and private entities for other developments at or in the vicinity of the proposed location;

(2) fish, wildlife, and plant life;

(3) noise emission levels and interference with communication signals;

(4) the proposed availability of the location to the public for recreational purposes, consistent with safety considerations and regulations;

(5) existing scenic areas, historic, cultural or religious sites and structures or archaeological sites at or in the vicinity of the proposed location; and,

(6) additional factors that require consideration under applicable federal and state laws pertaining to the location.

Q. DOES THE CORONA WIND NORTH GEN-TIE SYSTEM COMPLY WITH THE REQUIREMENTS OF THE SITING STATUTE?

A. Yes, the Joint Application and supporting testimony and exhibits demonstrate that the Corona Wind North Gen-Tie System complies with these requirements. As the Joint Applicants' other witnesses and I explain in our testimonies, the existing state, county, and municipal land use statutory and administrative regulations allow for the installation of the Corona Wind North Gen-Tie System and this system will not unduly impair important environmental values.

B. LOCATION RULE, 17.9.592 NMAC

1. THE CORONA WIND NORTH GENERATION

Q. WHAT IS YOUR UNDERSTANDING OF THE REQUIREMENTS OF THE COMMISSION'S LOCATION RULE, 17.9.592 NMAC, REGARDING APPLICATIONS FOR LOCATION OF GENERATION PLANTS?

A. Under the Location Rule, 17.9.592.9 NMAC for generating facilities ("Generation Location Rule") an applicant must file an application supported by written testimony and exhibits that contain the following information for generating plants for which location approval is required:

A. a description of the large capacity plant, including, but not limited to:

(1) a legal description of the property upon which the large capacity plant will be located;

(2) the size of the large capacity plant;

(3) fuel specifications including, but not limited to, the type of fuel to be used; and,

(4) a map showing the location of the large capacity plant;

B. identification of all applicable land use statutes and administrative regulations and proof of compliance or a statement of noncompliance with each;

C. identification of all applicable air and water pollution control standards and regulations and proof of compliance or a statement of noncompliance with each;

D. all written air and water quality authorizations necessary to begin construction of the large capacity plant;

E. all written air and water quality authorizations necessary to begin operation of the large capacity plant; if any such authorization cannot be obtained until after construction of the large capacity plant, proof of application for such authorization;

F. the expected date that the large capacity plant will be online;

G. proof that the application has been served on all local authorities in each county and township where the large capacity plant will be located, the New Mexico Attorney General, the New Mexico Environment Department, and the New Mexico State Engineer;

H. any other information, including photographs, which the applicant wishes to submit in support of the application.

Q. DOES THE CORONA WIND NORTH GENERATION_COMPLY WITH THE REQUIREMENTS OF THE GENERATION LOCATION RULE?

A. Yes, the Joint Application and the supporting testimony and exhibits we are submitting demonstrate that the Corona Wind North Generation complies with the requirements under the Generation Location Rule.

2. THE CORONA WIND NORTH GEN-TIE SYSTEM

Q. WHAT IS YOUR UNDERSTANDING OF THE REQUIREMENTS OF THE COMMISSION'S LOCATION RULE, 17.9.592 NMAC, REGARDING APPLICATIONS FOR LOCATION OF TRANSMISSION LINES?

A. Under the Location Rule, Rule 17.9.592.10 NMAC for transmission lines ("Transmission Location Rule") an applicant must file an application supported by written testimony and exhibits that contain the following information for transmission lines for which location approval is required:

A. a description of the transmission line including, but not limited to:

(1) the location of the transmission line;

(2) identification of the ownership of the land (such as private, bureau of land management, U.S. Forest Service, state trust, etc.) the transmission line will cross and the number of feet the transmission line will cross over each owner's land;

(3) the total length of each transmission line in feet;

(4) a description of interconnection facilities;

(5) a map showing the location of the transmission line; and

(6) a schematic diagram showing the transmission line and the interconnection of the transmission line to the transmission grid;

B. identification of all applicable land use statutes and administrative regulations and proof of compliance or statement of noncompliance with each;

C. if required under NEPA [National Environmental Policy Act], an environmental assessment prepared in connection with the transmission line;

D. if required under NEPA, an environmental impact statement and record of decision or a finding of no significant impact, prepared in connection with the transmission line;

E. if preparation of a federal environmental assessment or environmental impact statement is not required under NEPA in connection with the transmission line, then a report, comparable to an environmental impact statement, in the format prescribed in 40 C.F.R. Section 1502.10;

F. all written federal, state, and local environmental authorizations necessary to begin construction of the transmission line;

G. all written federal, state, and local environmental authorizations necessary to begin operation of the transmission line; if any such authorization cannot be obtained until after construction of the transmission line, proof of application for such authorization;

H. testimony demonstrating that the transmission line will not unduly impair important environmental values; important environmental values include, but are not limited to, preservation of air and water quality, land uses, soils, flora and fauna, and water, mineral, socioeconomic, cultural, historic, religious, visual, geologic and geographic resources;

I. the expected date that the transmission line will be online;

J. proof that the application has been served on all local authorities in each county and township where the transmission line will be located, the New Mexico attorney general, the New Mexico environment department, and the New Mexico state engineer;

K. any other information, including photographs, which the applicant wishes to submit in support of the application.

Q. DOES THE CORONA WIND NORTH GEN-TIE SYSTEM COMPLY WITH THE REQUIREMENTS OF THE TRANSMISSION LOCATION RULE?

A. Yes, the Joint Application and supporting testimony and exhibits demonstrate that the Corona Wind North Gen-Tie System complies with the requirements under the Transmission Location Rule.

C. <u>RIGHT-OF-WAY STATUTE, NMSA 1978, §62-9-3.2</u>

Q. WHAT IS YOUR UNDERSTANDING OF THE REQUIREMENT FOR ROW WIDTH APPROVAL?

A. My understanding is that NMSA 1978, §62-9-3.2 ("ROW Statute") provides that "unless otherwise agreed to by the parties, no person shall begin the construction of any transmission line requiring a width for right of way of greater than one hundred feet without first obtaining from the commission a determination of the necessary right-of-way width to construct and maintain the transmission line."

Q. DO YOU BELIEVE THAT THE CORONA WIND NORTH GEN-TIE SYSTEM SHOULD HAVE A 180-FOOT ROW WIDTH?

A. Based upon the results of the analysis from Greg Parent, who is submitting testimony on this issue in this proceeding on behalf of the Joint Applicants, I believe that a 180-foot ROW is necessary for the Corona Wind North Gen-Tie System.

Q. HAVE THE AFFECTED PARTIES AGREED TO THE ROW WIDTH REQUESTED BY THE JOINT APPLICANTS IN THIS PROCEEDING?

A. Yes. The Joint Applicants have or will secure the agreement of all the landowners, including the State Land Office of the proposed ROW width for the Corona Wind North Gen-Tie System. Construction of the Corona Wind North Gen-Tie System will not begin without such approvals.

Notwithstanding this fact, the Joint Applicants have still requested Commission approval of the proposed ROW width in this proceeding, to the extent that the Commission believes such approval is necessary.

V. COMPLIANCE WITH NEW MEXICO'S STATUTES AND REGULATIONS.

A. THE JOINT APPLICANTS WILL REQUIRE THE CORONA WIND NORTH GENERATION TO COMPLY WITH APPLICABLE AIR AND WATER POLLUTION CONTROL STANDARDS

Q. PLEASE CHARACTERIZE THE CORONA WIND NORTH GENERATION'S EXPECTED IMPACTS ON AIR QUALITY.

A. The Joint Applicants comply with all applicable air quality laws and regulations. This is further discussed in the Environmental Report.

Q. PLEASE CHARACTERIZE THE CORONA WIND NORTH GENERATION'S EXPECTED IMPACTS ON WATER RESOURCES?

A. The Joint Applicants will comply with all applicable water quality and water resource laws and regulations and will not unduly impair water quality and water resources. This is further discussed in the Environmental Report.

B. THE JOINT APPLICANTS WILL ASSURE THAT THE CORONA WIND NORTH GEN-TIE SYSTEM DOES NOT UNDULY IMPAIR IMPORTANT ENVIRONMENTAL VALUES

Q. HAVE THE JOINT APPLICANTS EVALUATED THE CORONA WIND NORTH GEN-TIE SYSTEM'S POTENTIAL IMPACTS ON THE FACTORS THE

COMMISSION MAY CONSIDER IN DETERMINING WHETHER LOCATION OF A TRANSMISSION LINE WILL UNDULY IMPAIR IMPORTANT ENVIRONMENTAL VALUES?

A. Yes. The Joint Applicants have reviewed the factors provided in NMSA 1978, §62-9-3(M), Commission Rule 17.9.592.10 NMAC, and additional factors, including existing plans for development of the proposed location; fish, wildlife, and plant life; noise levels; interference with communication signals; availability for recreational purposes; scenic, historic, cultural or religious sites and structures or archeological sites; cemeteries and burials; schools; aviation; soils; minerals and mining; geologic and paleontological resources; roads; and geographic resources. The Joint Applicants considered each of these factors with respect to the Corona Wind North Gen-Tie System. The Environmental Report provides further information on each of these resource areas. The protection measures included in the Environmental Report ("Protection Measures") provide detailed measures for resource impact avoidance and minimization that provide further evidence of the minimal impacts expected from the Corona Wind North Gen-Tie System. These Protection Measures are reflected in the BMPs, which the Joint Applicants are proposing to implement in the construction and operation of the Corona Wind North Project. See, Exhibit ACC-5.

Q. PLEASE SUMMARIZE YOUR FINDINGS WITH RESPECT TO AIR QUALITY.

A. The Corona Wind North Project will not unduly impair air quality and the Joint Applicants will comply with all applicable air quality laws and regulations. This is further discussed in the Environmental Report.

Q. PLEASE SUMMARIZE YOUR FINDINGS WITH RESPECT TO WATER QUALITY AND WATER RESOURCES.

A. The Joint Applicants will comply with all applicable water quality and water resource laws and regulations and will not unduly impair water quality and water resources. This is further discussed in the Environmental Report. Impacts to surface waters, whether waters of the United States or not, will be avoided to the maximum extent practicable.

Q. PLEASE SUMMARIZE YOUR FINDINGS WITH RESPECT TO LAND USES.

A. Existing land uses within the Corona Wind North Gen-Tie System consist primarily of ranching activities on both private and state land. The Corona Wind North Gen-Tie System is compatible with ranching activities. Revenue generated can be reasonably expected to be reinvested, to some extent, back into ranching activities, thus augmenting existing uses.

Q. PLEASE SUMMARIZE YOUR EFFORTS TO AVOID AND MINIMIZE IMPACTS WITH RESPECT TO FLORA AND FAUNA WITH THE CORONA WIND NORTH GEN-TIE SYSTEM.

A. Pattern Energy has worked extensively to limit impacts to flora and fauna. Our overall efforts have been described in the Environmental Report. The Corona Wind North Gen-Tie System will not unduly impair flora and fauna.

Q. PLEASE SUMMARIZE YOUR FINDINGS WITH RESPECT TO NOISE IMPACTS.

A. The Corona Wind North Gen-Tie System is not expected to contribute in a meaningful way to the noise levels of the existing environment. As discussed in the Environmental Report, the Corona Wind North Gen-Tie System will not unduly impair noise quality.

Q. WILL THE CORONA WIND NORTH GEN-TIE SYSTEM INTERFERE WITH COMMUNICATION SIGNALS?

A. The Corona Wind North Gen-Tie System is not expected to interfere with communication signals. As discussed in the Environmental Report, the Corona Wind North Gen-Tie System will not unduly impair communication signals.

Q. WILL THE CORONA WIND NORTH GEN-TIE SYSTEM IMPACT RECREATIONAL USES?

A. No. Most of the Corona Wind North Gen-Tie System is located on private land with participating landowners or on public state land. Hunting is the primary recreational use in the area and the Updated Gen-Tie System is compatible with this activity. As discussed in the Environmental Report, the Corona Wind North Gen-Tie System will not unduly impair recreational uses in the area.

Q. WHAT VISUAL IMPACT WILL THE CORONA WIND NORTH GEN-TIE SYSTEM HAVE?

A. Visual impacts will consist of the additional transmission structures and revised locations of previously approved segments of the Corona Wind North Gen-Tie System. As discussed in the Environmental Report, the Corona Wind North Gen-Tie System will not unduly impair visual uses in the area.

Q. WHAT IMPACT WILL THE CORONA WIND NORTH GEN-TIE SYSTEM HAVE ON HISTORIC AND ARCHEOLOGICAL RESOURCES?

A. As previously described, Pattern Energy takes extensive precautions to minimize any impacts to cultural resources such as historical and archaeological resources. This is the result of company BMPs. Any impacts on historic and archaeological resources will be minimized through siting decisions and will not unduly impair these resources.

Q. WILL THE CORONA WIND NORTH GEN-TIE SYSTEM IMPACT CEMETERIES OR BURIALS?

A. No. The Corona Wind North Gen-Tie System will avoid cemeteries and burials and will not unduly impair these resources.

Q. WILL THE CORONA WIND NORTH GEN-TIE SYSTEM IMPACT ANY SCHOOLS?

A. No. The Corona Wind North Gen-Tie System will avoid schools. Thus, these resources will not be unduly impaired. Further, the Corona Wind North Gen-Tie System is expected to be participating infrastructure in Industrial Revenue Bonds to be issued through counties resulting in payments-in-lieu of taxes that are likely to provide long-term revenue to schools in the area.

Q. WILL THE CORONA WIND NORTH GEN-TIE SYSTEM IMPACT RELIGIOUS RESOURCES?

A. No. The Corona Wind North Gen-Tie System will avoid religious resources and will not unduly impair these resources.

Q. WILL THE CORONA WIND NORTH GEN-TIE SYSTEM ADVERSELY AFFECT GEOLOGIC OR PALEONTOLOGICAL RESOURCES?

A. As discussed in the Environmental Report, the Corona Wind North Gen-Tie System will not unduly impair geologic or paleontological resources.

Q. WILL THE CORONA WIND NORTH GEN-TIE SYSTEM ADVERSELY AFFECT ROADS?

A. As part of the development of the Corona Wind North Gen-Tie System County Road use agreements will be entered with individual counties to ensure that all roads used will be repaired to a state that meets or exceeds the conditions prior to construction.

Q. HAVE THE JOINT APPLICANTS IDENTIFIED PROTECTION MEASURES TO AVOID AND MANAGE IMPACTS OF THE RESOURCES YOU HAVE DISCUSSED?

A. Yes. As discussed previously, Protection Measures will be implemented throughout the life of the Corona Wind North Gen-Tie System. These Protection Measures are included in the Environmental Report and mirror those adopted by the Commission in NMPRC Case No. 18-00065-UT and NMPRC Case No. 20-00008-UT and proposed by the Joint Applicants and the Staff in NMPRC Case No. 21-00281-UT.

Q. PLEASE SUMMARIZE YOUR CONCLUSIONS.

A. The Corona Wind North Gen-Tie System has been developed and will be constructed and operated with the implementation of a robust set of BMPs, scientific studies, and Protection Measures. Further, in light of the robust practices set out above, the Corona Wind North Gen-Tie System will stand out as a model of responsible development and most certainly will not unduly impair important environmental values.

C. LAND USE, LAND OWNERSHIP, AND COMPLIANCE WITH LAND USE STATUTES AND ADMINISTRATIVE REGULATIONS

Q. PLEASE DESCRIBE THE EXISTING LAND OWNERSHIP AND LAND USE ON THE CORONA WIND NORTH PROJECT.

A. The lands used in the Corona Wind North Project are privately held or owned by the State of New Mexico. Ranching is the predominant use of these lands.

Q. WILL THESE USES CONTINUE FOLLOWING CONSTRUCTION OF THE CORONA WIND NORTH GEN-TIE SYSTEM?

A. Yes. Ranching activities will continue since the land needed for both projects take up very little footprint. Also, the real estate leases with both the private landowners and the State of New Mexico do not restrict the owners from continuing ranching or farming activities.

Q. IN SUMMARY, WILL THE CORONA WIND NORTH GEN-TIE SYSTEM VIOLATE ANY EXISTING STATE, COUNTY, OR MUNICIPAL LAND USE STATUTORY OR ADMINISTRATIVE REGULATION?

A. No. The Joint Applicants will require contractors to comply with all state, county, or municipal land use statutory and administrative regulations. In Torrance County, the project is subject to the Torrance County Zoning Ordinance. The Torrance County Zoning Ordinance requires approval of a Special Use District for wind energy projects. The Joint Applicants will apply for Special Use District approval and adhere to all requirements of the Torrance County Zoning Ordinance. Guadalupe County does not have a zoning ordinance or other land use statutory or administrative regulation that the project would be subject to. The portion of the Corona Wind North Project that could be located in San Miguel County is located on state trust land, which is not subject to county land use regulations such as zoning ordinances.

D. COMPLIANCE WITH THE LOCATION RULE

1. THE CORONA WIND NORTH GENERATION

Q. DOES THE JOINT APPLICATION COMPLY WITH THE COMMISSION'S GENERATION LOCATION RULE?

A. Yes, as follows:

A. We have provided a description of the proposed generating plants, their size, and the fact that they are wind generating facilities. A legal description of the property and a map showing the location of the Corona Wind North Generation is provided in Exhibit JA-1 to the Joint Application.

B. My testimony explains Pattern Energy's compliance with all applicable land use statutes and administrative regulations.

C. My testimony identifies all applicable air and water pollution control standards and regulations that apply to the Corona Wind North Project.

D. My testimony identifies all written air and water quality authorizations necessary to begin operation of the Corona Wind North Project, which are all construction phase permits typically issued shortly before construction. The Joint Applicants will provide notification of receipt of these permits as they are obtained.

E. I have further stated that there are no air or water quality authorizations necessary for operation of the Corona Wind North Project.

F. I have also testified that the Corona Wind North Generation and the Corona Wind North Gen-Tie System are expected to be in service by the end of 2026.

G. The Joint Application has been served on all local authorities in Guadalupe, San Miguel and Torrance Counties in New Mexico, the New Mexico Attorney General, the New Mexico Environment Department, and the New Mexico Office of the State Engineer.

H. The Joint Application provides additional information to inform the Commission's decision-making on the Joint Applicants' request for location approval of the Corona Wind North Project.

2. <u>THE CORONA WIND NORTH GEN-TIE SYSTEM</u>

Q. DOES THE JOINT APPLICATION COMPLY WITH THE COMMISSION'S TRANSMISSION LOCATION RULE?

A. Yes, as follows:

A. We have provided a description of the Corona Wind North Gen-Tie System, including its location, private and state land ownership, estimated number of feet the Gen-Tie System will cross over private and state land, a total length of the line, a description of interconnection facilities, a location map, and representational schematic diagrams of the interconnection of the line. See Exhibits JA-2 and JA-3.

B. My testimony identifies all applicable land use statutes and administrative regulations and provides that the Joint Applicants comply with each.

C. Because the Corona Wind North Gen-Tie System does not require compliance with NEPA, an environmental assessment was not prepared.

D. The Environmental Report was prepared for the Joint Applicants in the format prescribed by 40 C.F.R. §1502.10.

E. As explained in my testimony, there are no zoning regulations in Guadalupe County and the project area located in San Miguel County is on state trust lands not subject to county zoning. Lastly, and an amendment to the previously approved SUD will be obtained from Torrance County.

F. As explained in the Environmental Report and as summarized in my testimony, the Corona Wind North Gen-Tie System will not unduly impair important environmental values, including resources associated with air and water quality, flora and fauna, water, land uses, visual and scenic, cultural, historic, and archaeological, religious, geological and paleontological, soils, mineral, socioeconomic, roads, noise, and communication.

G. My testimony states that the Corona Wind North Generation and the Corona Wind North Gen-Tie System are expected to be in service by the end of 2026.

H. The Joint Application has been served on all local authorities in Guadalupe, San Miguel and Torrance Counties in New Mexico, the New Mexico Attorney General, the New Mexico Environment Department, and the New Mexico Office of the State Engineer.

I. The Joint Application provides additional information to facilitate the Commission's decision-making on the Joint Applicants' request for location approval of the Corona Wind North Gen-Tie System.

E. <u>COMPLIANCE WITH THE ROW STATUTE</u>

Q. DOES THE CORONA WIND NORTH PROJECT COMPLY WITH THE ROW STATUTE IN THE EVENT THE COMMISSION'S DETERMINATION IS REQUIRED?

A. Yes. The ROW Statute, requires that, unless all parties agree otherwise, the Commission determines whether a proposed ROW width in excess of 100 feet is necessary. As I noted previously, the Joint Applicants will locate the Corona Wind North Gen-Tie System on private land subject to agreements with landowners or on state lands subject to leases with the State of New Mexico. Further, this Joint Application and other witnesses' testimonies demonstrate that the proposed 180-foot ROW width is necessary for the safe construction, operation, and maintenance of the Corona Wind North Gen-Tie System.

VI. CONCLUSION

Q. PLEASE SUMMARIZE YOUR CONCLUSION.

A. The Joint Applicants provided a comprehensive environmental impact analysis for the Corona Wind North Project, including the Corona Wind North Generation and Corona Wind North Gen-Tie System. The comprehensive analysis presented demonstrates that the Corona Wind North Project satisfies all statutory and regulatory requirements of the Commission.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

BEFORE THE NEW MEXICO PUBLIC REGULATION COMMISSION

IN THE MATTER OF THE JOINT APPLICATION FOR THE LOCATION APPROVAL OF THE CORONA WIND NORTH PROJECT AND FOR THE RIGHT-OF-WAY WIDTH APPROVAL PURSUANT TO THE PUBLIC UTILITY ACT, NMSA 1978, §62-9-3	)	**Case No. 22-000__-UT**
DAHLIA WIND LLC, GALLINAS MOUNTAIN WIND LLC, PASTURA WIND LLC, AND PATTERN SC HOLDINGS LLC,	)	
JOINT APPLICANTS.	)	

AFFIDAVIT OF ADAM CERNEA CLARK

STATE OF TEXAS)
) ss.
COUNTY OF HARRIS)

I have read the foregoing Rebuttal Testimony and under penalty of perjury under the laws of the State of New Mexico the statement is true and correct based on my own knowledge and belief.

SWORN on this 8th day of April, 2022.

Adam Cernea Clark

Emily McClary Davis
Notary Public

3-15-2022
My Commission Expires

EMILY MCCLARY-DAVIS
My Notary ID # 131046982
Expires March 15, 2025

NOTARY PUBLIC STATE OF TEXAS

Exhibit ACC-1

Reducing Avian Collisions with Power Lines

The State of the Art in 2012

Edison Electric Institute
Power by Association™

Avian Power Line Interaction Committee

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Reducing Avian Collisions with Power Lines

The State of the Art in 2012

Prepared by:

Avian Power Line Interaction Committee

October 2012

EEI Edison Electric Institute
Power by Association[SM]

Avian Power Line Interaction Committee

Additional copies of this book may be obtained through:

the Avian Power Line Interaction Committee (www.aplic.org) and the Edison Electric Institute (www.eei.org).

This book should be cited as follows:

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ABSTRACT

PURPOSE AND SCOPE OF THIS MANUAL

Reducing Avian Collisions with Power Lines (*Collision Manual*) was first published by the Avian Power Line Interaction Committee (APLIC) and Edison Electric Institute (EEI) in 1994 under the title *Mitigating Bird Collisions with Power Lines*. The 2012 edition of this manual provides electric utilities, wildlife agencies, and other stakeholders with guidance for reducing bird collisions with power lines based on the most current information. This is especially important given the need to reduce bird injury and mortality from collisions, comply with bird protection laws, and enhance the reliability of electrical energy delivery.

PROGRESS IN DEALING WITH COLLISION ISSUES

In the United States, most studies of bird collisions have occurred since the late 1970s. These studies described the problem and led to a growing awareness among stakeholders. In 1989, APLIC was founded to address whooping crane (*Grus americana*) collisions with power lines. APLIC published its first *Collision Manual* in 1994 to summarize the knowledge of bird collisions with power lines at that time. National and international collaboration on bird/power line interactions has since grown. Research today includes studies on collision reduction, monitoring systems, and standardization of collision mortality data collection. Future priorities include improving the comparability of studies, testing and documenting line marker efficacy, and refining remote collision detection devices.

As power line infrastructure expands to meet the growing demand for electricity, the collision risk to avian species also seems likely to increase. Yet, this risk may be reduced by assessing potential avian impacts during line siting and routing, improving line marking devices, standardizing study methods, and increasing awareness.

AVIAN REGULATIONS AND COMPLIANCE

In the United States, three federal laws protect almost all native avian species and prohibit *taking* (killing or injuring) them even if the act was unintended and occurred as a result of otherwise legal activities. The Migratory Bird Treaty Act (16 U.S.C. 703-712) protects 1,007 (2012) North American migratory bird species (50 CFR 10.13). The Bald and Golden Eagle Protection Act (16 U.S.C. 668-668c) provides additional protection for these two species. The Endangered Species Act (16 U.S.C. 1531-1555) provides protection to federally listed species (designated as threatened or endangered) and to their critical habitat. Utilities in the United States should work with both the U.S. Fish and Wildlife Service (USFWS) and state wildlife agencies to identify permits and procedures that may be required.

In Canada, two laws protect avian species by prohibiting *take*. The Migratory Birds Convention Act protects most species of migratory birds in Canada. The Canadian Species at Risk Act provides for the protection and recovery of threatened and endangered species. Additional protection for species at risk has been developed by the provincial governments, such as the Alberta Wildlife Act. Utilities in Canada should work with the Canadian Wildlife Service and provincial wildlife agencies to identify permits and procedures that may be required.

UNDERSTANDING BIRD COLLISIONS

Understanding the nature of bird collisions is essential for minimizing them. Bird collisions with power lines result from a complex mixture of biological, environmental, and engineering factors. Biological characteristics include body size, weight, maneuverability, flight behavior, vision, age, sex, health, time of day, season, habitat, and habitat use. Environmental conditions include land uses, weather, visibility, lighting, and sudden disturbances.

ABSTRACT

Engineering aspects include size of lines, line placement, line orientation, line configuration, structure type, and sometimes obstruction lighting under Federal Aviation Administration rules.

It is difficult to extrapolate collision risk from one power line study and apply or compare it with other studies because of site-specific conditions and the lack of standard study methods, which result in variability of reported mortality rates. Species of birds reported to be susceptible to collisions generally have a large body size, long wing span, heavy body, and poor maneuverability. Examples include species of loons, storks, grebes, waterfowl, and some species of hawks and eagles. Flight behavior and other biological attributes contribute to species risk. Individual losses from collision mortality are unlikely to affect large and robust populations. However, for species that are rare or endangered, the loss of a few or even one individual may impact a local population or the overall population's viability.

MINIMIZING COLLISION RISKS

Engineers and biologists can work together to identify and address collision issues when modifying existing lines or planning new lines. Early consideration of risk factors may reduce the need for costly modifications later. In addition, while a utility is taking steps to minimize collision risk, a proactive public participation program can address social issues by building positive relationships, increasing public knowledge, identifying and responding to public concerns early, and promoting responsible behavior (e.g., discouraging vandalism of line marking devices).

When modifying existing lines, study options include collision monitoring, line modification studies, and avian risk assessment. Line modifications must be carefully evaluated to identify, quantify, and balance the existing risks with the potential effectiveness and risks posed by the alternatives. Risk reduction options include line marking, managing surrounding lands, removing the shield wire, changing the size or configuration of wires, rerouting the line, and burying lines. Typically, the first options are line marking and managing surrounding lands because the remaining options are seldom feasible.

When planning new lines, three study options can be used to identify the optimal route: spatial analysis using GIS, field assessment, and avian risk assessment. Risk reduction options could include line placement, orientation, and configuration relative to biological and environmental factors.

LINE MARKING DEVICES

Studies suggest that most bird collisions occur with the shield wire, which is the smallest diameter and highest wire on a transmission line. Many studies of lines with high collision rates indicate that collision risk can be lowered by 50% to 80% when these lines are marked, though the most recent study published at this writing demonstrated only a 9.6% reduction (Barrientos 2012). However, recommendations for which device is the most effective and standard spacing are not possible due to differences in study designs and site-specific conditions. As a result of these differences, reduction rates may not be replicable from one line or study to another.

Since 1994, line marking devices have been further developed in North America, Europe, and South Africa. Advances in aerial marker spheres, spirals, and suspended devices include changes to design, colors, attachments, and materials in an effort to improve effectiveness and durability and to reduce possible damage to lines.

AVIAN PROTECTION PLANS

In 2005, APLIC and the USFWS announced their jointly developed *Avian Protection Plan Guidelines (Guidelines)*. An Avian Protection

ABSTRACT

Plan (APP) is a voluntary, utility-specific plan for reducing the risks to birds and system reliability that result from avian interactions with electric utility facilities. An APP provides the framework necessary for implementing a program to reduce bird mortalities, document utility actions, improve service reliability, and comply with bird protection laws. The *Guidelines* are intended to help utilities craft their own APPs for managing avian/power line issues that are particular to their location and operations.

PREVIOUS VIEW

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FOREWORD

Avian interactions with power lines, including collisions, electrocutions, and nesting have been documented since the early 1900s. Collisions with telegraph lines were first reported in 1876. However, it was not until the 1970s that biologists, engineers, resource agencies, and conservationists began to realize the extent of these interactions. It was then that they began investigating and addressing collision issues. We commend this early professional leadership in tackling a complex issue and building a foundation of credibility and cooperation that characterizes the relationship between the U.S. Fish and Wildlife Service (USFWS) and the Avian Power Line Interaction Committee (APLIC) today.

In December 1983, an ad hoc group began to address whooping crane *(Grus americana)* collisions with power lines in the San Luis Valley, Colorado. This work led to the 1989 founding of APLIC and the publication of *Mitigating Bird Collisions with Power Lines: State of the Art in 1994 (Collision Manual)*, which became the companion of *Suggested Practices for Raptor Protection on Power Lines: State of the Art in 1981 (Electrocution Manual)*. The 1994 *Collision Manual* brought together what was known about collision mitigation and presented research protocols for studying problem lines. It focused on standardizing these protocols so that data from various studies might be comparable and applicable to the issues experienced by electric utilities nationwide. This theme is carried forth and expanded upon in this 2012 revision.

Today electric utilities across North America recognize that bird/power line interactions may create operational risks, health and safety concerns, and avian injuries or mortalities, all of which reduce electrical reliability and increase a utility's liability. The USFWS is responsible for conserving and protecting United States trust resources covered by the Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and Endangered Species Act. It is within this potentially adversarial framework that the longstanding collaborative partnership between industry and agency has emerged.

With this edition of the *Collision Manual* (now titled *Reducing Avian Collisions with Power Lines*) along with the 2006 *Electrocution Manual*, the 2005 *Avian Protection Plan Guidelines*, and Edison Electric Institute's 2001 *Introduction to Public Participation*, utilities have a toolbox of the latest technology, science, expertise, and field experience. APLIC and the USFWS hope you will use this edition of the *Collision Manual*, along with its companion documents, to help implement avian protection plans, conserve protected birds, and improve electrical system reliability.

Jerome Ford
USFWS, Assistant Director Migratory Bird Program

Dave Bouchard
APLIC, Immediate Past Chair

Peggy Jelen
APLIC, Chair

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APLIC also wishes to thank the following individuals for their service during the production of this edition of the manual: Brad Loveless, Dave Bouchard, and Peggy Jelen for serving as Chair of APLIC and Rick Loughery for serving as the Edison Electric Institute Liaison to APLIC.

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A diverse collection of literature was used in the research to prepare this manual. APLIC acknowledges the great contribution that this body of literature made. This literature is included in Appendix A. Literature Cited and Bibliography.

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THIS PUBLICATION IS DEDICATED TO THE MEMORY OF

Richard "Dick" S. Thorsell

(April 11, 1927 – April 15, 2012)

Dick Thorsell had a lifetime devotion to birds and was one of the founders of APLIC. He brought electric utilities, government agencies, and environmental groups together to work in cooperation to study and mitigate bird deaths from power line collisions and electrocutions. Dick came to the Edison Electric Institute (EEI) in 1970 after serving as the Executive Director of the Stony Brook–Millstone Watershed Association in New Jersey. Dick was the producer of films on utility/natural resource issues, including *Silver Wires, Golden Wings.* The film featured Morley Nelson's work on understanding and reducing raptor electrocutions. It brought awareness of electrocution issues to electric utilities and credibility to the industry for its efforts to address the problem.

Dick was a WWII Navy veteran, and in 1953 he graduated from Lehigh University with a B.A. in Conservation. During the summer of 1950, he took a job as a Ranger Naturalist for the U.S. National Park Service. In 1954, as a graduate student, he travelled to Bermuda to help determine what was destroying nests of the Bermuda petrel, or cahow *(Petrodroma cahow),* a bird that until 1951 was thought to have been extinct for more than 300 years. During 47 days of field observations he conceived a way to reduce nest predation of the cahow by the more aggressive white-tailed tropic bird *(Phaethon lepturus),* known in the islands as the longtail. His solution was credited as one of the most critical developments in the cahow's recovery and conservation.

In 1988, Dick was honored by the Raptor Research Foundation for his pioneering efforts in raptor protection: *"All who appreciate the flight, spirit, and symbolism of the golden eagle are in your debt; and those who know you well enough understand that having hundreds, if not thousands of living eagles to your credit, is sufficient personal award for your accomplishments."*

Dick received APLIC's Morley Nelson Award in 2009 to acknowledge his efforts in pioneering avian/power line conservation and his dedication to developing and maintaining positive partnerships among the key interests in avian/power line issues.

Dick retired from EEI in1991 and pursued his personal interests while remaining ever ready to advise the industry on developing issues and to keep us on track.

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CHAPTER 1

Introduction

IN THIS CHAPTER

- Purpose and Scope of the Manual
- Reader Guide to the Manual
- Overview of Power Lines
- Perspectives for Dealing with Bird Collisions

Some birds flying in the vicinity of power lines may be susceptible to collision. While power lines are only one of numerous causes of bird injury and mortality, collisions with power lines can be reduced. This chapter introduces the problem of bird collisions, defines the categories and configurations of power lines, and presents the biological, engineering, economic, and social and cultural perspectives on bird/power line collisions.

PURPOSE AND SCOPE OF THE MANUAL

Reducing Avian Collisions with Power Lines (Collision Manual) was first published by the Avian Power Line Interaction Committee (APLIC) and the Edison Electric Institute (EEI) in 1994, under the title *Mitigating Bird Collisions with Power Lines*, as a comprehensive review of avian collisions with power lines (collisions) and recommendations for minimizing them. Since 1994, the understanding of bird collisions and the methods for reducing them has grown (e.g., Bevanger 1994, 1998; Janss 2000; Rubolini et al. 2005; and Jenkins et al. 2010). Collisions with power lines cannot be eliminated, but they can be reduced. This edition of the manual builds upon the foundation of the 1994 *Collision Manual* using the research and experience gained through the years since its original publication.

Power lines are an integral part of the modern landscape. Estimates of the number of miles of transmission lines in the United States range from 862,000 kilometers (km) (535,622 miles [mi]) (J. Goodrich-Mahoney, EPRI, pers. comm.) to 1,024,534 km (636,616 mi) (EEI 2010) based on 2009 and 2010 data from the Federal Energy Regulatory Commission, North American Electric Reliability Corporation, and other sources. For distribution lines, the number of miles is less certain, but it is about five to six times that of transmission lines based on two large company systems (D. Bouchard, pers. comm.).

Some bird species that are active in the vicinity of power lines are more susceptible to collision and electrocution risk than others. The risks and reduction measures for bird electrocutions are addressed in the publication *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006* (APLIC 2006).

Power lines are only one of numerous anthropogenic causes of bird collision mor-

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tality. Others include tall buildings, windows, vehicles, communication towers, airplanes, and wind turbines (Avery et al. 1980; Erickson et al. 2005). Estimates of bird collision mortality vary widely because of differences in mortality monitoring and extrapolations of those data. Based on reviews, Erickson et al. (2005) estimated that buildings and windows account for most bird collision mortality in the United States, followed by power lines, automobiles, communication towers, and wind turbines. This manual only addresses bird collisions with power lines.

Interactions between birds and power lines are a complex mixture of biological, environmental, and engineering factors. Electric utility stakeholders need to understand the nature of bird interactions with power lines when siting, routing, and designing power lines and determining mortality reduction measures. This is especially true given the need to reduce bird collisions, comply with bird protection laws, and enhance reliable electrical energy delivery.

This manual was developed for electric utilities, wildlife agencies, and other stakeholders and is based on what is known to date about collisions. It is intended to provide this audience with:

- An overview of power lines and perspectives on dealing with avian/power line collisions (Chapter 1)
- A summary of current knowledge, literature, and field experience related to avian collisions with power lines and the factors that influence them (Chapters 2 and 4)
- A discussion of the laws, regulations, and the operational implications of avian collisions (Chapter 3)
- A review and discussion of current practices for planning, management options, study design, and devices used to minimize avian collisions with power lines (Chapter 5, Chapter 6 and Appendix B)
- An overview for developing an Avian Protection Plan (Chapter 7)
- A compilation of collision literature spanning several decades (Appendix A)
- A glossary of collision terms and resources for further information (Appendices C and E)

FIGURE 1.1: The highest wire on a transmission line is the shield wire, which can be difficult for birds, especially flocking birds such as waterfowl, to see.

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READER GUIDE TO THE MANUAL

Table 1.1 provides a quick guide to common collision topics in this manual. Readers can also search the electronic version (a CD is included) for specific keywords. This manual consists of the following chapters and appendices.

TABLE 1.1: Quick guide to the Collision Manual.

Subject	Chapter(s)
Power lines, voltage, and the electric power system	1
Perspective of power line engineers	1, 4, 5, 6
Perspective of biologists	1, 4, 5, Appendix B
Perspective of the public and other stakeholders	1, 5, 6, 7
Advantages and disadvantages of underground power lines	1, 5
History of bird collisions and mitigation	2, 6, Appendix A
Current state of knowledge related to bird collisions	2, 4, 5, Appendix A
Funding organizations for collision research	2, Appendix E
Study methods and options	2, 4, 5, Appendix B
Strategies and approaches to address bird collisions	2, 4, 5, 6, 7
Laws and policies governing birds and bird mortality	3
Permits related to bird laws and policies	3
Factors that contribute to collisions	4
Variability in reported collision mortality rates	4
Significance of mortality for bird populations	4
Scientific methods to assess risk and impacts	4, 5, Appendix B
Methods for reducing bird collisions on an existing power line	5, 6
Methods for routing and designing a new power line while minimizing bird collisions	5, 6
Benefits of public participation	5, 7
Legal issues and other considerations for line marking	6
Effectiveness of line marking devices	6
How to develop a voluntary, utility-specific Avian Protection Plan	7

OVERVIEW OF POWER LINES

TRANSMISSION VERSUS DISTRIBUTION LINES

Power lines are rated and categorized, in part, by the level of electrical voltage they carry. Because the amount of electricity is large, voltage is usually specified as kilovolts (kV) where 1 kV is equal to 1,000 volts (V). In a power system, from the power generation facility to the customer (Figure 1.2), four voltage classifications are used: power source, transmission, distribution, and utilization (Table 1.2). Although there are exceptions to these voltage classifications, they hold in general and will be used this way in this manual.

Voltage classification also depends on the purpose a power line serves. Transmission lines (≥60 to 765 kV) are used to transmit large blocks of electricity from the power generation facility to the load centers (communities). Within load centers, the high voltage of transmission lines is reduced at substations and then delivered via distribution lines (2.4 to 60 kV) for residential, commercial, and industrial uses. The distribution voltages are again stepped down to the lower voltages for the end user (120 to 600 V) usually by pole- and pad-mounted transformers. Both transmission and distribution lines are power lines, a term used throughout this manual (Figure 1.3).

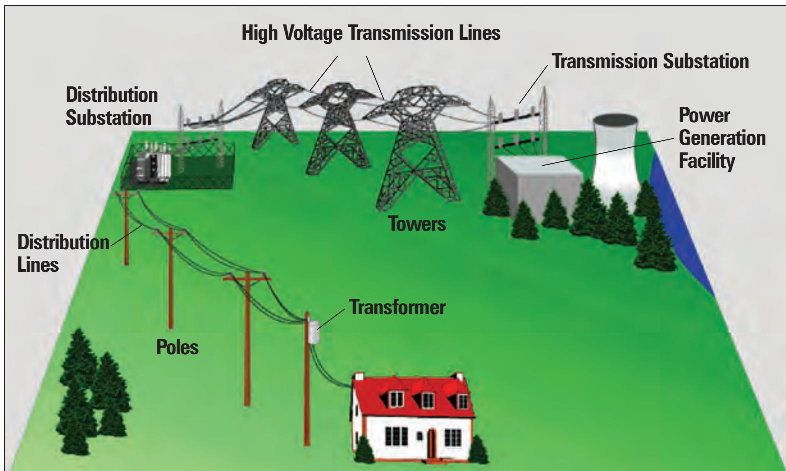

FIGURE 1.2: Schematic of the electric power system from the generation facility to the customer (modified from Rural Utilities Service).

TABLE 1.2: Voltage classifications in North America.

Classification	Voltage
Power Generation Facility	12 V to 22 kV
Transmission	60 to 765 kV*
Distribution	2.4 to 60 kV
Utilization	120 to 600 V

* This is the typical range for transmission; however, there are exceptions.

FIGURE 1.3: Transmission lines (left) and distribution lines (right).

© JERRY LIGUORI (LEFT) AND DAVE BOUCHARD, AEP (RIGHT)

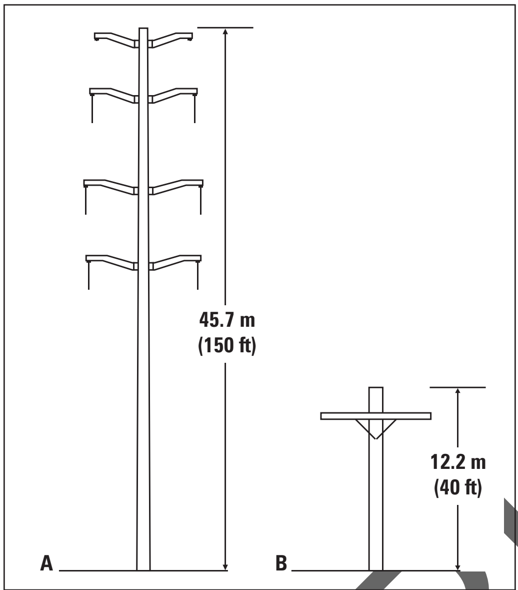

FIGURE 1.4: Height comparison of transmission (typically 18.3 to 58 m [60 to 190 ft] tall) (A) and distribution structures (typically 6.4 to 14.6 m [21 to 48 ft] tall) (B).

POWER LINE CONFIGURATION

Power lines may be energized (carrying electricity) or non-energized (grounded). Energized lines are called phase conductors. Distribution lines may have one, two, or three phase conductors per circuit. Alternating current (AC) transmission lines always have three phases per circuit, and structures may carry multiple circuits. For example, a three-phase, double-circuit line would have six phase conductors. Phase conductors may be configured horizontally or vertically on the tower or pole (Figure 1.5). High voltage transmission lines may be bundled, which means two to six lines per phase are placed in close proximity to each other instead of using only one line per phase (Figure 1.6). Distribution lines may also be installed on transmission structures below the transmission lines; this is referred to as a distribution underbuild (Figure 1.7).

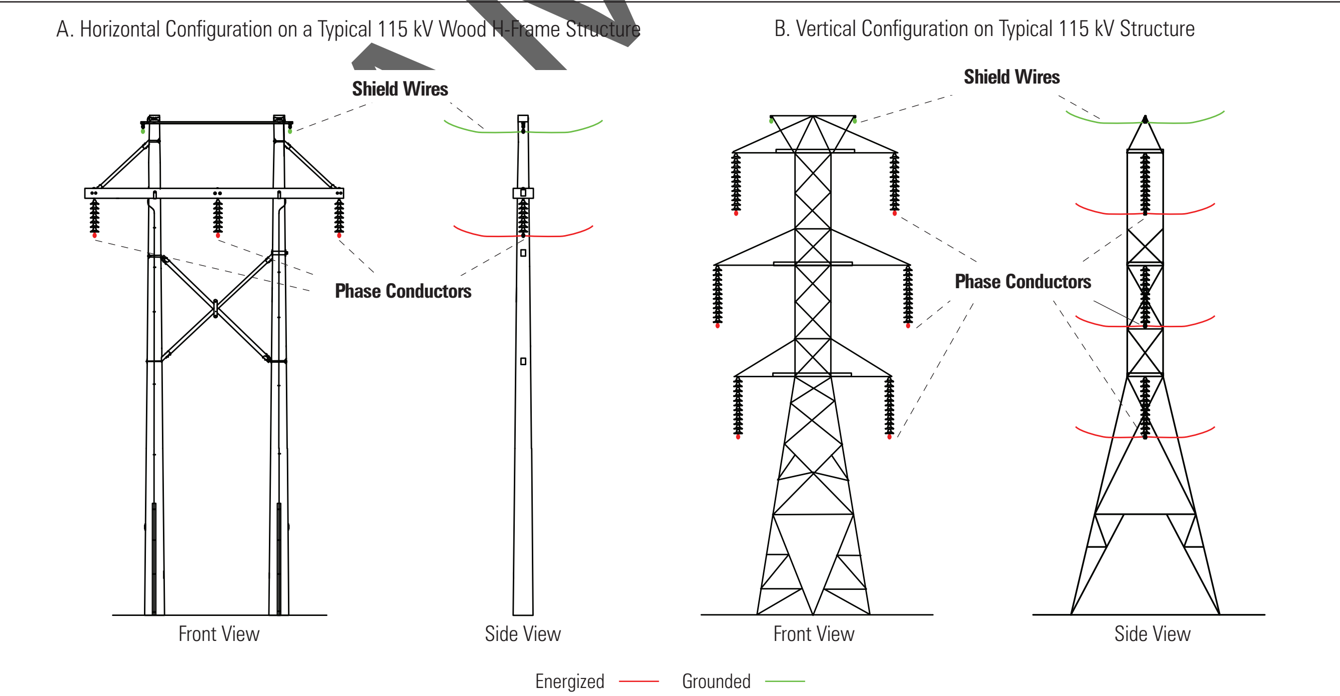

FIGURE 1.5: Horizontal (A) and vertical (B) transmission line configurations.

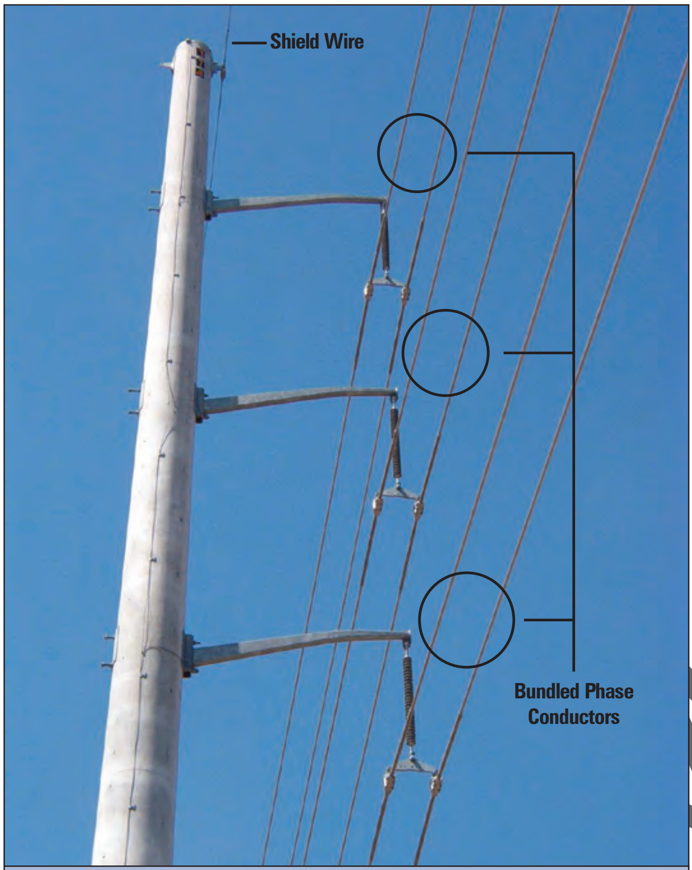

FIGURE 1.6: Bundled phase conductors on a three-phase, single-circuit, 138-kV transmission line.

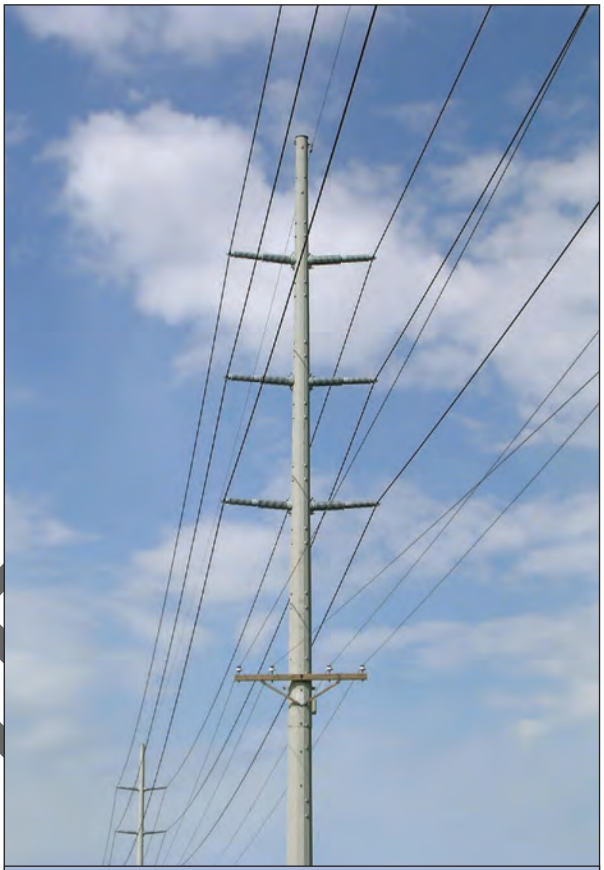

FIGURE 1.7: Distribution underbuild on a double-circuit transmission line.

Non-energized conductors are at ground potential or zero voltage potential. There are two kinds of non-energized conductors: shield wire (also called static wire or overhead ground wire) and neutral wire.

Shield wires are installed above the phase conductors on transmission lines to protect them from lightning (Figure 1.8). Static electricity from the shield wire is taken to earth (ground) by grounding conductors. In a low lightning area, some transmission lines with lower voltages (e.g., 69 kV) may not have a shield wire. Shield wires are the lines most associated with bird collisions on transmission lines because they are the highest wire and are smaller in diameter (1 to 1.3 centimeters [cm]; 0.4 to 0.5 inches [in])[1] than phase conductors (2.5 to 5 cm [1 to 2 in]; bundled lines are multiples of these), making them more difficult to see (e.g., Savereno et al. 1996). When birds are flying at the elevation of shield wires or gaining altitude to avoid the more visible phase conductors, the potential for collision with the shield wire increases. For more information on how power line configuration affects collision risk, see Chapters 4 and 5.

1 Measurements are provided first in metric, then in English form.

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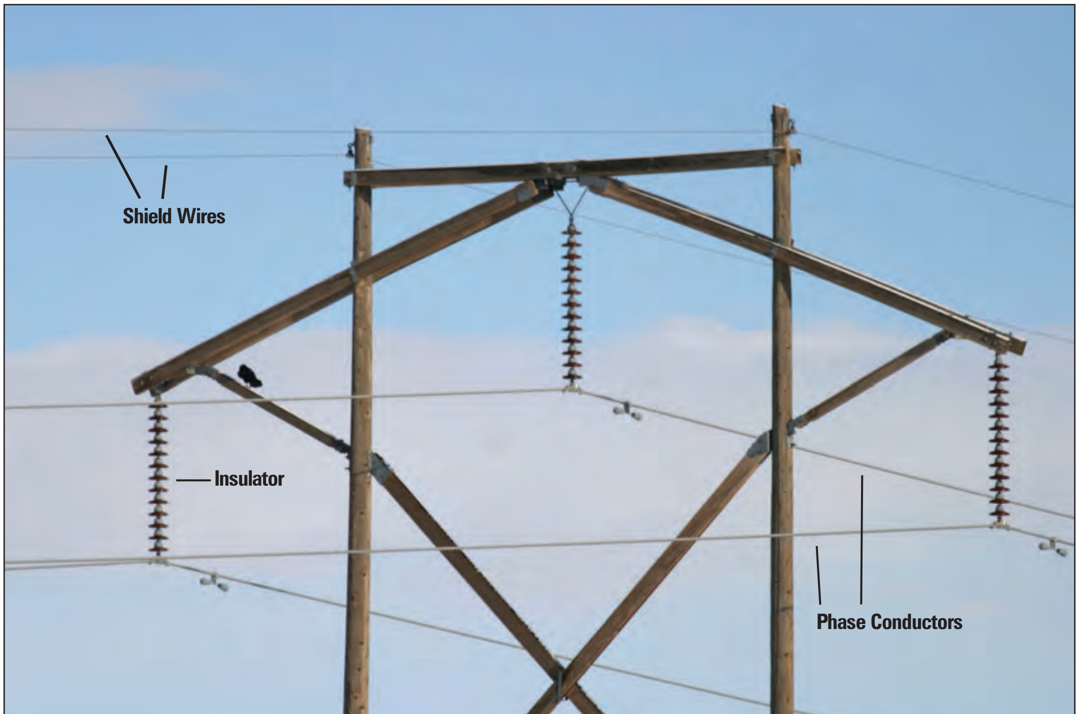

FIGURE 1.8: Shield wires are the highest wires on a transmission line.

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The neutral wire, with regional exceptions, is installed below or parallel to the phase conductors on a distribution line (Figure 1.9) and carries return current, which is taken safely to ground via grounding conductors. In high lightning areas there are exceptions where the neutral is also used as a shield wire on a distribution line.

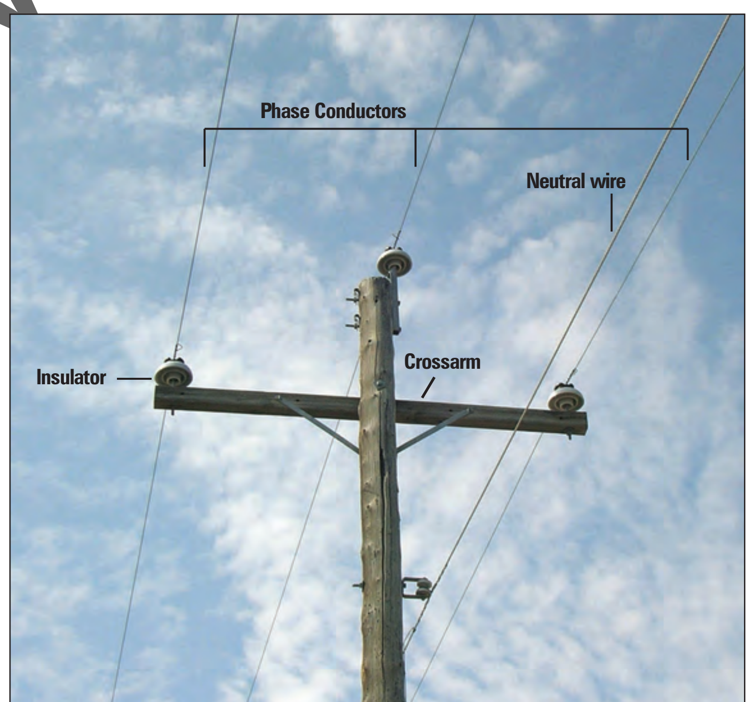

FIGURE 1.9: The neutral wire is usually positioned below the phase conductors on a distribution line.

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High Voltage: Alternating Current versus Direct Current

Alternating current (AC) transmission and distribution systems are the world's most prevalent type of line. AC transmission systems consist of three phases, each phase consists of 1 to 6 wires (two or more is a bundle). Three phases make a circuit, and a line may have more than one circuit. AC phases may be arranged either horizontally or vertically. As voltage increases, loss over distance decreases, but at some distance high voltage direct current (HVDC) becomes more efficient than high voltage alternating current (HVAC). HVDC transmission systems have a growing presence in the United States and the world. They are most effective in transmitting electricity long distances at high voltages (400 to 600 kV in North America and up to 800 kV in other countries). HVDC structure design is similar to HVAC designs, but with two poles instead of three phases (Figure 1.10). HVDC is transmitted on two bundled conductors known as positive and negative poles. The poles are spaced at least 9.1 meters (m) (30 feet [ft]) apart and are always arranged horizontally. Both systems require shield wires for lightning protection. Most importantly, both systems have the same cautions for attaching collision-preventive devices, i.e., these devices may be applied to shield wires, but are not always compatible with energized lines ≥150 kV or as manufacturers have otherwise demonstrated.

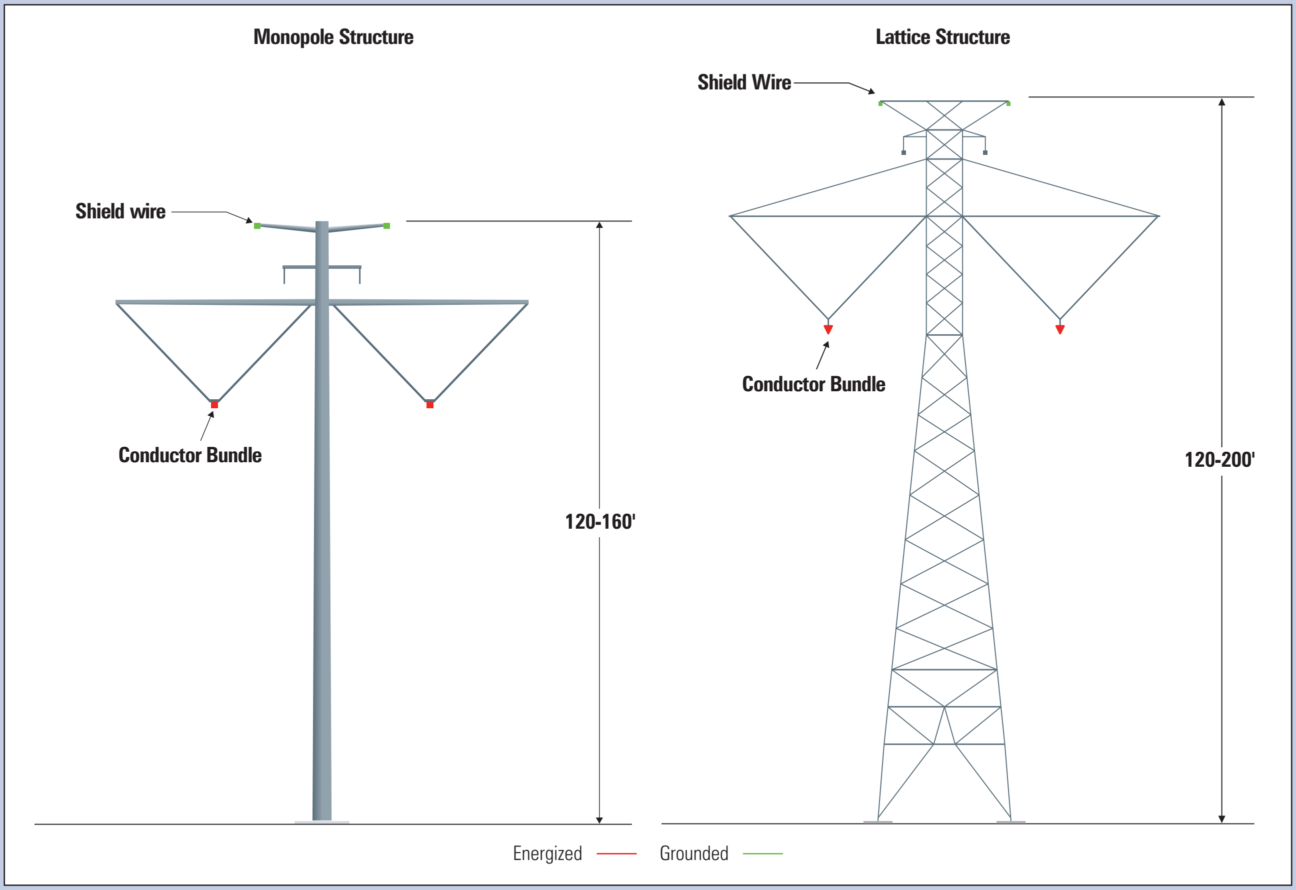

FIGURE 1.10: Typical high voltage direct current transmission line structures.

MEETING ELECTRICAL POWER DEMANDS (LOAD REQUIREMENTS)

A power line's voltage, configuration, conductor spacing, location, and structure type are determined by the present and anticipated power demands or load requirements the line will serve. Because electric utilities are required by law to provide reliable electrical service, they plan, fund, and build new power lines. If enough power is available in an area, then building new distribution lines can sometimes meet the increasing demand. Alternatively or additionally, transmission lines can be built to bring power to the load center from distant power generation facilities.

Transmission line corridors are determined by the location of power generation facilities and substations in relation to load centers. Within the corridor, the preferred and alternative routes are determined, among other things, by rights-of-way (ROWs) availability, land use patterns, potential environmental impacts, terrain, archeological sites, proximity to habitable dwellings, and crossings over water, highways, and other power lines (see *Planning New Power Lines* in Chapter 5 for a discussion and illustration of the planning process).

Different ROW widths are required for different transmission line voltage ratings; these are generally determined by state statutes and the National Electrical Safety Code. ROW widths are also a function of structure height, span length, the conductor height above ground, and the low point of the conductor. ROW widths for transmission lines will vary from 15.2 m (50 ft) to more than 60.9 m (200 ft). Because ROWs are becoming increasingly difficult to obtain,

Transmission Lines and Renewable Energy

Current renewable energy mandates are leading to the development of wind, solar, and other renewable sources. Because these renewable energy sources are typically remote, new transmission lines are often needed to connect them to the grid and carry electricity to load centers.

Overhead versus Underground Power Lines

Electric utilities install power lines either overhead or underground depending upon numerous considerations. Some key factors include customer needs, costs, code requirements, terrain, voltage, and technological and environmental restrictions. Cost is a major concern as electric utilities have mandates to serve customers with high quality, reliable electric service at the lowest cost possible.

Power lines, particularly residential distribution lines, are installed underground in many areas throughout the country where it has been found technically and financially feasible to do so. However, at transmission voltages, there are many more areas where installing lines underground is not feasible (see *Burying Power Lines* on page 62). It becomes more practical to build them overhead as the voltage of the line increases. Therefore, the focus of this manual is to provide guidance for addressing issues associated with reducing collision risks on overhead power lines.

it is a common practice to increase the voltage levels of lines in existing ROWs when statutes and safety allow. As voltages increase, the amount of power that can be transmitted increases by a greater multiple.[2] Transmission voltages for carrying electricity long distances are generally in the range of 115 to 765 kV in the United States.

PERSPECTIVES FOR DEALING WITH BIRD COLLISIONS

A single approach is rarely successful in solving a complicated, multi-faceted issue such as bird collisions with power lines. An integrated approach that considers the biological, environmental, engineering, economic, and social and cultural perspectives of collisions is needed.

BIOLOGICAL AND ENVIRONMENTAL PERSPECTIVES

Biologists generally focus on gathering data to better understand the problem and creating solutions to minimize collision risk. Utility biologists and/or their consultants may be responsible for site evaluation studies and collision studies (see Chapters 5 and 6 and Appendix B). Site evaluation studies determine baseline avian and habitat conditions and assess the possible collision risks to birds following power line construction. Collision studies can help determine reliable mortality rates and quantify the effectiveness of measures taken to minimize collisions.

Collecting high quality data is critical for collision studies. Utilities should plan their studies carefully, using methods and metrics that can be replicated to gather and analyze data. The data should be sufficient for use in estimating the likelihood of collisions and for measuring the effectiveness of collision reduction efforts. In addition, methods must be sufficiently flexible to accommodate the species and site-specific conditions being studied and applied consistently throughout a study and between studies (Bevanger 1999; Barrientos et al. 2011).

In most cases, the approach to these studies is based on type of information needed to make management decisions, determine if line modifications are effective, and/or identify areas of bird activity and high collision risk. In some cases, wildlife agencies may recommend specific studies or protocols, and it is advisable to obtain their comments on a study design. Utilities and their consultants should also consider peer review by independent scientists for the study findings, since the results may undergo rigorous legal cross-examination if the issue is litigated. Publication in a refereed scientific journal is encouraged because it makes the data more widely available and contributes to a greater resource pool for the development of study design methods.

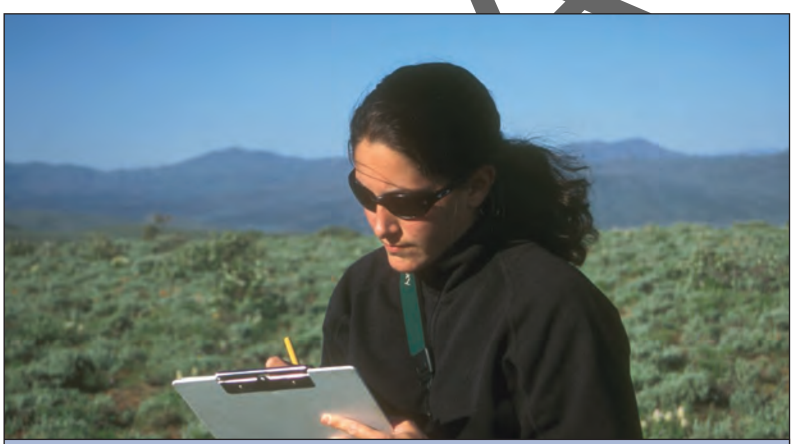

FIGURE 1.11: Biologists gather data to assess the risk of bird collisions.

[2] The carrying capacity of a line increases at a greater rate than the increase in voltage, i.e., one 765-kV circuit = three 500-kV circuits = six 345-kV circuits. Another advantage of higher voltage is that the voltage drop or loss over distance decreases as the voltage increases.

FIGURE 1.12: Engineers work with biologists to reduce risk through appropriate design and routing of power facilities.

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ENGINEERING PERSPECTIVE

Engineering research, development, and design are essential in the integrated approach to preventing or minimizing bird/power line collisions. Utility engineers should work with biologists early in the design and routing process to identify the key collision issues (see Chapter 4) and to develop feasible collision reduction strategies when modifying existing lines and planning new lines (see Chapters 5 and 6). Early science-based site evaluations and avian risk assessments can be part of improving route selection and line configurations to minimize collision problems. This can reduce or eliminate the need for costly modifications after construction. Design decisions also include other factors such as cost, routing through public or private land, crew availability, and material availability; as a result, a less favorable design for avian interactions may need to be used.

ECONOMIC PERSPECTIVE

No integrated approach would be complete without considering the economics of construction, operation, and maintenance of a power line. The cost for bird friendly power lines and configurations needs to be included during the design phase and route selection. A cost benefit analysis of appropriate collision minimization designs and mitigation can be performed. The later in the process that a biological or engineering solution is initiated, the more difficult, time-consuming, and costly it can become. Since electrical reliability is mandated by utility commissions, avoiding power outages, including those caused by birds, is a priority for electric utilities. Early planning can help meet requirements for reliability, regulatory compliance, efficiency, public acceptance, and cost-effectiveness.

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FIGURE 1.13: Engaging the public may help a utility meet requirements for electrical reliability and reduce collision risk to birds.

SOCIAL AND CULTURAL PERSPECTIVES

In addition to cost and power reliability, the public may have concerns about power line design and placement, including esthetics, environmental effects, wildlife, and safety. Vandalism is also a persistent problem. Electrical components and line marking devices on power lines can become targets. Engaging the public may make it easier for a utility to meet the requirements of providing reliable electricity while reducing risks to birds. It can also reduce delays and costs associated with controversy and litigation (EEI 2001).

Utilities and their consultants can use a variety of public participation tools to engage the public (see Chapter 5 and Appendix E). Used effectively, these tools can build positive relationships, increase public knowledge, identify and respond to public concerns early, and promote responsible behavior (e.g., discouraging vandalism of line marking devices).

CHAPTER 2

Progress in Dealing with Collision Issues

IN THIS CHAPTER

- North America
- International
- Future Research Priorities

Much progress has been made since the 1970s in understanding and addressing bird collisions with power lines. This chapter recalls the conferences and studies that have occurred in North America and internationally. The major avian power line research organizations are introduced, along with future research priorities.

NORTH AMERICA

UNITED STATES

The first reported bird collision with overhead lines in the United States was documented in 1876 (Coues 1876); numerous bird carcasses, mostly horned larks (*Eremophilia alpestris*), were reported during one week in a 5.8-kilometer (km) (3-mile [mi]) section of an overhead telegraph line between Cheyenne, Wyoming, and Denver, Colorado. Coues indicated that such collisions had already been reported in Europe, although no references were given. Another early report of collisions with electric wires in the United States was documented in 1904 (Emerson 1904). Emerson reported that shorebirds, as well as a black rail (*Laterallus jamaicensis*), collided with electrical wires over a salt marsh and evaporation ponds in the San Francisco Bay area. Avery et al. (1980) provides an annotated bibliography of other early power line collision literature.

Most collision studies have been published since the late 1970s and have led to a growing awareness among stakeholders. During the 1970s, Bonneville Power Administration conducted studies on reducing collisions with power lines (Lee and Meyer 1977; James and Haak 1980; and Beaulaurier 1981). Lee and Meyer (1977) proposed using devices such as image intensifiers for nocturnal observation and collision detectors that would measure the number of bird strikes on wires. They also suggested using thermal imaging, a relatively new technique at the time, to view birds and bats flying near power lines and wind turbines. Lee and his colleagues set a new scientific standard for studies of the interaction between birds in flight and power lines.

In 1978 bird/power line issues were addressed at a national conference sponsored by the U.S. Fish and Wildlife Service (USFWS),

FIGURE 2.1: APLIC has helped fund studies on the effectiveness of different types of line marking devices in reducing bird collisions with power lines.

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the Environmental Protection Agency, and the Oak Ridge Associated Universities (Avery 1978).[3] This conference was followed by a 1978 meeting at the Edison Electric Institute (EEI) in Washington, D.C. There, EEI and the Electric Power Research Institute (EPRI) discussed a research program on bird/power line interactions. EPRI funded an assessment of completed, ongoing, and planned research; an analysis of future research needs regarding the impact of power lines on birds in flight; and a series of studies aimed at developing different methods for measuring the impact of power lines on birds in flight.

In 1989, a group of biologists representing a wide range of utility interests, together with representatives from the USFWS and the National Audubon Society, formed the Avian Power Line Interaction Committee (APLIC).[4] APLIC, in cooperation with the USFWS, funded a study on the effectiveness of different types of line markers in the San Luis Valley of Colorado. Such a study was needed because aerial marker spheres were commonly recommended for power lines where bird collision potential existed, although there were no data that established their effectiveness. Further details can be found in Brown and Drewien (1995).

APLIC and EPRI were also instrumental in developing and providing funding for an international conference on bird interactions with utility structures (Miami, September 1992). The proceedings of that workshop included papers and case studies by researchers from various utilities and universities in the United States, Canada, South Africa, and India, and other organizations and agencies including the USFWS, Bureau of Land Management, and U.S. Navy.

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3 Avery 1978 is the citation for the USFWS version of the proceedings; the original proceedings were documented by Oak Ridge Associated Universities. This reference will be noted as Avery 1978 in this document.

4 Founding APLIC utility members included Bonneville Power Administration, Edison Electric Institute, Central and South West Services (currently American Electric Power), Florida Power & Light Company, Houston Lighting and Power Company (currently CenterPoint), Nebraska Public Power District, Pacific Gas and Electric Company, Pacific Power & Light Company (currently PacifiCorp), Public Service Company of Colorado (currently Xcel Energy), San Luis Rural Electric Cooperatives, Southern California Edison Company, and Virginia Power (currently Dominion). A list of current APLIC members can be found at www.aplic.org.

In 1994, APLIC published *Mitigating Bird Collisions with Power Lines* (APLIC 1994) to compile the research on bird collision issues to date. Since then, research and reviews of this issue have continued. In 1999, EPRI held a workshop sponsored by APLIC and EEI entitled Avian Interactions with Utility and Communication Structures, which included papers and discussions on the bird collision issues these two industries face (see EPRI 2001). Every three to four years since 1976, electric utilities and utility organizations including EEI, EPRI, and APLIC help sponsor the International Symposium on Environmental Concerns in Rights-of-Way Management. This symposium often includes papers on bird collisions. APLIC also conducts avian protection workshops at its semi-annual business meetings and at other times through the year upon request (see www.aplic.org for information on upcoming workshops).

Since the early 2000s, the California Energy Commission (CEC) has sponsored a large number of research projects including identification of research needs on avian collisions with power lines in California: *A Roadmap for PIER Research on Avian Collisions with Power Lines in California* (Hunting 2002). CEC also has a searchable database on avian collision literature, *An Annotated Bibliography of Avian Interactions with Utility Structures* (CEC 2011).

Other CEC, APLIC, and EPRI sponsored studies include:

- *Human-related Causes of Raptor Mortality in Western Montana: Things are not Always as They Seem* (Olson 2001)
- *Bird Strike Indicator/Bird Activity Monitor and Field Assessment of Avian Fatalities* (EPRI 2003)
- *Raptor and Raven Electrocutions in Northwestern Mexico* (Cartron et al. 2004)
- *Corona Testing Devices Used to Mitigate Bird Collisions* (EDM 2004).
- *Assessment of Avian Mortality from Collisions and Electrocutions* (Dorin and Spiegel 2005)
- *Preventing Raptor Electrocutions in an Urban Environment* (Dwyer and Mannan 2007)
- *Evaluating and Reducing Avian Collisions with Distribution Power Lines at Cosumnes River Preserve* (Yee 2007)
- *Bird Strike Indicator Field Deployment at the Audubon National Wildlife Refuge in North Dakota* (Pandey et al. 2008)
- *Raptor and Corvid Response to Power Distribution Line Perch Deterrents in Utah* (Prather and Messmer 2010)
- *Evaluating Diverter Effectiveness in Reducing Avian Collisions with Distribution Lines at San Luis National Wildlife Refuge Complex, Merced County, California* (Ventana Wildlife Society 2009)
- *Contemporary Knowledge and Research Needs Regarding the Potential Effects of Tall Structures on Sage-grouse* (UWIN Cooperative 2010)
- *Protocol for Investigating the Effects of Tall Structures on Sage-grouse (Centrocercus spp.) Within Designated or Proposed Energy Corridors* (UWIN 2011)
- *Line Marking Study near Coleharbor, ND, 2006-2008* (WAPA 2011)

Bibliographies of Collision Literature

Appendix A of this manual includes the literature cited and a bibliography of collision literature. An annotated bibliography of early collision literature was provided by Avery et al. (1980). In addition, the California Energy Commission hosts a searchable database on collisions: *On-Line Annotated Bibliography of Avian Interactions with Utility Structures* (CEC 2011).

FIGURE 2.2: In Canada, the first reported collision victims were snow geese.

CANADA

The first reported bird collision in Canada was published by Blokpoel and Hatch (1976) after several thousand snow geese (*Chen caerulescens*) were flushed by an aircraft into a transmission line. The geese had been feeding on a stubble field near Winnipeg, Manitoba. Between 25 and 75 geese were reportedly injured or killed after striking the wires.

Since then, there have been few published accounts of bird collisions in Canada. In 1997, the *Blue Jay* published a discussion on birds and power line risk (Curtis 1997). Other accounts can be found in proceedings from the Canadian hosted 5th and 7th International Symposium on Environmental Concerns in Rights-of-Way Management in Quebec (1993) and Alberta (2000). In 2007, a study on using a landscape-scale model to predict the risk of collisions in Alberta was completed (Heck 2007; Quinn et al. 2011). It examined the practicality of using GIS spatial modeling to predict areas with elevated collision frequency across large, existing electric service territories.

Bird/power line interaction knowledge is growing in Canada and more emphasis is being placed on identifying the root cause in relation to a utility's reliability issues. The cause of many outages has been identified as a direct result of wildlife interactions, including birds. Many utilities are also installing line marking devices in areas where collisions have been reported or suspected.

Depending on the species, collisions with power lines may be violations of federal and provincial wildlife laws (see Chapter 3) and can result in penalties. Most bird species present in Canada are migratory and are very often the same species present in the United States and subject to many of the same collision risks, which stem from the same biological, environmental, and engineering factors outlined in Chapter 4.

Although Canada has wildlife laws in place, as of 2011 there is not a Canadian organization addressing the management of bird interactions with power lines; so Canadian companies have turned to American utilities for support by joining APLIC. In 2012, the first APLIC workshop in Canada was held in Banff. Electric utility representatives, consultants, contractors, and government regulators from across the country attended.

In addition to legal requirements and due diligence, Canadian companies have recognized that bird collisions need to be minimized for environmental, public relations, and public health reasons. Through increased management of avian collision issues, companies have been better able to demonstrate to utility staff, regulators, and the public, their commitment to reducing utility impacts on birds.

MEXICO

In Mexico, the USFWS has been working with officials of the Mexican government through the Trilateral Committee of the North American Free Trade Agreement, the

Migratory Bird Treaty with Mexico, Partners in Flight, and the National Wind Coordinating Collaborative to help Mexico better address avian collision and electrocution issues. These efforts are also tied to Mexico's land-based wind energy development, which includes power line issues (R. Villegas-Patraca, pers. comm.; A. Manville, pers. comm.; Mexico Institute of Ecology and USFWS, unpubl. reports, respectively).

INTERNATIONAL

Important collision research has been conducted in Europe, Asia, and Africa. In 2003, BirdLife International prepared the guide *Protecting Birds from Power Lines: A practical guide on the risks to birds from electricity transmission facilities and how to minimize any such adverse effect* (BirdLife International 2003). It reviewed the risks from power lines, including collisions, and recommended standards to protect birds, siting considerations, use of underground power lines, hiding or obscuring power lines against more prominent landscape features, and the use of line marking devices. In 2007, BirdLife International developed a policy position statement on the risks to birds from transmission lines (BirdLife International 2007). In 2009, the Council of Europe issued *Follow-up Recommendation No 110, 2004* (Schuerenberg et al. 2009) on minimizing adverse effects of power lines on birds. It reviews standards and retrofitting methods and provides an exhaustive list of actions taken by 26 European countries.

In 2011, the United Nations Environment Programme (UNEP) for the African-Eurasian Waterbird Agreement (AEWA) and the Convention on Migratory Species (CMS) released a *Review of the Conflict between Migratory Birds and Electricity Power Grids in the African-Eurasian Region* (CMS 2011a) and the *Guidelines for Mitigating Conflict between Migratory Birds and Electricity Power Grids* (CMS 2011b). CMS (2011a) provides a summary of collision issues and hot spots in Europe, Asia, and Africa. Also in 2011, the *Budapest Declaration on Bird Protection and Power Lines* (MME 2011) was adopted by the participants of the Budapest Conference, Power Lines and Bird Mortality in Europe. The declaration aims for all new construction of power poles to be bird-safe by 2016 and all dangerous poles to be retrofitted by 2020. The conference was attended by 123 participants from 29 European and Central Asian countries, the European Commission, UNEP AWEA, six energy and utility companies, experts, businesses, and non-government organizations.

In Asia, the risk of bird collisions with power lines is being recognized as more studies are conducted on bird electrocutions associated with new power line structures. For example, in Mongolia, while performing a review of raptor electrocutions on new concrete poles with metal crossarms, researchers found that Pallas' sandgrouse (*Syrrhaptes paradoxus*) were killed after colliding with power lines during an unusual seasonal relocation (Gombobaatar et al. 2010).

In Uzbekistan, systematic collision monitoring using standard protocols has not been conducted and therefore reported mortalities can only be considered anecdotal. However, these observations have shown that certain species are more susceptible to collisions and/or electrocutions. It is known that during spring and autumn migration, medium and large size birds collide with or are electrocuted on the power lines, which include rare and declining species like the steppe eagle (*Aquila nipalensis*), golden eagle (*Aquila chrysaetos*), imperial eagle (*Aquila heliaca*), osprey (*Pandion haliaetus*), short-toed eagle (*Circaetus gallicus*), and Saker falcon (*Falco cherrug*) (Abdunazarov 1987; Shernazarov and Lanovenko 1994).

PREVIOUS VIEW

FIGURE 2.3: Researchers have studied the effects of power line collisions on vulnerable species, such as the Ludwig's bustard of Europe, Asia, and Africa.

In Kazakhstan, researchers found 409 bird carcasses of 34 different species during a 2006 survey of power line mortality. Many deaths were due to electrocutions and 44% were raptors. Deaths due to collisions were also noted (Lasch et al. 2010).

The great bustard (*Otis tarda*), which once ranged from Manchuria to Portugal, is now extirpated or endangered across much of the continent because of habitat loss, disease, and mortality from power line collisions (Janss and Ferrer 2000; Garcia-Montijano et al. 2002; Alonso and Martin 2005). It is one of the world's heaviest flying birds with a maximum weight of 21 kilograms (46 pounds). As a result, great bustards maneuver slowly in flight and are not able to avoid wires spotted at the last moment. Collisions have been observed by researchers in Mongolia (Kessler 2007). The research group notes that great bustard collisions with power lines are a common occurrence in developed Western Europe and are becoming more frequent in China.

In South Africa, The Endangered Wildlife Trust has a Wildlife & Energy Program that coordinates and sponsors research on bird/power line interactions (EWT 2011) (see Appendix E). This includes a study on the vision characteristics of the Ludwig's bustard (*Neotis ludwigii*) and blue crane (*Anthropoides paradiseus*) with respect to their ability to see power lines while in flight and how to reduce the collision risk for these species. It also includes a range-wide study of the collision rates of the Ludwig's bustard.[5]

In Kenya, a 2009 risk assessment of bird interactions with electrical infrastructure identified several sites of high collision risk to birds of conservation concern. These species included the grey-crowned crane (*Balearica regulorum*), lesser flamingo (*Phoeniconaias minor*), white stork (*Ciconia ciconia*), secretary-bird (*Sagittarius serpentarius*), and a number of vultures and raptors (Smallie and Virani 2010).

[5] The range of the Ludwig's bustard includes Angola, Botswana, Lesotho, Namibia, and South Africa.

FUTURE RESEARCH PRIORITIES

As more power lines are built across the landscape, collision risk is anticipated to increase. Yet, this risk may be offset through assessment of potential avian impacts during siting and route selection, improved line marking devices and study methods, and increased awareness among stakeholders. With the continued growth in power line mileage, more collision research is needed. Because of the susceptibility of some endangered species, such as the whooping crane (*Grus americana*) and California condor (*Gymnogyps californianus*), power lines in these species' ranges will require careful evaluation and routing in addition to line marking devices and/or other collision reduction measures.

National and international collaboration on bird/utility interactions has increased markedly since the late 1990s. Guidelines for the development of Avian Protection Plans are a product of this collaboration (see Chapter 7). Electric utilities are increasingly adopting avian protection policies, plans, and conservation measures, and APLIC will continue to provide guidance on bird collision issues. Cooperation in addressing collision issues will continue between electric utilities and wildlife agencies. This relationship will advance the collision risk reduction measures discussed in this manual (see Chapters 5 and 6).

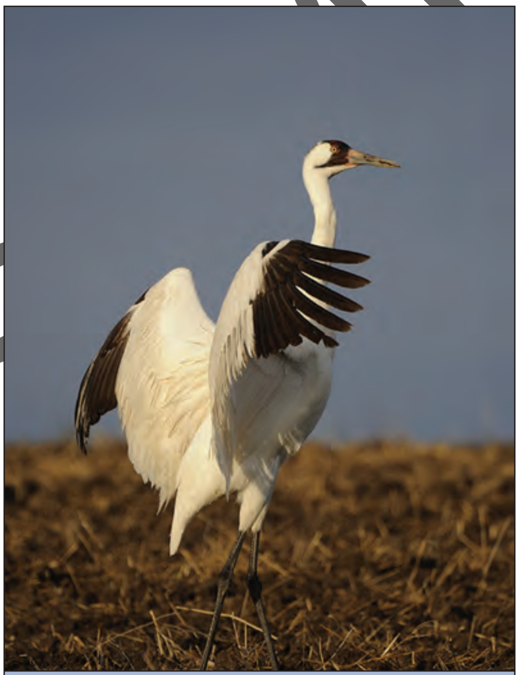

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FIGURE 2.4: Because of the susceptibility of some endangered species, such as the whooping crane, power lines in these species' ranges require careful evaluation and routing.

Regional and species-specific studies of collision mortality and methods for minimizing collisions would be especially helpful. At this time there is no organized attempt to understand the extent and magnitude of collision mortality from power lines. Current knowledge of collisions is geographically, regionally, and site biased because most studies have been conducted on lines with known collision problems. In addition, avian/power line collision risk is not uniformly distributed because it is highly dependent on species and habitat variables. Bevanger (1999) recommended several areas of investigation that combine well-planned observational studies with experimental studies rather than non-standardized collision records that cannot be scientifically or statistically compared. Recent studies on the effectiveness of line markers (e.g., Yee 2008 and Murphy et al. 2009) follow these recommendations. Standardized protocols for monitoring mortality at communication towers (e.g., Manville 2002, 2009b; Gehring et al. 2009) and wind turbines (e.g., CalWEA 2011) could also provide models that could be adapted for power line mortality assessments.

The effectiveness of line marking devices needs further study. In particular, more research is required to determine the device and spacing best suited to different environmental conditions and species. Except for studies sponsored by the CEC and APLIC (e.g., Ventana Wildlife Society 2009; Yee 2008; WAPA 2011) relatively few systematic studies have looked at the comparative effectiveness

PREVIOUS VIEW

of different line marking devices. Barrientos et al. (2011) conducted a meta-analysis of line marking studies, discussed the limitations, and provided recommendations for more scientifically rigorous evaluations. In addition, no systematic comparison of the effectiveness of these devices with different species, in different habitats, or in different weather conditions has been conducted. As new styles of line markers continue to be developed and existing markers are modified, associated effectiveness testing will be needed.

Funding Organizations for Collision Research

APLIC, EPRI, and CEC are three organizations that provide some funding for research on avian/power line interactions (see Appendix E). The USFWS conducts limited primary research and funds state research through Section 6 Endangered Species Act grants.

APLIC funds research projects that further the knowledge of avian/power line interactions including:

- Assessments of collision and/or electrocution rates associated with power lines
- Risk assessments to identify factors contributing to collisions and electrocution mortality risks for different species
- Evaluations of impacts of power line construction on bird species

EPRI's research priorities emphasize information and monitoring systems that will improve understanding of and mitigating for avian interactions with utility facilities. These include the Bird Activity Monitoring System and avian vision studies that may help develop more effective collision prevention devices.

The CEC (Hunting 2002) identified a number of research priorities that still apply today and need to be considered to better understand avian collisions with power lines. These include:

- Standardizing mortality estimation
- Testing and documenting the efficacy of line marking devices
- Testing and documenting the efficacy and limitations of remote collision detection devices
- Determining collision risk levels associated with potential high avian-use habitats
- Monitoring and reporting over the long term

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FIGURE 2.5: APLIC, EPRI, and CEC are three organizations that provide some funding for research on avian/power line interactions.

PREVIOUS VIEW

CHAPTER 3

Avian Regulations and Compliance

IN THIS CHAPTER

Most native North American birds are protected by the Migratory Bird Treaty Act. Additional statutes provide further protection for bald and golden eagles *(Haliaeetus leucocephalus* and *Aquila chrysaetos)* and birds that are threatened or endangered. This chapter describes United States' and Canada's federal regulations that protect these birds, their habitat, and the corresponding conservation and permitting measures.

OVERVIEW OF EXISTING LAWS AND POLICIES

UNITED STATES

Migratory Bird Treaty Act

The Migratory Bird Treaty Act of 1918 (MBTA) (16 U.S.C. 703–712) is the legal cornerstone of migratory bird conservation and protection in the United States. It is a strict liability statute, meaning that proof of intent is not required in the prosecution of a taking (injuring or killing) violation. Most actions that result in *taking* or possessing a protected species, its nest, parts, and/or eggs are violations.

The MBTA states: "Unless and except as permitted by regulations…it shall be unlawful at any time, by any means, or in any manner to pursue, hunt, *take*, capture, kill… possess, offer for sale, sell…purchase…ship, export, import…transport or cause to be transported…any migratory bird, any part, nest, or eggs of any such bird, or any product …composed in whole or in part, of any such bird or any part, nest, or egg thereof…."

Generally speaking, the MBTA protects the majority of birds that nest in North America (50 CFR 10.13). As of 2012 there were 1,007 bird species on the list of migratory bird species protected under the MBTA. The list includes waterfowl, shorebirds, seabirds, wading birds, raptors, and songbirds. The 1972 MBTA amendment extended protection to birds of prey—eagles, hawks, falcons, and owls—and to corvids, such as crows and ravens. However, the MBTA does not protect non-migratory upland game birds (such as grouse and quail) or introduced species such as house (English) sparrows (*Passer domesticus*), European starlings (*Sturnus vulgaris*), rock pigeons (common/feral pigeons, *Columba livia*), monk parakeets (*Myiopsitta monachus*), and 121 other less commonly encountered species that have been excluded from protection by the MBTA (USFWS 2005a [70 Fed. Reg. 49, 15 March 2005]).

PREVIOUS VIEW

FIGURE 3.1: The Migratory Bird Treaty Act of 1918 is the legal cornerstone of bird protection in the United States, protecting more than 1,000 North American bird species such as this cedar waxwing (*Bombycilla cedrorum*).

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An individual, which can mean a corporation or other organization, who violates the MBTA may be fined up to $15,000 and/or imprisoned for up to six months for a misdemeanor conviction. An individual who knowingly *takes* any migratory bird with the intent to sell, offer to sell, barter, or offer to barter such bird or who knowingly sells, offers for sale, barters, or offers to barter any migratory bird is subject to a felony violation with fines of up to $250,000 and/or imprisonment for up to two years. The MBTA has no provision for permitting incidental or accidental take.

Federal agencies taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations are directed by Executive Order 13186 (3 CFR 2001; Office of the President 2001. [66 Fed. Reg. 11, 17 January 2001]) to develop and implement a memorandum of understanding (MOU) with the U.S. Fish and Wildlife Service (USFWS) that shall promote the conservation of migratory bird populations.

This includes federal agencies' power line infrastructure-related collisions and electrocutions of protected birds. To date (2012), MOUs have been signed by the Department of Defense, Department of Energy, U.S. Forest Service, National Park Service, Bureau of Land Management, Minerals Management Service/Bureau of Ocean Energy Management, and the Federal Energy Regulatory Commission, with others under development.

Bald and Golden Eagle Protection Act

The Bald and Golden Eagle Protection Act of 1940 (BGEPA) (16 U.S.C. 668–668d) provides additional protection to these eagle species. If a proposed project or action would occur in areas where nesting, feeding, or roosting eagles occur, then utilities may need to take additional conservation measures to achieve compliance with the BGEPA.

The BGEPA prohibits the take, possession, sale, purchase, barter, offer to sell, purchase, or barter, transport, export or import, of any bald or golden eagle, alive or dead, including any part, nest, or egg, unless allowed by permit ([16 USC 668(a)]. *Take* under this statute is defined as "to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb" (50 CFR 22.3). *Programmatic take* is defined as "*take* that (1) is recurring, but not caused solely by indirect effects, and (2) occurs over the long-term and/or in a location or locations that cannot be specifically identified" (50 CFR 22.26). *Disturb* is defined as "to agitate, or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior" (50 CFR 22.3). Violators may be fined up to $100,000 and/or imprisoned for up to one year. Individuals with subsequent convictions or who commit intentional *takes* face penalties of up to $250,000 and/or two years imprisonment.

The BGEPA has been amended to provide a permit for non-purposeful *take,* including *take resulting in disturbance* and limited *take resulting in mortality* that may occur as a result of otherwise lawful activities, provided the breeding populations are stable or increasing. Because there are no breeding populations in the eastern United States that can sustain *take,* the USFWS will not authorize *take* for golden eagles east of approximately 100° west longitude, except for *take* of nests for safety emergency situations (USFWS 2009a).

FIGURE 3.2: Habitat Conservation Plans help landowners incorporate conservation measures for species, such as the wood stork (*Mycteria americana*), into their development plans.

Endangered Species Act

The Endangered Species Act of 1973 (ESA) (16 U.S.C. 1531–1544) protects the United States' native plants and animals that are in danger of becoming extinct and may also protect their habitats. Federal agencies are directed to use their authority to conserve listed and candidate[6] species and to ensure that their actions do not further jeopardize these species or adversely modify designated critical habitat for them. The law is administered by the USFWS and the National Marine Fisheries Service (NMFS). The USFWS has responsibility for terrestrial and freshwater organisms, while the NMFS oversees endangered marine life. These two agencies work with other agencies to plan or modify federal projects to minimize project impacts on listed species and their habitats. Protection is also gained through USFWS' financial and technical assistance partnerships with states, tribes, and private landowners.

Section 9 of the ESA makes it unlawful for a person to *take* a listed species. *Take* under the ESA is defined as "…to harass,[7] harm,[8] pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." The ESA authorizes the USFWS to issue Incidental Take Permits (ITP) for *take* resulting from otherwise legal activity.

Section 10 of the ESA allows Habitat Conservation Plans (HCP) for the con-

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6 *Candidate* species are those in decline which may be added to the list of threatened and endangered species in the near future.

7 Harass is defined as an intentional or negligent act or omission, which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly impair normal behavioral patterns including breeding, feeding, or sheltering (50 CFR 17.3).

8 Harm is defined as an act which actually kills or injures wildlife. Such acts may include significant habitat modification or degradation when it actually kills or injures wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering (50 CFR 17.3).

struction and management of facilities, e.g., transmission lines, on private lands that are used by endangered species. These plans help landowners incorporate conservation measures into their land and/or water development plans. Landowners who develop and implement HCPs can also receive ITPs that allow their activities to proceed with authorization for limited *take*.

State Policies and Regulations

States have additional bird protection regulations. A utility should consult with its respective state wildlife agency to determine whether more regulations apply and if permits are required.

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FIGURE 3.3: Canada geese (*Branta canadensis*) are protected by both the Migratory Bird Treaty Act and Canada's equivalent, the Migratory Birds Convention Act.

CANADA

Migratory Birds Convention Act

The Migratory Birds Convention Act (MBCA) of 1917 and amended 1994 (1994, c.22) is Canada's equivalent of the United States' MBTA (1918), which provides legal protection for migratory birds. One notable exception is raptors, which are protected by provincial and territorial wildlife acts instead of MBCA. The MBCA satisfies the terms of the Migratory Birds Convention of 1916, when both countries recognized concerns about overhunting waterfowl and shorebirds. The MBCA recognizes three classifications of protected birds: migratory game birds, migratory insectivorous birds, and migratory non-game birds. It further lists them by family and gives examples.

In Canada, the MBCA is administered by the Wildlife Enforcement Division of Environment Canada in cooperation with provincial and territorial governments. Enforcement of the Act is made in concert with the Canadian Wildlife Service (CWS), Royal Canadian Mounted Police, and provincial and territorial enforcement authorities.

The MBCA and its associated regulations state that "No person shall hunt a migratory bird except under authority of a permit," and "Subject to subsection 5(9), no person shall (a) disturb, destroy, or *take* a nest, egg, nest shelter, eider duck shelter or duck box of a migratory bird, or (b) have in his possession a live migratory bird, or a carcass, skin, nest or egg of a migratory bird."

Individuals, which includes corporations, who violate the MBCA and associated regulations may be subject to a fine of up to $300,000 and/or six months imprisonment. Upon summary conviction or upon indictment, fines of up to $1,000,000 and/or two years imprisonment may be applied.

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Species at Risk Act

The Canadian Species at Risk Act (SARA) was enacted in 2003. The objective of SARA is to protect native species from extinction, ensure measures are taken for the recovery of threatened or endangered species, and encourage best management practices for maintaining healthy populations.

SARA adopted the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as an advisory body to assess potentially at-risk wildlife species, identify existing and potential threats to the species, and classify the status of the species (i.e., extinct, extirpated, endangered, threatened, of special concern, or not currently at risk). Established in 1977, COSEWIC is an independent committee of wildlife experts and scientists from federal, provincial and territorial governments, universities, and non-government organizations that uses the best available science to support its recommendations. Under SARA, the government of Canada will take COSEWIC's designations into consideration when establishing the legal list of wildlife species at risk (COSEWIC 2009).

SARA states that "No person shall kill, harm, harass, capture or *take* an individual of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species." However, SARA does make allowance for the incidental *take* of animals through the issuance of permits (similar to the ESA in the United States).

Provincial Policy and Regulations

Federal and provincial governments have worked together to develop complementary policy and programs to protect species at risk. For example, the Alberta Wildlife Act and Regulations seek to protect wildlife whereby "a person shall not hunt wildlife unless the person holds a licence authorizing the person, or is authorized by or under a licence, to hunt wildlife of that kind." The legislation also states that "a person shall not wilfully molest, disturb or destroy a house,[9] nest or den of prescribed wildlife" where wildlife is defined as "big game, birds of prey, fur bearing animals, migratory game birds, non game animals, non-licence animals and upland game birds." Similarly, other provinces have enacted legislation for the protection of wildlife, including birds.

INTERNATIONAL POLICIES AND AGREEMENTS

Since 2000, there has been an increasing international awareness of the issue of bird collisions for certain species. International conventions and policies (see CMS 2011a) that are relevant to bird collisions include:

- Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA)
- Convention on Biological Diversity (CBD)
- Ramsar Convention on Wetlands, List of Wetlands of International Importance
- Convention on the Conservation of Migratory Species of Wild Animals (CMS)
- MOU on the Convention of Migratory Birds of Prey in Africa and Eurasia
- MOU on the Conservation and Management of the Middle-European Population of the Great Bustard
- Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention)
- Various European Union Directives

These agreements have resulted in research, reviews, and guidance on bird collisions that may provide some further insight into bird collisions.

[9] The term "house" includes artificial structures such as bird boxes and nesting platforms.

PERMIT REQUIREMENTS

UNITED STATES

Federal and state permits may be required for activities that may affect species protected by the MBTA, BGEPA, ESA, or state laws. For species protected by the MBTA, utilities are encouraged to contact their regional USFWS Migratory Bird Permit Office and their state wildlife agency to identify permit requirements and, if necessary, obtain permit applications. For species protected by the ESA and BGEPA, utilities must contact their USFWS Ecological Services field office.

Migratory Bird Permits

Migratory bird permits are issued by the regional USFWS Migratory Bird Permit Offices. Permits are issued for falconry, raptor propagation, scientific collection, rehabilitation, conservation education, migratory game bird propagation, salvage, *take* of depredating birds, taxidermy, waterfowl sale and disposal, and special purpose. Annual reporting to the USFWS is required as a condition of each permit. Policy for migratory bird permits is developed by the Division of Migratory Bird Management. The regulations governing migratory bird permits can be found in 50 CFR part 13, General Permit Procedures, and 50 CFR part 21, Migratory Bird Permits.

In 2003, the USFWS issued a memorandum clarifying the definition of *take* under the MBTA as it applies to active nests (nests containing eggs or young). Under the MBTA, the collection, possession, and transfer of inactive bird nests requires a permit, but the destruction of nests that do not contain eggs or birds is permissible. This does not apply to eagles or species listed by the ESA, whose active and inactive nests are protected. The memo also stated that the USFWS may issue permits for the removal of occupied nests when public safety is at risk (see 50 CFR 21.27).

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FIGURE 3.4: Most songbirds, such as these horned larks *(Eremophilia alpestris)*, are protected by the Migratory Bird Treaty Act.

Bald and Golden Eagle Permits

BGEPA permits are administered by the regional USFWS Migratory Bird Permit Offices in coordination with the Division of Migratory Bird Management's Washington, D.C. office and the local Ecological Services field office where an eagle *take* might occur.

Under BGEPA (50 CFR parts 22.26 and 22.27), the USFWS can issue permits to *take* bald eagles and golden eagles or their nests, where the *taking* is associated with, but not the purpose of, the activity and cannot practicably be avoided. Permits may be authorized for non-purposeful *take*, which includes *take resulting in disturbance* or limited *take resulting in mortality* provided the breeding populations are stable or increasing. USFWS will not issue golden eagle *take* permits east of the 100° meridian (see BGEPA discussion on page 22).

USFWS may also issue permits for programmatic *take* (e.g., recurring *take* for an entire power line over a specified amount of time) or for individual *take* (e.g., for disturbance due to one-time construction of a power line where the location of the *take* and when it will occur are known). *Programmatic take* permits may be issued to entities, such as electric utilities or transportation providers, that may currently *take* eagles in the course of

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FIGURE 3.5: Bald eagles are protected under the Bald and Golden Eagle Protection Act and the Migratory Bird Treaty Act.

otherwise lawful activities but who can work with the USFWS to develop and implement advanced conservation practices (ACPs). ACPs are defined as "scientifically supportable measures that are approved by the Service and represent the best available techniques to reduce eagle disturbance and ongoing mortalities to a level where remaining *take* is unavoidable" (50 CFR 22.3).

The regulations are intended to provide a mechanism—under carefully considered circumstances—where non-purposeful *take* of bald and golden eagles can be legally authorized. How-ever, BGEPA provides the Secretary of Interior with the authority to issue eagle *take* permits only if it is able to determine that the *take* is compatible with eagle conservation. This must be "…consistent with the goal of increasing or stable breeding populations."

Regulation establishes the issuance of permits for removing eagle nests where (1) necessary to alleviate a safety emergency to people or eagles, (2) necessary to ensure public health and safety, (3) the nest prevents the use of a human-engineered structure, or (4) the activity or mitigation for the activity will provide a net benefit to eagles (50 CFR 22.27). Only inactive nests may be *taken* except in the case of safety emergencies. Inactive eagle nests are defined by the continuous absence of any adult, egg, or dependent young at the nest for at least 10 consecutive days leading up to the time of *taking* the nest.

Special Purpose or Salvage or Miscellaneous Permit

In compliance with federal regulations, utilities may need certain permits to handle or "possess" injured or dead birds found along power lines. Salvaging and possessing carcasses of birds protected under the MBTA requires a Federal Special Purpose or Salvage or Miscellaneous Permit (50 CFR 21.27). This permit allows the burial or incineration of migratory birds found dead on a utility property or temporary possession for transporting to a suitable disposal location, rehabilitation facility, repository, or wildlife pathology laboratory. Permit conditions may vary but if the bird is a federally endangered or threatened species or eagle, most permits require the USFWS to be notified within 48 hours of discovery of the carcass. Depending on permit requirements, a quarterly and/or an annual report must be submitted to the USFWS regional permit office.

Endangered Species Act Consultation, Incidental Take Permit (ITP), and Habitat Conservation Plan (HCP)

When utilities propose the construction of, for example, power generation or transmission facilities where a federal nexus exists (i.e., on federal lands, with federal funding, or requiring federal authorization or permits), they must first consult with the USFWS through Section 7 of the ESA if any threatened or endangered species may be at risk. Before initiating an action, the federal agency owning the land or providing the funding or the non-federal permit applicant (e.g., an electric utility) should ask the USFWS to provide a list of threatened, endangered, proposed, and candidate species and designated critical habitats that may be present in the project area. The USFWS has developed a handbook that describes the consultation process in detail (USFWS and NMFS 1998). Based on a Biological Assessment, an ITP may be issued under Section 7 of the ESA.

When non-federal activities (i.e., lacking a federal nexus) will or may *take* threatened or endangered species, an ITP is required under Section 10 of the ESA. Approval of an ITP issued in conjunction with an HCP requires the Secretary of the Interior to find, after an opportunity for public comment, that among other things, the *taking* will be incidental and that the applicant will, to the maximum extent practicable, minimize and mitigate the impacts of such *taking*. An HCP must accompany the application for an ITP. The HCP associated with the permit is to ensure that conservation measures are adequate for avoiding jeopardy to the species or adversely modifying critical habitat. Information about consultations and HCPs can be obtained by contacting the local USFWS Ecological Services field office.

CANADA

Both MBCA and SARA provide for permitting and authorization of incidental *take* of migratory birds and species at risk. However, for MBCA, the Canadian government, through the CWS, has declared that they will not develop the permitting system; instead they recommend that companies use due diligence to prevent incidental impacts to migratory birds through best management practices.

SARA does provide for incidental harm to a species or destruction of its critical habitat under carefully controlled circumstances provided the activity does not jeopardize the survival or recovery of the species. These provisions include permits (three-year duration) or agreements (five-year duration). These authorizations are tied to strictly prescribed conditions. The government continues to work with stakeholders to develop operational policies to better implement SARA.

The requirement to protect critical habitat for migratory birds only applies in federal lands such as national parks, national wildlife areas, and bird sanctuaries. For critical habitat located in federally protected lands, the prohibition on destruction of this habitat applies automatically once the Environment Minister posts a description of the critical habitat in the Canada Gazette (typically within 90 days after the recovery strategy/action plan is posted to the SARA Public Registry).

The Environment Minister can recommend that the Cabinet protect a migratory bird species and/or the critical habitat of a species not on federal land if there is reason to believe the province or territory is not sufficiently protecting the species. However, the decision by the Cabinet to order protection is discretionary. There is also a species and habitat harm exemption clause in SARA for activities that have been authorized by other permits or agreements. This clause has not been implemented to date (2012).

CHAPTER 4

Understanding Bird Collisions

IN THIS CHAPTER

Understanding the nature of bird collisions is essential for minimizing and mitigating them. This chapter presents what is known about bird collisions including the susceptibility of certain species, variability in reported mortality rates, biological significance of collision mortality, and the biological, environmental, and engineering factors that influence collision risk.

Some bird species have a greater collision risk than others. Because of the need for power lines to deliver electricity, engineering design requirements, and potential interaction of birds with power lines, collisions cannot be eliminated, but they can be reduced. The understanding of bird collisions has grown since 1994 and revolves around the following principles:

- Exposure to collisions is largely a function of behavior. Specific behaviors (such as flushing, courtship displays, and aerial hunting) may distract birds from the presence of power lines.
- Exposure is increased for birds that make regular and repeated flights between nesting, feeding, and roosting areas in proximity to power lines.
- Susceptibility to collisions is partially a function of wing and body size and vision. Larger, heavy-bodied birds with short wing spans and poorer vision are more susceptible to collisions than smaller, lighter-weight birds with relatively large wing spans, agility, and good vision.
- Environmental conditions (such as inclement weather and darkness) may distract birds from the presence of power lines or obscure their visibility.
- Engineering aspects, including design and placement, can increase or decrease the exposure for collisions.

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SUSCEPTIBILITY OF BIRDS TO POWER LINE COLLISIONS

Summaries of studies on birds' susceptibility to collisions have primarily come from Europe (see Bevanger 1998; Janss 2000; Rubolini et al. 2005). Based on the Bevanger (1998) summary of risk, the orders of birds reported to be most susceptible to collisions included:

- Gaviforms (e.g., loons)
- Podicipediformes (e.g., grebes)
- Procellariiformes (e.g., shearwaters, albatross, petrels)
- Pelecaniformes (e.g., pelicans, cormorants)
- Cicioniformes (e.g., storks, ibis, herons)
- Anseriformes (e.g., ducks, geese)
- Falconiformes (e.g., hawks, eagles)
- Galliformes (e.g., grouse)
- Gruiformes (e.g., rails, cranes)
- Charadriformes (e.g., gulls, terns)
- Apodiformes (e.g., swifts)
- Columbiformes (e.g., pigeons, doves)
- Strigiformes (e.g., owls)
- Passeriformes (e.g., song birds)

The reasons for this susceptibility are functions of species characteristics, in particular the birds' body size, weight, wing shape, flight behavior, and nesting habits (see *Biological Characteristics Influencing Avian Collision Risks* on page 36). For example, literature shows that, in general, birds of prey are good fliers, have the ability to avoid obstacles, and are not prone to collisions. It is when they are engaged in certain activities (e.g., territorial defense, pursuing prey) that their collision risk increases (see Harness et al. 2003; Olendorff and Lehman 1986).

IDENTIFYING COLLISION MORTALITY

Reporting bird injuries and mortalities is part of the U.S. Fish and Wildlife Service (USFWS) permit requirements (see Chapter 3) and permits are an element of utility Avian Protection Plans (APPs; see Chapter 7). In order to report mortalities correctly, the affected species and the cause (collision or electrocution) needs to be properly identified. Field guides can be used to identify the bird species, and a guide for identifying raptor remains is also available (CEC 2005). The U.S. Geological Survey's National Wildlife Health Center also provides information and technical assistance for identifying bird carcasses (USGS 2011). See Appendix E for resources.

Table 4.1 lists the typical damage evident in bird carcasses from collision injuries. Electrocution injuries often occur as burn marks on the feathers and feet (see APLIC 2006). Collisions can also lead to electrocutions

TABLE 4.1: Typical evidence of bird injuries or mortalities from power line collisions.*

Evidence	Description
Predominant bone fractures	Fractured wings, legs, shoulder bones, vertebra, or skull; torn off limbs
Damage to plumage	Mechanical damage, such as torn off or broken feathers
Skin injuries	Skin torn open or off, and open muscle, sinew, and bone tissue visible; power line may leave imprint in skin where the bird struck the line; necropsy may reveal internal bleeding and bruising
Secondary damage to extremities	Limited areas of infection at open wounds, bones, sinews, and muscles
General condition of injured birds	State of shock; handicapped by injuries and secondary damage

* Source: Adapted from BirdLife International (2003)

(called collision-electrocutions) if the bird's size is sufficient to make simultaneous contact with two phase conductors or with a phase conductor and grounded equipment, or if the collision causes two lines to slap together or get close enough to cause an electric arc.

VARIABILITY IN REPORTED MORTALITY RATES

It is difficult to extrapolate collision risk from one study and apply it to other power lines or compare it with other studies because of site-specific conditions and varying study methods and metrics. Likewise, many collision studies have been conducted in high risk areas and would not be applicable to lower risk areas. Numerous authors have summarized collision mortality with power lines (e.g., Faanes 1987; Bevanger 1998; Alonso and Alonso 1999; Rubolini et al. 2005; and Jenkins et al. 2010) and report mortality rates ranging from no birds killed to several hundred birds killed along a given segment of line per year. The California Energy Commission (CEC) study (Hunting 2002) provides a summary of collision mortality rates per unit area per distance. Reported mortality rates are highly variable and do not lend themselves to extrapolation to other lines because of site- and study-specific differences in:

- Species involved, such as ducks and sandhill cranes (*Grus canadensis*)
- Habitats, such as wetlands and agriculture
- Time periods and sampling regimes, such as single seasons versus multiple seasons
- Weather conditions, such as fog, wind, etc.
- Sampling biases, such as scavenger removal rates and searcher efficiency
- Types of power lines

Another limit to extrapolating bird/power line collision mortality estimates is the tendency to select worst-case scenarios as case studies (e.g., Koops 1987; Erickson et al. 2001; Manville 2005a). The CEC study (Hunting 2002) points out the difficulty in generalizing collision rates, and Bevanger (1999) provides an excellent summary of the

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FIGURE 4.1: Collision risk is highly variable among species, with heavy-bodied birds, such as this common loon (*Gavia immer*), being more vulnerable because they cannot readily maneuver.

Bibliographies of Collision Literature

Appendix A of this manual includes the literature cited and a bibliography of collision literature. An annotated bibliography of early collision literature was provided by Avery et al. (1980). In addition, the California Energy Commission hosts a searchable database on collisions: *On-Line Annotated Bibliography of Avian Interactions with Utility Structures* (CEC 2011).

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methodological issues in calculating these rates. For example, Faanes' (1987) calculation of 125 collisions/kilometer(km)/year (0.62 miles[mi]/year) for a line near a North Dakota wetland with abundant waterfowl during migration periods has been referenced by others including Bevanger (1999) and Erickson et al. (2005). Janss and Ferrer (2000) calculated collision rates of "one of the densest breeding populations of the great bustard (*Otis tarda*) in Spain," and for a large wintering population of common cranes (*Grus grus*) feeding in grain fields. Extrapolations from these studies could lead to exaggerated overestimates.

Adding to the difficulty in providing an overall assessment of collision mortality is that bird collisions do not usually cause power outages and consequently are not usually discovered. On the other hand, electrocutions are more likely to cause power outages and be reported (see APLIC 2006). To generate collision estimates for a particular power line, power line segments have to be selected randomly for mortality monitoring and should represent a diversity of habitats. Collision mortality can be relatively high or low depending upon the species, habitat, and the local circumstances. Appendix B provides recommendations for collision monitoring studies.

BIOLOGICAL SIGNIFICANCE OF COLLISION MORTALITY

Understanding the biological significance of collision mortality is necessary for developing proper reduction strategies. Collision mortality may have significance from social, wildlife policy, and biological points of view. Social and wildlife policy aspects relate to how the public and wildlife agencies consider collision mortality. The biological aspects relate to how the mortality affects bird populations. The social or wildlife policy assumption of significance is not necessarily biologically significant.

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FIGURE 4.2: Because of their higher reproductive rates, common bird species are generally at less risk of population effects from power line collisions.

From a biological perspective, significance evaluates whether collision mortality will affect the viability of a species' population. Biological significance results from an influence that significantly affects the ability of a species' population to sustain itself or increase its size.

This definition is used by population biologists to understand the influence of an adverse effect on a particular population or species. During site evaluation studies, utility biologists need to be aware of the possible impacts to rare species and to determine if the line would create a biologically significant risk as well as significant risk from a wildlife policy perspective (see Chapter 3).

Drewitt and Langston (2008) conclude that few studies of bird collisions with power lines show that collisions are biologically significant, which means individual losses from collision mortality are unlikely to affect large and robust populations. As an independent mortality factor, the effect of power line collisions on bird populations is generally thought to be compensated for in populations that have high reproductive rates (Bevanger 1998).

Biologically significant risk from collisions may occur in a population that is so small that the loss of a few individuals may impact local, rare, or endangered populations (Crowder 2000). Power line collisions may be significant to very small and/or declining populations, as they may not be capable of compensating for this loss (Bevanger 1998). Drewitt and Langston (2008) note that low reproductive rates and small populations of some species may further contribute to the likelihood of population effects. In addition, there are examples where collision mortality has occurred locally and concern has been expressed. Although not a federally endangered species, recent studies of sandhill cranes in Nebraska have shown that local populations can be affected by collision mortality (Murphy et al. 2009). Collisions during spring migration stopovers at major night roosts along the Platte River in Buffalo County, Nebraska, have been historically high near two 69-kilovolt (kV) transmission lines. The Newell's shearwater (*Puffinus auricularis newelli*), an endangered species in Hawaii, is an example of a species with a relatively small and restricted population that is threatened by multiple factors including power line collisions (Podolosky et al. 1998). Other threats include ground nest predation by dogs, cats, rats, pigs, and mongooses; collisions with buildings, cars, and other objects; and attraction to lights that may disorient them and cause them to fly around the light until they fall from exhaustion. Power line collisions appear to be a major contributor to the threats to Newell's shearwater's survival (Podolosky et al. 1998; Day et al. 2003; R. Podolosky, pers. comm.).

Outside North America, collision mortality is considered biologically significant for these species with low population numbers:

- Red-crowned cranes (*Grus japonensis*) in Japan (Archibald 1987, cited in Crowder 2000)
- Wattled cranes (*Bugeranus carunculatus*) in South Africa (Van Rooyen and Ledger 1999, cited in Crowder 2000)
- Capercaillie (*Tetrao urogallus*) in Norway (Bevanger 1995; Bevanger and Broseth 2004)
- Dalmatian pelicans (*Pelecanus crispus*) in northern Greece (Crivelli et al. 1988, cited in Drewitt and Langston 2008)
- Bonelli's eagle (*Aquila fasciata*) in Spain (Mañosa and Real 2001)
- Sarus crane (*Grus antigone*) in India (Sundar and Choudury 2005)
- Eagle owl (*Bubo bubo*) in Sweden (Herren 1969)
- Mute swans (*Cygnus olor*) in the United Kingdom (Kelly and Kelly 2005)

In the United States, collision mortality from power lines is considered biologically significant for two species with small populations: the whooping crane (*Grus americana*) and the California condor (*Gymnogyps californianus*).

WHOOPING CRANE

Losses of wild and reintroduced (or experimental) whooping cranes to power line collisions have been reported (Crowder 2000; Brown et al. 1987; Morkill and Anderson 1991; Stehn and Wassenich 2007). The one natural wild population, the Aransas-Wood Buffalo Population (AWBP), has been subjected to significant natural causes of mortality such that additional collision mortality is viewed as a threat to the species. The loss of 57 cranes (21.4% of the flock of 266) that died of starvation and infectious disease in the 12 months following spring 2008 (34 between spring and fall, 23 during the winter) was a serious setback (T. Stehn, pers. comm.). The additional loss of more than 10 birds per year for any reason could destabilize this species' recovery. However, the population has shown resilience with 279 whooping cranes at the Aransas National Wildlife Refuge in the spring of 2011 (T. Stehn, pers. comm.) compared to 247 in the spring of 2009.

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FIGURE 4.3: The United States' population of endangered whooping cranes has had such significant mortality from natural causes that additional power line collision mortality is now viewed as a threat to the species.

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The actual percentage of whooping crane mortality caused by collisions with power lines is hard to extrapolate for the AWBP because monitoring the small population during migration over such a large area (Figure 4.4)[10] is so difficult. In the 1980s, two of nine radio-marked juvenile whooping cranes in the AWBP died within the first 18 months of life as a result of power line collisions; that is 33% of total post-fledging losses (n = 6) of the radio-marked birds during the study (Kuyt 1992). Five of 13 known causes of mortality (38%) for the AWBP between April and November from 1950 to 1987 resulted from collisions with power lines (total mortality from all causes equaled 133 cranes) (Lewis 1992).

Collisions have been reported in other whooping crane populations as well. In the non-migratory Florida population, 20 out of 166 cases with known causes of mortality (12%) were from collisions with power lines, and in the migratory Wisconsin population, 3 out of 18 mortalities (17%) were from collisions with power lines (Stehn and Wassenich 2007). From 1950 to 2008, out of 508 fledged whooping cranes that have died, only 44 (8.7%) of the carcasses were recovered (C. Strobel, USFWS, unpubl. data). Of the 44 carcasses recovered, no cause of death could be determined for 17. Of the remaining 27 carcasses where a cause of death was established, 9 (33%) were from power line strikes and 18 (67%) were from other causes (e.g., disease, predators, and shooting).

[10] The whooping crane migration corridor is 322 km (200 mi) wide and extends 4,023 km (2,500 mi) from Wood Buffalo National Park in the Alberta and Northwest territories in Canada to the Aransas National Wildlife Refuge on the Gulf Coast of Texas (see Stehn and Wassenich 2007).

CALIFORNIA CONDOR

The federally endangered California condor was rescued from extinction when the last remaining wild individuals were captured from the mountains of southern California in 1987 to establish a captive breeding and reintroduction program. In 1991, reintroduction of captive-bred individuals began in select areas of the southwestern United States. As of December 2011, the total wild population of California condors was 210 individuals (NPS 2011). Reintroduced individuals from the captive breeding program have come into contact with power lines and collision mortality has occurred. For example, in a six-month period, three of eight condors that died in the wild died after colliding with power lines (D. Pearson, pers. comm.).

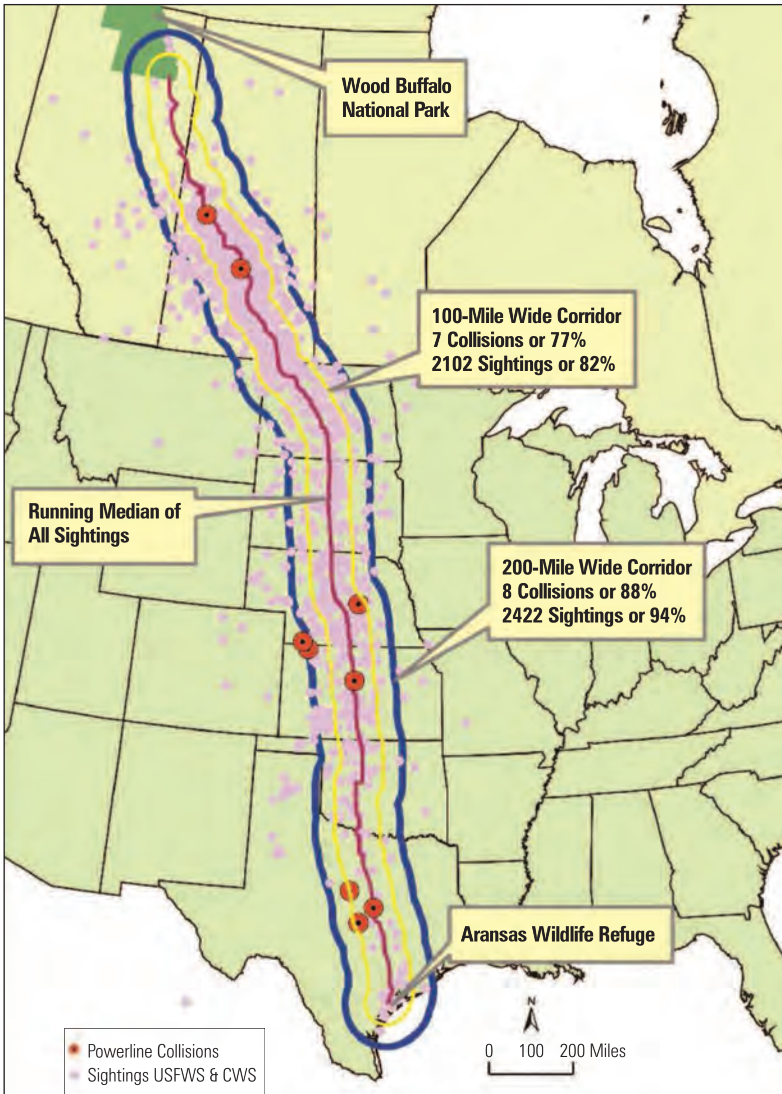

FIGURE 4.4: Whooping crane migration corridor in North America (2005 data from Stehn and Wassenich 2007).

FIGURE 4.5: Collision mortality has occurred with the expansion of the reintroduced population of the endangered California condor.

BIOLOGICAL CHARACTERISTICS INFLUENCING AVIAN COLLISION RISKS

Different bird species have different collision risks based on their biology, behavior, habitat use, and inherent abilities to avoid risk (e.g., Savereno et al. 1996) (see *Susceptibility of Birds to Power Line Collisions,* page 30). A number of biological characteristics influence the susceptibility of species to collisions with power lines:

- Body size, weight, and maneuverability
- Flight behavior
- Vision
- Age and sex
- Health
- Time of day and season
- Habitat and habitat use

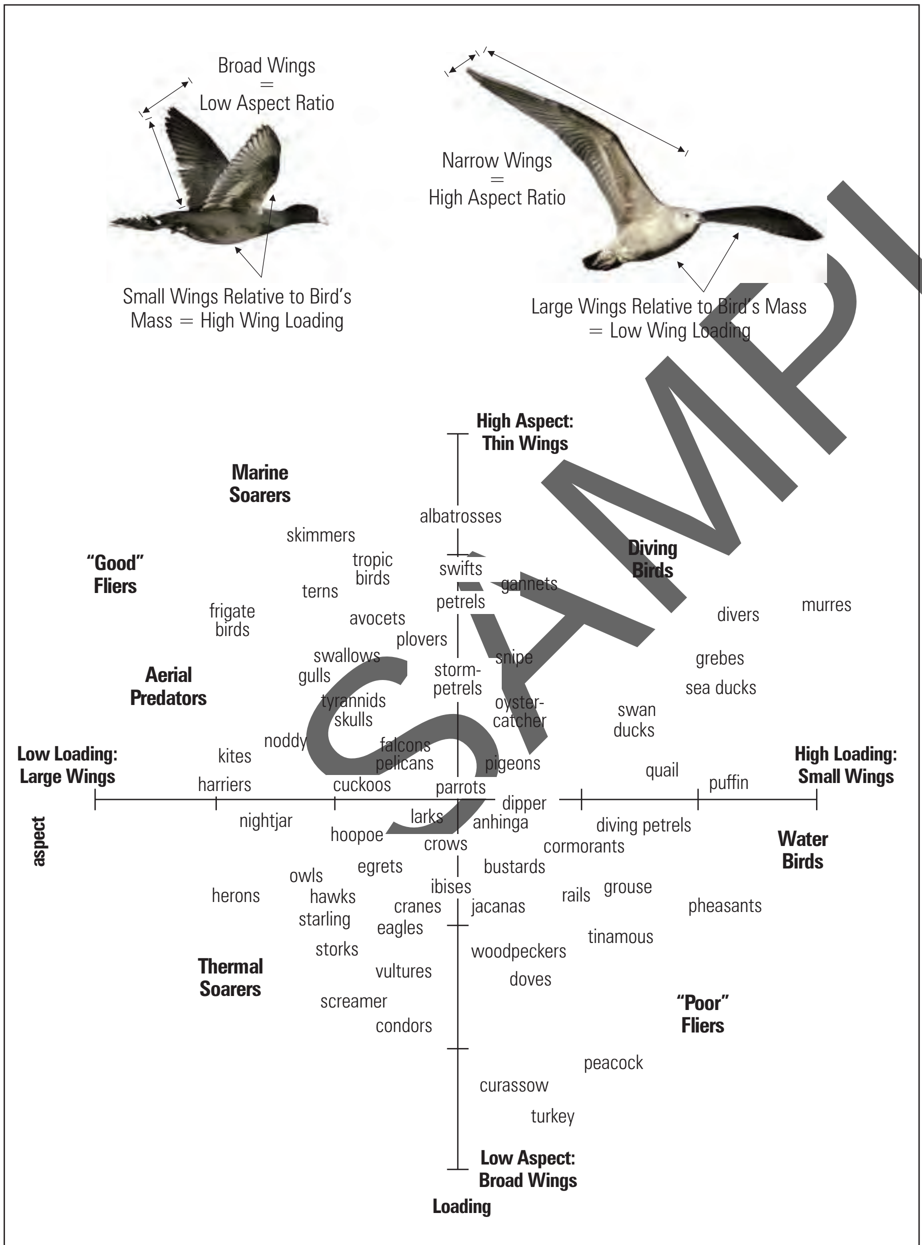

FIGURE 4.6: Wing loading and aspect ratio, among other factors, influence susceptibility to collisions (after Bevanger 1998).

Knowing what avian species are involved, when they are present, and how they use the habitat along a power line route will help to estimate risk.

BODY SIZE, WEIGHT, AND MANEUVERABILITY

Several studies of collision vulnerability have addressed the relationship between bird size and maneuverability (e.g., Bevanger 1994, 1998; Janss 2000; Crowder and Rhodes 2002; and Rubolini et al. 2005). They classified birds based on weight and with these characteristics quantified wing loading (the ratio of body weight to wing area) and wing aspect ratio (ratio of the square of the wing span to the wing area) (Figure 4.6). Using Rayner's characterization (Rayner 1988), bird species were grouped according to the relationship of wing loading and wing aspect ratio and analyzed for collision susceptibility (Bevanger 1998). He developed six categories: poor flyers, waterbirds, diving birds, marine soarers, aerial predators, and thermal soarers. Bevanger (1994, 1998), Janss (2000), Crowder and Rhodes (2002), and Rubolini et al. (2005) have also evaluated different species and their collision susceptibility using wing loading and wing aspect ratio. They found in general that birds

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with high wing loading are more susceptible to collisions than birds with low wing loading; and that birds with low aspect ratios are more susceptible than birds with high aspect ratios. Birds with high wing loading and low aspect ratios represent poor fliers. Bevanger (1998), supported by Janss (2000) and Rubolini et al. (2005), also found this to be true.

High wing loading birds are frequently reported as collision casualties, including large, heavy-bodied birds with large wing spans such as herons (Mead et al. 1979), cranes (Walkinshaw 1956; Tacha et al. 1979; Brown et al. 1987), swans (Banko 1956; Beer and Ogilvie 1972), pelicans (Willard et al. 1977), and condors (D. Pearson, pers. comm.). These and similar species generally lack the maneuverability to quickly avoid obstacles.

Heavy-bodied, fast fliers are also vulnerable to collision. This characteristic is typical of most waterfowl, coots, rails, grebes, pigeons and doves, and many shorebirds (e.g., sandpipers and plovers). For example, waterfowl accounted for the majority of collision mortality at a site in the San Luis Valley, Colorado (Brown and Drewein 1995). Researchers have also noted that species with long legs and necks collide more often than those with more compact profiles (NUS Corporation 1979, unpubl., cited in Hunting 2002).

In comparison, terns with low wing loading and smaller body size are considered agile fliers and have a keen ability to avoid lines despite their high potential exposure. Henderson et al. (1996) found only two casualties beneath wires in a study of a common tern (*Sterna hirundo*) colony located within an industrial complex, where birds of all age classes and both sexes were making hundreds of flybys per hour (>10,000 flybys observed).

Body size and maneuverability do not explain all collision risk. Other factors can also contribute. For example, gulls and terns have low wing loading, yet they can be subject to collisions because of behavioral

FIGURE 4.7: Birds with high wing loading, such as swans, are more susceptible to collisions.

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characteristics, such as flocking, spending large amounts of time in the air, and flying at night. Although the low wing loading (light body) gives gulls and terns a more buoyant, graceful, and potentially slow flight speed, they are over-represented in Janss' mortality data set because of their large abundance at his study sites. This point is also made by Bevanger (1998) who cites observational studies by Meyer (1978), James and Haak (1980), and Beaulaurier (1981) to assert that gulls were 50 to 100 times less likely to collide with power lines when compared with ducks.

Passerines (songbirds) were reported in Bevanger (1998) to have a great deal of variation in flight morphology, yet most are not particularly heavy bodied or thin winged. Certain songbirds such as European starlings (*Sternus vulgaris*) may be so abundant that their representation among power line collision casualties may actually be attributed to abundance rather than susceptibility (Janss 2000). On the other hand, passerine carcasses are so small that they are much more difficult to discover and may be under-reported (Scott et al. 1972, cited in Drewitt and Langston 2008).

FLIGHT BEHAVIOR

Understanding the flight behavior of birds active near a power line can be useful in identifying the potential risk for collisions and how those risks might be reduced. The following flight behaviors have been reported in the literature (e.g., Drewitt and Langston 2008) as influencing collision risk:

- Flocking
- Flight altitude patterns of migrating and non-migrating birds
- Courtship, nest building, and feeding flights to and from and around the nest, especially for colonial species
- Flight ability of fledglings and juveniles
- Flights between nesting/roosting and foraging areas

Flocking species, such as waterfowl and wading birds, are more vulnerable to collisions than solitary species (Bevanger 1998; Crowder 2000; Crowder and Rhodes 2002; Drewitt and Langston 2008). The density of large flocks leaves little room to maneuver around obstacles; in fact, birds sometimes collide with each other when panicked (Brown 1993). Bevanger (1998) and Drewitt and Langston (2008), citing several studies, conclude that flocking behavior may lead to greater susceptibility, as trailing birds have obstructed views of an upcoming obstacle. Crowder (2000) and Crowder and Rhodes (2002) observed that flocks react to power lines at a greater distance from the line than do solitary birds. Scott et al. (1972) and James and Haak (1980) stated that flocking behavior was an important factor in starling collisions, as did Blokpoel and Hatch (1976) for snow geese (*Chen caerulescens*). A number of birds within large flocks of sandhill cranes were involved in power line collisions in the Platte River area, Nebraska; in several instances collisions of some birds within flocks were observed (Murphy et al. 2009).

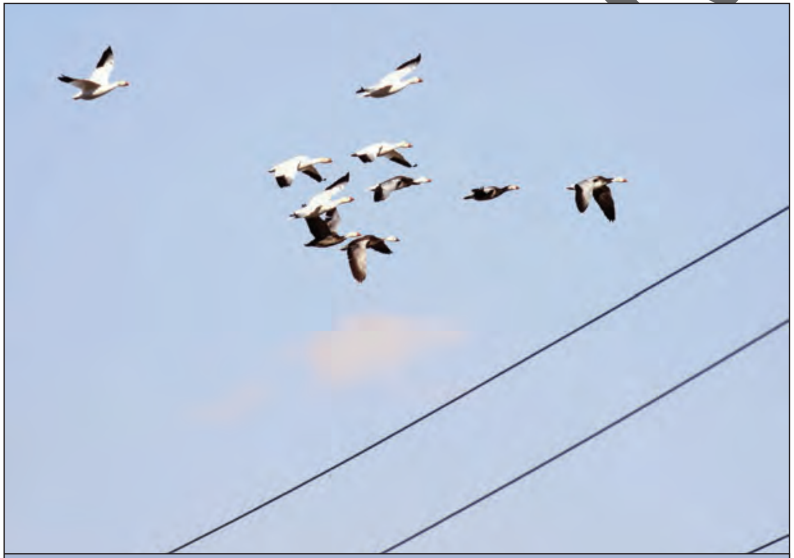

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FIGURE 4.8: Flocking species, such as these snow geese, can be more vulnerable to collisions.

Flight altitude is a function of species and environmental conditions such as winds, thermal conditions, visibility, precipitation, and time of day, as well as the type of flight (Newton 2008). Two types of bird flight altitude are observed: migrating or non-migrating.

Migrating birds take advantage of thermals and stronger tail winds when conditions permit, allowing them to conserve energy (Newton 2008) while staying well above power lines. In general, flight altitudes of migrating birds range from a couple hundred meters (m) (several hundred feet [ft]) to more than 6,000 m (20,000 ft). Weather conditions (e.g., wind speed and direction) influence flight altitude of migrants (see *Weather Conditions and Visibility*, page 48). Most transmission towers in the United States range from 15.2 m (50 ft) to less than 60.9 m (200 ft)[11] high depending upon design and voltage. If a

[11] Some structures exceed 61 m (200 ft) in height especially at river crossings and to clear other lines that might otherwise intersect (M. Schriner, pers. comm.; D. Bouchard, pers. comm.).

bird's flight altitude is at or below the height of power lines, collision risk can increase.

There are two basic types of migrating birds: long distance and daily migrants. Long distance migrants can fly thousands of kilometers (miles) without stopping and will have the least exposure to power lines during migration (e.g., some shorebirds, swallows, swifts, and terns). Most long distance migrants migrate at night, resting and feeding during the day (Manville 2007a). Daily migrants take shorter flights and make numerous stops to rest and feed (Newton 2008). Daily migrants include cranes, ducks, geese, and raptors. If power lines are in their landing or take-off paths, collision risk increases.

For non-migrating birds, flight altitude is likely to be within the range of power line height. Their flight is a function of their feeding, reproductive, and foraging behaviors. These behaviors usually occur within approximately 200 m (660 ft) of the ground, which can expose birds to collision risk when in the proximity of power lines. For predatory birds, the exposure to collision risk can be related, in part, to the pursuit of prey. Bevanger (1994) suggests that aerial hunters such as swifts, swallows, and certain raptors, such as the peregrine falcon (*Falco peregrines*), golden eagle (*Aquila chrysaetos*), and goshawk (*Accipiter gentilis*), typically have excellent maneuverability and very good vision. Yet because they chase prey at high speeds, the presence of a power line may not be perceived soon enough to avoid a collision with it.

Flight related to nesting behavior can increase collision risk if nests occur in close proximity to power lines. Such behavior includes courtship (e.g., aerial displays and pursuit), nest building, fledgling flights, feeding flights to and from the nest, territorial defense, and general flying around the nest or colony. These behaviors are most important

FIGURE 4.9: Aerial hunters that forage in flight within a couple hundred meters (several hundred feet) of the ground, such as swallows, can become collision victims.

for birds that nest in colonies, such as herons and egrets. Risks can also be associated with the age of a bird (i.e., adults and juveniles). Older birds are often acclimated to the presence of a line and will exhibit lower collision risk through well-developed flight patterns. Fledgling birds have less control of the flights and are more vulnerable to collisions than adults (see *Age and Sex*, page 41). There may also be risks for birds crossing a power line from the nesting site to a foraging area. Again, this is most important for colonial birds that will travel together to feed (see also *Habitat and Habitat Use*, page 44). Collision risks to foraging birds will occur when birds departing from and returning to a colony have to cross power lines. Their risk will be a function of the direction of foraging flights and the frequency of crossings. Mojica et al. (2009) reported 21 bald eagle (*Haliaeetus leucocephalus*) mortalities attributed to power line collisions in a study in Maryland conducted from 1985 to 2007.

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VISION

Information on the visual acuity of birds relative to power lines is generally lacking (Bevanger 1998). However, when they are able to see power lines, birds do exhibit avoidance behavior. The use of line marking devices that increase the visibility of lines has confirmed this (see Chapter 6).

For birds, detecting power lines depends on the visibility of the wires and on the characteristics of their vision. Compared to humans, the frontal vision of many bird species is not high-resolution, and many species mainly use their lateral vision to detect details (Martin 2011). Birds often tend to look downwards when in flight (e.g., to look for conspecifics [their own kind] or food), which for some species puts the direction of flight completely inside their blind zone (Martin and Shaw 2010; Martin 2011; CMS 2011a).

Some birds have highly developed vision that they use to capture prey and avoid predators (Gill 1995). The eyes of most birds are on the sides of their heads, which allows them to see things on each side at the same time as well as in front of them. This wide field of vision enables birds to spot predators and obstacles. However, widely spaced eyes can make judging distances and depth perception more difficult, except in the area where the eyes' fields-of-view overlap.

In addition, birds have blind spots caused by the length, width, and position of their bills. For some species, depending upon the size and movement of their bill, these blind spots can reduce the visual field. Researchers have noted that swans' poor frontal vision makes them more susceptible to collision (Martin and Shaw 2010). Martin and Shaw (2010) provided evidence that some species, such as bustards and cranes, have extensive blind spots in the frontal hemisphere and that downward head movement (forward pitch) greater than 25 degrees and 35 degrees, respectively, can render them blind in the direction of travel. If this occurs, objects directly ahead of the bird may not be detected during flight regardless of the visual capacities of the bird's eyes or the size and contrast of the object.

Raptors' eyes are closer to the front of their heads, giving them binocular vision, which is important for making distance judgments while pursuing prey. Having depth perception also makes them less vulnerable to collisions than birds with eyes on the sides of their head.

Birds with eyes adapted to underwater vision, such as ducks, tend to be emmetropic (objects are in sharp focus) in water and slightly myopic (nearsighted) in air (Jones et al. 2007). This may affect their ability to detect small diameter wires as they approach them at high speeds. A red-breasted merganser (*Mergus serrator*) was observed colliding with a shield wire with no reaction prior to the collision, and other mergansers were observed flying within 30.5 cm (12 in) of the shield wire with no reaction (N. Turley, pers. comm.). These observations suggest that the

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FIGURE 4.10: Swans' poor frontal vision, along with their large size, increases their susceptibility to collisions.

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mergansers were not aware of the wire, which indicates that vision characteristics may play a role in collision risk. Examples of other birds in this group with eyes adapted to underwater vision include loons, grebes, other diving ducks (buffleheads, scoters, and eiders), gannets, and kingfishers.

Some species have the ability to keep objects at different distances in focus simultaneously. For example, they are able to scan the horizon while keeping the ground in focus during flight, regardless of changes in elevation. This is believed to be achieved by asymmetry of the lens and cornea about an optical axis (Jones et al. 2007). This results in the eye being emmetropic in some parts of the visual field (the lateral and upper lateral visual fields) and myopic in others (lower lateral visual fields). For prey species such as pigeons, these characteristics allow the bird to scan the horizon for predators and conspecifics while foraging for objects on the ground. This same ability is also found in quail and sandhill cranes (Jones et al. 2007), but is generally not possessed by raptors or other species that must capture mobile prey.

FIGURE 4.11: Because they are nearsighted and fly at high speeds, mergansers may be unable to readily detect small diameter wires as they approach them.

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In the last two decades, research on avian vision has indicated that ultraviolet sensitivity is an important component of avian vision. Birds detect a wider bandwidth of light in the violet and ultraviolet (UV) spectrum (440 nanometers [nm] to 10 nm) than humans do. This difference in sensitivity may relate to many different aspects of bird behavior including prey detection, foraging, display and mating, navigation, and circadian rhythm (Hart et al 1998; Bennett and Thery 2007). Based on this research, UV materials have been applied to line marking devices to help birds detect hazards that otherwise would not be seen. However, these UV materials have not been systematically tested in collision studies.

Regardless of a bird's vision, environmental conditions such as inclement weather and the time of day (e.g., low light or dark) can reduce a bird's ability to see even marked power lines. A number of line modification and marking strategies can be used to reduce the effect of these factors (see Chapter 5 and Chapter 6).

AGE AND SEX

Age and sex have a species-specific influence on collision risk. Crowder (2000) cites numerous studies showing that juveniles are more susceptible than adults (Thompson 1978; McNeil et al. 1985; Brown et al. 1987; Crivelli 1988; Savereno et al. 1996; Mathiasson 1999) but also notes two examples where adults are more susceptible (Ogilvie 1966; Anderson 1978). Brown et al. (1987) and Morkill and Anderson (1991) demonstrated statistically that juvenile sandhill cranes col-

FIGURE 4.13: Endangered Newell's shearwater mortalities at a Kauai power line were mostly non-breeding adult and subadult birds.

lided with power lines more frequently than their proportion of the population would indicate. Conversely, Anderson (1978) found that adult mallards (*Anas platyrhynchos*) were more vulnerable to collisions than juveniles. Ogilvie (1966) suggested that age was not a factor in collision susceptibility for mute swans.

Many authors suggest that young birds or those unfamiliar with the area are more vulnerable than experienced birds (Anderson 1978; Thompson 1978; McNeil et al. 1985). The less-controlled flight of young birds also increases their collision risk. These birds are generally believed to be more susceptible to both electrocution and collision, though this may be confounded by the greater proportion of young birds in the population (Bevanger 1998). Most (11 of 14 = 78.6%) of Newell's shearwater collisions at a Kauai, Hawaii, power line were non-breeding birds, though many of those were likely subadults. The proportions of non-breeding adults and subadults in the population were not reported (Cooper and Day 1998). Juveniles of many migratory species are especially at risk because they have not yet encountered nor learned to avoid the assortment of risks they face.

Less information about the differing vulnerability of sexes exists because comparative data are rarely available. However, several studies have presented evidence that male ducks are more prone to collisions than females (Boyd 1961; Avery et al. 1977; Willard et al. 1977; Brown and Drewien 1995). The courtship and pursuit behaviors of male ducks greatly increase their frequency of local flights and can distract them from seeing and avoiding power lines. Distractions for other species also include pursuit of mates, competitors, or prey, which can increase collision risk (Willard et al. 1977; Anderson 1978).

FIGURE 4.12: Some juvenile birds, such as sandhill cranes, collide with power lines more frequently than their adult counterparts.

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HEALTH AND CONDITION OF THE BIRD

Studies of birds killed by power line collisions indicate that poor health may increase collision risk. Mute swans with elevated blood lead levels had higher collision risk than did healthier birds (Kelly and Kelly 2005). Low weight swans and swans with heavy burdens of toxins were over-represented among swans killed by collisions in Sweden (Mathiasson 1999).

The ability of the bird to maneuver can also be impaired by entanglement with fishing lines and other anthropogenic materials. Manville (2005b) reported on entanglement issues involving Canada geese (*Branta canadensis*) and other waterbird species with six-pack beverage rings and monofilament fishing line, along with plastic debris ingestion, all of which may increase their susceptibility to power line collisions due to weakened conditions, altered aero-dynamics, and impaired health.

Collision mortality can also lead to health effects in populations of birds. In rare instances, collisions that occur in high enough numbers can indirectly contribute to some diseases, such as botulism. Malcom (1982) reported the deaths of several thousand grebes and ducks from botulism that were initiated by the victims of collisions with a transmission line in south central Montana. The collision victims fell into a wetland where their carcasses provided the energy substrate in which dormant *Clostridium botulinum* spores became active. These bacteria produce a toxin that invertebrates consume and concentrate without ill effects. Those toxin-laden invertebrates (e.g., fly-egg-maggot) become food for other ducks and a vicious cycle can develop and become protracted (Rocke and Friend 1999), much as Malcom observed.

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FIGURE 4.14: Gulls (pictured) and waterfowl tend to make feeding flights at dusk and dawn, when reduced light increases collision risk.

TIME OF DAY AND SEASON

Time of Day

Studies have shown that time of day is important to collision frequency in daily flights and during migration. Different species generally feed at different times of day. Non-breeding birds, including migrating species, generally feed continuously during the day and are considered to have continuous exposure to power lines in the vicinity of their feeding areas. When birds are nesting, they often show a periodicity in feeding.

Collisions are much more likely during the night than the day (Scott et al. 1972; Krapu 1974; Anderson 1978; and James and Haak 1980; all cited in Crowder 2000; Pandey et al. 2008). Gulls and waterfowl tend to make feeding flights after sunset and before sunrise. Many waterbird species regularly fly at night in response to tidal cycles or prey activity (Black and Collopy 1982; Erwin 1977; Robert et al. 1989; Dodd and Colwell 1998) or predator avoidance. Inability to see the wires due to low light conditions probably raises the collision risk for these species (Scott et al. 1972; Krapu 1974; James and Haak 1980; Brown and Drewien 1995). At the San Luis National Wildlife Refuge Complex in California, bird flight diverters were effective on waterfowl but not on coots, which authors attribute to the fact that coots fly at night and cannot see the diverters (Ventana Wildlife Society 2009).

Species that migrate at night, such as songbirds and herons, may be vulnerable to collisions if weather forces them to fly at low altitudes. However, generalizing from one species to another or one habitat to another that nocturnal flight behavior may be more risky than diurnal flight behavior needs to be cautioned. Deng and Frederick (2001) investigated nocturnal bird flights of wading birds in the vicinity of a 550-kV transmission line adjacent to the Everglades in south Florida. They observed nine species of wading birds including herons, egrets, and wood storks (*Mycteria americana*). The investigation showed that nocturnal-flying wading birds were less responsive to the power lines than diurnal-flying birds; however, the birds generally flew higher over the power lines at night than during the day. No collisions were observed but the authors stated that the sampling period was short (118 hours). One of the suggested reasons for the lack of collisions was that the birds were acclimated to the presence of the line.

Similarly, radar data collected by Harmata et al. (1997) along the Missouri River indicated that birds flying at night flew at heights well above power lines. By flying higher at night, waterbirds and other species may lower collision risk with natural and anthropogenic obstacles. However, there may be risks from lines that occur in the departing and arriving zones for roosting or foraging habitats. For example, dark-rumped petrels (*Pterodroma phaeopygia*) and Newell's shearwaters in Kauai, Hawaii, crossed much closer to power lines in morning seaward flights than in evening landward flights, and all recorded Newell's shearwater collisions occurred during morning flights (Cooper and Day 1998).

Season

Seasonal bird abundance is also correlated with collision mortality. For example, seasonal flight behavior differences resulted in more wintertime collisions for ptarmigan in Norway (Bevanger and Broseth 2004). Migration seasons generally pose a greater risk to migrating birds because of both higher flyover frequency and unfamiliarity with local landscapes. The nighttime proportion of crane and waterfowl collision mortality versus total collision mortality was 31.8% in the fall (1990) during migration and 7.7% in the spring (1991) in San Luis Valley, Colorado (Brown and Drewein 1995).

Willard (1978) described a situation in the Klamath Basin, Oregon, that illustrates how both collision mortality and its population effects can increase during the breeding season. At Lower Klamath Lake National Wildlife Refuge, adult American white pelicans (*Pelecanus erythrorhynchos*) flew low over canals and collided with power lines while searching for food. For this species, this meant a double loss: first, the loss of the adult that collided with the line, and second, the loss of the young, which rarely fledge after one parent is lost because both parents must forage extensively to feed them.

HABITAT AND HABITAT USE

Power lines located near habitats with high avian use (such as nesting, foraging, roosting, and resting sites) may pose greater exposure to collisions for some species. For example, power lines between foraging and roosting sites of wading birds will be frequently crossed, which increases the collision risk potential. This is especially true when only a short distance separates the two habitats. Birds in these situations typically fly at low altitudes, potentially putting them at the height of power lines. Willard et al. (1977) suggested that overhead wires within a single habitat (e.g., within a wetland) are more likely to cause collisions than those between two habitats (e.g., wetlands and uplands); other studies have found the opposite to be true (e.g., Faanes 1987; Brown et al. 1987; Morkill and Anderson 1991).

The critical questions are how often, and in what numbers, do birds fly across a power line during their daily routines? For example, in a study in the San Luis Valley of Colorado, Brown et al. (1987) found that power lines dividing wetlands (used for roosting) from grain fields (used for feeding) caused the most collisions for sandhill cranes and field-feeding waterfowl. This occurred because these habitats encouraged the birds to cross the lines at low altitudes several times each day. However, the same power lines had little effect on diving ducks, which had restricted their activities to wetlands. Thus, the risk of a particular power line depends in part upon the way each species uses the adjacent habitat.

FIGURE 4.15: Power lines located between the foraging and roosting sites of wading birds, such as this white ibis *(Eudocimus albus)*, may result in higher collision risk.

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FIGURE 4.16: Research conflicts on whether or not overhead wires within a single habitat, such as this wetland, are more likely to cause collisions than those between two habitats.

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Power lines, including those that border habitat such as a wetland used by many birds, may present little risk if the adjacent habitat separated by the power lines is not attractive to birds (e.g., a city rail yard). Conversely, if the adjacent habitat is a grain field, collisions may result in fall and winter for field-feeding birds that make daily flights between wetland roosts and foraging sites, including sandhill cranes, Canada geese, mallards, and pintails (*Anas acuta*) (Thompson 1978; Brown et al. 1987; Morkill and Anderson 1991). The same line may represent lower risk during the breeding season when these birds remain in wetlands throughout the day. Although forested habitats located near power lines can

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sometimes reduce collision risk (see *Managing Surrounding Lands* on page 58), in some forested habitats where there are open clearings for the power lines, collision risk may be higher for birds that fly across the open corridor while going between forested areas.

During migration, birds make stopovers in their preferred habitats. When migratory birds' staging, roosting, resting, and foraging areas are located near power lines, especially when ingress or egress coincides with inclement weather, collision risk increases (Manville 2005a, 2009a). This can be especially true when there are large concentrations of birds; for example, sandhill cranes that number in the tens of thousands along the Platte River in Nebraska (Murphy et al. 2009).

Some habitats, such as lakes and ponds, have seasonal use patterns. Proximity to shoreline habitat was linked to bald eagle collisions (21) and electrocutions (24) at Aberdeen Proving Grounds, Maryland (Mojica et al. 2009). Higher collision mortality was found at power lines near shorelines used as feeding areas. The 16,000 hectare (39,537 acre) area on Chesapeake Bay had 42 resident pairs and seven known communal roosts used by migrants from the north and south during the winter and summer months, respectively. In a high bird concentration area along Lake Ontario, double-crested cormorants (*Phalacrocorax auritus*) were the most commonly reported collision victim, although they were over-represented relative to their abundance in the area, and gulls and waterfowl were the next most commonly reported species to collide with lines (Barrett and Weseloh 2008). A PacifiCorp study calculated the distance of collision mortalities to the nearest water body using survey data collected in Oregon, California, Idaho, Utah, and Wyoming from 2004 to 2009 (S. Liguori, PacifiCorp, unpubl. data) (Table 4.2).

TABLE 4.2: Average distance of collision mortalities from nearest water body.*

Species	Sample Size	Average Distance
Snow goose *(Chen caerulescens)*	37	82.3 m (270 ft)
American white pelican *(Pelecanus erythrorhynchos)*	17	82.6 m (271 ft)
Tundra swan *(Cygnus columbianus)*	3	89.3 m (293 ft)
Sandhill crane *(Grus canadensis)*	7	119.8 (393 ft)
Great blue heron *(Ardea herodias)*	7	154 m (505 ft)
Mallard *(Anas platyrhynchos)*	5	213.4 m (700 ft)

* Source: PacifiCorp, unpubl. data

ENVIRONMENTAL CONDITIONS INFLUENCING AVIAN COLLISION RISKS

Environmental conditions that can increase the risk for collisions with power lines include:

- Land uses
- Weather conditions and visibility
- Sudden disturbances

The relative importance of these conditions varies with location, season, species, and different populations of the same species.

LAND USES

Land uses, such as conservation, recreational, residential, agricultural, and industrial, have habitats and management practices that can attract or discourage bird use. Collision risk depends on the location of power lines within these areas and the bird species that are drawn to them.

Conservation and Nature-Based Recreation Lands

Conservation areas and wildlife refuges vary greatly in size and habitat type and are often managed for specific types of wildlife and/or nature-based recreation uses. Many conservation lands have distribution lines that supply their power needs and may also be crossed by transmission lines. These lines may present collision risk depending on the habitats, species, and human activities present. The potential for disturbing and flushing birds into nearby power lines can be higher in recreation areas due to increased human activity or lower if resident birds are acclimated to human activity. Power lines that cross high avian-use habitats such as wetlands or are placed between foraging and roosting areas may also result in a higher risk of bird collisions (see *Habitat and Habitat Use* on page 44). Although a proposed power line route may not be able to avoid such conservation areas, managers need to be aware of the potential risks so they may be minimized (see Chapter 5).

FIGURE 4.17: Power lines crossing agricultural fields with seasonally attractive crops or residue can contribute to collision risk for some flocking species, such as cranes, waterfowl, songbirds, and these trumpeter swans (*Cygnus buccinator*).

Residential and Urban Recreation Lands

Residential and urban recreation lands vary widely in their attractiveness to birds (e.g., Chace and Walsh 2006). Generally, urban recreation lands such as parks and golf courses are interspersed within or between densely populated residential areas. These lands often become habitat islands. For example, they may have small wetlands that are used by various protected birds. Distribution lines may be especially plentiful in residential and recreational areas and can pose a collision risk, depending on the susceptibility of the species, when situated in the flight patterns of birds.

Agricultural Lands

Agricultural fields and ponds can attract birds; for example, grain crops are seasonally attractive to many flocking species such as cranes, waterfowl, and blackbirds, along with rodents that attract raptors. Because grain fields are used only as feeding areas by these species, they may be attractive when they are in close proximity to nesting, roosting, or wintering habitat. Agricultural fields, especially those that are managed with burning or flooding or have nearby wetlands, can also attract a variety of bird species during staging and migration and may even result in shortstopping, i.e., drawing birds to these attractive sites for the winter rather than their historical wintering sites (Viverette et al. 1996). Collision problems may develop when birds must cross power lines to make daily, low-altitude flights between feeding areas and nesting or roosting sites. See also *Habitat and Habitat Use* (page 44).

Industrial Lands

Industrial lands sometimes provide attractive bird habitat. Gulls, vultures, crows, ravens, and other scavengers often gather at landfills in large numbers. Cooling ponds at electricity generation facilities, municipal sewage ponds, settling ponds at mines, and other industrial water bodies can attract waterbirds, shorebirds, and raptors. As with other types of land use, the degree of hazard posed by power lines will vary depending upon the proximity of the lines to these avian-use areas (see *Habitat and Habitat Use* on page 44). If bird collisions become a problem, property managers may be able to choose from a variety of options to modify or discourage bird use of the area (see *Managing Surrounding Lands* on page 58).

WEATHER CONDITIONS AND VISIBILITY

Weather conditions play a very important role in both the visibility of power lines and in the behavior of birds in flight during migration and local movements, such as daily foraging activity. When weather conditions interact with biological characteristics (e.g., flight behavior, wing loading and aspect ratio, and season), collision risk may be dramatically affected.

Adverse weather conditions, such as fog, dense cloud cover, high and variable wind speeds, precipitation, and reduced or zero visibility are associated with greater collision risk. Reduced visibility and high wind speeds can also cause birds to fly at lower altitudes, potentially putting them at the same height as power lines. The influence of weather on flight altitude was reviewed in depth by Shamoun-Baranes et al. (2006), and the effect of weather on flight height and behavior has been observed in many bird species (Drewitt and Langston 2008; Newton 2008).

Weather and biological factors are often interrelated and may affect flights within high bird-use areas. The timing of daily flights may subject certain species to adverse weather conditions associated with collisions, such as fog (Scott et al. 1972; Tacha et al. 1979) or wind (Brown 1993). This is especially true in coastal and low-lying areas that are frequently foggy or windy. When possible, birds will avoid flying in heavy precipitation or fog. Problems most often occur when birds unexpectedly encounter these conditions. Storms or fog can arise quickly and birds may collide with power lines when attempting to leave feeding areas for protected roosts (Wheeler 1966; Tacha et al. 1979). In foul weather, birds may be attracted to lighted areas on the ground (Manville 2007a). If power lines are also in or near those areas they could be in the landing approach of the attracted birds and become a collision risk (see *Lighting*, page 52).

Wind, wind shear, and turbulence most often appear to influence collisions when birds fly at power line heights. Some birds decrease flight altitude in high winds (Scott et al. 1972; Raevel and Tombal 1991). Poor conditions—wet feathers, precipitation, high winds, wind gusts, and turbulence—also hamper birds' ability to control flight and further increase collision risk (Walkinshaw 1956; Avery et al. 1977; Willard et al. 1977; Anderson 1978). In high-velocity winds, birds may collide with other birds, buffeting them into fully visible and familiar power lines (Brown et al. 1987; Morkill and Anderson 1991; Raevel and Tombal 1991; Brown and Drewien 1995).

In the San Luis Valley, Colorado, collisions occurred more frequently on days with winds >24 km per hour (15 mi per hour) (Brown and Drewein 1995). Collisions were also more likely with tailwinds, which increase a bird's ground speed, than with headwinds, which have the opposite effect (Savereno et al. 1996). Crowder (2000) reviewed older evidence of power line collisions resulting from stormy (Wheeler 1966), foggy (Tacha et al. 1979), or windy (Brown et al. 1987; Morkill and Anderson 1991) conditions. These studies showed that wind, especially associated with stormy weather, is an important contributor to collisions. It has been suggested that birds, such as gulls, with a high aspect ratio and low wing loading are more susceptible to being blown into lines than other bird

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FIGURE 4.18: Birds usually initiate migration in favorable weather conditions, but when they encounter inclement weather they may decrease their flight altitude, which increases collision risk when power lines are present.

species without these physical characteristics (Bevanger 1998).

The impact of weather is also related to season, as adverse weather may pose a greater risk during migration (APLIC 2007) and can influence the initiation of migration (Shamoun-Baranes et al. 2010). Songbirds usually begin migration in favorable conditions, but may encounter inclement weather en route. The weather hazard may be worsened when migratory birds respond to fog and precipitation by decreasing their flight altitude (Gauthreaux 1978a) or by attempting to land (Manville 2007a). In known or historic staging, roosting, resting, feeding, or stopover areas for migratory birds located in immediate proximity to power lines, there can be a substantial increase in collision risk, especially when bird ingress or egress coincides with inclement weather (Manville 2005a, 2009a). This effect is magnified when flocks are very large, as with migrating sandhill cranes in the Platte River area of Nebraska (Murphy et al. 2009).

The flight altitudes of migratory birds can vary greatly and are strongly correlated with winds aloft, air clarity, turbulence, thermals, and weather, both day and night. In particular, thunderstorms and low cloud ceiling conditions are known to cause nocturnally migrating songbirds to land or to fly at lower altitudes that increase collision risk, particularly with illuminated structures (Winkelman 1995; Gill et al. 1996; Erickson et al. 2001; Johnson et al. 2002; Kerlinger 2003). Various radar studies have estimated that under normal weather conditions, 84% to 97% of nocturnally migrating songbirds fly at altitudes of 125 m (410 ft) or more above ground level where they are not exposed to risk of collision with power lines (Mabee and Cooper 2002; Cooper 2004; Mabee 2004).

SUDDEN DISTURBANCES

Sudden disturbance can panic and flush birds, especially flocks of birds, into nearby power lines and has been well documented as a contributing factor to collisions (Krapu 1974; Blokpoel and Hatch 1976; Anderson 1978; Brown et al. 1984; Archibald 1987). Birds may be flushed by vehicles, trains, pedestrians, aircraft, farm equipment, hazing, hunters, predators, etc., along ROWs and may collide with power lines in their effort to escape (APLIC 2007). Crowder (2000) reviewed older evidence of power line collisions resulting from sudden disturbance of geese by vehicles (Schroeder 1977) or airplanes (Blokpoel and Hatch 1976). One such disturbance resulted in a collision event with mallards during Crowder's (2000) field study. Murphy et al. (2009) support the idea that most sandhill crane collisions at Platte River, Nebraska, occur when closely congregated birds are flushed after dark. In Washington, roosting American white pelicans collided with an adjacent distribution line when flushed during the night by a passing train, even though line marking devices were installed (S. Liguori, PacifiCorp, pers. comm.).

ENGINEERING ASPECTS INFLUENCING AVIAN COLLISION RISKS

The following engineering aspects can influence the risk of collisions with power lines:

- Diameter of lines (shield wires versus phase conductors)
- Line placement (proximity to avian habitat)
- Line orientation (relative to biological and environmental factors)
- Line configuration (aligned vertically or horizontally and the number of lines)
- Structure type (guyed versus self-supporting)
- Lighting (steady burning versus blinking)

DIAMETER OF LINES

The smaller diameter of transmission line shield wires compared to phase conductors influences the risk of collisions, with shield wires being the lines most often involved (Scott et al. 1972; Willard et al. 1977; Brown et al. 1987; Faanes 1987; APLIC 1994; Savereno et al. 1996; Jenkins et al. 2010). Because of their smaller diameter (1 to 1.3 centimeters [0.4 to 0.5 inches]) compared to phase conductors (2.5 to 5 cm [1 to 2 in]) and their position above the phase conductors, shield wires are the least visible type of power lines and they are in the flight path of birds that gain altitude to avoid the more obvious phase conductors. The shield wire protects, or shields, the phase conductors from lightning strikes.

Distribution lines consist of phase conductors and a neutral wire, which is at the same level or below the phase conductors. Though it is not absolute, most birds gain altitude to avoid an obvious line, which implies that neutral lines are less likely to be involved in collisions.

LINE PLACEMENT

The proximity of power lines to bird take-off and landing areas can affect collision risk (Lee 1978; Thompson 1978; Faanes 1987), but no specific setback distance has been found in the literature. Brown et al. (1984, 1987) found that no sandhill crane or waterfowl collisions occurred where distances from power lines to bird-use areas were ≥1.6 km (1 mi). Faanes (1987) found that collision rates dropped off dramatically after 400 m (1,312 ft). Faanes (1987) stated that "among the sites I examined, power lines situated 400 m (1,312 ft) or more from the edge of the water generally had lower observed mortality than sites where the power line was within this distance." Quinn et al. (2011) found no bird carcasses under power lines that were situated more than 500 m (1,640 ft) from the edge of the water; at distances of 60 m (197 ft), collision mortality dropped off dramatically ($p = 0.0012$, $df = 3$). See also *Habitat and Habitat Use* on page 44. See Chapter 5 for examples of risk and reduced risk situations.

LINE ORIENTATION

Orientation of power lines relative to biological characteristics (e.g., flight behavior, season, habitat, and habitat use) and environmental conditions (e.g., topographical features and weather patterns) can influence collision risk. When planning power line routes, features that are traditional flight corridors, such as mountain ridges, river valleys, and shorelines, should be considered (Colson and Yeoman 1978; Faanes 1987). Power lines that parallel primary bird flight paths pose less risk than a perpendicular orientation (Crowder 2000; Scott et al. 1972; McNeil et al. 1985). For example, the perpendicular orientation of a line relative to a topographical feature poses a greater collision risk to local and migrating birds than a parallel orientation (see Figure 4.19).

Lines that are at or below the height of nearby trees rarely present a problem to small tree-dwelling birds because of their maneuverability; furthermore, large birds will gain altitude to fly over the tree line and consequently avoid the power line (Thompson 1978; Raevel and Tombal 1991). For example,

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FIGURE 4.19: Orientation of power lines parallel to ridges or narrow, low altitude flyways presents a lower risk of collision than perpendicular orientation.

a power line that crosses a narrow river bordered by trees that are taller than the line is likely to have a lower collision risk than lines crossing broad rivers because most birds will fly over the tree tops to cross the narrow river valley (CMS 2011a).

Strong tail winds can be detrimental to birds' ability to execute avoidance maneuvers. Brown (1993) suggested that north-south orientation of lines increased collision frequency for cranes and waterfowl in the San Luis Valley, Colorado, because birds crossing them on an easterly heading were often subjected to prevailing westerly winds. See also *Biological Characteristics*, on page 36, and *Weather Conditions and Visibility* on page 48.

LINE CONFIGURATION

Line configuration—phase conductors aligned vertically or horizontally, and the number of conductors—is a collision factor that intuitively makes sense, but there are too few studies to draw conclusions. Most researchers agree that keeping the vertical arrangement of multi-conductor transmission lines to a minimum is beneficial because it reduces the height of the collision zone. However, a single-pole vertical structure is often esthetically more acceptable and requires less ROW width.

Thompson (1978) and others (Bevanger 1998; Crowder 2000; Drewitt and Langston 2008) have suggested that clustering lines (i.e., several power lines sharing the same ROW) may reduce the risk of collisions because the resulting network of wires is confined to a smaller area and is more visible. Birds only have to make a single ascent to cross lines before resuming their preferred altitude. However, when there is decreased visibility, collision risk for birds may increase where several lines are clustered together. In addition, when there are two shield wires at different heights, and only the higher one is marked, there may be collisions at the lower unmarked shield wire, thus both shield wires may need to be marked (S. Liguori, pers. comm.). See Chapter 5 for examples of risk and reduced risk situations.

STRUCTURE TYPE

Because of the collision risk posed by guyed communication towers (e.g., Shire et al. 2000; Manville 2007a; Gehring et al. 2009; Gehring et al. 2011; Longcore et al. 2012), the question of collision risk associated with guyed power line structures has occasionally been asked. Guy wires on power line structures are used for support and stability especially where a line ends (deadend structure) or changes direction (e.g., makes a 90-degree turn). There is no published information to suggest that guyed power line structures pose a significant collision risk for birds. PacifiCorp has surveyed over 120,000 poles in six states and has not found collision victims at any of the guyed structures (S. Liguori, pers. comm.). Based on exposure alone, the relative short lengths of the guy wires and the low heights on power lines pose much less risk to birds than do the longer, multiple guy wires on communication towers whose height can

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exceed 300 m (>1,000 ft; Gehring et al. 2011). In addition, some types of lighting on communication towers can attract birds into the collision zone in low visibility weather. Because transmission towers are, with very few exceptions, unlit, they are not expected to have the same risk.

LIGHTING

Studies of bird collisions with communication towers and other tall structures have shown that steady-burning white or red lights can disorient migrating birds at night especially when migration coincides with inclement weather (Manville 2007a, 2009; Gehring et al. 2009, 2011). This disorientation can cause birds to collide with the lighted structure, guy wires on a communication tower, or each other. It can also cause the birds to circle the light source, which may also result in exhaustion and injury or death. Collision incidence on lighted communication towers, for example, depends on the type and intensity of the lights (i.e., steady burning, blinking, or strobe) as well as whether the birds are navigating visually or magnetically. In a Michigan communication tower study, extinguishing steady-burning, L-810, red side lights, while leaving on the red, blinking incandescent pilot warning lights, reduced bird collision mortality by up to 72% (Manville 2007a; Gehring et al. 2009). However, any light, including blinking incandescent and strobe lights, can cause some bird attraction, even during clear weather (Manville 2009a).

In the United States, any structure that is ≥60.9 m (200 ft) above ground level is subject to Federal Aviation Administration (FAA) lighting requirements for aviation safety. Transmission towers in the United States are typically <60.9 m (200 ft) tall[12] and do not have lights. However, shorter structures may also require lighting depending on their location (e.g., in proximity to airports). If lighting is used on transmission lines, it should be compatible with FAA regulations, the Canadian Aviation Regulation, and USFWS bird protection guidelines, and these agencies should be consulted on lighting. The FAA no longer recommends using L-810 steady-burning red lights.[13] In general, the USFWS recommends avoiding lights, particularly steady-burning lights, and using motion- and heat-sensitive lighting where feasible (e.g., for infrastructure security lighting).

[12] Some structures exceed 60.1 m (200 ft) in height, especially at river crossings and to clear other lines that might otherwise intersect (M. Schriner, pers. comm.; D. Bouchard, pers. comm.).

[13] This change is expected to be included in the revision to the FAA's 2007 lighting circular, which is underway at this time (2012). As a preliminary step, in June 2012 the FAA published the results of its pilot conspicuity studies on the elimination of steady-burning red (L-810) side lights at communication towers.

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CHAPTER 5

Minimizing Collision Risks

IN THIS CHAPTER

- Opportunities for Minimizing Collision Risks
- Modifying Existing Power Lines
- Planning New Power Lines
- Public Participation to Address Social and Cultural Issues

There are a number of design and engineering strategies for minimizing collision risk with power lines. This chapter introduces evaluation studies and risk reduction strategies for modifying existing lines and planning new lines. This chapter also discusses how to address social and cultural issues through public participation programs.

OPPORTUNITIES FOR MINIMIZING COLLISION RISKS

By working together, engineers and biologists can identify and address collision issues when modifying existing lines and planning new lines (Figure 5.1). Collision issues typically develop or are discovered long after a power line is built, which makes minimizing collision risk more difficult. However, early evaluation of factors that influence collisions (see Chapter 4) can reduce collision potential and may reduce the need for costly modifications later.

Engineers and biologists can reduce collisions when…

Modifying Existing Power Lines	Planning New Power Lines
Evaluation studies include: • Collision monitoring to examine the causes and conditions associated with the risk and to help determine the type and effectiveness of modifications. • Avian risk assessment and spatial analysis to prioritize line segments for modification.	*Evaluation studies include:* • Spatial analysis that considers habitat variables, species, behavior, and other factors to help choose the optimal route. • Field assessment to identify species, abundance, and high bird-use areas. • Avian risk assessment to evaluate collision risk along potential routes.
Risk reduction options include: • Line marking to increase the visibility of the line. • Managing surrounding land to influence bird use. • Removing the shield wire if lightning is not an issue or if lightning arresters can be used instead. • Increasing the diameter or changing the configuration of wires when a line is being rebuilt. • Rerouting the line if all other attempts have been exhausted and populations are significantly impacted. • Burying the lines if feasible and warranted.	*Risk reduction options include:* • Line placement that takes migratory patterns and high bird-use areas into account. • Line orientation that considers biological and environmental factors such as bird flight paths, prevailing winds, and topographical features. • Line configuration that reduces vertical spread of lines, clusters multiple lines in the same right-of-way (ROW), increases the visibility of lines, and/or decreases the span length if such options are feasible. • Line marking to increase the visibility of the line. • Burying lines if feasible and warranted.

FIGURE 5.1: Opportunities and strategies for minimizing collision risks.

MODIFYING EXISTING POWER LINES

EVALUATION STUDIES FOR LINE MODIFICATIONS

If a significant collision risk has been observed along a segment of line, it may be possible to eliminate or minimize the risk by modifying the line in various ways. Line modifications should be supported by collision monitoring studies that examine the causes and conditions associated with a high collision rate (e.g., bird species involved, avian use patterns, mortality rates, weather, and biological significance of mortality levels). Although collision monitoring study methods must be tailored to site-specific biological, environmental, and engineering factors (see Chapter 4), basic, standardized ornithological field survey procedures should be used to produce results that would be comparable to other studies. Appendix B presents considerations and issues for designing site-specific

Comparing the Effectiveness of Line Modifications

Assessments of line modification effectiveness are often based on pre- and post-modification mortality (Rigby 1978; Beaulaurier 1981; Archibald 1987; Brown et al. 1987). Although evaluations based on casual observations or limited sampling of collisions contribute to the knowledge of line modification effectiveness, more rigorous studies are necessary to adequately compare the effectiveness of various measures (e.g., Crowder 2000; Yee 2007, 2008; Ventana Wildlife Society 2009; and Pandey et al. 2008).

study methods for collision monitoring. Once monitoring data are collected, line modification options can be evaluated to identify, quantify, and balance existing risks with the effectiveness and risks posed by the modifications.

Collision Monitoring Studies

To design a collision monitoring study, a number of key questions need to be answered:

- What species is/are at risk?
- What is the magnitude of risk?
- Does this risk contribute to population level impacts?
- What biological, environmental, and engineering factors contribute to collision risk?
- Is the study protocol scientifically sound?
- What are the regulatory and policy considerations of collisions?
- What methods effectively minimize collisions for new and existing power lines?

Collision monitoring results should include the following information:

- Collision rates among species and between sexes and ages (if known) within a single species
- Collision rates expressed as the number of bird collisions relative to the number of birds that are exposed to the line in the strike zone, i.e., collisions/flybys
- Biological, environmental, and engineering factors affecting collision risks (see Chapter 4)
- Mortality corrected for site-specific sampling bias (see Appendix B)
- Behavioral responses of different species to the lines and to line marking devices or other modifications
- Effectiveness of line marking devices based on changes in mortality after marking devices were installed or other line modifications were made

These and other monitoring considerations are discussed in greater detail in Appendix B.

To understand the mortality risk for an entire line, it is essential to study representative segments of the line rather than focusing only on high collision segments, since doing so will overestimate the overall mortality risk. The study method should ensure that test and control segments are of comparable length and that they have as much environmental homogeneity as possible (see Appendix B). On lines with high environmental variability across their length, stratified random sampling may allow the investigator to treat the segments similarly enough to collect meaningful data.

The greatest problem faced by researchers in most field studies is controlling for external variables (e.g., Alonso and Alonso 1999; Jenkins et al. 2010; Barrientos et al. 2011). The results of Brown and Drewien (1995) support the hypothesis of Thompson (1978) that collision rates are not predictable from one study to another and one season to another. They found that rates varied among species, seasons, and years and attributed much of the variability to changes in the local environment, which, in turn, influenced bird densities (see also Blair 1996). This suggests that, ideally, studies should compare test and control line segments within the same time period.

Regardless of whether assessments are made before or after line modification or by using test and control segments, collision risk comparisons are most meaningful if collisions are expressed in relation to bird numbers or, preferably, flybys. This allows a collision rate to be calculated. Where feasible, observations of birds' avoidance behavior when crossing the lines are valuable in understanding how a line affects flight behavior. Actual mortality may be low, which presents a statistical challenge in comparing retrofitting options. This condition should be anticipated and integrated into the study design (see Appendix B).

Collision monitoring studies should incorporate the basic methods used in other mortality evaluations (see Appendix B) including:

- Defining the collision zone for birds crossing lines
- Establishing an adequate search area for mortalities (increasing with the height of the line)
- Obtaining sampling bias estimates for injuries, searcher efficiency, scavenger removal, and habitat differences

Evaluation of bird behavior at marked and unmarked lines provides insight to collision rates. Morkill and Anderson (1991) and Brown and Drewien (1995) demonstrated that bird responses varied with marked and unmarked lines. Observations should be made on marked and unmarked portions simultaneously to minimize environmental variability. For example, Deng and Frederick (2001) showed that the number of birds flying above or below marked and unmarked lines was not statistically significant; however, they observed that the birds approaching a marked line reacted earlier than birds approaching an unmarked line.

Behavioral criteria evaluated may include:

- Type of reaction to lines
- Distance from the line that the reaction occurred
- Height above the line when crossing

Because these estimates require evaluations by observers, it is important to standardize survey procedures (see Appendix B). All observers should be given training and practice time before the study begins and, when possible, the same observers should be used throughout the study. Brown and Drewien (1995) found that most observers required about 12 hours of practice before they became consistent. As an alternative to field observers, the Bird Strike Indicator (BSI), a vibration sensing and recording tool, can be installed on lines to detect bird strikes (see box, page 57). However, the BSI does not identify what species struck the line; hence, mortality monitoring or field observations, which would also reveal pre-strike behavior, would be required.

Avian Risk Assessment and Spatial Analysis

Avian risk assessment and spatial analysis can be used to prioritize segments of line for modification. See *Evaluation Studies for Siting New Power Lines* on page 64.

OPTIONS FOR MODIFYING EXISTING LINES

Potential options for line modification include line marking, managing surrounding land, removing the shield wire, changing the diameter or configuration of wires, and rerouting or burying existing lines where feasible. Utilities are encouraged to work with wildlife agencies (see Chapter 3) to evaluate collision risks to species of concern and options for reducing those risks. Typically, the first option is marking high risk segments of the line and/or managing the surrounding lands. Redesigning, reframing, relocating, or

Remote Sensing with the Bird Strike Indicator

The Bird Strike Indicator (BSI) is an automated vibration sensing and recording tool designed by Electric Power Research Institute (EPRI) to detect bird strikes on overhead lines. Previously, the only means for identifying whether collisions were occurring was for observers to monitor lines and to conduct ground surveys for bird carcasses. Manually monitoring bird collisions is labor-intensive, expensive, and its effectiveness is limited to daylight hours. Carcass surveys may correct for lack of monitoring during low-light periods, but these are often associated with vegetation, water, and scavenger detection biases (see Appendix B). Some birds also may fly beyond the search zone after the collision. If the collision itself was not observed then this type of contact would be missed by standard monitoring methods.

FIGURE 5.2: The Bird Strike Indicator, a tool used to detect bird strikes with power lines, can be installed from a bucket truck or helicopter.

BSI sensors can be installed on phase conductors or shield wires. Each installation will be unique to the surrounding environment. For example, the lightweight accelerometers in BSIs are meant to detect stress waves caused by avian collisions, but in one study, BSIs also picked up the vibrations from daily trains (M. Schriner, pers. comm.). For a horizontal line configuration, the BSI is only needed on the outside wires (M. Schriner, pers. comm.). The BSI generates a collision log including the wire struck along with the date, time, and temperature. The BSI wirelessly transmits these data to a base station in real time. Base stations serve multiple sensors simultaneously and are accessible through an interface. Each sensor is designed for up to six months of autonomous operation between battery replacements. The units check and report their health each morning and can be reprogrammed remotely.

Research during the development of the BSI (Pandey et al. 2008) and independent trials conducted afterwards (Murphy et al. 2009) demonstrated that the BSI is as reliable as human observers for detecting collisions during daylight. The technology is especially useful for monitoring collisions in low-light or no-light conditions and over-water crossings where carcass recovery is compromised. However, unlike human observations, BSI does not identify the species that struck the line; mortality monitoring or field observations would be required to determine this. The BSI has also been successfully used to monitor communication tower guy wire collisions in Cold Bay, Alaska, which demonstrated that the BSI allows continuous line monitoring under all lighting and weather conditions (R. Harness, pers. comm.).

As of 2012, a new companion technology to the BSI, called the Bird Activity Monitoring System (BAMS), is in its technical development phase with EPRI funding and is envisioned as an intelligent, image-based, sensing and recording tool that will assist with detailed study of wildlife interactions with various types of structures including power lines.

burying power lines may not be economically or technically feasible. Such options are usually a last resort and only contemplated when an avian resource has been documented to be seriously affected.

Line Marking

Most studies have shown a reduction in collisions and/or an increase in behavioral avoidance at marked lines when compared to unmarked lines, but this can vary with location, type of line marking device, and bird species (Jenkins et al. 2010; Barrientos et al. 2011; see Chapter 6 for detailed information on devices and effectiveness). There are three general categories of line marking devices: aerial marker spheres, spirals, and suspended devices (swinging, flapping, and fixed). Large diameter wire may also improve line visibility and has been used with line marking devices to reduce risk of collision-electrocutions and collisions (see Chapter 6). Line marking devices are selected based on product availability and durability, cost, ease of installation, compliance and legal issues, spacing and positioning, safety codes related to ice and wind loading, corona effects, esthetics, and potential for vandalism.

Lighting has also been successfully used to reduce collisions. In Washington, a spot light (using the line as a power source) was installed in an uninhabited area to illuminate a section of marked distribution line at night. This effectively reduced collisions of American white pelicans (*Pelecanus erythrorhynchos*) that roost adjacent to the distribution line. The pelicans had collided with the line when flushed during the night by passing trains, even though line marking devices were installed (S. Liguori, PacifiCorp, pers. comm.). In Botswana and South Africa, the Mace Bird Lite, a spiral device with a fluorescent light, has been used to reduce flamingo collisions (Eskom 2003; Eskom Transmission 2009; see *Devices Available in Other Countries* on page 97).

When using lighting, the effects of lighting on birds as well as applicable regulations for lighting should be considered (see *Lighting* on page 52).

Managing Surrounding Lands

The location and condition of habitat and the surrounding or nearby land uses, such as wetlands and agriculture, and their proximity to power lines influences collision risk (see Chapter 4). Modifying habitat, land uses, or management practices to influence bird use in strategic areas can reduce collision risk where there is a willing agency or landowner. Sometimes, land management can be less costly and more effective than other line modifications. Options are discussed for conservation, recreation, residential, agricultural, and industrial land uses.

Planting Trees

Where climate and location will allow, planting native trees that will grow to or above the height of nearby power lines, without interfering with line operations, may prevent collisions by forcing birds to gain enough altitude to clear the more visible tree line (Thompson 1978; Raevel and Tombal 1991). For instance, greater white-fronted geese (*Anser albifrons*) flew over power lines more in woodlands than over lines in rice fields in Japan (Shimada 2001), and areas with shorter trees had higher collision rates than areas with taller trees for ptarmigan in Norway (Bevanger and Broseth 2004). For mitigation purposes, tree planting is a long-term strategy because of the time it takes for trees to grow to the desired height; thus, short-term mitigation would likely be necessary in the interim. Because trees can potentially cause operational and reliability problems with lines, a design engineer and a forester should be consulted concerning minimum clearances and line maintenance requirements so appropriate tree species and planting locations can be determined.

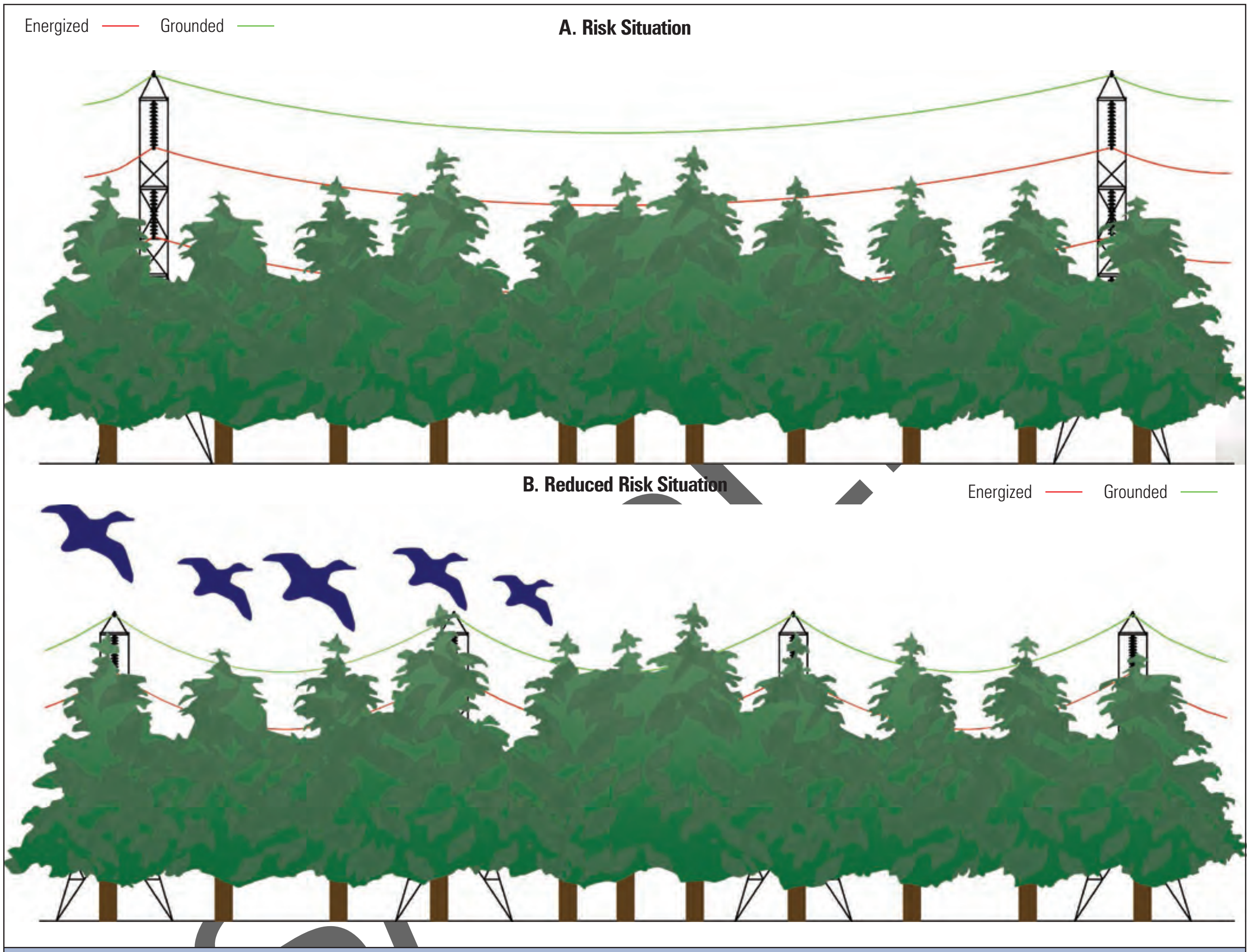

FIGURE 5.3: Reducing collisions in wooded areas. A tree line or other obvious obstacle at the appropriate height warns birds to gain altitude, which results in birds flying over the power line screened by the trees (after Thompson 1978).

Removing Disturbances

Reducing and modifying human access points to decrease the likelihood that human activities will disturb birds where they congregate near power lines can reduce collisions caused by frightening and flushing birds into the power lines (see *Sudden Disturbances* on page 49). Restricting access roads on power line ROWs to utility-related activities is an option that may be open to landowners or land managers. Conservation area managers and private landowners can limit or prohibit hunting or other high-disturbance activities near power lines. On public access roads, speed limit restrictions and signage indicating bird-use areas may reduce flushing of birds. Crane and waterfowl collisions at Bosque del Apache National Wildlife Refuge in New Mexico were reduced simply by having personnel drive slowly and stop when birds were on refuge roads, which allowed the birds to leave the area without panic. However, this was not successful enough and the lines were eventually buried. (J. Bradenburg, pers. comm.)

Habitat Modification on Conservation, Recreation, and Residential Lands

Land managers and landowners may be able to manipulate bird habitat to minimize collision risk. For example, when waterfowl need to use two distinct habitat types (e.g., one for feeding and one for roosting), they will generally select those that are closest to each other. If a power line divides those habitats, the collision risk is greater. It may be possible to create both habitat types on one side of the line to reduce the crossing frequency (see *Line Placement* on page 66).

Management Practices on Agricultural Lands

Sometimes it is possible to enlist the help of landowners to modify management practices, including the timing of practices that may be attractive to birds, such as burning or flooding fields, where a line is experiencing a high collision rate. For example, in the San Luis Valley, Colorado, farmers plow barley stubble into the ground in preparation for planting in late fall and early spring—times when sandhill and, in the past, whooping cranes (*Grus canadensis* and *Grus americana*) forage in the stubble. The cranes may collide with power lines that border these fields, especially when feeding very close to the line. Through a program sponsored by utility companies, farmers were encouraged to begin plowing the stubble closest to the lines before the birds arrived. This reduced the risk of collisions by causing

FIGURE 5.4: Habitat modifications, such as cooperative programs to encourage earlier plowing of grain stubble, which is attractive to migrating sandhill cranes, may help to reduce collision risk.

the birds to forage farther from the lines where the stubble remained standing (C. Bryant, pers. comm.).

Discourage Bird Use of Industrial Lands

For industrial features such as landfills, cooling ponds, municipal sewage ponds, settling ponds at mines, and other industrial water bodies, property managers can choose from a variety of options that will discourage bird use, such as covering garbage, placing nets over a pond, and using visual or sonic deterrents. Cost, effectiveness, and maintenance should be considered when evaluating bird dissuasion options.

Removing the Shield Wire

Removal of the shield wire from transmission structures (AC or DC) can reduce bird collisions (Beaulaurier 1981; Brown et al. 1987), but is rarely a viable option because it exposes the lines to lightning strikes, which jeopardize service reliability (Figure 5.5). Shield wires are typically installed on the top of transmission structures to protect the phase conductors from lightning strikes and the electric grid from lightning related power outages. This overhead shielding has proven to be the most effective and economical lightning protection for transmission lines.

The lightning arrester system, one alternative to the shield wire, is effective when used on lines with distribution voltages from 4.2 to 35 kilovolts (kV) and provides sufficient protection to the line and associated equipment. However, lightning arresters may not be a viable option due to cost, design characteristics, and effectiveness for transmission voltages. Their presence would also increase the electrocution risk to birds that perch on power line structures. Because the shield wire often incorporates a fiberoptic communication line, the cost of modifications to the communications system would also need to be included in the analysis.

FIGURE 5.5: Removing shield wires can reduce bird collisions but leaves the lines unprotected from lightning strikes and jeopardizes service reliability.

Changing the Line Configuration

When collisions cannot be reduced by another method such as line marking or managing surrounding lands, the configuration of an existing line can sometimes be changed to minimize collisions. This is usually only possible for new construction or when a line is being rebuilt. Effective design changes would need to be based on studies of the flight behaviors of the bird species at risk (see *Evaluation Studies for Line Modifications*, page 54). In addition, the redesigned section(s) of line would need to be compatible with the rest of the line. Options for changes might include:

- Lowering the height of the lines (e.g., below the tree line)
- Changing the wire diameter
- Bundling wires
- Using spacers to improve visibility

- Rearranging wire configuration (e.g., converting from vertical to horizontal)
- Changing the structure type to increase its visibility
- Decreasing span length (e.g., by adding a pole mid-span)

Rerouting Existing Lines

If all other attempts to reduce significant collision risks to an acceptable level have been exhausted, rerouting may need to be considered. This option would require routing analysis, acquisition of a new or additional ROW, removal and relocation of existing structures, and a scheduled outage for the work. The rerouting analysis should include a comparative risk assessment to evaluate the collision risk for the new line (i.e., whether its risk is measurably lower than that of the existing line) to determine if the rerouting is justified (see *Avian Risk Assessment* on page 65). Environmental benefits and economic cost should be part of the risk analysis. Given the potential land costs and limited options for ROW , together with the cost of structure changes, the economics and logistics of rerouting make this option rarely possible.

Burying Power Lines

Burying power lines with voltages less than 345 kV have been proposed to reduce collisions. However, there are innate characteristics of buried lines that make them only rarely feasible. These include voltage and type of cable, land use patterns, soil conditions, regulatory acceptance, outage risk and reliability requirements, termination facility requirements, length and operating limits, and other environmental concerns. Depending on these characteristics, the cost of buried power lines can vary from 3 to 20 times that of an overhead line (Bumby et al. 2009).

Voltage and Type of Cable

As the voltage increases, costs increase. The type of cable (power line) used also affects the cost. Current options include paper-insulated cable installed in oil-filled pipes, and solid dielectric cables installed in conduits or buried directly in the earth with selected backfill (see *Soil Conditions*, page 63).

Lines ≥69 kV are normally installed in pressurized, oil-filled pipes in order to eliminate voids and moisture pockets in the cable insulation. They have an excellent reliability record when properly designed, installed, and maintained. The oil also tends to dissipate the heat generated by the current flow in the cables. If the oil can be circulated under pressure, the capacity and reliability of the cable will be enhanced.

Solid dielectric cables are currently being used for 115-kV and 230-kV applications. They are less reliable than oil-filled pipes. The preferred design is to place them in a conduit so that construction in highly developed areas may move rapidly and the necessary excavation can be covered quickly to reduce the impact and inconvenience to the public. The conduit also provides some physical protection to the cable from accidental excavations.

Land Use Patterns (Urban, Rural, etc.)

In highly developed areas where other utilities are buried (e.g., water, sewer, gas, communication), costs and space are at a premium. In rural areas, some conflict may exist with pipelines, rivers, and lakes (see Figure 5.6 and *Environmental Concerns* on page 63). In undeveloped areas, geologic formations may prevent economical trenching. In addition, underground lines require termination areas at both ends, similar to small substations, to accommodate the overhead-to-underground transitions.

FIGURE 5.6: Buried power lines may be a solution to bird collisions in some instances, but can cost from 3 to 20 times more than overhead lines and have other environmental impacts.

Soil Conditions

The soils must be able to dissipate heat during periods of high electricity demand. Soil condition also directly affects construction cost (i.e., sandy soils are more easily trenched than rocky soils). In many cases, the spoils from the cable trench have to be hauled away and replaced with heat-dissipating sands to meet the cable design standards.

Regulatory Acceptance

Utility regulatory commissions set rates and control costs. This can have a direct bearing on the feasibility of an underground project. There are documented projects where regulatory commissions have instructed the parties requesting underground construction to pay the difference in installation cost (e.g., Colorado Public Utility Commission Decision No. R82-93).

Outage Risk and Reliability Requirements

Cable failures are difficult to locate and the line must be dug up for repairs and maintenance. Extended outages normally result because of the length of time it takes to locate and repair a fault in the cable. Certain customers, such as hospitals and large industrial or mining operations, have higher reliability requirements than others.

Requirements for Termination Facilities

These include access for large equipment, a fenced area, transition structures, switches and other protective equipment, a transmission line tower or distribution structure, and in some cases a pumping station. Such overhead electrical facilities should be designed to minimize avian electrocution risk (see *Suggested Practices for Avian Protection on Power Lines,* APLIC 2006).

Length and Operating Limitations

As the length of the line increases, the operating limitations are approached and the options to address this will further increase costs.

Environmental Concerns

Environmental damage can result if a buried power line is near or crosses a waterway or is in wetlands or other sensitive habitats (Figure 5.6). If an oil-filled pipe leaks, the oil would contaminate the water and surrounding soils. Ground disturbance during construction, repairs, and maintenance can result in large, permanent displacement of excavated soil and subsequent issues with re-establishing native vegetation and preventing the overgrowth of invasive species. A University of California study (Bumby et al. 2009) found that underground power lines have more environmental impacts than overhead power lines for all categories and most scenarios in southern California.

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PLANNING NEW POWER LINES

EVALUATION STUDIES FOR SITING NEW POWER LINES

The potential for avian/power line interactions can be identified and addressed during corridor and routing evaluations such as spatial analysis, field assessment, and avian risk assessment. Methods for these evaluations differ because every route is unique with regard to the species, habitat, and line design. Ornithologists or wildlife biologists knowledgeable in local bird issues should be consulted for pertinent information on bird movement patterns and the presence of species of concern that could be affected by collisions with power lines. Habitats that influence bird presence and movement may present a collision risk and should be identified. Other biological, environmental, and engineering factors that contribute to collision risk should be understood (see Chapter 4) and considered as well.

Spatial Analysis

The siting process for new lines is in large part a geospatial analysis that facilitates the selection of a route that is compatible with regulatory, land use and availability, environmental, economic, and engineering considerations. Spatial analysis of habitats has been aided by the development of GIS software, which can help identify and characterize risk. GIS is often preferred because it can predict the optimal route by incorporating all the variables under consideration. Features in some GIS software systems can apply segment weighting to help determine the optimal route. GIS software specifically for siting and routing power lines has been developed by the Transmission Line Siting Methodology research project (see EPRI 2006). It uses a multi-step approach that starts with a large study area (corridor) and through various levels of evaluation selects potential routes and a preferred route. GIS software can also be used to create maps, which may be used to rank habitats for their prospective bird use within potential line routes. This approach is especially useful when species of concern occur along a proposed route.

About GIS

GIS (geographic information systems) software incorporates, stores, analyzes, manages, and presents data linked to a specific geographical location. It merges cartography, statistical analysis, and database technology. As a tool, GIS software helps decision-makers understand and predict the relationships between human uses and natural resources such as wildlife and habitat.

Field Assessment

Field assessment can often minimize collision risks (see Chapter 4) by identifying high-use bird habitats to avoid during route evaluation. Study designs should be scientifically defensible and developed to meet the needs of the project. Ideally, the following information should be obtained during the field assessment:

- Presence and abundance of bird species in the vicinity of the alternative routes
- Occurrence of species of concern, such as endangered species
- Location of habitat used by birds of concern
- Daily and seasonal use patterns for each species, including a differentiation between migration and daily use

This information can be obtained by using standard bird survey techniques, such as point counts, and from existing avian databases, such as the Christmas Bird Count and eBird (see Appendix E).

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Avian Risk Assessment

Avian risk assessment can be used to characterize the collision risk of a planned or existing line and to prioritize the segments that need to be modified. Risk assessment is a systematic process for characterizing the probability of an adverse effect occurring (USEPA 1998). It has been adapted for a

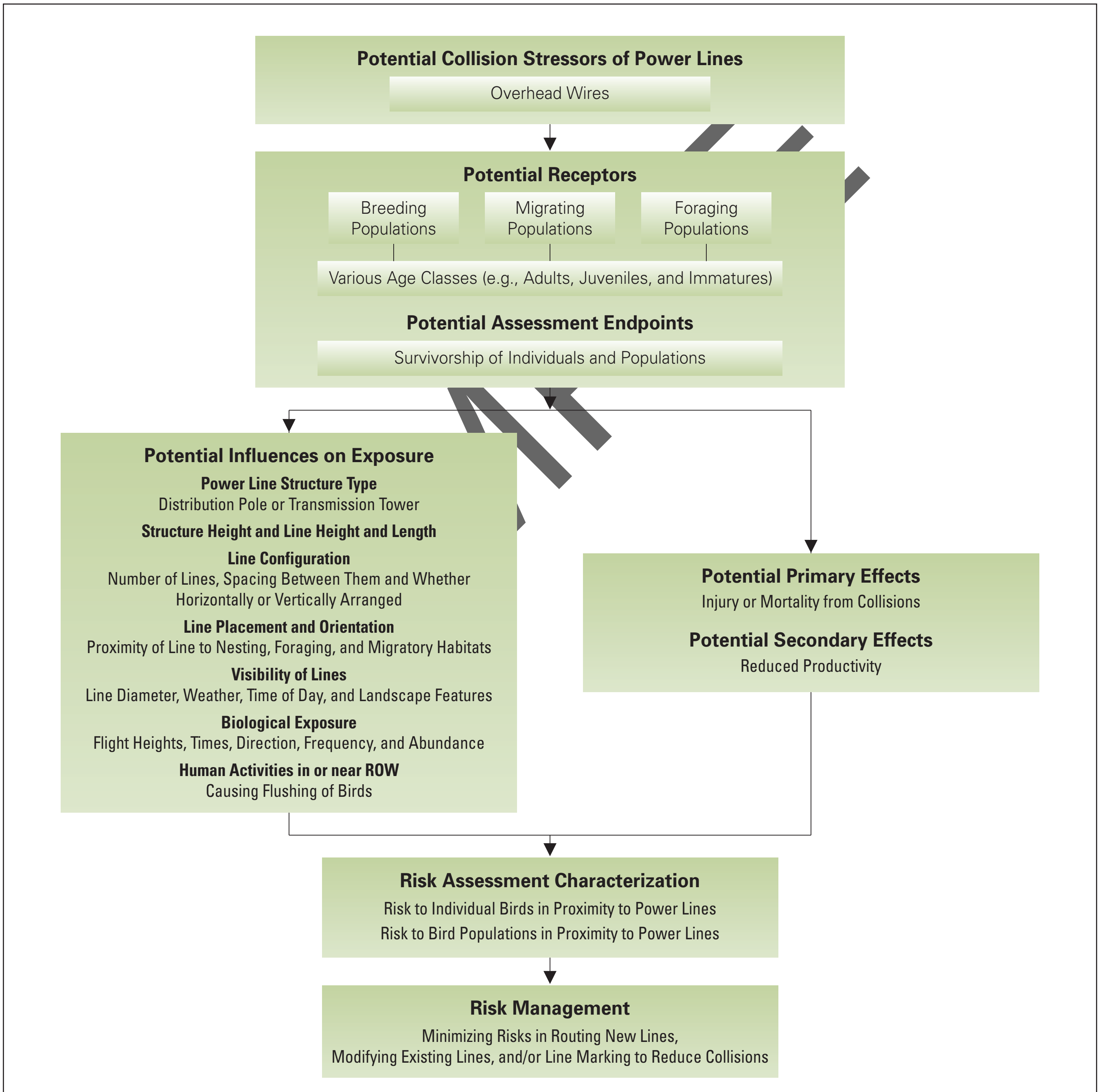

FIGURE 5.7: Conceptual model of avian collision risk assessment.

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PREVIOUS VIEW

wide range of applications, including avian/power line interactions. Avian risk assessment in this context evaluates the collision risk that a power line may pose to birds. It includes several steps: problem formulation (e.g., identifying species affected and specific collision issues), characterization of exposure and effects, risk assessment, and risk management. Figure 5.7 presents a conceptual model of avian collision risk assessment.

Both qualitative and quantitative estimates of risk can be used. One or both of these approaches may be appropriate depending upon the type of risk characterization required and the data available.

Qualitative risk assessment provides a non-numeric narrative description of risks. The resulting risk statement is descriptive (not mathematically quantifiable) and provides an estimate of risk, such as low, moderate, high, etc. This approach uses existing information about the proposed site, its ecological resources, literature on the physiology and behavior of species of concern, and reported effects (e.g., accounts of known collision mortality at existing power line projects). Implementing a qualitative methodology does not generally require field studies before construction, but uses site visits to confirm conditions and supplement available information.

Quantitative risk assessments provide estimates of the number of birds anticipated to be at risk to collisions. A quantitative approach accounts for, among other things, the spatial configuration of the stressor (power lines) and the spatial and temporal exposure of the receptor (birds) (i.e., the number of receptors that interact with the stressors in question).[14] Quantitative risk assessments can be developed using literature and other data but, because this method is typically used when greater precision is needed, it is frequently supplemented by site-specific data on power line engineering and/or design and site-specific observations and studies to further assess collision potential.

Sometimes a tiered risk assessment can be used starting with a qualitative assessment and proceeding to a quantitative assessment. For example, if more than one route is being compared for risks, a higher or lower risk ranking may be appropriate using a qualitative approach. If a specific prediction of the amount of mortality is required, a quantitative or modeled approach may be appropriate. Spatial analyses have been used with quantitative modeling to identify and prioritize high risk bird collision areas with varying degrees of success depending upon the quality and quantity of the data (see Heck 2007; Shaw et al. 2010; and Quinn et al. 2011).

OPTIONS FOR MINIMIZING COLLISION RISK DURING ROUTE EVALUATION

Engineering aspects such as line placement, line orientation, and line configuration all contribute to either increasing or decreasing the level of collision risk relative to biological and environmental factors (see Chapter 4). However, line routing is primarily a function of the origin and destination of the power being carried by these lines (see Figure 5.8), so other options such as line marking in areas where there is unavoidable collision risk and burying power lines where feasible and warranted may need to be considered.

Line Placement

Broadly, line routing should consider migratory patterns, areas of high bird use, and, if available, historical bird abundance information. On a finer scale, proximity to bird habitats (e.g., wetlands, trees, and other roosting, nesting, and foraging sites) is an important

[14] A stressor is a hazard in the environment that is capable of causing an adverse effect on a receptor. A wildlife receptor can be wildlife individuals, populations, or habitats that are subject to the potential impacts of a stressor.

Terminology Used When Planning New Transmission Lines

For transmission line planning, the following terms may have different meanings to various stakeholders. Figure 5.8 illustrates these terms, which will be used in this manual in the following way.

Planning is the process that identifies the need for a transmission line to deliver electricity from the generation facility to a load or demand center.

Siting determines where the ends of the line need to be—Point A and Point B.

Corridor or study area is usually a rectangular boundary between Points A and B within which the alternative and preferred transmission line routes are plotted.

Alternative routes through the corridor are identified based on a long list of considerations that include endangered species and wildlife habitat. Examples of additional considerations are:

- Cities and towns
- Landowner agreement
- Crossings, such as highway, water, other power lines
- Airports
- Heliports
- Cemeteries
- Communication towers
- Historic places and archaeological sites
- Wetlands
- Land availability
- Land use
- Homes/businesses/schools
- Hospitals
- Parks/recreation
- Pipelines
- Churches
- Wells
- Bridges
- Topography
- Line voltage, design, engineering, and construction

Determining a route through public land is distinctly different than through private land. On public land, an agreement with only a few landowners is necessary; whereas on private land, hundreds of landowners may be involved along with a diversity of land uses and concerns to consider.

The **preferred route** is suggested by the utility. After stakeholder participation, the public utility commission determines the final route, which may be the preferred route, an alternative route, or a combination of the preferred and alternative routes.

The **right-of-way (ROW)** is the land that will be used for the power line. Easements along the ROW give utility crews access to the line for maintenance and are legal agreements, including compensation, between the utility and the landowner.

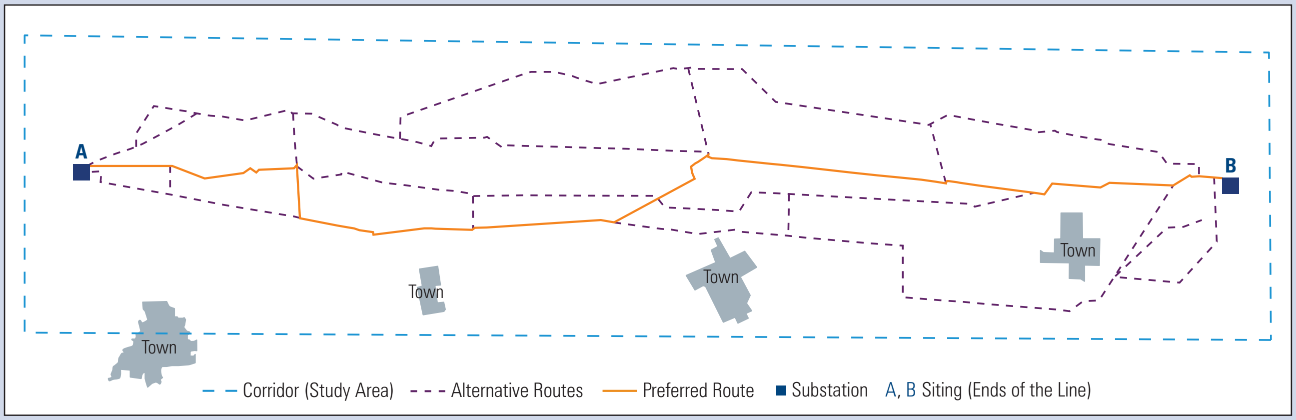

FIGURE 5.8: Schematic of the terminology used when planning new transmission lines.

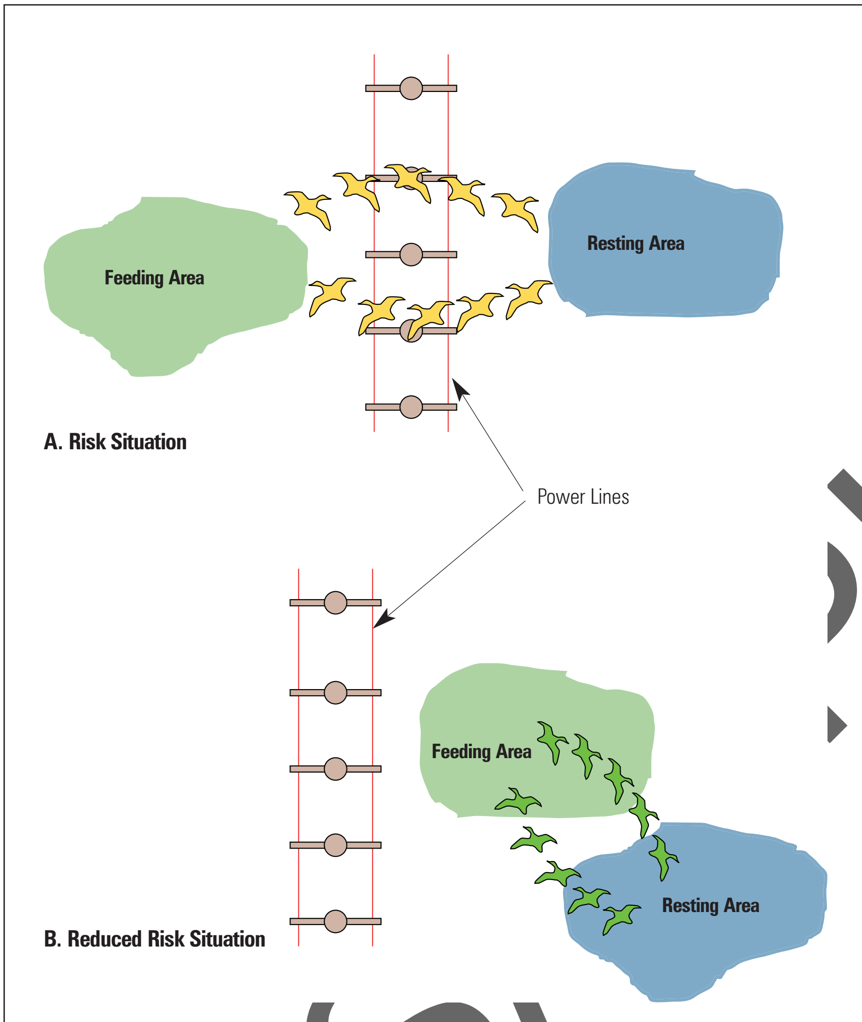

FIGURE 5.9: Potential collision risk (A) has been reduced (B) when bird-use areas are on the same side of the line (modified from Thompson 1978).

consideration when selecting a line route (see Chapter 4). The proximity of power lines to bird take-off and landing areas can affect the risk of collision (Lee 1978; Thompson 1978; Faanes 1987; Brown et al. 1984, 1987; Heck 2007; Quinn et al. 2011). For results of studies on distance of collision mortalities from specific areas, see *Habitat and Habitat Use* (page 44) and *Line Placement* (page 50). Spatial analysis with GIS is useful for evaluating different power line placement options relative to bird migration and habitat use patterns (see *Spatial Analysis* on page 64).

Line Orientation

Orientation of power lines relative to biological characteristics (e.g., flight behavior, season, and habitat use) and environmental conditions (e.g., weather patterns and topographical features) can influence collision risk. When planning power line routes, features such as mountain ridges, river valleys, and shorelines that are in traditional flight corridors should be considered (Colson and Yeoman 1978; Faanes 1987; Figure 5.10). Power lines that parallel primary bird flight paths pose less risk than a perpendicular orientation (Crowder 2000; Scott et al. 1972; McNeil et al. 1985). For example, the perpendicular orientation of a line relative to a topographical feature poses a greater collision risk to local and migrating birds, whereas a parallel orientation reduces risk.

Where perpendicular orientation cannot be avoided, forest habitats located near power lines can sometimes reduce collision risk (see Figure 5.3) Lines that are at or below the height of nearby trees rarely present a problem to small tree-dwelling birds because of their maneuverability; furthermore, large birds will gain altitude to fly over the tree line and will consequently avoid the power line (Thompson 1978; Raevel and Tombal 1991). For example, a power line crossing a narrow river bordered by trees that are taller than the line is likely to pose a lower collision risk than a broad river crossing because most birds will fly over the tree tops to cross the narrow river valley (CMS 2011a).

Strong tail winds can be detrimental to birds' ability to maneuver. Brown (1993) suggested that north-south orientation of lines increased collision frequency for cranes and waterfowl in the San Luis Valley, Colorado, because birds crossing them on an easterly heading were often subjected to prevailing westerly winds.

Line Configuration

Line configuration—phase conductors aligned vertically or horizontally and the number of conductors—is a collision factor that intuitively makes sense, but there are too few studies to draw conclusions. Most researchers agree that keeping the vertical arrangement of multi-conductor transmission lines to a minimum is beneficial because it reduces the height of the collision zone. However, a single-pole, vertical structure is often esthetically more acceptable and requires less ROW width.

Thompson (1978) and others (Bevanger 1998; Crowder 2000; Drewitt and Langston

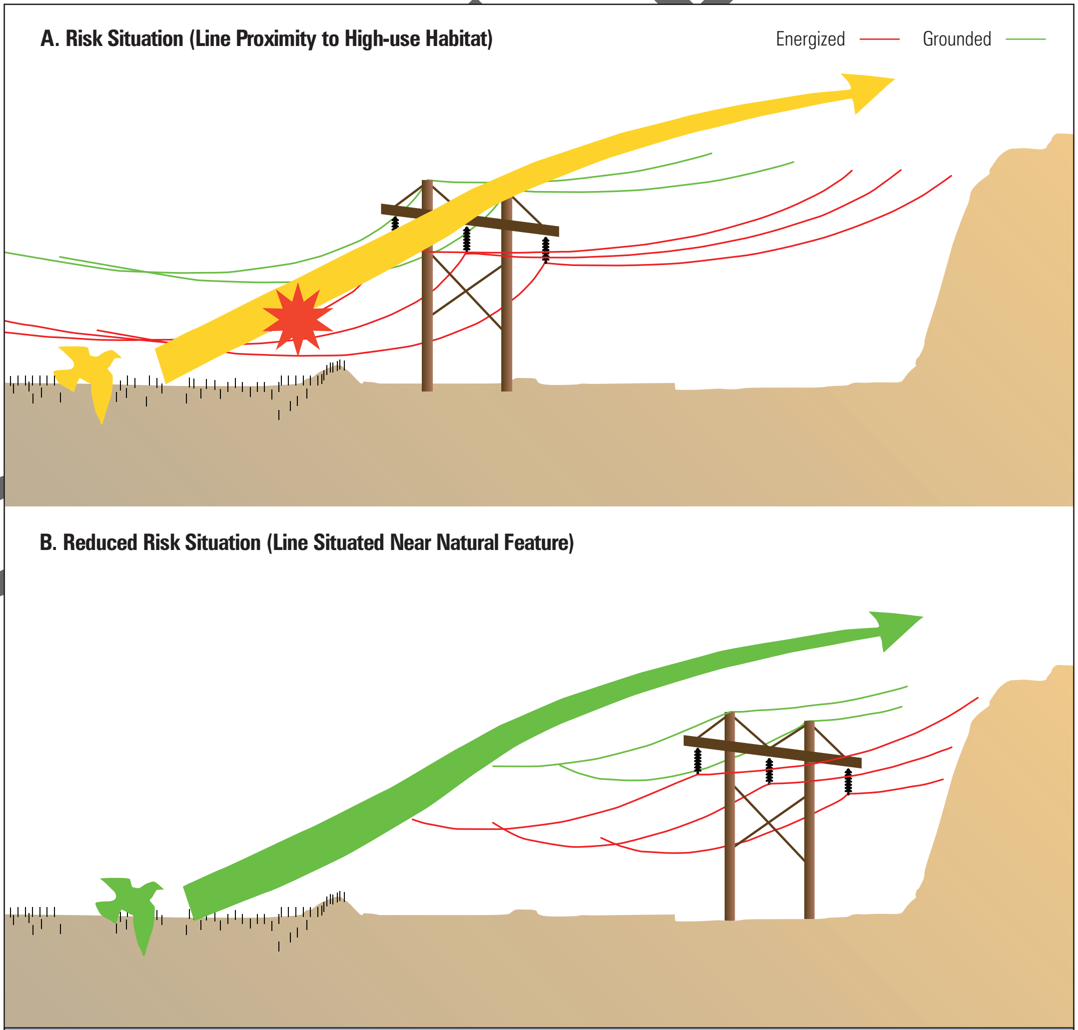

FIGURE 5.10: Routing with respect to local topographic features (after Thompson 1978).

2008) have suggested that clustering lines (i.e., several power lines sharing the same ROW) may reduce collision risk because the resulting network of wires is confined to a smaller area and is more visible. Birds only have to make a single ascent and descent to cross lines in this arrangement (Figure 5.11 and Figure 5.12). However, when there is decreased visibility, collision risk for birds may increase where several lines are clustered. When there are two shield wires at different heights, and only the higher one is marked, there may be collisions at the lower unmarked shield wire; both shield wires may need to be marked (S. Liguori, pers. comm.).

Other configuration options include:

- Lowering the height of the lines (e.g., below the tree line)
- Changing the wire diameter
- Bundling wires
- Using spacers to improve visibility

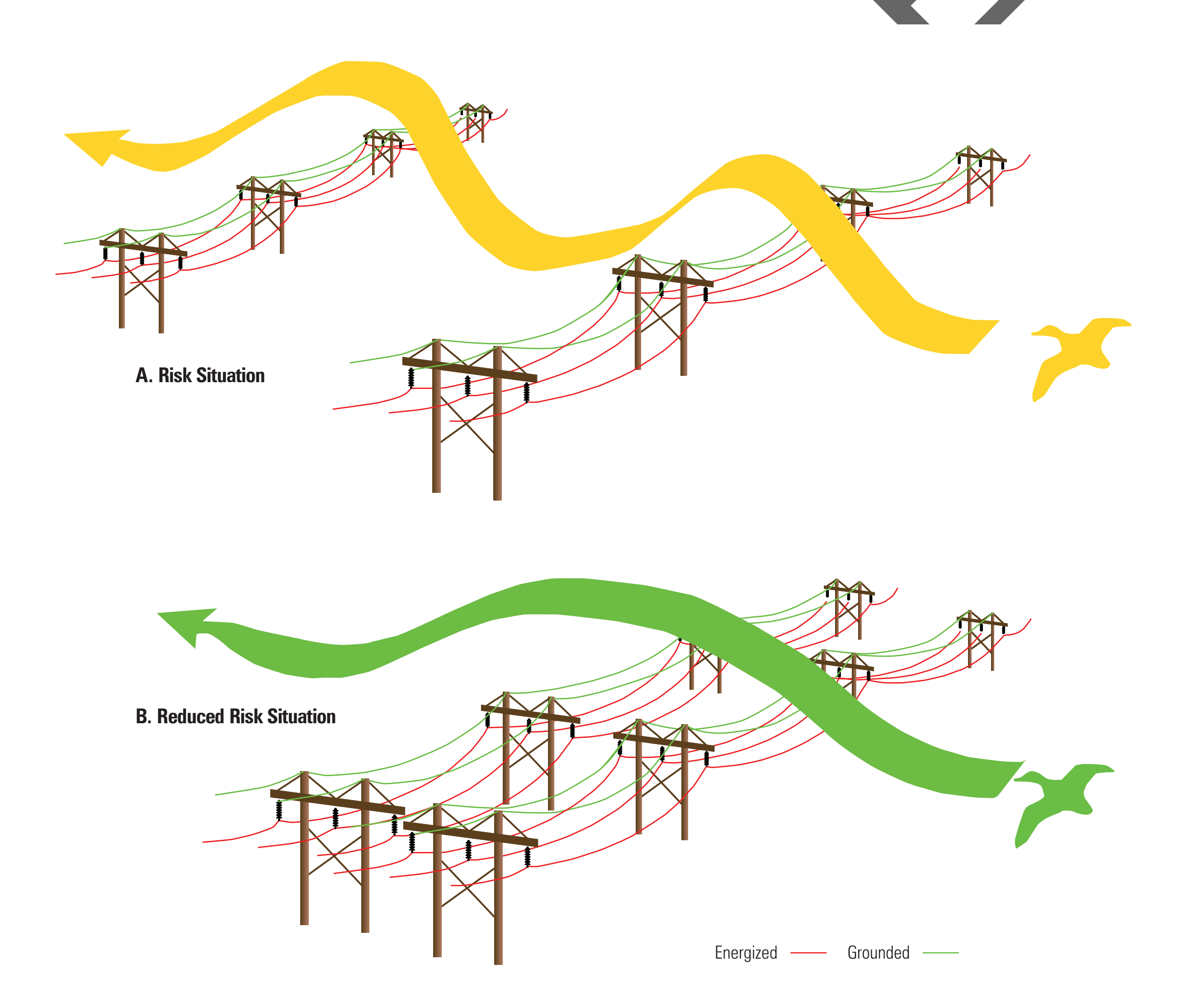

FIGURE 5.11: Reducing collisions by clustering lines in one right-of-way (after Thompson 1978).

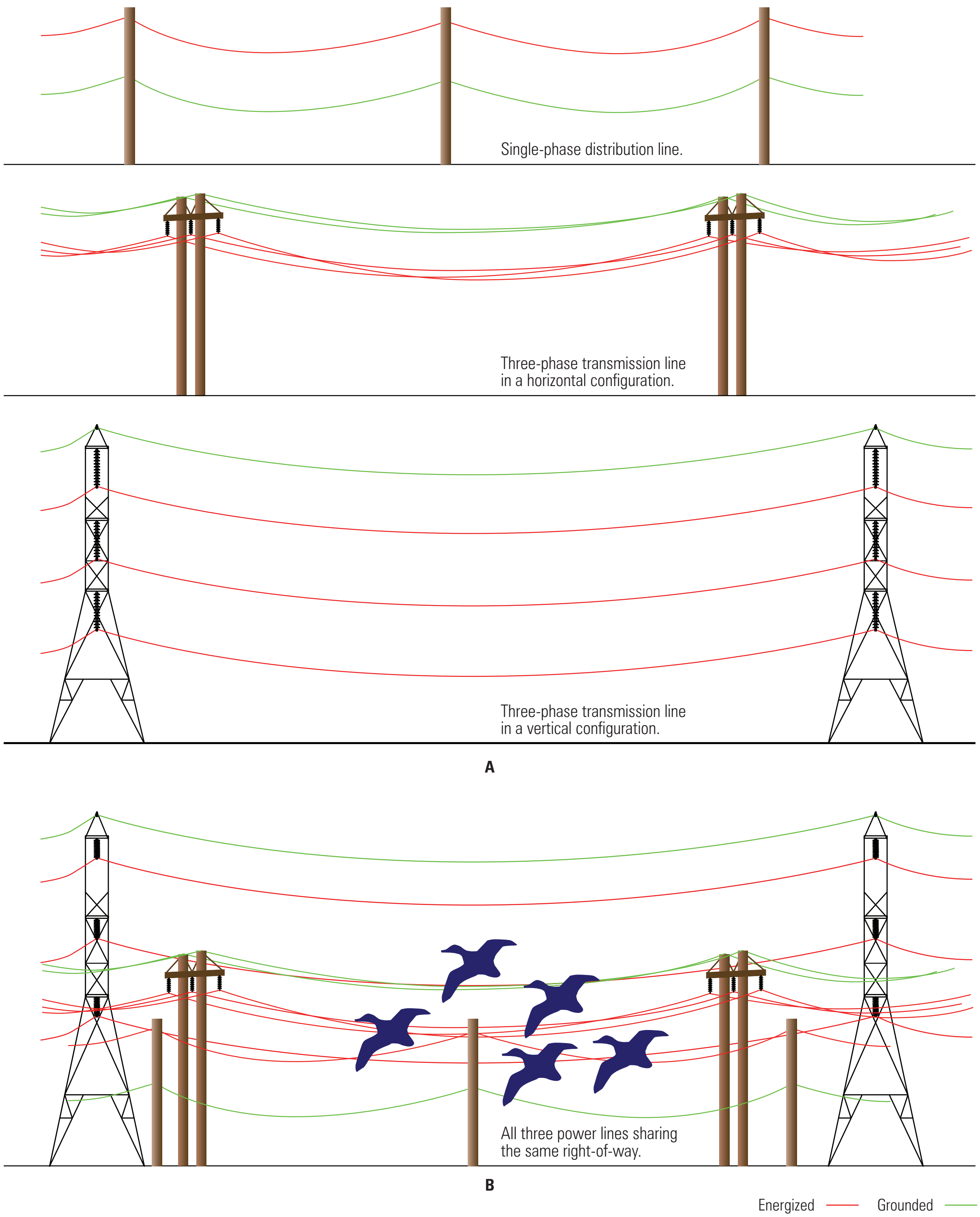

FIGURE 5.12: Collision risks for separate (A) and clustered (B) lines (after Thompson 1978).

- Rearranging wire configuration (e.g., converting from vertical to horizontal)
- Changing the structure type to increase its visibility
- Decreasing span length (e.g., by adding a pole mid-span)

Line Marking

In areas where there is collision risk, line marking devices should be considered. Most studies have shown a reduction in collisions and/or an increase in behavioral avoidance at marked lines when compared to unmarked lines, but this can vary with location, type of line marking device, and bird species (Jenkins et al. 2010; Barrientos et al. 2011; see Chapter 6 for detailed information on devices and effectiveness).There are three general categories of line marking devices: aerial marker spheres, spirals, and suspended devices (swinging, flapping, and fixed). Large diameter wire may also improve line visibility and has been used with line marking devices to reduce risk of collision-electrocutions and collisions (see Chapter 6). Line marking options are based on accessibility of the line, product availability and durability, ease of installation, cost, compliance and legal issues, spacing and positioning, safety codes related to ice and wind loading, corona effects, esthetics, and potential for vandalism.

Burying Power Lines

See the discussion on *Burying Power Lines* under *Options for Modifying Existing Lines* (page 62).

PUBLIC PARTICIPATION TO ADDRESS SOCIAL AND CULTURAL ISSUES

The public may have concerns about power line design and placement, including esthetics, environmental effects, wildlife, and safety. Vandalism is also a persistent problem—electrical equipment and line marking devices can become targets. When a utility is taking steps to minimize collision risk, a public participation program can help build positive relationships, increase public knowledge, identify and respond to public concerns, and promote responsible behavior (e.g., discouraging vandalism of line marking devices).

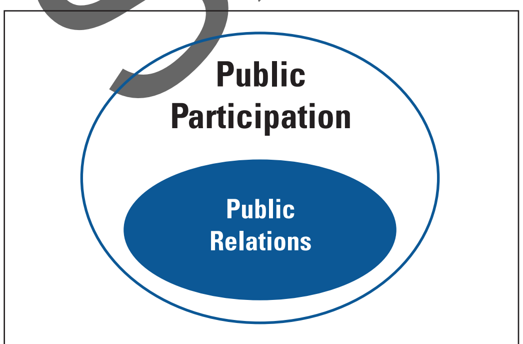

FIGURE 5.13: Public participation programs may provide information through a public relations campaign, but they also go further to engage the public in discussions and decision making (after EEI 2001).

WHAT IS PUBLIC PARTICIPATION?

Public participation is different from public relations or public information programs. While a public relations campaign provides information to the public, public participation programs actively engage the public in discussions and decision making. A well-designed public participation program requires the expertise of someone who can communicate technical information in an easily accessible way, facilitate groups, and cultivate trust with stakeholders. For a public participation program to succeed, the commitment and involvement of top management including the key decision makers is essential.

Utilities can use a variety of public participation tools to address social and cultural aspects of collision risk (see EEI 2001 and Appendix E for resources). Exhibits, signs, publications, web pages, and public announcements can be used to inform the public. Other techniques, such as webcasts, public forums, interviews, polls, retreats, citizen advisory panels, social media communications, and workshops promote engagement in the process. All efforts should be based on knowledge of the target audiences, consistent messages, audience participation in building a shared understanding, complete and objective information, and partnerships with supportive organizations and businesses. Edison Electric Institute's (EEI) *Introduction to Public Participation* (EEI 2001) is an excellent source of practical information for electric utilities.

Case Study: How Public Participation Benefitted Transmission Line Routing

The Project: Florida Power & Light (FPL) Crane-Bridge-Plumosis Transmission Line in southeast Florida (Martin and Palm Beach counties).

The Issue: FPL sought licensing for a 64.4-kilometer (40-mile) transmission line that traversed two densely populated counties. The route chosen for the power line generated some controversy because it included residential areas and a sensitive environmental tract. Alternative routes were proposed and submitted by various non-governmental and neighborhood groups as well as individuals. Continued opposition was expected.

Public Participation: A Citizens Advisory Panel (CAP) was appointed that included members from many different interest groups. The CAP recommended a route that was similar to the one originally recommended by FPL staff and consultants. FPL chose the panel's route.

The Result: The chosen route was initially rejected by the permitting agency but formed the basis of the final approved route.

Benefits of Public Participation: By establishing and working with the CAP, FPL precluded numerous separate meetings with different interest groups. The CAP increased understanding and support for the project despite initial opposition by individual parties. The discussions led to acceptable compromises, and costly appeals and reviews were avoided. In the end, FPL had an approved route that was similar to their preferred route and many members of the CAP felt positive that their input resulted in an improved project. The goodwill developed in the community benefited FPL's public image and set the stage for better relations on future projects.

(Modified from a case study that originally appeared in EEI 2001)

BENEFITS OF EFFECTIVE PUBLIC PARTICIPATION

Past experience shows that public participation has a record of creating cooperative working relationships (EEI 2001). According to EEI (2001), public participation:

- Reduces delays and costs associated with controversy and litigation. It often reduces implementation time because the public already supports or accepts the decision.
- Builds a positive relationship with the public, which is important even when it is necessary to make an unpopular decision.
- Develops and maintains credibility even with those who disagree with a given decision. A negative public image in one arena can affect a company's bottom line and trigger opposition in other arenas.
- Creates collaborative problem solving for achieving better and more acceptable decisions. When people believe that utility decisions are being imposed on them, they are more likely to increase their opposition.
- Gathers information from the public that the utility needs to make informed decisions.
- Can improve programs and policies, which will enjoy greater support.
- Can help management understand that technical issues have important social components. Some decisions appear to be technical, but are actually decisions about values.

CREATING A STRUCTURED PROGRAM

There are three phases to establishing a successful public participation program: decision analysis, program planning, and implementation. For case studies and a thorough description of how to plan and implement a public participation program use *Introduction to Public Participation* (EEI 2001) as your guide.

Phase 1: Decision Analysis

Clearly identify the decision-making process for the project and establish what role the public will play. Consider who will be affected by the project and if public support for the project is needed. Determine whether regulatory requirements or constraints may limit the opportunities for public participation. A thorough decision analysis will ensure that you engage the public for the right reasons and are not promising something that is not in your power to provide.

Phase 2: Program Planning

Successful participation plans address the needs and goals of both the utility and the public. The steps in creating a participation plan are:

- Identify the issues that will be important and assess the level of controversy of each. Issues and concerns typically focus on one or more of the following: mandate, economics, health, proximity, values, and existing uses of the property or area.
- Identify the parties (stakeholders) that need to be represented in the process. Invite a cross-section of the public including those who will be affected, those with a vested interest, and those who have decision-making power.
- Determine the goals for your public participation program. Goals provide focus and a course of action for the process. Clearly defined goals also make it easier to evaluate the success of the process.
- Define the level of public participation needed and state this clearly when inviting participants. In some cases, the public may be making decisions, while in other cases they may be providing support or recommendations.
- Select appropriate techniques of public participation based on the issues, level of controversy, and audience. Techniques, such as newsletters, web pages, exhibits or news releases provide information, whereas focus groups, meetings, workshops, polls, and interviews foster active public participation and collaboration.
- Outline the decision-making process including all steps from identifying the problem to formulating, evaluating, and selecting alternative approaches.

Phase 3: Implementation

Implement the program according to the collaboratively developed plan. During implementation, participants may see the need to make adjustments or changes, so be flexible and prepared.

Characteristics of Successful Public Participation

Successful public participation programs often do the following:

- Make public participation an integral part of the project, rather than an afterthought.
- Commit to a decision-making process at the outset and maintain that commitment.
- Ensure that the interested public is involved in all phases of decision making: definition of the problem, range of possible alternatives, criteria used to evaluate alternatives, and selection of the final course of action.
- Carefully assess the needs of different audiences and choose techniques appropriate for all groups and for the information that will be collected.
- Ensure that management is engaged and has endorsed the program. This will create a climate of acceptance, which is essential to meaningful public participation.

CHAPTER 6

Line Marking to Reduce Collisions

IN THIS CHAPTER

A common observation in collision studies is that birds show the ability to avoid a power line if they see the lines early enough. Many of these studies indicate that collision risk can be lowered by more than half and, in some cases, by as much as 80% after lines have been marked. This chapter discusses what is known about line marking, including the different devices, their reported effectiveness, and considerations in their use.

OVERVIEW OF LINE MARKING DEVICES

Studies suggest that the majority of bird collisions occur with the smallest diameter wire, which is typically the shield wire located above the phase conductors on transmission lines (e.g., Savereno et al. 1996) or the phase conductor and neutral wire on distribution lines. Most collisions occur mid-span (e.g., Eskom Transmission 2009). As a result, most of the efforts to reduce bird collisions have focused on marking the shield wires on transmission lines and the phase conductors on distribution lines. As discussed in Chapter 4, different biological, environmental, and engineering factors contribute to birds' ability to see and avoid a power line; each should be considered when choosing among line marking options.

There are three general types of line marking devices: aerial marker spheres, spirals, and suspended devices (swinging, flapping, and fixed). In addition, large diameter wire, though not a marking device, may also improve line visibility and has been used with line marking devices to reduce risk of collision-electrocutions and collisions (see *Large Diameter Wire* on page 100). Since 1994, aerial marker spheres, spirals, and suspended devices have been further developed. Advances include changes to shape, colors and color patterns, and attachments, along with UV resistance, which improves durability and colorfastness. Other designs have been developed, but are not currently available in the United States (see *Devices Available in Other Countries* on page 97).

Because there are few comparative studies, no single device is considered to be the best performing. However, Jenkins et al. (2010) concluded that any sufficiently large line marking device that thickens the appearance of the line for at least 20 centimeters (cm) (7.8 inches [in]) in length and is placed with at least 5 to 10 meters (m) (16.4 to 32.8 feet [ft]) spacing is likely to lower collision rates by 50% to 80%. In addition, the South African Electric Supply Commission (Eskom Transmission 2009) describes its use of spirals and suspended devices on transmission lines and recommends suspended devices over small-diameter spirals because their swinging or flapping motion makes them more visible and more effective.

Devices can be purchased in a variety of colors, which may be important but there are insufficient comparative studies to provide firm conclusions. In general, what seems to be effective is to alternate the colors to make the lines more obvious (Eskom Transmission 2009). For aerial marker spheres, yellow seems to be the preferred choice over international orange because they provide better contrast in poor light conditions.

Table 6.1 provides a general description of the most commonly used devices that are available in the United States.

TABLE 6.1: Summary of data on line marking devices available in the United States.*

Name†	Description	Dimensions	Spacing§	General Comments on Effectiveness§
Aerial Marker Spheres				
Aerial Marker Spheres or Aviation Balls	Large, colored spheres that attach to wires.	Diameter ranges from 23 cm (9 in) to 137 cm (54 in). The 23 cm (9 in) and 30.5 cm (12 in) are most often used for line marking.	Up to 100 m (328 ft) apart. See Table 6.3 for details.	Reduction in collisions noted in certain situations. Sometimes this marker is used in conjunction with other line marking devices. See Table 6.4 for details.
Spirals				
Spiral Vibration Damper (SVD)	Extruded plastic (PVC) spiral device that fits over the shield wire and distribution conductors.	Various lengths, ranging from 112 to 165 cm (46 to 65 in), to fit different conductor sizes.	Often placed about 3 m (9.8 ft) apart on the shield wire. Stagger on distribution lines to prevent interphase contact.	Reduction in collisions noted. Not as commonly studied as other line marking devices. See Table 6.6 for details.
Bird-Flight™ Diverter (BFD)	Spiral device made from high impact PVC that attaches at one end to the shield wire or distribution conductor and increases in diameter at the other end.	Lengths range from 17.8 to 59.7 cm (7 to 23.5 in). Diameter at the large end ranges from 3.8 to 12.7 cm (1.5 to 5 in).	Ranges from 4.6 to 21 m (15 to 68.9 ft) apart. See Table 6.7 for details.	Shows varying amounts of effectiveness in collision risk reduction and flight behavior alteration. Commonly included in collision studies. See Table 6.8 for details.
Swan-Flight™ Diverter (SFD)	Similar to the BFD, but this device attaches at both ends with the larger diameter spirals in the center.	Lengths range from 50.8 to 116.8 cm (20 to 46 in). Diameter of central spiral ranges from 17.8 to 20.3 cm (7 to 8 in).	Ranges from 15 to 30 m (49.2 to 98.4 ft) apart. See Table 6.9 for details.	Shows varying amounts of effectiveness in collision risk reduction and flight behavior alteration. Commonly included in collision studies. See Table 6.10 for details.

Continued

TABLE 6.1: Summary of data on line marking devices available in the United States.* (cont.)

Name†	Description	Dimensions	Spacing§	General Comments on Effectiveness§
Suspended Devices				
General Designs	Swinging and fixed devices; plastic flapper of various shapes and colors with reflective and glowing surfaces; connected to a clamp that attaches to the power line.	Size and shape varies with device and design.	5 to 30 m (16.4 to 98.4 ft) apart. Staggering devices on parallel lines is recommended. See Table 6.11 for details.	Shows varying amounts of effectiveness in collision risk reduction and flight behavior alteration. Commonly included in collision studies. See Table 6.12 for details.
FireFly™	Swinging and fixed models; rectangular devices with reflective and glowing surfaces; connected to a clamp that attaches to the power line.	Acrylic plastic tag measures 9 cm x 15 cm (3.5 in x 6 in).	4.6 to 15.2 m (15 to 50 ft) apart. See Table 6.13 for details.	Shows varying amounts of effectiveness in collision risk reduction and flight behavior alteration. See Table 6.14 for details.
BirdMark BM-AG	Swinging perforated disk has a reflective center and spins and flutters, it also glows; connected to a clamp that attaches to the power line; perforations allow device more wear resistance in high wind locations.	29.21 cm (11.5 in) long with a 13.33-cm (5.25-in) diameter disk.	4.6 m (15 ft) apart	Mentioned in reviews, but no scientific studies were found.

* Source: Summarized from available literature and Hunting (2002); see *Line Marking Devices* on page 85 for detailed information and sources.
† This table only includes devices that are available in the United States; see *Devices Available in Other Countries* on page 97.
§ Summarized from different sources and studies with varying methodologies, environments, and species; see tables in *Line Marking Devices* for detailed information and sources.

EFFECTIVENESS OF DESIGNS

EARLY STUDIES (1960 TO 1994)

In Europe during the 1960s and 1970s, numerous studies addressed the effectiveness of different devices to make power lines more visible so collision rates could be reduced. Most of these studies tested aerial marker spheres (aviation balls) and various types of plastic or rubber strips attached to the lines. These studies found that increasing the visibility of lines resulted in a statistically significant reduction of collision risk.

In 1964, a 275-kilovolt (kV) line near Teeside, England, was marked with 15-cm (6-in) black vanes (flags). Koops and de Jong (1982) reported that this effort was successful in reducing bird collisions, although no quantitative data were given. Renssen et al. (1975, cited in Beaulaurier 1981) investigated several marking schemes: black, white, and orange aerial marker spheres on the shield wire.

Overall, the dozen or more studies during this period (see lists in Beaulaurier 1981 and Hunting 2002) found that marking devices ranged from no effect to a 60% reduction in collisions. The limitation of these early studies was that most were conducted over a short period of time or they were not held to rigorous experimental protocols. Often, quantifying and comparing flight intensities over marked and unmarked lines were not done.

In addition, the durability of these devices was often very limited because of the plastic and cloth materials used.

LATER STUDIES (1995 TO 2012)

Testing and reporting on the effectiveness of line marking devices have broadened to include the behavioral responses of birds approaching power lines. Hunting (2002), Lislevand (2004), Jenkins et al. (2010), and Barrientos et al. (2011) identified approximately two dozen studies that have focused on the effectiveness of certain devices for selected species. However, most of these studies involved transmission lines, and relatively few have looked at the comparative effectiveness of different devices. Hunting (2002) also concluded that making recommendations on the comparative device effectiveness is not possible due to the variation in study designs.

Barrientos et al. (2011) conducted a meta-analysis of published and unpublished collision studies to evaluate whether line marking reduced the number of collisions and which devices might be more effective. Although they showed that line marking reduced collision rates by 78%, the variability in study designs made it impossible to compare the effectiveness of these devices with different species, in different habitats, in different weather conditions, or on different line configurations. Barrientos et al. (2012), a before-after-control-impact (BACI) study of the effectiveness of two spiral devices (the smaller bird flight diverter and the larger swan flight diverter), concluded that line marking is an effective way of reducing mortality on distribution and transmission lines. Their estimate of overall effectiveness was significant, but not as high as others have reported; more definitive predictions were not possible because of study design and data limitations.

Comparison studies that use the same monitoring time intervals, control for habitat differences, and standardization of the periodicity of carcass searches are necessary to determine the device best suited to a given set of environmental conditions and species intended for protection. The following examples reflect various approaches to studying the effectiveness of line marking devices. (For studies on the effectiveness of each device, see *Line Marking Devices* on page 85.)

In San Luis Valley, Colorado, Brown and Drewien (1995) evaluated the effectiveness of two devices: yellow spiral vibration dampers (SVDs) and yellow swinging fiberglass plates with a diagonal black stripe (30.5 cm × 30.5 cm [12 in × 12 in]). Marked segments 0.8 kilometers (km) (0.5 mile [mi]) long were compared with unmarked segments of equal length during spring and fall seasons over a three-year period. They found that SVDs reduced sandhill crane (*Grus canadensis*) and waterfowl mortality by 60% and the swinging plates reduced mortality by 63%. Flight intensities were quantified. Evaluation of the flight behavior of sandhill cranes, Canada geese (*Branta canadensis*), and ducks at marked and unmarked lines indicated that birds reacted to marked lines by increasing their altitude and reaction distance. Although both devices significantly reduced mortality, the swinging plates damaged power lines.[15] The authors suggested that the silhouette of the swinging plate also provided an important benefit in low-light conditions.

In west-central Spain, Janss and Ferrer (1998) studied the effectiveness of three devices (white spiral, series of crossed bands, and thin black strips) on marked and unmarked transmission (380 kV and 132 kV) and distribution (13 kV) lines over a four-year period. The three devices were examined by comparing marked to unmarked spans

[15] The concept of swinging plates has developed into a variety of suspended devices. This new generation of suspended devices has reduced the line-wear problem while maintaining effectiveness.

along the same power line. Monthly carcass searches were conducted without correcting for monitoring biases (see Appendix B). The species exhibiting the highest mortality included bustards, cranes, and shorebirds. The white spiral devices (30 cm × 100 cm [11.8 in × 39.4 in]), similar to a Swan-Flight™ Diverter (SFD), reduced expected mortality by 81% for all birds. The series of two black, crossed bands (35 cm × 5 cm [13.8 in × 1.9 in]) reduced expected mortality by 76% for all birds but not for great bustard (*Otis tarda*). The thin black strips (70 cm × 0.8 cm [28.6 in × 0.3 in]) placed at 12-m (39.4 ft) intervals from the central conductor did not reduce mortality. The authors state that the data could not be used for statistical comparison of effectiveness of the different diverters for specific species.

FIGURE 6.1: Studies at the San Luis National Wildlife Refuge show that the line marking devices tested work well for most species, the exception being the American coot, which is more vulnerable to collisions because it primarily flies at night.

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The Ventana Wildlife Society (2009) conducted a comparative effectiveness study of Bird Flight™ Diverters (BFD) and SFDs at six sites at San Luis National Wildlife Refuge Complex in California. Although approximately 800 hours of observation were made during three winter seasons from 2005 to 2008, few collisions were observed. However, many reactions to power lines were documented, such as altitude changes or sudden changes in flight direction called flutter or flare. The birds exhibited reactions at greater distances from power lines after flight diverters were installed, especially on lines with SFDs. Estimated total collisions were significantly higher for the unmarked control lines than for the lines marked with BFDs or SFDs. The difference in estimated total collisions between control lines and marked lines was even greater when the analysis excluded the American coot (*Fulica americana*), which primarily flies at night and accounted for approximately half of all carcasses found. The study concluded that both diverters were ineffective for the American coot. The study also suggested that site-specific differences can influence the effectiveness of diverters.

Western Area Power Administration conducted a line marking study along 3.2 km (2 mi) of line in 2006, 2007, and 2008 (WAPA 2011). Three line marking devices were used: SFD, BirdMark (solid orange), and FireFly™. The study occurred near Coleharbor, North Dakota, along the Audubon causeway, which separates Lake Audubon on the east from Lake Sakakawea on the west. More than 1,000 bird carcasses (from road mortality and collisions with power lines) and 300 hours of observational data were collected. The results indicated that marking the line decreased the number of observed flyovers for the majority of species; rather than flying over the lines, birds turned and flew parallel to the line. The study also indicated that the differences in device efficacy were minimal.

Regardless of the variability in studies on the effectiveness of devices, most studies have shown a reduction in collisions and/or an increase in behavioral avoidance when compared to unmarked sections of a line.

MARKING CONSTRAINTS AND CONSIDERATIONS

The choice of marking device is often based on consideration of product availability and durability, cost, ease of product installation, compliance and legal issues, spacing and positioning, safety codes related to ice and wind loading, corona effects, esthetics, and vandalism. Utilities are encouraged to investigate and test products before installing them on a large scale. A general discussion of these considerations is presented here. For specific considerations on each device, see *Line Marking Devices* on page 85. For additional information on what devices may be appropriate, utility companies can consult with the manufacturer and with other utilities.

PRODUCT AVAILABILITY AND DURABILITY

Three general types of devices are available in North America: aerial marker spheres, spirals, and suspended devices. In addition, larger diameter wire can be considered for increasing line visibility. Several distributors supply these devices, so utility managers should consult with their suppliers for available options. Other devices have been developed, but are not currently available in the United States (see *Devices Available in other Countries*, page 97).

The durability of line marking devices and diverters was a commonly reported concern in the 1990s and 2000s. Since then most manufacturers have redesigned these devices to withstand ultraviolet (UV) light degradation, and they have improved the attachment clamps on suspended devices so that damage to the power line is reduced or eliminated—device specifications can be obtained from the manufacturer.

Static devices (such as spirals) and dynamic devices (such as some suspended devices) have different durability. Static devices have been more durable since they do not have moving parts. However, they have had limited success in South Africa since they can be less visible than dynamic devices. It is assumed that the motion is what makes the dynamic devices more visible. The disadvantage of dynamic devices is that they are subject to wear and have a more limited useful life than static devices. Some dynamic devices can also cause wear damage on the power line (Eskom Transmission 2009). In high wind areas, some devices with moving parts broke within several months (PacifiCorp, unpubl. data).

COST CONSIDERATIONS

Costs will vary with power line access, installation method, type of device, spacing, number of devices needed, and durability of the device. These depend in part on the line design, voltage, and length of line to be marked. Cost will also vary if the marking is done during construction of new lines or retrofitting existing lines. Power lines that are higher or over a water body (e.g., rivers, lakes, etc.) can be difficult to access and require more costly installation methods, such as a boat or helicopter. The durability of each device also varies, which makes long-term maintenance and impacts on line reliability additional considerations in cost estimates. Product cost contributes the least to the overall cost of line marking.

EASE OF INSTALLATION

The various types of line marking devices require different installation techniques: from the ground, bucket truck, boat, helicopter, line trolley, or other means. Some devices can be attached by hand and others need to be attached by a hot stick. Devices that coil onto

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FIGURE 6.2: A helicopter crew installing line marking devices on a power line.

lines may be easier to install by hand, if possible, than by hot stick. Some, such as suspended devices, may be installed by either one or two people, and a tool may be required for one-person installation.[16] In areas where access to the power line is difficult, product durability may be a more important consideration than ease of installation. For products with a shorter lifespan, the ease of product removal for repairs or replacement should also be considered.

COMPLIANCE AND LEGAL ISSUES

Associated issues must be considered to ensure that the line marking system complies with all applicable company, industry, and legal requirements. Installation must not reduce National Electrical Safety Code (NESC) clearance requirements, cause damage to standard power line hardware, conductors, and/or supporting structures, or affect the line or system reliability. Attachment procedures must adhere to worker and industry safety standards and be compatible with standard industry tools and equipment. Where facilities are shared, the easement documents may have restrictions concerning additions or modifications. In addition, legal counsel of some utility companies may object to the use of aerial marker spheres for preventing bird collisions because they prefer that the spheres only be used in compliance with Federal Aviation Administration (FAA) regulations to mark hazards to aircraft.

SPACING AND POSITIONING

Spacing and positioning determine the ability of marking devices to increase line visibility, the number of devices needed to mark each span, and how much the marking will add to the ice and wind loading. Over the years, studies have discussed spacing and positioning of devices on power lines. However, there have been no systematic comparisons of devices and their spacing and positioning. The following are general recommendations for spacing and positioning. For specific recommendations on each device, see *Line Marking Devices* on page 85.

Spacing recommendations vary depending on species considerations, environmental conditions, line location, and engineering specifications (e.g., wind and ice loading, conductor size, and the presence or absence of the shield wire). In general, intervals of 5 to 30 m (16 to 98 ft) have been most commonly used and recommended for all but the aerial marker spheres (aviation balls), where a greater spacing is used, and SVDs, where less spacing is used (see Table 6.1). Jenkins et al. (2010) concluded that any sufficiently large line marking device that increases the diameter of the line by at least 20 cm (8 in) for a length of at least 10 to 20 cm (4 to 8 in) and is placed at intervals of 5 to 10 m (16 to 32 ft) is likely to lower general collision rates by 50% to 80%.

For positioning, Eskom Transmission (2009) recommends marking only 60% of a span, the central portion of the shield wires on transmission lines, since this is where

[16] A utility should consult with its safety department to determine appropriate practices for individual or crew work.

PREVIOUS VIEW

TABLE 6.2: Distance of collision mortalities from the nearest pole (parallel to distribution lines in the right-of-way).*

Taxa or Species	Sample Size	Distance	
		Mean Std Dev	Range
Geese	43	11.9 ± 10.7 m (39 ± 35 ft)	0.6 to 45.7 m (2 to 150 ft)
Ducks	25	16.2 ± 13.1 m (53 ± 43 ft)	0.6 to 48.8 m (2 to 160 ft)
Swans	5	18.6 ± 9.4 m (61 ± 31 ft)	6.1 to 60.9 m (20 to 200 ft)
Raptors	12	37.5 ± 11.9 m (123 ± 39 ft)	18.3 to 54.9 m (60 to 180 ft)
Great blue heron (*Ardea herodias*)	7	17.4 ± 12.8 m (57 ± 42 ft)	1.5 to 33.5 m (5 to 110 ft)
American white pelican (*Pelecanus erythrorhynchos*)	16	19.8 ± 15.2 m (65 ± 50 ft)	1.8 to 45.7 m (6 to 150 ft)
Sandhill crane (*Grus canadensis*)	6	21.9 ± 16.5 m (72 ± 54 ft)	6.1 to 45.7 m (20 to 150 ft)

* Source: PacifiCorp, unpubl. data

most collisions occur. In surveys conducted from 2004 to 2009 in Oregon, California, Idaho, Utah, and Wyoming, PacifiCorp (unpubl. data) found that most waterfowl collision mortalities were found mid-span in the right-of-way (ROW), parallel to distribution lines, at distances of 12 to 18 m (39 to 61 ft) from the nearest pole (Table 6.2); typical span lengths were 91.5 to 121.9 m (300 to 400 ft). Sandhill cranes (*Grus canadensis*), American white pelicans (*Pelecanus erythrorhynchos*), and raptors were found farther from the nearest pole than were other species (PacifiCorp, unpubl. data.). These distances can help direct the placement of line marking devices (Figure 6.3).

Another commonly recommended strategy is to stagger the devices on parallel lines in the same plane to increase the visual density of the marked power line (Figure 6.4 and Figure 6.5). This would also reduce the number of markers on each individual line and each line's ice and wind loading.

SAFETY CODES: ICE AND WIND LOADING

The NESC identifies minimum safety and engineering standards for power lines within the United States. The NESC ice and wind loading and safety criteria for conductors and supporting structures must be reviewed prior to marking. These guidelines are used when designing a line so the constructed power lines meet or exceed NESC criteria. In addition, some states have adopted additional codes and regulations that further specify design criteria.

When any device is added to an overhead power line, it adds to the weight or loading of the line. Ice or wind adds still more loading to the line and supporting structures. The added weight of the devices and the extra wind and ice loading must not exceed line

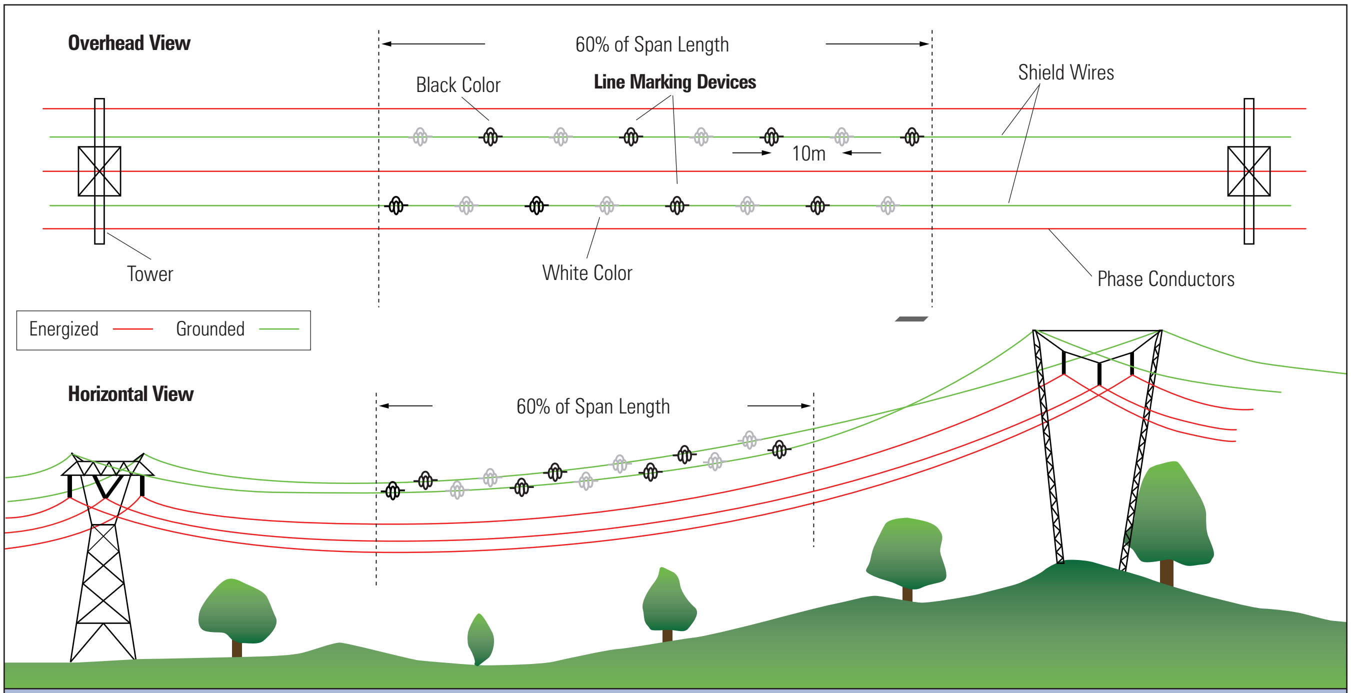

FIGURE 6.3: Positioning of line marking devices on the central portion of two shield wires on transmission lines (after Eskom Transmission [South Africa] 2009).

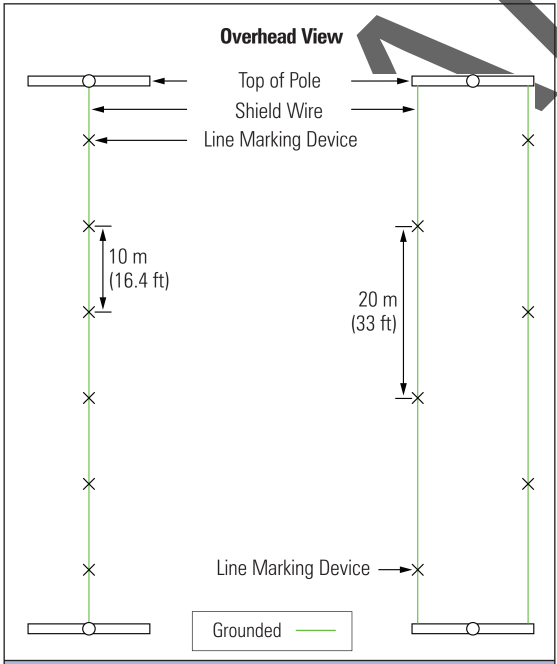

FIGURE 6.4: Positioning of line marking devices on one shield wire or staggered on two parallel shield wires.

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FIGURE 6.5: Line marking devices staggered on a distribution line.

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FIGURE 6.6: When a device is added to a power line, it may add to the loading of the line, which further increases under icy or windy conditions and may also cause problems for deicing operations.

design limits and code requirements or cause additional sag that could lead to interphase contact (one conductor contacting another) and an outage. Consultation with the design engineers is imperative to ensure that adding any type of line marking device will not exceed design criteria. For existing lines, additional loading must be considered when retrofitting with line marking devices. When designing new power lines that may require marking, include allowances for the additional loading of those marking systems to prevent safety criteria from being exceeded.

CORONA EFFECTS

Electric corona occurs when the voltage of a phase conductor, typically 115 kV or greater, ionizes the surrounding air, which also becomes a conductor (Hurst 2004). Corona can degrade certain materials over time (Hurst 2004). Corona discharges appear as bluish tufts or streamers around the phase conductor, generally concentrated at irregularities on the conductor surface. A hissing sound, an odor of ozone, and local radio interference often occurs. Sharp corners of energized parts and voids, bubbles, and other heterogeneous components within solid materials (e.g., diverters) can cause corona effects.

Hurst (2004) tested several devices (Bird Flapper, FireFly™, BirdMark BM-AG, BFD, and SFD) at three simulated voltages. The study found that most of the devices had very little or no corona at 115 kV (except for some of the suspended devices) but did have corona effects at 230 kV and 345 kV. The best-performing devices at 115 kV were the BFD and the SFD, neither of which had any detectable corona discharge. At 230 kV, the BFD and the SFD had a medium level of corona, whereas suspended devices were characterized with a high level. At 345 kV, all of the devices had a very high level of corona. The corona generally occurred at the point of attachment to the phase conductor and at the top of the Bird Flapper and FireFly.

ESTHETICS

Visual management and esthetics have become concerns related to the construction or modification of power lines. With appearance as a consideration, dull rather than shiny materials are now widely used for overhead lines. Consequently, power lines were designed to blend with the background and be as invisible as possible, particularly in heavily forested areas. However, with growing concern about bird collisions, design goals are changing toward making the line acceptable to people but not invisible to birds.

If the power line is located where the viewshed is an environmental value, such as on or near public land or in residential areas, the addition of line marking devices may become an esthetic issue. For public lands and resi-

Using Public Participation to Address Social Constraints of Line Marking

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FIGURE 6.7: Power structures and line markers can become targets for vandalism and a detriment to service reliability. Public participation and outreach programs, like this hotline, may reduce vandalism.

Participation and outreach programs can increase public support for strategies such as line marking and can change or reduce behaviors such as vandalism. This can make it easier for a utility to meet requirements for electrical reliability and customer satisfaction while reducing risks to birds. See Chapter 5 for a discussion on using public participation to address social issues that influence collision risk. Appendix E includes resources.

dential areas, the marking system should be effective and acceptable in appearance. Public participation and outreach programs can increase support for line marking in areas where viewshed or esthetics are concerns, which could avoid the need for making a trade-off between esthetics and collisions (see *Public Participation* in Chapter 5).

VANDALISM

Vandalism is a persistent problem with overhead power lines, particularly from irresponsible shooters. In general, the poles, insulators, towers, signs, and line marking devices can become targets when lines traverse sparsely populated areas. As a result, electrical conductors have been damaged or severed, and extensive outages have resulted. Repair and replacement costs are ultimately borne by the utility companies and ratepayers. In addition, some customers with critical electricity needs, such as hospitals and mining operations, have had to rely on emergency back-up measures in order to maintain safety levels (A. D. Miller, pers. comm.). When evaluating any line marking system, the potential for vandalism should be addressed. Public participation and outreach programs may help reduce or prevent vandalism (see *Public Participation* in Chapter 5).

LINE MARKING DEVICES

AERIAL MARKER SPHERES (AVIATION BALLS)

Aerial marker spheres (or aviation balls) were one of the earliest devices used in an attempt to reduce bird collisions (Figure 6.8 and Figure 6.9). Originally they were used to warn aircraft pilots of power lines. These large, colored balls are usually attached to distribution phase conductors or transmission shield wires. They are available in a variety of diameters: 23 cm (9 in) to 137 cm (54 in). The most often used sizes for line marking are 23 cm (9 in) and 30.5 cm (12 in).

Aerial marker spheres are available in a variety of colors, including international orange, gloss white, or gloss yellow. Studies

PREVIOUS VIEW

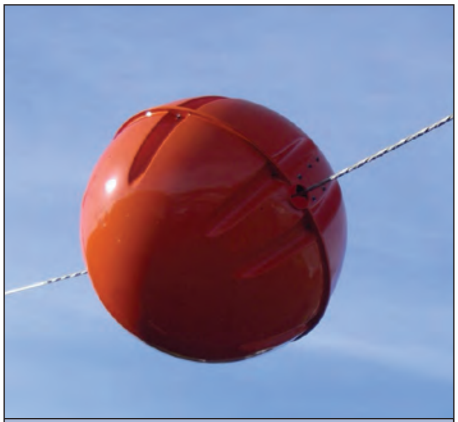

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FIGURE 6.8: Aerial marker spheres, also known as aviation balls, were designed to make power lines more visible to aircraft operators.

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FIGURE 6.9: Aerial marker spheres in use on a power line above a wetland habitat.

regarding the effectiveness of color for warning pilots have shown that international orange is not the most effective color for all lighting conditions (Electrical World 1986). The FAA suggests a combination of international orange, gloss white, or gloss yellow for marking lines for aircraft. In bird collision studies, yellow has been shown useful because it reflects light better at dawn and dusk, and it does not blend in with the background colors as readily as international orange.

Recommended spacing between spheres generally ranges from 30 to 100 m (100 to 328 ft) (Table 6.3 and Table 6.4). For an existing line that crosses water, where the addition of aerial marker spheres may not be suitable, a separate (non-energized) cable for the purpose of holding the aerial markers could be installed. In this application, a larger size cable (visible to birds) should be used so that it does not contribute to bird collisions. This may provide adequate marking to reduce collisions.

TABLE 6.3: Spacing and positioning for aerial marker spheres (aviation balls).*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Aerial Marker Spheres (Aviation Balls)	30 to 100 m (98.4 to 328 ft) apart (APLIC)	Spacing is not critical and will depend upon local conditions. The general rule is 20 m (65.6 ft) apart (Preformed Line Products)	Up to 100 m (328 ft) apart. Some studies staggered devices on parallel lines to increase visual density.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.
† See Table 6.4 for study details and sources.

PREVIOUS VIEW

TABLE 6.4: Representative studies for aerial marker spheres (aviation balls).

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
Yellow spheres with black vertical stripe, 30 cm (11.8 in)/spacing: irregular intervals	Nebraska/ sandhill cranes	Transmission, 69 kV to 345 kV	Behavioral avoidance was greater (birds flew higher and reacted sooner) for marked versus unmarked line	Significantly reduced collisions	Morkill and Anderson 1991
Yellow aviation balls with black stripes, 30 cm (11.8 in)/spacing: 100 m (328 ft); staggered on opposing shield wires for a visual effect of 50 m (164 ft)	South Carolina/ various waterfowl species	Transmission, 115 kV	Behavioral avoidance was greater (birds reacted sooner) for marked versus unmarked line	Collision rate was 53% lower at marked line	Savereno et al. 1996
Yellow aviation marker ball with 20.3 cm (8 in) black dots/spacing: not provided	Hawaii/ shearwaters	–	–	Reduced collisions	Telfer 1999 cited in Bridges et al. 2008

Considerations for Aerial Marker Spheres (Aviation Balls)

- Improper design or installation of aerial marker spheres on phase conductors or shield wires can cause spheres to work loose and slide to the center of the span or be pushed by wind to the end of a span. Line damage from this may cause an outage.
- Aerial marker sphere size should be compatible with the design constraints of the line. For example, very large spheres can be heavy and should only be used on lines that can handle this weight.
- Adding aerial marker spheres can affect line tension and structure design more than other devices, particularly in areas where heavy ice and wind loading occurs. Accommodating the additional loading could affect construction costs.
- When installed on higher voltage conductors, there can be corona damage (depending on the type of marker balls). To avoid corona damage, marker balls designed for installation on higher voltage lines, though more costly, should be used.
- Spheres are moderately labor-intensive to install on an existing line, but less costly when added to a new line during construction.
- Although aerial marker spheres are more costly per unit than spirals, the overall cost of marking new or existing lines would be about the same because fewer spheres would be required.
- The legal counsel of some utility companies objects to the use of aerial marker spheres to prevent bird collisions. They prefer that spheres be used only in compliance with FAA regulations to mark hazards to aircraft.
- Depending upon the location, aerial marker spheres can be targets for irresponsible shooters.
- The size and number of aerial marker spheres used may result in visual degradation of environments where esthetics are important (tourist areas, scenic mountain views, historic areas, etc.)

SPIRALS

Spirals available in the United States include spiral vibration dampers (SVDs), Bird-Flight™ Diverters (BFDs), and Swan-Flight™ Diverters (SFDs).

Spiral Vibration Damper (SVD)

Spiral vibration dampers (SVDs) are pre-formed PVC spirals that were designed to reduce line vibration (aeolian vibration), but were also found to increase line visibility and to reduce collision risk. Aeolian vibration is induced by low-velocity winds of 4.8 to 12.9 km per hour (3 to 8 mi per hour) (Figure 6.10). SVDs change the airfoil of a power line under normal and icing conditions to reduce conductor gallop.

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FIGURE 6.10: Spiral vibration dampers act to reduce line vibration, and they also make power lines more visible to birds.

SVDs are available in various lengths, ranging from 112 to 165 cm (46 to 65 in), to fit different wire sizes. Standard SVDs are made of solid thermal plastic. They are available in gray or yellow with UV stabilizers that help the devices retain color, flexibility, and durability when exposed to extreme sunlight and weather conditions. They are also available in a yellow, high-impact PVC.

SVDs are often placed about 3 m (9.8 ft) apart on transmission line shield wires (Table 6.5 and Table 6.6). For distribution lines, to prevent interphase contact and increase line visibility, SVDs should be staggered so that every third one is on an alternate phase conductor.

TABLE 6.5: Spacing and positioning for spiral vibration dampers (SVDs).*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Spiral Vibration Damper (SVD)	2.7 m (9 ft) on the shield wire. On distribution phase conductors, stagger SVDs to prevent interphase contact. (APLIC)	–	3.3 m (10.8 ft) apart (Brown and Drewien 1995)

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.
† See Table 6.6 for study details and sources.

TABLE 6.6: Representative studies for spiral vibration dampers (SVDs).

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
Yellow spiral vibration dampers, 1.27 cm × 112 to 125 cm (0.5 in × 44 to 49.2 in) / spacing: 3.3 m (10.8 ft)	Colorado/ waterfowl and sandhill cranes	Distribution, 7.2 kV Transmission, 69 to 115 kV	Reacted sooner and changed flight patterns in marked versus unmarked lines	Reduced mortality by 60%	Brown and Drewien 1995

Considerations for Spiral Vibration Dampers

- When installed on triangularly spaced distribution lines, SVDs should be staggered on all three phase conductors. Despite their light weight, if they are only applied on the top or ridge phase conductor, wind or ice may make the top phase sag, which may cause interphase contact.
- When installed on a single shield wire, given the relatively light weight of SVDs, the rate of coverage, and the distance between the shield wire and the phase conductors, line sag on the shield wire would rarely present an issue.
- SVDs are not recommended for use on transmission phase conductors (AC or DC) with voltage ≥230 kV because of corona effects (see *Corona Effects*, page 84). However, future design materials may address this issue.
- Installation of SVDs is moderately labor intensive on lower-height distribution lines and more so on transmission lines that range from 15.2 to 59 m (50 to 195 ft) above the ground.

FIGURE 6.11: The Bird-Flight™ Diverter is a spiral device made of PVC.

Bird-Flight™ Diverter (BFD)

BFDs are preformed, increasing-radius spirals made of extruded, high-impact PVC (Figure 6.11 and Figure 6.12). One end of the spiral grips the power line while the radius quickly increases toward the other end of the spiral. BFDs were developed in Great Britain and have been used in Europe since the early 1970s and more recently in the United States and South Africa. They are also called "small pigtails" in South Africa (Eskom Transmission 2009). Since 1994, more designs have become available.

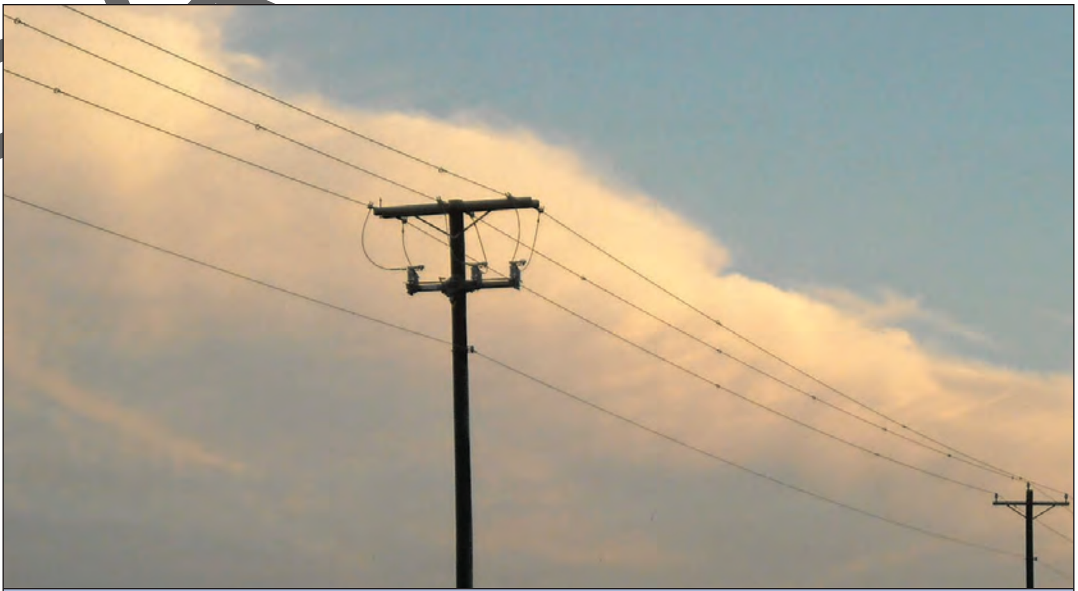

FIGURE 6.12: Bird-Flight™ Diverters installed on a distribution line.

TABLE 6.7: Spacing and positioning for Bird-Flight Diverters (BFDs).*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Bird-Flight Diverter (BFD)	4.9 to 15.2 m (16 to 50 ft) (APLIC) 10 m (32.8 ft), staggered (Eskom) 21 m (68.9 ft) (Iberdrola)	4.6 m (15 ft) apart depending upon local conditions (Preformed Line Products)	5 m (16.4 ft), 10 m (32.8 ft), 15 m (49.2 ft), and 20 m (65.6 ft). Some studies staggered devices on parallel lines to increase or maintain visual density and to reduce and distribute loading equally.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions. Manufacturer recommendations are the closest spacing that would be required.
† See Table 6.8 for study details and sources.

Various sizes of BFDs are available to fit different line diameters. The lengths can range from 17.8 to 59.7 cm (7 to 23.5 in). The diameter of the spiral at the large end of the diverter ranges from 3.8 to 12.7 cm (1.5 to 5 in). UV stabilizers are added to the PVC to protect BFDs from sunlight. They are produced in a variety of colors, such as yellow, orange, red, green, brown, gray, and black, and some glow.

Spacing recommendations for BFDs vary (Table 6.7 and Table 6.8). In the Netherlands, wires have been marked in bird-collision zones using 10 cm (3.9 in) spirals at 5 m (16.4 ft) intervals. This reportedly has an average mortality reduction of approximately 90% (Koops 1993). For the United States, one manufacturer (Preformed™ Line Products) recommends 4.6 m (15 ft) spacing intervals depending upon local conditions. In studies conducted in the Netherlands, marking devices have been staggered on parallel shield wires so that the line marking devices appear to be 5 m (16.4 ft) apart (Koops 1979; Koops and de Jong 1982; Koops 1987). On each shield wire, however, they are 10 m (32.8 ft) apart. Staggering line marking devices on alternate lines reduces the loading that a single marked line would otherwise have to bear.

Considerations for Bird-Flight Diverters

- BFDs add some aeolian vibration stabilization since their profile changes the airflow over the line.
- BFDs are not recommended for use on transmission line phase conductors (AC or DC) with voltage ≥230 kV because of corona effects (see *Corona Effects*, page 84). However, future design materials may address this issue.
- Eskom has used BFDs in South Africa for years with no reports of mechanical failure (van Rooyen 2000) although some red PVC devices have faded.
- BFD installation is labor intensive whether by bucket truck, boat, helicopter, or line trolley. Robotic installation devices are being developed.

TABLE 6.8: Representative studies for Bird-Flight Diverters (BFDs).

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness: Behavioral Avoidance	Effectiveness: Reduction in Collisions	Reference
White BFD, 5 cm (1.9 in) diameter/ spacing: 5 m, 10 m, and 20 m (16.5, 32.8, and 65.6 ft) White BFD, 10 cm (3.9 in) diameter/spacing: 15 m (49.2 ft)	Netherlands/ various species	–	–	When spaced at 20 m (32.8 ft), they reduced collisions by 58%. Total mortality was reduced by 57% to 89%, depending upon the size and spacing	Koops 1987; Koops and de Jong 1982; Koops 1993 (cited in Janss and Ferrer 1998)
Red spiral BFD, 30 cm (11.8 in) maximum diameter, 1 m (3.3 ft) long/spacing:10 m (32.8 ft)	Spain/various species including cranes and bustards	Transmission, 380 kV with dual shield wires	61% reduction in birds crossing the lines, more birds flying over, fewer flying through lines	60% reduction in collisions	Alonso et al. 1994
Yellow and gray BFD	Indiana/ waterfowl	Transmission, 345 kV		Reduced bird collision by 73.3% compared to unmarked lines	Crowder 2000
Yellow PVC BFD spirals, 25 cm (9.8 in) diameter, 80 cm (31.5 in) length /spacing: 10 m (32.3 ft); staggered on both shield wires	Colombia/ night flying rallids, herons, and ducks	Transmission, 500 kV	Birds detected BFD line at a greater distance than unmarked line, fewer flew at conductor height	Reduction in collision frequency for marked versus unmarked lines, but collision rate was highly variable regardless of line condition	De La Zerda and Roselli 2003
Yellow and gray BFD/ spacing: 4.6 m (15 ft); staggered on 3 phase conductors	California/ waterfowl	Distribution	Birds exhibited greater reactive distances	Reduced waterfowl collisions, but not coot collisions (coots fly at night)	Ventana Wildlife Society 2009
Small spirals, 10 cm (3.9 in) diameter, 24 cm (9.4 in) long/ spacing was not provided	Spain/various species including bustards, storks, and doves	Distribution and transmission	–	Reduced collisions overall after line marking (9.6%)	Barrientos et al. 2012

Swan-Flight™ Diverter (SFD)

The SFD is another spiral design, which is also called a Double Loop Bird Flight Diverter (Figure 6.13 and Figure 6.14). SFDs have two gripping ends and a central spiral with a larger diameter.

Sizes are available to fit different conductor diameters. The lengths can range from 50.8 to 116.8 cm (20 to 46 in). The diameter of the central spiral can range from 17.8 to 20.3 cm (7 to 8 in). SFDs are extruded in yellow and gray high-impact PVC with UV

FIGURE 6.13: The Swan-Flight™ Diverter is a double-ended spiral device.

FIGURE 6.14: Swan-Flight™ Diverters installed on the phase conductors of a distribution line.

stabilization. Gray is the standard color but SFDs are available in: black, blue, brown, green, purple, red, orange, and pink, and some that glow.

Spacing depends upon local conditions (Table 6.9 and Table 6.10).

Considerations for Swan-Flight Diverters

- SFDs can be used on the shield wires of high-voltage lines.
- SFDs on the line add some aeolian vibration stabilization since their profile changes the airflow over the line.
- SFDs are not recommended for use on transmission line phase conductors (AC or DC) with voltages ≥230 kV because of corona effects (see *Corona Effects*, page 84). However, future design materials may address this issue.
- Wind and ice loading should be considered, as these have been a concern in Canada and the northern United States (N. Heck, pers. comm.).
- Colors of some SFDs may fade.
- Installation is labor intensive whether done from bucket truck, boat, helicopter, or line trolley. Robotic installation devices are also being developed.

TABLE 6.9: Spacing and positioning for Swan-Flight Diverters (SFDs).*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Swan-Flight Diverter (SFD)	15.2 m (50 ft) (APLIC) 21 m (68.9 ft) (Iberdrola)	Spacing is not critical and will depend upon local conditions. The recommended ranges are 10 to 15 m (32.8 to 49.2 ft) (Preformed Line Products) up to 30 m (98.4 ft) (FCI)	5 m (16.4 ft), 10 m (32.8 ft), and 15 m (49.2 ft). Some studies staggered devices on parallel lines to increase visual density and distribute loading equally.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.
† See Table 6.10 for study details and sources.

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TABLE 6.10: Representative studies for Swan-Flight Diverters (SFDs).

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
White spirals (SFD), 30 cm (11.8 in) diameter/ spacing: 10 m (32.8 ft)	Spain/various species including cranes, storks, and bustards	Various size distribution and transmission lines	–	Effective at reducing collisions	Roig-Soles and Navazo-Lopez 1997
White polypropylene spirals, 1 m (3.3 ft) long, 30 cm (11.8 in) maximum diameter/spacing: 10 m (32.8 ft); staggered on 2 shield wires for a visual effect of 5-m (16.4-ft) intervals	Spain/cranes	Transmission, 380 kV and 132 kV Distribution, 13 kV	–	Small sample size did not permit specific species evaluation. Reduced mortality for common cranes. The reduction in actual versus predicted mortality for all birds was 81%	Janss and Ferrer 1998
Yellow and gray SFD/spacing was not provided	Indiana/ waterfowl	Transmission, 345 kV	–	Reduced collisions by 37.5% on marked lines compared to unmarked lines	Crowder 2000
Yellow SFD/ spacing: 15.2 m (50 ft); staggered on parallel wires for a visual effect of 7.6-m (25-ft) spacing	Wisconsin/ trumpeter swans (*Cygnus buccinator*)	Distribution, 23.9 kV	–	Eliminated collisions completely	Rasmussen 2001, cited in Hunting 2002
Red SFD, 32 cm (12.6 in) for the gripping section and 17.5 cm (6.9 in) for the outside diameter of the central spiral/spacing: 5-m (16.4-ft) intervals on shield wire	England/ mute swans (*Cygnus olor*)	Transmission, 132 kV	–	Reduced collisions	Frost 2008
Gray SFD/ spacing: 4.6 m (15 ft); staggered on 3 phase conductors	California/ waterfowl	Distribution	Birds exhibited greater reactive distances	Reduced waterfowl collisions, but not coot collisions (coots fly at night)	Ventana Wildlife Society 2009
Large spirals, 35 cm (13.8 in) diameter, 1 m (3.3 ft) long/ spacing was not provided	Spain/various species including bustards, storks, and doves	Distribution and transmission	–	Reduced collisions overall after line marking (9.6%)	Barrientos et al. 2012

ESKOM 2009

FIGURE 6.15: Examples of suspended devices (swinging and fixed).

SUSPENDED DEVICES (SWINGING, FLAPPING, AND FIXED)

There are several types of suspended devices including general designs and branded designs (e.g., FireFly™ and BirdMark BM-AG), which are discussed separately on page 95 and page 96. They have a clamp that attaches to the power line so that the device can move in the wind. Some are designed to swing, flap, and spin, while others, for use in high wind locations, are nearly immobile but do allow some motion. Some have reflective and glow-in-the-dark properties.

General Designs

Suspended devices have a polycarbonate, UV stabilized, plastic flapper (swinging or fixed) connected to a clamp that attaches to the power line (Figure 6.15). The movement and reflectivity of the device enhances the visibility of the line. Suspended devices are available in many colors and shapes with panels that reflect visible and UV light and glow. They can be attached to distribution phase conductors up to 40 kV and to shield wires up to a diameter of 1.9 cm (0.75 in) (Table 6.11 and Table 6.12).

TABLE 6.11: Spacing and positioning for general designs of suspended devices.*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
Swinging or fixed device	5 m (16.4 ft), staggered (Eskom)	Staggering devices on parallel lines is recommended. The general spacing rule is 10 to 15 m (32.8 to 49.2 ft) (Preformed Line Products).	–

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.

TABLE 6.12: Representative studies for general designs of suspended devices.

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
Swinging or fixed device (specifications and spacing not provided)	South Africa/ bustards and cranes	Distribution, 22 kV Transmission, up to 440 kV	– –	Reduced collisions More effective than the BFD	van Rooyen 2000; Anderson 2001; McCann 2001
Yellow fiberglass swinging plate, 30.5 x 30.5 cm, (12 × 12 in) with a black stripe/ spacing: 20 to 30 m (65.6 to 98.4 ft) on shield wires or center phase conductor	Colorado/ sandhill cranes and waterfowl	Distribution, 7.2 kV Transmission, 69 kV to 115 kV	Birds reacted earlier and flew higher over marked lines than unmarked lines	63% reduction in mortality rates overall, but there was considerable seasonal variation. Over 30% of collisions in fall occurred at night.	Brown and Drewien 1995

FireFly™

There are several types of FireFlys, two of which (the FireFly FF and the FireFly HW) are designed as suspended devices (Figure 6.16). FireFlys have a strong spring-loaded clamp that attaches to the line so that the device can swing. The device increases the line profile slightly, but its motion and reflectivity attract attention and alert birds of the line's presence.

The FireFly FF has an acrylic plastic tag that measures 9 cm × 15 cm (3.5 in × 6 in), is 3 mm (0.13 in) thick, and is covered with yellow and orange reflective tape and photo-reactive coatings. They are UV light stabilized and constructed to be highly reflective during the day. According to the manufacturer they glow for up to 10 to 12 hours after sunset. They are attached to the clamp by swivels so they swing and spin in the wind.

The FireFly HW is similar in size to the FireFly FF but the HW model's plastic tag does not swivel and is designed to withstand higher, sustained winds. The manufacturer claims similar effectiveness. Results from installation in a high raptor use area on a new power line in central California have shown these devices to be effective without any damage to the line or failure of the devices (M. Schriner, pers. comm.).

FireFlys have been attached 4.6 to 15.2 m (15 to 50 ft) apart. For lines with parallel shield wires, they can be staggered so that the device density appears greater, e.g., when spaced at 12.2 m (40 ft) on each shield wire and staggered, they appear to be 6.1 m (20 ft) apart (Table 6.13 and Table 6.14).

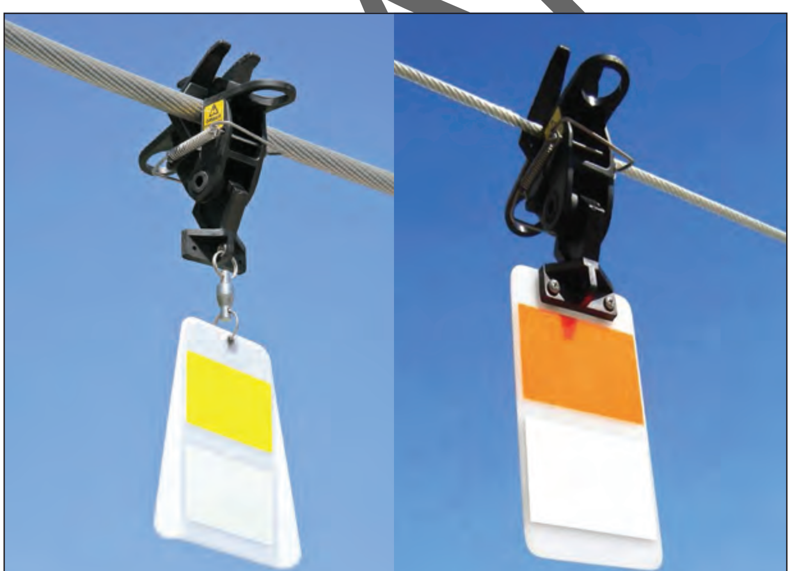

FIGURE 6.16: The FireFly™ FF (left) has a swinging tag for use in light winds and the FireFly™ HW (right) has a fixed tag to withstand higher, sustained winds.

TABLE 6.13: Spacing and positioning for FireFlys.*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies†
FireFly™	15.2 m (50 ft) spacing, staggered on alternating wires (PacifiCorp)	Recommendations depend on the tower height: 4.6 m (15 ft) apart for towers less than 30.5 m (100 ft) and 9.1 m (30 ft) apart for towers that are greater than 30.5 m (100 ft) tall (Birdbusters).	5 to 12 m (16.4 to 39.3 ft) apart. Some studies staggered devices on parallel lines to either increase visual density or distribute loading equally.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.
† See Table 6.14 for study details and sources.

TABLE 6.14: Representative studies for FireFlys.

Description/Spacing	Location/ Species	Power Line Characteristics	Effectiveness		Reference
			Behavioral Avoidance	Reduction in Collisions	
FireFly™, 9 cm × 15 cm (3.5 in × 6 in), 3 mm (0.13 in) thick, luminescent strip, spinning swivel, contrasting reflective colors on opposite sides/spacing: 5 m (16.4 ft); staggered on conductors	California/ sandhill crane, song birds, other species	Distribution, 12 kV	No changes in flight height or reaction distance	60% reduction in collision frequency on marked lines, collision frequency also decreased on adjacent spans	Yee 2008
FireFly™, acrylic plastic tag measures 9 cm × 15 cm (3.5 in × 6 in), 3 mm (0.13 in) thick, yellow and orange reflective tape and photo-reactive coatings/ spacing: 12-m (39.3-ft) intervals	Nebraska/ sandhill cranes	Transmission, 69 kV	Cranes reacted more quickly (mainly by gradually gaining altitude) to avoid the marked line than they did to unmarked lines	Reduced collisions by half	Murphy et al. 2009

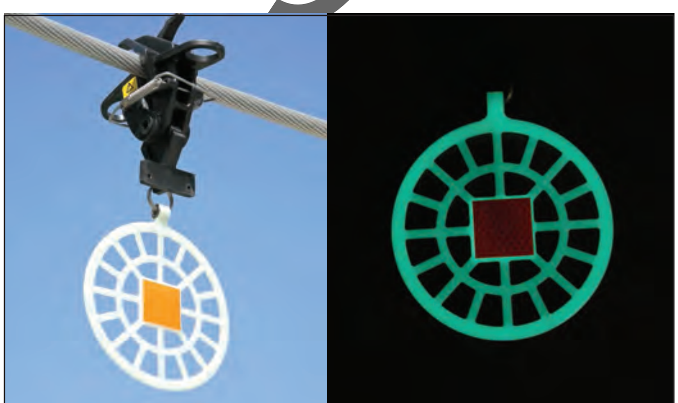

FIGURE 6.17: BirdMark BM-AG (After Glow) in daylight (left) and darkness (right).

BirdMark BM-AG (After Glow)

The BirdMark BM-AG (After Glow) has a perforated swinging disk that spins and flutters (Figure 6.17). This device is 29.21 cm (11.5 in) long with a 13.33 cm (5.25 in) diameter disk with a reflective center. The BirdMark BM-AG is designed with a strong spring-loaded clamp that attaches to wires up to a diameter of 6.4 cm (2.5 in). The reflective disks glow for up to 10 hours after sunset and are available in orange, white, and red.

The manufacturer recommends 4.6 m (15 ft) spacing (Table 6.15). The movement of the device adds to the visibility of the line.

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TABLE 6.15: Spacing and positioning for BirdMark BM-AG.*

Device	Utility Industry Practices	Manufacturer Recommendations	Spacing Lengths Used in Experimental Studies
BirdMark BM-AG	–	4.6 m (15 ft) (P&R Technologies)	No scientific studies on the BirdMark BM-AG were found.

* Actual spacing depends on engineering requirements, manufacturer specifications, species involved, and site-specific conditions.

Considerations for Suspended Devices

- In some of the earlier versions, there were problems with the device shifting (van Rooyen 2000).
- Depending upon the location, suspended devices can be targets for irresponsible shooters.
- The devices can be installed and removed from the ground or bucket truck with a hot stick. Two people are required for installation unless a special tool is used; homemade tools have worked better than some manufactured tools (S. Liguori, pers. comm.). New manufactured tools are being made and tested.
- Corona effects can occur depending upon the voltage (see *Corona Effects*, page 84).
- Installation cost increases with line height and in areas that are difficult to access such as river and lake crossings.
- Swivels have failed prematurely in high wind locations.

DEVICES AVAILABLE IN OTHER COUNTRIES

The following devices are not distributed in the United States at this time (2012).

Baliza Avifauna

The Baliza Avifauna is manufactured in Spain by Saprem. It is a variation of hanging strips that consists of two black neoprene crossed bands (measuring 6 cm × 28 cm [2.4 in × 11 in]). Some versions have a phosphorescent stripe.

Janss and Ferrer (1998) describe a similar device (with crossed bands measuring 5 cm × 35 cm [1.9 in × 13.8 in]) that was staggered on the conductors every 24 m (78.7 ft) (a visual effect of 12 m [39.3 ft] intervals). The device consisted of two black neoprene crossed bands slightly shorter than the com-

FIGURE 6.18: Hanging strips of neoprene, such as this Spanish-made Baliza Avifauna, are being used as line marking devices in Europe and South Africa.

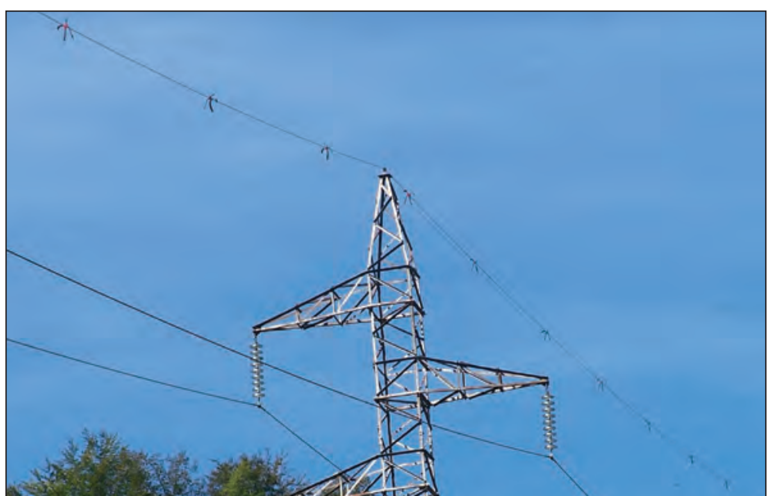

FIGURE 6.19: Baliza Avifauna installed on a power line in Europe.

FIGURE 6.20: The Avifaune Spiral is commonly used in France and other parts of Europe.

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FIGURE 6.21: Avifaune Spirals installed.

© DR/RTE

FIGURE 6.22: The Mace Bird Lite is a spiral device with a central fluorescent tube that is illuminated by the ambient electrical field.

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mercially available strips. Janss and Ferrer (1998) found the device reduced collisions by 76% on transmission (380 kV and 132 kV) and distribution (13 kV) lines. The device pictured here is widely used in Europe and South Africa.

Avifaune Spiral

The Avifaune Spiral is used in France and other parts of Europe. These are preformed PVC similar to the SFDs described previously. Avifaune Spirals are 91 cm (36 in) long and have two 36-cm (14-in) spirals in the middle. They are produced in two UV light protected colors: red and white. French researchers recommend alternating the colors. Raevel and Tombal (1991) indicate that the color combination is effective in variable light conditions on transmission lines. Avifaune Spirals have been used on phase conductors and shield wires with a recommended spacing of 7 to 10 m (23 to 32.8 ft).

Mace Bird Lite

The Mace Bird Lite is a spiral vibration damper with a fluorescent light attached inside a plastic tube. The light is energized by a phase conductor's electrical field and can be seen at night. These were designed specifically for 132-kV lines, but it should be possible to use them with other voltages. Although no precise scientific data are available on its effectiveness, this technology has been successfully used in Botswana and South Africa (Eskom 2003) in reducing flamingo collisions (Eskom Transmission 2009). The potential issue of the light attracting birds to a line was not addressed.

RIBE Bird Flight Diverter Fittings

RIBE bird flight diverter fittings are available in two versions: a swinging rectangular tag and a series of 10 alternating black-and-white, rigid plastic pieces that swing on a rod attached at both ends to a shield wire or phase conductor.

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FIGURE 6.23: The RIBE line marking device is available as a swinging triangular tag or as a series of black-and-white, rigid plastic pieces that swing (pictured).

According to the manufacturer, results from a three-year field trial on the Bernbrug-Susigke 110-kV line in South Africa showed that these are effective at reducing bird collisions with power lines when compared to lines without diverters. The information suggests that closer spacing (20 m versus 40 m [65.6 ft versus 131.2 ft] apart) is more effective. However no description of the study design nor specific data was provided.

Inotec BFD 88

The Inotec BFD 88 is a relatively new device with characteristics of both suspended devices and spheres. It is a reflective stainless steel sphere, 7 cm (2.8 in) in diameter, attached to a metal spiral, which is attached to the wire. When installed they appear as small metal spheres suspended from the wire.

This device is made of 316-grade stainless steel and is naturally reflective and corrosion resistant. The crimp is made from marine-grade aluminum, a highly durable adhesive, and conductive rubber. According to the manufacturer, the clamp does not come into contact with the phase conductor, so there is no chance of galvanic cell reaction or mechanical damage to the power line. The stainless steel sphere does not sway and cannot touch the power line.

FIGURE 6.24: The Inotec BFD 88, a South African device, is a reflective stainless steel sphere reported to be visible from all angles and in low-light conditions.

Eskom Transmission (2009) indicates that these metal spheres are visibly superior to colored (red, yellow, white, or black) objects in low light, especially at dawn and dusk when birds are flying between roosting and feeding areas. The spherical shape reflects available light and is claimed to be visible from all directions including above or below the diverter. When viewed during low-light conditions, the device is visible against dark backgrounds such as the ground, trees, or high ground. It is also visible against bright clouds when viewed from below (Eskom Transmission 2009).

The diverter can be attached while a line is energized and installed from the ground with a hot stick. Because of the spherical design, it does not display corona. It was developed in South Africa for use on shield wires and phase conductors up to 88 kV, and no radio interference was detected up to 88 kV.

PLASTIC TUBES

Archibald (1987) reported that yellow plastic tubes placed on power lines near Hokkaido, Japan, in 1982 reduced mortality of red-crowned cranes (*Grus japonensis*). Plastic tubes along with various versions of ribbons, however, are not durable enough for use.

LARGE DIAMETER WIRE

OVERSIZED SHIELD WIRE FOR TRANSMISSION LINES

A limited study compared the use of an oversized shield wire with a conventional shield wire (Brown et al. 1987; Miller 1990). The oversized wire was 2.52 cm (1 in) in diameter, or 2.6 times greater than standard shield wire (0.95 cm [0.4 in]). Researchers found that there was no significant difference between these wires. Other studies have identified the conventional, small-diameter shield wire as the highest risk wire for collisions with transmission lines (e.g., Savereno et al. 1996), which suggests that diameter and distance visibility are factors involved in collision risk. The use of larger-diameter shield wire is considerably more expensive. Though anecdotal reports suggest larger diameter shield wire is effective, studies of its effectiveness are needed before it can be recommended for reducing collision risk.

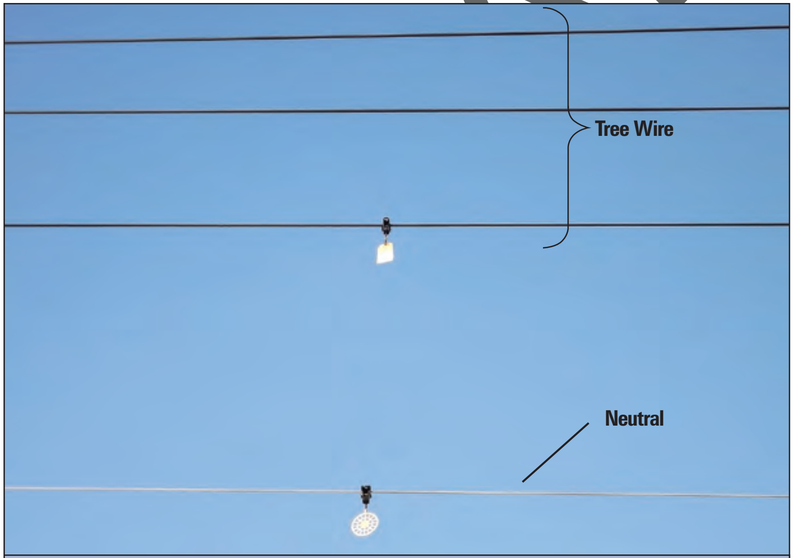

FIGURE 6.25: Tree wire on all three phases of a distribution line marked with suspended devices.

TREE WIRE TO PREVENT COLLISION-ELECTROCUTIONS ON DISTRIBUTION LINES

Tree wire is a type of insulated phase conductor used on distribution lines to provide protection from momentary contact with tree branches, which would otherwise cause an electric arc (Figure 6.25, Figure 6.26, and Figure 6.27). The insulation is also sufficient[17] to protect birds from collision-electrocutions, which are caused by phase-to-phase contact when large birds, such as eagles and swans, brush phase conductors while flying between them. The electric arc created in collision-electrocutions can kill multiple birds in a flock, even if only one bird makes phase-to-phase contact. Because tree wire can prevent collision-electrocutions, it has even been used in some open areas for rebuilt and new distribution lines (M. Walters, pers. comm.).

Tree wire may also be an effective means of reducing collision incidence because the insulated covering increases the diameter of the wire, making the line more visible. However, no scientific studies were found to verify this.

Retrofitting a line with tree wire is usually only a consideration when outages are caused by tree branches. It would be unusual to retrofit an existing line with tree wire to prevent collisions because line marking devices are more cost effective. However, when a distribution line is being upgraded or a new line is being built, tree wire may be a cost-effective option when used for the center

[17] The insulation on tree wire is not considered protective for human safety.

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FIGURE 6.26: Tree wire (right of pole) and standard wire (left of pole) on a distribution line.

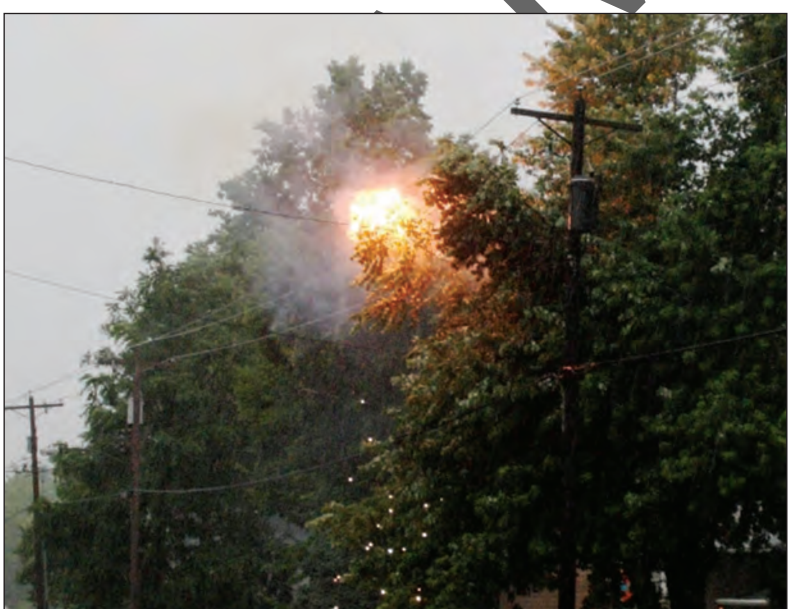

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FIGURE 6.27: Collision-electrocutions cause an electrical short, like this one caused by tree branches, and can kill two or three birds in a flock even if only one bird makes phase-to-phase contact.

phase. The difference in cost (2011 $) between tree wire (336ACSR TW= $0.89 per 30.5 cm [12 in]) and standard wire (397KCM = $0.77 per 30.5 cm [12 in]) is approximately $0.12 per 30.5 cm (12 in) or $1,900 per 1.6 km (1 mi) for a standard three-phase distribution feeder. Tree wire is also heavier than standard wire and may require higher class poles, more poles (1 to 2 per 1.6 km [1 mi]), and possibly additional guying. The average lifespan of tree wire is 40 years. The advantages to tree wire are that it reduces the risk of collision-electrocution at mid-span for flying birds, reduces the risk of electrocution for perching birds, and reduces the maintenance requirements usually associated with suspended devices.

Unpublished observations show that tree wire used in conjunction with line marking devices, such as the FireFly™ and/or Bird-Mark BM-AG, is effective at reducing collision-electrocutions and collisions for trumpeter swans (*Cygnus buccinator*), waterfowl, and raptors (M. Walters, pers. comm.). When rebuilding lines already equipped with flight diverters, the diverters are reinstalled on the new tree wire lines. The increased visibility of tree wire reduces the risk, which is further reduced by installing FireFlys (M. Walters, pers. comm.).

In the Chimacum Valley, Washington, from 2000 to 2007, an eight-span lateral line averaged three bird-caused outages per year due to swan and waterfowl collisions, including 10 swan mortalities in 2006 alone. In 2007, the line was modified with tree wire to prevent collision-electrocutions and with FireFlys to reduce collision risk. No swan mortalities or outages have occurred since the line was modified in spite of increasing swan populations and their continued use of this flight corridor. The landowner reported that the swan flight path is much higher over the lines since these modifications were made (M. Walters, pers. comm).

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At another site in western Washington's Skagit Valley, five swan mortalities occurred on a single-phase line in the winter of 2008–2009, and others had been documented in previous years. The line was rebuilt in a three-phase configuration during the summer of 2009, which included tree wire on the center phase along with alternating FireFly™ and BirdMark BM-AG devices on all three phase conductors. In the following winter season, no mortalities or outages occurred, although swan populations continue to increase. Between 1,000 and 2,000 swans forage in this area throughout the winter (M. Walters, pers. comm.).

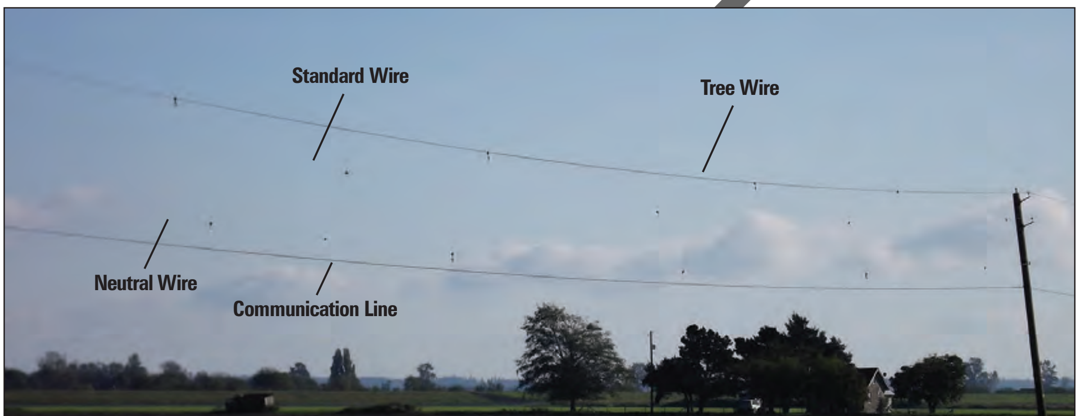

FIGURE 6.28: Tree wire on the top phase conductor of a two-phase distribution line (vertical configuration) with line marking devices.

CHAPTER 7

Avian Protection Plans

IN THIS CHAPTER

An Avian Protection Plan is a voluntary, utility-specific plan that provides a framework for reducing bird mortalities, documenting utility actions, and improving service reliability. In 2005, the U.S. Fish and Wildlife Service and the Avian Power Line Interaction Committee jointly published Avian Protection Plan Guidelines to provide utilities with resources and guidance for developing Avian Protection Plans. This chapter is based on those guidelines.

OVERVIEW OF AVIAN PROTECTION PLANS

An Avian Protection Plan (APP) is a utility-specific program for reducing the operational and avian risks that result from avian interactions with electric utility facilities. In 2005, the Avian Power Line Interaction Committee (APLIC) and the U.S. Fish and Wildlife Service (USFWS) announced their jointly developed Avian Protection Plan Guidelines (*Guidelines*) that are intended to help utilities manage their avian/power line issues. The *Guidelines* offer resources for developing APPs and provide a toolbox from which utilities may select and tailor APP components to fit their needs. An APP should provide the framework necessary for developing a program to reduce bird mortalities, document utility actions, and improve service reliability. The APP components are summarized in this section. The complete version of the *Guidelines* can be obtained from either the APLIC (www.aplic.org) or USFWS (www.fws.gov) websites.

An APP represents a utility's commitment to reducing its avian impacts. Since they are created by a utility, APPs are more easily modified to address newly developing or unforeseen problems. Despite the fact that APPs are generally initiated by utilities, a cooperative dialog between the utility and the USFWS is encouraged during development and implementation. This sets the tenor for those conversations that will inevitably follow as the APP is implemented and refined over time.

Implementing the *Guidelines* will reduce avian collision and electrocution risks. An APP represents responsible environmental practices to all stakeholders, and a utility that creates an APP to address its specific avian issues can benefit through regulatory compliance, reliability improvements, potential long-term cost savings, and positive recognition from regulators, employees, and customers.

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COMPONENTS OF AN AVIAN PROTECTION PLAN

Although each utility's APP will be different, the overall goal of reducing avian mortality is the same. The *Guidelines* provide a framework along with principles and examples to help a utility craft an APP to best fit its needs. Because of utility-specific circumstances, some of the *Guidelines*' elements may not be applicable. The *Guidelines* present a comprehensive overview of the elements that should be considered in an APP. The APP should also be a "living document" that is modified over time to improve its effectiveness. Some or all of the following elements may be implemented:

- Corporate policy
- Training
- Permit compliance
- Construction design standards
- Nest management
- Avian reporting system
- Risk assessment methodology
- Mortality reduction measures
- Avian enhancement options
- Quality control
- Public awareness
- Key resources

Details on the nature of these elements and how they may be developed by a utility are discussed on the following pages.

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FIGURE 7.1: Utility employee training should include the reasons and methods for reporting bird mortalities, nest management protocols, proper disposal of carcasses, applicable regulations, and the consequences of non-compliance.

CORPORATE POLICY

An APP usually includes a statement that balances the company's commitment to minimizing its impact on migratory birds, complying with bird-protection regulations, and providing reliable, cost-effective electrical service. To do this, it will comply with all necessary permits, monitor avian mortality incidents, and make reasonable efforts to construct and alter infrastructure to reduce the incidence of avian mortality.

TRAINING

Training is an integral component of an APP. Workshops and short courses on avian/power line interactions are provided by APLIC (www.aplic.org) and Edison Electric Institute (EEI) (www.eei.org). A two-hour overview of avian electrocutions and collisions intended for training use is also available to APLIC members through the APLIC website as part of the APP toolbox. Each company will have its own approach to training. All appropriate utility personnel, including managers, supervisors, line crews, engineering, dispatch, design personnel, and vegetation management personnel should be trained in avian issues. This training should encompass the reasons, needs, and methods for reporting avian mortalities, following nest management protocols, disposing of carcasses, complying with applicable

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regulations, and understanding the potential consequences of non-compliance. Supplemental training also may be appropriate when there are changes in regulations, personnel, permit conditions, construction standards, bird protection materials, or internal policies.

PERMIT COMPLIANCE

Each utility developing an APP should familiarize itself with the different avian regulations and permit types and should work with wildlife agencies to determine whether permits are required for operational activities that may affect protected avian species (see Chapter 3). An APP should discuss how this is done and identify company permits. Particular attention should be given to activities that may require special purpose or related permits, including but not limited to nest relocation, temporary possession, depredation, salvage or disposal, scientific collection, and miscellaneous. State permits may also be required to manage protected bird nests or for temporary possession of nests, birds, or their parts.

CONSTRUCTION DESIGN STANDARDS

To improve system reliability, avian interactions should be considered when siting and designing new facilities and when operating and maintaining existing facilities. For those reasons the accepted standards for both new construction and retrofitting for risk minimization should be included in an APP. Companies can either rely upon the recommendations in APLIC documents for electrocutions and collisions or develop their own standards that meet or exceed these guidelines.

An APP may indicate that all new or rebuilt lines in identified avian-use areas or potential problem areas be built to current standards for minimizing electrocutions and collisions. Employing avian-safe construction standards in such areas will reduce future legal and public relations problems and will enhance service reliability.

NEST MANAGEMENT

An APP may include procedures for managing nests on utility structures and in power line rights-of-way (ROW). This could include procedures for handling problem nests (ones that need to be relocated or removed) as well as for creating safe nest sites. These procedures should be explained to company employees during training to ensure uniform treatment of avian nest issues and compliance with regulations or permits related to nest management. For more detailed guidance regarding nest management, see *Suggested Practices for Avian Protection on Power Lines* (APLIC 2006).

AVIAN REPORTING SYSTEM

An avian reporting system is used for documenting bird injuries, fatalities, and nest management activities. This system should be described in the APP and designed to meet the needs of the utility and applicable avian permit reporting requirements. The reporting system should be compatible with a utility's other data management and analysis programs so this information can be effectively collected and recorded. The system could be based on paper forms or may be an internal web-based program. The information collected should be used to help a utility conduct risk assessments of avian problem areas and high risk structures or lines. To protect birds and minimize outages, these data can be prioritized for corrective actions. Avian information collected by a utility should be maintained internally. Reporting is required as a condition of the USFWS permit for direct *take* of birds or their nests (see Chapter 3).

The USFWS Office of Law Enforcement also maintains a voluntary, internet-based Bird Fatality/Injury Reporting Program.[18]

[18] The USFWS (2012) has been internally referring to this as the Bird Information and Mortality Reporting System. The title on the web page may assume this title as well (A. Manville pers. comm.).

This program provides a clearinghouse of useful information for the electric utility industry to mitigate the impacts of energy delivery systems on birds and to address specific bird/power line problems on an incident-specific basis (USFWS 2009b). This database was designed to collect information about bird collisions and electrocutions to help with preventing future bird/power line incidents. It is also intended for utilities to see which structures pose a greater risk than others and under what conditions they occur. Utilities can establish a password-protected account with this voluntary program, and privacy and confidentiality are protected including several exemptions from the Freedom of Information Act (FOIA). The data collected include the characteristics of the fatality or injury, location, configuration of the equipment, environmental conditions, etc. To date (2012), at least 33 electric utilities have been voluntarily reporting through this program.

RISK ASSESSMENT METHODOLOGY

A utility can cost-effectively reduce avian mortalities by focusing its efforts on the areas of greatest risk. Therefore, an APP should include a method for evaluating and prioritizing the risks that a company's operations pose to migratory birds. A risk assessment will often begin with a review of available data that address areas of high avian use, avian mortality, problem nests, established flyways, migration corridors, concentration and staging areas, other preferred habitats, prey populations, perch availability, effectiveness of existing procedures, remedial actions, and other factors that can increase avian interactions with utility facilities. The avian reporting system discussed in the previous section is an integral component of this risk assessment, as is the use of avian experts, birders, and biologists who can provide additional information on avian distribution. A risk assessment can be used to develop models that will enable a company to use biological and electrical design information to choose an optimal route during corridor and ROW siting and to prioritize existing poles and lines most in need of modification. A risk assessment may also provide data about the various causes of avian mortality as well as the benefits birds receive from utility structures. For more discussion on avian risk assessment, see Chapter 5.

MORTALITY REDUCTION MEASURES

As a part of an APP, a mortality reduction process is described. A utility can use the results of an avian risk assessment to focus its efforts on areas of concern, ensure that its responses are not out of proportion to the risks presented to protected birds, and determine whether avian mortality reduction plans need to be implemented.

Mortality reduction plans may use strategies that include preventive, reactive, and proactive measures that focus on issues, risks, and reliability commitments facing a utility. The following are examples of how this multi-faceted approach may be used.

- **Preventive**: Construct all new or rebuilt lines in high avian-use areas to avian-safe standards. Apply collision minimization measures for new construction in high risk areas. Ensure that the APP is in compliance with applicable laws, regulations, and permits.
- **Reactive**: Document bird mortalities and problem nests, conduct assessment of problems, and apply remedial measures where appropriate. Notify resource agencies in accordance with the utility's permits and policies.
- **Proactive**: Provide resources and training to improve employees' knowledge and awareness. Partner with organizations that conduct research on effects of bird interactions with power lines. Evaluate risks of existing lines in high avian-use areas and prioritize structures or lines for retrofitting or mitigation according to their risk level.

A successful APP and mortality reduction plan requires management support as well as the following:

- Assessment of facilities to identify risks
- Allocation of resources
- Standards for new or retrofit construction
- Budget for operation and maintenance and capital investment
- System for tracking remedial actions and associated costs
- Timely implementation of remedial measures
- Positive working relationships with agencies

An APP should be reviewed annually in the context of risk assessment and modified as appropriate, ideally with wildlife agency input.

AVIAN ENHANCEMENT OPTIONS

In addition to reducing avian mortality risk, an APP also may include descriptions of opportunities for a utility to enhance avian populations or habitat. These opportunities may include installing nest platforms, managing habitats to benefit migratory birds, or working with agencies or organizations in these efforts. Where feasible, new ideas and methods for protecting migratory birds should be encouraged and explored.

There are also opportunities to collaborate with agencies or organizations and to educate the public about the company's APP and its partnerships. USFWS and state wildlife agencies, as well as other experts, can be consulted for recommendations on habitat enhancement projects. Nest box construction, maintenance, and monitoring can be done in conjunction with volunteers, such as Boy Scouts, Girl Scouts, and avian/wildlife conservation organizations.

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FIGURE 7.2: An Avian Protection Plan may include opportunities to enhance avian populations or habitat with nesting structures, habitat restoration, or other projects.

QUALITY CONTROL

A quality control mechanism can and should be incorporated into an APP to evaluate the effectiveness of a company's avian protection procedures. Some examples of quality control include the following:

- Effectiveness of remedial actions in reducing avian mortality
- Effectiveness of avian protection devices as well as their ease of application and durability
- Mortality reporting procedures to ensure that discoveries of avian mortalities are properly documented
- Response to avian mortalities to ensure that appropriate and timely actions are taken
- Compliance with company policy to ensure that personnel are consistently following company procedures for avian-safe construction, mortality reporting, nest management, training, etc.
- Public and agency feedback and opinions on system reliability and avian protection

The quality control component of an APP is a continuous process that is used to ensure that a company's APP is accomplishing what

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it is intended to do. Information gathered during assessments of existing practices should be used to improve the effectiveness and timeliness of avian protection efforts, which, in turn, can help to reduce costs associated with such efforts.

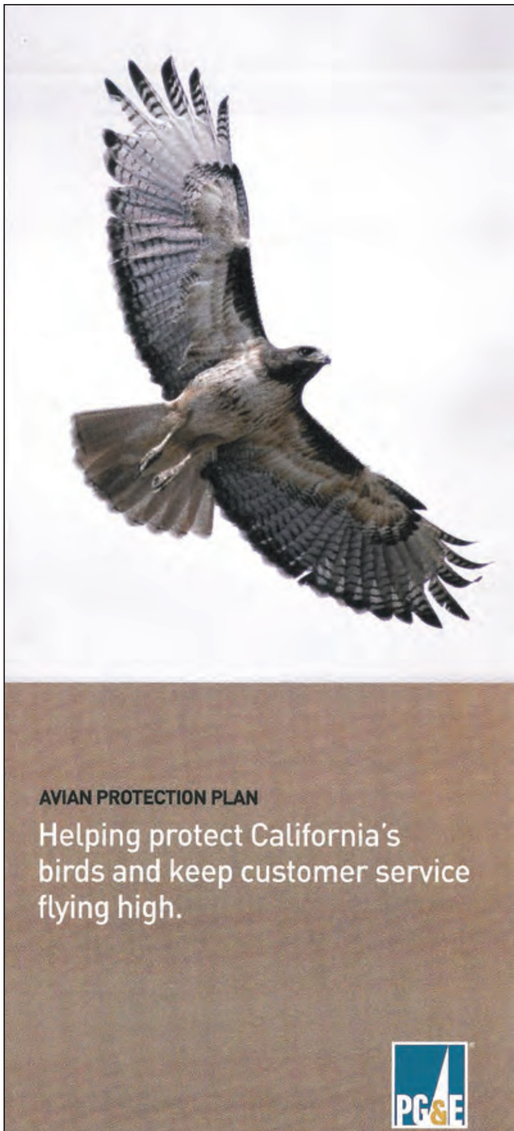

FIGURE 7.3: Raising public awareness about avian collisions and the utility's commitment to avian protection can increase support for an Avian Protection Plan.

PUBLIC AWARENESS

An APP may include a method for educating the public about avian collision issues, the company's avian protection program, and its successes in avian protection. A public awareness program can be an integral part of an APP and can be used to enhance public awareness and support for a company's APP. Public participation allows stakeholders such as government agencies, tribes, non-profit organizations, wildlife rehabilitators, and other interested parties an opportunity to provide input to the decision-making process, enabling all parties to work openly and collaboratively towards recommendations that can be effectively implemented. This collaboration often leads to improved relationships within the community and to more efficient and positive projects (see Chapter 5). The relationships developed through this process may also encourage the public to report bird mortalities and encourage them to seek assistance for birds that have been injured in power line-related accidents.

Communicating an APP can be accomplished through a variety of public outreach tools, including fact sheets, newsletters, brochures, videos, websites, public workshops, short courses, special training sessions, and speaker bureau presentations. These tools can also be used to record the success of an APP, thereby documenting the utility and electric industry's efforts to reduce avian mortalities. The goal of these outreach efforts is to convey to the public that electric utilities are responsible environmental stewards working cooperatively with wildlife agencies towards reducing avian mortalities while continuing to provide safe, reliable, and affordable electricity to their customers.

Many utilities have examples of their environmental stewardship and of the innovative ways they have reduced environmental impacts through their business decisions. A company's efforts to minimize avian mortalities should be shared with the public and resource agencies. For more information, see *Public Participation* in Chapter 5.

KEY RESOURCES

An APP should identify the key resources that address avian protection issues. Key resources include utility personnel and external contacts. This would include a list of experts who may be called upon to help resolve avian-caused problems. Experts could include company specialists, consultants, state and federal resource agents, university faculty, or other biologists. Internal personnel may include representatives from environmental, engineering, operations and maintenance, standards, procurement, outage management, etc. Engineers may find that company personnel such as environmental specialists (or biologists) can help find creative solutions to avian interaction problems. An understanding of avian behavior can also influence how and when avian protection should be provided. An APP that connects biologists with utility decision-makers may reduce bird mortality and improve system reliability.

Members of organizations like APLIC can help with workshops, materials, and contacts. External resources may include biologists and law enforcement agents from wildlife agencies, avian specialists from NGOs or universities, wildlife rehabilitators, and industry consultants. Utility industry resources include APLIC, EEI, Electric Power Research Institute, Institute of Electrical and Electronics Engineers, National Rural Electric Cooperative Association, and the Rural Utilities Service. Contact information and websites for a number of resources are available in the *Guidelines* (see www.aplic.org).

CREATING AND IMPLEMENTING AN AVIAN PROTECTION PLAN

Integrating an APP into an electric utility's operations will help the utility meet demands for reliable, cost-efficient, and environmentally compatible power delivery. A utility that creates and manages an APP will quickly become familiar with the avian-related science, engineering, and laws. It will also need to satisfy utility employees, utility customers, investors, and other stakeholders.

The ease of creating and implementing an APP will depend on a utility's size, the location of its transmission and distribution system, the range of avian species in the service area, and the frequency of bird/power line interactions. The extent of bird/power line interactions may not be realized until several years into a fully implemented reporting program. Thus, APP implementation and operation is a long-term commitment and a process of continual evaluation and improvement.

Depending on the company's culture, the rate of adoption may vary. An APP may be the first species-oriented environmental compliance initiative to which utility employees are exposed. High-profile endorsements by corporate officers and managers can facilitate a program's implementation. Some larger utilities have effectively linked APP compliance with financial incentives, similar to more common budget, schedule, and safety incentives. Compliance with an APP will reduce utility costs in the long term through improved reliability and reduced regulatory risk.

Creating and implementing an APP will be more successful if all the affected departments within the utility also support it. An effective way to build a broad consensus during APP preparation is to form a team within the utility that includes representatives from standards, engineering, environmental services, vegetation management, construction, operations and maintenance, public relations, customer service, and other departments that will be impacted by the APP. Considerable input and assistance from team members are needed to understand how APP implementation will

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FIGURE 7.4: Integrating an Avian Protection Plan into an electric utility's operations will help the utility meet demands for reliable, cost-efficient, and environmentally compatible power delivery while protecting and enhancing bird populations.

best fit the operations of each department. Solutions to reduce avian mortality can be developed that are responsive to the work requirements of each functional unit. In this manner, individuals from each department will feel invested in the mortality reduction solutions they helped develop and will have an interest in assuring APP effectiveness.

Beyond developing and communicating a corporate APP policy, the most important component of an APP is a consistent and mandatory reporting process. An electronic or paper form of documenting bird/power line conflicts (e.g., time, place, equipment) becomes the foundation for appropriate corrective action—both to correct unsafe situations and to build a dataset to guide future engineering/construction needs. Managing data for these purposes, as well as for meeting any state and federal agency reporting requirements, is an important function of APP administration. Using GIS technology to track and report bird mortalities, remedial actions, outages, and avian risks enables a utility to identify problems and to track the effectiveness of its APP.

Use of existing processes and systems (e.g., outage reporting, environmental review, asset management, and accounting) will help control costs of developing and implementing an APP. Whether an APP is driven by an environmental, engineering, or operations department, cooperation will be necessary across all departments to reduce actual and potential avian/power line conflicts. As with any project, better planning yields better results. The goals of an APP are a measurable decrease in avian/power line injuries and mortalities and an increase in electric service reliability—ultimately benefiting the birds, the utility, its customers, the regulators, and the affected public.

APPENDIX A

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APPENDIX B

Designing Site-Specific Studies for Collision Monitoring

With any study design for collision monitoring it is important that the resulting data can be compared to similar studies (see *Variability of Reported Mortality Rates* in Chapter 4 and *Effectiveness of Designs* in Chapter 6). The information in this appendix will help you design site-specific study methods that produce useful and comparable results. Table B.1 summarizes the considerations and issues presented in this appendix.

TABLE B.1: Summary of considerations and issues for designing site-specific collision monitoring.

Considerations for Site-Specific Collision Monitoring	Issues Related to Estimating Mortality Rates
Behavioral Monitoring • Bird density • Evaluation criteria • Estimating bird flight height • Radar observation and detection • Metrics • Study segments	Equations for Calculating Mortality Rate • Accuracy • Variability in methods
Mortality Monitoring • Differences in sampling design • Questions to ask • Data to record • Remote sensing	Sampling Biases • Crippling loss • Searcher efficiency • Scavenger removal • Habitat differences

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CONSIDERATIONS FOR SITE-SPECIFIC COLLISION MONITORING

BEHAVIORAL MONITORING SURVEYS

The most direct way to determine how collisions are occurring is to observe behavior as birds are approaching, crossing, or colliding with power lines. Behavioral monitoring is used to characterize the birds' reaction to lines by giving each reaction a behavioral avoidance value. In line modification studies, behavioral monitoring can be used to measure the effectiveness of line marking devices.

Bird Density

Past studies (e.g., Bevanger 1999; Janss 2000) have counted collisions per flyby (observed collisions per number of birds flying by a line). With high bird density, counting collisions per flyby is feasible. But with low bird density, counting flybys is not practical because so few observations can be made, even over an extended period of time. Direct observation can be especially time consuming with low bird density or intermittent high bird density. Observations may also be restricted by poor visibility due to weather or time of day. In such cases, the most feasible method may be to conduct mortality monitoring to estimate collisions (see *Mortality Monitoring Surveys* on page 141). Bird collisions with power lines can also be detected with remote sensing devices (see *Remote Sensing* on page 142), although they do not yield behavioral and species data.

Evaluation Criteria

A study's behavioral criteria may include the type of reaction to lines, distance from the line when the reaction occurred, and height above the line when crossing. Because estimates are provided by different observers, all observers must be trained and given time to practice before the study begins, and the same observers should be used throughout the study when possible to minimize observer bias. Records of approach, crossing, and departure heights should be kept. If behavioral avoidance is observed, the reaction to and distance from the line should be recorded. The following are possible reaction categories and definitions:

- No reaction—Birds maintain constant altitude and unaltered flight
- Swerve and over—Birds turn from course, flying up and over line
- Swerve and under—Birds turn from course, flying down and under line
- Over and swerve—Birds flying over line swerve immediately after crossing the lines
- Turn and leave—Birds turn and retreat from the line after approaching within 50 meters (m) (164 feet [ft]) of the line
- Collision and fly—Birds in flight hit a line but keep flying outside of the transect boundaries
- Collision and fall—Birds in flight hit a line and drop within the study transect (the specific line should be noted in the comments section)
- Land on line—Birds land on line or pole

Estimating Bird Flight Height

Bird flight altitude information should be estimated relative to the structure height and the height of phase conductors, neutral wires, and shield wires. Height classes will vary depending on the type of power line (e.g., conductor arrangement, voltage) and the species studied. Figure B.1 provides an example of altitude classes for transmission lines. Since power lines will vary in design, site-specific altitude criteria should be developed.

The manner of recording flight altitude should be modified according to line configuration and the species studied. If the wires are in the same horizontal plane, then the area included in the study is above and below the line for a certain number of meters (feet). If the wires are in a vertical configuration, then the area observed is above and below the multiple planes including the shield wire and a distribution underbuild if present. If the structure type is an H-frame, then the obser-

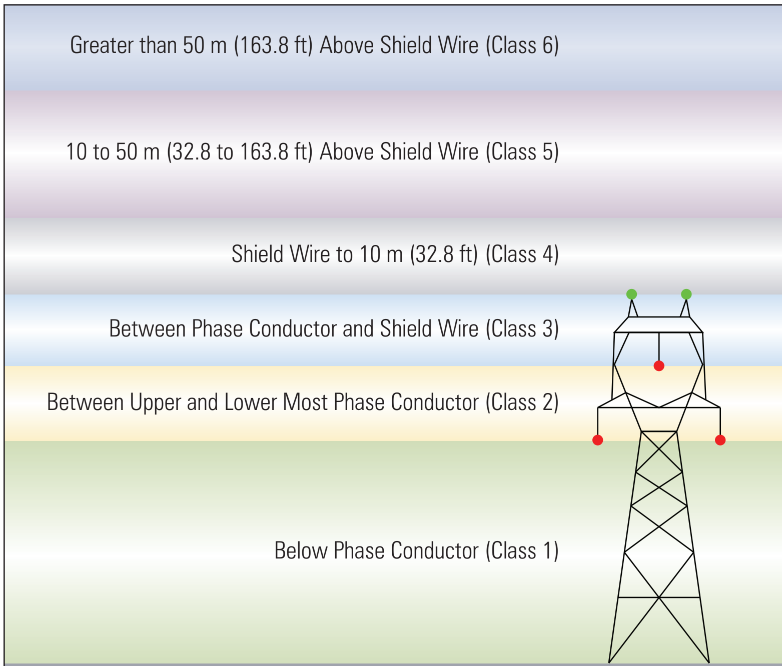

FIGURE B.1: Classes used to describe birds' approach, crossing, and departure altitudes in collision studies on transmission lines (after James and Haak 1979).

vational box might be different than if the tower is steel lattice or a V-shape supported by guy wires. The size of the line structure may warrant extending the observational area farther from the poles (i.e., begin recording at 30.5 m (100 ft) away from a distribution single pole, but 152.4 m (500 ft) from a steel lattice transmission tower) in order to account for reaction times related to the size of the structure and the height and arrangement of the lines.

Bird flight height can be estimated and measured in various ways with varying degrees of expense, effort, accuracy, and efficiency. Visual categorization, rangefinders, and radar systems can all collect data on the flight height and each approach has its advantages and disadvantages (see *Radar Observation and Detection* on page 140). When choosing which techniques to use, the following must be considered: project goals, species identification and concentration, migration data, and project budget. For example, if the major bird migration occurs in spring, data needs to be collected for a sufficient period in the spring to characterize bird movement and behavior. If you need to estimate the overall impacts of the mortality to the local bird population, you will need an understanding of that population in the area surrounding the study site throughout its seasonal fluctuations including breeding, migration, and wintering.

One of the simplest field techniques for estimating flight height is to visually categorize height, such as above the lines, below the lines, etc. This approach only requires a known reference point in the field. Survey flags and reaction zones can help observers estimate the distance from the line and the section of the line as they record behavioral avoidance. For example, survey flags can be placed 5 m (16.4 ft), 5 to 25 m (16.4 to 82 ft), and >25 m (>82 ft) from the line (Brown and Drewien 1995). This technique works well in terrestrial situations and eliminates the need for a rangefinder. In another approach, a reaction zone of 200 m (656.2 ft) on each side of a 500-kV transmission line has been used (Willdan Associates 1981, 1982).

This approach can be expanded by using visual estimation in conjunction with electronic rangefinders, which are used to measure the height of reference structures in the field. Electronic rangefinders come equipped with a laser and built in clinometers, which measure straight line distance to the bird and the angle of the measurement above horizontal. The measurements can be used to estimate an object's (bird's) height above ground. Height is calculated as:

SIN([Angle[1]])*[Distance to Object] = Flight height

[1] if calculating in Excel use the radian function to convert degree units into radians so the number will be compatible with the SIN function

Once the heights are known for several tall objects in the area, bird flight heights can be estimated. This approach can be further expanded by directly measuring the flight heights of birds using an electronic rangefinder. This approach can be effective if birds are in close range and are big and reflective enough to bounce a signal back to the rangefinder. Other factors that affect successful measuring of flight height using the rangefinder include:

- Distance of the observer to the bird (shorter distances reflect better signals)
- Size of the bird (larger birds reflect the laser better than smaller birds)
- Reflectivity of the bird (white birds reflect the signal better than dark birds; Klimentjew et al. 2010; M. Schriner, pers. comm.)

A limitation of measuring bird flight height directly is that it is difficult to record multiple heights simultaneously. In areas where bird passage rates are high, multiple observers, digital tape recorders, or video cameras may be needed to adequately capture multiple measurements of flight height.

Radar Observation and Detection

Although the use of radar in power line studies is not common, it is a useful tool for characterizing bird movements. Two types of radar, Nexrad and portable radar, have been used in bird studies to collect data on nocturnal movements and broad front migrations, which may be missed by field observations. Nexrad radar (Next-Generation Radar) is a network of Doppler weather radars operated by the National Weather Service. Nexrad radar has the advantage of being able to collect data on the density of targets within an area and examine the temporal variation in target activity over many years. Portable radars are smaller and include systems such as modified marine, pencil beam tracking, and other specialized radar systems. Portable radar collects data on flight height, direction, and speed of targets and can distinguish different size classes of targets which provides some level of certainty as to what is being detected (e.g., songbirds versus herons).

Despite the unique information that radar can collect, it does have limitations. Nexrad cannot distinguish between birds, bats, and insects, and the height of airspace that is surveyed is dependent on the distance from the Nexrad station. Portable radar detects targets (e.g., birds, bats, insects, weather, etc.) in flight and can classify them by size and speed and movement patterns (R. Larkin, pers. comm.). Software filters can help refine target specificity by removing weather images, leaving images of desired targets. While size classes can be used to indicate species groups to some extent, distinguishing between species groups that are of similar size is not possible. Ground clutter, visual obstructions, and inclement weather can also limit the ability of radar to detect objects at a distance. The longer the distance between radar and subject, the more likely ground clutter will interfere. Finally, the cost of radar systems can be high, which limits their applicability.

Metrics

Metrics used in behavioral observations of collisions are generally expressed as the number of observed collisions per number of birds flying by a line (flybys), often expressed as a percentage. For example, Meyer (1978, cited in Bevanger 1998) observed the number of collisions to be 0.003% to 0.07% of flybys for waders and gulls. Janss and Ferrer (2000) reported collisions per flyby as 3.93×10^{-5} for the common crane (*Grus grus*) and 6.34×10^{-3} for the great bustard (*Otis tarda*).

Study Segments

It is essential that study segments represent the line as a whole (unless there is a need to identify high risk areas), that test and control segments be of comparable length, and that they have as much environmental homogeneity as possible. Variability will be reduced by including an adequate number of test and control segments. Contiguous segments are convenient but not essential. Koops and de Jong (1982) marked alternating spans, and Brown and Drewien (1995) marked alternate 0.8-kilometer (km) (0.5-mile [mi]) segments of eight different test lines. The length of study segments may vary according to bird density, seasonal use, habitat type, size of the power line, etc. However, in line modification studies it is important that test and control segments are separated sufficiently so control segments are not affected by the presence of markers on the test segments. Thus, when evaluating markers on small distribution lines that have short spans (pole to pole distance), each test and control segment should consist of several spans. Barrientos et al. (2011) provides recommendations on reasons for standardizing segment length.

MORTALITY MONITORING SURVEYS

The most common way to determine if collisions have occurred is to survey the power line right-or-way (ROW) for dead and injured birds and attempt to identify the cause of injury or death. Mortality monitoring surveys provide a more accurate assessment of collision mortality.

Differences in Sampling Design

There are numerous monitoring approaches and each has different strengths and weaknesses (e.g., APLIC 1994; Bevanger 1999; Hunting 2002). Mortality surveys conducted through 2011 generally differ in sampling design including:

- Segment selection
- Lengths of lines sampled
- Width of the area sampled
- Duration and intensity of the study
- Seasonal sampling

The fact that all these considerations are not routinely included leads to difficulty in comparing studies (Hunting 2002; Barrientos et al. 2011). Typically the sampling biases (i.e., searcher efficiency, crippling loss, scavenger removal, and habitat differences; see *Sampling Biases* on page 143), which need to be accounted for to correct the estimated mortality rates, are not implemented systematically or in a manner that is consistent with the expected monitoring program survey designs. In addition, because of sampling uncertainty, a variety of statistical methods are applied to estimate the actual number of birds affected based on the number of birds found.

Site-specific study designs and correction factors need to be developed for mortality monitoring to account for these variables. Bevanger (1999) concluded that, given the site-specific factors and local conditions (e.g., biological, environmental, and engineering) that influence collision and mortality estimation, it is not expedient to develop a set of standard study design methods or use general correction factors. Barrientos et al. (2011) presented three recommendations for conducting line marking device effectiveness studies that also apply to mortality monitoring:

1. Collecting data on carcass counts and flight frequency for the same length of time and at the same time of the year at marked and unmarked wire segments
2. Studying marked (test segment) and unmarked (control segment) lines in areas with similar vegetation and topography, with similar lengths of time spent searching for carcasses, and with transects of equal lengths and widths
3. Standardizing the timing of carcass searches and search area widths

For search area width, searches should cover the width of ROW with reference to the height of the power line (James and Haak 1979; Raevel and Tombal 1991) and the zone in which carcasses are expected to fall.

Questions to Ask

The study design phase should focus on the questions being asked, the data needed to answer these questions, and the appropriate methods, including duration and intensity, to provide those data. A series of hierarchical questions that need to be considered may include the following:

1. Are collision injuries and/or mortalities occurring?
2. What species of birds are involved? Are they protected species?
3. Where along the power line are the birds colliding?
4. When are they being killed?
5. Under what circumstances (e.g., weather, time of day) are they being killed?
6. What biological, environmental, and engineering factors appear to be important in influencing collisions?
7. What line modification actions can be taken to reduce these collisions?

Questions 1 and 2 are the simplest to answer if the carcasses are detected. Many of the past studies have focused on answering the first two questions and sometimes 3 and 4. More recent studies have attempted to address questions 5, 6, and 7. There is a tendency to focus on sampling worst-case situations or locations where high numbers of collisions have occurred as opposed to sampling representative locations along a given power line to understand the overall collision risk. Although results from worst-case situations may skew general mortality risk, determining this information is still important because it provides data needed for reducing risk.

Data to Record

For each bird found, the following information should be gathered when possible:

- Location of the carcass in proximity to the power line (e.g., GPS position)
- Species
- Sex
- Age: adult or juvenile
- Date or approximate time of death
- Physical injuries and conditions (e.g., broken bones, lacerations, abrasions, blood, discolorations, gunshot wounds, decomposition, feather spots, feeding by scavengers)
- Probable cause of death
- Necropsy[19]

Environmental conditions should also be recorded, especially visibility, wind speed and direction, weather events, avian habitats, as well as the type and abundance of bird species in the study area.

Remote Sensing

An alternative to directly observing bird collisions is to use a Bird Strike Indicator (BSI). BSI is a vibration sensing and recording tool that is fitted to a power line to detect collisions with that line. It is especially useful for monitoring collisions in low-light or no-light conditions. However, BSI does not identify what species struck the line; mortality monitoring or field observations would be required to determine this. See Chapter 5 for a discussion on the BSI.

[19] In the United States, the possession of any protected migratory bird will require a Special Purpose or Scientific Collecting permit (see Chapter 3), unless otherwise instructed by an agent of U.S. Fish and Wildlife Service Office of Law Enforcement.

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ISSUES RELATED TO ESTIMATING MORTALITY RATES

EQUATIONS FOR CALCULATING MORTALITY RATE

Accuracy

Few mathematical equations for estimating mortality have been tested for accuracy using experimentally designed, rigorous field studies (Bevanger 1999). Furthermore, there are no agreed upon methods that link the equation to the type of field trials necessary for site-specific calculation of mortality, nor are methods for incorporating uncertainty often provided.

These issues are not unique to power lines. Similar uncertainty is found in calculating actual mortality from estimates of bird carcasses collected from wind turbine collisions, building window collisions, pesticide application, and avian diseases. Although the causes of mortality are different, the ability to find bird carcasses in the field is affected by the same sampling biases (i.e., crippling loss, searcher efficiency, scavenger removal, and habitat differences; see discussion on this page). Huso (2011) evaluated the accuracy and precision of mortality estimators for power lines and other structures and proposed one that improves reliability. This limitation in calculating mortality rates is also presently being investigated by the wind industry, U.S. Fish and Wildlife Service, U.S. Geological Survey, and others. The California Energy Commission (CEC) is funding a controlled field study through the California Wind Energy Association strictly looking at the mathematical relationships of scavenger removal and searcher efficiency as they relate to calculating actual mortality rates. The study report should be available in 2012 (J. Newman, pers. comm.).

Variability in Methods

While designing a study, the most recent literature on mortality rate calculations should be reviewed before selecting a particular method. Bevanger (1999) and Hunting (2002) provide an excellent review of collision mortality for power lines. A mortality rate of the number of carcasses/distance of line surveyed/time period is the most commonly used metric found in the literature. However, the search area (i.e., estimated annual mortality/hectare/kilometer [/acre/mile]) also needs to be included (Hunting 2002).

Finally, as mentioned earlier, there is great variability in monitoring methods, which prevents useful comparison of mortality rates and effectiveness of markers to reduce collisions.

SAMPLING BIASES

When conducting mortality monitoring, the mortality rate calculation must take a number of sampling biases into account, including the following:

- Crippling loss
- Searcher efficiency
- Scavenger removal
- Habitat differences

Crippling Loss Bias

The crippling loss bias occurs when birds strike a line and fall outside the search area or when injured birds move out of the search area and are not observed by searchers. Bevanger (1999) cites several studies that found 22% (Hiltunen 1953) to 50% (Renssen et al. 1975) to 74% (Beaulaurier 1981) of birds fatally injured in power line collisions move far enough away from the power line before dying that they are not found during carcass searches.

In Beaulaurier's (1981) study, crippling loss bias was defined as the percent of observed collisions in which birds continued flying out of the study area after the collision. Because she did not observe a collision during her study, she used an estimate of 74%—the average measure of crippling loss bias calculated by Meyer (1978) as 75% and James and Haak (1980) as 73%. These authors assume

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a worst-case estimate with all injured birds dying from their injuries. The estimates were also based on collisions with shield wires.

Because great time and effort are involved in monitoring flights and recording collisions, crippling loss bias estimates are extremely difficult to obtain and they are the least likely to be calculated in a study. Application of estimates from other studies is inappropriate, and, in fact, very misleading. Once again, the size of the bird may make a significant difference because of flight dynamics. A crane or swan that just tips a line is more likely to tumble to the ground and sustain fatal injuries than is a smaller, lighter bird that may be able to recover its flight mid-air and die later at some distance from the line (W. Brown, pers. comm.). Consequently, smaller birds might have a higher crippling loss bias than larger birds. This may need to be examined in future research.

Searcher Efficiency Bias

During carcass searches, some of the carcasses will be missed depending on several variables (e.g., number of observers, their skill and experience, and how the surveys are conducted). This is called searcher efficiency bias or searcher bias. Searcher bias is also influenced by vegetation type, height, and density, search pattern, presence of waterbodies, bird size, and other factors (Bevanger 1999; Erickson et al. 2005). Searcher bias in carcass detection must be carefully controlled (Bevanger 1999; Erickson et al. 2005). Searcher efficiency biases are specific to the site and the season. Bias needs to be determined while the mortality monitoring is taking place and not extrapolated from or to other locations, seasons, or studies (Bevanger 1999; Barrientos et al. 2011). APLIC (1994) and Bevanger (1999) give examples of the calculations for determining searcher bias. CEC is also studying searcher efficiency factors for calculating wind turbine-caused bird mortality.

The use of trained dogs in mortality monitoring studies can increase carcass recovery, particularly of small carcasses in dense vegetation (Homan et al. 2001; Anderson 1978; Rusz et al. 1986; Bevanger 1995, cited in Bevanger 1999). However, the availability of trained dogs is limited and their efficiency varies with individuals, seasons, weather conditions, vegetation structure, breed, length of use, and level of fatigue.

Scavenger Removal Bias

Scavengers may remove carcasses before a search is completed, which results in underestimating mortality. Scavenging rates are very important to include in mortality rate estimation (Bevanger 1999; Rivera-Milan et al. 2004; Erickson et al. 2005; Gehring et al. 2009). Bevanger (1999) gives an example of the calculation. Scavenging rate varies by habitat, season, time of day, scavenger type, bird size, bird species, etc. (Bevanger 1999; Erickson et al. 2005). Evidence of seasonal variation in scavenging rates in United Kingdom farmland is presented by Prosser et al. (2008).

In some cases scavenging can be a quick process, occurring in a matter of minutes depending on the scavenger species as well as the bird species involved. A review of the scavenging studies from various mortality monitoring studies (including power lines, communication towers, wind turbines, pesticide application, and bird disease) indicates that the majority of scavenging takes place within a short period of time after death for many species. For example, preliminary results of a scavenging removal study at one communication tower location on the Alaska Peninsula suggest that carcass removal from scavenging is as high as 50% removal per day (P. Flint, USGS pers. comm.; E. Lance, USFWS pers. comm.; USFWS 2007 unpubl. Data, cited in Manville 2007a); scavenged carcasses included eiders, waterfowl, and shorebirds, among others. This degree of scavenging is consistent with what Herbert Stoddard (Crawford and Engstrom 2001) found in a 29-year study of a communication tower in Florida where about 92% of carcasses were removed by scavengers within 24 hours. Peterson et al. (2001) reported that in British Columbia, Canada, 52/54 poisoned waterfowl carcasses were discovered by avian scavengers within 72 hours. Kostecke et al. (2001) reported carcasses scavenged mostly by skunks with 66% of carcasses scavenged within five days in a South Dakota study. Erickson et al. (2005) cites a number of case studies with average carcass persistence times ranging from less than one to 28 days. In other cases it can be longer (Brown and Drewien 1995). They found that crane carcasses sometimes remained for as much as a year after death and that no crane carcasses were removed by scavengers during the removal studies. Likewise, large bird carcasses (e.g., raptors, pelicans) may persist for extended periods (several months to 32 months) without scavenger removal (S. Liguori, pers. comm.). Raevel and Tombal (1991) and others have noted that removal bias varies with the size of the birds (i.e., smaller birds usually disappear more quickly and more frequently). Consequently, the effects of size and perhaps species must be included in calculations of removal bias for a study. In controlled studies where a known number of carcasses were placed in the field showed that many carcasses were removed within a short period time, e.g. days; however, even small birds can persist in the field for long periods of time as they become desiccated and less preferred for scavenging.

Scavenger removal bias is site-specific and needs to be determined when the mortality monitoring is taking place rather than extrapolating it from other locations, seasons, or studies (Bevanger 1999). Scavengers can quickly learn where carcasses or injured birds are readily available, suggesting the need to update these bias correction factors throughout the study, as needed, to account for learning behavior.

Habitat Differences Bias

Habitat bias is used to account for unsearchable areas. Some portions of a study area may not be searchable because of water, bogs, dense vegetation, or topography. Researchers should not extrapolate beyond the area sampled because the rate of collision may vary with habitat type. Habitat bias should be used only in situations where unsearchable habitat is finely interspersed with searchable habitat and where researchers can demonstrate that the numbers of birds found in searchable and unsearchable habitats are similar.

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APPENDIX C

Glossary

adult
A bird that has acquired its final plumage.

aspect ratio
Aspect ratio is the wing breadth divided by wing length. A low aspect ratio generally correlates with relatively thin wings and high aspect ratio with relatively wide wings.

avian-safe
A power pole configuration designed to minimize avian electrocution risk.

circuit (multiple)
A configuration that supports more than one circuit.

circuit (single)
A conductor or system of conductors through which an electric current is intended to flow. The circuit is energized at a specified voltage.

conductivity
The capacity to transmit electrical energy.

conductor
The material (usually copper or aluminum)—usually in the form of a wire, cable, or bus bar—suitable for carrying an electric current (AC, DC, and shield); a material that offers little resistance to the flow of electricity.

conductor gallop
Also known as galloping. The high-amplitude, low-frequency oscillation of overhead power lines often due to wind. The movement of the wires occurs most commonly in the vertical plane, although horizontal or rotational motion is also possible. Galloping can cause power lines to slap together, which results in outages and damage to the lines and equipment. Icing conditions, wind velocity, and conductor tension are some of the factors that interact to cause galloping.

configuration
The arrangement of parts or equipment. A distribution configuration would include the necessary arrangement of crossarms, braces, insulators, etc. to support one or more electrical circuits.

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conspecific
Members of the same species.

corona
A process by which current in a conductor with a high potential ionizes the air surrounding it to create a plasma. The ions generated eventually pass charge to nearby areas of lower potential or recombine to form neutral gas molecules.

corridor
The broad area between the origin and termination of a new line, within which the potential routes lie. The area in which a new line's routing alternatives are proposed and evaluated before the final route is determined.

corvid
Birds belonging to the family Corvidae; includes crows, ravens, magpies, and jays.

crossarm
A horizontal supporting member used to support electrical conductors and equipment for the purpose of distributing electrical energy. Usually made of wood, fiberglass, or steel, and manufactured in various lengths.

current
A movement or flow of electricity passing through a conductor. Current is measured in amperes.

distribution line
Lower-voltage wires, energized at voltages from 2.4 kV to 60 kV, and used to distribute electricity to residential, industrial, and commercial customers, i.e., end users.

facility
As used in this manual, this term refers to all the equipment, wires, structures (e.g., poles and towers), etc., that are involved in carrying electricity.

fault
A power disturbance that interrupts the quality of electrical supply. A fault can have a variety of causes including fires, ice storms, lightning, animal collisions/electrocutions, or equipment failures. Also known as arc, short circuit, or flash.

flappers
Suspended collision reduction devices that clamp to and hang from a line and swing and spin in the wind. There are variations on this theme that have little or no motion, which are used when high winds cause moving parts to wear rapidly.

flaring
A sudden panic avoidance reaction to power lines, in which birds ascend almost vertically with rapid wing beats or fold their wings and fall down and backwards away from the obstacle.

fledgling
A bird that has recently learned to fly and left the nest, but may still be dependent on its parents for food.

ground
Material that conducts electricity and makes an electrical connection with the earth.

ground rod
Normally a copper-clad steel rod or galvanized steel rod, driven into the ground so that the necessary parts of a facility can be physically connected to ground potential.

grounding conductor
A conductor used to ground the shield and neutral wires. Grounding conductors may be copper-clad, solid copper, or stranded galvanized wires and are attached to the structure. Sometimes also called a down wire. When steel structures are used the structure becomes the grounding conductor.

guy
Secures the upright position of a pole and offsets physical loads imposed by conductors, wind, ice, etc. Guys are normally attached to anchors that are securely placed in the ground.

immature
All plumages other than adult.

juvenile
(Plumage)—first plumage of a bird.
(Bird)—a bird in its first year of life.

Kilovolt (kV)
1,000 volts

latticework
The combination of steel members connected together to make complete structures, such as transmission towers or substation structures.

lightning arrester
An electrical protection device used to divert the energy of lightning strikes to the earth.

lightning days
Lightning or thunderstorm days. A day with one or more lightning storms would be classified as a lightning day.

maneuvering
Any change in flight behavior, height, or direction, and in this context, in response to obstacles such as power lines.

necropsy
Postmortem examination of wildlife often used to determine cause of death.

nestling
A young bird that has not yet reached sufficient size and maturity to leave the nest.

neutral wire
A non-energized conductor that carries the primary current back to its substation. The neutral is at ground potential (i.e., it grounds a distribution power line system).

outage
Event that occurs when the energy source is cut off from the load.

overhead ground wire
See **shield wire**.

phase conductor
An energized power line that carries alternating current electricity.

phase-to-ground
The contact of an energized conductor to ground potential. A bird can cause a phase-to-ground fault when fleshy parts of its body touch an energized phase and ground simultaneously.

phase-to-phase
The contact of two energized conductors. Birds can cause a phase-to-phase fault when the fleshy part of their wings or other body parts contact two energized conductors of different phases at the same time.

pole

1. A vertical structure used to support electrical conductors and equipment for the purpose of transporting electrical energy. It can be made of wood, fiberglass, concrete, or steel and manufactured in various heights.

2. DC transmission lines use bundled conductors also known as poles, which refers to the positively and negatively charged conductors in a DC design.

power generation facility
The location where electricity is generated, which may be a power plant, station, wind turbines, solar farm, or hydro-electric dam, among others.

power line
A line made of conductive material that transmits electricity from its source to its point of use.

ramping
A contemplated maneuver frequently seen in wading birds approaching a power line at or below conductor levels. During their approach waders swerve and continue parallel to the power line until sufficient altitude is reached for crossing. Ramping is most frequently observed on clear days with moderate winds and apparently allows birds to assess and negotiate the power line before crossing.

raptor
Bird of prey. Raptors are members of the orders Falconiformes (diurnal raptors) and Strigiformes (owls). Raptors have a sharp hooked bill and sharp talons used for killing and eating prey.

rebuild
The act of upgrading an existing line by replacing its wires and/or structures.

reliability
The percentage of time a line is delivering uninterrupted electricity.

reroute
The act of removing an existing line from the original right-of-way and rebuilding it along another route that will avoid the interactions encountered in the original route.

retrofit
The modification of an existing electrical power line structure to make it avian-safe.

right-of-way (ROW)
The strip of land that has been acquired by an agreement between two or more parties for the purpose of constructing and maintaining a utility easement. The width of right-of-way required by each voltage level is generally dictated by state statutes and the National Electrical Safety Code (NESC) and is a function of span length, the conductor height above ground, and the conductor's low point of sag.

route
The pathway on which a right-of-way will be cleared and the new line constructed.

sailing
Crossing of conductors and shield wires with wings set. Most frequently seen in birds flying through or close to the conductor-shield wire complex.

separation
The physical distance between energized conductors or between energized and non-energized conductors.

shield wire
Also called static wire or overhead ground wire. A conductor that provides a path to ground for static electricity. Lightning is its most common source of static electricity. Since lightning follows pathways to ground, the shield wire protects phase (AC) and pole (DC) conductors from lightning strikes.

shortstopping
Wintering in more northerly latitudes than has been historic for the species.

siting
The process of identifying the points in the electrical system that need new lines of connection to deliver electricity to growing or new demand centers.

span
The pole-to-pole or tower-to-tower distance of a power line.

static wire
See **shield wire**.

structure
A pole or lattice assembly that supports electrical conductors and equipment for the transmission or distribution of electricity.

subadult
Stage of a bird between juvenile and adult.

substation
A transitional point (where voltage is increased or decreased) in transmission and distribution systems.

transmission line
Power line that delivers electricity from its source over long distances to substations where the voltage is reduced for distribution. Transmission voltages range from 60 to 765 kV in the United States.

trust resource
Wildlife held in the public trust and managed and protected by federal and state agencies. These trust agencies are designated by statute and regulations as responsible for upholding the protection, conservation, and management of these resources.

underbuild
Refers to a circuit that is placed on the same pole but underneath another circuit of a higher voltage. The lower circuit is often referred to as the underbuilt circuit.

volt
The measure of electrical potential.

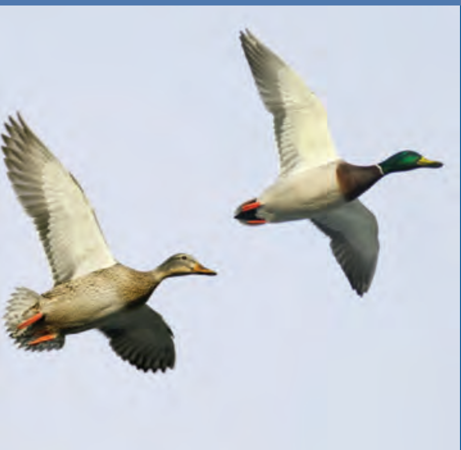
voltage
Electromotive force can be expressed in volts. Power lines are rated and categorized by voltage.

voltage rating

The voltage rating of a transmission line depends on the utility's existing transmission system voltages, interconnections with other utilities, potential delivery points, and the amount of power that must be transmitted to meet load requirements. As voltages increase, the amount of power that can be transmitted increases. Various line-design parameters such as conductor size and configuration, spacing, and the number of conductors per phase (bundling) allow for increased transmission capability. Transmission voltages for carrying energy long distances are generally in the 115- to 765-kV range in North America.

wing loading

Wing loading is a bird's mass divided by its wing surface area. High wing loading describes a bird that is heavy relative to its wing area. Low wing loading describes a bird that is light relative to its wing area.



APPENDIX D

Acronyms

AC	Alternating Current
ACP	Advanced Conservation Practice
APLIC	Avian Power Line Interaction Committee
APP	Avian Protection Plan
AWBP	Aransas-Wood Buffalo Population (whooping cranes)
BAMS	Bird Activity Monitoring System
BFD	Bird-Flight™ Diverter
BGEPA	Bald and Golden Eagle Protection Act (United States)
BSI	Bird Strike Indicator
CAP	Citizens Advisory Panel
CEC	California Energy Commission
cm	centimeter
CFR	Code of Federal Regulations (United States)
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CWS	Canadian Wildlife Service
DC	Direct Current
EEI	Edison Electric Institute
EPRI	Electric Power Research Institute
ESA	Endangered Species Act (United States)
FAA	Federal Aviation Administration
ft	feet
GIS	Geographic Information Systems
GPS	Global Positioning System
HCP	Habitat Conservation Plan
HVAC	High Voltage Alternating Current
HVDC	High Voltage Direct Current
in	inch
ITP	Incidental Take Permit
km	kilometer
kV	kilovolt
m	meter
mi	mile
MBCA	Migratory Birds Convention Act (Canada)
MBTA	Migratory Bird Treaty Act (United States)
MOU	Memorandum of Understanding
NESC	National Electrical Safety Code
NMFS	National Marine Fisheries Service (United States)
NRECA	National Rural Electric Cooperative Association
PVC	Polyvinyl Chloride
ROW	Right-of-Way (singular), Rights-of-Way (plural)
SARA	Species at Risk Act (Canada)
SFD	Swan-Flight™ Diverter
SVD	Spiral Vibration Damper

PREVIOUS VIEW

USEPA	U.S. Environmental Protection Agency	USGS	U.S. Geological Survey
USFWS	U.S. Fish and Wildlife Service	UV	Ultraviolet
		V	Volt

APPENDIX E

Resources

BIRD IDENTIFICATION AND NATURAL HISTORY

All About Birds
Cornell Lab of Ornithology
Includes bird identification information and bird songs.
www.allaboutbirds.org/Page.aspx?pid=1189

Birds of North America
Cornell Lab of Ornithology
Comprehensive reference covering the life histories of North America's breeding birds.
http://bna.birds.cornell.edu/bna

Tools for Learning About Birds
USGS Patuxent Wildlife Research Center
Includes bird pictures and songs.
www.mbr-pwrc.usgs.gov/bbs/ident.html

Bird Identification Pages
Idaho Museum of Natural History
Includes a visual key with silhouettes.
http://imnh.isu.edu/digitalatlas/bio/birds/main/birdid.htm

Florida Bird Sounds
Florida Museum of Natural History
www.flmnh.ufl.edu/birds/sounds.htm

BIRD DATABASES AND CONSERVATION INFORMATION

Migratory Bird Program
USFWS Division of Migratory Birds
Resources and regulations for the conservation and management of migratory birds.
www.fws.gov/migratorybirds

Migratory Bird Treaty Act (MBTA)
USFWS Division of Migratory Birds
www.fws.gov/laws/lawsdigest/migtrea.html

Bald and Golden Eagle Protection Act (BGEPA)
USFWS Division of Migratory Birds
www.fws.gov/laws/lawsdigest/baldegl.html

Endangered Species Act of 1973 (ESA)
USFWS Division of Migratory Birds
www.fws.gov/laws/lawsdigest/esact.html

Endangered Species Consultation Handbook (1998)
USFWS and NMFS
Procedures for conducting consultation and conference activities under Section 7 of the Endangered Species Act.
www.fws.gov/midwest/endangered/section7/index.html

PREVIOUS VIEW

North American Waterfowl Management Plan
USFWS Division of Bird Habitat Conservation
Includes waterfowl status reports.
www.fws.gov/birdhabitat/NAWMP/index.shtm

Bird Conservation Initiatives
U.S. Environmental Protection Agency
Portal to major United States bird conservation plans and organizations.
www.epa.gov/owow/birds/bird.html

Conservation Plans, Databases, Strategies, and Assessments
Partners in Flight—U.S.
www.partnersinflight.org

North American Landbird Conservation Plan (2004)
Partners in Flight
www.pwrc.usgs.gov/pif/cont_plan

U.S. Shorebird Conservation Plan (2001)
USFWS
www.fws.gov/shorebirdplan

North American Waterbird Conservation Plan (2002)
Waterbird Conservation for the Americas
www.pwrc.usgs.gov/nacwcp/nawcp.html

Migratory Birds (Canada)
Environment Canada
Conservation, monitoring and reporting, and regulations for Canadian migratory birds.
www.ec.gc.ca/nature/default.asp?lang=En&n=FDF836EF-1

Migratory Birds Convention Act and Regulations (Canada)
Environment Canada
Polices, regulations, and list of birds protected in Canada under the MBCA.
www.ec.gc.ca/nature/default.asp?lang=En&n=7CEBB77D-1

Species at Risk Public Registry (Canada)
Government of Canada
Information and regulations for at-risk species in Canada.
www.sararegistry.gc.ca/default_e.cfm

Committee on the Status of Endangered Wildlife in Canada
Committee of experts that assesses wildlife species in danger of disappearing.
www.cosewic.gc.ca/eng/sct5/index_e.cfm

North American Bird Conservation Initiative
Bird Studies Canada
Describes and maps the North American bird conservation regions.
www.bsc-eoc.org/nabci.html

Christmas Bird Counts
National Audubon Society
Annual "snapshot" of North American bird populations over many decades. Because of issues with detection and database limitations, this database should only be used for indications of species presence and season of use.
http://birds.audubon.org/christmas-bird-count

eBird
Audubon and Cornell Lab of Ornithology
International database of bird observations with graphs and range maps. Because of issues with detection and database limitations, this database should only be used for indications of species presence and season of use.
http://ebird.org/content/ebird

Avian Knowledge Network (AKN)
Downloadable version of the eBird reference dataset for the Western Hemisphere.
www.avianknowledge.net/content

National Biological Information Infrastructure: Bird Conservation
USGS Biological Informatics Program
Portal to maps, data, and bird conservation procedures for conservation of bird populations and their habitats in North America.
www.nbii.gov/portal/server.pt/community/bird_conservation/460

Ornithological Information System (ORNIS)
National Science Foundation
Data from collections of a network of museum and academic partners.
www.ornisnet.org

North American Breeding Bird Survey
U.S. Geological Survey
Data since 1966 on the status and trends of North American bird populations. Because of issues with detection and database limitations, this database should only be used for indications of species presence and season of use.
www.pwrc.usgs.gov/BBS

Landbird Population Estimates Database
Partners in Flight/Rocky Mountain Bird Observatory
Based on the Breeding Bird Survey data of the 1990s.
www.rmbo.org/pif_db/laped/default.aspx

Raptor Information System
U.S. Geological Survey
Keyword catalog of over 32,000 references on the biology and management of raptors.
http://ris.wr.usgs.gov

BIRD/ENERGY PROGRAMS AND AVIAN PROTECTION PLANNING

Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006
Avian Power Line Interaction Committee
www.aplic.org/documents.php

Avian Protection Plan Guidelines 2005
Avian Power Line Interaction Committee and USFWS
www.aplic.org/uploads/files/2634/APPguidelines_final-draft_Aprl2005.pdf

Short Courses and Workshops on Avian-Power Line Interactions
Avian Power Line Interaction Committee
www.aplic.org (see Upcoming Events)

California Energy Commission
www.energy.ca.gov/index.html

On-Line Annotated Bibliography of Avian Interactions with Utility Structures
California Energy Commission
www.energy.ca.gov/research/environmental/avian_bibliography

Right-of-Way Siting, Vegetation Management, and Avian Issues—Program 57
Electric Power Research Institute
http://portfolio.epri.com/ProgramTab.aspx?sId=ENV&rId=134&pId=5117

Conserving Birds and Their Habitats on Department of Defense Lands
U.S. Department of Defense and Partners in Flight
Includes a variety of resources such as bird conservation maps and avian protection planning guidelines.
www.dodpif.org

Materials on Bird-Power Line Interactions for Electric Utilities and their Employees
New Mexico Avian Protection Working Group
http://nmavianprotection.org//resources.html

Wildlife and Energy Programme
Endangered Wildlife Trust
www.ewt.org.za/WHATWEDO/OurProgrammes/WildlifeEnergyProgramme.aspx

PREVIOUS VIEW

HIGH VOLTAGE DIRECT CURRENT (HVDC) TRANSMISSION SYSTEMS

Technology Information, Resource Library, and Student/Teacher Education
Clean Line Energy Partners
www.cleanlineenergy.com

AVIAN HEALTH, MORTALITY, AND CARCASS IDENTIFICATION

National Wildlife Health Center
U.S. Geological Survey
www.nwhc.usgs.gov

Field Manual of Wildlife Diseases, General Field Procedures and Diseases of Birds
U.S. Geological Survey
www.nwhc.usgs.gov/publications/field_manual

Wildlife Health Bulletin #06-02: Wild bird mortality reporting
U.S. Geological Survey
www.nwhc.usgs.gov/publications/wildlife_health_bulletins/WHB_06_02.jsp

Avian Necropsy Manual for Biologists in Remote Refuges
U.S. Geological Survey
http://www.nwhc.usgs.gov/publications/necropsy_manuals/index.jsp

Causes of Mortality in Common Loons
U.S. Geological Survey
www.nwhc.usgs.gov/publications/documents/92JCF.CLE01.pdf

Field Guide to Raptor Remains
California Energy Commission
www.energy.ca.gov/index.html

Wing and Tail Image Collection (Useful for Carcass Identification)
University of Puget Sound
www.pugetsound.edu/academics/academic-resources/slater-museum/biodiversity-resources/birds/wing-image-collection

PUBLIC PARTICIPATION RESOURCES

Introduction to Public Participation
Edison Electric Institute
Practical information for working with the public as a partner.
www2.eei.org/products_and_services/descriptions_and_access/intro_pub_partic.htm

Bird Education Network
Council for Environmental Education
Coalition developing a national strategy for bird education.
www.birdeducation.org

Flying Wild
Council for Environmental Education
Classroom bird education resources.
www.flyingwild.org

International Migratory Bird Day
Environment for the Americas
Annual event focusing on migratory birds of the Americas.
www.birdday.org

Project BEAK (Bird Education and Awareness for Kids)
Nebraska Partnership for All-Bird Conservation, Nebraska Environmental Trust, Nebraska Game and Fish Commission, U.S. Environmental Protection Agency
Exemplary bird education program.
http://projectbeak.org

National Wildlife Refuge System
U.S. Fish and Wildlife Service
552 refuges, many of which focus on bird conservation and public outreach.
www.fws.gov/refuges

FUNDING ORGANIZATIONS

Avian Power Line Interaction Committee
APLIC funds research projects that further the knowledge of avian/power line interactions, including causes and solutions to avian mortalities due to power line electrocutions and collisions.
www.aplic.org/proposals.php

California Energy Commission
CEC funds various programs; see their website for a complete list.
www.energy.ca.gov/contracts/index.html

Electric Power Research Institute
EPRI funds research and development through competitive selection of contractors.
http://my.epri.com
(see About EPRI and Contractor Resources)

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Edison Electric Institute
Power by Association℠

Avian Power Line Interaction Committee

Exhibit ACC-2

U.S. Fish & Wildlife Service

U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines

Cover Photo:

Wind Turbine. Photo by Stefanie Stavrakas, USFWS

OMB Control No, 1018-0148
Expiration Date: 11/30/2021

U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines

March 23, 2012

Acknowledgements

The U.S. Fish and Wildlife Service (Service) would like to recognize and thank the Wind Turbine Guidelines Advisory Committee for its dedication and preparation of its Recommendations. The Recommendations have served as the basis from which the Service's team worked to develop the Service's Land-Based Wind Energy Guidelines. The Service also recognizes the tireless efforts of the Headquarters, Regional and Field Office staff that helped to review and update these Guidelines.

Paperwork Reduction Act Statement: The Land-Based Wind Energy Guidelines contain reporting and recordkeeping requirements that require Office of Management and Budget approval in accordance with the Paperwork Reduction Act of 1995. Your response is voluntary. We collect this information in order to provide technical assistance related to addressing wildlife conservation concerns at all stages of land-based wind energy development. For each response, we estimate the time necessary to provide the information as follows:

Tier 1 – 83 hours
Tier 2 – 375 hours
Tier 3 – 2,880 hours
Tier 4 – 2,550 hours
Tier 5 – 2,400 hours

The above estimates include time for reviewing instructions, gathering and maintaining data, and preparing and transmitting reports. Send comments regarding these estimates or any other aspect of the requirements to the Service Information Collection Clearance Officer, U.S. Fish and Wildlife Service, 4401 N. Fairfax Drive, MS 2042-PDM, Arlington, VA 22203.

We may not conduct and you are not required to respond to a collection of information unless it displays a currently valid OMB control number.

Table of Contents

List of Figures and Tables

Executive Summary

As the Nation shifts to renewable energy production to supplant the need for carbon-based fuel, wind energy will be an important source of power. As wind energy production increases, both developers and wildlife agencies have recognized the need for a system to evaluate and address the potential negative impacts of wind energy projects on species of concern. These voluntary Guidelines provide a structured, scientific process for addressing wildlife conservation concerns at all stages of land-based wind energy development. They also promote effective communication among wind energy developers and federal, state, and local conservation agencies and tribes. When used in concert with appropriate regulatory tools, the Guidelines form the best practical approach for conserving species of concern. The Guidelines have been developed by the Interior Department's U.S. Fish and Wildlife Service (Service) working with the Wind Turbine Guidelines Advisory Committee. They replace interim voluntary guidance published by the Service in 2003.

The Guidelines discuss various risks to "species of concern" from wind energy projects, including collisions with wind turbines and associated infrastructure; loss and degradation of habitat from turbines and infrastructure; fragmentation of large habitat blocks into smaller segments that may not support sensitive species; displacement and behavioral changes; and indirect effects such as increased predator populations or introduction of invasive plants. The Guidelines assist developers in identifying species of concern that may potentially be affected by their proposed project, including migratory birds; bats; bald and golden eagles and other birds of prey; prairie and sage grouse; and listed, proposed, or candidate endangered and threatened species. Wind energy development in some areas may be precluded by federal law; other areas may be inappropriate for development because they have been recognized as having high wildlife value based on their ecological rarity and intactness.

The Guidelines use a "tiered approach" for assessing potential adverse effects to species of concern and their habitats. The tiered approach is an iterative decision-making process for collecting information in increasing detail; quantifying the possible risks of proposed wind energy projects to species of concern and their habitats; and evaluating those risks to make siting, construction, and operation decisions. During the pre-construction tiers (Tiers 1, 2, and 3), developers are working to identify, avoid and minimize risks to species of concern. During post-construction tiers (Tiers 4 and 5), developers are assessing whether actions taken in earlier tiers to avoid and minimize impacts are successfully achieving the goals and, when necessary, taking additional steps to compensate for impacts. Subsequent tiers refine and build upon issues raised and efforts undertaken in previous tiers. Each tier offers a set of questions to help the developer evaluate the potential risk associated with developing a project at the given location.

Briefly, the tiers address:

- Tier 1 – Preliminary site evaluation (landscape-scale screening of possible project sites)
- Tier 2 – Site characterization (broad characterization of one or more potential project sites)
- Tier 3 – Field studies to document site wildlife and habitat and predict project impacts
- Tier 4 – Post-construction studies to estimate impacts[1]
- Tier 5 – Other post-construction studies and research

The tiered approach provides the opportunity for evaluation and decision-making at each stage, enabling a developer to abandon or proceed with project development, or to collect additional information if required. This approach does not require that every tier, or every element within each tier, be implemented for every project. The Service anticipates that many distributed or community facilities will not need to follow the Guidelines beyond Tiers 1 and 2. Instead, the tiered approach allows efficient use of developer and wildlife agency resources with increasing levels of effort.

If sufficient data are available at a particular tier, the following outcomes are possible:

1. The project proceeds to the next tier in the development process without additional data collection.
2. The project proceeds to the next tier in the development process with additional data collection.
3. An action or combination of actions, such as project

[1] The Service anticipates these studies will include fatality monitoring as well as studies to evaluate habitat impacts.

modification, mitigation, or specific post-construction monitoring, is indicated.

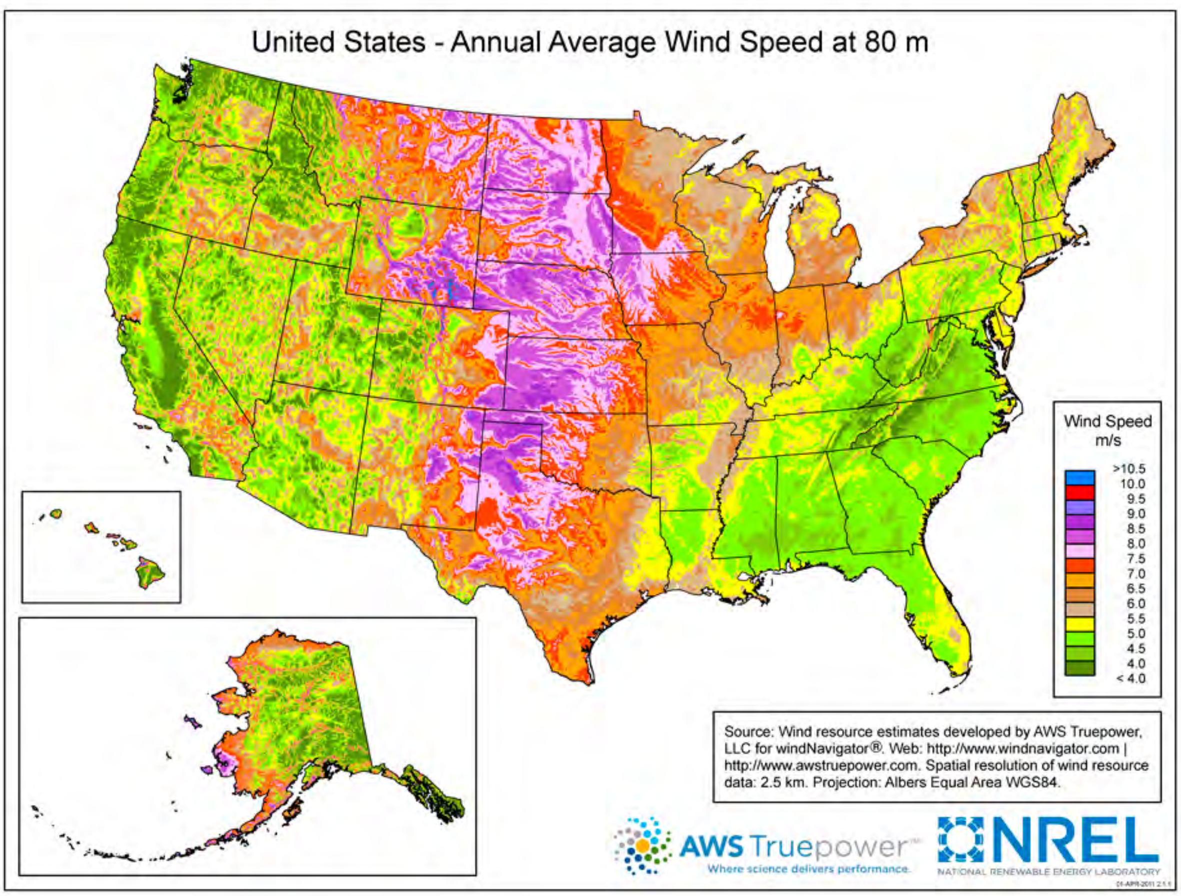
4. The project site is abandoned because the risk is considered unacceptable.

If data are deemed insufficient at a tier, more intensive study is conducted in the subsequent tier until sufficient data are available to make a decision to modify the project, proceed with the project, or abandon the project.

The most important thing a developer can do is to consult with the Service as early as possible in the development of a wind energy project. Early consultation offers the greatest opportunity for avoiding areas where development is precluded or where wildlife impacts are likely to be high and difficult or costly to remedy or mitigate at a later stage. By consulting early, project developers can also incorporate appropriate wildlife conservation measures and monitoring into their decisions about project siting, design, and operation.

Adherence to the Guidelines is voluntary and does not relieve any individual, company, or agency of the responsibility to comply with laws and regulations. However, if a violation occurs the Service will consider a developer's documented efforts to communicate with the Service and adhere to the Guidelines. The Guidelines include a Communications Protocol which provides guidance to both developers and Service personnel regarding appropriate communication and documentation.

The Guidelines also provide Best Management Practices for site development, construction, retrofitting, repowering, and decommissioning. For additional reference, a glossary of terms and list of literature cited are included in the appendices.



Wind Resource Map. Credit: NREL

Chapter 1 - General Overview

The mission of the U.S. Fish and Wildlife Service (Service) is working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people. As part of this, the Service implements statutes including the Endangered Species Act, Migratory Bird Treaty Act, and Bald and Golden Eagle Protection Act. These statutes prohibit taking of federally listed species, migratory birds, and eagles unless otherwise authorized.

Recent studies have documented that wind energy facilities can kill birds and bats. Mortality rates in fatalities per nameplate MW per year vary among facilities and regions. Studies have indicated that relatively low raptor (e.g., hawks, eagles) fatality rates exist at most modern wind energy developments with the exception of some facilities in California and Wyoming. Turbine-related bat deaths have been reported at each wind facility to date. Generally, studies in the West have reported lower rates of bat fatalities than facilities in the East. There is still much uncertainty regarding geographic distribution and causes of bat fatalities (NWCC 2010).

These Guidelines are intended to:

(1) Promote compliance with relevant wildlife laws and regulations;

(2) Encourage scientifically rigorous survey, monitoring, assessment, and research designs proportionate to the risk to species of concern;

(3) Produce potentially comparable data across the Nation;

(4) Mitigate, including avoid, minimize, and compensate for potential adverse effects on species of concern and their habitats; and,

(5) Improve the ability to predict and resolve effects locally, regionally, and nationally.

As the United States moves to expand wind energy production, it also must maintain and protect the Nation's wildlife and their habitats, which wind energy production can negatively affect. As with all responsible energy development, wind energy projects should adhere to high standards for environmental protection. With proper diligence paid to siting, operations, and management of projects, it is possible to mitigate for adverse effects to wildlife, and their habitats. This is best accomplished when the wind energy project developer communicates as early as possible with the Service and other stakeholders. Such early communication allows for the greatest range of development and mitigation options. The following website contains contact information for the Service Regional and Field offices as well as State wildlife agencies: http://www.fws.gov/offices/statelinks.html.

In response to increasing wind energy development in the United States, the Service released a set of voluntary, interim guidelines for reducing adverse effects to fish and wildlife resources from wind energy projects for public comment in July 2003. After the Service reviewed the public comments, the Secretary of the Interior (Secretary) established a Federal Advisory Committee[2] to provide recommendations to revise the guidelines related to land-based wind energy facilities. In March 2007, the U.S. Department of the Interior established the Wind Turbine Guidelines Advisory Committee (the Committee). The Committee submitted its final Recommended Guidelines (Recommendations) to the Secretary on March 4, 2010. The Service used the Recommendations to develop its Land-Based Wind Energy Guidelines.

The Service encourages project proponents to use the process described in these voluntary Land-based Wind Energy Guidelines (Guidelines) to address risks to species of concern. The Service intends that these Guidelines, when used in concert with the appropriate regulatory tools, will form the best practical approach for conservation of species of concern.

Statutory Authorities

These Guidelines are not intended nor shall they be construed to limit or preclude the Service from exercising its authority under any law, statute, or regulation, or from conducting enforcement action against any individual, company, or agency. They are not meant to relieve any individual, company, or agency of its obligations to comply with any applicable federal, state,

[2] Committee membership, from 2008 to 2011, has included: Taber Allison, Massachusetts Audubon; Dick Anderson, California Energy Commission; Ed Arnett, Bat Conservation International; Michael Azeka, AES Wind Generation; Thomas Bancroft, National Audubon; Kathy Boydston, Texas Parks and Wildlife Department; René Braud, EDP Renewables; Scott Darling, Vermont Fish and Wildlife Department; Michael Daulton, National Audubon; Aimee Delach, Defenders of Wildlife; Karen Douglas, California Energy Commission; Sam Enfield, MAP Royalty; Greg Hueckel, Washington Department of Fish and Wildlife; Jeri Lawrence, Blackfeet Nation; Steve Lindenberg, U.S. Department of Energy; Andy Linehan, Iberdrola Renewables; Rob Manes, The Nature Conservancy, Kansas; Winifred Perkins, NextEra Energy Resources; Steven Quarles, Crowell & Moring; Rich Rayhill, Ridgeline Energy; Robert Robel, Kansas State University; Keith Sexson, Association of Fish and Wildlife Agencies; Mark Sinclair, Clean Energy States Alliance; David Stout, U.S. Fish and Wildlife Service; Patrick Traylor, Hogan Lovells.

tribal, or local laws, statutes, or regulations. The Guidelines do not prevent the Service from referring violations of law for enforcement when a company has not followed the Guidelines.

Ultimately it is the responsibility of those involved with the planning, design, construction, operation, maintenance, and decommissioning of wind projects to conduct relevant wildlife and habitat evaluation and determine, which, if any, species may be affected. The results of these analyses will inform all efforts to achieve compliance with the appropriate jurisdictional statutes. Project proponents are responsible for complying with applicable state and local laws.

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) is the cornerstone of migratory bird conservation and protection in the United States. The MBTA implements four treaties that provide for international protection of migratory birds. It is a strict liability statute, meaning that proof of intent, knowledge, or negligence is not an element of an MBTA violation. The statute's language is clear that actions resulting in a "taking" or possession (permanent or temporary) of a protected species, in the absence of a Service permit or regulatory authorization, are a violation of the MBTA.

The MBTA states, "Unless and except as permitted by regulations … it shall be unlawful at any time, by any means, or in any manner to pursue, hunt, take, capture, kill … possess, offer for sale, sell … purchase … ship, export, import … transport or cause to be transported … any migratory bird, any part, nest, or eggs of any such bird …. [The Act] prohibits the taking, killing, possession, transportation, import and export of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior." 16 U.S.C. 703. The word "take" is defined by regulation as "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect." 50 CFR 10.12.

The MBTA provides criminal penalties for persons who commit any of the acts prohibited by the statute in section 703 on any of the species protected by the statute. See 16 U.S.C. 707. The Service maintains a list of all species protected by the MBTA at 50 CFR 10.13. This list includes over one thousand species of migratory birds, including eagles and other raptors, waterfowl, shorebirds, seabirds, wading birds, and passerines. The MBTA does not protect introduced species such as the house (English) sparrow, European starling, rock dove (pigeon), Eurasian collared-dove, and non-migratory upland game birds. The Service maintains a list of introduced species not protected by the Act. See 70 Fed. Reg. 12,710 (Mar. 15, 2005).

Bald and Golden Eagle Protection Act

Under authority of the Bald and Golden Eagle Protection Act (BGEPA), 16 U.S.C. 668–668d, bald eagles and golden eagles are afforded additional legal protection. BGEPA prohibits the take, sale, purchase, barter, offer of sale, purchase, or barter, transport, export or import, at any time or in any manner of any bald or golden eagle, alive or dead, or any part, nest, or egg thereof. 16 U.S.C. 668. BGEPA also defines take to include "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb," 16 U.S.C. 668c, and includes criminal and civil penalties for violating the statute. See 16 U.S.C. 668. The Service further defined the term "disturb" as agitating or bothering an eagle to a degree that causes, or is likely to cause, injury, or either a decrease in productivity or nest abandonment by substantially interfering with normal breeding, feeding, or sheltering behavior. 50 CFR 22.3. BGEPA authorizes the Service to permit the take of eagles for certain purposes and under certain circumstances, including scientific or exhibition purposes, religious purposes of Indian tribes, and the protection of wildlife, agricultural, or other interests, so long as that take is compatible with the preservation of eagles. 16 U.S.C. 668a.

In 2009, the Service promulgated a final rule on two new permit regulations that, for the first time, specifically authorize the incidental take of eagles and eagle nests in certain situations under BGEPA. See 50 CFR 22.26 & 22.27. The permits authorize limited, non-purposeful (incidental) take of bald and golden eagles; authorizing individuals, companies, government agencies (including tribal governments), and other organizations to disturb or otherwise take eagles in the course of conducting lawful activities such as operating utilities and airports.

Bald Eagle, Credit: USFWS

Removal of active eagle nests would usually be allowed only when it is necessary to protect human safety or the eagles. Removal of inactive nests can be authorized when necessary to ensure public health and safety, when a nest is built on a human-engineered structure rendering it inoperable, and when removal is necessary to protect an interest in a particular locality, but only if the take or mitigation for the take will provide a clear and substantial benefit to eagles.

To facilitate issuance of permits under these new regulations, the Service has drafted Eagle Conservation Plan (ECP) Guidance. The ECP Guidance is compatible with these Land-Based Wind Energy Guidelines. The Guidelines guide developers through the process of project development and operation. If eagles are identified as a potential risk at a project site, developers are strongly encouraged to refer to the ECP Guidance. The ECP Guidance describes specific actions that are recommended to comply with the regulatory requirements in BGEPA for an eagle take permit, as described in 50 CFR 22.26 and 22.27. The ECP Guidance provides a national framework for assessing and mitigating risk specific to eagles through development of ECPs and issuance of programmatic incidental takes of eagles at wind turbine facilities. The Service will make its final ECP Guidance available to the public through its website.

Endangered Species Act

The Endangered Species Act (16 U.S.C. 1531–1544; ESA) was enacted by Congress in 1973 in recognition that many of our Nation's native plants and animals were in danger of becoming extinct. The ESA directs the Service to identify and protect these endangered and threatened species and their critical habitat, and to provide a means to conserve their ecosystems. To this end, federal agencies are directed to utilize their authorities to conserve listed species, and ensure that their actions are not likely to jeopardize the continued existence of these species or destroy or adversely modify their critical habitat. Federal agencies are encouraged to do the same with respect to "candidate" species that may be listed in the near future. The law is administered by the Service and the Commerce Department's National Marine Fisheries Service (NMFS). For information regarding species protected under the ESA, see: http://www.fws.gov/endangered/.

Indiana bat. Credit: USFWS

The Service has primary responsibility for terrestrial and freshwater species, while NMFS generally has responsibility for marine species. These two agencies work with other agencies to plan or modify federal projects so that they will have minimal impact on listed species and their habitats. Protection of species is also achieved through partnerships with the states, through federal financial assistance and a system of incentives available to encourage state participation. The Service also works with private landowners, providing financial and technical assistance for management actions on their lands to benefit both listed and non-listed species.

Section 9 of the ESA makes it unlawful for a person to "take" a listed species. Take is defined as "... to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct." 16 U.S.C. 1532(19). The terms harass and harm are further defined in our regulations. See 50 CFR 17.3. However, the Service may authorize "incidental take" (take that occurs as a result of an otherwise legal activity) in two ways.

Take of federally listed species incidental to a lawful activity may be authorized through formal consultation under section 7(a)(2) of the ESA, whenever a federal agency, federal funding, or a federal permit is involved. Otherwise, a person may seek an incidental take permit under section 10(a)(1)(B) of the ESA upon completion of a satisfactory habitat conservation plan (HCP) for listed species. Developers not receiving federal funding or authorization should contact the Service to obtain an incidental take permit if a wind

Utility-Scale Wind turbine with an anemometer tower in the background. Credit: University of Minnesota College of Science and Engineering

energy project is likely to result in take of listed threatened or endangered wildlife species. For more information regarding formal consultation and the requirements of obtaining HCPs, please see the Endangered Species Consultation Handbook at http://www.fws.gov/endangered/esa-library/index.html#consultations and the Service's HCP website, http://www.fws.gov/endangered/what-we-do/hcp-overview.html.

Implementation of the Guidelines

Because these Guidelines are voluntary, the Service encourages developers to use them as soon as possible after publication. To receive the considerations discussed on page 6 regarding enforcement priorities, a wind energy project would fall into one of three general categories relative to timing and implementation:

- For projects initiated after publication, the developer has applied the Guidelines, including the tiered approach, through site selection, design, construction, operation and post-operation phases of the project, and has communicated and shared information with the Service and considered its advice.
- For projects initiated prior to publication, the developer should consider where they are in the planning process relative to the appropriate tier and inform the Service of what actions they will take to apply the Guidelines.
- For projects operating at the time of publication, the developer should confer with the Service regarding the appropriate period of fatality monitoring consistent with Tier 4, communicate and share information with the Service on monitoring results, and consider Tier 5 studies and mitigation options where appropriate.

Projects that are already under development or are in operation are not expected to start over or return to the beginning of a specific tier. Instead, these projects should implement those portions of the Guidelines relevant to the current phases of the project per the bullets above.

The Service is aware that it will take time for Service staff and other personnel, including wind energy developers and their biologists, to develop expertise in the implementation of these Guidelines. Service staff and many staff associated with the wind energy industry have been involved with developing these Guidelines. Therefore, they have a working knowledge of the Guidelines. To further refine their training, the Service will make every effort to offer an in-depth course within 6 months of the final Guidelines being published.

The Communications Protocol on page 5 provides guidance to Service staff and developers in the exchange of information and recommendations at each tier in the process. Although the advice of the Service is not binding, a developer should review such advice, and either accept or reject it. If they reject it, they should contemporaneously document with reasoned justification why they did so. Although the Guidelines leave decisions up to the developer, the Service retains authority to evaluate whether developer efforts to mitigate impacts are sufficient, to determine significance, and to refer for prosecution any unlawful take that it believes to be reasonably related to lack of incorporation of Service recommendations or insufficient adherence with the Guidelines.

Table 1. Suggested Communications Protocol
This table provides examples of potential communication opportunities between a wind energy project developer and the Service. Not all projects will follow all steps indicated below.

TIER	*Project Developer/Operator Role*	*Service Role*
Tier 1: Preliminary site evaluation	• Landscape level assessment of habitat for species of concern • Request data sources for existing information and literature	• Provide lists of data sources and references, if requested
Tier 2: Site characterization	• Assess potential presence of species of concern, including species of habitat fragmentation concern, likely to be on site • Assess potential presence of plant communities present on site that may provide habitat for species of concern • Assess potential presence of critical congregation areas for species of concern • One or more reconnaissance level site visit by biologist • Communicate results of site visits and other assessments with the Service • Provide general information about the size and location of the project to the Service	• Provide species lists, for species of concern, including species of habitat fragmentation concern, for general area, if available • Provide information regarding plant communities of concern, if available • Respond to information provided about findings of biologist from site visit • Identify initial concerns about site(s) based on available information • Inform lead federal agencies of communications with wind project developers
Tier 3: Field studies and impact prediction	• Discuss extent and design of field studies to conduct with the Service • Conduct biological studies • Communicate results of all studies to Service field office in a timely manner • Evaluate risk to species of concern from project construction and operation • Identify ways to mitigate potential direct and indirect impacts of building and operating the project	• Respond to requests to discuss field studies • Advise project proponent about studies to conduct and methods for conducting them • Communicate with project proponent(s) about results of field studies and risk assessments • Communicate with project proponents(s) ways to mitigate potential impacts of building and operating the project • Inform lead federal agencies of communications with wind project developers
Tier 4: Post construction studies to estimate impacts	• Discuss extent and design of post-construction studies to conduct with the Service • Conduct post-construction studies to assess fatalities and habitat-related impacts • Communicate results of all studies to Service field office in a timely manner • If necessary, discuss potential mitigation strategies with Service • Maintain appropriate records of data collected from studies	• Advise project operator on study design, including duration of studies to collect adequate information • Communicate with project operator about results of studies • Advise project operator of potential mitigation strategies, when appropriate
Tier 5: Other post-construction studies and research	• Communicate with the Service about the need for and design of other studies and research to conduct with the Service, when appropriate, particularly when impacts exceed predicted levels • Communicate with the Service about ways to evaluate cumulative impacts on species of concern, particularly species of habitat fragmentation concern • Conduct appropriate studies as needed • Communicate results of studies with the Service • Identify potential mitigation strategies to reduce impacts and discuss them with the Service	• Advise project proponents as to need for Tier 5 studies to address specific topics, including cumulative impacts, based on information collected in Tiers 3 and 4 • Advise project proponents of methods and metrics to use in Tier 5 studies • Communicate with project operator and consultants about results of Tier 5 studies • Advise project operator of potential mitigation strategies, when appropriate, based on Tier 5 studies

Consideration of the Guidelines in MBTA and BGEPA Enforcement

The Service urges voluntary adherence to the Guidelines and communication with the Service when planning and operating a facility. While it is not possible to absolve individuals or companies from MBTA or BGEPA liability, the Office of Law Enforcement focuses its resources on investigating and prosecuting those who take migratory birds without identifying and implementing reasonable and effective measures to avoid the take. The Service will regard a developer's or operator's adherence to these Guidelines, including communication with the Service, as appropriate means of identifying and implementing reasonable and effective measures to avoid the take of species protected under the MBTA and BGEPA.[3] The Chief of Law Enforcement or more senior official of the Service will make any decision whether to refer for prosecution any alleged take of such species, and will take such adherence and communication fully into account when exercising discretion with respect to such potential referral. Each developer or operator will be responsible for maintaining internal records sufficient to demonstrate adherence to the Guidelines and response to communications from the Service. Examples of these records could include: studies performed in the implementation of the tiered approach; an internal or external review or audit process; a bird and bat conservation strategy; or a wildlife management plan.

If a developer and operator are not the same entity, the Service expects the operator to maintain sufficient records to demonstrate adherence to the Guidelines.

Scope and Project Scale of the Guidelines

The Guidelines are designed for "utility-scale" land-based wind energy projects to reduce potential impacts to species of concern, regardless of whether they are proposed for private or public lands. A developer of a distributed or community scale wind project may find it useful to consider the general principles of the tiered approach to assess and reduce potential impacts to species of concern, including answering Tier 1 questions using publicly available information. In the vast majority of situations, appropriately sited small wind projects are not likely to pose significant risks to species of concern. Answering Tier 1 questions will assist a developer of distributed or community wind projects, as well as landowners, in assessing the need to further communicate with the Service, and precluding, in many cases, the need for full detailed pre-construction assessments or monitoring surveys typically called for in Tiers 2 and 3. If landowners or community/distributed wind developers encounter problems locating information about specific sites they can contact the Service and/or state wildlife agencies to determine potential risks to species of concern for their particular project.

Communication with Christy Johnson-Hughes. Credit: Rachel London, USFWS

The tiered approach is designed to lead to the appropriate amount of evaluation in proportion to the anticipated level of risk that a project may pose to species of concern and their habitats. Study plans and the duration and intensity of study efforts should be tailored specifically to the unique characteristics of each site and the corresponding potential for significant adverse impacts on species of concern and their habitats as determined through the tiered approach. This is why the tiered approach begins with an examination of the potential location of the project, not the size of the project. In all cases, study plans and selection of appropriate study methods and techniques may be tailored to the relative scale, location, and potential for significant adverse impacts of the proposed site.

The Service considers a "project" to include all phases of wind energy development, including, but not limited to, prospecting, site assessment, construction, operation, and decommissioning, as well as all associated infrastructure and interconnecting electrical lines. A "project site" is the land and airspace where development occurs

[3] With regard to eagles, this paragraph will only apply when a project is not likely to result in take. If Tiers 1, 2, and/or 3 identify a potential to take eagles, developers should consider developing an ECP and, if necessary, apply for a take permit

or is proposed to occur, including the turbine pads, roads, power distribution and transmission lines on or immediately adjacent to the site; buildings and related infrastructure, ditches, grades, culverts; and any changes or modifications made to the original site before development occurs. Project evaluations should consider all potential effects to species of concern, which includes species 1) protected by the MBTA, BGEPA, or ESA (including candidate species), designated by law, regulation or other formal process for protection and/or management by the relevant agency or other authority, or that have been shown to be significantly adversely affected by wind energy development; and 2) determined to be possibly affected by the project.

These Guidelines are not designed to address power transmission beyond the point of interconnection to the transmission system.

Service Review Period

The Service is committed to providing timely responses. Service Field Offices should typically respond to requests by a wind energy developer for information and consultation on proposed site locations (Tiers 1 and 2), pre- and post-construction study designs (Tiers 3 and 4), and proposed mitigation (Tier 3) within 60 calendar days. The request should be in writing to the Field Office and copied to the Regional Office with information about the proposed project, location(s) under consideration, and point of contact. The request should contain a description of the information needed from the Service. The Service will provide a response, even if it is to notify a developer of additional review time, within the 60 calendar day review period. If the Service does not respond within 60 calendar days of receipt of the document, then the developer can proceed through Tier 3 without waiting for Service input. If the Service provides comments at a later time, the developer should incorporate the comments if feasible. It is particularly important that if data from Tier 1-3 studies predict that the project is likely to produce significant adverse impacts on species of concern, the developer inform the Service of the actions it intends to implement to mitigate those impacts. If the Service cannot respond within 60 calendar days, this does not relieve developers from their MBTA, BGEPA, and ESA responsibilities.

The tiered approach allows a developer in certain limited circumstances to move directly from Tier 2 to construction (e.g., adequate survey data for the site exists). The developer should notify the Service of this decision and give the Service 60 calendar days to comment on the proposed project prior to initiating construction activities.

Introduction to the Decision Framework Using a Tiered Approach

The tiered approach provides a decision framework for collecting information in increasing detail to evaluate risk and make siting and operational decisions. It provides the opportunity for evaluation and decision-making at each tier, enabling a developer to proceed with or abandon project development, or to collect additional information if necessary. This approach does not require that every tier, or every element within each tier, be implemented for every project. Instead, it allows efficient use of developer and wildlife agency resources with increasing levels of effort until sufficient information and the desired precision is acquired for the risk assessment.

Figure 1 ("General Framework of Tiered Approach") illustrates the tiered approach, which consists of up to five iterative stages, or tiers:

- Tier 1 – Preliminary site evaluation (landscape-scale screening of possible project sites)
- Tier 2 – Site characterization (broad characterization of one or more potential project sites)
- Tier 3 – Field studies to document site wildlife and habitat and predict project impacts
- Tier 4 – Post-construction studies to estimate impacts[4]
- Tier 5 – Other post-construction studies and research

At each tier, potential issues associated with developing or operating a project are identified and questions formulated to guide the decision process. Chapters Two through Six outline the questions to be posed at each tier, and describe recommended methods and metrics for gathering the data needed to answer those questions.

The first three tiers correspond to the pre-construction evaluation phase of wind energy development. At each of the three tiers, the Guidelines provide questions that developers should answer, followed by recommended methods and metrics to use in answering the questions. Some questions are repeated at each tier, with successive tiers requiring a greater investment in data collection to answer certain questions. For example, while Tier 2 investigations may discover some existing information on federal or state-listed species and their use of the proposed development site, it may be necessary to collect empirical data in Tier 3 studies to determine the presence of federal or state-listed species.

Developers decide whether to proceed to the next tier. Timely communication and sharing of information will allow opportunities for the Service to provide, and developers to consider, technical advice. A developer should base the decision on the information obtained from adequately answering the questions in this tier, whether the methods used were appropriate for the site selected, and the resulting

[4] The Service anticipates these studies will include fatality monitoring as well as studies to evaluate habitat impacts.

Wind turbines in California. Credit: Rachel London, USFWS

assessment of risk posed to species of concern and their habitats.

If sufficient data are available at a particular tier, the following outcomes are possible:

1. The project proceeds to the next tier in the development process without additional data collection.

2. The project proceeds to the next tier in the development process with additional data collection.

3. An action or combination of actions, such as project modification, mitigation, or specific post-construction monitoring, is indicated.

4. The project site is abandoned because the risk is considered unacceptable.

If data are deemed insufficient at a tier, more intensive study is conducted in the subsequent tier until sufficient data are available to make a decision to modify the project, proceed with the project, or abandon the project.

The tiered approach used in these Guidelines embodies adaptive management by collecting increasingly detailed information that is used to make decisions about project design, construction, and operation as the developer progresses through the tiers. Adaptive management is an iterative learning process producing improved understanding and improved management over time (Williams et al 2007). DOI has determined that its resource agencies, and the natural resources they oversee, could benefit from adaptive management. Use of adaptive management in DOI is guided by the DOI Policy on Adaptive Management. DOI has adopted the National Research Council's 2004 definition of adaptive management, which states:

"Adaptive management promotes flexible decision making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Careful monitoring of these outcomes both advances scientific understanding and helps adjust policies or operations as part of an iterative learning process. Adaptive management also recognizes the importance of natural variability in contributing to ecological resilience and productivity. It is not a 'trial and error' process, but rather emphasizes learning while doing. Adaptive management does not represent an end in itself, but rather a means to more effective decisions and enhanced benefits. Its true measure is in how well it helps meet environmental, social, and economic goals, increases scientific knowledge, and reduces tensions among stakeholders."

This definition gives special emphasis to uncertainty about management effects, iterative learning to reduce uncertainty, and improved management as a result of learning. The DOI Adaptive Management Technical Guide is located on the web at: www.doi.gov/initiatives/AdaptiveManagement/index.html.

Figure 1. General Framework of Tiered Approach

TIER 1

A. Species of concern known to be present?
   1. No ……………………………………………………………………proceed to Tier 2
   2. Unknown - Insufficient or inconclusive data …………proceed to Tier 2
   3. Yes………………………………………………abandon site or proceed to Tier 2

TIER 2

A. Probability of significant adverse impacts?
   1. Unknown - Insufficient or inconclusive data …………proceed to Tier 3
   2. Low……………proceed to obtain state and local permit (if required), design, and construction following BMPs
   3. Moderate ………………………………………proceed to Tier 3 and mitigate
   4. High, and:
      a. can be adequately mitigated…modify project and proceed to Tier 3
      b. cannot be adequately mitigated…………………………abandon project

TIER 3

A. Probability of significant adverse impacts?
   1. Low ………………………………………………………………proceed to Tier 4
   2. Moderate to high, and:
      a. certainty regarding mitigation …………………………… proceed to Tier 4
      b. uncertainty regarding mitigation ………………………proceed to Tier 4
   3. High, and:
      a. can be adequately mitigated………………………………proceed to Tier 4
      b. cannot be adequately mitigated …………..modify or abandon project

TIER 4a (See Table 2, pg 39)

A. Tier 3 studies indicate <u>low</u> probability of significant adverse impacts
   1. Documented fatalities are equal to or lower than predicted………………..no further studies or mitigation needed
   2. Documented fatalities are higher than predicted, but not significant, and:
      a. comparable data are available that support findings of not significant………………………………………………no further studies needed
      b. comparable data not available to support findings of not significant……………..additional year(s) of monitoring recommended
   3. Documented fatalities are higher than predicted and are significant………………………………………………communicate with Service

B. Tier 3 studies indicate <u>moderate</u> probability of significant adverse impacts
   1. Documented fatalities are lower than or no different predicted, and:
      a. are not significant and no ESA or BGEPA species are affected ……………………..no further monitoring or mitigation needed
      b. are significant *OR* ESA or BGEPA species are affected ……………………………………………communicate with Service
   2. Documented fatalities are greater than predicted and are likely to be significant *OR* ESA or BGEPA species are affected…………………………………………………communicate with Service

C. Tier 3 studies indicate <u>high</u> probability of significant adverse impacts
   1. Documented fatalities are less than predicted and are not significant, and no ESA or BGEPA species are affected……………………..no further monitoring or mitigation needed
   2. Documented fatalities are less than predicted but are still significant, and no ESA or BGEPA species are affected…………………further monitoring or mitigation needed
   3. Fatalities are equal to or greater than predicted and are significant OR ESA or BGEPA species are affected…………………communicate with Service regarding additional mitigation

TIER 4b (See Table 3, pg. 42)

A. Species of habitat fragmentation concern potentially present?
   1. No……………………………………………………………no further studies needed
   2. Yes, and:
      a. Tier 3 studies do not confirm presence…no further studies needed
      b. Tier 3 studies confirm presence, but no significant adverse impacts predicted, and:
         i. Tier 4b studies confirm Tier 3 predictions…………………no further studies or mitigation needed
         ii. Tier 4b studies indicate potentially significant adverse impacts ………………Tier 5 studies and mitigation may be needed
      c. Tier 3 studies confirm presence, and significant adverse impacts predicted and mitigation plan is developed and implemented, and:
         i. Tier 4b studies determine mitigation is effective …………………no further studies or mitigation needed
         ii. Tier 4b studies determine mitigation not effective………..further mitigation and, where appropriate, Tier 5 studies needed

Considering Risk in the Tiered Approach

In the context of these Guidelines, risk refers to the likelihood that adverse impacts will occur to individuals or populations of species of concern as a result of wind energy development and operation. Estimates of fatality risk can be used in a relative sense, allowing comparisons among projects, alternative development designs, and in the evaluation of potential risk to populations. Because there are relatively few methods available for direct estimation of risk, a weight-of-evidence approach is often used (Anderson et al. 1999). Until such time that reliable risk predictive models are developed regarding avian and bat fatality and wind energy projects, estimates of risk would typically be qualitative, but should be based upon quantitative site information.

For the purposes of these Guidelines, risk can also be defined in the context of populations, but that calculation is more complicated as it could involve estimating the reduction in population viability as indicated by demographic metrics such as growth rate, size of the population, or survivorship, either for local populations, metapopulations, or entire species. For most populations, risk cannot easily be reduced to a strict metric, especially in the absence of population viability models for most species. Consequently, estimating the quantitative risk to populations is usually beyond the scope of project studies due to the difficulties in evaluating these metrics, and therefore risk assessment will be qualitative.

Risk to habitat is a component of the evaluation of population risk. In this context, the estimated loss of habitat is evaluated in terms of the potential for population level effects (e.g., reduced survival or reproduction).

The assessment of risk should synthesize sufficient data collected at a project to estimate exposure and predict impact for individuals and their habitats for the species of concern, with what is known about the population status of these species, and in communication with the relevant wildlife agency and industry wildlife experts. Predicted risk of these impacts could provide useful information for determining appropriate mitigation measures if determined to be necessary. In practice in the tiered approach, risk assessments conducted in Tiers 1 and 2 require less information to reach a risk-based decision than those conducted at higher tiers.

Cumulative Impacts of Project Development

Cumulative impacts are the comprehensive effect on the environment that results from the incremental impact of a project when added to other past, present, and reasonably foreseeable future actions. Developers are encouraged to work closely with federal and state agencies early in the project planning process to access any existing information on the cumulative impacts of individual projects on species and habitats at risk, and to incorporate it into project development and any necessary wildlife studies. To achieve that goal, it is important that agencies and organizations take the following actions to improve cumulative impacts analysis:

- review the range of development-related significant adverse impacts;
- determine which species of concern or their habitats within the landscape are most at risk of significant adverse impacts from wind development in conjunction with other reasonably foreseeable significant adverse impacts; and
- make that data available for regional or landscape level analysis.

The magnitude and extent of the impact on a resource depend on whether the cumulative impacts exceed the capacity for resource sustainability and productivity.

For projects that require a federal permit, funding, or other federal nexus, the lead federal agency is required to include a cumulative impacts analysis in their National Environmental Policy Act (NEPA) review. The federal action agency coordinates with the developer to obtain the necessary information for the NEPA review and cumulative impacts analysis. To avoid project delays, federal and state agencies are encouraged to use existing wildlife data for the cumulative impacts analysis until improved data are available.

Where there is no federal nexus, individual developers are not expected to conduct their own cumulative impacts analysis. However, a cumulative impacts analysis would help developers and other stakeholders better understand the significance of potential impacts on species of concern and their habitats.

Other Federal Agencies

Other federal agencies, such as the Bureau of Land Management, National Park Service, U.S. Department of Agriculture Forest Service and Rural Utility Service, Federal Energy Regulatory Commission and Department of Energy are often interested in and involved with wind project developments. These agencies have a variety of expertise and authorities they implement. Wind project developers on public lands will have to comply with applicable regulations and policies of those agencies. State and local agencies and Tribes also have additional interests and knowledge. The Service recommends that, where appropriate, wind project developers contact these agencies early in the tiered process and work closely with them throughout project planning and development to assure that projects address issues of concern to those agencies. The definition of “species of concern” in these Guidelines includes species which are trust resources of States and of federal agencies (See Glossary). In those instances where a project may significantly affect State trust resources, wind energy developers should work closely with appropriate State agencies.

Relationship to Other Guidelines

These Guidelines replace the Service's 2003 interim voluntary guidelines. The Service intends that these Guidelines, when used in concert with the appropriate regulatory tools, will form the best practical approach for conservation of species of concern. For instance, when developers find that a project may affect an endangered or threatened species, they should comply with Section 7 or 10 of the ESA to obtain incidental take authorization. Other federal, state, tribal and local governments may use these Guidelines to complement their efforts to address wind energy development/wildlife interactions. They are not intended to supplant existing regional or local guidance, or landscape-scale tools for conservation planning, but were developed to provide a means of improving consistency with the goals of the wildlife statutes that the Service is responsible for implementing. The Service will continue to work with states, tribes, and other local stakeholders on map-based tools, decision-support systems, and other products to help guide future development and conservation. Additionally, project proponents should utilize any relevant guidance of the appropriate jurisdictional entity, which will depend on the species and resources potentially affected by proposed development.

Pronghorn Antelope. Credit: Steve Hillebrand, USFWS

Chapter 2: Tier 1 – Preliminary Site Evaluation

For developers taking a first look at a broad geographic area, a preliminary evaluation of the general ecological context of a potential site or sites can serve as useful preparation for working with the federal, state, tribal, and/or local agencies. The Service is available to assist wind energy project developers to identify potential wildlife and habitat issues and should be contacted as early as possible in the company's planning process. With this internal screening process, the developer can begin to identify broad geographic areas of high sensitivity due to the presence of: 1) large blocks of intact native landscapes; 2) intact ecological communities; 3) fragmentation-sensitive species' habitats; or 4) other important landscape-scale wildlife values.

Tier 1 may be used in any of the following three ways:

1. To identify regions where wind energy development poses significant risks to species of concern or their habitats, including the fragmentation of large-scale habitats and threats to regional populations of federal- or state-listed species.

2. To "screen" a landscape or set of multiple potential sites to avoid those with the highest habitat values.

3. To begin to determine if a single identified potential site poses serious risk to species of concern or their habitats.

Tier 1 can offer early guidance about the sensitivity of the site within a larger landscape context; it can help direct development away from sites that will be associated with additional study need, greater mitigation requirements, and uncertainty; or it can identify those sensitive resources that will need to be studied further to determine if the site can be developed without significant adverse impacts to the species of concern or local population(s). This may facilitate discussions with the federal, state, tribal, and/or local agencies in a region being considered for development. In some cases, Tier 1 studies could reveal serious concerns indicating that a site should not be developed.

Developers of distributed or community scale wind projects are typically considering limited geographic areas to install turbines. Therefore, they would not likely consider broad geographic areas. Nevertheless, they should consider the presence of habitats or species of concern before siting projects.

Development in some areas may be precluded by federal law. This designation is separate from a determination through the tiered approach that an area is not appropriate for development due to feasibility, ecological reasons, or other issues. Developers are encouraged to visit Service and other publicly available databases or other available information during Tier 1 or Tier 2 to see if a potential wind energy area is precluded from development by federal law. Some areas may be protected from development through state or local laws or ordinances, and the appropriate agency should be contacted accordingly. Service field offices are available to answer questions where they are knowledgeable, guide developers to databases, and refer developers to other agency contacts.

Some areas may be inappropriate for large scale development because they have been recognized according to scientifically credible information as having high wildlife value, based solely on their ecological rarity and intactness (e.g., Audubon Important Bird Areas, The Nature Conservancy portfolio sites, state wildlife action plan priority habitats). It is important to identify such areas through the tiered approach, as reflected in Tier 1, Question 2 below. Many of North America's native landscapes are greatly diminished, with some existing at less than 10 percent of their pre-settlement occurrence.

Attwater's prairie chicken. Credit: Gary Halvorsen, USFWS

Herbaceous scrub-shrub steppe in the Pacific Northwest and old growth forest in the Northeast represent such diminished native resources. Important remnants of these landscapes are identified and documented in various databases held by private conservation organizations, state wildlife agencies, and, in some cases, by the Service. Developers should collaborate with such entities specifically about such areas in the vicinity of a prospective project site.

Tier 1 Questions

Questions at each tier help determine potential environmental risks at the landscape scale for Tier 1 and project scale for Tiers 2 and 3. Suggested questions to be considered for Tier 1 include:

1. **Are there species of concern present on the potential site(s), or is habitat (including designated critical habitat) present for these species?**

2. **Does the landscape contain areas where development is precluded by law or areas designated as sensitive according to scientifically credible information? Examples of designated areas include, but are not limited to: federally-designated critical habitat; high-priority conservation areas for non-government organizations (NGOs); or other local, state, regional, federal, tribal, or international categorizations.**

3. **Are there known critical areas of wildlife congregation, including, but not limited to: maternity roosts, hibernacula, staging areas, winter ranges, nesting sites, migration stopovers or corridors, leks, or other areas of seasonal importance?**

4. **Are there large areas of intact habitat with the potential for fragmentation, with respect to species of habitat fragmentation concern needing large contiguous blocks of habitat?**

Tier 1 Methods and Metrics

Developers who choose to conduct Tier 1 investigations would generally be able to utilize existing public or other readily available landscape-level maps and databases from sources such as federal, state, or tribal wildlife or natural heritage programs, the academic community, conservation organizations, or the developers' or consultants' own information. The Service recommends that developers conduct a review of the publicly available data. The analysis of available sites in the region of interest will be based on a blend of the information available in published and unpublished reports, wildlife range distribution maps, and other such sources. The developer should check with the Service Field Office for data specific to wind energy development and wildlife at the landscape scale in Tier 1.

Tier 1 Decision Points

The objective of the Tier 1 process is to help the developer identify a site or sites to consider further for wind energy development. Possible outcomes of this internal screening process include the following:

1. One or more sites are found within the area of investigation where the answer to each of the above Tier 1 questions is "no," indicating a low probability of significant adverse impact to wildlife. The developer proceeds to Tier 2 investigations and characterization of the site or sites, answering the Tier 2 questions with site-specific data to confirm the validity of the preliminary indications of low potential for significant adverse impact.

2. If a developer answers "yes" to one or more of the Tier 1 questions, they should proceed to Tier 2 to further assess the probability of significant adverse impacts to wildlife. A developer may consider abandoning the area or identifying possible means by which the project can be modified to avoid or minimize potential significant adverse impacts.

3. The data available in the sources described above are insufficient to answer one or more of the Tier 1 questions. The developer proceeds to Tier 2, with a specific emphasis on collecting the data necessary to answer the Tier 2 questions, which are inclusive of those asked at Tier 1.

Chapter 3: Tier 2 – Site Characterization

At this stage, the developer has narrowed consideration down to specific sites, and additional data may be necessary to systematically and comprehensively characterize a potential site in terms of the risk wind energy development would pose to species of concern and their habitats. In the case where a site or sites have been selected without the Tier 1 preliminary evaluation of the general ecological context, Tier 2 becomes the first stage in the site selection process. The developer will address the questions asked in Tier 1; if addressing the Tier 1 questions here, the developer will evaluate the site within a landscape context. However, a distinguishing feature of Tier 2 studies is that they focus on site-specific information and should include at least one visit by a knowledgeable biologist to the prospective site(s). Because Tier 2 studies are preliminary, normally one reconnaissance level site visit will be adequate as a "ground-truth" of available information. Notwithstanding, if key issues are identified that relate to varying conditions and/or seasons, Tier 2 studies should include enough site visits during the appropriate times of the year to adequately assess these issues for the prospective site(s).

If the results of the site assessment indicate that one or more species of concern are present, a developer should consider applicable regulatory or other agency processes for addressing them. For instance, if migratory birds and bats are likely to experience significant adverse impacts by a wind project at the proposed site, a developer should identify and document possible actions that will avoid or compensate for those impacts. Such actions might include, but not be limited to, altering locations of turbines or turbine arrays, operational changes, or compensatory mitigation. As soon as a developer anticipates that a wind energy project is likely to result in a take of bald or golden eagles, a developer should prepare an ECP and, if necessary, apply for a programmatic take permit. As soon as a developer realizes endangered or threatened species are present and likely to be affected by a wind project located there, a federal agency should consult with the Service under Section 7(a)(2) of the ESA if the project has a federal nexus or the developer should apply for a section 10(a)(1)(B) incidental take permit if there is not a federal nexus, and incidental take of listed wildlife is anticipated. State, tribal, and local jurisdictions may have additional permitting requirements.

Developers of distributed or community scale wind projects are typically considering limited geographic areas to install turbines. Therefore, they would likely be familiar with conditions at the site where they are considering installing a turbine. Nevertheless, they should do preliminary site evaluations to determine the presence of habitats or species of concern before siting projects.

Tier 2 Questions

Questions suggested for Tier 2 can be answered using credible, publicly available information that includes published studies, technical reports, databases, and information from agencies, local conservation organizations, and/or local experts. Developers or consultants working on their behalf should contact the federal, state, tribal, and local agencies that have jurisdiction or management authority and responsibility over the potential project.

1. **Are known species of concern present on the proposed site, or is habitat (including designated critical habitat) present for these species?**

2. **Does the landscape contain areas where development is precluded by law or designated as sensitive according to scientifically credible information? Examples of designated areas include, but are not limited to: federally-designated critical habitat;**

Open landscape with wind turbines. Credit: NREL

high-priority conservation areas for NGOs; or other local, state, regional, federal, tribal, or international categorizations.

3. **Are there plant communities of concern present or likely to be present at the site(s)?**

4. **Are there known critical areas of congregation of species of concern, including, but not limited to: maternity roosts, hibernacula, staging areas, winter ranges, nesting sites, migration stopovers or corridors, leks, or other areas of seasonal importance?**

5. **Using best available scientific information has the developer or relevant federal, state, tribal, and/or local agency identified the potential presence of a population of a species of habitat fragmentation concern?**

6. **Which species of birds and bats, especially those known to be at risk by wind energy facilities, are likely to use the proposed site based on an assessment of site attributes?**

7. **Is there a potential for significant adverse impacts to species of concern based on the answers to the questions above, and considering the design of the proposed project?**

Tier 2 Methods and Metrics

Obtaining answers to Tier 2 questions will involve a more thorough review of the existing site-specific information than in Tier 1. Tier 2 site characterizations studies will generally contain three elements:

1. A review of existing information, including existing published or available literature and databases and maps of topography, land use and land cover, potential wetlands, wildlife, habitat, and sensitive plant distribution. If agencies have documented potential habitat for species of habitat fragmentation concern, this information can help with the analysis.

2. Contact with agencies and organizations that have relevant scientific information to further help identify if there are bird, bat or other wildlife issues. The Service recommends that the developer make contact with federal, state, tribal, and local agencies that have jurisdiction or management authority over the project or information about the potentially affected resources. In addition, because key NGOs and relevant local groups are often valuable sources of relevant local environmental information, the Service recommends that developers contact key NGOs, even if confidentiality concerns preclude the developer from identifying specific project location information at this stage. These contacts also provide an opportunity to identify other potential issues and data not already identified by the developer.

3. One or more reconnaissance level site visits by a wildlife biologist to evaluate current vegetation/habitat coverage and land management/use. Current habitat and land use practices will be noted to help in determining the baseline against which potential impacts from the project would be evaluated. The vegetation/habitat will be used for identifying potential bird and bat resources occurring at the site and the potential presence of, or suitable habitat for, species of concern. Vegetation types or habitats will be noted and evaluated against available information such as land use/land cover mapping. Any sensitive resources located during the site visit will be noted and mapped or digital location data recorded for future reference. Any individuals or signs of species of concern observed during the site visit will be noted. If land access agreements are not in place, access to the site will be limited to public roads.

Specific resources that can help answer each Tier 2 question include:

1. **Are known species of concern present on the proposed site, or is habitat (including designated critical habitat) present for these species?**

   Information review and agency contact: locations of state and federally listed, proposed and candidate species and species of concern are frequently documented in state and federal wildlife databases. Examples include published literature such as: Natural Heritage Databases, State Wildlife Action Plans, NGOs publications, and developer and consultant information, or can be obtained by contacting these entities.

   Site Visit: To the extent practicable, the site visit(s) should evaluate the suitability of habitat at the site for species identified and the likelihood of the project to adversely affect the species of concern that may be present.

2. **Does the landscape contain areas where development is precluded by law or designated as sensitive according to scientifically credible information?** Examples of designated areas include, but are not limited to: federally-designated critical habitat; high-priority conservation areas for NGOs; or other local, state, regional, federal, tribal, or international categorizations.

   Information review and agency contact such as: maps of political and administrative boundaries; National Wetland Inventory data files; USGS National Land Cover data maps; state, federal and tribal agency data on areas that have been designated to preclude development, including wind energy development; State Wildlife Action Plans; State Land and Water Resource Plans; Natural Heritage databases; scientifically credible information provided by NGO and local

Tall grass prairie. Credit: Amy Thornburg, USFWS

resources; and the additional resources listed in Appendix C: Sources of Information Pertaining to Methods to Assess Impacts to Wildlife of this document, or through contact of agencies and NGOs, to determine the presence of high priority habitats for species of concern or conservation areas.

Site Visit: To the extent practicable, the site visit(s) should characterize and evaluate the uniqueness of the site vegetation relative to surrounding areas.

3. **Are plant communities of concern present or likely to be present at the site(s)?**

   Information review and agency contact such as: Natural Heritage Data of state rankings (S1, S2, S3) or globally (G1, G2, G3) ranked rare plant communities.

   Site Visit: To the extent practicable, the site visit should evaluate the topography, physiographic features and uniqueness of the site vegetation in relation to the surrounding region. If plant communities of concern are present, developers should also assess in Tier 3 whether the proposed project poses risk of significant adverse impacts and opportunities for mitigation.

4. **Are there known critical areas of wildlife congregation, including, but not limited to, maternity roosts, hibernacula, staging areas, winter ranges, nesting sites, migration stopovers or corridors, leks, or other areas of seasonal importance?**

   Information review and agency contact such as: existing databases, State Wildlife Action Plan, Natural Heritage Data, and NGO and agency information regarding the presence of Important Bird Areas, migration corridors or stopovers, leks, bat hibernacula or maternity roosts, or game winter ranges at the site and in the surrounding area.

   Site Visit: To the extent practicable, the site visit should, during appropriate times to adequately assess these issues for prospective site(s), evaluate the topography, physiographic features and uniqueness of the site in relation to the surrounding region to assess the potential for the project area to concentrate resident or migratory birds and bats.

5. **Using best available scientific information, has the relevant federal, state, tribal, and/or local agency determined the potential presence of a population of a species of habitat fragmentation concern?**

   If not, the developer need not assess impacts of the proposed project on habitat fragmentation.

Habitat fragmentation is defined as the separation of a block of habitat for a species into segments, such that the genetic or demographic viability of the populations surviving in the remaining habitat segments is reduced; and risk, in this case, is defined as the probability that this fragmentation will occur as a result of the project. Site clearing, access roads, transmission lines and turbine tower arrays remove habitat and displace some species of wildlife, and may fragment continuous habitat areas into smaller, isolated tracts. Habitat fragmentation is of particular concern when species require large expanses of habitat for activities such as breeding and foraging.

Consequences of isolating local populations of some species include decreased reproductive success, reduced genetic diversity, and increased susceptibility to chance events (e.g. disease and natural disasters), which may lead to extirpation or local extinctions. In addition to displacement, development of wind energy infrastructure may result in additional loss of habitat for some species due to "edge effects" resulting from the break-up of continuous stands of similar vegetation resulting in an interface (edge) between two or more types of vegetation. The extent of edge effects will vary by species and may result in adverse impacts from such effects as a greater susceptibility to colonization by invasive species, increased risk of predation, and competing species favoring landscapes with a mosaic of vegetation.

Site Visit: If the answer to Tier 2 Question 5 is yes, developers should use the general framework for evaluating habitat fragmentation at a project site in Tier 2 outlined below. Developers and the Service may use this method to analyze the impacts of habitat fragmentation at wind development project sites on species of habitat fragmentation concern. Service field offices may be able to provide the available information on habitat types, quality and intactness. Developers may use this information in combination with site-specific information on the potential habitats to be impacted by a potential development and how they will be impacted.

<u>General Framework for Evaluating Habitat Fragmentation at a Project Site (Tier 2)</u>

A. The developer should define the study area. The study area should not only include the project site for the proposed project, but be based on the distribution of habitat for the local population of the species of habitat fragmentation concern.

B. The developer should analyze the current habitat quality and spatial configuration of the study area for the species of habitat fragmentation concern.

   i. Use recent aerial and remote imagery to determine distinct habitat patches, or boundaries, within the study area, and the extent of existing habitat fragmenting features (e.g., highways).

   ii. Assess the level of fragmentation of the existing habitat for the species of habitat fragmentation concern and categorize into three classes:

      - High quality: little or no apparent fragmentation of intact habitat
      - Medium quality: intact habitat exhibiting some recent disturbance activity
      - Low quality: Extensive fragmentation of habitat (e.g., row-cropped agricultural lands, active surface mining areas)

C. The developer should determine potential changes in quality and spatial configuration of the habitat in the study area if development were to proceed as proposed using existing site information.

D. The developer should provide the collective information from steps A-C for all potential developments to the Service for use in assessing whether the habitat impacts, including habitat fragmentation, are likely to affect population viability of the potentially affected species of habitat fragmentation concern.

6. Which species of birds and bats, especially those known to be at risk by wind energy facilities, are likely to use the proposed site based on an assessment of site attributes?

Information review and agency contact: existing published information and databases from NGOs and federal and state resource agencies regarding the potential presence of:

- Raptors: species potentially present by season
- Prairie grouse and sage grouse: species potentially present by season and location of known leks
- Other birds: species potentially present by season that may be at risk of collision or adverse impacts to habitat, including loss, displacement and fragmentation
- Bats: species likely to be impacted by wind energy facilities and likely to occur on or migrate through the site

  Site Visit: To the extent practicable, the site visit(s) should identify landscape features or habitats that could be important to raptors, prairie grouse, and other birds that may be at risk of adverse impacts, and bats, including nesting and brood-rearing habitats, areas of high prey density, movement corridors and features such as ridges that may concentrate raptors. Raptors, prairie grouse, and other presence or sign of species of concern seen during the site visit should be noted, with species identification if possible.

7. Is there a potential for significant adverse impacts to species of concern based on the answers to the questions above, and considering the design of the proposed project?

The developer has assembled answers to the questions above and should make an initial evaluation of the probability of significant adverse impacts to species of concern and their habitats. The developer should make this evaluation based on assessments of the potential presence of species of concern and their habitats, potential presence of critical congregation areas for species of concern, and any site visits. The developer is encouraged to communicate the results of these assessments with the Service.

Tier 2 Decision Points

Possible outcomes of Tier 2 include the following:

1. The most likely outcome of Tier 2 is that the answer to one or more Tier 2 questions is inconclusive to address wildlife risk, either due to insufficient data to answer the question or because of uncertainty about what the answers indicate. The developer proceeds to Tier 3, formulating questions, methods, and assessment of potential mitigation measures based on issues raised in Tier 2 results.

2. Sufficient information is available to answer all Tier 2 questions, and the answer to each Tier 2 question indicates a low probability of significant adverse impact to wildlife (for example, infill or expansion of an existing facility where impacts have been low and Tier 2 results indicate that conditions are similar, therefore wildlife risk is low). The developer may then decide to proceed to obtain state and local permit (if required), design, and construction following best management practices (see Chapter 7: Best Management Practices).

3. Sufficient information is available to answer all Tier 2 questions, and the answer to each Tier 2 question indicates a moderate probability of significant adverse impacts to species of concern or their habitats. The developer should proceed to Tier 3 and identify measures to mitigate potential significant adverse impacts to species of concern.

4. The answers to one or more Tier 2 questions indicate a high probability of significant adverse impacts to species of concern or their habitats that:

   a) Cannot be adequately mitigated. The proposed site should be abandoned.

   b) Can be adequately mitigated. The developer should proceed to Tier 3 and identify measures to mitigate potential significant adverse impacts to species of concern or their habitats.

Greater sage grouse, Credit: Stephen Ting, USFWS

Chapter 4: Tier 3 – Field Studies to Document Site Wildlife and Habitat and Predict Project Impacts

Tier 3 is the first tier in which a developer would conduct quantitative and scientifically rigorous studies to assess the potential risk of the proposed project. Specifically, these studies provide pre-construction information to:

- Further evaluate a site for determining whether the wind energy project should be developed or abandoned
- Design and operate a site to avoid or minimize significant adverse impacts if a decision is made to develop
- Design compensatory mitigation measures if significant adverse habitat impacts cannot acceptably be avoided or minimized
- Determine duration and level of effort of post-construction monitoring. If warranted, provide the pre-construction component of post-construction studies necessary to estimate and evaluate impacts

At the beginning of Tier 3, a developer should communicate with the Service on the pre-construction studies. At the end of Tier 3, developers should communicate with the Service regarding the results of the Tier 3 studies and consider the Service's comments and recommendations prior to completing the Tier 3 decision process. The Service will provide written comments to a developer that identify concerns and recommendations to resolve the concerns based on study results and project development plans.

Not all Tier 3 studies will continue into Tiers 4 or 5. For example, surveys conducted in Tier 3 for species of concern may indicate one or more species are not present at the proposed project site, or siting decisions could be made in Tier 3 that remove identified concerns, thus removing the need for continued efforts in later tiers. Additional detail on the design issues for post-construction studies that begin in Tier 3 is provided in the discussion of methods and metrics in Tier 3.

Turkey vulture and wind turbine. Credit: Rachel London, USFWS

Tier 3 Questions

Tier 3 begins as the other tiers, with problem formulation: what additional studies are necessary to enable a decision as to whether the proposed project can proceed to construction or operation or should be abandoned? This step includes an evaluation of data gaps identified by Tier 2 studies as well as the gathering of data necessary to:

- Design a project to avoid or minimize predicted risk
- Evaluate predictions of impact and risk through post-construction comparisons of estimated impacts
- Identify compensatory mitigation measures, if appropriate, to offset significant adverse impacts that cannot be avoided or minimized

The problem formulation stage for Tier 3 also will include an assessment of which species identified in Tier 1 and/or Tier 2 will be studied further in the site risk assessment. This determination is based on analysis of existing data from Tier 1 and existing site-specific data and Project Site (see Glossary in Appendix A) visit(s) in Tier 2, and on the likelihood of presence and the degree of adverse impact to species or their habitat. If the habitat is suitable for a species needing further study and the site occurs within the historical range of the species, or is near the existing range of the species but presence has not been documented, additional field studies may be appropriate. Additional analyses should not be necessary if a species is unlikely to be present or is present but adverse impact is unlikely or of minor significance.

Tier 3 studies address many of the questions identified for Tiers 1 and 2, but Tier 3 studies differ because they attempt to quantify the distribution, relative abundance, behavior, and site use of species of concern. Tier 3 data also attempt to estimate the extent that these factors expose these species to risk from the proposed wind energy facility. Therefore, in answering Tier 3 questions 1-3, developers should collect data sufficient to analyze and answer Tier 3 questions 4-6. High risk sites may warrant additional years of pre-construction studies. The duration and intensity of studies needed should be determined through communication with the Service.

If Tier 3 studies identify species of concern or important habitats, e.g., wetlands, which have specific regulatory processes and requirements, developers should work with appropriate state, tribal, or federal agencies to obtain required authorizations or permits.

Tier 3 studies should be designed to answer the following questions:

1. **Do field studies indicate that species of concern are present on or likely to use the proposed site?**

2. **Do field studies indicate the potential for significant adverse impacts on affected population of species of habitat fragmentation concern?**

3. **What is the distribution, relative abundance, behavior, and site use of species of concern identified in Tiers 1 or 2, and to what extent do these factors expose these species to risk from the proposed wind energy project?**

4. **What are the potential risks of adverse impacts of the proposed wind energy project to individuals and local populations of species of concern and their habitats? (In the case of rare or endangered species, what are the possible impacts to such species and their habitats?)**

5. **How can developers mitigate identified significant adverse impacts?**

6. **Are there studies that should be initiated at this stage that would be continued in post-construction?**

The Service encourages the use of common methods and metrics in Tier 3 assessments for measuring wildlife activity and habitat features. Common methods and metrics provide great benefit over the long-term, allowing for comparisons among projects and for greater certainty regarding what will be asked of the developer for a specific project. Deviation from commonly used methods should be carefully considered, scientifically justifiable and discussed with federal, tribal, or state natural resource agencies, or other credible experts, as appropriate. It may be useful to consult other scientifically credible information sources.

Tier 3 studies will be designed to accommodate local and regional characteristics. The specific protocols by which common methods and metrics are implemented in Tier 3 studies depend on the question being addressed, the species or ecological communities being studied and the characteristics of the study sites. Federally-listed threatened and endangered species, eagles, and some other species of concern and their habitats, may have specific protocols required by local, state or federal agencies. The need for special surveys and mapping that address these species and situations should be discussed with the appropriate stakeholders.

In some instances, a single method will not adequately assess potential collision risk or habitat impact. For example, when there is concern about moderate or high risk to nocturnally active species, such as migrating passerines and local and migrating bats, a combination of remote sensing tools such as radar, and acoustic monitoring for bats and indirect inference from diurnal bird surveys during the migration period may be necessary. Answering questions about habitat use by songbirds may be accomplished by relatively small-scale observational studies, while answering the same question related to wide-ranging species such as prairie grouse and sage grouse may require more time-consuming surveys, perhaps including telemetry.

Because of the points raised above and the need for flexibility in application, the Guidelines do not make specific recommendations on protocol elements for Tier 3 studies. The peer-reviewed scientific literature (such as the articles cited throughout this section) contains numerous recently published reviews of methods for assessing bird and bat activity, and tools for assessing habitat and landscape level risk. Details on specific methods and protocols for recommended studies are or will be widely available and should be consulted by industry and agency professionals.

Many methods for assessing risk are components of active research involving collaborative efforts of public-private research partnerships with federal, state and tribal agencies, wind energy developers and NGOs interested in wind energy-wildlife interactions (e.g., Bats and Wind Energy Cooperative and the Grassland Shrub Steppe Species Cooperative). It is important to recognize the need to integrate the results of research that improves existing methods or describes new methodological developments, while acknowledging the value of utilizing common methods that are currently available.

The methods and metrics that may be appropriate for gathering data to answer Tier 3 questions are compiled and outlined in the Technical Resources section, page 26. These are not meant to be all inclusive and other methods and metrics are available, such as the NWCC Methods & Metrics document (Strickland et al. 2011) and others listed in Appendix C:

Avian Radar

Sources of Information Pertaining to Methods to Assess Impacts to Wildlife.

Each question should be considered in turn, followed by a discussion of the methods and their applicability.

1. **Do field studies indicate that species of concern are present on or likely to use the proposed site?**

In many situations, this question can be answered based on information accumulated in Tier 2. Specific presence/absence studies may not be necessary, and protocol development should focus on answering the remaining Tier 3 questions. Nevertheless, it may be necessary to conduct field studies to determine the presence, or likelihood of presence, when little information is available for a particular site. The level of effort normally contemplated for Tier 3 studies should detect common species and species that are relatively rare, but which visit a site regularly (e.g., every year). In the event a species of concern is very rare and only occasionally visits a site, a determination of "likely to occur" would be inferred from the habitat at the site and historical records of occurrence on or near the site.

State, federal and tribal agencies often require specific protocols be followed when species of concern are potentially present on a site. The methods and protocols for determining presence of species of concern at a site are normally established for each species and required by federal, state and tribal resource agencies. Surveys should sample the wind turbine sites and applicable disturbance area during seasons when species are most likely present. Normally, the methods and protocols by which they are applied also will include an estimate of relative abundance. Most presence/absence surveys should be done following a probabilistic sampling protocol to allow statistical extrapolation to the area and time of interest.

Determining the presence of diurnally or nocturnally active mammals, reptiles, amphibians, and other species of concern will typically be accomplished by following agency-required protocols. Most listed species have required protocols for detection (e.g., the black-footed ferret). State, tribal and federal agencies should be contacted regarding survey protocols for those species of concern. See Corn and Bury 1990, Olson et al. 1997, Bailey et al. 2004, Graeter et al. 2008 for examples of reptile and amphibian protocols, survey and analytical methods. See Tier 3 Study Design Considerations on page 24 for further details.

2. **Do field studies indicate the potential for significant adverse impacts on affected populations of species of habitat fragmentation concern?**

If Tier 2 studies indicate the presence of species of habitat fragmentation concern, but existing information did not allow for a complete analysis of potential impacts and decision-making, then additional studies and analyses should take place in Tier 3.

As in Tier 2, the particulars of the analysis will depend on the species of habitat fragmentation concern and how habitat block size and fragmentation are defined for the life cycles of that species, the likelihood that the project will adversely affect a local population of the species and the significance of these impacts to the viability of that population.

To assess habitat fragmentation in the project vicinity, developers should evaluate landscape characteristics of the proposed site prior to construction and determine the degree to which habitat for species of habitat fragmentation concern will be significantly altered by the presence of a wind energy facility.

A general framework for evaluating habitat fragmentation at a project site, following that described in Tier 2, is outlined on page 27. This framework should be used in those circumstances when the developer, or a relevant federal, state, tribal and/or other local agency determines the potential presence of a population of a species of habitat fragmentation concern that may be adversely affected by the project. Otherwise, the developer need not assess the impacts of the proposed project on habitat fragmentation. This method for analysis of habitat fragmentation at project sites must be adapted to the local population of the species of habitat fragmentation concern potentially affected by the proposed development.

3. **What is the distribution, relative abundance, behavior, and site use of species of concern identified in Tiers 1 or 2, and to what extent do these factors expose these species to risk from the proposed wind energy project?**

For those species of concern that are considered at risk of collisions or habitat impacts, the questions to be answered in Tier 3 include: where are they likely to occur (i.e., where is their habitat) within a project site or vicinity, when might they occur, and in what abundance. The spatial distribution of species at risk of collision can influence how a site is developed. This distribution should include the airspace for flying species with respect to the rotor-swept zone. The abundance of a species and the spatial distribution of its habitat can be used to determine the relative risk of impact to species using the sites, and the absolute risk when compared to existing projects where similar information exists. Species abundance and habitat distribution can also be used in modeling risk factors.

Surveys for spatial distribution and relative abundance require coverage of the wind turbine sites and applicable site disturbance area, or a sample of the area using observational methods for the species of concern during the seasons of interest. As with presence/absence (see Tier 3, question 1, above) the methods used to determine distribution, abundance, and behavior may vary with the species and its ecology. Spatial distribution is determined by applying presence/absence or using surveys in a probabilistic manner over the entire area of interest. Suggested survey protocols for birds, bats, and other wildlife are found in the Technical Resources section on page 26.

Whooping crane. Credit: Ryan Hagerty, USFWS

4. **What are the potential risks of adverse impacts of the proposed wind energy project to individuals and local populations of species of concern and their habitats? (In the case of rare or endangered species, what are the possible impacts to such species and their habitats?)**

Methods used for estimating risk will vary with the species of concern. For example, estimating potential bird fatalities in Tier 3 may be accomplished by comparing exposure estimates (described earlier in estimates of bird use) at the proposed site with exposure estimates and fatalities at existing projects with similar characteristics (e.g., similar technology, landscape, and weather conditions). If models are used, they may provide an additional tool for estimating fatalities, and have been used in Australia (Organ and Meredith 2004), Europe (Chamberlin et al. 2006), and the United States (Madders and Whitfield 2006). As with other prediction tools, model predictions should be evaluated and compared with post-construction fatality data to validate the models. Models should be used as a subcomponent of a risk assessment based on the best available empirical data. A statistical model based on the relationship of pre-construction estimates of raptor abundance and post-construction raptor fatalities is described in Strickland et al. (2011) and promises to be a useful tool for risk assessment.

Collision risk to individual birds and bats at a particular wind energy facility may be the result of complex interactions among species distribution, relative abundance, behavior, weather conditions (e.g., wind, temperature) and site characteristics. Collision risk for an individual may be low regardless of abundance if its behavior does not place it within the rotor-swept zone. If individuals frequently occupy the rotor-swept zone but effectively avoid collisions, they are also at low risk of collision with a turbine (e.g., ravens). Alternatively, if the behavior of individuals frequently places them in the rotor-swept zone, and they do not actively avoid turbine blade strikes, they are at higher risk of collisions with turbines regardless of abundance. For a given species (e.g., red-tailed hawk), increased abundance increases the likelihood that individuals will be killed by turbine strikes, although the risk to individuals will remain about the same. The risk to a population increases as the proportion of individuals in the population at risk to collision increases.

At some projects, bat fatalities are higher than bird fatalities, but the exposure risk of bats at these facilities is not fully understood (National Research Council (NRC) 2007). Horn et al. (2008) and Cryan (2008) hypothesize that bats are attracted to turbines, which, if true, would further complicate estimation of exposure. Further research is required to determine if bats are attracted to turbines and if so, to evaluate 1) the influence on Tier 2 methods and predictions, and 2) if this increased individual risk translates into higher population-level impacts for bats.

The estimation of indirect impact risk requires an understanding of animal behavior in response to a project and its infrastructure, and a pre-construction estimate of presence/absence of species whose behavior would cause them to avoid areas in proximity to turbines, roads and other components of the project. The amount of habitat that is lost to indirect impacts will be a function of the sensitivity of individuals to the project and to the activity levels associated with the project's operations. The population-level significance of this indirect impact will depend on the amount of habitat available to the affected population. If the indirect impacts include habitat fragmentation, then the risk to the demographic and genetic viability of the isolated animals is increased. Quantifying cause and effect may be very difficult, however.

5. How can developers mitigate identified significant adverse impacts?

Results of Tier 3 studies should provide a basis for identifying measures to mitigate significant adverse impacts predicted for species of concern. Information on wildlife use of the proposed area is most useful when designing a project to avoid or minimize significant adverse impacts. In cases of uncertainty with regard to impacts to species of concern, additional studies may be necessary to quantify significant adverse impacts and determine the need for mitigation of those impacts.

Chapter 7, Best Management Practices, and Chapter 8, Mitigation, outline measures that can be taken to mitigate impacts throughout all phases of a project.

The following discussion of prairie grouse and sage grouse as species of concern illustrates the uncertainty mentioned above by describing the present state of scientific knowledge relative to these species, which should be considered when designing mitigation measures. The extent of the impact of wind energy development on prairie grouse and sage grouse lekking activity (e.g., social structure, mating success, persistence) and the associated impacts on productivity (e.g., nesting, nest success, chick survival) is poorly understood (Arnett et al. 2007, NRC 2007, Manville 2004). However, recent published research documents that anthropogenic features (e.g., tall structures, buildings, roads, transmission lines) can adversely impact vital rates (e.g., nesting, nest success, lekking behavior) of lesser prairie-chickens (Pruett et al. 2009, Pitman et al. 2005, Hagen et al. 2009, Hagen et al. 2011) and greater prairie-chickens over long distances. Pitman et al. (2005) found that transmission lines reduced nesting of lesser prairie chicken by 90 percent out to a distance of 0.25 miles, improved roads at a distance of 0.25 miles, a house at 0.3 miles, and a power plant at >0.6 miles. Reduced nesting activity of lesser prairie chickens may extend farther, but Pitman et al. (2005) did not analyze their data for lower impacts (less than 90 percent reduction in nesting) of those anthropogenic features on lesser prairie chicken nesting activities at greater distances. Hagen et al. (2011) suggested that development within 1 to 1 ½ miles of active leks of prairie grouse may have significant adverse impacts on the affected grouse population. It is not unreasonable to infer that impacts from wind energy facilities may be similar to those from these other anthropogenic structures. Kansas State University, as part of the National Wind Coordinating Collaborative's Grassland and Shrub Steppe Species Subgroup, is undertaking a multi-year telemetry study to evaluate the effects of a proposed wind-energy facility on displacement and demographic parameters (e.g., survival, nest success, brood success, fecundity) of greater prairie-chickens in Kansas.[5]

The distances over which anthropogenic activities impact sage grouse are greater than for prairie grouse. Based primarily on data documenting reduced fecundity (a combination of nesting, clutch size, nest success, juvenile survival, and other factors) in sage grouse populations near roads, transmissions lines, and areas of oil and gas development/production (Holloran 2005, Connelly et al. 2000), development within three to five miles (or more) of active sage grouse leks may have significant adverse impacts on the affected grouse population. Lyon and Anderson (2003) found that in habitats fragmented by natural gas development, only 26 percent of hens captured on disturbed leks nested within 1.8 miles of the lek of capture, whereas 91 percent of hens from undisturbed areas nested within the same area. Holloran (2005) found that active drilling within 3.1 miles of sage grouse lek reduced the number of breeding males by displacing adult males and reducing recruitment of juvenile males. The magnitudes and proximal causes (e.g., noise, height of structures, movement, human activity, etc.) of those impacts on vital rates in grouse populations are areas of much needed research (Becker et al. 2009). Data accumulated through such research may improve our understanding of the buffer distances necessary to avoid or minimize significant adverse impacts to prairie grouse and sage grouse populations.

When significant adverse impacts cannot be fully avoided or adequately minimized, some form of compensatory mitigation may be

[5] www.nationalwind.org

appropriate to address the loss of habitat value. For example, it may be possible to mitigate habitat loss or degradation for a species of concern by enhancing or restoring nearby habitat value comparable to that potentially influenced by the project.

6. **Are there studies that should be initiated at this stage that would be continued in post-construction?**

During Tier 3 problem formulation, it is necessary to identify the studies needed to address the Tier 3 questions. Consideration of how the resulting data may be used in conjunction with post-construction Tier 4 and 5 studies is also recommended. The design of post-construction impact or mitigation assessment studies will depend on the specific impact questions being addressed. Tier 3 predictions will be evaluated using data from Tier 4 studies designed to estimate fatalities for species of concern and impacts to their habitat, including species of habitat fragmentation concern. Tier 3 studies may demonstrate the need for mitigation of significant adverse impacts. Where Tier 3 studies indicate the potential for significant adverse direct and indirect impacts to habitat, Tier 4 studies will provide data that evaluate predictions of those impacts, and Tier 5 studies, if necessary, will provide data to evaluate the effect of those impacts on populations and the effectiveness of mitigation measures. Evaluations of the impacts of a project on demographic parameters of local populations, habitat use, or some other parameter(s) are considered Tier 5 studies, and typically will require data on these parameters prior to as well as after construction of the project.

Tier 3 Study Design Considerations

Specific study designs will vary from site to site and should be adjusted to the circumstances of individual projects. Study designs will depend on the types of questions, the specific project, and practical considerations. The most common considerations include the area being studied, the species of concern and potential risk to those species, potentially confounding variables, time available to conduct studies, project budget, and the magnitude of the anticipated impacts. Studies will be necessary in part to assess a) which species of concern are present within the project area; b) how these species are using the area (behavior); and c) what risks are posed to them by the proposed wind energy project.

Rows of wind turbines. Credit: Joshua Winchell, USFWS

Assessing Presence

A developer should assess whether species of concern are likely to be present in the project area during the life of the project. Assessing species use from databases and site characteristics is a potential first step. However, it can be difficult to assess potential use by certain species from site characteristics alone. Various species in different locations may require developers to use specific survey protocols or make certain assumptions regarding presence. Project developers should seek local wildlife expertise, such as Service Field Office staff, in using the proper procedures and making assumptions.

Some species will present particular challenges when trying to determine potential presence. For instance, species that a) are rare or cryptic; b) migrate, conduct other daily movements, or use areas for short periods; c) are small or nocturnal; or d) have become extirpated in parts of their historical range can be difficult to observe. One of these challenges is migration, broadly defined as the act of moving from one spatial unit to another (Baker 1978), or as a periodic movement of animals from one location to another. Migration is species-specific, and for birds and bats occurs throughout the year.

Assessing Site Use/Behavior

Developers should monitor potential sites to determine the types of migratory species present, what type of spatial and temporal use these species make of the site (e.g., chronology of migration or other use), and the ecological function the site may provide in terms of the migration cycle of these species. Wind developers should determine not only what species may migrate through a proposed development site and when, but also whether a site may function as a staging area or stopover habitat for wildlife on their migration pathway.

For some species, movements between foraging and breeding habitat, or between sheltering and feeding habitats, occur on a daily basis. Consideration of daily movements (morning and evening; coming and going) is a critical factor when considering project development.

Duration/Intensity of Studies

Where pre-construction assessments are warranted to help assess risk to wildlife, the studies should be of sufficient duration and intensity to ensure adequate data are collected to accurately characterize wildlife presence and use of the area. In ecological systems, resource quality and quantity can fluctuate rapidly. These fluctuations occur naturally, but human actions can significantly affect (i.e., increase or decrease) natural oscillations. Pre-construction monitoring and assessment of proposed wind energy sites are "snapshots in time," showing occurrence or no occurrence of a species or habitat at the specific time surveyed. Often due to prohibitive costs, assessments and surveys are conducted for very low percentages (e.g., less than 5 percent) of the available sample time in a given year, however, these data are used to support risk analyses over the projected life of a project (e.g., 30 years of operations).

To establish a trend in site use and conditions that incorporates annual and seasonal variation in meteorological conditions, biological factors, and other variables, pre-construction studies may need to occur over multiple years. However, the level of risk and the question of data requirements will be based on site sensitivity, affected species, and the availability of data from other sources. Accordingly, decisions regarding studies should consider information gathered during the previous tiers, variability within and between seasons, and years where variability is likely to substantially affect answers to the Tier 3 questions. These studies should also be designed to collect data during relevant breeding, feeding, sheltering, staging, or migration periods for each species being studied. Additionally, consideration for the frequency and intensity of pre-construction monitoring should be site-specific and determined through consultation with an expert authority based on their knowledge of the specific species, level of risk and other variables present at each individual site.

Assessing Risk to Species of Concern

Once likely presence and factors such as abundance, frequency of use, habitat use patterns, and behavior have been determined or assumed, the developer should consider and/or determine the consequences to the "populations" and species.

Below is a brief discussion of several types of risk factors that can be considered. This does not include all potential risk factors for all species, but addresses the most common ones.

<u>Collision</u>

Collision likelihood for individual birds and bats at a particular wind energy facility may be the result of complex interactions among species distribution, "relative abundance," behavior, visibility, weather conditions, and site characteristics. Collision likelihood for an individual may be low regardless of abundance if its behavior does not place it within the "rotor-swept zone." Individuals that frequently occupy the rotor-swept zone but effectively avoid collisions are also at low likelihood of collision with a turbine.

Alternatively, if the behavior of individuals frequently places them in the rotor-swept zone, and they do not actively avoid turbine blade strikes, they are at higher likelihood of collisions with turbines regardless of abundance. Some species, even at lower abundance, may have a higher collision rate than similar species due to subtle differences in their ecology and behavior.

At many projects, the numbers of bat fatalities are higher than the numbers of bird fatalities, but the exposure risk of bats at these facilities is not fully understood. Researchers (Horn et al. 2008 and Cryan 2008) hypothesize that some bats may be attracted to turbines, which, if true, would further complicate estimation of exposure. Further research is required to determine whether bats are attracted to turbines and if so, whether this increased individual risk translates into higher population-scale effects.

<u>Habitat Loss and Degradation</u>

Wind project development results in direct habitat loss and habitat modification, especially at sites previously undeveloped. Many of North America's native landscapes are greatly diminished or degraded from multiple causes unrelated to wind energy. Important remnants of these landscapes are identified and documented in various databases held by private conservation organizations, state wildlife agencies, and, in some cases, by the Service. Species that depend on these landscapes are susceptible to further loss of habitat, which will affect their ability to reproduce and survive. While habitat lost due to footprints of turbines, roads, and other infrastructure is obvious, less obvious is the potential reduction of habitat quality.

<u>Habitat Fragmentation</u>

Habitat fragmentation separates blocks of habitat for some species into segments, such that the individuals in the remaining habitat segments may suffer from effects such as decreased survival, reproduction, distribution, or use of the area. Site clearing, access roads, transmission lines, and arrays of turbine towers may displace some species or fragment continuous habitat areas into smaller, isolated tracts. Habitat fragmentation is of particular concern when species require large expanses of habitat for activities such as breeding, foraging, and sheltering.

Habitat fragmentation can result in increases in "edge" resulting in direct effects of barriers and displacement as well as indirect effects of nest parasitism and predation. Sensitivity to fragmentation effects varies among species. Habitat fragmentation and site modification are important issues that should be assessed at the landscape scale early in the siting process. Identify areas of high sensitivity due to the presence of blocks of native habitats, paying particular attention to known or suspected "species sensitive to habitat fragmentation."

Displacement and Behavioral Changes

Estimating displacement risk requires an understanding of animal behavior in response to a project and its infrastructure and activities, and a pre-construction estimate of presence/absence of species whose behavior would cause them to avoid or seek areas in proximity to turbines, roads, and other components of the project. Displacement is a function of the sensitivity of individuals to the project and activity levels associated with operations.

Indirect Effects

Wind development can also have indirect effects to wildlife and habitats. Indirect effects include reduced nesting and breeding densities and the social ramifications of those reductions; loss or modification of foraging habitat; loss of population vigor and overall population density; increased isolation between habitat patches, loss of habitat refugia; attraction to modified habitats; effects on behavior, physiological disturbance, and habitat unsuitability. Indirect effects can result from introduction of invasive plants; increased predator populations or facilitated predation; alterations in the natural fire regime; or other effects, and can manifest themselves later in time than the causing action.

When collection of both pre- and post-construction data in the areas of interest and reference areas is possible, then the Before-After-Control-Impact (BACI) is the most statistically robust design. The BACI design is most like the classic manipulative experiment.[6] In the absence of a suitable reference area, the design is reduced to a Before-After (BA) analysis of effect where the differences between pre- and post-construction parameters of interest are assumed to be the result of the project, independent of other potential factors affecting the assessment area. With respect to BA studies, the key question is whether the observations taken immediately after the incident can reasonably be expected within the expected range for the system (Manly 2009). Reliable quantification of impact usually will include additional study

Virginia big-eared bat. Credit: USFWS

components to limit variation and the confounding effects of natural factors that may change with time.

The developer's timeline for the development of a wind energy facility often does not allow for the collection of sufficient pre-construction data and/or identification of suitable reference areas to complete a BACI or BA study. Furthermore, alterations in land use or disturbance over the course of a multi-year BACI or BA study may complicate the analysis of study results. Additional discussion of these issues can be found in Tier 5 Study Design Considerations.

Tier 3 Technical Resources

The following methods and metrics are provided as suggested sources for developers to use in answering the Tier 3 questions.

Tier 3, Question 1

Acoustic monitoring can be a practical method for determining the presence of threatened, endangered or otherwise rare species of bats throughout a proposed project (Kunz et al. 2007). There are two general types of acoustic detectors used for collection of information on bat activity and species identification: the full-spectrum, time-expansion and the zero-crossing techniques for ultrasound bat detection (see Kunz et al. 2007 for detailed discussion). Full-spectrum time expansion detectors provide nearly complete species discrimination, while zero-crossing detectors provide reliable and cost-effective estimates of total bat use at a site and some species discrimination. Myotis species can be especially difficult to discriminate with zero-crossing detectors (Kunz et al. 2007). Kunz et al. (2007) describe the strengths and weaknesses of each technique for ultrasonic bat detection, and either type of detector may be useful in most situations except where species identification is especially important and zero-crossing methods are inadequate to provide the necessary data. Bat acoustics technology is evolving rapidly and study objectives are an important consideration when selecting detectors. When rare or endangered species of bats are suspected, sampling should occur during different seasons and at

[6] In this context, such designs are not true experiments in that the treatments (project development and control) are not randomly assigned to an experimental unit, and there is often no true replication. Such constraints are not fatal flaws, but do limit statistical inferences of the results.

multiple sampling stations to account for temporal and spatial variability.

Mist-netting for bats is required in some situations by state agencies, Tribes, and the Service to determine the presence of threatened, endangered or otherwise rare species. Mist-netting is best used in combination with acoustic monitoring to inventory the species of bats present at a site, especially to detect the presence of threatened or endangered species. Efforts should concentrate on potential commuting, foraging, drinking, and roosting sites (Kuenzi and Morrison 1998, O'Farrell et al. 1999). Mist-netting and other activities that involve capturing and handling threatened or endangered species of bats will require permits from state and/or federal agencies.

Tier 3, Question 2

The following protocol should be used to answer Tier 3, Question 2. This protocol for analysis of habitat fragmentation at project sites should be adapted to the species of habitat fragmentation concern as identified in response to Question 5 in Tier 2 and to the landscape in which development is contemplated. The developer should:

1. Define the study area. The study area for the site should include the "footprint" for the proposed facility plus an appropriate surrounding area. The extent of the study area should be based on the area where there is potential for significant adverse habitat impacts, including indirect impacts, within the distribution of habitat for the species of habitat fragmentation concern.

2. Determine the potential for occupancy of the study area based on the guidance provided for the species of habitat fragmentation concern described above in Question 1.

3. Analyze current habitat quality and spatial configuration of the study area for the species of habitat fragmentation concern.

   a. Use recent aerial or remote imagery to determine distinct habitat patches or boundaries within the study area, and the extent of existing habitat fragmenting features.

      i. Assess the level of fragmentation of the existing habitat for the species of habitat fragmentation concern and categorize into three classes:

         - High quality: little or no apparent fragmentation of intact habitat

         - Medium quality: intact habitat exhibiting some recent disturbance activity

         - Low quality: extensive fragmentation of habitat (e.g., row-cropped agricultural lands, active surface mining areas)

      ii. Determine edge and interior habitat metrics of the study area:

         - Identify habitat, non-habitat landscape features and existing fragmenting features relative to the species of habitat fragmentation concern, to estimate existing edge

         - Calculate area and acres of edge

         - Calculate area of intact patches of habitat and compare to needs of species of habitat fragmentation concern

   b. Determine potential changes in quality and spatial configuration of the habitat in the study area if development proceeds as proposed using existing site information and the best available spatial data regarding placement of wind turbines and ancillary infrastructure:

      i. Identify, delineate and classify all additional features added by the development that potentially fragment habitat for the species of habitat fragmentation concern (e.g., roads, transmission lines, maintenance structures, etc.)

      ii. Assess the expected future size and quality of habitat patches for the species of habitat fragmentation concern and the additional fragmenting features, and categorize into three classes as described above

      iii. Determine expected future acreages of edge and interior habitats

      iv. Calculate the area of the remaining patches of intact habitat

   c. Compare pre-construction and expected post-construction fragmentation metrics:

      i. Determine the area of intact habitat lost (to the displacement footprint or by alteration due to the edge effect)

      ii. Identify habitat patches that are expected to be moved to a lower habitat quality classification as a result of the development

4. Assess the likelihood of a significant reduction in the demographic and genetic viability of the local population of the species of habitat fragmentation concern using the habitat fragmentation information collected under item 3 above and any currently available demographic and genetic data. Based on this assessment, the developer makes the finding whether or not there is significant reduction. The developer should share the finding with the relevant agencies. If the developer finds the likelihood of a significant reduction, the developer should

consider items a, b or c below:

a. Consider alternative locations and development configurations to minimize fragmentation of habitat in communication with species experts, for all species of habitat fragmentation concern in the area of interest.

b. Identify high quality habitat parcels that may be protected as part of a plan to limit future loss of habitat for the impacted population of the species of habitat fragmentation concern in the area.

c. Identify areas of medium or low quality habitat within the range of the impacted population that may be restored or improved to compensate for losses of habitat that result from the project (e.g., management of unpaved roads and ORV trails).

Tier 3, Question 3

The following protocols are suggested for use in answering Tier 3, Question 3.

Bird distribution, abundance, behavior and site use

Diurnal Avian Activity Surveys

The commonly used data collection methods for estimating the spatial distribution and relative abundance of diurnal birds includes counts of birds seen or heard at specific survey points (point count), along transects (transect surveys), and observational studies. Both methods result in estimates of bird use, which are assumed to be indices of abundance in the area surveyed. Absolute abundance is difficult to determine for most species and is not necessary to evaluate species risk. Depending on the characteristics of the area of interest and the bird species potentially affected by the project, additional pre-construction study methods may be necessary. Point counts or line transects should collect vertical as well as horizontal data to identify levels of activity within the rotor-swept zone.

Avian point counts should follow the general methodology described by Reynolds et al. (1980) for point counts within a fixed area, or the line transect survey similar to Schaffer and Johnson (2008), where all birds seen within a fixed distance of a line are counted. These methods are most useful for pre- and post-construction studies to quantify avian use of the project site by habitat, determine the presence of species of concern, and to provide a baseline for assessing displacement effects and habitat loss. Point counts for large birds (e.g., raptors) follow the same point count method described by Reynolds et al. (1980), Ralph et al. (1993) and Ralph et al. 1995).

Point count plots, transects, and observational studies should allow for statistical extrapolation of data and be distributed throughout the area of interest using a probability sampling approach (e.g., systematic sample with a random start). For most projects, the area of interest is the area where wind turbines and permanent meteorological (met) towers are proposed or expected to be sited. Alternatively, the centers of the larger plots can be located at vantage points throughout the potential area being considered with the objective of covering most of the area of interest. Flight height should also be collected to focus estimates of use on activity occurring in the rotor-swept zone.

Sampling duration and frequency will be determined on a project-by-project basis and by the questions being addressed. The most important consideration for sampling frequency when estimating abundance is the amount of variation

Hoary bat. Credit: Paul Cryan, USGS

expected among survey dates and locations and the species of concern.

The use of comparable methods and metrics should allow data comparison from plot to plot within the area of interest and from site to site where similar data exist. The data should be collected so that avian activity can be estimated within the rotor-swept zone. Relating use to site characteristics requires that samples of use also measure site characteristics thought to influence use (i.e., covariates such as vegetation and topography) in relation to the location of use. The statistical relationship of use to these covariates can be used to predict occurrence in unsurveyed areas during the survey period and for the same areas in the future.

Surveys should be conducted at different intervals during the year to account for variation in expected bird activity with lower frequency during winter months if avian activity is low. Sampling frequency should also consider the episodic nature of activity during fall and spring migration. Standardized protocols for estimating avian abundance are well-established and should be consulted (e.g., Dettmers et al. 1999). If a more precise estimate of density is required for a particular species (e.g., when the goal is to determine densities of a special-status breeding bird species), the researcher will need more sophisticated sampling procedures, including estimates of detection probability.

Raptor Nest Searches

An estimate of raptor use of the project site is obtained through appropriate surveys, but if potential impacts to breeding raptors are a concern on a project, raptor nest searches are also recommended. These surveys provide information to predict risk to the local breeding population of raptors, for micro-siting decisions, and for developing an appropriate-sized non-disturbance buffer around nests. Surveys also provide baseline data for estimating impacts and determining mitigation requirements. A good source of information for raptor surveys and monitoring is Bird and Bildstein (2007).

Red-tailed hawk. Credit: Dave Menke, USFWS

Searches for raptor nests or raptor breeding territories on projects with potential for impacts to raptors should be conducted in suitable habitat during the breeding season. While there is no consensus on the recommended buffer zones around nest sites to avoid disturbance of most species (Sutter and Jones 1981), a nest search within at least one mile of the wind turbines and transmission lines, and other infrastructure should be conducted. However, larger nest search areas are needed for eagles, as explained in the Service's ECP Guidance, when bald or golden eagles are likely to be present.

Methods for these surveys are fairly common and will vary with the species, terrain, and vegetation within the survey area. The Service recommends that protocols be discussed with biologists from the lead agency, Service, state wildlife agency, and Tribes where they have jurisdiction. It may be useful to consult other scientifically credible information sources. At minimum, the protocols should contain the list of target raptor species for nest surveys and the appropriate search protocol for each site, including timing and number of surveys needed, search area, and search techniques.

Prairie Grouse and Sage Grouse Population Assessments

Sage grouse and prairie grouse merit special attention in this context for three reasons:

1. The scale and biotic nature of their habitat requirements uniquely position them as reliable indicators of impacts on, and needs of, a suite of species that depend on sage and grassland habitats, which are among the nation's most diminished ecological communities (Vodehnal and Haufler 2007).

2. Their ranges and habitats are highly congruent with the nation's richest inland wind resources.

3. They are species for which some known impacts of anthropogenic features (e.g., tall structures, buildings, roads, transmission lines, wind energy facilities, etc.) have been documented.

Populations of prairie grouse and sage grouse generally are assessed by either lek counts (a count of the maximum number of males attending a lek) or lek surveys (classification of known leks as active or inactive) during the breeding season (e.g., Connelly et al. 2000). Methods for lek counts vary slightly by species but in general require repeated visits to known sites and a systematic search of all suitable habitat for leks, followed by repeated visits to active leks to estimate the number of grouse using them.

Recent research indicates that viable prairie grouse and sage grouse populations are dependent on suitable nesting and brood-rearing habitat (Connelly et al. 2000, Hagen et al. 2009). These habitats generally are associated with leks. Leks are the approximate centers of nesting and brood-rearing habitats (Connelly et al. 2000, but see Connelly et al. 1988 and Becker et al. 2009). High quality nesting and brood rearing habitats surrounding leks are critical to sustaining viable prairie grouse and sage grouse populations (Giesen and Connelly 1993, Hagen et al. 2004, Connelly et al. 2000). A population assessment study area should include nesting and brood rearing habitats that may extend several miles from leks. For example, greater and lesser prairie-chickens generally nest in suitable habitats within one to two miles of active leks (Hagen et al. 2004), whereas the average distances from nests to active leks of non-migratory sage grouse range from 0.7 to four miles (Connelly et al. 2000), and potentially much more for migratory populations (Connelly et al. 1988).

While surveying leks during the spring breeding season is the most common and convenient tool for monitoring population trends of prairie grouse and sage grouse, documenting available nesting and brood rearing habitat within and adjacent to the potentially affected area is recommended. Suitable nesting and brood rearing habitats can be mapped based on habitat requirements of individual species. The distribution and abundance of nesting and brood rearing habitats can be used to help in the assessment of adverse impacts of the proposed project to prairie grouse and sage grouse.

Mist-Netting for Birds

Mist-netting is not recommended as a method for assessing risk of wind development for birds. Mist-netting cannot generally be used to develop indices of relative bird abundance, nor does it provide an estimate of collision risk as mist-netting is not feasible at the heights of the rotor-swept zone and captures below that zone may not adequately reflect risk. Operating mist-nets requires considerable experience, as well as state and federal permits.

Occasionally mist-netting can help confirm the presence of rare species at documented fallout or migrant stopover sites near a proposed project. If mist-netting is to be used, the Service recommends that procedures for operating nets and collecting data be followed in accordance with Ralph et al. (1993).

Nocturnal and Crepuscular Bird Survey Methods

Additional studies using different methods should be conducted if characteristics of the project site and surrounding areas potentially pose a high risk of collision to night migrating songbirds and other nocturnal or crepuscular species. For most of their flight, songbirds and other nocturnal migrants are above the reach of wind turbines, but they pass through the altitudinal range of wind turbines during ascents and descents and may also fly closer to the ground during inclement weather (Able, 1970; Richardson, 2000). Factors affecting flight path, behavior, and "fall-out" locations of nocturnal migrants are reviewed elsewhere (e.g., Williams et al., 2001; Gauthreaux and Belser, 2003; Richardson, 2000; Mabee et al., 2006).

In general, pre-construction nocturnal studies are not recommended unless the site has features that might strongly concentrate nocturnal birds, such as along coastlines that are known to be migratory songbird corridors. Biologists knowledgeable about nocturnal bird migration and familiar with patterns of migratory stopovers in the region should assess the potential risks to nocturnal migrants at a proposed project site. No single method can adequately assess the spatial and temporal variation in nocturnal bird populations or the potential collision risk. Following nocturnal study methods in Kunz et al. (2007) is recommended to determine relative abundance, flight direction and flight altitude for assessing risk to migrating birds, if warranted. If areas of interest are within the range of nocturnal species of concern (e.g., marbled murrelet, northern spotted owl, Hawaiian petrel, Newell's shearwater), surveyors should use species-specific protocols recommended by state wildlife agencies, Tribes or Service to assess the species' potential presence in the area of interest.

In contrast to the diurnal avian survey techniques previously described, considerable variation and uncertainty exist on the optimal protocols for using acoustic monitoring devices, radar, and other techniques to evaluate species composition, relative abundance, flight height, and trajectory of nocturnal migrating birds. While an active area of research, the use of radar for determining passage rates, flight heights and flight directions of nocturnal migrating animals has yet to be shown as a good indicator of collision risk. Pre- and post-construction studies comparing radar monitoring results to estimates of bird and bat fatalities will be necessary to evaluate radar as a tool for predicting collision risk. Additional studies are also needed before making recommendations on the number of nights per season or the number of hours per night that are appropriate for radar studies of nocturnal bird migration (Mabee et al., 2006).

<u>Bat survey methods</u>

The Service recommends that all techniques discussed below be conducted by biologists trained in bat identification, equipment use, and the analysis and interpretation of data resulting from the design and conduct of the studies. Activities that involve capturing and handling bats may require permits from state and/or federal agencies.

Acoustic Monitoring

Acoustic monitoring provides information about bat presence and activity, as well as seasonal changes in species occurrence and use, but does not measure the number of individual bats or population density. The goal of acoustic monitoring is to provide a prediction of the potential risk of bat fatalities resulting from the construction and operation of a project. Our current state of knowledge about bat-wind turbine interactions, however, does not allow a quantitative link between pre-construction acoustic assessments of bat activity and operations fatalities. Discussions with experts, state wildlife trustee agencies, Tribes, and

Tri-colored bat. Credit: USFWS

Service will be needed to determine whether acoustic monitoring is warranted at a proposed project site.

The predominance of bat fatalities detected to date are migratory species and acoustic monitoring should adequately cover periods of migration and periods of known high activity for other (i.e., non-migratory) species. Monitoring for a full year is recommended in areas where there is year round bat activity. Data on environmental variables such as temperature and wind speed should be collected concurrently with acoustic monitoring so these weather data can be used in the analysis of bat activity levels.

The number and distribution of sampling stations necessary to adequately estimate bat activity have not been well established but will depend, at least in part, on the size of the project area, variability within the project area, and a Tier 2 assessment of potential bat occurrence.

The number of detectors needed to achieve the desired level of precision will vary depending on the within-site variation (e.g., Arnett et al. 2006, Weller 2007, See also, Bat Conservation International website for up-to-date survey methodologies). One frequently used method is to place acoustic detectors on existing met towers, approximately every two kilometers across the site where turbines are expected to be sited. Acoustic detectors should be placed at high positions (as high as practicable, based on tower height) on each met tower included in the sample to record bat activity at or near the rotor swept zone, the area of presumed greatest risk for bats. Developers should evaluate whether it would be cost effective to install detectors when met towers are first established on a site. Doing so might reduce the cost of installation later and might alleviate time delays to conduct such studies.

If sampling at met towers does not adequately cover the study area or provide sufficient replication, additional sampling stations can be established at low positions (~1.5-2 meters) at a sample of existing met towers and one or more mobile units (i.e., units that are moved to different locations throughout the study period) to increase coverage of the proposed project area. When practical and based on information from Tier 2, it may be appropriate to conduct some acoustic monitoring of features identified as potentially high bat use areas within the study area (e.g., bat roosts and caves) to determine use of such features.

There is growing interest in determining whether "low" position samples (~1.5-2 meters) can provide equal or greater correlation with bat fatalities than "high" position samples (described above) because this would substantially lower cost of this work. Developers could then install a greater number of detectors at lower cost resulting in improved estimates of bat activity and, potentially, improved qualitative estimates of risk to bats. This is a research question that is not expected to be addressed at a project.

Other bat survey techniques

Occasionally, other techniques may be needed to answer Tier 3 questions and complement the information from acoustic surveys. Kunz et al. (2007), NAS (2007), Kunz and Parsons (2009) provide comprehensive descriptions of bat survey techniques, including those identified below that are relevant for Tier 3 studies at wind energy facilities.

Roost Searches and Exit Counts

Pre-construction survey efforts may be recommended to determine whether known or likely bat roosts in mines, caves, bridges, buildings, or other potential roost sites occur within the project vicinity, and to confirm whether known or likely bat roosts are present and occupied by bats. If active roosts are detected, it may be appropriate to address questions about colony size and species composition of roosts. Exit counts and roost searches are two approaches to answering these questions, and Rainey (1995), Kunz and Parsons (2009), and Sherwin et al. (2009) are resources that describe options and approaches for these techniques. Roost searches should be performed cautiously because roosting bats are sensitive to human disturbance (Kunz et al. 1996). Known maternity and hibernation roosts should not be entered or otherwise disturbed unless authorized by state and/or federal wildlife agencies. Internal searches of abandoned mines or caves can be dangerous and should only be conducted by trained researchers. For mine survey protocol and guidelines for protection of bat roosts, see the appendices in Pierson et al. (1999). Exit surveys at known roosts generally should be limited to non-invasive observation using low-light binoculars and infrared video cameras.

Multiple surveys should be conducted to determine the presence or absence of bats in caves and mines, and the number of surveys needed will vary by species of bats, sex (maternity or bachelor colony) of bats, seasonality of use, and type of roost structure (e.g., caves or mines). For example, Sherwin et al. (2003) demonstrated that a minimum of three surveys are needed to determine the absence of large hibernating colonies of Townsend's big-eared bats in mines (90 percent probability), while a minimum of nine surveys (during a single warm season) are necessary before a mine could be eliminated as a bachelor roost for this species (90 percent probability). An average of three surveys was needed before surveyed caves could be eliminated as bachelor roosts (90 percent probability). The Service recommends that decisions on level of effort follow discussion with relevant agencies and bat experts.

Activity Patterns

If active roosts are detected, it may be necessary to answer questions about behavior, movement patterns, and patterns of roost use for bat species of concern, or to further investigate habitat features that might attract bats and pose fatality risk. For some bat species, typically threatened, endangered, or state-listed species, radio telemetry or radar may be recommended to assess both the direction of movement as bats leave roosts, and the bats' use of the area being considered for development. Kunz et al. (2007) describe the use of telemetry, radar and other tools to evaluate use of roosts, activity patterns, and flight direction from roosts.

Mist-Netting for Bats

While mist-netting for bats is required in some situations by state agencies, Tribes, and the Service to determine the presence of threatened, endangered or other bat species of concern, mist-netting is not generally recommended for determining levels of activity or assessing risk of wind energy development to bats for the following reasons: 1) not all proposed or operational wind energy facilities offer conditions conducive to capturing bats, and often the number of suitable sampling points is minimal or not closely associated with the project location; 2) capture efforts often occur at water sources offsite or at nearby roosts and the results may not reflect species presence or use on the site where turbines are to be erected; and 3) mist-netting isn't feasible at the height of the rotor-swept zone, and captures below that zone may not adequately reflect risk of fatality. If mist-netting is employed, it is best used in combination with acoustic monitoring to inventory the species of bats present at a site.

White-Nose Syndrome

White-nose syndrome is a disease affecting hibernating bats. Named for the white fungus that appears on the muzzle and other body parts of hibernating bats, WNS is associated with extensive mortality of bats in eastern North America. All contractors and consultants hired by developers should employ the most current version of survey and handling protocols to avoid transmitting white-nose syndrome between bats.

Mule deer. Credit: Tupper Ansel Blake, USFWS

Other wildlife

While the above guidance emphasizes the evaluation of potential impacts to birds and bats, Tier 1 and 2 evaluations may identify other species of concern. Developers are encouraged to assess adverse impacts potentially caused by development for those species most likely to be negatively affected by such development. Impacts to other species are primarily derived from potential habitat loss or displacement. The general guidance on the study design and methods for estimation of the distribution, relative abundance, and habitat use for birds is applicable to the study of other wildlife. References regarding monitoring for other wildlife are available in Appendix C:

Sources of Information Pertaining to Methods to Assess Impacts to Wildlife. Nevertheless, most methods and metrics will be species-specific and developers are advised to work with the state, tribal, or federal agencies, or other credible experts, as appropriate, during problem formulation for Tier 3.

Tier 3 Decision Points

Developers and the Service should communicate prior to completing the Tier 3 decision process. A developer should inform the Service of the results of its studies and plans. The Service will provide written comments to a developer on study and project development plans that identify concerns and recommendations to resolve the concerns. The developer and, when applicable, the permitting authority will make a decision regarding whether and how to develop the project. The decision point at the end of Tier 3 involves three potential outcomes:

1. Development of the site has a low probability of significant adverse impact based on existing and new information.

   There is little uncertainty regarding when and how development should proceed, and adequate information exists to satisfy any required permitting. The decision process proceeds to permitting, when required, and/or development, and Tier 4.

2. Development of the site has a moderate to high probability of significant adverse impacts without proper measures being taken to mitigate those impacts. This outcome may be subdivided into two possible scenarios:

   a. There is certainty regarding how to develop the site to adequately mitigate significant adverse impacts. The developer bases their decision to develop the site adopting proper mitigation measures and appropriate post-construction fatality and habitat studies (Tier 4).

   b. There is uncertainty regarding how to develop the site to adequately mitigate significant adverse impacts, or a permitting process requires additional information on potential significant adverse wildlife impacts before permitting future phases of the project. The developer bases their decision to develop the site adopting proper mitigation measures and appropriate post-construction fatality and habitat studies (Tier 4).

3. Development of the site has a high probability of significant impact that:

   a. Cannot be adequately mitigated.

   Site development should be delayed until plans can be developed that satisfactorily mitigate for the significant adverse impacts. Alternatively, the site should be abandoned in favor of known sites with less potential for environmental impact, or the developer begins an evaluation of other sites or landscapes for more acceptable sites to develop.

   b. Can be adequately mitigated.

   Developer should implement mitigation measures and proceed to Tier 4.

Little brown bat with white nose syndrome. Credit: Marvin Moriarty, USFWS

Chapter 5: Tier 4 – Post-construction Studies to Estimate Impacts

The outcome of studies in Tiers 1, 2, and 3 will determine the duration and level of effort of post-construction studies.

Tier 4 post-construction studies are designed to assess whether predictions of fatality risk and direct and indirect impacts to habitat of species of concern were correct. Fatality studies involve searching for bird and bat carcasses beneath turbines to estimate the number and species composition of fatalities (Tier 4a). Habitat studies involve application of GIS and use data collected in Tier 3 and Tier 4b and/or published information. Post-construction studies on direct and indirect impacts to habitat of species of concern, including species of habitat fragmentation concern need only be conducted if Tier 3 studies indicate the potential for significant adverse impacts.

Tier 4a – Fatality Studies

At this time, community- and utility-scale projects should conduct at least one year of fatality monitoring. The intensity of the studies should be related to risks of significant adverse impacts identified in pre-construction assessments. As data collected with consistent methods and metrics increases (see discussion below), it is possible that some future projects will not warrant fatality monitoring, but such a situation is rare with the present state of knowledge.

Fatality monitoring should occur over all seasons of occupancy for the species being monitored, based on information produced in previous tiers. The number of seasons and total length of the monitoring may be determined separately for bats and birds, depending on the pre-construction risk assessment, results of Tier 3 studies and Tier 4 monitoring from comparable sites (see Glossary in Appendix A) and the results of first year fatality monitoring. Guidance on the relationship between these variables and monitoring for fatalities is provided in Table 2.

A male Eastern red bat perches among green foliage. Credit: ©MerlinD.Tuttle,BatConservationInternational,www.batcon.org

It may be appropriate to conduct monitoring using different durations and intervals depending on the species of concern. For example, if raptors occupy an area year-round, it may be appropriate to monitor for raptors throughout the year (12 months). It may be warranted to monitor for bats when they are active (spring, summer and fall or approximately eight months). It may be appropriate to increase the search frequency during the months bats are active and decrease the frequency during periods of inactivity. All fatality monitoring should include estimates of carcass removal and carcass detection bias likely to influence those rates.

Tier 4a Questions

Post-construction fatality monitoring should be designed to answer the following questions as appropriate for the individual project:

1. **What are the bird and bat fatality rates for the project?**
2. **What are the fatality rates of species of concern?**
3. **How do the estimated fatality rates compare to the predicted fatality rates?**
4. **Do bird and bat fatalities vary within the project site in relation to site characteristics?**
5. **How do the fatality rates compare to the fatality rates from existing projects in similar landscapes with similar species composition and use?**
6. **What is the composition of fatalities in relation to migrating and resident birds and bats at the site?**
7. **Do fatality data suggest the need for measures to reduce impacts?**

Tier 4a studies should be of sufficient statistical validity to address Tier 4a questions and enable determination of whether Tier 3 fatality predictions were correct. Fatality monitoring results also should allow comparisons with other sites, and provide a basis for determining if operational changes or other mitigation measures at the site are appropriate. The Service encourages project operators to discuss Tier 4 studies with local, state, federal, and tribal wildlife agencies. The number of years of monitoring is based on outcomes of Tier 3 and Tier 4 studies and analysis of comparable Tier 4 data from other projects as indicated in Table 2. The Service may recommend multiple years of monitoring for projects located near a listed species or bald or golden eagle, or other situations, as appropriate.

Tier 4a Protocol Design Considerations

The basic method of measuring fatality rates is the carcass search. Search protocols should be standardized to the greatest extent possible, especially for common objectives and species of concern, and they should include methods for adequately accounting for sampling biases (searcher efficiency and scavenger removal). However, some situations warrant exceptions to standardized protocol. The responsibility of demonstrating that an exception is appropriate and applicable should be on the project operator to justify increasing or decreasing the duration or intensity of operations monitoring.

Some general guidance is given below with regard to the following fatality monitoring protocol design issues:

- Duration and frequency of monitoring
- Number of turbines to monitor
- Delineation of carcass search plots, transects, and habitat mapping
- General search protocol
- Field bias and error assessment
- Estimators of fatality

More detailed descriptions and methods of fatality search protocols can be found in the California (California Energy Commission 2007) and Pennsylvania (Pennsylvania Game Commission 2007) state guidelines and in Kunz et al. (2007), Smallwood (2007), and Strickland et al. (2011).

<u>Duration and frequency of monitoring</u>

Frequency of carcass searches (search interval) may vary for birds and bats, and will vary depending on the questions to be answered, the species of concern, and their seasonal abundance at the project site. The carcass searching protocol should be adequate to answer applicable Tier 4 questions at an appropriate level of precision to make general conclusions about the project, and is not intended to provide highly precise measurements of fatalities. Except during low use times (e.g. winter months in northern states), the Service recommends that protocols be designed such that carcass searches occur at some turbines within the project area most days each week of the study.

The search interval is the interval between carcass searches at individual turbines, and this interval may be lengthened or shortened depending on the carcass removal rates. If the primary focus is on fatalities of large raptors, where carcass removal is typically low, then a longer interval between searches (e.g., 14-28 days) is sufficient. However, if the focus is on fatalities of bats and small birds and carcass removal is high, then a shorter search interval will be necessary.

There are situations in which studies of higher intensity (e.g., daily searches at individual turbines within the sample) may be appropriate. These would be considered only in Tier 5 studies or in research programs because the greater complexity and level of effort goes beyond that recommended for typical Tier 4 post construction monitoring. Tier 5 and research studies could include evaluation of specific measures that have been implemented to mitigate potential significant adverse impacts to species of concern identified during pre-construction studies.

Number of turbines to monitor

If available, data on variability among turbines from existing

Wind turbine. Credit: NREL

projects in similar conditions within the same region are recommended as a basis for determining needed sample size (see Morrison et al., 2008). If data are not available, the Service recommends that an operator select a sufficient number of turbines via a systematic sample with a random start point. Sampling plans can be varied (e.g., rotating panels [McDonald 2003, Fuller 1999, Breidt and Fuller 1999, and Urquhart et al. 1998]) to increase efficiency as long as a probability sampling approach is used. If the project contains fewer than 10 turbines, the Service recommends that all turbines in the area of interest be searched unless otherwise agreed to by the permitting or wildlife resource agencies. When selecting turbines, the Service recommends that a systematic sample with a random start be used when selecting search plots to ensure interspersion among turbines. Stratification among different habitat types also is recommended to account for differences in fatality rates among different habitats (e.g., grass versus cropland or forest); a sufficient number of turbines should be sampled in each strata.

Delineation of carcass search plots, transects, and habitat mapping

Evidence suggests that greater than 80 percent of bat fatalities fall within half the maximum distance of turbine height to ground (Erickson 2003 a, b), and a minimum plot width of 120 meters from the turbine should be established at sample turbines. Plots will need to be larger for birds, with a width twice the turbine height to ground. Decisions regarding search plot size should be made in discussions with the Service, state wildlife agency, permitting agency and Tribes. It may be useful to consult other scientifically credible information sources.

The Service recommends that each search plot should be divided into oblong subplots or belt transects and that each subplot be searched. The objective is to find as many carcasses as possible so the width of the belt will vary depending on the ground cover and its influence on carcass visibility. In most situations, a search width of 6 meters should be adequate, but this may vary from 3-10 meters depending on ground cover.

Searchable area within the theoretical maximum plot size varies, and heavily vegetated areas (e.g., eastern mountains) often do not allow surveys to consistently extend to the maximum plot width. In other cases it may be preferable to search a portion of the maximum plot instead of the entire plot. For example, in some landscapes it may be impractical to search the entire plot because of the time required to do an effective search, even if it is accessible (e.g., croplands), and data from a probability sample of subplots within the maximum plot size can provide a reasonable estimate of fatalities. It is important to accurately delineate and map the area searched for each turbine to adjust fatality estimates based on the actual area searched. It may be advisable to establish habitat visibility classes in each plot to account for differential detectability, and to develop visibility classes for different landscapes (e.g., rocks, vegetation) within each search plot. For example, the Pennsylvania Game Commission (2007) identified four classes based on the percentage of bare ground.

The use of visibility classes requires that detection and removal biases be estimated for each class. Fatality estimates should be made for each class and summed for the total area sampled. Global positioning systems (GPS) are useful for accurately mapping the actual total area searched and area searched in each habitat visibility class, which can be used to adjust fatality estimates. The width of the belt or subplot searched may vary depending on the habitat and species of concern; the key is to determine actual searched area and area searched in each visibility class regardless of transect width. An adjustment may also be needed to take into account the density of fatalities as a function of the width of the search plot.

General search protocol

Personnel trained in proper search techniques should look for bird and bat carcasses along transects or subplots within each plot and record and collect all carcasses located in the searchable areas. The Service will work with developers and operators to provide necessary permits for carcass possession. A complete search of the area should be accomplished and subplot size (e.g., transect width) should be adjusted to compensate for detectability differences in the search area. Subplots should be smaller when vegetation makes it difficult to detect carcasses; subplots can be wider in open terrain. Subplot width also can vary depending on the size of the species being looked for. For example, small species such as bats may require smaller subplots than larger species such as raptors.

Data to be recorded include date, start time, end time, observer, which turbine area was searched (including GPS coordinates) and weather data for each search. When a dead bat or bird is found, the searcher should place a flag near the carcass and continue the search. After searching the entire plot, the searcher returns to each carcass and records information on a fatality data sheet, including date, species, sex and age (when possible), observer name, turbine number, distance from turbine, azimuth from turbine (including GPS coordinates), habitat surrounding carcass, condition of carcass (entire, partial, scavenged), and estimated time of death (e.g., <1 day, 2 days). The recorded data will ultimately be housed in the FWS Office of Law Enforcement Bird Mortality Reporting System. A digital photograph of the carcass should be taken. Rubber gloves should be used to handle all carcasses to eliminate possible transmission of rabies or other diseases and to reduce possible human scent bias for carcasses later used in scavenger removal trials. Carcasses should be placed in a plastic bag and labeled. Unless otherwise conditioned by the carcass possession permit, fresh carcasses (those determined to have been killed the night immediately before a search) should be redistributed at random points on the same day for scavenging trials.

Field bias and error assessment

During searches conducted at wind turbines, actual fatalities are likely incompletely observed. Therefore carcass counts must be adjusted by some factor that accounts for imperfect detectability (Huso 2011). Important sources of bias and error include: 1) fatalities that occur on a highly periodic basis; 2) carcass removal by scavengers; 3) differences in searcher efficiency; 4) failure to account for the influence of site (e.g. vegetation) conditions in relation to carcass removal and searcher efficiency; and 5) fatalities or injured birds and bats that may land or move outside search plots.

Some fatalities may occur on a highly periodic basis creating a potential sampling error (number 1 above). The Service recommends that sampling be scheduled so that some turbines are searched most days and episodic events are more likely detected, regardless of the search interval. To address bias sources 2-4 above, it is strongly recommended that all fatality studies conduct carcass removal and searcher efficiency trials using accepted methods (Anderson 1999, Kunz et al. 2007, Arnett et al. 2007, NRC 2007, Strickland et al. 2011). Bias trials should be conducted throughout the entire study period and searchers should be unaware of which turbines are to be used or the number of carcasses placed beneath those turbines during trials. Carcasses or injured individuals may land or move outside the search plots (number 5 above). With respect to Tier 4a fatality estimates, this potential sampling error is considered to be small and can be assumed insignificant (Strickland et al. 2011).

Prior to a study's inception, a list of random turbine numbers and random azimuths and distances (in meters) from turbines should be generated for placement of each bat or bird used in bias trials. Data recorded for each trial carcass prior to placement should include date of placement, species, turbine number, distance and direction from turbine, and visibility class surrounding the carcass. Trial carcasses should be distributed as equally as possible among the different visibility classes throughout the study period and study area. Studies should attempt to avoid "over-seeding" any one turbine with carcasses by placing no more than one or two carcasses at any one time at a given turbine. Before placement, each carcass must be uniquely marked in a manner that does not cause additional attraction, and its location should be recorded. There is no agreed upon sample size for bias trials, though some state guidelines recommend from 50 - 200 carcasses (e.g., PGC 2007).

Estimators of fatality

If there were a direct relationship between the number of carcasses observed and the number killed, there would be no need to develop a complex estimator that adjusts observed counts for detectability, and observed counts could be used as a simple index of fatality (Huso 2011). But the relationship is not direct and raw carcass counts recorded using different search intervals and under different carcass removal rates and searcher efficiency rates are not directly comparable. It is strongly recommended that only the most contemporary equations for estimating fatality be used, as some original versions are now known to be extremely biased under many commonly encountered field conditions (Erickson et al. 2000b, Erickson et al. 2004, Johnson et al. 2003, Kerns and Kerlinger 2004, Fiedler et al. 2007, Kronner et al. 2007, Smallwood 2007, Huso 2011, Strickland et al. 2011).

Tier 4a Study Objectives

In addition to the monitoring protocol design considerations described above, the metrics used to estimate fatality rates must be selected with the Tier 4a questions and objectives in mind. Metrics considerations for each of the Tier 4a questions are discussed briefly below. Not all questions will be relevant for each project, and which questions apply would depend on Tier 3 outcomes.

1. What are the bird and bat fatality rates for the project?

The primary objective of fatality searches is to determine the overall estimated fatality rates for birds and bats for the project. These rates serve as the fundamental basis for all comparisons of fatalities, and if studies are designed appropriately they allow researchers to relate fatalities to site characteristics and environmental variables, and to evaluate mitigation measures. Several metrics are available for expressing fatality rates. Early studies reported fatality rates per turbine. However, this metric is somewhat misleading as turbine sizes and their risks to birds vary significantly (NRC 2007). Fatalities are frequently reported per nameplate capacity (i.e. MW), a metric that is easily calculated and better for comparing fatality rates among different sized turbines. Even with turbines of the same name plate capacity, the size of the rotor swept area may vary among manufacturers, and turbines at various sites may operate for different lengths of time and during different times of the day and seasons. With these considerations in mind, the Service recommends that fatality rates be expressed on a per-turbine and per-nameplate MW basis until a better metric becomes available.

2. What are the fatality rates of species of concern?

This analysis simply involves calculating fatalities per turbine of all species of concern at a site when sample sizes are sufficient to do so. These fatalities should be expressed on a per nameplate MW basis if comparing species fatality rates among projects.

3. How do the estimated fatality rates compare to the predicted fatality rates?

There are several ways that predictions can be evaluated with actual fatality data. During the planning stages in Tier 2, predicted fatalities may be based on existing data at similar facilities in similar landscapes used by similar species. In this case, the assumption is that use is similar, and therefore that fatalities may be similar at the proposed facility. Alternatively, metrics derived from pre-construction assessments for an individual species or group of species – usually an index of activity or abundance at a proposed project – could be used in conjunction with use and fatality estimates from existing projects to develop a model for predicting fatalities at the proposed project site. Finally, physical models can be used to predict the probability of a bird of a particular size striking a turbine, and this probability, in conjunction with estimates of use and avoidance behavior, can be used to predict fatalities.

The most current equations for estimating fatality should be used to evaluate fatality predictions. Several statistical methods can be found in the revised Strickland et al. 2011 and used to evaluate fatality predictions. Metrics derived from Tier 3 pre-construction assessments may be correlated with fatality rates, and (using the project as the experimental unit), in Tier 5 studies it should be possible to determine if different preconstruction metrics can in fact accurately predict fatalities and, thus, risk.

4. Do bird and bat fatalities vary within the project site in relation to site characteristics?

Data from pre-construction studies can demonstrate patterns of activity that may depend upon the site characteristics. Turbines placed near escarpments or cliffs may intrude upon airspace used by raptors soaring on thermals. Pre-construction and post construction studies and assessments can be used to avoid siting individual, specific turbines within an area used by species of concern. Turbine-specific fatality rates may be related to site characteristics such as proximity to water, forest edge, staging and roosting sites, known stop-over sites, or other key resources, and this relationship may be estimated using regression analysis. This information is particularly useful for evaluating micro-siting options when planning a future facility or, on a broader scale, in determining the location of the entire project.

5. How do the fatality rates compare to the fatality rates from existing facilities in similar landscapes with similar species composition and use?

Comparing fatality rates among facilities with similar characteristics can be useful to determine patterns and broader landscape relationships. Developers should communicate with the Service to ensure that such comparisons are appropriate to avoid false conclusions. Fatality rates should be expressed on a per nameplate MW or some other standardized metric basis for comparison with other projects, and may be correlated with site characteristics – such as proximity to wetlands, riparian corridors, mountain-foothill interface, wind patterns, or other broader landscape features – using regression analysis. Comparing fatality rates from one project to fatality rates of other projects provides insight into whether a project has relatively high, moderate or low fatalities.

Big brown bat. Credit: USFWS

6. What is the composition of fatalities in relation to migrating and resident birds and bats at the site?

The simplest way to address this question is to separate fatalities per turbine of known resident species (e.g., big brown bat, prairie horned lark) and those known to migrate long distances (e.g. hoary bat, red-eyed vireo). These data are useful in determining patterns of species composition of fatalities and possible mitigation measures directed at residents, migrants, or perhaps both, and can be used in assessing potential population effects.

[7] In situations where a project operator was not the developer, the Service expects that obligations of the developer for adhering to the Guidelines transfer with the project.

Table 2. Decision Framework for Tier 4a Fatality Monitoring of Species of Concern.[8]

Probability of Significant Adverse Impacts in Tier 3	*Recommended Fatality Monitoring Duration and Effort*	*Possible Outcomes of Monitoring Results*
Tier 3 Studies indicate LOW probability of significant adverse impacts	Duration: At least one year of fatality monitoring to estimate fatalities of birds and bats. Field assessments should be sufficient to confirm that risk to birds and/or bats is indeed "low."	1. Documented fatalities are approximately equal to or lower than predicted risk. No further fatality monitoring or mitigation is needed. 2. Fatalities are greater than predicted, but are not likely to be significant (i.e., unlikely to affect the long-term status of the population). If comparable fatality data at similar sites also supports that impacts are not likely to be high enough to affect population status, no further monitoring or mitigation is needed. If no comparable fatality data are available or such data indicates high risk, one additional year of fatality monitoring is recommended. If two years of fatality monitoring indicate levels of impacts that are not significant, no further fatality monitoring or mitigation is recommended. 3. Fatalities are greater than predicted and are likely to be significant OR federally endangered or threatened species or BGEPA species are affected. Communication with the Service is recommended. Further efforts to address impacts to BGEPA or ESA species may be warranted, unless otherwise addressed in an ESA or BGEPA take permit.
Tier 3 studies indicate MODERATE probability of significant adverse impacts	Duration: Two or more years of fatality monitoring may be necessary. Field assessments should be sufficient to confirm that risk to birds and/or bats is indeed "moderate." Closely compare estimated effects to species to those determined from the risk assessment protocol(s).	1. Documented fatalities after the first two years are lower or not different than predicted and are not significant and no federally endangered species or BGEPA species are affected - no further fatality monitoring or mitigation is needed. 2. Fatalities are greater than predicted and are likely to be significant OR federally endangered or threatened species or BGEPA species are affected, communication with the Service is recommended. Further efforts to address impacts to BGEPA or ESA species may be warranted, unless otherwise addressed in an ESA or BGEPA take permit.
Tier 3 studies indicate HIGH probability of significant adverse impacts	Duration: Two or more years of fatality monitoring may be necessary to document fatality patterns. If fatality is high, developers should shift emphasis to exploring opportunities for mitigation rather than continuing to monitor fatalities. If fatalities are variable, additional years are likely warranted.	1. Documented fatalities during each year of fatality monitoring are less than predicted and are not likely to be significant, and no federally endangered or threatened species or BGEPA species are affected – no further fatality monitoring or mitigation is needed. 2. Fatalities are equal to or greater than predicted and are likely to be significant - further efforts to reduce impacts are necessary; communication with the Service are recommended. Further efforts, such as Tier 5 studies, to address impacts to BGEPA or ESA species may be warranted, unless otherwise addressed in an ESA or BGEPA take permit.

[8] Ensure that survey protocols, and searcher efficiency and scavenger removal bias correction factors are the most reliable, robust, and up to date (after Huso 2009).

7. Do fatality data suggest the need for measures to reduce impacts?

The Service recommends that the wind project operator[7] and the relevant agencies discuss the results from Tier 4 studies to determine whether these impacts are significant. If fatalities are considered significant, the wind project operator and the relevant agencies should develop a plan to mitigate the impacts.

Tier 4b – Assessing direct and indirect impacts of habitat loss, degradation, and fragmentation

The objective of Tier 4b studies is to evaluate Tier 3 predictions of direct and indirect impacts to habitat and the potential for significant adverse impacts on species of concern as a result of these impacts. Tier 4b studies should be conducted if Tier 3 studies indicate the presence of species of habitat fragmentation concern, or if Tier 3 studies indicate significant direct and indirect adverse impacts to species of concern (see discussion below). Tier 4b studies should also inform project operators and the Service as to whether additional mitigation is necessary.

Tier 4b studies should evaluate the following questions:

1. **How do post-construction habitat quality and spatial configuration of the study area compare to predictions for species of concern identified in Tier 3 studies?**

2. **Were any behavioral modifications or indirect impacts noted in regard to species of concern?**

3. **If significant adverse impacts were predicted for species of concern, and the project was altered to mitigate for adverse impacts, were those efforts successful?**

4. **If significant adverse impacts were predicted for species of concern, and the project was altered to mitigate for adverse impacts, were those efforts successful?**

The answers to these questions will be based on information estimating habitat loss, degradation, and fragmentation information collected in Tier 3, currently available demographic and genetic data, and studies initiated in Tier 3. As in the case of Tier 4a, the answers to these questions will determine the need to conduct Tier 5 studies. For example, in the case that significant adverse impacts to species of concern were predicted, but mitigation was not successful, then additional mitigation and Tier 5 studies may be necessary. See Table 3 for further guidance.

1. **How do post-construction habitat quality and spatial configuration of the study area compare to predictions for species of concern identified in Tier 3 studies?**

GIS and demographic data collected in Tier 3 and/or published information can be used to determine predictions of impacts to species of concern from habitat loss, degradation, and fragmentation. The developer can provide development assumptions based on Tier 3 information that can be compared to post-construction information. Additional post-construction studies on impacts to species of concern due to direct and indirect impacts to habitat should only be conducted if Tier 3 studies indicate the potential for significant adverse impacts.

2. **Were any behavioral modifications or indirect impacts noted in regard to affected species?**

Evaluation of this question is based on the analysis of observed use of the area by species of concern prior to construction in comparison with observed use during operation. Observations and demographic data collected during Tier 3, and assessment of published information about the potential for displacement and demographic responses to habit impacts could be the basis for this analysis. If this analysis suggests that direct and/or indirect loss of habitat for a species of concern leads to behavioral modifications or displacement that are significant, further studies of these impacts in Tier 5 may be appropriate.

3. **If significant adverse impacts were not predicted in Tier 3 because of loss, degradation, or fragmentation of habitat, but Tier 4b studies indicate such impacts have the potential to occur, can these impacts be mitigated?**

When Tier 4b studies indicate significant impacts may be occurring, the developer may need to conduct an assessment of these impacts and what opportunities exist for additional mitigation.

4. **If significant adverse impacts were predicted for species of concern, and the project was altered to mitigate for adverse impacts, were those efforts successful?**

When Tier 4b studies indicate significant impacts may be occurring, the developer may need to conduct an assessment of these impacts and what opportunities exist for additional mitigation. Evaluation of the effectiveness of mitigation is a Tier 4 study and should follow design considerations discussed in Tier 5 and from guidance in the scientific literature (e.g. Strickland et al. 2011).

When Tier 3 studies identified potential moderate or high risks to species of concern that caused a developer to incorporate mitigation measures into the project, Tier 4b studies should evaluate the effectiveness of those mitigation measures. Determining such effectiveness is important for the project being evaluated to ascertain whether additional mitigation measures are appropriate as well as informing future decisions about how to improve mitigation at wind energy facilities being developed.

Tier 4b Protocol Design Considerations

Impacts to a species of concern resulting from the direct and indirect loss of habitat are important and must be considered when a wind project is being considered for development. Some species of concern are likely to occur at every proposed wind energy facility. This occurrence may range from a breeding population, to seasonal occupancy, such as a brief occurrence while migrating through the area. Consequently the level of concern regarding impacts due to direct and indirect loss of habitat will vary depending on the species and the impacts that occur.

If a breeding population of a species of habitat fragmentation concern occurs in the project area and Tier 3 studies indicate that fragmentation of their habitat is possible, these predictions should be evaluated following the guidance indicated in Table 3 using the protocols described in Tier 3. If the analysis of post-construction GIS data on direct and indirect habitat loss suggests that fragmentation is likely, then additional displacement studies and mitigation may be necessary. These studies would typically begin immediately and would be considered Tier 5 studies using design considerations illustrated by examples in Tier 5 below and from guidance in the scientific literature (e.g. Strickland et al. 2011).

Significant direct or indirect loss of habitat for a species of concern may occur without habitat fragmentation if project impacts result in the reduction of a habitat resource that potentially is limiting to the affected population. Impacts of this type include loss of use of breeding habitat or loss of a significant portion of the habitat of a federally or state protected species. This would be evaluated by determining the amount of the resource that is lost and determining if this loss would potentially result in significant impacts to the affected population. Evaluation of potential significant

Black-capped Vireo. Credit: Greg W. Lasley

impacts would occur in Tier 5 studies that measure the demographic response of the affected population.

The intention of the Guidelines is to focus industry and agency resources on the direct and indirect loss of habitat and limiting resources that potentially reduce the viability of a species of concern. Not all direct and indirect loss of a species' habitat will affect limiting resources for that species, and when habitat losses are minor or non-existent no further study is necessary.

Tier 4b Decision Points

The developer should use the results of the Tier 4b studies to evaluate whether further studies and/or mitigation are needed. The developer should communicate the results of these studies, and decisions about further studies and mitigation, with the Service. Table 3 provides a framework for evaluating the need for further studies and mitigation. Level of effort for studies should be sufficient to answer all questions of interest. Refer to the relevant methods sections for Tier 2 Question 5 and Tier 3 Question 2 in the text for specific guidance on study protocols.

Table 3. Decision Framework to Guide Studies for Minimizing Impacts to Habitat and Species of Habitat Fragmentation (HF) Concern.

Outcomes of Tier 2	*Outcomes of Tier 3*	*Outcomes of Tier 4b*	*Suggested Study/Mitigation*
• No species of HF concern potentially present	• No further studies needed	• n/a	• n/a
• Species of HF concern potentially present	• No species of HF concern confirmed to be present	• No further studies needed	• n/a
	• Species of HF concern demonstrated to be present, but no significant adverse impacts predicted	• Tier 4b studies confirm Tier 3 predictions	• No further studies or mitigation needed
		• Tier 4b studies indicate potentially significant adverse impacts	• Tier 5 studies and mitigation may be needed
• Species of HF concern potentially present	• Species of HF concern demonstrated to be present; significant adverse impacts predicted	• Tier 4b studies determine mitigation plan is effective; no significant adverse impacts demonstrated	• No further studies or mitigation needed
	• Mitigation plan developed and implemented	• Tier 4b studies determine mitigation plan is NOT effective; potentially significant adverse impacts	• Further mitigation and, where appropriate, Tier 5 studies

Chapter 6: Tier 5 – Other Post-construction Studies

Tier 5 studies will not be necessary for most wind energy projects. Tier 5 studies can be complex and time consuming. The Service anticipates that the tiered approach will steer projects away from sites where Tier 5 studies would be necessary.

When Tier 5 studies are conducted, they should be site-specific and intended to: 1) analyze factors associated with impacts in those cases in which Tier 4 analyses indicate they are potentially significant; 2) identify why mitigation measures implemented for a project were not adequate; and 3) assess demographic effects on local populations of species of concern when demographic information is important, including species of habitat fragmentation concern.

Tier 5 Questions

Tier 5 studies are intended to answer questions that fall in three major categories; answering yes to any of these questions might indicate a Tier 5 study is needed:

1. **To the extent that the observed fatalities exceed anticipated fatalities, are those fatalities potentially having a significant adverse impact on local populations? Are observed direct and indirect impacts to habitat having a significant adverse impact on local populations?**

For example, in the Tier 3 risk assessment, predictions of collision fatalities and habitat impacts (direct and indirect) are developed. Post-construction studies in Tier 4 evaluate the accuracy of those predictions by estimating impacts. If post-construction studies demonstrate potentially significant adverse impacts, Tier 5 studies may also be warranted and should be designed to understand observed versus predicted impacts.

2. **Were mitigation measures implemented (other than fee in lieu) not effective? This includes habitat mitigation measures as well as measures undertaken to reduce collision fatalities.**

Tier 4a and b studies can assess the effectiveness of measures taken to reduce direct and indirect impacts as part of the project and to identify such alternative or additional measures as are necessary. If alternative or additional measures were unsuccessful, the reasons why would be evaluated using Tier 5 studies.

3. **Are the estimated impacts of the proposed project likely to lead to population declines in the species of concern (other than federally-listed species)?**

Impacts of a project will have population level effects if the project causes a population decline in the species of concern. For non-listed species, this assessment will apply only to the local population.

Wind turbines and habitat. Credit: NREL

Tier 5 studies may need to be conducted when:

- Realized fatality levels for individual species of concern reach a level at which they are considered significant adverse impacts by the relevant agencies.

  For example, if Tier 4a fatality studies document that a particular turbine or set of turbines exhibits bird or bat collision fatality higher than predicted, Tier 5 studies may be useful in evaluating alternative mitigation measures at that turbine/turbine string.

- There is the potential for significant fatality impacts or significant adverse impacts to habitat for species of concern, there is a need to assess the impacts more closely, and there is uncertainty over how these impacts will be mitigated.

- Fatality and/or significant adverse habitat impacts suggest the potential for a reduction in the viability of an affected population, in which case studies on the potential for population impacts may be warranted.

- A developer evaluates the effectiveness of a risk reduction measure before deciding to continue the measure permanently or whether to use the measure when implementing future phases of a project.

  In the event additional turbines are proposed as an expansion of an existing project, results from Tier 4 and Tier 5 studies and the decision-making framework contained in the tiered approach can be used to determine whether the project should be expanded and whether additional information should be collected. It may also be necessary to evaluate whether additional measures are warranted to reduce significant adverse impacts to species.

Tier 5 Study Design Considerations

As discussed in Chapter 4 Tier 3, Tier 5 studies will be highly variable and unique to the circumstances of the individual project, and therefore these Guidelines do not provide specific guidance on all potential approaches, but make some general statements about study design. Specific Tier 5 study designs will depend on the types of questions, the specific project, and practical considerations. The most common practical considerations include the area being studied, the time period of interest, the species of concern, potentially confounding variables, time available to conduct studies, project budget, and the magnitude of the anticipated impacts. When possible it is usually desirable to collect data before construction to address Tier 5 questions. Design considerations for these studies are including in Tier 3.

One study design is based on an experimental approach to evaluating mitigation measures, where the project proponent will generally select several alternative management approaches to design, implement, and test. The alternatives are generally incorporated into sound experimental designs. Monitoring and evaluation of each alternative helps the developer to decide which alternative is more effective in meeting objectives, and informs adjustments to the next round of management decisions. The need for this type of study design can be best determined by communication between the project operator, the Service field office, and the state wildlife agency, on a project-by-project basis. This study design requires developers and operators to identify strategies to adjust management and/or mitigation measures if monitoring indicates that anticipated impacts are being exceeded. Such strategies should include a timeline for periodic reviews and adjustments as well as a mechanism to consider and implement additional mitigation measures as necessary after the project is developed.

When pre-construction data are unavailable and/or a suitable reference area is lacking, the reference Control Impact Design (Morrison et al. 2008) is the recommended design. The lack of a suitable reference area also can be addressed using the Impact Gradient Design, when habitat and species use are homogenous in the assessment area prior to development. When applied both pre- and post-construction, the Impact Gradient Design is a suitable replacement for the classic BACI (Morrison et al. 2008).

In the study of habitat impacts, the resource selection function (RSF) study design (see Anderson et al 1999; Morrison et al. 2008; Manly et al. 2002) is a statistically robust design, either with or without pre-construction and reference data. Habitat selection is modeled as a function of characteristics measured on resource units and the use of those units by the animals of interest. The RSF allows the estimation of the probability of use as a function of the distance to various environmental features, including wind energy facilities, and thus provides a direct quantification of the magnitude of the displacement effect. RSF could be improved with pre-construction and reference area data. Nevertheless, it is a relatively powerful approach to documenting displacement or the effect of mitigation measures designed to reduce displacement even without those additional data.

Tier 5 Examples

As described earlier, Tier 5 studies will not be conducted at most projects, and the specific Tier 5 questions and methods for addressing these questions will depend on the individual project and the concerns raised during pre-construction studies and during operational phases. Rather than provide specific guidance on all potential approaches, these Guidelines offer the following case studies as examples of studies that have attempted to answer Tier 5 questions.

<u>Habitat impacts - displacement and demographic impact studies</u>

Rows of wind turbines. Credit: Joshua Winchell, USFWS

Studies to assess impacts may include quantifying species' habitat loss (e.g., acres of lost grassland habitat for grassland songbirds) and habitat modification. For example, an increase in edge may result in greater nest parasitism and nest predation. Assessing indirect impacts may include two important components: 1) indirect effects on wildlife resulting from displacement, due to disturbance, habitat fragmentation, loss, and alteration; and 2) demographic effects that may occur at the local, regional or population-wide levels due to reduced nesting and breeding densities, increased isolation between habitat patches, and effects on behavior (e.g., stress, interruption, and modification). These factors can individually or cumulatively affect wildlife, although some species may be able to habituate to some or perhaps all habitat changes. Indirect impacts may be difficult to quantify but their effects may be significant (e.g., Stewart et al. 2007, Pearce-Higgins et al. 2008, Bright et al. 2008, Drewitt and Langston 2006, Robel et al. 2004, Pruett et al. 2009).

Example: in southwestern Pennsylvania, development of a project is proceeding at a site located within the range of a state-listed terrestrial species. Surveys were performed at habitat locations appropriate for use by the animal, including at control sites. Post-construction studies are planned at all locations to demonstrate any displacement effects resulting from the construction and operation of the project.

The Service recognizes that indirect impact studies may not be appropriate for most individual projects. Consideration should be given to developing collaborative research efforts with industry, government agencies, and NGOs to conduct studies to address indirect impacts.

Indirect impacts are considered potentially significant adverse threats to species such as prairie grouse (prairie chickens, sharp-tailed grouse), and sage grouse, and demographic studies may be necessary to determine the extent of these impacts and the need for mitigation.

Displacement studies may use any of the study designs describe earlier. The most scientifically robust study designs to estimate displacement effects are BACI, RSF, and impact gradient. RSF and impact gradient designs may not require specialized data gathering during Tier 3.

Telemetry studies that measure impacts of the project development on displacement, nesting, nest success, and survival of prairie grouse and sage grouse in different environments (e.g., tall grass, mixed grass, sandsage, sagebrush) will require spatial and temporal replication, undisturbed reference sites, and large sample sizes covering large areas. Examples of study designs and analyses used in the studies of other forms of energy development are presented in Holloran et al. (2005), Pitman et al. (2005), Robel et al. (2004), and Hagen et al. (2011). Anderson et al. (1999) provides a thorough discussion of the design, implementation, and analysis of these kinds of field studies and should be consulted when designing the BACI study.

Studies are being initiated to evaluate effects of wind energy development on greater sage grouse in Wyoming. In addition to measuring demographic patterns, these studies will use the RSF study design (see Sawyer et al. 2006) to estimate the probability of sage grouse use as a function of the distance to environmental features, including an existing and a proposed project.

In certain situations, such as for a proposed project site that is relatively small and in a more or less homogeneous landscape, an impact gradient design may be an appropriate means to assess avoidance of the wind energy facility by resident populations (Strickland et al., 2002). For example, Leddy et al. 1999 used the impact gradient design to evaluate grassland bird density as a function of the distance from wind turbines. Data were collected at various distances from turbines along transects.

This approach provides information on whether there is an effect, and may allow quantification of the gradient of the effect and the distance at which the displacement effect no longer exists – the assumption being that the data collected at distances beyond the influence of turbines are the reference data (Erickson et al., 2007). An impact gradient analysis could also involve measuring the number of breeding grassland birds counted at point count plots as a function of distance from the wind turbines (Johnson et al. 2000).

Sound and Wildlife

Turbine blades at normal operating speeds can generate levels of sound beyond ambient background levels. Construction and maintenance activities can also contribute to sound levels by affecting communication distance, an animal's ability to detect calls or danger, or to forage. Sound associated with developments can also cause behavioral and/or physiological effects, damage to hearing from acoustic over-exposure, and masking of communication signals and other biologically relevant sounds (Dooling and Popper 2007). Some birds are able to shift their vocalizations to reduce the masking effects of noise. However, when shifts don't occur or are insignificant, masking may prove detrimental to the health and survival of wildlife (Barber et al. 2010). Data suggest noise increases of 3 dB to 10 dB correspond to 30 percent to 90 percent reductions in alerting distances for wildlife, respectively (Barber et al. 2010).

The National Park Service has been investigating potential impacts to wildlife due to alterations in sound level and type. However, further research is needed to better understand this potential impact. Research may include: how wind facilities affect background sound levels; whether masking, disturbance, and acoustical fragmentation occur; and how turbine, construction, and maintenance sound levels can vary by topographic area.

Levels of fatality beyond those predicted

More intensive post-construction fatality studies may be used to determine relationships between fatalities and weather, wind speed or other covariates, which usually require daily carcass searches. Fatalities determined to have occurred the previous night can be correlated with that night's weather or turbine characteristics to establish important relationships that can then be used to evaluate the most effective times and conditions to implement measures to reduce collision fatality at the project.

Measures to address fatalities

The efficacy of operational changes (e.g. changing turbine cut-in speed) of a project to reduce collision fatalities has only recently been evaluated (Arnett et al. 2009, Baerwald et al 2009). Operational changes to address fatalities should be applied only at sites where collision fatalities are predicted or demonstrated to have significant adverse impacts.

Tier 5 Studies and Research

The Service makes a distinction between Tier 5 studies focused on project-specific impacts and research (which is discussed earlier in the Guidelines). For example, developers may be encouraged to participate in collaborative studies (see earlier discussion of Research) or asked to conduct a study on an experimental mitigation technique, such as differences in turbine cut-in speed to reduce bat fatalities. Such techniques may show promise in mitigating the impacts of wind energy development to wildlife, but their broad applicability for mitigation purposes has not been demonstrated. Such techniques should not be routinely applied to projects, but application at appropriate sites will contribute to the breadth of knowledge regarding the efficacy of such measures in addressing collision fatalities. In addition, studies involving multiple sites and academic researchers can provide more robust research results, and such studies take more time and resources than are appropriately carried out by one developer at a single site. Examples below demonstrate collaborative research efforts to address displacement, operational changes, and population level impacts.

Studies of Indirect Effects

The Service provides two examples below of ongoing studies to assess the effects of indirect impacts related to wind energy facilities.

Kansas State University, as part of the NWCC Grassland Shrub-steppe Species Collaborative, is undertaking a multi-year research project to assess the effects of wind energy facilities on populations of greater prairie-chickens (GPCH) in Kansas. Initially the research was based on a Before/After Control/Impact (BACI) experimental design involving three replicated study sites in the Flint Hills and Smoky Hills of eastern Kansas. Each study site consisted of an impact area where a wind energy facility was proposed to be developed and a nearby reference area with similar rangeland characteristics where no development was planned. The research project is a coordinated field/laboratory effort, i.e., collecting telemetry and observational data from adult and juvenile GPCH in the field, and determining population genetic attributes of GPCH in the laboratory from blood samples of birds and the impact and reference areas. Detailed data on GPCH movements, demography, and population genetics were gathered from all three sites from 2007 to 2010. By late 2008, only one of the proposed wind energy facilities was developed (the Meridian Way Wind Farm in the Smoky Hills of Cloud County), and on-going research efforts are focused on that site. The revised BACI study design now will produce two years of pre-construction data (2007 and 2008), and three years of post-construction data (2009, 2010, and 2011) from a single wind energy facility site (impact area) and its reference area. Several hypotheses were formulated for testing to determine if wind energy facilities impacted GPCH populations, including but not limited to addressing issues relating to: lek attendance, avoidance of turbines and associated features, nest success and chick survival, habitat usage, adult mortality and survival, breeding behavior, and natal dispersal. A myriad of additional significant avenues are being pursued as a result of the rich database that has been developed for the GPCH during this research effort. GPCH reproductive data will be collected through the summer of 2011 whereas collection of data from transmitter-equipped GPCH will extend through the lekking season of 2012 to allow estimates of survival of GPCH over the 2011-2012 winter. At the conclusion of the study, the two years of pre-construction data and three years of post-construction data will be analyzed and submitted to peer-reviewed journals for publication.

Erickson et al. (2004) evaluated the displacement effect of a large wind energy facility in the Pacific Northwest. The study was conducted in a relatively homogeneous grassland landscape. Erickson et al. (2004) conducted surveys of breeding grassland birds along 300 meter transects perpendicular to strings of wind turbines. Surveys were conducted prior to construction and after commercial operation. The basic study design follows the Impact Gradient Design (Morrison et al. 2008) and in this application, conformed to a special case of BACI where areas at the distal end of each transect were considered controls (i.e., beyond the influence of the turbines). In this study, there is no attempt to census birds in the area, and observations per survey are used as an index of abundance. Additionally, the impact-gradient study design resulted in less effort than a BACI design with offsite control areas. Erickson et al. (2004) found that grassland passerines as a group, as well as grasshopper sparrows and western meadowlarks, showed reduced use in the first 50 meter segment nearest the turbine string. About half of the area within that segment, however, had disturbed vegetation and separation of behavior avoidance from physical loss of habitat in this portion of the area was impossible. Horned larks and savannah sparrows appeared unaffected. The impact gradient design is best used when the study area is relatively small and homogeneous.

<u>Operational Changes to Reduce Collision Fatality</u>

Arnett et al. (2009) conducted studies on the effectiveness of changing turbine cut-in speed on reducing bat fatality at wind turbines at the Casselman Wind Project in Somerset County, Pennsylvania. Their objectives were to: 1) determine the difference in bat fatalities at turbines with different cut-in-speeds relative to fully operational turbines; and 2) determine the economic costs of the experiment and estimated costs for the entire area of interest under different curtailment prescriptions and timeframes. Arnett et al. (2009) reported substantial reductions in bat fatalities with relatively modest power losses.

In Kenedy County, Texas, investigators are refining and testing a real-time curtailment protocol. The projects use an avian profiling radar system to detect approaching "flying vertebrates" (birds and bats), primarily during spring and fall bird and bat migrations. The blades automatically idle when risk reaches a certain level and weather conditions are particularly risky. Based on estimates of the number and timing of migrating raptors, feathering (real-time curtailment) experiments are underway in Tehuantepec, Mexico, where raptor migration through a mountain pass is extensive.

Other tools, such as thermal imaging (Horn et al. 2008) or acoustic detectors (Kunz et al. 2007), have been used to quantify post-construction bat activity in relation to weather and turbine characteristics for improving operational change efforts. For example, at the Mountaineer project in 2003, Tier 4 studies (weekly searches at every turbine) demonstrated unanticipated and high levels of bat fatalities (Kerns and Kerlinger 2004). Daily searches were instituted in 2004 and revealed that fatalities were strongly associated with low-average-wind-speed nights, thus providing a basis for testing operational changes (Arnett 2005, Arnett et al. 2008). The program also included behavioral observations using thermal imaging that demonstrated higher bat activity at lower wind speeds (Horn et al. 2008).

Studies are currently underway to design and test the efficacy of an acoustic deterrent device to reduce bat fatalities at wind facilities (E.B. Arnett, Bat Conservation International, under the auspices of BWEC). Prototypes of the device have been tested in the laboratory and in the field with some success. Spanjer (2006) tested the response of big brown bats to a prototype eight speaker deterrent emitting broadband white noise at frequencies from 12.5–112.5 kHz and found that during non-feeding trials, bats landed in the quadrant containing the device significantly less when it was broadcasting broadband noise. Spanjer (2006) also reported that during feeding trials, bats never successfully took a tethered mealworm when the device broadcast sound, but captured mealworms near the device in about 1/3 of trials when it was silent. Szewczak and Arnett (2006, 2007) tested the same acoustic deterrent in the field and found that when placed by the edge of a small pond where nightly bat activity was consistent, activity dropped significantly on nights when the deterrent was activated. Horn et al. (2007) tested the effectiveness of a larger, more powerful version of this deterrent device on reducing nightly bat activity and found mixed results. In 2009, a new prototype device was developed and tested at a project in Pennsylvania. Ten turbines were fitted with deterrent devices, daily fatality searches were conducted, and fatality estimates were compared with those from 15 turbines without deterrents (i.e., controls) to determine if bat fatalities were reduced. This experiment found that estimated bat fatalities per turbine were 20 to 53 percent lower at treatment turbines compared to controls.

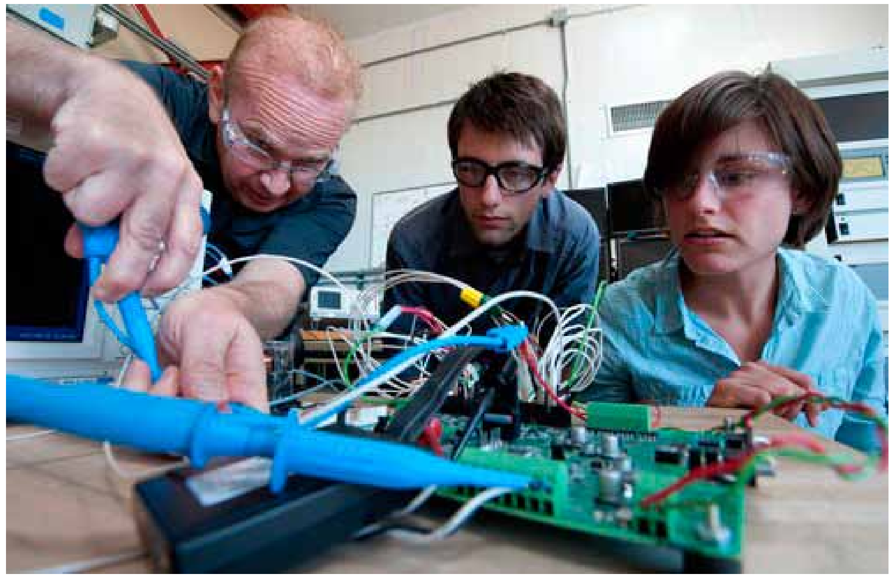
More experimentation is required. At the present time, there is not an operational deterrent available that has demonstrated effective reductions in bat kills (E. B. Arnett, Bat Conservation International, unpublished data).

Assessment of Population-level Impacts

The Altamont Pass Wind Resource Area (APWRA) has been the subject of intensive scrutiny because of avian fatalities, especially for raptors, in an area encompassing more than 5,000 wind turbines (e.g., Orloff and Flannery 1992; Smallwood and Thelander 2004, 2005). Field studies on golden eagles, a long-lived raptor species, have been completed using radio telemetry at APWRA to understand population demographics, assess impacts from wind turbines, and explore measures to effectively reduce the incidence of golden eagle mortality for this area. (Hunt et al. 1999, and Hunt 2002). Results from nesting surveys (Hunt 2002) indicated that there was no decline in eagle territory occupancy. However Hunt (2002) also found that subadult and floater components of golden eagle populations at APWRA are highly vulnerable to wind turbine mortality and results from this study indicate that turbine mortality prevented the maintenance of substantial reserves of nonbreeding adults characteristic of healthy populations elsewhere, suggesting the possibility of an eventual decline in the breeding population (Hunt and Hunt 2006). Hunt conducted follow-up surveys in 2005 (Hunt and Hunt 2006) and determined that all 58 territories occupied by eagle pairs in 2000 were occupied in 2005. It should be noted however that golden eagle studies at APWRA (Hunt et al. 1999, Hunt 2002, and Hunt and Hunt 2006) were all conducted after the APWRA was constructed and the species does not nest within the footprint of the APWRA itself (Figure 4; Hunt and Hunt 2006). The APWRA is an area of about 160 sq. km (Hunt 2002) and presumably golden eagles formerly nested within this area. The loss of breeding eagle pairs from the APWRA suggests these birds have all been displaced by the project, or lost due to various types of mortality including collisions with turbine blades.

Golden eagle. Credit: George Gentry, USFWS

Chapter 7: Best Management Practices



Wind electronic developers. Credit: NREL

Site Construction and Operation

During site planning and development, careful attention to reducing risk of adverse impacts to species of concern from wind energy projects, through careful site selection and facility design, is recommended. The following BMPs can assist a developer in the planning process to reduce potential impacts to species of concern. Use of these BMPs should ensure that the potentially adverse impacts to most species of concern and their habitats present at many project sites would be reduced, although compensatory mitigation may be appropriate at a project level to address significant site-specific concerns and pre-construction study results.

These BMPs will evolve over time as additional experience, learning, monitoring and research becomes available on how to best minimize wildlife and habitat impacts from wind energy projects. Service should work with the industry, stakeholders and states to evaluate, revise and update these BMPs on a periodic basis, and the Service should maintain a readily available publication of recommended, generally accepted best practices.

1. Minimize, to the extent practicable, the area disturbed by pre-construction site monitoring and testing activities and installations.

2. Avoid locating wind energy facilities in areas identified as having a demonstrated and unmitigatable high risk to birds and bats.

3. Use available data from state and federal agencies, and other sources (which could include maps or databases), that show the location of sensitive resources and the results of Tier 2 and/or 3 studies to establish the layout of roads, power lines, fences, and other infrastructure.

4. Minimize, to the maximum extent practicable, roads, power lines, fences, and other infrastructure associated with a wind development project. When fencing is necessary, construction should use wildlife compatible design standards.

5. Use native species when seeding or planting during restoration. Consult with appropriate state and federal agencies regarding native species to use for restoration.

6. To reduce avian collisions, place low and medium voltage connecting power lines associated with the wind energy development underground to the extent possible, unless burial of the lines is prohibitively expensive (e.g., where shallow bedrock exists) or where greater adverse impacts to biological resources would result:

   a. Overhead lines may be acceptable if sited away from high bird crossing locations, to the extent practicable, such as between roosting and feeding areas or between lakes, rivers, prairie grouse and sage grouse leks, and nesting habitats. To the extent practicable, the lines should be marked in accordance with Avian Power Line Interaction Committee (APLIC) collision guidelines.

   b. Overhead lines may be used when the lines parallel tree lines, employ bird flight diverters, or are otherwise screened so that collision risk is reduced.

   c. Above-ground low and medium voltage lines, transformers and conductors should follow the 2006 or most recent APLIC "Suggested Practices for Avian Protection on Power Lines."

7. Avoid guyed communication towers and permanent met towers at wind energy project sites. If guy wires are necessary,

bird flight diverters or high visibility marking devices should be used.

8. Where permanent meteorological towers must be maintained on a project site, use the minimum number necessary.

9. Use construction and management practices to minimize activities that may attract prey and predators to the wind energy facility.

10. Employ only red, or dual red and white strobe, strobe-like, or flashing lights, not steady burning lights, to meet Federal Aviation Administration (FAA) requirements for visibility lighting of wind turbines, permanent met towers, and communication towers. Only a portion of the turbines within the wind project should be lighted, and all pilot warning lights should fire synchronously.

11. Keep lighting at both operation and maintenance facilities and substations located within half a mile of the turbines to the minimum required:

    a. Use lights with motion or heat sensors and switches to keep lights off when not required.

    b. Lights should be hooded downward and directed to minimize horizontal and skyward illumination.

    c. Minimize use of high-intensity lighting, steady-burning, or bright lights such as sodium vapor, quartz, halogen, or other bright spotlights.

    d. All internal turbine nacelle and tower lighting should be extinguished when unoccupied.

12. Establish non-disturbance buffer zones to protect sensitive habitats or areas of high risk for species of concern identified in pre-construction studies. Determine the extent of the buffer zone in consultation with the Service and state, local and tribal wildlife biologists, and land management agencies (e.g., U.S. Bureau of Land Management (BLM) and U.S. Forest Service (USFS)), or other credible experts as appropriate.

13. Locate turbines to avoid separating bird and bat species of concern from their daily roosting, feeding, or nesting sites if documented that the turbines' presence poses a risk to species.

14. Avoid impacts to hydrology and stream morphology, especially where federal or state-listed aquatic or riparian species may be involved. Use appropriate erosion control measures in construction and operation to eliminate or minimize runoff into water bodies.

15. When practical use tubular towers or best available technology to reduce ability of birds to perch and to reduce risk of collision.

16. After project construction, close roads not needed for site operations and restore these roadbeds to native vegetation, consistent with landowner agreements.

17. Minimize the number and length of access roads; use existing roads when feasible.

18. Minimize impacts to wetlands and water resources by following all applicable provisions of the Clean Water Act (33 USC 1251-1387) and the Rivers and Harbors Act (33 USC 301 et seq.); for instance, by developing and implementing a storm water management plan and taking measures to reduce erosion and avoid delivery of road-generated sediment into streams and waters.

19. Reduce vehicle collision risk to wildlife by instructing project personnel to drive at appropriate speeds, be alert for wildlife, and use additional caution in low visibility conditions.

20. Instruct employees, contractors, and site visitors to avoid harassing or disturbing wildlife, particularly during reproductive seasons.

21. Reduce fire hazard from vehicles and human activities (instruct employees to use spark arrestors on power equipment, ensure that no metal parts are dragging from vehicles, use caution with open flame, cigarettes, etc.). Site development and operation plans should specifically address the risk of wildfire and provide appropriate cautions and measures to be taken in the event of a wildfire.

22. Follow federal and state measures for handling toxic substances to minimize danger to water and wildlife resources from spills. Facility operators should maintain Hazardous Materials Spill Kits on site and train personnel in the use of these.

23. Reduce the introduction and spread of invasive species by following applicable local policies for invasive species prevention, containment, and control, such as cleaning vehicles and equipment arriving from areas with known invasive species issues, using locally sourced topsoil, and monitoring for and rapidly removing invasive species at least annually.

24. Use invasive species prevention and control measures as specified by county or state requirements, or by applicable federal agency requirements (such as Integrated Pest Management) when federal policies apply.

25. Properly manage garbage and waste disposal on project sites to avoid creating attractive nuisances for wildlife by providing them with supplemental food.

26. Promptly remove large animal carcasses (e.g., big game,

domestic livestock, or feral animal).

27. Wildlife habitat enhancements or improvements such as ponds, guzzlers, rock or brush piles for small mammals, bird nest boxes, nesting platforms, wildlife food plots, etc. should not be created or added to wind energy facilities. These wildlife habitat enhancements are often desirable but when added to a wind energy facility result in increased wildlife use of the facility which may result in increased levels of injury or mortality to them.

Retrofitting, Repowering, and Decommissioning

As with project construction, these Guidelines offer BMPs for the retrofitting, repowering, and decommissioning phases of wind energy projects.

Retrofitting

Retrofitting is defined as replacing portions of existing wind turbines or project facilities so that at least part of the original turbine, tower, electrical infrastructure or foundation is being utilized. Retrofitting BMPs include:

1. Retrofitting of turbines should use installation techniques that minimize new site disturbance, soil erosion, and removal of vegetation of habitat value.

2. Retrofits should employ shielded, separated or insulated electrical conductors that minimize electrocution risk to avian wildlife per APLIC (2006).

3. Retrofit designs should prevent nests or bird perches from being established in or on the wind turbine or tower.

4. FAA visibility lighting of wind turbines should employ only red, or dual red and white strobe, strobe-like, or flashing lights, not steady burning lights.

5. Lighting at both operation and maintenance facilities and substations located within half a mile of the turbines should be kept to the minimum required:

    a. Use lights with motion or heat sensors and switches to keep lights off when not required.

    b. Lights should be hooded downward and directed to minimize horizontal and skyward illumination.

    c. Minimize use of high intensity lighting, steady-burning, or bright lights such as sodium vapor, quartz, halogen, or other bright spotlights.

6. Remove wind turbines when they are no longer cost effective to retrofit.

Repowering

Repowering may include removal and replacement of turbines and associated infrastructure. BMPs include:

1. To the greatest extent practicable, existing roads, disturbed areas and turbine strings should be re-used in repower layouts.

2. Roads and facilities that are no longer needed should be demolished, removed, and their footprint stabilized and re-seeded with native plants appropriate for the soil conditions and adjacent habitat and of local seed sources where feasible, per landowner requirements and commitments.

3. Existing substations and ancillary facilities should be re-used in repowering projects to the extent practicable.

4. Existing overhead lines may be acceptable if located away from high bird crossing locations, such as between roosting and feeding areas, or between lakes, rivers and nesting areas. Overhead lines may be used when they parallel tree lines, employ bird flight diverters, or are otherwise screened so that collision risk is reduced.

5. Above-ground low and medium voltage lines, transformers and conductors should follow the 2006 or most recent APLIC "Suggested Practices for Avian Protection on Power Lines."

6. Guyed structures should be avoided. If use of guy wires is absolutely necessary, they should be treated with bird flight diverters or high visibility marking devices, or are located where known low bird use will occur.

7. FAA visibility lighting of wind turbines should employ only red, or dual red and white strobe, strobe-like, or flashing lights, not steady burning lights.

8. Lighting at both operation and maintenance facilities and substations located within ½ mile of the turbines should be kept to the minimum required.

    a. Use lights with motion or heat sensors and switches to keep lights off when not required.

    b. Lights should be hooded downward and directed to minimize horizontal and skyward illumination.

Towers are being lifted as work continues on the 2 MW Gamesa wind turbine that is being installed at the NWTC. Credit: NREL

c. Minimize use of high intensity lighting, steady-burning, or bright lights such as sodium vapor, quartz, halogen, or other bright spotlights.

Decommissioning

Decommissioning is the cessation of wind energy operations and removal of all associated equipment, roads, and other infrastructure. The land is then used for another activity. During decommissioning, contractors and facility operators should apply BMPs for road grading and native plant re-establishment to ensure that erosion and overland flows are managed to restore pre-construction landscape conditions. The facility operator, in conjunction with the landowner and state and federal wildlife agencies, should restore the natural hydrology and plant community to the greatest extent practical.

1. Decommissioning methods should minimize new site disturbance and removal of native vegetation, to the greatest extent practicable.

2. Foundations should be removed to a minimum of three feet below surrounding grade, and covered with soil to allow adequate root penetration for native plants, and so that subsurface structures do not substantially disrupt ground water movements. Three feet is typically adequate for agricultural lands.

3. If topsoils are removed during decommissioning, they should be stockpiled and used as topsoil when restoring plant communities. Once decommissioning activity is complete, topsoils should be restored to assist in establishing and maintaining pre-construction native plant communities to the extent possible, consistent with landowner objectives.

4. Soil should be stabilized and re-vegetated with native plants appropriate for the soil conditions and adjacent habitat, and of local seed sources where feasible, consistent with landowner objectives.

5. Surface water flows should be restored to pre-disturbance conditions, including removal of stream crossings, roads, and pads, consistent with storm water management objectives and requirements.

6. Surveys should be conducted by qualified experts to detect populations of invasive species, and comprehensive approaches to preventing and controlling invasive species should be implemented and maintained as long as necessary.

7. Overhead pole lines that are no longer needed should be removed.

8. After decommissioning, erosion control measures should be installed in all disturbance areas where potential for erosion exists, consistent with storm water management objectives and requirements.

9. Fencing should be removed unless the landowner will be utilizing the fence.

10. Petroleum product leaks and chemical releases should be remediated prior to completion of decommissioning.

Chapter 8: Mitigation

Mitigation is defined in this document as avoiding or minimizing significant adverse impacts, and when appropriate, compensating for unavoidable significant adverse impacts, as determined through the tiered approach described in the recommended Guidelines. The Service places emphasis in project planning on first avoiding, then minimizing, potential adverse impacts to wildlife and their habitats. Several tools are available to determine appropriate mitigation, including the Service Mitigation Policy (USFWS Mitigation Policy, 46 FR 7656 (1981)). The Service policy provides a common basis for determining how and when to use different mitigation strategies, and facilitates earlier consideration of wildlife values in wind energy project planning.

Under the Service Mitigation Policy, the highest priority is for mitigation to occur on-site within the project planning area. The secondary priority is for the mitigation to occur off-site. Off-site mitigation should first occur in proximity to the planning area within the same ecological region and secondarily elsewhere within the same ecological region. Generally, the Service prefers on-site mitigation over off-site mitigation because this approach most directly addresses project impacts at the location where they actually occur. However, there may be individual cases where off-site mitigation could result in greater net benefits to affected species and habitats. Developers should work with the Service in comparing benefits among multiple alternatives.

In some cases, a project's effects cannot be forecast with precision. The developer and the agencies may be unable to make some mitigation decisions until post-construction data have been collected. If significant adverse effects have not been adequately addressed, additional mitigation for those adverse effects from operations may need to be implemented.

Mitigation measures implemented post-construction, whether in addition to those implemented pre-construction or whether they are new, are appropriate elements of the tiered approach. The general terms and funding commitments for future mitigation and the triggers or thresholds for implementing such compensation should be developed at the earliest possible stage in project development. Any mitigation implemented after a project is operational should be well defined, bounded, technically feasible, and commensurate with the project effects.

NEPA Guidance on Mitigation

CEQ issued guidance in February 2011 on compliance with the National Environmental Policy Act (NEPA) entitled, "Appropriate Use of Mitigation and Monitoring and Clarifying the Appropriate Use of Mitigated Findings of No Significant Impact." This new guidance clarifies that when agencies premise their Finding of No Significant Impact on a commitment to mitigate the environmental impacts of a proposed action, they should adhere to those commitments, publicly report on those efforts, monitor how they are implemented, and monitor the effectiveness of the mitigation.

To the extent that a federal nexus with a wind project exists, for example, developing a project on federal lands or obtaining a federal permit, the lead federal action agency should make its decision based in part on a developer's commitment to mitigate adverse environmental impacts. The federal action agency should ensure that the developer adheres to those commitments, monitors how they are implemented, and monitors the effectiveness of the mitigation. Additionally, the lead federal action agency should make information on mitigation monitoring available to the public through its web site;

Greater prairie chicken. Credit: Amy Thornburg, USFWS and should ensure that mitigation successfully achieves its goals.

Compensatory Mitigation

Compensatory mitigation as defined in this document refers to replacement of project-induced losses to fish and wildlife resources. Substitution or offsetting of fish and wildlife resource losses with resources considered to be of equivalent biological value.

- **In-kind** – Providing or managing substitute resources to replace the value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate to those lost.

- **Out-of-kind** – Providing or managing substitute resources to replace the value of the resources lost, where such substitute resources are physically or biologically different from those lost. This may include conservation or mitigation banking, research or other options.

The amount of compensation, if necessary, will depend on the effectiveness of any avoidance and minimization measures undertaken. If a proposed wind development is poorly sited with regard to wildlife effects, the most important mitigation opportunity is largely lost and the remaining options can be expensive, with substantially greater environmental effects.

Compensation is most often appropriate for habitat loss under limited circumstances or for direct take of wildlife (e.g., Habitat Conservation Plans). Compensatory mitigation may involve contributing to a fund to protect habitat or otherwise support efforts to reduce existing impacts to species affected by a wind project. Developers should communicate with the Service and state agency prior to initiating such an approach.

Ideally, project impact assessment is a cooperative effort involving the developer, the Service, tribes, local authorities, and state resource agencies. The Service does not expect developers to provide compensation for the same habitat loss more than once. But the Service, state resource agencies, tribes, local authorities, state and federal land management agencies may have different species or habitats of concern, according to their responsibilities and statutory authorities. Hence, one entity may seek mitigation for a different group of species or habitat than does another.

Migratory Birds and Eagles

Some industries, such as the electric utilities, have developed operational and deterrent measures that when properly used can avoid or minimize "take" of migratory birds. Many of these measures to avoid collision and electrocution have been scientifically tested with publication in peer-reviewed, scientific journals. The Service encourages the wind industry to use these measures in siting, placing, and operating all power lines, including their distribution and grid-connecting transmission lines.

E.O. 13186, which addresses responsibilities of federal agencies to protect migratory birds, includes a directive to federal agencies to restore and enhance the habitat of migratory birds as practicable. E.O. 13186 provides a basis and a rationale for compensating for the loss of migratory bird habitat that results from developing wind energy projects that have a federal nexus.

Regulations concerning eagle take permits in 50 CFR 22.26 and 50 CFR 22.27 may allow for compensation as part of permit issuance. Compensation may be a condition of permit issuance in cases of nest removal, disturbance or take resulting in mortality that will likely occur over several seasons, result in permanent abandonment of one or more breeding territories, have large scale impacts, occur at multiple locations, or otherwise contribute to cumulative negative effects. The draft ECP Guidance has additional information on the use of compensation for programmatic permits.

Endangered Species

The ESA has provisions that allow for compensation through the issuance of an Incidental Take Permit (ITP). Under the ESA, mitigation measures are determined on a case by case basis, and are based on the needs of the species and the types of effects anticipated. If a federal nexus exists, or if a developer chooses to seek an ITP under the ESA, then effects to listed species need to be evaluated through the Section 7 and/or Section 10 processes. If an ITP is requested, it and the associated HCP must provide for minimization and mitigation to the maximum extent practicable, in addition to meeting other necessary criteria for permit issuance. For further information about compensation under federal laws administered by the Service, see the Service's Habitat and Resource Conservation website http://www.fws.gov/habitatconservation.

Bald eagle. Credit: USFWS

Chapter 9: Advancing Use, Cooperation and Effective Implementation

This chapter discusses a variety of policies and procedures that may affect the way wind project developers and the Service work with each other as well as with state and tribal governments and non-governmental organizations. The Service recommends that wind project developers work closely with field office staff for further elaboration of these policies and procedures.

Conflict Resolution

The Service and developers should attempt to resolve any issues arising from use of the Guidelines at the Field Office level. Deliberations should be in the context of the intent of the Guidelines and be based on the site-specific conditions and the best available data. However, if there is an issue that cannot be resolved within a timely manner at the field level, the developer and Service staff will coordinate to bring the matter up the chain of command in a stepwise manner.

Bird and Bat Conservation Strategies (BBCS)

The Service has recommended that developers prepare written records of their actions to avoid, minimize and compensate for potential adverse impacts. In the past, the Service has referred to these as Avian and Bat Protection Plans (ABPP). However, ABPPs have more recently been used for transmission projects and less for other types of development. For this reason the Service is introducing a distinct concept for wind energy projects and calling them Bird and Bat Conservation Strategies (BBCS).

Electricity towers and wind turbines. Credit: NREL

Typically, a project-specific BBCS will explain the analyses, studies, and reasoning that support progressing from one tier to the next in the tiered approach. A wind energy project-specific BBCS is an example of a document or compilation of documents that describes the steps a developer could or has taken to apply these Guidelines to mitigate for adverse impacts and address the post-construction monitoring efforts the developer intends to undertake. A developer may prepare a BBCS in stages, over time, as analysis and studies are undertaken for each tier. It will also address the post-construction monitoring efforts for mortality and habitat effects, and may use many of the components suggested in the Suggested Practices for Avian Protection on Power Lines (APLIC 2006). Any Service review of, or discussion with a developer, concerning its BBCS is advisory only, does not result in approval or disapproval of the BBCS by the Service, and does not constitute a federal agency action subject to the National Environmental Policy Act or other federal law applicable to such an action.

Project Interconnection Lines

The Guidelines are designed to address all elements of a wind energy facility, including the turbine string or array, access roads, ancillary buildings, and the above- and below-ground electrical lines which connect a project to the transmission system. The Service recommends that the project evaluation include consideration of the wildlife- and habitat-related impacts of these electrical lines, and that the developer include measures to reduce impacts of these lines, such as those outlined in the Suggested Practices for Avian Protection on Power Lines (APLIC 2006). The Guidelines are not designed to address transmission beyond the point of interconnection to the transmission system. The national grid and proposed smart grid system are beyond the scope of these Guidelines.

Confidentiality of Site Evaluation Process as Appropriate

Some aspects of the initial pre-construction risk assessment, including preliminary screening and site characterization, occur early in the development process, when land or other competitive issues limit developers' willingness to share information on projects with the public and competitors. Any consultation or coordination with agencies at this stage may include confidentiality agreements.

Collaborative Research

Much uncertainty remains about predicting risk and estimating impacts of wind energy development on wildlife. Thus there is a need for additional research to improve scientifically based decision-making when siting wind energy facilities, evaluating impacts on wildlife and habitats, and testing the efficacy of mitigation measures. More extensive studies are needed to further elucidate patterns and test hypotheses regarding possible solutions to wildlife and wind energy impacts.

It is in the interests of wind developers and wildlife agencies to improve these assessments to better mitigate the impacts of wind energy development on wildlife and their habitats. Research can provide data on operational factors (e.g. wind speed, weather conditions) that are likely to result in fatalities. It could also include studies of cumulative impacts of multiple wind energy projects, or comparisons of different methods for assessing avian and bat activity relevant to predicting risk. Monitoring and research should be designed and conducted to ensure unbiased data collection that meets technical standards such as those used in peer review. Research projects may occur at the same time as project-specific Tier 4 and Tier 5 studies.

Research would usually result from collaborative efforts involving appropriate stakeholders, and is not the sole or primary responsibility of any developer. Research partnerships (e.g., Bats and Wind Energy Cooperative (BWEC)[9], Grassland and Shrub Steppe Species Collaborative (GS3C)[10]) involving diverse players will be helpful for generating common goals and objectives and adequate funding to conduct studies (Arnett and Haufler 2003). The National Wind Coordinating Collaborative (NWCC)[11] , the American Wind Wildlife Institute (AWWI)[12] , and the California Energy Commission (CEC)'s Public Interest Energy Research Program[13] all support research in this area.

Study sites and access will be necessary to design and implement research, and developers are encouraged to participate in these research efforts when possible. Subject to appropriations, the Service also should fund priority research and promote collaboration and information sharing among research efforts to advance science on wind energy-wildlife interactions, and to improve these Guidelines.

Service - State Coordination and Cooperation

The Service encourages states to increase compatibility between state guidelines and these voluntary Guidelines, protocols, data collection methods, and recommendations relating to wildlife and wind energy. States that desire to adopt, or those that have formally adopted, wind energy siting, permitting, or environmental review regulations or guidelines are encouraged to cooperate with the Service to develop consistent state level guidelines. The Service may be available to confer, coordinate and share its expertise with interested states when a state lacks its own guidance or program to address wind energy-wildlife interactions. The Service will also use states' technical resources as much as possible and as appropriate.

The Service will explore establishing a voluntary state/federal program to advance cooperation and compatibility between the Service and interested state and local governments for coordinated review of projects under both federal and state wildlife laws. The Service, and interested states, will consider using the following tools to reach agreements to foster consistency in review of projects:

- Cooperation agreements with interested state governments.
- Joint agency reviews to reduce duplication and increase coordination in project review.
- A communication mechanism:
  - To share information about prospective projects
  - To coordinate project review
  - To ensure that state and federal regulatory processes, and/or mitigation requirements are being adequately addressed

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[9] www.batsandwind.org
[10] www.nationalwind.org
[11] www.nationalwind.org
[12] http://www.awwi.org
[13] http://www.energy.ca.gov/research

- To ensure that species of concern and their habitats are fully addressed

- Establishing consistent and predictable joint protocols, data collection methodologies, and study requirements to satisfy project review and permitting.

- Designating a Service management contact within each Regional Office to assist Field Offices working with states and local agencies to resolve significant wildlife-related issues that cannot be resolved at the field level.

- Cooperative state/federal/ industry research agreements relating to wind energy -wildlife interactions.

The Service will explore opportunities to:

- Provide training to states.

- Foster development of a national geographic data base that identifies development-sensitive ecosystems and habitats.

- Support a national database for reporting of mortality data on a consistent basis.

- Establish national BMPs for wind energy development projects.

- Develop recommended guidance on study protocols, study techniques, and measures and metrics for use by all jurisdictions.

- Assist in identifying and obtaining funding for national research priorities.

Wind turbine in California.. Credit: NREL

Service - Tribal Consultation and Coordination

Federally-recognized Indian Tribes enjoy a unique government-to-government relationship with the United States. The United States Fish and Wildlife Service (Service) recognizes Indian tribal governments as the authoritative voice regarding the management of tribal lands and resources within the framework of applicable laws. It is important to recall that many tribal traditional lands and tribal rights extend beyond reservation lands.

The Service consults with Indian tribal governments under the authorities of Executive Order 13175 "Consultation and Coordination with Indian Tribal Governments" and supporting DOI and Service policies. To this end, when it is determined that federal actions and activities may affect a Tribe's resources (including cultural resources), lands, rights, or ability to provide services to its members, the Service must, to the extent practicable, seek to engage the affected Tribe(s) in consultation and coordination.

Tribal Wind Energy Development on Reservation Lands

Indian tribal governments have the authority to develop wind energy projects, permit their development, and establish relevant regulatory guidance within the framework of applicable laws.

The Service will provide technical assistance upon the request of Tribes that aim to establish regulatory guidance for wind energy development for lands under the Tribe's jurisdiction. Tribal governments are encouraged to strive for compatibility between their guidelines and these Guidelines.

Tribal Wind Energy Development on Lands that are not held in Trust

Indian tribal governments may wish to develop wind energy projects on lands that are not held in trust status. In such cases, the Tribes should coordinate with agencies other than the Service. At the request of a Tribe, the Service may facilitate discussions with other regulatory organizations. The Service may also lend its expertise in these collaborative efforts to help determine the extent to which tribal resource management plans and priorities can be incorporated into established regulatory protocols.

Non-Tribal Wind Energy Development – Consultation with Indian Tribal Governments

When a non-Tribal wind energy project is proposed that may affect a Tribe's resources (including cultural resources), lands, rights, or ability to govern or provide services to its members, the Service should seek to engage the affected Tribe(s) in consultation and coordination as early as possible in the process. In siting a proposed project that has a federal nexus, it is incumbent upon the regulatory agency to notify potentially affected Tribes of the proposed activity. If the Service or other federal agency determines that a project may affect a Tribe(s), they should notify the Tribe(s) of the action at the earliest opportunity. At the request of a Tribe, the Service may facilitate and lend its expertise in collaborating with other organizations to help determine the extent to which tribal resource management plans and priorities can be incorporated into established regulatory protocols or project implementation. This process ideally should be agreed to by all involved parties.

In the consultative process, Tribes should be engaged as soon as possible when a decision may affect a Tribe(s). Decisions made that affect Indian Tribal governments without adequate federal effort to engage Tribe(s) in consultation have been overturned by the courts. See, e.g., Quechan Tribe v. U.S. Dep't of the Interior, No. 10cv2241 LAB (CAB), 2010 WL 5113197 (S.D. Cal. Dec. 15, 2010). When a tribal government is consulted, it is neither required, nor expected that all of the Tribe's issues can be resolved in its favor. However, the Service must listen and may not arbitrarily dismiss concerns of the tribal government. Rather, the Service must seriously consider and respond to all tribal concerns. Regional Native American Liaisons are able to provide in-house guidance as to government-to-government consultation processes. (See Service - State Coordination and Cooperation, above).

Non-Governmental Organization Actions

If a specific project involves actions at the local, state, or federal level that provide opportunities for public participation, non-governmental organizations (NGOs) can provide meaningful contributions to the discussion of biological issues associated with that project, through the normal processes such as scoping, testimony at public meetings, and comment processes. In the absence of formal public process, there are many NGOs that have substantial scientific capabilities and may have resources that could contribute productively to the siting of wind energy projects. Several NGOs have made significant contributions to the understanding of the importance of particular geographic areas to wildlife in the United States. This work has benefited and continues to benefit from extensive research efforts and from associations with highly qualified biologists. NGO expertise can – as can scientific expertise in the academic or private consulting sectors – serve highly constructive purposes. These can include:

- Providing information to help identify environmentally sensitive areas, during the screening phases of site selection (Tiers 1 and 2, as described in this document)
- Providing feedback to developers and agencies with respect to specific sites and site and impact assessment efforts
- Helping developers and agencies design and implement mitigation or offset strategies
- Participating in the defining, assessing, funding, and implementation of research efforts in support of improved predictors of risk, impact assessments and effective responses
- Articulating challenges, concerns, and successes to diverse audiences

Non-Governmental Organization Conservation Lands

Implementation of these Guidelines by Service and other state agencies will recognize that lands owned and managed by non-government conservation organizations represent a significant investment that generally supports the mission of state and federal wildlife agencies. Many of these lands represent an investment of federal conservation funds, through partnerships between agencies and NGOs. These considerations merit extra care in the avoidance of wind energy development impacts to these lands. In order to exercise this care, the Service and allied agencies can coordinate and consult with NGOs that own lands or easements which might reasonably be impacted by a project under review.

Appendix A: Glossary

Accuracy – The agreement between a measurement and the true or correct value.

Adaptive management – An iterative decision process that promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from management actions and other events become better understood. Comprehensively applying the tiered approach embodies the adaptive management process.

Anthropogenic – Resulting from the influence of human beings on nature.

Area of interest – For most projects, the area where wind turbines and meteorological (met) towers are proposed or expected to be sited, and the area of potential impact.

Avian – Pertaining to or characteristic of birds.

Avoid – To not take an action or parts of an action to avert the potential effects of the action or parts thereof. First of three components of "mitigation," as defined in Service Mitigation Policy. (See mitigation.)

Before-after/control-impact (BACI) – A study design that involves comparisons of observational data, such as bird counts, before and after an environmental disturbance in a disturbed and undisturbed site. This study design allows a researcher to assess the effects of constructing and operating a wind turbine by comparing data from the "control" sites (before and undisturbed) with the "treatment" sites (after and disturbed).

Best management practices (BMPs) – Methods that have been determined by the stakeholders to be the most effective, practicable means of avoiding or minimizing significant adverse impacts to individual species, their habitats or an ecosystem, based on the best available information.

Buffer zone – A zone surrounding a resource designed to protect the resource from adverse impact, and/or a zone surrounding an existing or proposed wind energy project for the purposes of data collection and/or impact estimation.

Community-scale – Wind energy projects greater than 1 MW, but generally less than 20 MW, in name-plate capacity, that produce electricity for off-site use, often partially or totally owned by members of a local community or that have other demonstrated local benefits in terms of retail power costs, economic development, or grid issues.

Comparable site – A site similar to the project site with respect to topography, vegetation, and the species under consideration.

Compensatory mitigation – Replacement of project-induced losses to fish and wildlife resources. Substitution or offsetting of fish and wildlife resource losses with resources considered to be of equivalent biological value.

- **In-kind** – Providing or managing substitute resources to replace the value of the resources lost, where such substitute resources are physically and biologically the same or closely approximate to those lost.

- **Out-of-kind** – Providing or managing substitute resources to replace the value of the resources lost, where such substitute resources are physically or biologically different from those lost. This may include conservation or mitigation banking, research or other options.

Cost effective – Economical in terms of tangible benefits produced by money spent.

Covariate – Uncontrolled random variables that influence a response to a treatment or impact, but do not interact with any of the treatments or impacts being tested.

Critical habitat – For listed species, consists of the specific areas designated by rule making pursuant to Section 4 of the Endangered Species Act and displayed in 50 CFR § 17.11 and 17.12.

Cumulative impacts – See impact.

Curtailment – The act of limiting the supply of electricity to the grid during conditions when it would normally be supplied. This is usually accomplished by cutting-out the generator from the grid and/or feathering the turbine blades.

Cut-in Speed – The wind speed at which the generator is connected to the grid and producing electricity. It is important to note that turbine blades may rotate at full RPM in wind speeds below cut-in speed.

Displacement – The loss of habitat as result of an animal's behavioral avoidance of otherwise suitable habitat. Displacement may be short-term, during the construction phase of a project, temporary as a result of habituation, or long-term, for the life of the project.

Distributed wind – Small and mid-sized turbines between 1 kilowatt and 1 megawatt that are installed and produce electricity at the point of use to off-set all or a portion of on-site energy consumption.

Ecosystem – A system formed by the interaction of a community of organisms with their physical and chemical environment. All of the biotic elements (i.e., species, populations, and communities) and abiotic elements (i.e., land, air, water, energy) interacting in a given geographic area so that a flow of energy leads to a clearly defined trophic structure, biotic diversity, and material cycles. Service Mitigation Policy adopted definition from E. P. Odum 1971 Fundamentals of Ecology.

Edge effect – The effect of the juxtaposition of contrasting environments on an ecosystem.

Endangered species – See listed species.

Extirpation – The species ceases to exist in a given location; the species still exists elsewhere.

Fatality – An individual instance of death.

Fatality rate – The ratio of the number of individual deaths to some parameter of interest such as megawatts of energy produced, the number of turbines in a wind project, the number of individuals exposed, etc., within a specified unit of time.

Feathering – Adjusting the angle of the rotor blade parallel to the wind, or turning the whole unit out of the wind, to slow or stop blade rotation.

Federal action agency – A department, bureau, agency or instrumentality of the United States which plans, constructs, operates or maintains a project, or which reviews, plans for or approves a permit, lease or license for projects, or manages federal lands.

Federally listed species – See listed species.

Footprint – The geographic area occupied by the actual infrastructure of a project such as wind turbines, access roads, substation, overhead and underground electrical lines, and buildings, and land cleared to construct the project.

G1 (Global Conservation Status Ranking) Critically Imperiled – At very high risk of extinction due to extreme rarity (often five or fewer populations), very steep declines, or other factors.

G2 (Global Conservation Status Ranking) Imperiled – At high risk of extinction or elimination due to very restricted range, very few populations, steep declines, or other factors.

G3 (Global Conservation Status Ranking) Vulnerable – At moderate risk of extinction or elimination due to a restricted range, relatively few populations, recent and widespread declines, or other factors.

Guy wire – Wires used to secure wind turbines or meteorological towers that are not self-supporting.

Habitat – The area which provides direct support for a given species, including adequate food, water, space, and cover necessary for survival.

Habitat fragmentation – Habitat fragmentation separates blocks of habitat for some species into segments, such that the individuals in the remaining habitat segments may suffer from effects such as decreased survival, reproduction, distribution, or use of the area.

Impact – An effect or effects on natural resources and on the components, structures, and functioning of affected ecosystems.

- **Cumulative** – Changes in the environment caused by the aggregate of past, present and reasonably foreseeable future actions on a given resource or ecosystem.
- **Direct** – Effects on individual species and their habitats caused by the action, and occur at the same time and place.
- **Indirect impact** – Effects caused by the action that are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect impacts include displacement and changes in the demographics of bird and bat populations.

Infill – Add an additional phase to the existing project, or build a new project adjacent to existing projects.

In-kind compensatory mitigation – See compensatory mitigation.

Intact habitat – An expanse of habitat for a species or landscape scale feature, unbroken with respect to its value for the species or for society.

Intact landscape – Relatively undisturbed areas characterized by maintenance of most original ecological processes and by communities with most of their original native species still present.

Lattice design – A wind turbine support structure design characterized by horizontal or diagonal lattice of bars forming a tower rather than a single tubular support for the nacelle and rotor.

Lead agency – Agency that is responsible for federal or non-federal regulatory or environmental assessment actions.

Lek – A traditional site commonly used year after year by males of certain species of birds (e.g., greater and lesser prairie-chickens, sage and sharp-tailed grouse, and buff-breasted sandpiper), within which the males display communally to attract and compete for female mates, and where breeding occurs.

Listed species – Any species of fish, wildlife or plant that has been determined to be endangered or threatened under section 4 of the Endangered Species Act (50 CFR §402.02), or similarly designated by state law or rule.

Local population – A subdivision of a population of animals or plants of a particular species that is in relative proximity to a project.

Loss – As used in this document, a change in wildlife habitat due to human activities that is considered adverse and: 1) reduces the biological value of that habitat for species of concern; 2) reduces population numbers of species of concern; 3) increases population numbers of invasive or exotic species; or 4) reduces the human use of those species of concern.

Megawatt (MW) – A measurement of electricity-generating capacity equivalent to 1,000 kilowatts (kW), or 1,000,000 watts.

Migration – Regular movements of wildlife between their seasonal ranges necessary for completion of the species lifecycle.

Migration corridor – Migration routes and/or corridors are the relatively predictable pathways that a migratory species travel between seasonal ranges, usually breeding and wintering grounds.

Migration stopovers – Areas where congregations of wildlife assemble during migration. Such areas supply high densities of food or shelter.

Minimize – To reduce to the smallest practicable amount or degree.

Mitigation – (Specific to these Guidelines) Avoiding or minimizing significant adverse impacts, and when appropriate, compensating for unavoidable significant adverse impacts.

Monitoring – 1) A process of project oversight such as checking to see if activities were conducted as agreed or required; 2) making measurements of uncontrolled events at one or more points in space or time with space and time being the only experimental variable or treatment; 3) making measurements and evaluations through time that are done for a specific purpose, such as to check status and/or trends or the progress towards a management objective.

Mortality rate – Population death rate, typically expressed as the ratio of deaths per 100,000 individuals in the population per year (or some other time period).

Operational changes – Deliberate changes to wind energy project operating protocols, such as the wind speed at which turbines "cut in" or begin generating power, undertaken with the object of reducing collision fatalities. Considered separately from standard mitigation measures due to the fact that operational changes are considered as a last resort and will rarely be implemented if a project is properly sited.

Passerine – Describes birds that are members of the Order Passeriformes, typically called "songbirds."

Plant communities of concern –Plant communities of concern are unique habitats that are critical for the persistence of highly specialized or unique species and communities of organisms. Often restricted in distribution or represented by a small number of examples, these communities are biological hotspots that significantly contribute to the biological richness and productivity of the entire region. Plant communities of concern often support rare or uncommon species assemblages, provide critical foraging, roosting, nesting, or hibernating habitat, or perform vital ecosystem functions. These communities often play an integral role in the conservation of biological integrity and diversity across the landscape. (Fournier et al. 2007) Also, any plant community with a Natural Heritage Database ranking of S1, S2, S3, G1, G2, or G3.

Population – A demographically and genetically self-sustaining group of animals and/or plants of a particular species.

Practicable – Capable of being done or accomplished; feasible.

Prairie grouse – A group of gallinaceous birds, includes the greater prairie-chicken, the lesser prairie-chicken, and the sharp-tailed grouse.

Project area – The area that includes the project site as well as contiguous land that shares relevant characteristics.

Project commencement – The point in time when a developer begins its preliminary evaluation of a broad geographic area to assess the general ecological context of a potential site or sites for wind energy project(s). For example, this may include the time at which an option is acquired to secure real estate interests, an application for federal land use has been filed, or land has been purchased.

Project Site – The land that is included in the project where development occurs or is proposed to occur.

Project transmission lines – Electrical lines built and owned by a project developer.

Raptor – As defined by the American Ornithological Union, a group of predatory birds including hawks, eagles, falcons, osprey, kites, owls, vultures and the California condor.

Relative abundance – The number of organisms of a particular kind in comparison to the total number of organisms within a given area or community.

Risk – The likelihood that adverse effects may occur to individual animals or populations of species of concern, as a result of development and operation of a wind energy project. For detailed discussion of risk and risk assessment as used in this document see Chapter One - General Overview.

Rotor – The part of a wind turbine that interacts with wind to produce energy. Consists of the turbine's blades and the hub to which the blades attach.

Rotor-swept area – The area of the circle or volume of the sphere swept by the turbine blades.

Rotor-swept zone – The altitude within a wind energy project which is bounded by the upper and lower limits of the rotor-swept area and the spatial extent of the project.

S1 (Subnational Conservation Status Ranking) Critically Imperiled – Critically imperiled in the jurisdiction because of extreme rarity or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation from the jurisdiction.

S2 (Subnational Conservation Status Ranking) Imperiled – Imperiled in the jurisdiction because of rarity due to very restricted range, very few populations, steep declines, or other factors making it very vulnerable to extirpation from jurisdiction.

S3 (Subnational Conservation Status Ranking) Vulnerable – Vulnerable in the jurisdiction due to a restricted range, relatively few populations, recent and widespread declines, or other factors making it vulnerable to extirpation.

Sage grouse – A large gallinaceous bird living in the sage steppe areas of the intermountain west, includes the greater sage grouse and Gunnison's sage grouse.

Significant – For purposes of characterizing impacts to species of concern and their habitats, "significance" takes into account the duration, scope, and intensity of an impact. Impacts that are very brief or highly transitory, do not extend beyond the immediate small area where they occur, and are minor in their intensity are not likely to be significant. Conversely, those that persist for a relatively long time, encompass a large area or extend well beyond the immediate area where they occur, or have substantial consequences are almost certainly significant. A determination of significance may include cumulative impacts of other actions. There is probably some unavoidable overlap among these three characteristics, as well as some inherent ambiguity in these terms, requiring the exercise of judgment and the development of a consistent approach over time.

Species of concern – For a particular wind energy project, any species which 1) is either a) listed as an endangered, threatened or candidate species under the Endangered Species Act, subject to the Migratory Bird Treaty Act or Bald and Golden Eagle Protection Act; b) is designated by law, regulation, or other formal process for protection and/or management by the relevant agency or other authority; or c) has been shown to be significantly adversely affected by wind energy development, and 2) is determined to be possibly affected by the project.

Species of habitat fragmentation concern—Species of concern for which a relevant federal, state, tribal, and/or local agency has found that separation of their habitats into smaller blocks reduces connectivity such that the individuals in the remaining habitat segments may suffer from effects such as decreased survival, reproduction, distribution, or use of the area. Habitat fragmentation from a wind energy project may create significant barriers for such species.

String – A number of wind turbines oriented in close proximity to one another that are usually sited in a line, such as along a ridgeline.

Strobe – Light consisting of pulses that are high in intensity and short in duration.

Threatened species – See listed species.

Tubular design – A type of wind turbine support structure for the nacelle and rotor that is cylindrical rather than lattice.

Turbine height – The distance from the ground to the highest point reached by the tip of the blades of a wind turbine.

Utility-scale – Wind projects generally larger than 20 MW in nameplate generating capacity that sell electricity directly to utilities or into power markets on a wholesale basis.

Voltage (low and medium) – Low voltages are generally below 600 volts, medium voltages are commonly on distribution electrical lines, typically between 600 volts and 110 kV, and voltages above 110 kV are considered high voltages.

Wildlife – Birds, fishes, mammals, and all other classes of wild animals and all types of aquatic and land vegetation upon which wildlife is dependent.

Wildlife management plan – A document describing actions taken to identify resources that may be impacted by proposed development; measures to mitigate for any significant adverse impacts; any post-construction monitoring; and any other studies that may be carried out by the developer.

Wind turbine – A machine for converting the kinetic energy in wind into mechanical energy, which is then converted to electricity..

Appendix B: Literature Cited

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Appendix C: Sources of Information Pertaining to Methods to Assess Impacts to Wildlife

The following is an initial list of references that provide further information on survey and monitoring methods. Additional sources may be available.

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http://www.fws.gov

March 2012

Statement of Safety and Health Commitments

Pattern Energy is committed to the safety and health of our employees, contractors, and people in the communities where we work. There is nothing more important than having our people return home safely at the end of each workday. We incorporate safety and wellness into our decision making in everything we do. We believe in having an injury-free workplace, and we aspire to create an environment where this is possible. To this end, Pattern Energy strives to:

- Follow all applicable health and safety laws and regulations as our minimum standard.
- Engage our employees to identify potential hazards and develop proper mitigations.
- Provide training to all employees so they may recognize and mitigate risks.
- Empower our workforce to use their “stop work” authority to halt activity if they perceive a hazard that may endanger themselves or others.
- Identify root causes and learn from any accidents that may occur.
- Construct our projects and operate our facilities using best practices to prevent injury to employees, contractors, and the public.
- Contract with companies that share our values and commit to supporting our vision of an injury-free workplace.
- Work to monitor, report, and continually improve our overall safety performance.

Statement of Environmental Commitments

Pattern Energy is committed to protecting the environment. We believe climate change is the world's biggest environmental challenge, and producing energy from clean, renewable sources is essential to reducing the global carbon footprint. We consider it our responsibility to produce and transport renewable energy to consumers in a way that respects the integrity of our environment. To this end, Pattern Energy strives to:

- Develop, construct, and operate responsibly by complying with all environmental laws and regulations as our minimum standard and implementing best practices where local regulations are not as stringent.
- Assess potential positive and negative ecological impacts and incorporate them into our decision-making, applying our creative spirit and energy to explore sustainable mitigation solutions to minimize adverse effects.
- Listen to people in communities where we work, including community representatives and natural resource agencies, during the planning of our projects.
- Site and design our projects in a manner that respects wildlife and their habitats.
- Construct our projects using best practices to prevent pollution and conserve our natural resources.
- Work to monitor, report, and continually improve our overall environmental performance.

Statement of Community and Cultural Commitments

Pattern Energy considers our company to be a part of the local communities where we have a presence. We believe acting as a good neighbor benefits both the areas where we operate and our company's long-term success. We are committed to listening to and respecting the communities that host our projects and being involved in engagement and giving activities for the long term. To this end, Pattern Energy strives to:

- Share information and solicit input to build local relationships while respecting and considering all points of view.
- Explore ways to support the growth of healthy and vibrant communities where we work through sponsorships and donations.
- Identify and assess potential positive and negative community and cultural impacts to inform our planning and decision-making.
- Design and construct our projects and operate our facilities in a manner that complies with all siting regulations.
- Work to monitor, report, and continually improve our overall performance, incorporating feedback into our outreach and giving programs.

Statement of Diversity, Equity, and Inclusion Commitments

Pattern Energy is committed to a diverse, equitable, and inclusive workplace where all employees belong, regardless of gender, gender identity, race, ethnicity, national origin, age, sexual orientation, religion, or ability. We believe having diversity in our teams and our leadership, while providing an environment where employees from underrepresented groups are encouraged and empowered, leads to a more engaged workforce and better business outcomes. We recognize diversity, equity, and inclusion are multifaceted and changing behaviors and systems takes work and time. We pledge to take actions that result in lasting change at Pattern Energy by committing to the following:

- Develop and act on strategic action plans to ensure our Diversity, Equity, and Inclusion (DE&I) commitments achieve concrete results and prioritize and drive accountability.
- Identify, track, and report on DE&I performance metrics and progress on DE&I initiatives.
- Determine and address DE&I barriers that impact talent acquisition and development, retention, recognition, and advancement.
- Create a community where employees are comfortable bringing their authentic selves to work and are open to participating in difficult conversations, allowing employees to gain greater awareness of each other's experiences and perspectives.
- Encourage, support, and resource our employee-led Affinity Networks.
- Support the Pattern Energy DE&I Council to provide input into our DE&I initiatives.
- Enhance our culture by demonstrating these commitments throughout all levels of the organization.

Building Wildlife-Friendly Wind

As a renewable energy company, Pattern Energy is committed to protecting the environment. We consider it our responsibility to provide renewable energy with the least amount of impact to the environment, especially when it comes to wildlife.

Pattern Energy follows in-depth wildlife protection protocols at all of our wind farms. In fact, we are one of the industry leaders in promoting environmentally-friendly wind energy, while conserving and protecting wildlife. Take a look at some of what we do to ensure that we build wildlife-friendly wind energy:

1. Identify Potential Impacts From the Start

With every new wind farm, we study and identify the wildlife that could potentially be affected by our activities before we move forward with any project.

2. Build Wisely

Once we've selected a specific location to build a wind farm, our team begins conducting studies, consulting with regulatory agencies and other stakeholders, and working with other departments at key stages of development to ensure that we:

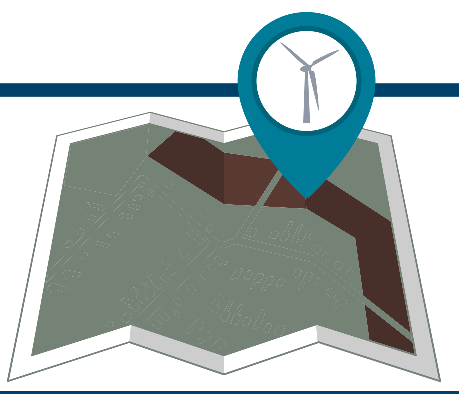
A. Avoid Impact

If there are certain areas of a site that could significantly affect wildlife, we will try to avoid that area and build around it.

***Example:** If there's an eagle nest nearby, Pattern Energy will try to site project turbines away from that nest.*

B. Minimize Impact

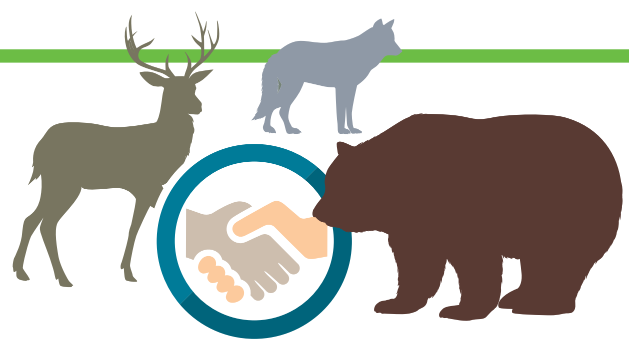
When avoidance isn't feasible, we try to minimize impacts.



***Example:** If project areas contain native prairie grassland, we will try to microsite turbines in already disturbed areas such as cropland. This helps to preserve the intact habitat that could be utilized by grouse species like prairie chickens, which are species of habitat fragmentation concern.*

C. Mitigate Impact

When avoidance and minimization isn't enough to reduce significant adverse impacts, we provide compensatory mitigation.



***Example:** If impacts are unavoidable, Pattern may provide compensatory mitigation such as the purchase and management of prime habitat for at risk wildlife in the area.*

***Example:** If we're in an area where there are endangered bats, we will employ various mitigation measures such as cave gating and operate our turbines in a manner that reduces impacts to bats during crucial migration periods.*

3. Monitor the Area

Our work of protecting wildlife doesn't stop once the site is up and running. We make sure that all on-site employees are mindful of local wildlife and train them in the proper protocol to avoid, minimize and mitigate impacts.

Monitoring is different and specialized for each location. Whether it's sending a biomonitor out to make sure we aren't affecting nearby endangered lizards or physically relocating species so they aren't impacted by the turbines, we employ a diverse set of tools to address specific issues of each project.

At Pattern Energy, we believe that it is fundamental to produce energy in a way that respects the integrity of our natural environment. Through our protocols, we work to continually improve our overall environmental performance so we can protect the environment, especially wildlife, at all of our wind farms.

To learn more about our environmental protocol, contact Rene Braud at rene.braud@patternenergy.com today.

Exhibit ACC-5

Category	No.	Final BMP Language
Design	1	New surface disturbance will be minimized within 200 feet of the boundary of riparian areas, wetlands, playas or other water bodies (e.g., the ordinary high water mark) to the extent practicable. Where avoidance is not practicable, impacts will be minimized and comply with the U.S. Army Corps of Engineers Nationwide Permit under Section 404 of the Clean Water Act. Boring under these water features may be utilized where practicable and designs are approved. To minimize new surface disturbance within 200 feet of the boundary of any riparian area, wetland, playa or other water body means: only temporary use will be allowed; no blading, grading, or digging; no permanent structures; no permanent roads (with the exception of the permanent maintenance road where no other route is possible, but never across playas); no introduction of outside material, (ie gravel, caliche, base course), no mechanical compaction, and full reclamation requirements for any temporary use: flipping or ripping compacted temporary use areas if necessary; reseeding, weed control, re-contouring to previous condition. For any permanent maintenance road crossing a riparian area, to minimize new surface disturbance means the minimium width that is absolutely necessary, and the road must be designed to allow the natural hydrology of the basin to continue functioning as if the road was not there: built to allow water to move under, through or across the road, without catchments or pooling or channeling, with erosion control structures and flow dispersal structures as necessary, and plantings as necessary to manage hydrologic functioning condition.
	2	All efforts should be made to minimize new surface disturbance: new roads and rights-of-way should make use of pre-existing disturbed areas, including existing roadbeds, pipeline or utility line rights-of-way, or in pre-existing or dedicated corridors when practicable.
	3	No new surface disturbance will be permitted within 200' feet of the centerline of ephemeral drainages, floodways, arroyos or other short duration flow channels, except when crossing these channels and drainages. Where avoidance is not practicable, impacts will be minimized and comply with the U.S. Army Corps of Engineers Nationwide Permit under Section 404 of the Clean Water Act. Drainage crossings will be perpendicular to flow, and will be built to accommodate 25-year flood events and to control erosion. Boring under these water features may be utilized where practicable and designs are approved.
	4	Establish property boundaries.
	5	Minimize new surface disturbance and design for minimum necessary width/area of impact according to expected purpose and use.
	6	Avoid wetlands, known critical habitat and protected areas;
	7	Avoid steep slopes (>12%) where practicable; grades from 4-10% are preferred for managing drainage; roads and rights-of-way are best placed at the toe of slopes where cross slope is between 5% and 40%
	8	Preserve as much natural vegetation and living root structure as possible. If the material is less than three inches in diameter, lopping and scattering is permitted. If greater than three inches, the material can be chipped or masticated then spread to no thicker than four and a half inches.
	9	Provide adequate surface drainage; as grade steepens drainage features, such as water bars, must be closer together; drainage features on fine grained soils should be closer together;

10	Account for cultural resources at least in accordance with minimum standards as set forth in NMSLO policy ADM-0106	
11	Account for biological resources at least in accordance with minimum standards as set forth in NMSLO Policy ADM-0105	
12	Include a spill containment and prevention plan where hazardous materials are involved	
13	Include a reclamation plan detailing soil stabilization and revegetation process;	
14	Include an access control plan	
15	All reclamation success criteria shall follow federal NPDES guidelines whereas a minimum of 70% density (of pre-existing conditions) of native flora shall be successfully reestablished prior to release from permit requirements for ongoing inspections and maintenance of temporary ESC BMPs.	
16	Use only native weed-free certified seed for reclamation	
17	Include a noxious weed prevention plan	ADDED
18	Include a dust abatement plan	ADDED

Land Office Required Practices for Surface Users			
		19	Address crown, inslope, outslope and shoulder design (roads)
		20	Address trenching and boring design, including depth, casing, core sampling, valve location and access management (pipelines)
		21	Define use, location and size of temporary work space, temporary storage and turnouts;
		22	Address logistics of construction;
		1	Address all pertinent state and federal regulations.
		2	Control access to the construction site;
		3	Control unauthorized use of space adjacent to permitted rights-of-way and use areas
		4	Maintain temporary erosion control structures, such as silt fencing to prevent sediment flow during construction
		5	All water utilized for dust abatement shall be suitable for meeting federal NPDES guidelines for revegetation, whereby a minimum of 70% density (of pre-existing conditions) of native flora shall be successfully reestablished prior to release from permit requirements for ongoing inspections and maintenance of temporary ESC BMPs
		6	When requested by the Commissioner, engage a compliance inspection officer to monitor quality control and compliance with NMSLO best management practices
		7	Sample, test and monitor to ensure construction materials meet design specifications;
		1	Dispose of unsuitable or excess excavation material in approved locations to minimize adverse impacts to water quality or other resources.
		2	Grade and shape roadway surfaces to maintain distinct inslope, outslope or crown shape to move water effectively off the road surface

New Mexico State		3	Compact graded roadway surfaces to preserve hard driving surface; replace surface material when needed; implement dust abatement plans
		4	Fill ruts and potholes with gravel or compacted fill or remove ruts through rolling dips and water bars; reshape structures to maintain proper function
		5	Clean ditches and reshape when necessary to allow adequate flow capacity;
		6	Remove debris from the entrance of culverts to prevent plugging and overtopping; check for signs of damage
		7	Replace or repair rock armor, erosion control structures, or vegetation used for slope protection, scour protection or energy dissipation
		8	Inspect and repair fencing, gates, cattle-guards and other access control structures;
		1	Inspect reclamation, revegetation and noxious weed treatments and retreat as necessary to maintain proper functioning of erosion control and establishment of native vegetation
		2	Seek a remediation right-of-entry for any reclamation of state trust land outside the bounds of the permitted right-of-way
		3	Verify compliance with NMSLO biological and cultural resource policies (ADM-0105 and ADM-0106) for the area to be reclaimed;
		4	Sample, remove and properly dispose of any contaminated soils
		5	Remove and properly dispose of any caliche or other surface base course
		6	Contaminated soils and caliche should be disposed of only in state permitted disposal locations, such as land farms or hazardous disposal sites

	Reclamation	7	Replace caliche, base course or contaminated soils with certified clean top soil comparable to undisturbed clean soils in the near vicinity
		8	Contour the ground surface to blend in with the surrounding topography and to allow the natural hydrology of the basin to function without impediment or impact;
		9	Install erosion control structures as necessary to repair and control gullies, head-cuts, rills, and other forms of sediment movement
		10	Erosion control structures should be designed to restore natural hydrologic function and to the extent possible should use local rock or bio-degradable materials and low-energy, minimum necessary designs;
		11	Structures may include, but are not limited to, one rock dams, rock mulch rundowns, zuni bowls, media lunas, swales, berms, terraces, wattles, rock or log mats, hay mulch, gabions, bales or other stabilizing enhancements to control erosion
		12	Prepare the seedbed to maximize potential for success. This may include, but is not limited to, a combination of watering, mechanical packing to consolidate loose soils, disking to loosen compacted soils, or crimping hay mulch into the soil, (2 tons/acre), adding soil amendments, contouring and/or importing top soil

		13	Install water bars, or other NMSLO approved flow control, at an angle of 30% to the grade along the contour of the road or right-of-way, up to two feet high and six feet wide; water bars should be placed on any slope greater than level, every ten feet in elevation change or every 300 feet, whichever is less	
		14	Seed the prepared seedbed with a drill seeder or hydraulic seeder. Hydroseeding will be used on 3:1 slopes or greater. The seed mix will be based on NMSLO revegetation guidelines and will be provided or approved by the NMSLO;	
		15	In the event of a spill or hazardous materials release, the project SPCC Plan guidelines must be followed and reporting requirements set forth by NMED shall be followed. Provide draft copy of SPCC Plan to SLO for approval.	
		16	A noxious weed plan will be developed and noxious weeds will be monitored and treated on an annual basis, or as needed, for three years post construction.	ADDED
	Category			
	Objective		To reduce and prevent erosion, remove contaminants and contaminated materials, restore clean soils, restore native plant diversity and abundance, restore and maintain hydrological regime, and restore and maintain productive habitat for livestock and wildlife;	

Applicability		These Minimum Requirements are applicable to all reclamation activities on state trust lands including: hazardous materials spills/releases, site closure for oil and gas, mineral and business leases, plug and abandon site reclamation, mine site reclamation, pit, pad, or pond reclamation, illegal dump reclamation, road and pipeline reclamation, dairy farm or other agricultural impact reclamation, and any other clean up or reclamation activity on state trust land;
Access	**1**	If the spill/release or reclamation project extends beyond the lease boundary or permitted right of way, contact the NMSLO Rights Of Way Division and obtain a remediation right-of-entry;
Compliance	**2**	Before commencing any new ground disturbing activity:
	3	(a). Conduct an archaeological survey of the impacted area, or verify that the area has already been surveyed and that no cultural properties will be impacted by ground disturbing activities;
	4	(b). If cultural properties have been impacted by a spill/release or reclamation project, immediately stop all ground disturbing activities and contact NMSLO for further direction;
	5	(c). Verify compliance with NMSLO biological and cultural resource policies (ADM-0105 and ADM-0106) for the area to be reclaimed; conduct surveys where necessary;
	6	(d). Verify compliance with all state and federal regulations, including but not limited to storm water pollution and prevention, air quality control, and hazardous materials disposal;
	7	Other Spills/Releases: (i). Upon discovery of any non-oil and gas related hazardous material release, including mine waste, either current or historic, immediately notify NMED and NMSLO;

emens for Surface Reclamation

Delineation	**8**	Upon discovery of contaminated soils, delineate the horizontal and vertical extent of the contamination;
	9	For any spill on State Trust Lands: Written Report for all spills. For spills greater than 25 gallons, immediate notification (email address to be defined) to SLO within 24 hours
	10	For non-oil and gas related contamination, the NMED may require delineation and monitoring related to surface and ground water impacts
	11	The NMSLO may require any necessary sampling or reclamation related to the restoration of surface conditions within 60 days post-notification.
Reclamation Plan	**12**	A project revegetation plan will be designed to meet NPDES requirements and submitted to NMSLO for review and approval.
Removal/Containment	**13**	Remove and replace, or stabilize and contain any contaminated soils, including contaminated caliche or base course; remove and replace all caliche or base course; contaminated soils and caliche should be disposed of only in state permitted disposal locations, such as land farms or hazardous disposal sites, and in accordance with state and federal regulations
Soil Replacement	**14**	Replace contaminated soils, caliche or base course, and uncontaminated caliche or base course, with certified clean top soil; soils should have comparable structure and chemistry to healthy, native undisturbed soils in the vicinity;
Trash and Debris	**15**	Unless equipment is to be re-used onsite, any trash, debris, garbage, rubbish, junk, scrap, or broken or contaminated equipment, such as pipelines, plastic lining, surface flowlines, tanks, scrap materials of any kind, or other equipment must be removed and disposed of in accordance with state and federal regulations within 30 days of final use or completion of construction;
	16	No hazardous substances, trash or litter will be buried or placed in pits
Surface Preparation	**17**	Contour the ground surface to blend in with the surrounding topography to allow the natural hydrology of the basin to function without impediment or impact;

New Mexico State Land Office Minimum Requir

	18	No major depressions or pits will be left that will trap water or cause ponding except where the project involves a mining pit where there is no possible outlet, such as a caliche pit;
Erosion Control	19	Where active transportation of sediment through gullying, headcutting, slumping or deep or excessive rills (greater than 3 inches deep) occurs within the lease area or within the adjacent area of impact, install erosion control structures to repair and control gullies, head-cuts, rills, and other forms of sediment movement
	20	(a). Erosion control structures should be designed to restore natural hydrological function and flood regime, and to the extent possible should use local rock or biodegradable materials and low-energy, minimum-necessary designs
	21	(b). Erosion control structures may include, but are not limited to, one rock dams, rock mulch rundowns, zuni bowls, media lunas, swales, berms, terraces, wattles, rock or log mats, hay mulch, gabions, bales or other stabilizing enhancements to control erosion
Drainage Control	22	Drainage control structures should be designed to mimic natural hydrological function and flood regime as much as possible so as not to increase the erosional impact of hydrologic flows to the structure or to the upstream or downstream landscape; drainage control designs should be engineered and stamped by a PE.
	23	(b). Drainage control structures may include but are not limited to road bars, culverts, water bars, parallel and lateral ditches, drains, and low water crossings;
Seedbed Preparation	24	Revegetation to meet or exceed 70% density of surrounding cover. If straw/hay mulching is used, straw/hay must be certified weed free.
Revegetation	25	On 3:1 slopes or greater additional revegetation BMPs shall be deployed (such as: hydromulching, crimp mulching, or erosion control blanket)
Noxious Weeds	26	A noxious weed plan will be developed and approved by the NMSLO and noxious weeds will be monitored and treated on a semi-annual basis for three years post-construction.

Access Control * applicable to SLO properties	**27**	a. Gate and Fencing Specifications: Unless otherwise directed by the NMSLO, a locked metal gate with 4-inch H-braces and a permanent fence extending at least 100 feet from either side of the gate, or to the next adjacent gate, will be installed to block public access to all closed reclamation sites; fence will be constructed with steel T-posts on 16-foot spacing, with stays every 8 feet and 4 strands ofbarbed wire; the top wire should be set at 42 inches above the ground surface; inline braces will be used at intervals not to exceed 660 feet; corners will be braced and set in concrete; fence wire will be attached on the outside of the T-posts with wire ties;
	28	b. Permanent Closure Specifications: Dirt berms, permanent hard barriers or rock barricades will be installed to block unauthorized access points to reclamation sites; berms and barriers will be at least 3 feet high and will extend the width of the access point; berms will be hard packed; barriers and barricades may be constructed of metal pipe rail, concrete, or rock and may be used in combination with berm work to ensure closure of an access point; Keep these areas from being general access routes for the public. Require fencing with requests for other options on a case-by- case basis.
Monitoring	**29**	The responsible party will monitor the reclamation site annually until relinquished by the NMSLO during restoration sign-off process and completion of action item list.

		30	Prior to relinquishment, the NMSLO will retain the right to inspect and to provide sign-off prior to release and may require supplemental clean up, maintenance of erosion control structures, additional reseeding efforts, or noxious weed treatments to ensure success of reclamation.
		31	The NMSLO may request detailed annual monitoring reports depending on the severity of the situation
	Reporting	32	The NMSLO may require monthly updates during the course of the initial reclamation work; monthly updates will include a brief narrative statement of work completed with photo documentation; upon completion of the initial reclamation work, the responsible party will notify the NMSLO that the site is ready for inspection; rights of way lessees will provide an affidavit of completion (NMAC 19.2.10.21); annual monitoring reports may be required depending on the severity of the situation.
	Relinquishment	33	The NMSLO will inspect the initial reclamation work upon completion and will provide the responsible party with a statement indicating that the initial work has been completed as required and detailing any follow up work that may be necessary prior to relinquishment; notice of relinquishment will be provided upon complete satisfaction of all NMSLO reclamation requirements;
W	**Watershed**	1	Minimize the number of roads constructed in a watershed through comprehensive road planning, recognizing intermingled ownership, and foreseeable future uses.
		2	All personnel appointed as fire watch under hot work permitting will have immediate access to shovel, fire extinguisher, and backpack water sprayer. In addition, all project work will follow guidelines detailed in the site fire protection and prevention plan.
	Riparian/Wetland Edge	3	No constructed features of the project should be located in a wetland. Linear features which must cross a riparian area will be required to follow U.S. Army Corps of Engineers regulations.
		4	Wetlands and other environmentally sensitive areas will be marked in the field for easy identification by crews. Sensitive features will be defined in Waters of the U.S. Report.
	Streamside Management Areas	5	200' minimum for Streamside Management Area (SMA) boundaries
		6	Leave trees on the bank that will eventually fall across the stream, helping to create a stair step of pools in the stream channel, providing a fish habitat component. Larger trees increase the benefits for the habitat. Hazard trees may be felled and left in place at contractor's discretion.
		7	Do not service vehicles where chemicals, oil, or other toxic substances might contaminate soils, waterways, or waterbodies.
		8	Properly design roads and drainage facilities to prevent potential water quality problems before construction starts.
		9	Minimize the number of roads constructed in a watershed through comprehensive planning, recognizing intermingled ownership, and future uses.
		10	Road design specifications should be included in a contract between the landowner and the road builder. The contract should include exact road locations, dimensions, erosion control and drainage features, stream crossing and structure specifications, season(s) of construction and use, and maintenance schedule, road closure and re-vegetation procedures, and penalties for non-compliance. The more specific the road contract, the more protection there is for the resources and landowner.

	Roads	11	Fit the road to the landscape. This entails altering natural drainage patterns as little as possible by following contours and minimizing cuts, fill, and stream crossings. Utilize natural road building locations away from streams.
		12	Avoid problem areas such as flood zones, narrow canyon bottoms, wet areas and highly erodible or unstable soils. Do not locate roads on slopes more than 60 percent.
		13	Keep the road grade to a minimum, usually less than 10 percent. This can be exceeded for short distances where necessary. An easy grade prevents runoff from building up erosive force and also provides for safer and more efficient travel.
		14	Prevent the concentration of water on the road by designing adequate drainage features. Some suggested drainage methods are insloping and outsloping the road surface, and installation of grade dips and cross drains. Installation of these features is explained in the civil details.
		15	When a stream crossing is necessary, locate the site on a stable, straight portion of the stream. The approach to the crossing should be at a minimal grade and a right angle to the stream.
		16	Leave 200' buffer of undisturbed soil and vegetation on either side of a stream being impacted.
		17	Schedule construction activities to avoid heavy seasonal rains. Excavation operations may expose mineral soil which is highly susceptible to erosion. Soil stabilization and erosion control measures should be completed before the monsoon (thunderstorm) season of July, August, and September. Clear only that part of the route that can be completed in the current season.
		18	Minimize disturbance during construction activities by restricting machinery to the designated road. Clear vegetation to the width required for cut and fill slopes. Excessive removal of vegetation further increases erosion and is more costly. Keep machinery out of streams except when absolutely necessary for culvert installation and bridge construction. Round the top of cut slopes only when this will provide more stability than a vertical cut.

	Culverts	19	During clearing operations, do not mix organic debris with fill materials. Trees and brush will eventually decay in the fill material causing the road surface to become unstable. Dispose of organic debris properly by utilization, piling and burning, chipping, or lopping and scattering. A good use for slash is to place it along fill slopes to slow runoff and trap sediment.
		20	Remove debris from stream channels that was added during construction. It is a good practice to remove all debris from channels for at least 100 feet upstream from culverts to reduce the chance of the culvert becoming plugged. However, never remove well established logs from a stream, as this will likely cause accelerated channel erosion.
		21	Deposit surplus soil and rock in designated areas where sediment from this material will not threaten streams. Do not simply cast surplus material downslope from the road. This material is highly susceptible to erosion and may have future value as fill.
		22	Compact all fill material. This can be done simply by running a bulldozer up and down the fill slope where it is safe to do so. Large fills should be constructed and compacted in layers of approximately 18 inches. The slots made perpendicular to the slope in the soil by the bulldozer's tracks retard runoff and moisture, thus inhibiting erosion and encouraging re-vegetation. In addition, the chance of fill slumping and requiring expensive repair will be reduced.
		23	Servicing and refueling machinery must be conducted well away from wetlands, lakes or watercourses. Fluids such as oil, diesel fuel, and antifreeze are easily washed or leached into streams and present a significant threat to water quality and aquatic life.
		24	Make certain the road surface is adequately drained. This can be accomplished in a number of ways depending on the site factors, the type and level of use, and the standard to which the road is built.
	Culverts	25	A shallow gravel fill on either side of the culvert will lessen maintenance requirements. As with any cross drain, rocks and slash should be placed at the outlet to slow runoff and spread sediment. Size of the culverts, of any type, should follow recommendations in Table 3 (page 63). Care must be taken to disperse the discharge from these cross drains through vegetation.
		26	The culvert must be long enough to extend at least one foot beyond the fill.
		27	Align the culvert exactly with the stream, on the existing grade, and at the depth of the streambed.
		28	Culverts on fish-bearing streams must be installed to allow fish passage so as not to isolate populations.

	Claunch-Pinto specific recommendations	**29**	Fill should be well compacted to half the diameter of the culvert, and fill over the culvert should be to a depth of half the diameter but not less than one foot. Compaction will prevent water from seeping around the culvert and washing away the fill material. Fill over the culvert must be deep enough to prevent damage from heavy vehicles. If more than one culvert must be installed side by side, they should spread half their diameter so that the fill may be compacted between them
		30	Protect the fill material around the culvert inlets and outlets with riprap. Deep fills or culverts on large streams may require more elaborate protection such as wingwalls constructed of concrete or gabions
		31	Inspect newly constructed roads after the first good rain to insure all drainage structures and erosion control features are functioning properly. Gullies forming on cut and fill slopes should be filled in and the drainage formed.
		32	Grade the road surface as needed to correct washboarding and rutting. Maintain the proper inslope, outslope, or crown, and reshape grade dips. Ditches should be disturbed only if they are becoming clogged with sediment. Apply gravel to spots on the road that are persistently wet
		33	Inspect drainage structures frequently. Culverts and ditches should be cleared of sediment and debris.
		34	Application of chemicals to roads to reduce dust should be limited to those road sections where dust will cause major discomfort. Applications should be avoided where road runoff discharges into or near a stream.
		35	Inspect all tracked equipment for excessive soil prior to entering the site.

Corona Wind North Project - Project Agency Consultation Table
U.S. Fish and Wildlife Agency
U.S. Army Corps of Engineers
U.S. Department of Defense
New Mexico State Lands Office
New Mexico Environment Department, Air Quality Bureau
New Mexico Department of Game and Fish