Guidelines for Wind Energy and Wildlife Resource Management in Nebraska

The Nebraska Wind and Wildlife Working Group

Objective

This document was created to identify environmental concerns that should be considered during the wind energy development process. These Guidelines are a set of non-regulatory statewide recommendations designed to help developers assess and minimize potential environmental impacts that could result from development of wind energy facilities. However, not all recommendations will be applicable to all wind energy development projects, which are reviewed and discussed on a project-by-project basis.

Introduction

Wind energy is seen as a "green" energy source because during the operation of a wind energy facility there are no emissions of greenhouse gases or other pollutants. In general, the conservation community supports the development of wind energy as a means of reducing the impacts of climate change. However, no energy source has yet been found to be without some degree of environmental costs and wind energy is no exception. The purpose of these guidelines is to provide consistent statewide guidance for the development of wind energy projects that avoid, minimize, and mitigate impacts to wildlife and their habitats in Nebraska.

Nebraska ranks third nationally in terms of wind resources to generate electrical energy, with wind energy potential to produce over 3.5 million gigawatts per year (United States (U.S.) Department of Energy 2010). The current Governor and State Legislature consider wind energy development in Nebraska a high priority. With much open land, low population densities in areas where wind turbines are likely to be placed, and relatively high average wind velocities, Nebraska seems destined to be a national focal point for wind energy development and exportation.

The Nebraska Wind and Wildlife Working Group is a consortium of state and federal agencies, non-governmental conservation organizations, and public utilities that formed to develop guidance for wind energy development in the state. The group works closely with wind developers and consultants who have developed or are looking to develop wind energy in Nebraska. The group consists of representatives from Nebraska Game and Parks Commission (NGPC), U.S. Fish & Wildlife Service (USFWS), the Nebraska Energy Office, The Nature Conservancy, Audubon Nebraska, the Nebraska Wildlife Federation, the Nebraska Sierra Club, and other interested parties. Collectively the group represents a great diversity and depth of expertise in wildlife management and conservation in Nebraska. The group has no rule-making

or regulatory authority; rather it works cooperatively to discuss mutual concerns, learn of the latest developments, and coordinate action as warranted. The group supports the development of wind energy in Nebraska when the planning and siting process avoids or minimizes impacts to wildlife populations and natural areas.

Wildlife Concerns

Wind energy development impacts wildlife populations in two ways: (1) direct impacts, such as individuals colliding with infrastructure or barotrauma in bats, and (2) indirect impacts, such as loss and degradation of habitat.

Direct Impacts

Direct impacts (i.e., mortality) occur when birds and bats collide with wind turbines, towers, or transmission lines servicing wind farms. While numerous variables (including location of turbines, time of year, weather, scavenger removal rates, etc.) make it difficult to elucidate trends from multiple wind farms, some patterns have emerged. Recent studies show direct impacts may increase significantly when turbines are placed in or very near major migration corridors, such as mountain passes, large river valleys, and saddles or the edge of ridge-tops and bluffs (Drewitt and Langston 2008, Kunz et al. 2007); or at stopover sites such as wetlands along migration routes. Because birds tend to follow or congregate along these natural landscape features during their semiannual migrations, wind turbines placed near these features have potential for causing increased bird kills in spring and fall.

Nebraska has several important areas used by migrating birds, most notably the principle spring staging area for migratory waterfowl within the Central Flyway. Millions of waterfowl and other water birds semiannually migrate distances of 2,500 to 5,000 miles through the Central Flyway between their breeding grounds and wintering grounds to complete their life cycle. During the spring sandhill crane migration, 450,000 to 550,000 cranes stage in Nebraska during a 6 to 8-week period, roosting in the central Platte River and feeding in meadows and crop fields. The federal and state listed endangered whooping crane also migrates through Nebraska, and the central Platte River is one of the five geographic areas designated in the Central Flyway as critical habitat for whooping cranes. In addition, this species utilizes rivers and wetlands outside of the Platte River valley (e.g., Rainwater Basin, Central Table Plays, the South, Middle, and North Loup Rivers, the Niobrara River, and the Republican River) as it migrates through the state.

As noted above, the Central Flyway in Nebraska hosts an unusually high concentration of migratory birds each spring and fall, and given the rarity of some species, like the whooping crane, the mortality of a few individuals would have a significant negative impact on the species' population. For these reasons, direct impacts are of greater concern in portions of Nebraska than in other Midwestern states.

For reasons still being studied (e.g., barotrauma, migration patterns, etc.) bats are likely to experience higher direct mortality rates than birds at many wind farms (Howe et al. 2002, Kunz et al. 2007, Kuvlesky et al. 2007, Molvar 2008). Resident bats in Nebraska are usually associated

with trees or wooded areas and wetlands, where the insects on which they feed are abundant. However, bats commonly feed over grasslands and agricultural fields as well. Recent studies have shown tree-roosting migratory bats are at a higher risk of direct impacts from wind turbines (Arnett et al. 2008, Cryan and Barclay 2009, Kunz et al. 2007) than local bats. Currently there is no clear reason as to why so many bats are being killed by turbines (Cryan and Barclay 2009) and until such reasons are elucidated, extra vigilance should be used when siting turbines near areas of potential stopover and roosting habitat.

Indirect Impacts

Indirect impacts (e.g., habitat loss and degradation from wind farm and their associated infrastructure) represent an environmental cost that may be greater than direct impacts, especially in the grasslands of the Great Plains. Development of infrastructure can impact species' habitats in two main ways. The first is through loss of habitat due to conversion of natural communities to roads, tower sites, and other infrastructure within the wind farm. This habitat loss affects all species in the impacted area, including plants and non-flying animals that are not subject to turbine collision mortality. In addition, even small size roads, such as those constructed in a wind farm, have been shown to negatively impact a number of bird species, facilitate the spread of invasive plants, and increase habitat fragmentation (Ingelfinger and Anderson 2004). Thus, threatened, endangered, and at-risk species (flying and non-flying) may be impacted by habitat loss and degradation from wind farm development.

The second form of habitat loss occurs when certain species are displaced from otherwise suitable habitat near a turbine due to avoidance of vertical structures in grasslands. A number of studies have demonstrated the negative reaction of birds to the presence of wind towers (Stewart et al. 2005), including several grassland bird species (Leddy et al. 1999). For example, the lesser prairie-chicken will vacate areas of otherwise suitable habitat to avoid tall features (Anderson 1969), especially anthropogenic features (Pitman et al. 2005, Pruett et al. 2009, Robel et al. 2004). These avoidance behaviors could result in a large area of intact grassland becoming fragmented into smaller use areas, each fragment being too small to sustain a population of that species over the long term. In addition, many bird species return and use traditional breeding areas, migratory routes, and wintering grounds, leaving little possibility of pioneering into new regions if there is too much disturbance to their established migration corridor.

Few studies have addressed the long-term (more than five years post-construction) effects of wind farms or cumulative impacts that several wind farms in close proximity may have on native species. Preliminary studies indicate these items may negatively impact birds; however, more research is needed to evaluate the magnitude of these impacts (Langston and Pullan 2003, Stewart et al. 2005). Since grassland birds as a group have suffered the steepest declines in population over the past 30 years among all North American birds, and given that Nebraska is home to some of the largest, least degraded grasslands in the Great Plains, habitat loss and degradation from widely distributed wind farms poses a credible and potentially large environmental cost in our state.

Wind Energy and Wildlife Guidelines

The purpose of these guidelines is to provide consistent statewide guidance for the development of wind energy projects that avoid, minimize, and mitigate impacts to wild animals and plants and their habitats in Nebraska. The guidelines include information on: 1) pre-construction site assessment; 2) practices to avoid and minimize impacts to wildlife; 3) post-construction surveys and operational monitoring; 4) mitigation for long-term habitat impacts and 5) research to further develop tools to assess and minimize impacts to animals, plants, and their habitats.

1. Pre-construction Assessments

The construction of a utility-scale wind project may impact wildlife through direct mortality and through the loss, degradation, or fragmentation of habitat. It is therefore critical to establish the presence or absence of various wild species and important natural communities well in advance of construction activities. The primary purposes of pre-construction assessments are to: 1) collect information suitable for predicting the potential impacts of the project on animal and plant species and their habitats and 2) design the project layout (e.g., turbine and road locations) so that impacts on biological resources are avoided and/or minimized.

The site-specific components and the duration of the assessment should depend on the size of the project, the availability, quality, and extent of existing and applicable information in the vicinity of the project, the habitats potentially affected, the likelihood and timing of occurrence of threatened, endangered, and other special-status species at the site, the magnitude of impacts to other species (e.g., bats, passerines, etc.), and other factors. Before initiating any surveys, the project proponent is strongly encouraged to contact the NGPC and the USFWS to discuss details of survey methods. A review of current National Wind Coordinating Collaborative study guidelines and recommendations pertaining to wind and wildlife interactions is strongly recommended and is available at: http://www.nationalwind.org/publications/wildlifewind.aspx.

An initial assessment of the proposed project site should determine which species and habitats will need on-the-ground surveys. The results of the information review and baseline studies should be reported to the NGPC and USFWS in a timely fashion. To allow comparison of results among projects and to maximize the benefits of pre-construction assessments, the use of standard protocols is strongly encouraged. The NGPC, in cooperation with various researchers and biologists, is in the process of creating a set of standard protocols for use within the state. These protocols will incorporate recommendations from various national guidelines (e.g., National Wind Coordinating Collaborative, USFWS, etc.) but will be tailored to Nebraska's species and landscapes. For specific avian protocols, please see *Wind Energy and Nebraska's Wildlife: Avian Assessment Guidance for Wind Energy Facilities*, available from NGPC.

The following pre-construction surveys and associated timeframes are recommended for all projects; however, alternate timeframes can be established on a project-by-project basis (taking into consideration the characteristics of the project area and the availability of useful existing data) if NGPC and USFWS are consulted early and often in the planning process.

Nesting Raptor Surveys
A minimum of two years of pre-construction nesting raptor surveys should be conducted during the breeding season within the project area as well as a two mile buffer around the project area. Surveys should determine the location and species of active nests that could potentially be disturbed by construction activities, and identify species and active and potentially active nest sites with the highest likelihood of being impacted by the operation of the facility. All raptors are federally protected under the Migratory Bird Treaty Act, and eagles are also protected under the Bald and Golden Eagle Protection Act. Some raptors have been identified as Tier I or Tier II at-risk species in the Nebraska Natural Legacy Project (Schneider et al. 2005) (Nebraska's State Wildlife Action Plan, http://outdoornebraska.ne.gov/wildlife/programs/legacy/). Tier 1 species (e.g. ferruginous hawk) are those that are most imperiled, globally or nationally, and occur in Nebraska.

Whooping Crane Desktop Assessment
It is currently not known how whooping cranes will respond to wind energy development. There are concerns that whooping cranes may collide with wind turbines. Numerous (n=59) whooping crane mortalities have occurred as a result of collisions with power lines. There are also concerns that whooping cranes may avoid areas with wind turbines. If this is the case, whooping cranes will lose crucial stopover habitat if wind energy facilities are developed in the species' migration corridor. Currently, the risks of collision and habitat loss are difficult to quantify because of high uncertainty. Project proponents are encouraged to acknowledge this uncertainty and to prepare for a range of scenarios ranging from no effect to large numbers of mortalities and/or habitat loss if their project occurs within the main migration corridor. This preparation should begin with a rapid (or desktop) risk assessment. This assessment should use information about 1) whooping crane migration ecology, 2) location of the proposed project site relative to the whooping crane migration corridor, and 3) a GIS analysis of wetland and habitat resources located within and adjacent to the proposed project site. For further information, please view the following USFWS (2009) document: *Whooping Cranes and wind development: an issue paper*. Available online at:
ftp://wiley.kars.ku.edu/windresource/Whooping_Crane_and_Wind_Development_FWS_%20April%202009.pdf

Breeding Bird Surveys
A minimum of two years of pre-construction breeding bird surveys are recommended to estimate the use of the project area by avian species/groups of interest during their breeding season. Surveys for at-risk (Legacy Tier I and II) grassland nesting birds, including greater prairie-chicken (see below), are highly recommended. These species may suffer habitat loss due to avoidance of otherwise suitable habitat that is in proximity to turbines.

Prairie Grouse Surveys
Nebraska has two species of prairie grouse: the greater prairie-chicken (*Tympanuchus cupido*) and the sharp-tailed grouse (*Tympanuchus phasianellus*). A minimum of two years of pre-construction surveys are recommended to determine the presence of prairie grouse, lek locations, and the number of males and females at each lek. A one-mile buffer should be added to the project area to ensure all potentially affected leks are located. Aerial surveys using fixed-wing aircraft are strongly encouraged and can be combined with the nesting raptor surveys.

Bat Surveys
Recent studies have brought attention to the number of bats being killed at several wind farms in the U.S. (Arnett et al. 2008, Baerwald and Barclay 2009, Cryan and Barclay 2009, Kunz et al. 2007). The majority of bats killed (approximately 75%) are tree-dwelling migratory bats belonging to one of three species: eastern red bat (*Lasiurus borealis*), hoary bat (*Lasiurus cinereus*), or silver-haired bat (*Lasionycteris noctivagans*) (Arnett et al. 2008, Kunz et al. 2007). All three of these species are present in Nebraska, as well as eleven other documented bat species. Several trends have been identified about bats' susceptibility to direct mortality by wind turbines, including: 1) the species with the highest fatality rates, 2) most individuals are killed in late summer and early fall, most likely during their migration and 3) most fatalities occur during nights with low wind speeds (Arnett et al. 2008, Cryan and Barclay 2009, Kunz et al. 2007).

While there are many hypotheses as to why bats are experiencing high fatality rates at some wind farms, there are few data that consistently support any one hypothesis (Cryan and Barclay 2009). Because of the potential long-term impacts to bat populations caused by excessive bat fatalities, two years of pre-construction surveys (see below) are recommended for all new wind farms in Nebraska. We recommend these surveys in all areas because the species most often killed are long-distance migrants; as a result, even stop-over sites of low-quality habitat have the potential to result in a high number of bat fatalities.

An assessment of potential bat habitat along with passive acoustic surveys during the spring, summer, and fall are strongly encouraged for all projects in areas of potential roosts, hibernacula, and migratory pathways. At a minimum, acoustical detection units should be placed on all meteorological towers and on each 'corner' or 'side' of the project area. Consultations with NGPC and USFWS to review data from the habitat assessment and the acoustic survey(s) will determine if further bat surveys, including active sampling (mist nets and/or harp traps) are needed. Appropriate survey methods, including species-discriminating bat detectors and radar, survey periods, and locations will depend on local habitat and environmental conditions, and vary by species and/or life stage.

Additional bat surveys are recommended in the following cases: 1) use of the site by bat species is estimated to be high, and/or 2) there are limited or no relevant data regarding seasonal use of the project site (e.g., data from nearby areas of similar habitat type), and/or 3) areas where low density or migrating species may be affected. The NGPC is currently drafting a guidance document to detail more specific bat survey recommendations.

Threatened and Endangered Species Surveys
Early consultation (at least two years prior to construction) with NGPC and USFWS is highly recommended to determine if focused surveys for state and/or federally listed threatened and endangered (T&E) species are needed. The NGPC's Natural Heritage Program maintains range maps, habitat information, and a database of documented occurrences for all listed species in the state. Both NGPC and USFWS will conduct environmental reviews of proposed project sites to determine known occurrences, potential suitable habitat, and need for surveys for T&E species. Consultation with the NGPC and USFWS for species specific survey protocols is also highly recommended.

Plant Community Surveys
The Nebraska Natural Legacy Project (Schneider et al. 2005) identifies numerous at-risk plant communities within the state (e.g., tallgrass prairie, oak woodland, saline wetland), which contain significant biological diversity. An assessment should be conducted to determine if any rare or high quality plant communities occur in the project area. Further loss, degradation, and fragmentation of remaining occurrences of these rare communities should be avoided. Early identification of these communities within a project area can aid in designing infrastructure to avoid or minimize impacts. The Natural Heritage Program maintains a classification of plant communities in the state and a database of documented occurrences of communities, and can provide community survey recommendations.

2. Avoidance and Minimization of Wildlife Impacts

Proper siting and design of wind energy projects can avoid and minimize many of the impacts to wildlife. The following recommendations have been collected from a variety of sources, including the US Fish & Wildlife Service Interim Guidelines for siting and construction of wind energy facilities, and recommendations from the National Wind Coordinating Collaborative.

General Siting Recommendations

- A map has been developed that delineates areas of particular concern for possible adverse effects by wind turbines upon wildlife and habitat in Nebraska (http://outdoornebraska.ne.gov/wildlife/windwildlife.asp). Wind energy developers and planners are encouraged to refer to this map as an initial step when considering new sites. However, potential adverse effects will be greatly influenced by site-specific factors that cannot be captured in a statewide map. Wind energy projects in mapped low-sensitivity areas may have significant impacts due to specific siting of infrastructure. Conversely, there may be some sites within mapped high-sensitivity areas where wind development would be appropriate when coupled with conservation measures. In general, higher sensitivity areas have a higher probability of wildlife impacts and it is recommended that projects be sited outside of these areas. Consultation with the NGPC and the USFWS biologists is recommended at the earliest stages of project development to aid in selecting suitable sites.

- Develop an Avian Protection Plan (APP) to help identify and minimize risks to all migratory and resident birds. A sample APP can be found at: http://www.eei.org/ourissues/TheEnvironment/Land/Documents/AvianProtectionPlanGuidelines.pdf.

- Possible *cumulative* regional effects of multiple wind energy projects should be considered by all parties involved in the development process. While one project alone may result in few concerns for wildlife, multiple projects across one landscape could significantly multiply adverse effects (Langston and Pullan 2003).

Specific Siting Recommendations

- We recommend siting wind energy facilities on previously altered landscapes, such as areas of extensive cultivation, near towns, or urban and industrial areas. Avoid siting wind energy facilities in areas of contiguous intact native habitat.

    - Consider siting turbines and other infrastructure away from occurrences of rare plant communities (e.g., tallgrass prairie, oak woodland, saline wetlands) and try to avoid siting turbines in a manner that will effectively fragment or split larger patches of native habitats.

    - Avoid placing turbines at locations where they would have a direct or indirect impact on documented occurrences of fish, wildlife, or plants protected under the federal Endangered Species Act and Bald and Golden Eagle Protection Act; and the Nebraska Nongame and Endangered Species Conservation Act. Information regarding the species protected under these laws may be obtained by contacting the Nebraska Natural Heritage Program with NGPC in Lincoln and the USFWS in Grand Island.

    - Consider siting turbines in areas where impacts to migratory birds would be minimized in accordance with the Migratory Bird Treaty Act.

    - Consider placing turbines outside of recognized bird and bat concentration areas or migration pathways, which may include such features as: lakes, wetlands, forests, river valleys, ridge tops or bluff tops, native prairie, known roosting areas, and areas with frequent incidence of fog, mist, or low clouds. While there is no consistent data on the amount of buffer zone needed between turbines and these habitats, a separation distance of at least one mile is recommended as a minimum distance. In some cases, a greater separation distance may be recommended based on the species typically using specific lakes, rivers, wetlands, or other natural features.

    - Consider placing turbines away from habitat known to be occupied by prairie grouse or other species that exhibit extreme avoidance of vertical features. In known prairie grouse habitat, consider placing turbines three miles away from known leks (traditional courtship display areas, typically adjacent to breeding grounds).

    - To minimize bat fatalities consider increasing turbine cut-in speeds (the lowest wind speed at which a wind turbine begins producing power) to 5.0 m s^{-1} near bat migration corridors or areas of high bat use (Arnett et al. 2010).

    - Existing roads and utility corridors should be utilized to the greatest extent practicable and new access roads and utility corridors should be configured to avoid high quality habitats and minimize habitat fragmentation. Access roads and utility corridors should have alignments that minimize stream crossing and wetland impacts. For more information on wetland habitats in Nebraska see

Guide to Nebraska's wetlands and their conservation needs (LaGrange 2005), available online at: http://outdoornebraska.ne.gov/wildlife/programs/wetlands/pdf/wetlandsguide.pdf.

- State and Federally owned and managed wildlife or recreation properties (e.g., State Parks, Wildlife Management Areas, State Recreation Areas, Waterfowl Production Areas, National Wildlife Refuges, etc.) should be avoided entirely both for biological (rare landscapes, extensive wildlife breeding, and migrating activities, etc.) and aesthetic reasons. A one-mile buffer is recommended around all state owned and managed wildlife and recreation properties. In some cases, a larger buffer may be recommended depending on the location and wildlife use of the area.

- Whooping cranes migrate through central Nebraska during the spring and fall and a map of their migration corridor can be obtained from the USFWS office in Grand Island. While whooping cranes are opportunistic in selection of stopover areas, all areas that contain riverine or palustrine wetlands with broad areas of shallow water and good visibility provide suitable roost habitat. Suitable roost habitat areas, where repeated use by migrating whooping cranes has been documented, need to be avoided (e.g., Rainwater Basin areas, central Platte River, Central Table Playas in Custer County, eastern Sandhill wetlands, etc. – see *Wind Energy and Nebraska's Wildlife* map at: http://outdoornebraska.ne.gov/wildlife/pdfs/wildlifewind.pdf).

- If a proposed wind energy project falls within the whooping crane migration corridor, a specific risk assessment should be conducted and a contingency plan should be developed (see previous section *Whooping Crane Desktop Assessment*). Additional measures should be taken to minimize the likelihood of whooping cranes colliding with all above ground power lines associated with the wind energy facilities.

- Electric power lines within the wind farm (collection lines) should be buried. Any above ground power lines (e.g., from the wind farm to the power grid), riser poles, transformers, and conductors should comply with the most recent Avian Power Line Interaction Committee (APLIC), *Suggested Practices for Avian Protection on Power Lines*. This includes marking all above ground power lines with bird flight diverters.

- Consider spacing turbines widely apart, preferably in arrays parallel to normal bird migration routes (typically north-south) which can reduce avian collisions. Depending on local landscape features, number of turbines installed, and other factors, turbine spacing recommendations may vary.

Turbine Design and Operation Recommendations

- Tubular support towers with pointed tops greatly reduce opportunities for birds to perch or nest upon the structures; lattice support towers should be avoided when possible. Avoiding placement of permanent external ladders or platforms on tubular towers also reduces nesting and perching.

- Consider using free-standing (i.e., no guy-wires) support towers for turbines and meteorological towers. Any existing guy wires should be marked with recommended bird deterrent devices (APLIC standards).

- Taller turbines, having a top-of-rotor sweep exceeding 199 feet, may require lights for aviation safety. The minimum amount of pilot warning and avoidance lighting necessary should be used, and unless otherwise required by the Federal Aviation Administration, only white strobe lights should be used at night. These should be minimized in number, intensity, and number of flashes per minute. Solid red or pulsating red lights should *not* be used, as they appear to attract more night-migrating birds than do white strobes.

- Where the height of rotor-sweep area produces high wildlife collision risks, consider lowering tower heights to reduce risks.

- When older facilities must be upgraded or retrofitted, the above guidelines should be employed as closely as possible.

3. Post-Construction Surveys and Operational Monitoring

Mortality of birds and bats is expected to result from wind energy projects. However, it is anticipated that significant impacts to wildlife can be avoided or minimized if these guidelines are employed. Post-construction surveys and monitoring studies, including monitoring for carcasses *and* surveying (i.e., breeding bird, prairie grouse, and nesting raptor surveys) should be conducted to determine the estimated direct and indirect impacts of the wind farm on birds and bats. These data are essential for both identifying potential measures to mitigate the impact of operations at existing sites as well as assessing potential risks associated with future developments.

In general, post-construction surveys and monitoring of birds and bats (or other relevant species) should be conducted for a minimum of two years following initiation of project operations; however, longer-term monitoring is encouraged and would provide more reliable data (Erickson et al. 2007, Parker and Wiens 2005). Project proponents should work with NGPC and USFWS to develop and/or determine acceptable survey and monitoring protocols for use. Project operators are encouraged to develop incidental fatality reporting protocols to coincide with regular on-going operational activities.

Use of standard protocols is encouraged and would allow for a comparison of results among projects. For specific avian protocols, please see *Wind Energy and Nebraska's Wildlife: Avian Assessment Guidance for Wind Energy Facilities*, available from NGPC.

4. Mitigation for Permanent Habitat Impacts

Permanent impacts to habitat are those anticipated to persist and cannot be restored within the life of the project. Permanent impacts may include new permanent roads, operations and

maintenance facilities, turbine pads, impervious and/or areas devoid of native vegetation resulting from project operations, and areas excluded from species use due to avoidance of turbines (displacement).

The following principles will be used to develop a suitable mitigation package, when warranted:

- In general, habitat mitigation would be at a 1:1 ratio. However, in cases of rare habitat types (e.g., good quality tallgrass prairie, wetlands, etc.), the ratio would be higher.

- In general, no mitigation would be required for impacts to highly disturbed sites such as cropland and industrial or urban areas. However, this does not mean that all highly disturbed sites are suitable for development. Exceptions would include cases where the disturbed area is utilized by sensitive species (e.g., mountain plover nesting in crop fields) or is adjacent to habitat used by sensitive species (e.g., a crop field adjacent to a wetland utilized by whooping cranes).

- In areas where whooping crane habitat is impacted, mitigation for acres lost should follow USFWS guidelines as suggested in *Whooping Cranes and wind development: an issue paper*, available at: ftp://wiley.kars.ku.edu/windresource/Whooping_Crane_and_Wind_Development_FWS_%20April%202009.pdf

- Where appropriate, mitigation acreage for indirect impacts (i.e., displacement) should be calculated as a 180 meter radius buffer around each turbine.

- Mitigation habitat should be of like kind (e.g., tallgrass prairie for tallgrass prairie) and of equal or higher habitat value than the impacted area.

- Mitigation habitat should be in the same geographical region as the impacted habitat.

- Mitigation habitat should be given legal protection through acquisition in fee, a permanent conservation easement, or other enforceable means.

- Wind project developers are responsible for ensuring that mitigation habitat is protected and managed in perpetuity. A wind developer may choose to work through a land trust to ensure perpetual protection.

- Mitigation packages should be negotiated in consultation with NGPC and USFWS.

- The functions and values of the mitigation package should meet the extent of the impact on habitat.

- Research (see below) and mitigation are not interchangeable.

5. Research

Much uncertainty remains about predicting risk and estimating impacts of wind energy development on wildlife. It is in the interest of wind developers, wildlife agencies, and conservation organizations to support research to better understand these impacts so they can be avoided or minimized. Because the results of current and future research activities will directly impact future costs, siting recommendations, and survey protocols, it would greatly benefit wind proponents to play an active role in research. Proponents can be involved by providing researchers with access to wind farm properties, trying new technologies which minimize impacts to wildlife, and providing funds for research. The NGPC encourages cooperation among wind proponents, local agencies, and universities to engage in productive research projects.

Standard pre-and post-construction assessment surveys and standard fatality operational monitoring are separate from research-oriented studies. At some projects, additional studies that utilize pre-construction data may be conducted to test specific research hypotheses about impacts to a particular species, community, or landscape. Rather than being necessary for pre-project assessment, such studies are focused on research, such as indirect impacts (e.g., displacement, cumulative impacts, etc.), that potentially provide information for future projects. In addition, non-project related research may be warranted, such as the identification of bat migration routes throughout the state.

Current research priorities for Nebraska include: appropriate buffer distances (indirect impacts) for prairie grouse, assessing the cumulative impacts of multiple wind farms in an area, locating any bat migration corridors within the state, and establishing several long-term post-construction survey and monitoring efforts to explore the potential long-term impacts of wind energy development on wildlife. Research activities could also focus on ways to design and operate turbines and power lines that may reduce bird and bat strikes, effective ways to mark power lines, and technologies to document bird or bat strikes on turbines or power lines.

Other Considerations

These guidelines focus on the potential impacts of wind energy development on wildlife and natural habitats. However, other issues should be considered including, but not limited to, impacts on historic and cultural resources, water quality, and noise pollution. Wind energy developers should work with the State Historic Preservation Office, the Nebraska Department of Environmental Quality, and others to address these issues.

Related Links
The following websites of other agencies and organizations may be useful in further understanding of potential wind energy and wildlife conflicts, and how to reduce or mitigate threats to wildlife:

http://www.ngpc.state.ne.us/wildlife/windwildlife.asp

http://www.fws.gov/habitatconservation/wind.pdf

http://www.abcbirds.org/abcprograms/policy/collisions/wind_farms.html

http://www.batsandwind.org/

http://www.nationalwind.org/publications/default.aspx

Literature Cited

Anderson, R.K. 1969. Prairie chicken responses to changing booming-ground cover type and height. Journal of Wildlife Management 33(3):636-649.

Arnett, E.B., M.M.P. Huso, M.R. Schirmacher, and J.P. Hayes. 2010. Altering turbine speed reduces bat mortality at wind-energy facilities. Frontiers in Ecology and the Environment (e-View). Available online at: http://www.esajournals.org/doi/abs/10.1890/100103.

Arnett, E.B., W.K. Brown, W.P. Erickson, J.K. Fiedler, B.L Hamilton, T.H. Henry, A. Jain, G.D. Johnson, J. Kerns, R.R. Koford, C.P. Nicholson, T.J. O'Connell, M.D. Piorkowski, and R.D. Tankersley, Jr. 2008. Patterns of bat fatalities at wind energy facilities in North America. Journal of Wildlife Management 72(1):61-78.

Baerwald, E.F. and R.M.R. Barclay. 2009. Geographic variation in activity and fatality of migratory bats at wind energy facilities. Journal of Mammalogy 90(6):1341-1349.

Cryan, P.M. and R.M.R. Barclay. 2009. Causes of bat fatalities at wind turbines: hypotheses and predictions. Journal of Mammalogy 90(6):1330-1340.

Drewitt, A.L., and R.H.W. Langston. 2008. Collision effects of wind-power generators and other obstacles on birds. Annals of the New York Academy of Sciences 1134:233-266.

Erickson, W., D. Strickland, J. Shaffer, and D. Johnson. 2007. Protocol for the investigating displacement effects of wind facilities on grassland songbirds. Prepared for the National Wind Coordinating Collaborative. Available online at: http://www.nationalwind.org/assets/publications/SongbirdProtocolFinalJune07.pdf.

Howe, R.W., W. Evans, and A. Wolf. 2002. Effects of wind turbines on birds and bats in northeastern Wisconsin. A report submitted to Wisconsin Public Service Corporation and Madison Gas and Electric Company.

Ingelfinger, F. and S. Anderson. 2004. Passerine response to roads associated with natural gas extraction in a sagebrush steppe habitat. Western North American Naturalist 64(3):385-395.

Kunz, T.H., E.B. Arnett, W.P. Erickson, A.R. Hoar, G.D. Johnson, R.P. Larkin, M.D. Strickland, R.W. Thresher, and M.D. Tuttle. 2007. Ecological impacts of wind energy development on bats: Questions, research needs, and hypotheses. Frontiers in Ecology and the Environment 5(6):315-324.

Kuvlesky, W.P. Jr., L.A. Brennan, M.L. Morrison, K.K. Boydston, B.M. Ballard, and F.C. Bryant. 2007. Wind energy development and wildlife conservation: challenges and opportunities. Journal of Wildlife Management 71(8):2487-2498.

LaGrange, T. 2005. Guide to Nebraska's wetlands and their conservation needs. Nebraska

Game and Parks Commission, Second Edition. Available online at: http://outdoornebraska.ne.gov/wildlife/programs/wetlands/pdf/wetlandsguide.pdf.

Langston, R.H.W. and Pullan, J.D. 2003. Windfarms and birds: an analysis of the effects of wind farms on birds, and guidance on environmental assessment criteria and site selection issues. Report T-PVS/Inf (2003) 12, by BirdLife International to the Council of Europe, Bern Convention on the Conservation of European Wildlife and Natural Habitats. RSPB/BirdLife in the UK.

Leddy, K.L., K.F. Higgins, and D.E. Naugle. 1999. Effects of wind turbines on upland nesting birds in Conservation Reserve Program grasslands. Wilson Bulletin 111(1):100-104.

Molvar, E.M. 2008. Wind power in Wyoming: Doing it smart from the start. Laramie, WY: Biodiversity Conservation Alliance, 55 pp.

Parker, K.R. and J.A. Wiens. 2005. Assessing recovery following environmental accidents: Environmental variation, ecological assumptions, and strategies. Ecological Applications 15(6):2037-2051.

Pitman, J.C., C.A. Hagen, R.J. Robel, T.M. Loughin, and R.D. Applegate. 2005. Location and success of lesser prairie-chicken nests in relation to vegetation and human disturbance. Journal of Wildlife Management 69(3):1259-1269.

Pruett, C.L., M.A. Patten, and D.H. Wolfe. 2009. It's not easy being green: Wind energy and a declining grassland bird. BioScience 59(3):257-262.

Robel, R.J., J.A. Harrington, C.A. Hagen, J.C. Pitman, and R.R. Reker. 2004. Effect of energy development and human activity on the use of sand sagebrush habitat by lesser prairie-chickens in southwestern Kansas. Transactions of the North American Wildlife and Natural Resource Conference 69:251-266.

Schneider, R., M. Humpert, K. Stoner, and G. Steinauer. 2005. The Nebraska Natural Legacy Project: A comprehensive wildlife conservation strategy. Nebraska Game and Parks Commission, Lincoln, NE. Available online at: http://outdoornebraska.ne.gov/wildlife/programs/legacy/

Stewart, G.B., A.S. Pullin, and C.F. Coles. 2005. Effects of wind turbines on bird abundance. Systematic Review No. 4. Centre for Evidence-Based Conservation. Birmingham, UK.

United States Department of Energy. 2010. Estimates of windy land area and wind energy potential by state for areas >= 30% capacity factor at 80m. Wind Powering America. Available online at: http://www.windpoweringamerica.gov/docs/wind_potential_80m_30percent.xls.

U.S. Fish and Wildlife Service. 2009. Whooping Cranes and wind development: an issue paper. U.S. Fish and Wildlife Service Regions 2 and 6. Available online at: ftp://wiley.kars.ku.edu/windresource/Whooping_Crane_and_Wind_Development_FWS_%20April%202009.pdf.