Guidelines for Avoiding, Minimizing, and Mitigating Impacts of Wind Energy on Biodiversity in Nebraska

The Nebraska Wind and Wildlife Working Group

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CONTACTS

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OVERVIEW

Developing Nebraska's abundant wind resources can be balanced with maintaining biodiversity by avoiding, minimizing, and mitigating the impacts of wind energy development and operation. A series of statewide, non-regulatory guidance documents have been created to assist wind energy developers achieve this balance. **These guidance documents do not replace coordination or consultation with the Nebraska Game and Parks Commission (NGPC) and the U.S. Fish and Wildlife Service (USFWS).** All of the documents are based on the best available science and will be updated when new information for recommendations becomes available.

Guidance Documents and Tools

State

Guidelines for Avoiding, Minimizing, and Mitigating Impacts of Wind Energy on Biodiversity in Nebraska (https://wind-energy-wildlife.unl.edu/nebraska-guidelines)

Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map (https://wind-energy-wildlife.unl.edu/biodiversity-and-wind-map)

Avian Assessment Guidance for Wind Energy Facilities in Nebraska (http://outdoornebraska.gov/environmentalreview/)

Bat Assessment Guidance for Wind Energy Facilities in Nebraska (https://wind-energy-wildlife.unl.edu/bat-assessment-guidance-wind-energy-facilities-nebraska)

Whooping Crane Operational Contingency Plan (https://wind-energy-wildlife.unl.edu/whooping-crane-operational-contingency-plan)

Federal

U.S. Fish and Wildlife Service Land-Based Wind Energy Guidelines (https://wind-energy-wildlife.unl.edu/usfws-guidelines)

USFWS Eagle Conservation Plan Guidance: Module 1 – Land-based Wind Energy (v2) (https://wind-energy-wildlife.unl.edu/usfws-eagle-guidance)

OBJECTIVE

These guidelines are non-regulatory statewide recommendations designed to help developers assess and minimize potential environmental impacts that could result from development and operation of wind energy facilities. **Not all recommendations will be applicable to all wind energy development projects, which are reviewed and discussed on a project-by-project basis. Site-specific recommendations may be made that are not included in this document**.

INTRODUCTION

Wind energy is a renewable energy source for which the potential environmental impacts of development and operation need to be considered. 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 and operation of wind energy projects that avoid, minimize, and mitigate impacts to wildlife and habitats in Nebraska.

Nebraska has great wind energy development potential. Nebraska ranks third nationally in terms of wind resources to generate electrical energy, with wind energy potential to produce more than 3.5 million gigawatt hours per year (United States Department of Energy 2010). With much open land, low population densities in areas where wind turbines are likely to be placed, and relatively high average wind velocities, Nebraska could be a popular state for wind energy development and exportation.

Global climate change and the need to reduce greenhouse gas emissions are now recognized by most scientists. 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 and no water is used. Although the threat of climate change increases, the need to critically assess where wind energy is suitable is still important and may be increasing in importance. Habitat loss has historically been the greatest threat to wildlife. Human developments continue to impact natural lands, creating new challenges for wildlife and other species. The degree to which species are predicted to be able to adapt to climate change is related to the amount of intact natural lands available near their current range. Therefore, impacts to species and natural lands should be considered when developing wind energy.

Nebraska’s biodiversity (i.e., the variety within and between all species of plants, animals, and micro-organisms and the ecosystems within which they interact) is composed of thousands of plant and animal species. Hundreds of species of wildlife use Nebraska year-round or during migration or breeding seasons; several of these species and their habitats are considered at-risk and may be more sensitive to development. Nebraska has 17 federally and 30 state plant or animal species that are listed as endangered or threatened (http://outdoornebraska.gov/atriskspecies/). The Nebraska Natural Legacy Project State Wildlife Action Plan (Schneider et al. 2011) identifies at-risk species and categorizes them as Tier I or Tier II. Tier I species are those that are most imperiled, globally or nationally, and occur in Nebraska. The Tier II list contains those species that are at-risk within Nebraska while apparently doing well in other parts of their range. Biologically Unique Landscapes (BULs) have been identified by the Nebraska Natural Legacy Project as areas with the greatest potential for at-risk species and natural community conservation. Quantifying species to assess biodiversity is relatively simple compared to understanding the intricate connections between species and the environment that create the complex tapestries of the natural world. If done appropriately, siting and operation can help conserve Nebraska's biodiversity.

There are places in the state where no amount of minimization measures or mitigation would appropriately offset impacts to highly sensitive areas and/or species.

Mitigation for impacts of wind energy development on Nebraska lands has become more refined with the development of each new wind energy project. For previous projects, a negotiation process between wind energy developers, NGPC staff, and the USFWS Nebraska Field Office staff was undertaken to determine the area impacted by development and the cost of the mitigation to offset those impacts. One of the goals of this document is to streamline and standardize the negotiation process.

The Nebraska Nongame and Endangered Species Conservation Act and the U.S. Endangered Species Act (collectively referred to herein as "Acts") protect species listed as endangered or threatened under these Acts in Nebraska. **Following the guidelines in this document does not replace consultation or coordination at the state or federal level required by these Acts. Therefore, at any given site, additional measures may also be needed above and beyond what is recommended in this document.**

These guidelines provide information on ways to avoid, minimize, and mitigate impacts of wind energy on wildlife and habitats. However, other issues should be considered including, but not limited to, impacts on historic and cultural resources, national monuments, trails, and scenic rivers, water quality, noise pollution, human health concerns, or county zoning. Wind energy developers should work with the State Historic Preservation Office, the National Park Service, the Nebraska Department of Environmental Quality, county boards, and others to address these issues.

The Nebraska Wind and Wildlife Working Group

The Nebraska Wind and Wildlife Working Group is a consortium of state and federal agencies, non-governmental conservation organizations, public utilities, and others 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 the NGPC, the 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. This document was developed in two separate stages, the general guidelines and the mitigation guidelines, and therefore, the combination of individual stakeholders may have varied, but the concept of stakeholder engagement and input remained.

BIODIVERSITY CONCERNS

Wind energy can impact biodiversity. Impacts are often classified in two ways, direct and indirect impacts.

Direct Impacts

Direct impacts occur when birds and bats collide with or when bats come in close proximity to moving turbine blades, towers, or transmission lines servicing wind farms and when habitat that could be used by wildlife is removed.

Estimates of fatalities at wind energy facilities in the U.S. for one year when less than 52,000 megawatts of wind power were installed were 573,000 birds and 880,000 bats (Smallwood 2013).

Studies show direct impacts may increase significantly when turbines are placed in or near major migration corridors or natural features used during daily animal travel (e.g., mountain passes, large river valleys, and saddles or the edges of ridge-tops and bluffs) (Drewitt and Langston 2008, Kunz et al. 2007), or at migration stopover sites or frequently visited areas such as wetlands and lakes. Because birds and bats tend to follow or congregate along these natural landscape features, wind turbines placed near these features have potential for causing an increase in bird and/or bat mortalities.

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 through the Central Flyway between their breeding grounds and wintering grounds. In Nebraska, nearly one-half million Sandhill cranes (*Grus canadensis*) roost along the Central Platte River and feed in the meadows and crop fields adjacent to the river for six to eight weeks during the spring migration. The federal and state-listed endangered whooping crane (*Grus americana*) also migrates through Nebraska. The central Platte River is one of the five geographic areas designated in the Central Flyway as critical habitat for whooping cranes. Rivers and wetlands outside of the Platte River valley (e.g., Rainwater Basin, Central Table Playas, the South, Middle, and North Loup Rivers, the Niobrara River, and the Republican River) are also used by whooping cranes as they migrate through the state. Given the rarity of some migratory species in Nebraska, the mortality of a few individuals could have a significant negative impact on the species' populations; for these reasons, direct impacts of winds energy development on migratory bird species are of great concern in Nebraska.

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. Studies have shown tree-roosting migratory bats are at a higher risk of direct impacts from wind turbines; three particularly susceptible species are the 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 ten other documented bat species. Several trends have been identified about bats' susceptibility to direct mortality by wind turbines, including: 1) fatality rates differ among species, 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). Currently there is no clear reason why so many bats are being killed by turbines and until such reasons are known, extra vigilance should be used when siting turbines near areas of potential bat stopover and roosting habitat or migration corridors.

Habitat lost through the construction of wind turbine and building pads, roads, and other infrastructure is another direct impact. Although an individual wind turbine pad is not great in size, when the cumulative habitat loss of all of the wind turbine pads and new roads are considered, the area could be substantial. The amount of land impacted in central North America by oil and hydraulic fracturing operations (e.g., well pads, roads, and storage facilities) from 2000-2012 is estimated to be about 3 million hectares or the equivalent of three Yellowstone National Parks (Alfred et al. 2015). The amount of land required to produce comparable amounts of wind energy is twice as much land as needed for oil and gas (Jones and Pejchar 2013). Wind energy can be developed on previously disturbed lands and can be repeatedly sited in the same locations, minimizing the amount of land impacted and habitat loss.

Indirect Impacts

Indirect impacts can affect all species in the impacted area, including plants and non-flying animals. These impacts represent an environmental cost that may be greater than direct impacts. Development of infrastructure (roads, tower sites, turbine pads, etc.) can result in wildlife species being displaced from otherwise suitable habitat near a turbine or other wind farm infrastructure, or a species determining an area no longer can provide what it requires to survive. Fragmentation, the process of dividing habitat patches into smaller patches, results in reduced patch size, increased distances between suitable habitats, and the introduction of new habitat types. For species that rely on large, intact landscapes, fragmentation can have a range of impacts, such as reduced gene flow between habitat patches and increased nest predation (Herkert et al. 2003). In addition, wind energy development can impede migration of both volant (flying) and non-volant (terrestrial) wildlife when the species avoid the area of development.

Fragmentation Explained

Humans would experience the impacts of fragmentation on their "habitat" if a bridge connecting portions of the city was no longer available for use. If the bridge connected the city center and a subdivision, individuals living on the side of the city center may continue to live happily without the bridge because their needs (grocery store, medical facilities, etc.) are still being met. Conversely, the residents of the subdivision may be forced to relocate, to abandon their home (habitat) because their basic needs can no longer be met now that they are separated or fragmented from the city center.

Roads and Fill

Small roads, such as those constructed within a wind farm to access turbines, have been shown to negatively impact a number of bird species (Ingelfinger and Anderson 2004). Vehicle traffic along roads can disturb wildlife within visual or audible range of the road and create dust that can coat nearby vegetation. Roads increase habitat fragmentation and habitat edges which many species avoid. Roads also facilitate the spread of invasive plants, thus changing the plant composition, altering the habitat, and potentially making it unsuitable for some wildlife species. Turbine pads and other infrastructure development that require placing fill (i.e., the soil or other material used to raise the grade of a site area) on a previously unfilled location can have similar impacts to the habitat as roads.

Turbine Avoidance

Certain species avoid 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).

Long-Term and Cumulative Impacts

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 the long-term and/or cumulative impacts may negatively impact birds; however, more research is needed to evaluate the magnitude of these impacts on species (Langston and Pullan 2003, Stewart et al. 2005). A comprehensive before-after-control-impact design study conducted in native mixed-grass prairies found that seven out of the nine grassland birds studied displayed displacement to 100 meters and beyond and this displacement persisted for at least five years post-construction (Shaffer and Buhl 2015). Because 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.

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 substantially multiply adverse effects (Langston and Pullan 2003).

PRACTICES TO AVOID AND MINIMIZE IMPACTS TO BIODIVERSITY

Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map

The *Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map* (Figure 1) was developed to delineate areas where potential adverse impacts of wind energy on biodiversity including wildlife concentrations in Nebraska are most likely to occur and the subsequent level of mitigation that will likely be recommended. The *Map* is based on a variety of other maps and GIS layers, some of which were developed specifically for these guidelines. An explanation of how maps and layers contributing to the *Map* were developed is provided in Appendix A. A full page *Map* is available in Appendix B.

Wind energy developers and planners are encouraged to refer to this *Map* as an initial step when considering new sites. However, potential adverse impacts to biodiversity and seasonal wildlife concentrations will be greatly influenced by site-specific factors that cannot be captured in a statewide map. Wind energy projects in areas mapped as Low Relative Sensitivity and Minimum Mitigation may have significant impacts due to specific siting of infrastructure. Conversely, there may be some sites within areas mapped as High Relative Sensitivity and Maximum Mitigation where wind development would be appropriate when coupled with conservation measures. In general, higher sensitivity and mitigation areas have a higher probability of impacts to biodiversity; 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**.

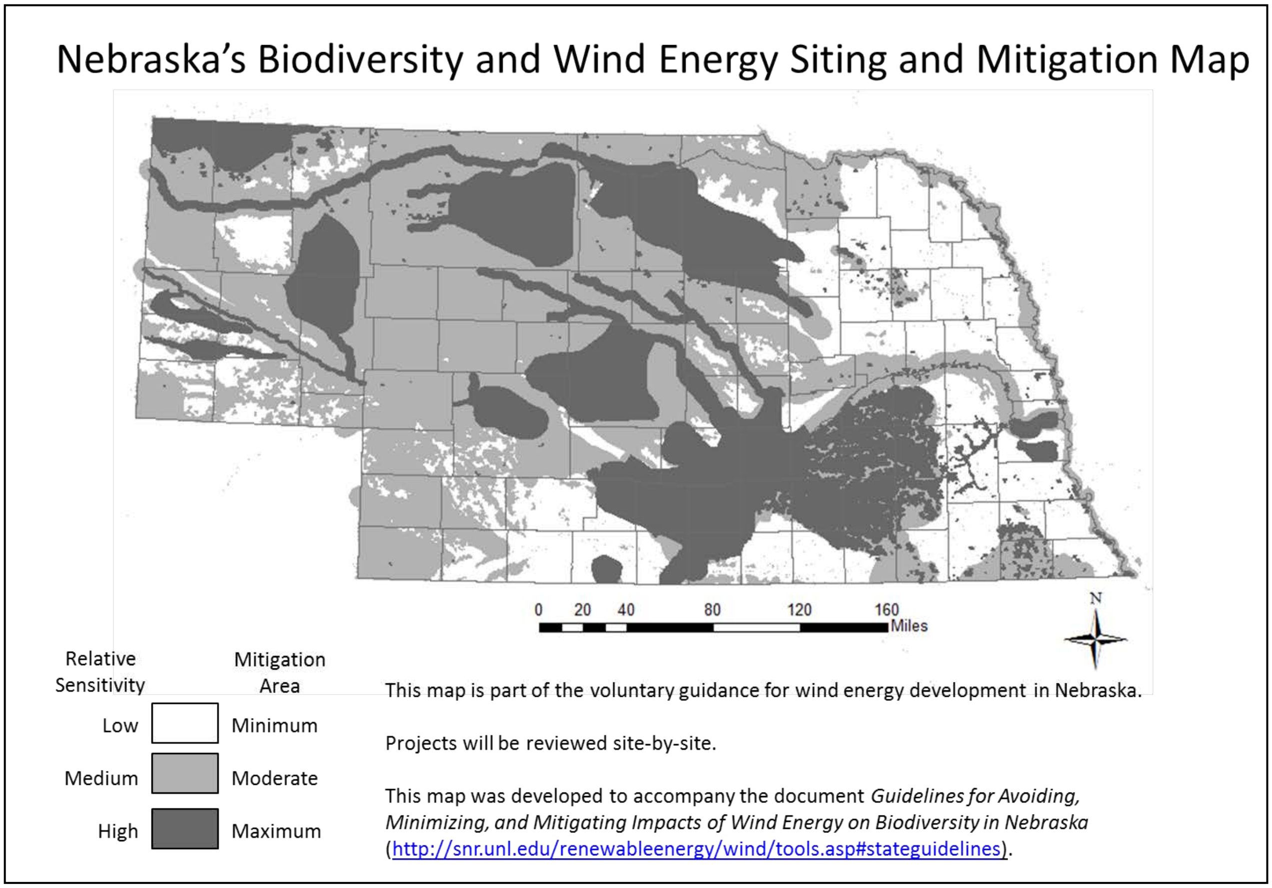

Figure 1. The *Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map* uses a series of maps containing information on species diversity and wildlife concentrations. The colors represent three levels of relative sensitivity and mitigation based on the anticipated impacts of wind energy on biodiversity.

General Recommendations

Siting wind energy facilities on previously altered landscapes, such as areas of cultivation, near towns, or urban and industrial areas is highly recommended in most circumstances. Avoid siting wind energy facilities in areas of contiguous intact native habitat and areas of concentrated wildlife use.

1. 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* (http://outdoornebraska.gov/nebraskawetlands/).

2. 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.

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

4. Place 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. Although there is no consistent data on the amount of buffer 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.

5. Avoid placing turbines at locations where they would have a direct or indirect impact on documented occurrences of wildlife or plants protected under the federal Endangered Species Act, the Bald and Golden Eagle Protection Act, and/or the Nebraska Nongame and Endangered Species Conservation Act. Site turbines in areas where impacts to migratory birds would be minimized in accordance with the Migratory Bird Treaty Act. Information regarding the species protected under these laws may be obtained by contacting the NGPC or the USFWS Nebraska Field Office.

Avoid roost habitat areas with documented repeated use by migrating whooping cranes. Examples of such areas include the Rainwater Basins, the central Platte River, the Loup rivers, the Niobrara River, the Central Table Playas in Custer County, and the eastern Sandhill wetlands. If a proposed wind energy project falls within the whooping crane migration corridor, a specific risk assessment should be conducted (see 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.

6. Place turbines away from habitat known to be occupied by prairie grouse or other species that exhibit extreme avoidance of vertical features. If such habitat cannot be avoided, construction should not take place within ½ mile of leks during the lekking season.

7. Decommission, minimize, and restore roads and other disturbed areas not needed for facility operations. Use site-appropriate native species when replanting or seeding areas that have been disturbed.

Develop Contingency, Conservation, and Protection Plans

1. Develop an operational contingency plan outlining what steps will be taken in the event a species of concern is observed near the wind energy project. It is highly recommended that wind energy developers and operators develop an operational contingency plan for Whooping Cranes for every project in Nebraska. A *Whooping Crane Operational Contingency Plan* template is available at: https://wind-energy-wildlife.unl.edu/whooping-crane-operational-contingency-plan.

2. Develop an Avian Protection Plan (APP) using the APP Guidelines developed by the Avian Power Line Interaction Committee and the USFWS to help identify and minimize risks to all migratory and resident birds (https://wind-energy-wildlife.unl.edu/avian-protection-plan-app-guidelines).

3. Develop a Bird and Bat Conservation Strategy (BBCS) or a Wildlife Conservation Strategy (WCS) that outlines what processes the wind energy developer and operator will incorporate to comply with state and federal conservation recommendations and identifies impacts to wildlife species and the conservation and mitigation measures that will be employed during project development and operation.

Infrastructure Design Recommendations

1. Use 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 according to the document *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006* by Avian Power Line Interactive Committee (http://www.aplic.org/uploads/files/2643/SuggestedPractices2006(LR-2).pdf).

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

3. Bury electric power lines within the wind farm (collection lines). Any above ground power lines (i.e., from the wind farm to the power grid), riser poles, transformers, and conductors should comply with the document *Suggested Practices for Avian Protection on Power Lines: The State of the Art in 2006* by Avian Power Line Interactive Committee (http://www.aplic.org/uploads/files/2643/SuggestedPractices2006(LR-2).pdf). This includes marking all above ground power lines with bird flight diverters.

4. 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 red or dual red and white strobe or flashing lights should be used. These should be minimized in number, intensity, and number of flashes per minute. Steady burning red or white lights should *not* be used; they attract more night-migrating birds than do strobes.

5. Minimize the number and intensity of lights associated with operation and maintenance facilities and substations located within half a mile of the turbines. Use lights with motion sensors that are hooded downward (i.e., down-shielded). All internal turbine nacelle and tower lights should be turned off unless the structure is occupied. All interior site lighting in buildings and facilities should be turned off at night, except those required for safety/compliance purposes. Lights should only be illuminated when needed by personnel at the site.

6. Employ these guidelines when older facilities are upgraded or retrofitted.

Operation Recommendations

1. Feather or change the pitch angle of the turbine blades below cut-in speed as a standard practice. It is highly recommended that all turbines be programmed to feather blades when they are not producing electricity.

2. Increase turbine cut-in speeds (the lowest wind speed at which a wind turbine begins producing power) during periods of low wind speed during months when bats are present. In areas where northern long-eared bats (*Myotis septentrionalis*) could be present, the recommended cut-in speed is 5 meters per second. Northern long-eared bats are state and federally listed as threatened.

3. Curtail turbine operations by shutting turbines down in areas of high bird and bat use to minimize fatalities during migration periods.

4. Advise wind energy facility personnel to be aware of wildlife in the area, reduce vehicle speed, and avoid disturbing wildlife.

5. Promptly remove all large wildlife (not including carcasses used in post-construction surveys) and livestock carcasses from roads, fields, and all other areas in and around the wind energy facility. Carrion attracts avian scavengers such as crows and raptors, including golden eagles, all of which could collide with wind turbines.

PRE- AND POST-CONSTRUCTION GUIDELINES

Pre-construction Site Assessments

It is critical to establish the presence or absence of various 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 impacted, the likelihood and timing of occurrence of endangered, threatened, and other special-status species at the site, the magnitude of impacts to 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 the current National Wind Coordinating Collaborative report, *Comprehensive Guide to Studying Wind Energy/Wildlife Interactions*, is recommended (https://www.nationalwind.org/comprehensive-guide/).

An initial assessment of the proposed project site should determine which species and natural communities will need on-the-ground surveys. The results of the information review and baseline studies should be reported to the NGPC and the 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 following pre-construction surveys and associated timeframes are recommended for all projects; however, alternate timeframes can be established on a project-by-project basis if the NGPC and the USFWS are consulted early and often in the planning process.

1. Avian Surveys

For additional information and guidance regarding the following avian assessments and surveys, please go to: https://wind-energy-wildlife.unl.edu/avian-assessment-guidance-wind-energy-facilities.

Whooping Crane Desktop Assessment

It is currently not known how whooping cranes will respond to wind energy development, but there are concerns that whooping cranes may collide with wind turbines and associated infrastructure. Whooping cranes are state and federally listed as endangered and are a Tier I species in every ecoregion of Nebraska. Since 1956, numerous whooping crane mortalities or serious injuries have occurred as a result of collisions with power lines (U.S. Fish and Wildlife Service 2009). 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 USFWS (2009) document: *Whooping Cranes and Wind Development- An Issue Paper*. For tips on how to conduct a desktop assessment with mapping tools freely available on line, go to: https://wind-energy-wildlife.unl.edu/whooping-crane-desktop-assessment.

It is highly recommended that wind energy developers and operators develop an operational contingency plan for whooping cranes for wind energy development projects across the state. An operational contingency plan outlines what steps will be taken in the unlikely event a whooping crane is observed near a wind energy project and can help reduce the potential for whooping crane – wind turbine collisions. A *Whooping Crane Operational Contingency Plan* template is available at: https://wind-energy-wildlife.unl.edu/whooping-crane-operational-contingency-plan.

Nesting Raptor Surveys

A minimum of two years of pre-construction nesting raptor surveys are recommended during the breeding season within the project area as well as a two mile buffer around the project area. Surveys should determine the location of active or potentially active nests and the species occupying such nests that could potentially be disturbed by construction activities or have 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. Several raptors have been identified as Tier I or Tier II at-risk species in the Nebraska Natural Legacy Project State Wildlife Action Plan (Schneider et al. 2011). If projects are proposed in areas where certain species of raptors occur that are susceptible to collisions with wind turbines, then a larger buffer around the project area will need to be surveyed.

If the project occurs in areas where golden or bald eagles occur during anytime of the year, it will be highly recommended to follow the USFWS *Eagle Conservation Plan Guidance, Module 1 – Land-based Wind Energy* (v2).

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 grassland nesting birds identified as Tier I or II are highly recommended. These species may be at risk for collisions with turbines or associated structures or suffer from habitat loss due to avoidance of otherwise suitable habitat that is in proximity to turbines or associated structures.

Prairie Grouse Surveys

Nebraska has two species of prairie grouse: the greater prairie-chicken (*Tympanuchus cupido*) and the sharp-tailed grouse (*Tympanuchus phasianellus*). The greater prairie-chicken is a Tier I species in all ecoregions of Nebraska. 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.

2. Bat Surveys

Because of the potential long-term impacts to bat populations caused by excessive bat fatalities, a minimum of one year of pre-construction surveys are recommended for all new wind energy facilities 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. Consultations with the NGPC and the 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, 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 migrating species may be affected.

Recommendations for bat surveys are in the *Bat Assessment Guidance for Wind Energy Facilities in Nebraska* (https://wind-energy-wildlife.unl.edu/bat-assessment-guidance-wind-energy-facilities-nebraska).

3. Endangered and Threatened Species Surveys

Early consultation (at least two years prior to construction) with the NGPC and the USFWS is highly recommended to determine if focused surveys for state and/or federally listed endangered and threatened (E&T) species are needed. The NGPC's Natural Heritage Program maintains range maps, habitat information, and a database of documented occurrences for all at-risk species and communities in the state, including listed species. Developers are strongly encouraged to request the NGPC and the USFWS to conduct environmental reviews of proposed project sites to determine known occurrences, potential suitable habitat, and need for surveys for E&T species.

4. Plant Community Surveys

The Nebraska Natural Legacy Project (Schneider et al. 2011) 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.

Post-Construction Surveys and Operational Monitoring

Post-construction surveys and monitoring studies, including monitoring for carcasses *and* conducting surveys (e.g., breeding bird, nesting raptor, prairie grouse, and bat acoustic surveys) should be conducted to determine the estimated direct and indirect impacts of the wind farm. 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 (and other relevant species) should be conducted for a minimum of two years following initiation of project operations (see *Wind Energy and Nebraska's Wildlife: Avian Assessment Guidance for Wind Energy Facilities* and *Bat Assessment Guidance for Wind Energy Facilities in Nebraska*); however, longer-term monitoring is encouraged and would provide more reliable data (Erickson et al. 2007, Parker and Wiens 2005). In some cases, long-term monitoring may be required depending on the species which could potentially be affected. Project proponents should work with the NGPC and the USFWS to develop and/or determine acceptable survey and monitoring protocols for use. Use of standard protocols is encouraged and would allow for a comparison of results among projects.

Estimating Fatalities

Estimating bird and bat fatalities from wind energy operation requires a good survey design to detect the fatalities and a reliable estimator to determine how many fatalities may have occurred. There are several factors that contribute to the detection of a carcass including: 1) when the carcass arrived; 2) fraction of turbines searched; 3) proportion of fatalities in the searched area (relative density of carcasses); 4) proportion of carcasses persisting to the next search; and 5) searcher efficiency. Through survey design, some of these factors can be controlled to help increase the detection probability.

Recommendations:

1) Search as many turbines as possible.

2) Target searches in easier visibility classes. Detection probability should be over 30%.
3) Take into consideration the density weighting of carcasses (the probability of a carcass landing in the search area). Smaller carcasses generally fall closer to the wind turbine than larger carcasses.
4) Use a minimum of 20 small birds and bats and 10 large birds for searcher efficiency and carcass persistence trials (trials can be designed so the same carcasses can be used for both). Place carcasses continuously throughout the study period, e.g., one or two every other day rather than several on one day, then none for a long period of time.
5) To determine carcass persistence rates, place a small number of carcasses out each day and observe their persistence at day 1, 2, 3, 4, 7, 10, 14, 21 … (longer studies for larger carcasses or longer search intervals). It is important to check the persistence more often immediately after placing the carcass. Many small carcasses do not persist very long on the land and knowing the persistence pattern is important to accurately estimate how often searches need to be conducted and, ultimately, fatalities.
6) Evidence of Absence Software (http://pubs.er.usgs.gov/publication/ds881) is a free, user-friendly application that can be used to design search protocols. Prior to initiating fatality surveys, it is highly recommended the survey design be tested in this software program to determine the detection probability.
7) Use a non-biased fatality estimator to estimate fatalities of non-rare species. A recommended, free fatality estimator is available at: http://pubs.usgs.gov/ds/729/. The estimator software uses carcasses counts and detection-rate information provided by the user. A very important feature of the software is that it provides measures of uncertainty in the estimates it produces.
8) For rare species (e.g. threatened and endangered species, eagles, or other species of concern), for which fewer than 10 fatalities are predicted, use the Evidence of Absence Software (http://pubs.er.usgs.gov/publication/ds881). The Software uses information about the search process and scavenging rates to estimate detection probabilities to determine a maximum credible number of fatalities, even when zero or few carcasses are observed.

Reporting:

1) The estimate of turbine-caused fatality reported will always be greater than or equal to what was observed at the wind energy facility.
2) Include:
    a. Proportion of wind turbines surveyed for different methods (e.g., complete searches out to 80-120 meters, modified road and pad, etc.).
    b. Wind turbine numbers searched.
    c. Sampling coverage (density weighted proportion of area searched for each carcass size class and each turbine).

d. Search interval for each for different method (e.g., complete searches out to 80-120 meters, modified road and pad, etc.).
e. Carcass persistence and searcher efficiency results for bats, small, medium, and large birds.
f. Number and species of fatalities found.
g. Estimate of fatality per turbine and for entire facility for bats, small, medium, and large birds.
h. 95% confidence interval around estimates.

Remember, failing to detect and estimate a fatality (absence of evidence) cannot necessarily be interpreted as evidence of a fatality being absent (evidence of absence).

For more information see Huso and Dalthorp 2014 (http://onlinelibrary.wiley.com/doi/10.1002/jwmg.663/abstract).

Incidental Fatality Reporting

Project operators are encouraged to develop incidental fatality reporting protocols to coincide with regular on-going operational activities. With such a protocol, wind farm technicians and other personnel who work at the facility can help track bird and bat fatalities found on roads and wind turbine pads.

MITIGATION GUIDELINES

Purpose

These guidelines are intended to provide wind energy developers and operators with a better idea of what, if any, mitigation will likely be recommended for permanent impacts based on proposed wind turbine locations of utility-scale (at least 10-20 MW or more than 5 wind turbines) wind energy developments. By having areas in the state identified where no, minimum, moderate, or maximum mitigation would be recommended, developers can be better informed and prepared for the level of mitigation which is likely to be recommended, as well as avoidance and minimization by location choices. Once a project location is selected, the mitigation ratios established in this document can help developers estimate the cost of mitigation for a given project and incorporate the cost into their budget. The mitigation worksheet is designed to assist in the calculation of mitigation costs for each type of infrastructure in each habitat category. Administrative fees are also added onto the mitigation cost in the mitigation worksheet. Lastly, this section outlines different options for designating funds and additional recommendations.

In October 2013, the Secretary of the Interior issued a Secretarial Order to improve the mitigation policies and practices of the Department of the Interior (Order No. 3330). The purpose of the Order is to establish a department-wide mitigation strategy that will ensure consistency and efficiency in the review and permitting process. The strategy will include the use of a landscape-scale approach to identify and facilitate investment in key conservation priorities, early integration of mitigation considerations in project planning and design, durable mitigation measures over time, transparency and consistency in mitigation decisions, and focusing on mitigation measures that will improve the resilience of our Nation's resources in the face of climate change.

Each of the strategies listed in Order No. 3330 are present in these mitigation guidelines. Wildlife and native plant communities were evaluated across the state and the *Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map* was developed to identify levels of mitigation and relative sensitivity based on impacts to species and native habitats. The *Map*, mitigation ratios for different habitat categories and impacts, and the mitigation worksheet, can all be used to determine potential mitigation costs early in the project planning phase. The recommendations set forth in these guidelines are supported by the best available science, and will help standardize the mitigation process. Additionally, these guidelines accounts for the importance of intact grasslands, forests, wetlands, and other native habitats for wildlife now and as the climate changes.

Group Members

The Mitigation Guidelines are a result of the collaborative efforts of a group of professionals dedicated to developing recommendations to mitigate impacts to Nebraska's biodiversity while not unnecessarily hindering wind energy development. Participation in the group is open to any interested individual.

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Subject Expert Reviewers

A series of meetings were held with experts from a number of fields (e.g., wetlands, plant community, waterfowl) to gather recommendations on buffer distances and input on how well this set of guidelines addressed mitigation for their areas of expertise. Reviewers were selected based on known expertise in the field.

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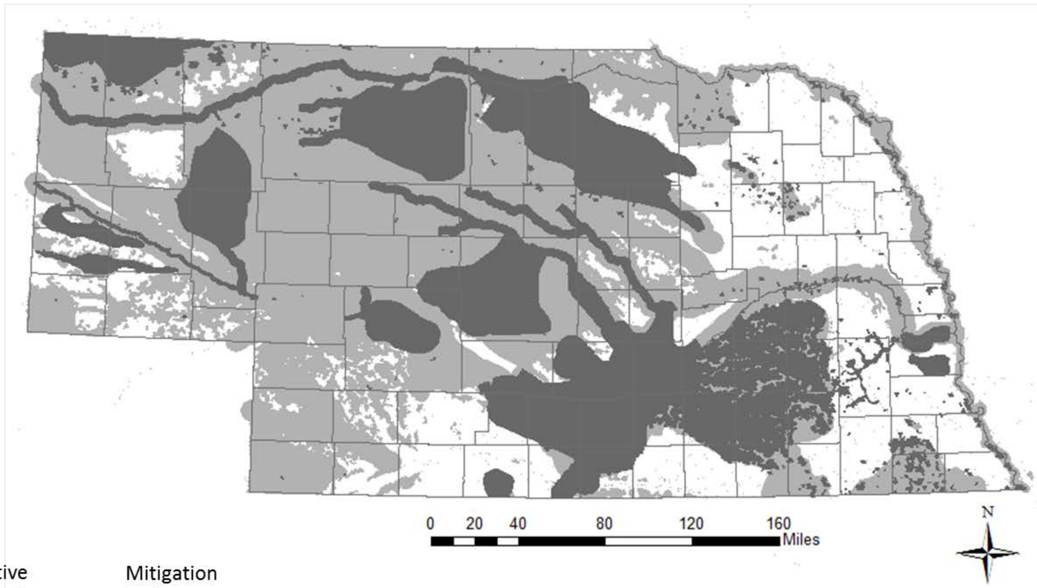
Mitigation Areas

For detailed explanations and maps, see Appendix A.

Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map



Relative Sensitivity		Mitigation Area
Low	(white)	Minimum
Medium	(light gray)	Moderate
High	(dark gray)	Maximum

This map is part of the voluntary guidance for wind energy development in Nebraska.

Projects will be reviewed site-by-site.

This map was developed to accompany the document *Guidelines for Avoiding, Minimizing, and Mitigating Impacts of Wind Energy on Biodiversity in Nebraska* (http://snr.unl.edu/renewableenergy/wind/tools.asp#stateguidelines).

Minimum Mitigation Areas are in white and correspond to areas in the state with Low Relative Sensitivity to impacts from wind energy. These are areas in the state where the quantity and quality of habitat and wildlife concentrations are not as great as other areas in the state. Developing wind energy projects in these areas would likely have fewer impacts to wildlife and biodiversity, in general, than developing in other areas. There are locations within the Minimum Mitigation Areas where mitigation will still be recommended (such as grasslands, wetlands, and forests), but the recommended mitigation ratio will be less than recommended for the Moderate Mitigation Areas.

Moderate Mitigation Areas are in light gray and correspond to areas in the state with Medium Relative Sensitivity to impacts from wind energy. The mitigation ratio for impacts to lands within the Moderate Mitigation Areas is set higher than for Minimum Mitigation Areas. Areas included under this designation are all areas classified as Ranks 1 and 2 for Intact Natural

Landscapes, most Biologically Unique Landscapes, all Natural Communities ranked as G3 to G5 or S3 to S5, all Wetlands, the Lower Platte and Missouri River Wetland Complexes, Playa Clusters outside of the Rainwater Basin, and buffers on Important Rivers for Waterfowl.

Maximum Mitigation Areas are represented in dark gray and correspond to areas in the state with High Relative Sensitivity to impacts from wind energy. In many of these areas, it is unlikely any amount of mitigation would compensate for the impacts to biodiversity; therefore, avoiding development in these areas is recommended. If a site within the Maximum Mitigation Areas is acceptable for development, mitigation will be determined for the site. Areas included under this designation are select Biologically Unique Landscapes, all Natural Communities ranked as G1 to G2 or S1 to S2, Lower Platte and Central Platte Wetland Complexes, Playas in the Rainwater Basin, Whooping Crane Priority Stopover Landscapes, select Important Rivers for Waterfowl, and Known Bat Hibernacula.

Calculating Mitigation Costs

The recommended mitigation ratio will be based on the type of habitat (Category), mitigation area (Minimum, Moderate, Maximum), and type of impact (Direct, Indirect). To determine the amount of habitat directly and indirectly impacted by wind energy development and operation, site-specific assessments and calculations will be needed. NGPC and USFWS personnel may request a site visit to verify mitigation assessments and associated calculations.

No mitigation will be recommended for wind turbines, roads, or other infrastructure in Minimum Mitigation or Moderate Mitigation Areas if all lands within established buffer distances fall into the tilled agricultural lands category, and if upon a site specific evaluation no adverse impacts to biodiversity or wildlife concentrations are identified.

Calculations of mitigation costs for both direct and indirect impacts are for permanent impacts to the land (i.e., will persist as long as or longer than the wind energy facility is in operation). Temporary impacts (e.g., widening roads for construction) are impacts that result during a stage of development or maintenance. Recommendations for addressing temporary impacts can be found in the General Recommendations.

Direct Impacts permanently remove habitat that could be used by wildlife or other species. This includes habitat lost through the construction of wind turbine and building pads, roads, and other infrastructure.

Indirect Impacts occur when wildlife use and biodiversity of an area is reduced due to the development and/or operation of wind turbines. To calculate the indirect impacts infrastructure development and wind turbine operation may have on wildlife species, two buffer distances have been established, one for wind turbines and another for roads and other infrastructure constructed for the wind energy development. These buffer distances are based on documented and anticipated impacts of wind turbine or road development on wildlife and other species in each habitat type (Appendix C).

To determine the amount of indirect impacts, establish a buffer for each category based on the distance provided in the table below for each wind turbine and other type of infrastructure (e.g., road, building, parking area, etc.). For every category, determine the percent area represented by that category within the designated buffer distance. For wetlands, if the buffer falls anywhere in a wetland, the entire wetland should be mitigated for. Examples of mitigation scenarios can be found in Appendix D.

Mitigation Categories and Ratios

		Mitigation Ratio						
Category	**Description**	**Minimum Mitigation Areas**		**Moderate Mitigation Areas**		**Maximum Mitigation Areas**	**Wind Turbine Buffer Distances**[3]	**Road & Other Infrastructure Buffer Distances**[3]
		Direct Impacts	*Indirect Impacts*	*Direct Impacts*	*Indirect Impacts*	*All Impacts*		
Tilled Agricultural Lands	Tilled agricultural lands that have been tilled for at least five years.	0	0	0	0	Mitigation will be determined for site.	Buffer will be determined for Maximum Mitigation Areas.	Buffer will be determined for Maximum Mitigation Areas.
Non-Native Grasslands	Grasslands that were tilled or modified and contain >75% non-native plants.	0.5:1	0.25:1	0.5:1	0.25:1	Mitigation will be determined for site.	200 meters	100 meters
Restored Native Grasslands	Grasslands that were tilled or modified, but have been restored with prairie grasses and forbs; predominately (>75%) native plants.	1:1	0.5:1	2:1	1:1	Mitigation will be determined for site.	200 meters	100 meters
Unbroken Grasslands	Grasslands that have never been tilled or have not been tilled in the last 30 years.	2:1	1:1	3:1	1.5:1	Mitigation will be determined for site.	200 meters	100 meters
Forests/ Woodlands	Native forest/woodlands dominated by >50% native trees.	2:1	1:1	3:1	1.5:1	Mitigation will be determined for site.	100 meters	10 meters

		Mitigation Ratio						
Category	**Description**	**Minimum Mitigation Areas**		**Moderate Mitigation Areas**		**Maximum Mitigation Areas**	**Wind Turbine Buffer Distances**[3]	**Road & Other Infrastructure Buffer Distances**[3]
		Direct Impacts	*Indirect Impacts*	*Direct Impacts*	*Indirect Impacts*	*All Impacts*		
Wetlands and other waterbodies[1]	Wetlands- lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water[2]. (Cowardin 1977). Wildlife Use/Disturbance		1:1		1.5:1	Mitigation will be determined for site.	800 meters for wetlands suitable for Whooping Crane or other water or shorebirds; 200 meters for all others	10 meters for all wetlands
	Hydrological Function	2:1		3:1		Mitigation will be determined for site.	10 meters for all wetlands	10 meters for all wetlands
Streams and Rivers	Bodies of water with a current and confined in a bed by banks.	2:1	1:1	3:1	1.5:1	Mitigation will be determined for site.	800 meters for streams and rivers with known water or shorebird use; 200 meters for all others	10 meters for all streams and rivers

[1]Impacts to hydrological function will be considered direct; impacts to wildlife use will be considered indirect. [2] For the purposes of this classification wetlands must have one of more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year (Cowardin 1977). [3] Buffer distances were established based on literature listed in Appendix C and expert input.

Mitigation Worksheet

An Excel workbook was developed to aid in the calculation of acres directly and indirectly impacted by wind energy development (see Appendix D for an example). There are two worksheets available, one for developments in Minimum Mitigation Areas and one for developments in Moderate Mitigation Areas. In each of the worksheets, formulas are in place that will automatically determine, based on values entered, how much monetary mitigation will likely be recommended for each category and for the entire project.

Cost per Acre

The easement or purchase value of the land for which mitigation is being determined should be evaluated at the time of construction. This may require some flexibility in the wind energy developer's mitigation budget if the project takes several years to develop to completion. Having the land independently appraised is recommended. Once the value of the land is determined, an additional 20% will be added to ensure active management of the land to maintain or improve habitat.

Designating Use of Mitigation Funds

If mitigation is recommended for a wind energy development, there are a number of options for off-setting the ecological impacts of development. The most suitable option will depend on the nature and extent of the impacts. Mitigation dollars will be used to offset impacts to the habitat type impacted. For example, if a project impacts grasslands and wetlands, the mitigation amount for grasslands will be used to help restore or protect grassland habitat of the same type impacted. Likewise, the mitigation amount for wetlands will be used to help restore or protect wetland habitat of the same type impacted.

Mitigation Habitat Recommendations

Mitigation habitat generally should be:

1. Of like kind (e.g., tallgrass prairie for tallgrass prairie);
2. In the same geographical and ecological region as the impacted habitat, but at least 5 miles from wind energy facilities;
3. Of equal or higher quality habitat than the impacted area OR land that can be restored to equal or higher quality habitat.

Ideally, the mitigation habitat will be under threat from development or conversion that would degrade or decrease habitat, either imminently or likely within the next 25 years.

Options for Use of Funds

There are a number of different ways mitigation funds can be used to offset impacts on habitat and it is recommended that each has a land management plan. Native habitats in Nebraska require active management. Historically, the habitats of Nebraska were frequently disturbed by wildfire, bison grazing, and other natural disturbances. With the suppression of fire, the subdivision of the land into private parcels, and the conversion of large tracts of grassland to row crop agriculture, the remaining native lands are rarely subjected to natural disturbances sufficient enough to keep invasive species at bay, ensure plant diversity, etc. For example, if a conservation easement is placed on a native grassland and management practices (e.g., prescribed fire and grazing rotations) are not implemented, the grassland could transition into a red cedar forest and would no longer support the wildlife species and grassland plants for which the conservation easement was established.

Wind energy developers can discuss these options with the NGPC and USFWS.

Restoration and/or Land Management

Habitat impacted by wind energy may no longer be suitable for wildlife or other species and therefore is lost. To make up for the habitat lost, restoring the quantity of suitable habitat and/or managing existing habitat to increase its suitability are options. Activities funded could include prescribed fire, grazing management, removing invasive plants, re-seeding grassland, and/or re-introducing desired species. All activities would be guided by a restoration or multi-year management plan designed and/or agreed on by appropriate resource management entities.

Conservation Easement/Fee Title Acquisition

One of the most generally suitable options for off-setting ecological impacts of wind development is a conservation easement. A conservation easement allows a qualified private land conservation organization (land trusts, etc.) or government agency (municipal, county, state or federal) to exercise rights otherwise held by a landowner to achieve certain conservation purposes. The land conservation organization or agency acquires these rights from a ***willing*** landowner and enters into either a term or perpetual partnership to maintain the ecological integrity of the land. A typical conservation easement used to mitigate wind development would be a perpetual easement and would restrict wind development and any other activities that would diminish the natural character and conservation value of the land and its waters. Certain compatible uses of the land could still be permitted, for example, ranching, hunting, and other recreation. The land conservation organization or agency would have the responsibility to monitor the land annually and ensure compliance with the easement agreement.

Mitigation funds could also be provided to an organization to purchase property. The organization must be committed to managing the land to meet conservation goals (e.g., maintain wetland hydrology, minimize invasive species encroachment in a grassland) for as long as the infrastructure associated with the wind energy development is in place.

Mitigation funds would be used to cover the price of the easement/purchase and the cost of administrative fees. For both easements and fee title acquisition, funds for active management of the property to maintain or improve habitat quality would be included in the mitigation cost. Land management goals will be included in the contract for the conservation easement or contract with the organization responsible for managing the land acquired through the fee title acquisition.

Mitigation Bank

There are several entities who can accept mitigation dollars. Implementing conservation practices on the land can be expensive; pooling mitigation dollars from multiple projects can provide more opportunity to fund projects.

RESEARCH

Much uncertainty remains regarding predicting risk and estimating impacts of wind energy development on biodiversity. 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 habitats, providing funds for research, and making their organization's research data and results publically available.** The Nebraska Wind and Wildlife Working Group 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, but both types of studies could provide valuable information about wind energy – wildlife interactions. Data collected during standard pre- and post- construction surveys at a number of wind energy facilities could be used to test specific research hypotheses about impacts to a particular species, community, or landscape. By sharing data collected during pre- and post- construction surveys, wind proponents can facilitate these studies at no additional financial cost.

Research studies, such as assessing the indirect impacts could provide information for future projects and potentially help to minimize the uncertainty of wind energy impacts on wildlife. Funding for research studies is needed, but through collaboration across stakeholder groups, the resources needed could be shared. For example, a wind proponent could provide funding for a research project that could be carried out by a graduate student who seeks additional funding through grants.

Current research priorities for Nebraska include: assessing the cumulative impacts of multiple wind farms in an area, locating bat migration corridors within the state, and establishing long-term post-construction survey and monitoring efforts to explore the potential long-term impacts of wind energy development on wildlife. Other valuable research activities could 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.

RELATED LINKS

The Nebraska Wind Energy and Wildlife Project - https://wind-energy-wildlife.unl.edu/

Nebraska Game and Parks Commission – Biodiversity - Birds - http://outdoornebraska.gov/biodiversitybirds/

USFWS Ecological Services – Wind Power Development in Nebraska – http://www.fws.gov/nebraskaes/wind.php

American Wind Wildlife Institute (AWWI) - http://www.awwi.org/

Bats and Wind Energy Cooperative (BWEC) - http://www.batsandwind.org/

National Wind Coordinating Collaborative (NWCC) - https://www.nationalwind.org/

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APPENDIX A: MAPS USED IN THE DEVELOPMENT OF THE NEBRASKA'S BIODIVERSITY AND WIND ENERGY SITING AND MITIGATION MAP

Each of the following maps was used to help develop the Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map. Following the description of each map is an explanation on how the map was used. In some cases, a given area had different overlapping levels of relative sensitivity and mitigation assigned to it due to different ranking criterion of each map. In these cases, the area was classified with the highest level of relative sensitivity and mitigation.

There are three levels of relative sensitivity and mitigation areas. All Low Relative Sensitivity Areas are Minimum Mitigation Areas, whereas all High Relative Sensitivity Areas are Maximum Mitigation Areas.

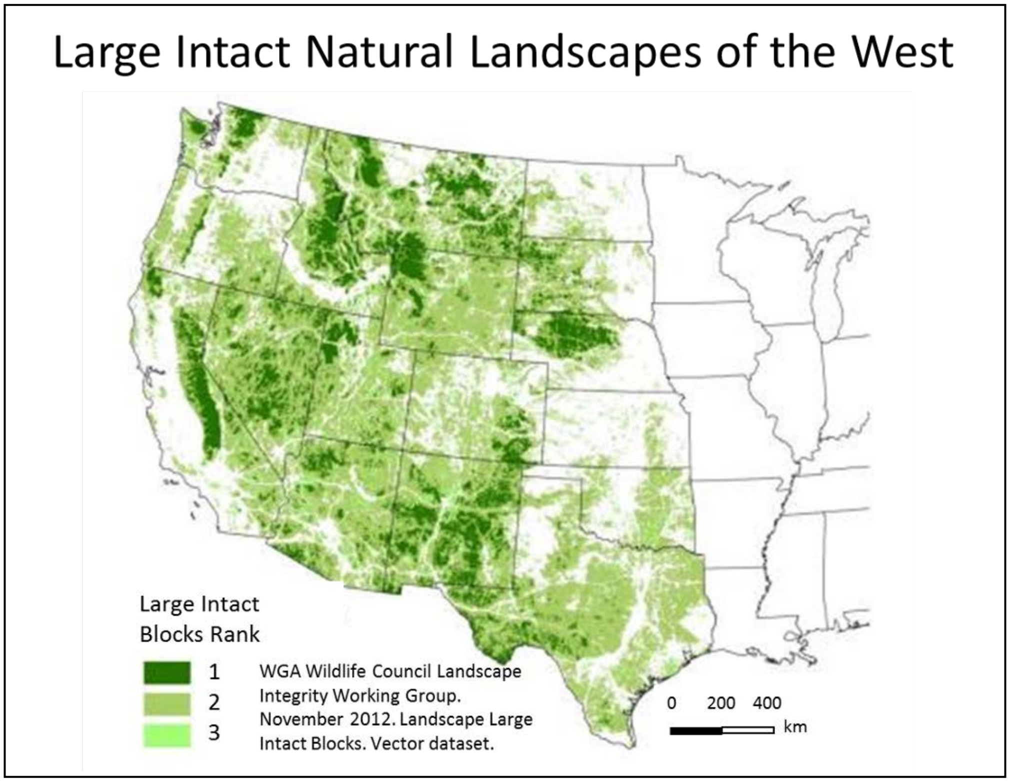
Relative Sensitivity		**Mitigation Area**
Low		Minimum
Medium		Moderate
High		Maximum

Maps/Layers Used:

- Intact Native Landscapes in Nebraska
- Biologically Unique Landscapes in Nebraska
- Natural Communities in Nebraska
- Wetlands in Nebraska
- Nebraska's Wetland Complexes
- Playa Clusters in Nebraska
- Whooping Crane Priority Stopover Landscapes
- Important Rivers for Waterfowl in Nebraska
- Known Bat Hibernacula in Nebraska

Intact Natural Landscapes in Nebraska

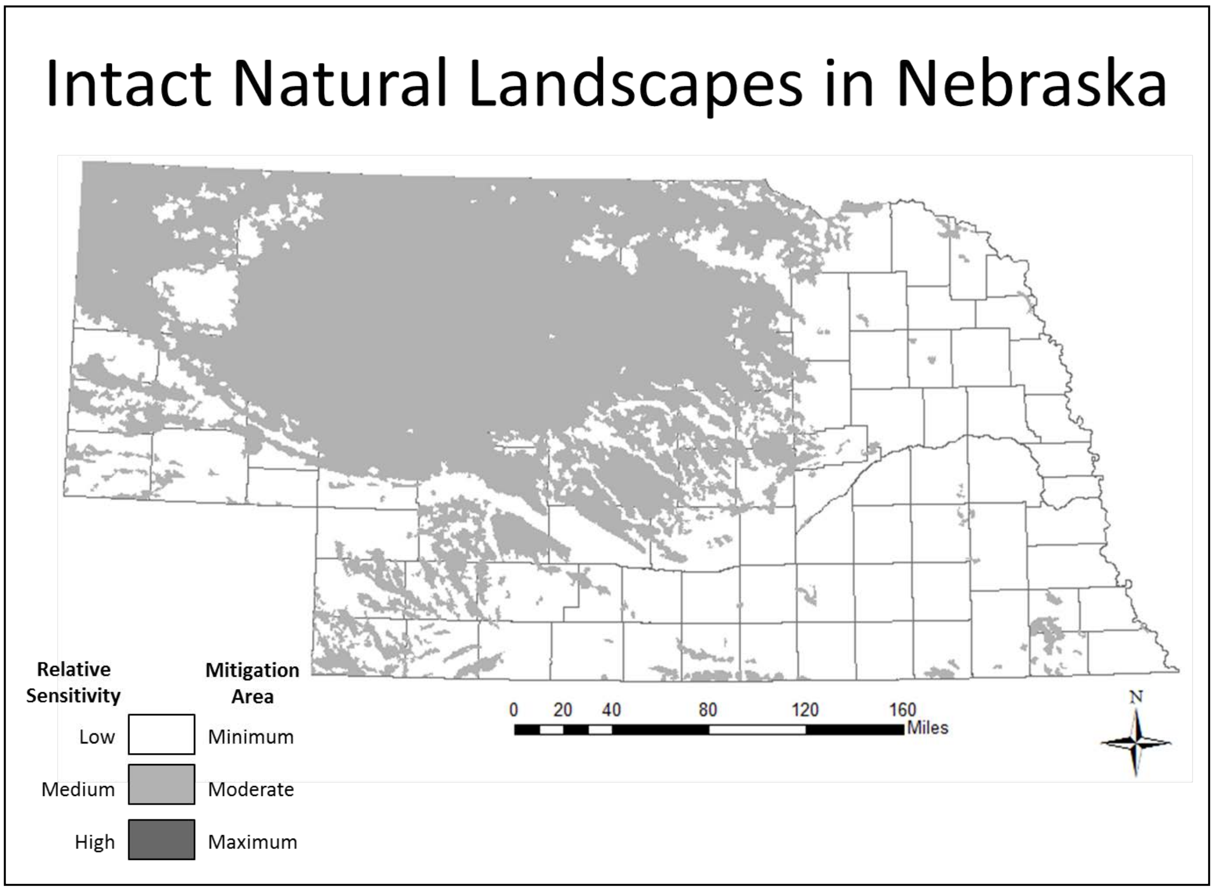
Obermeyer *et al*. in their 2011 paper, *Development by Design: Mitigating Wind Development's Impacts on Wildlife in Kansas*, used two categories of intactness to describe unfragmented landscapes, 50-95% grassland cover and ≥ 95% grassland cover. For Nebraska, a similar methodology was used, but included all intact native lands instead of only grassland cover. The layer used is the intact blocks developed by the landscape integrity workgroup of the Western Governors' Association (WGA) Crucial Habitat Assessment Tool (CHAT) technical team (WGA Wildlife Council Landscape Integrity Working Group. November 2012. Landscape Large Intact Blocks. Vector Dataset.). The Large Intact Blocks (LIB) dataset was calculated from the NatureServe Landscape Condition Model (Comer, P. J. & J. Hak. 2012. Landscape Condition in the Conterminous United States. Spatial Model Summary. NatureServe, Boulder, CO) as a way to identify large areas that were relatively intact or had low levels of anthropogenic impacts. A minimum LIB size was set at 1,000 hectares, but the threshold for "impacted" varied by ecodivisions to account for regional differences. Areas with a rank of 1 are the highest quality intact blocks for the ecoregion. For use in this document, the data layer was slightly modified to include small areas under two square miles that were not part of intact blocks but were completely inside intact blocks.



The Sandhills is the most intact landscape left in the Great Plains and is "one of the highest quality, intact prairie landscapes in the country" (Schneider et al. 2011). The importance of the intact Sandhills for conservation of biodiversity at a global level is underscored by the fact that they harbor globally imperiled species such as American burying beetle (*Nicrophorus americanus*, G2G3), Hall's bulrush (*Schoenoplectus hallii*, G2G3), and regal fritillary (*Speyeria idalia*, G2), as well as species in decline elsewhere such as greater prairie-chicken (*Tympanuchus cupido*, G4) and Blanding's turtle (*Emydoidea blandingii*, G4).

The Sandhills is the most important breeding area for mallards (*Anas platyrhynchos*), blue-winged teal (*Anas discors*), and northern pintails (*Anas acuta*) south of the prairie pothole region (Schneider et al. 2011). The Sandhills is an important nesting area for the long-billed curlew (*Numenius americanus*) (e.g., Gregory et al. 2012), a species considered "highly imperiled" by the U.S. Shorebird Conservation Plan. The region is also an important nesting area for American avocet (*Recurvirostra americana*), willet (*Tringa semipalmata*) and Wilson's phalarope (*Phalaropus tricolor*) and an important staging and stopover area for American avocet, Baird's sandpiper (*Calidris bairdii*) and Wilson's phalarope and other shore- and waterbirds.

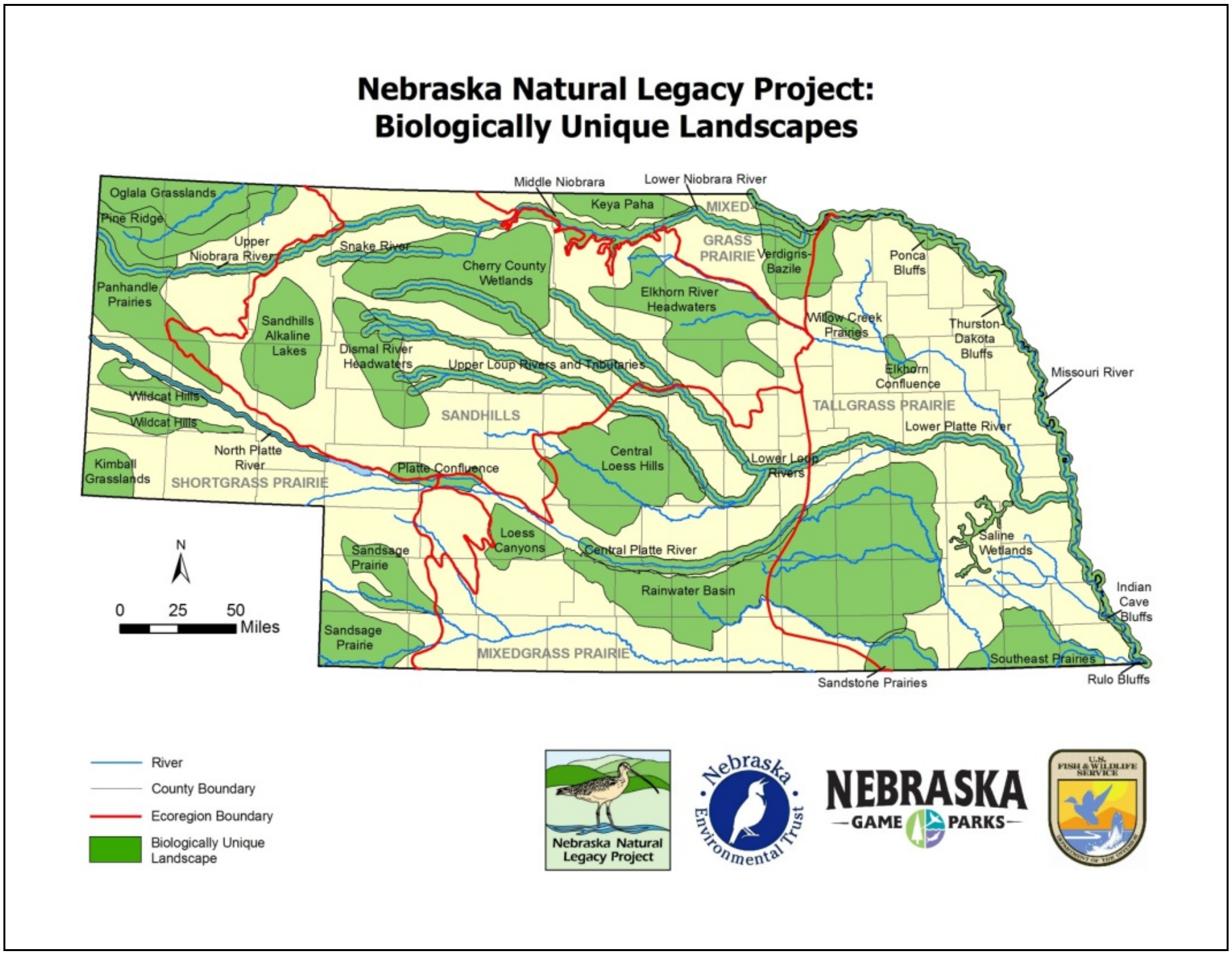
There are several specific areas in the Sandhills which are more sensitive to wind energy development and are considered High Relative Sensitivity and Maximum Mitigation Areas. These areas are described in the following sections.



How this map was used: All areas classified as Ranks 1 and 2 in Nebraska were classified as Medium Relative Sensitivity and Moderate Mitigation Areas.

Biologically Unique Landscapes in Nebraska

The Nebraska Natural Legacy Project: State Wildlife Action Plan (http://outdoornebraska.gov/naturallegacyproject/) identifies landscapes based on known occurrences of natural communities and at-risk species and sets goals for each community type and certain at-risk species (Schneider et al. 2011). A set of landscapes were determined that offer some of the best opportunities for conserving the full array of biological diversity in Nebraska. Thirty-nine landscapes across the state were considered to be some of the last strongholds in Nebraska for many species and were, therefore, designated Biologically Unique Landscapes (BULs). The *Plan* has a description of the landscapes, a list of the species at-risk of extinction or extirpation from the state, and an outline of conservation strategies for each of the BULs.



Middle Niobrara River BUL: A stretch of this BUL located in Cherry, Keya Paha and Brown counties has been designated as a National Wild and Scenic River due to its unique natural resource values. The Niobrara River valley in this reach is often referred to as the “Biological Crossroads of the Midwest” due to its diversity of plant communities and unique array of plant and animal species they support. The Middle Niobrara BUL supports multiple at-risk species, some of which are threatened or endangered. The Nature Conservancy’s Niobrara Valley Preserve alone supports 581 plants species, 213 birds, 86 lichens, 44 mammals, 25 fishes, 17 reptiles, and 8 amphibians. Other conservation lands within the BUL include Fort Niobrara National Wildlife Refuge, Smith Falls State Park, and several state wildlife management areas and state recreation areas.

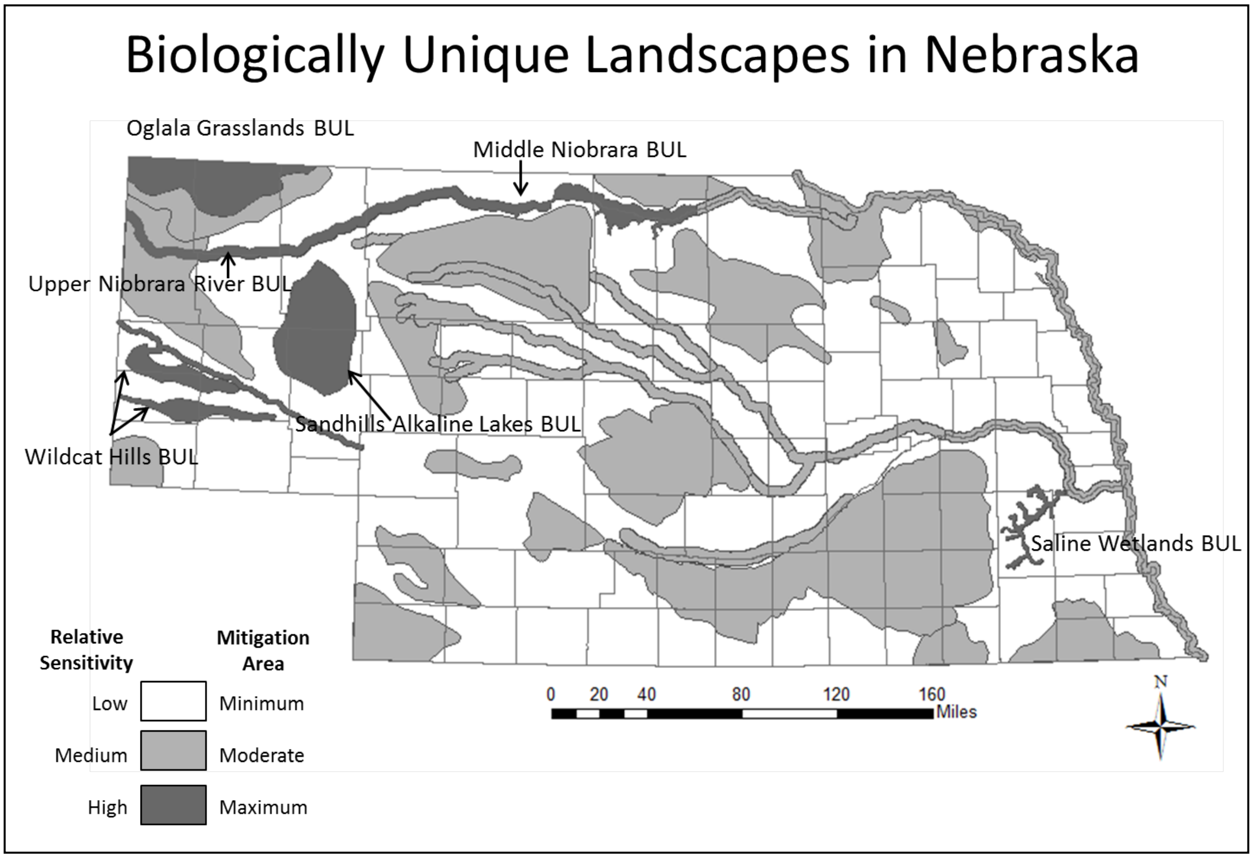
Oglala Grasslands BUL: This area supports a unique array of high-quality plant communities including northwestern mixed-grass prairie, threadleaf sedge western mixed-grass prairie, silver sagebrush shrub prairie, greasewood shrub prairie, badlands, rock outcrops, spikerush vernal pool, among others. This BUL also supports populations of four Tier 1 at-risk plant species including Barr's milkvetch (*Astragalus barrii*), dog-parsley (*Lomatium nuttallii*), Gordon's wild buckwheat (*Eriogonum gordonii*), and Rocky Mountain bulrush (*Schoenoplectus saximontanus*). The area is also an important nesting area for ferruginous hawk (*Buteo regalis*) and chestnut-collared longspurs (*Calcarius ornatus*) and an important foraging area for golden eagles (*Aquila chrysaetos*) and prairie falcon (*Falco mexicanus*). The BUL is the location of the Oglala National Grasslands, which provides a large complex of conservation lands.

Saline Wetlands BUL: These rare wetlands provide habitat for a number of resident and migratory species. The state and federally endangered Salt Creek tiger beetle (*Cicindela nevadica lincolniana*), one of the world's rarest insects, is known to occur only in these saline wetlands. More than 200 species of migratory birds have been recorded using the wetlands. Saltwort (*Salicornia rubra*), an endangered plant species in Nebraska, is only found in these wetlands and represent the southernmost permanent extant of the species. Once expansive enough to consider as for a salt mining operation, many of these wetlands have been lost due to urban expansion and agricultural activities.

Sandhills Alkaline Lakes BUL: This is a highly pristine area of the Nebraska Sandhills containing a mix of upland prairie communities and both alkaline and freshwater wetlands. The uplands contain both sandhills dune prairie and sandhills dry valley prairie (G3/S4), as well as wetland types including western alkaline marsh, western alkaline meadow (G3/S3), reed marsh, northern pondweed aquatic wetland, among others. The region also supports some of the largest populations of the federally and state endangered blowout penstemon (*Penstemon haydenii*). This species occupies open sand blowouts on dune tops, which would be highly susceptible to wind development. Wetlands in this BUL are critical for migratory and breeding shorebirds and waterfowl.

Upper Niobrara River BUL: This rugged upper Niobrara River valley supports a diverse array of near-pristine plant communities. Uplands support several mixed-grass prairie communities and extensive rock outcrops. The river bottoms support some of our state's most extensive examples of western subirrigated alkaline meadow, a G3/S2 plant community, among other wetland types. This BUL supports populations of four Tier 1 at-risk species: Gordon's wild buckwheat, large-spike prairie-clover (*Dalea cylindriceps*), meadow lousewort (*Pedicularis crenulata*), and the state's only population of the state and federally threatened Ute lady's-tresses (*Spiranthes diluvialis*). The upper Niobrara River valley is one of the state's most important raptor nesting areas.

Wildcat Hills BUL: Despite the area's small size it has some of the greatest plant diversity in the state. The escarpments contain a diverse mosaic of high-quality plant communities ranging from pine woodlands and forests (G3G4/S3S4), mountain mahogany shrublands, western sedge meadow, threadleaf sedge western mixed-grass prairie, sandsage prairie, badlands, and rock outcrops, among others. The occurrences of mountain mahogany shrublands are by far the most extensive in the state. Extensive portions of the Wildcat Hills (over 20,000 acres) are under conservation ownership, making the region even more valuable for biodiversity conservation. The Wildcat Hills are one of the state's most important areas for nesting raptors, including golden eagles. The state's most stable population of bighorn sheep (*Ovis canadensis*) is also found here. The Wildcat Hills and the Pine Ridge have been identified as priority landscapes for fringed myotis (*Myotis thysanodes*), a G2 subspecies and Tier 1 bat species.



How this map was used: Most BULs were classified as Medium Relative Sensitivity and Moderate Mitigation Areas. The six BULs discussed above were classified as High Relative Sensitivity and Maximum Mitigation Areas based on their importance to biodiversity, high percentage of intact native landscapes, and other variables.

Natural Communities in Nebraska

A global rank was assigned to natural communities by NatureServe, a non-profit conservation organization with a network of natural heritage programs (http://www.natureserve.org/), according to their relative rarity and endangerment on a scale of 1 to 5. In general, more endangered communities are considered higher priority for conservation efforts.

Nebraska uses a state ranking system similar to NatureServe to designate the conservation status or relative endangerment within the state of species or ecological communities. Primary factors used in determining rank for species are population size, number of occurrences, viability of occurrences, population trend, and threats. Secondary factors are geographic distribution, environmental specificity, protection and management, and intrinsic vulnerability.

Global Ranks:

G1 = Critically imperiled at range-wide level

G2 = Imperiled at a range-wide level

G3 = Vulnerable at a range-wide level

G4 = Apparently secure at a range-wide level

G5 = Secure at a range-wide level

State Ranks:

S1 = Critically imperiled in Nebraska

S2 = Imperiled in Nebraska

S3 = Rare and uncommon in Nebraska

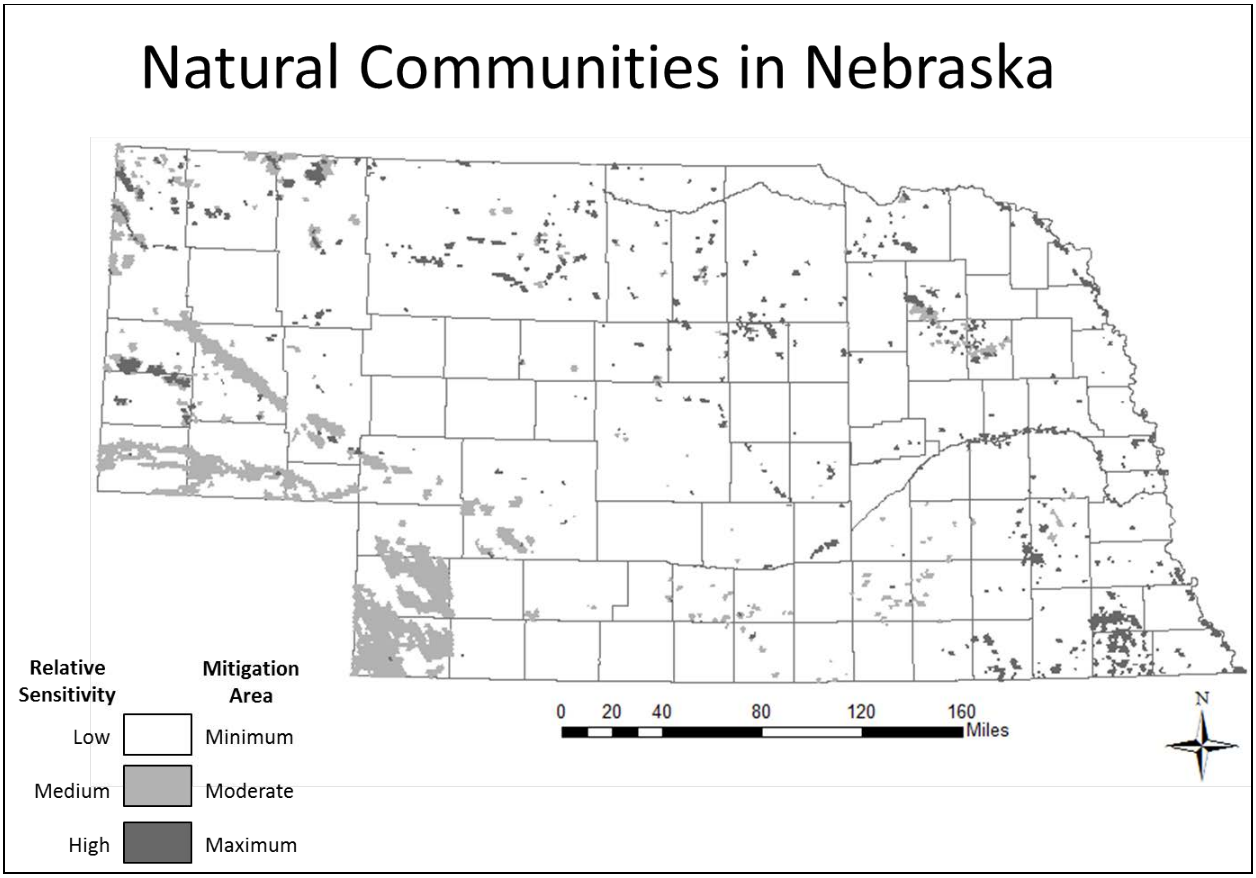
S4 = Apparently secure in Nebraska

S5 = Secure and widespread in Nebraska

Individual community types are often difficult for persons unfamiliar with the Nebraska classification system to distinguish from other similar community types. Therefore, the Nebraska Natural Communities have been lumped into 12 general types and assigned to a category.

Medium Sensitivity/Moderate Mitigation:
Cedar Woodland
Shrubland
Mixed-grass Prairie
Sand Prairie
Sandbar
Sparsely Vegetated Community
Wetland

High Sensitivity/Maximum Mitigation:
Riparian Forest and Woodland
Eastern Deciduous Forest and Woodland
Pine Forest and Woodland
Tallgrass Prairie
Wet Meadow and Fen

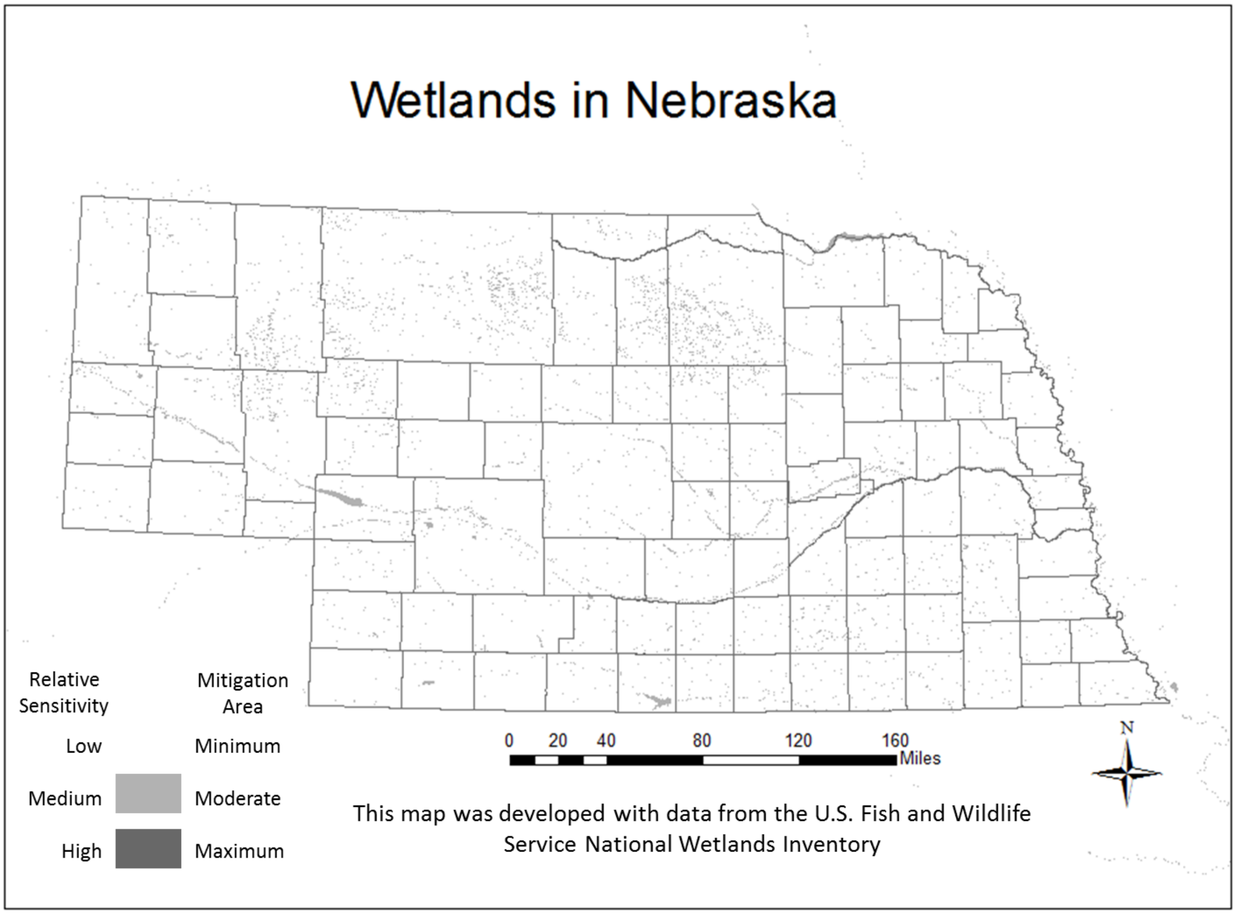


How this map was used: All natural communities ranked by NatureServe as G3 to G5 and communities ranked by the Nebraska Natural Heritage Program as S3 to S5 were classified as Medium Relative Sensitivity and Moderate Mitigation Areas. All natural communities ranked by NatureServe as G1 to G2 and communities ranked by the Nebraska Natural Heritage Program as S1 to S2 were classified as High Relative Sensitivity and Maximum Mitigation Areas.

Wetlands in Nebraska

The landscape in Nebraska is dotted with thousands of wetlands, many of which provide valuable wildlife habitat. Because many of the wetlands are small, a statewide map at this scale may not show all wetlands.

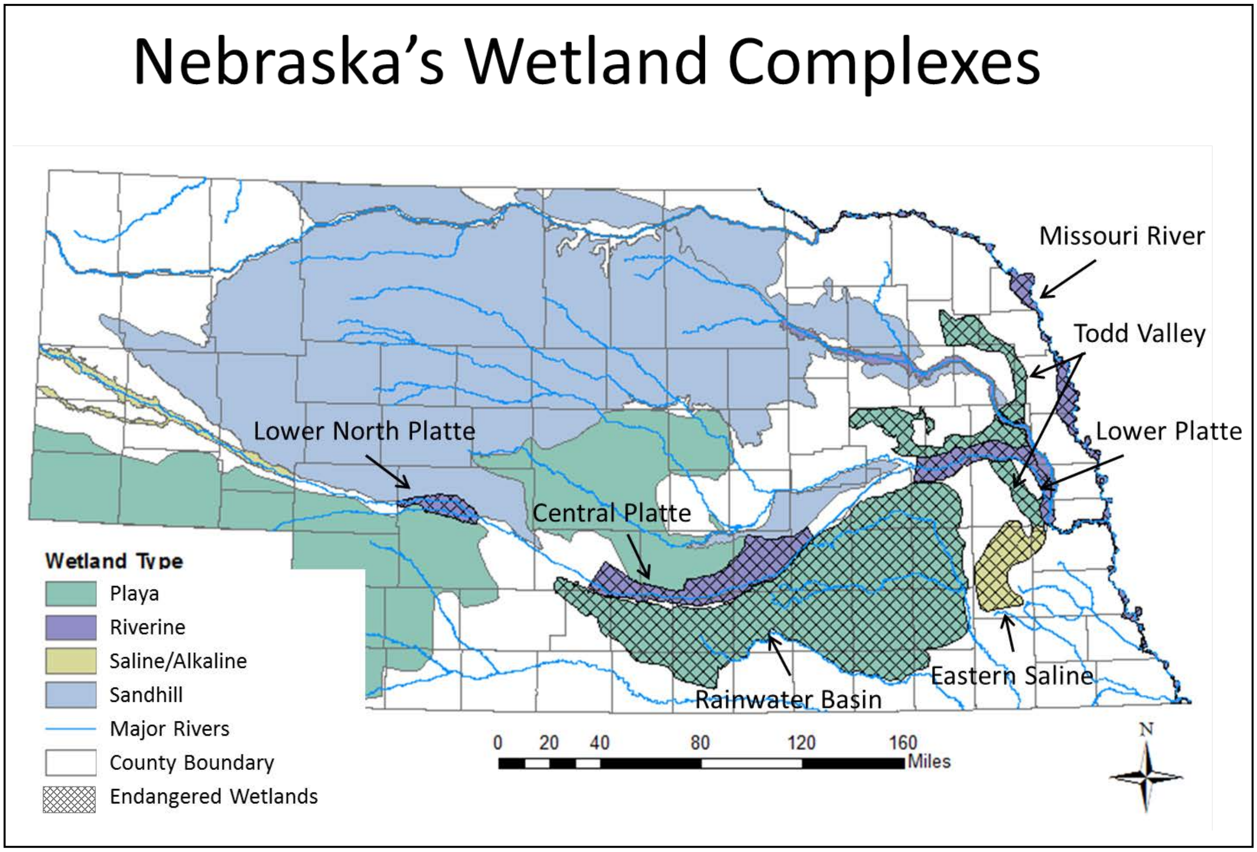
During the siting phase of a wind energy development, it is highly recommended that all jurisdictional and non-jurisdictional wetlands in the project area are identified and delineated. The U.S. Fish and Wildlife Services National Wetlands Inventory can be used as a source for wetlands in Nebraska and across the U.S. (https://www.fws.gov/wetlands/Data/Mapper.html).



How this map was used: All wetlands included in this map were classified as Medium Relative Sensitivity and Moderate Mitigation Areas. A demonstration by a developer that a wetland is not viable or is already heavily disturbed may result in a reclassification of that wetland to a lower mitigation ratio.

Nebraska's Wetland Complexes

In the *Guide to Nebraska's Wetlands and Their Conservation Needs*, four regional wetland categories and seven endangered wetland complexes were identified (LaGrange 2005). A complex is considered a geographically definable concentration of wetlands that are similar in form and function. In Nebraska, the four wetland categories are Playa, Riverine, Saline/Alkaline, and Sandhill. Seven of the complexes were ranked in the Nebraska Wetlands Priority Plan as endangered based on wetland functions, losses, and threats. The complexes are Central Platte, Eastern Saline, Lower North Platte, Lower Platte, Missouri River, Rainwater Basin, and Todd Valley.



Central Platte: The wetlands and surrounding lands in this area provide habitat for several federally threatened and endangered species and is threatened by agricultural conversion, diminished flow, and altered sedimentation regimes. Each year, hundreds of thousands of Sandhill cranes (*Grus canadensis*) and the endangered whooping Crane (*Grus americana*) rest and feed in and around these riverine wetlands during spring migration.

Eastern Saline: See Saline Wetlands BUL in the Biologically Unique Landscapes in Nebraska section.

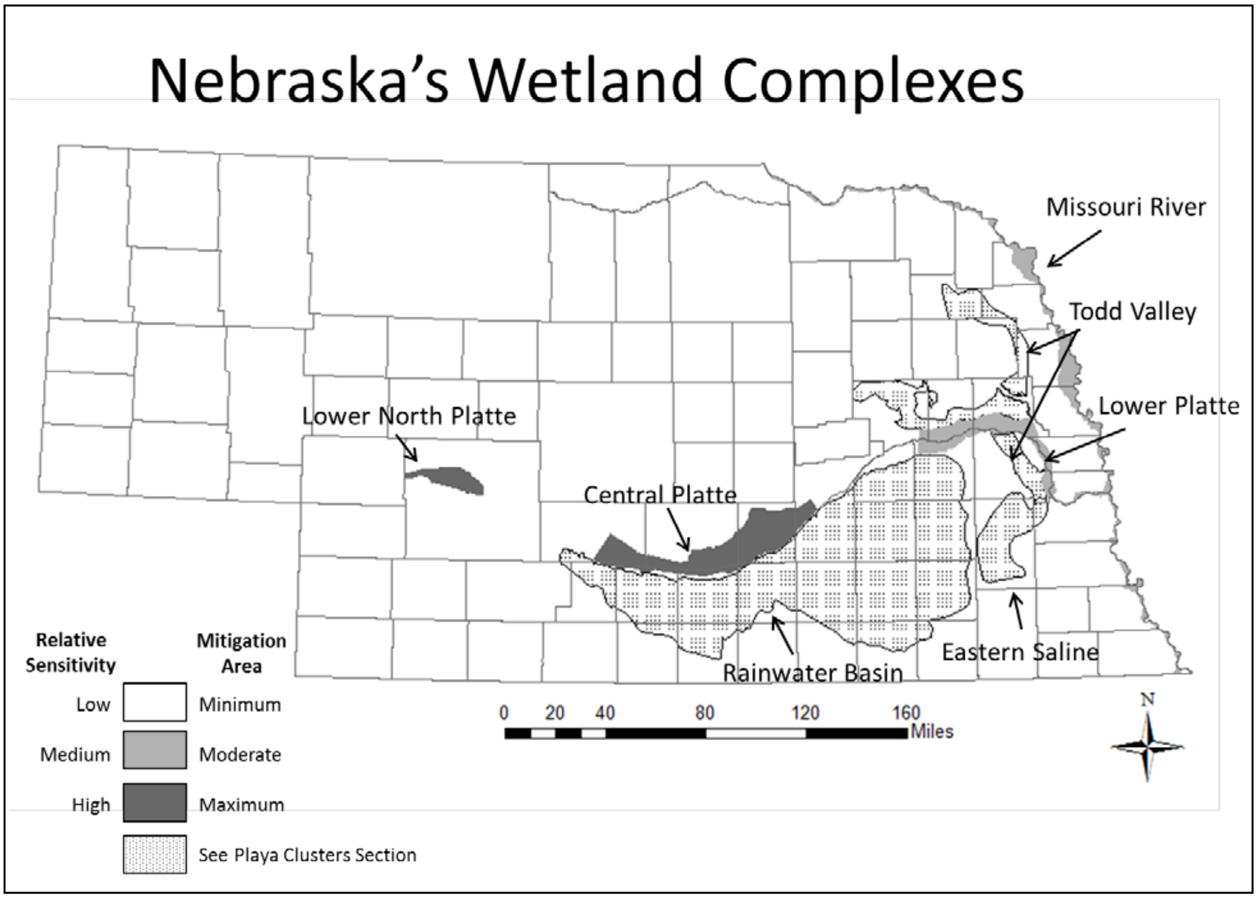
Lower North Platte: The riverine and marsh-like wetlands of this complex provide staging areas for hundreds of thousands of Sandhill cranes during migration. Waterfowl and bald eagles (*Haliaeetus leucocephalus*) use the area both during migration and for wintering.

Lower Platte: This historically more wooded complex of wetlands provides habitat for migrating waterfowl as well as nesting habitat for wood ducks (*Aix sponsa*). Both the interior least tern (*Sterna antillarum athalassos*, state and federal endangered) and the piping plover (*Charadrius melodus*, state and federal threatened) nest on sandbars along the river and several great-blue heron (*Ardea herodias*) rookeries can be found in the area.

Missouri River: This wetland complex has experienced a great deal of destruction and degradation already. Yet, it provides habitat for nesting bald eagles, interior least terns, and piping plovers, all of whom are protected.

Rainwater Basin: See Playa Clusters in Nebraska section.

Todd Valley: See Playa Clusters in Nebraska section.

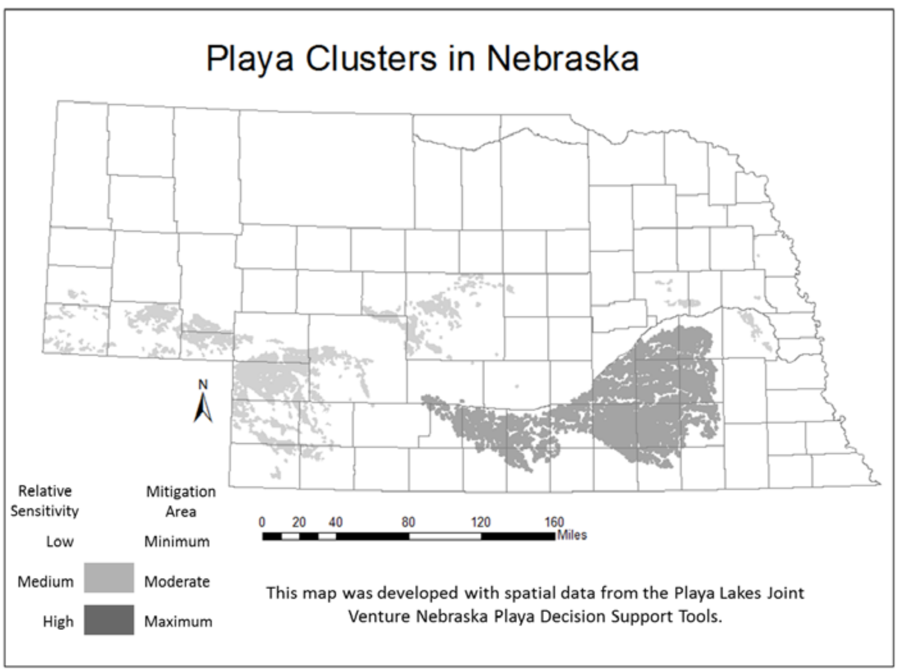


How this map was used: The Lower Platte and Missouri River wetland complexes were classified as Medium Relative Sensitivity and Moderate Mitigation Areas. The Lower North Platte and Central Platte were classified as High Relative Sensitivity and Maximum Mitigation Areas. The Rainwater Basin and Todd Valley are discussed in the Playa Clusters in Nebraska section. The Eastern Saline is discussed in the Biologically Unique Landscapes in Nebraska section.

Playa Clusters in Nebraska

Playas are small, temporary wetlands that function to recharge the High Plains Aquifer. Playas are important wetland habitats for a variety of wildlife, including waterfowl and other birds in the Nebraska. Playa clusters represent groups or complexes of playas that likely provide increased benefits to wildlife as compared to playas that are more sparsely distributed. Research shows that clusters of playas are more frequently used by migrating waterfowl and shorebirds than sparsely distributed playas. Playa clusters were defined by identifying areas with either high playa density or high playa surface area (http://www.pljv.org/playa-dss/nebraska).

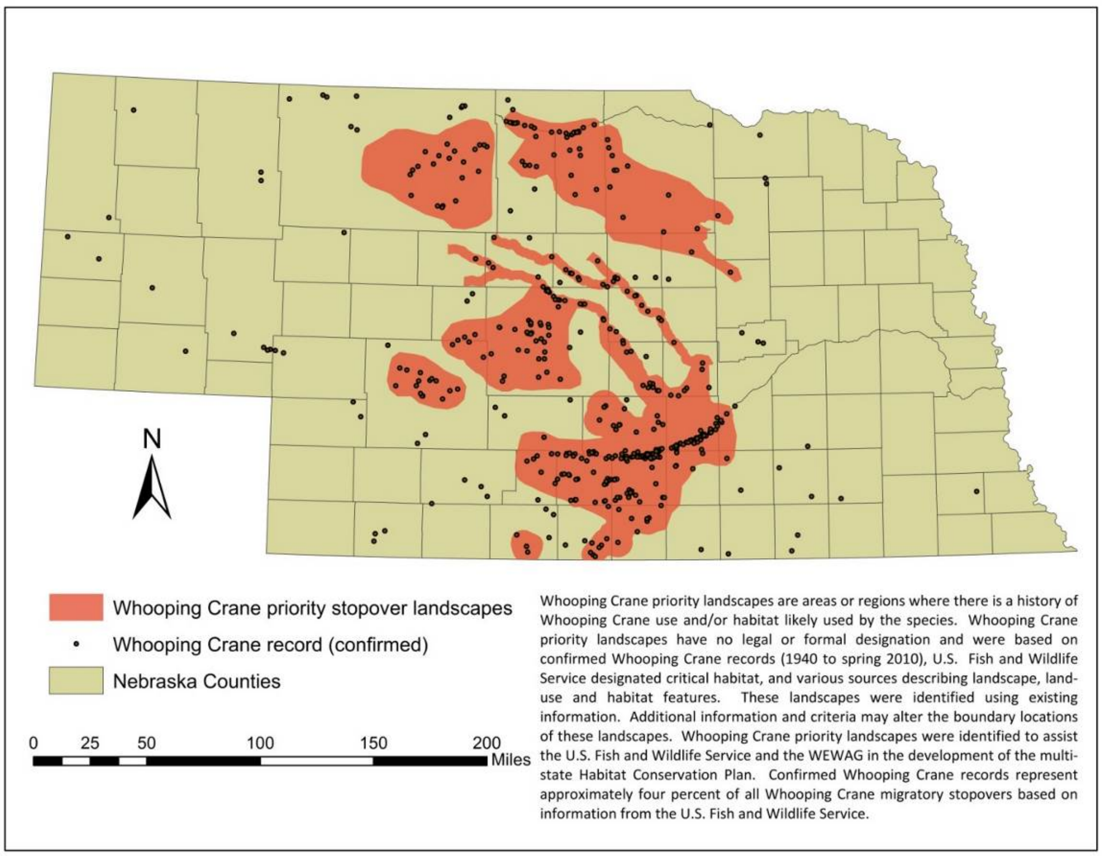
The Rainwater Basin and adjacent central Platte River are complimentary and create a macro wetland complex that provide essential spring staging habitat for millions of waterfowl, shorebirds, and Sandhill cranes (*Grus canadensis*). The Rainwater Basin provides a unique resting and feeding location for birds during their northern migration. The network of shallow playa wetlands combined with nearby agricultural fields provides nutrient rich food sources needed by the birds to store energy during migration. Studies conducted in this area indicate that many of the birds travel several kilometers (km) daily from roosting to foraging locations. Northern pintails (*Anas acuta*) fly, on average, 4.3 km during their evening forage flights (Pearse et al. 2011). Daily movements for white-fronted geese (*Anser albifrons*) and snow geese (*Chen caerulescens*) were 2.3 km and 3.4 km, respectively (A.T. Pearse, U.S. Geological Survey, unpublished data). In addition, Sandhill cranes were observed feeding up to four km from the Platte River, where they roost (Pearse et al. 2010). Bird use of individual wetlands can vary annually due to the dynamic nature of water availability; therefore, flight paths from roosting to foraging areas are variable.



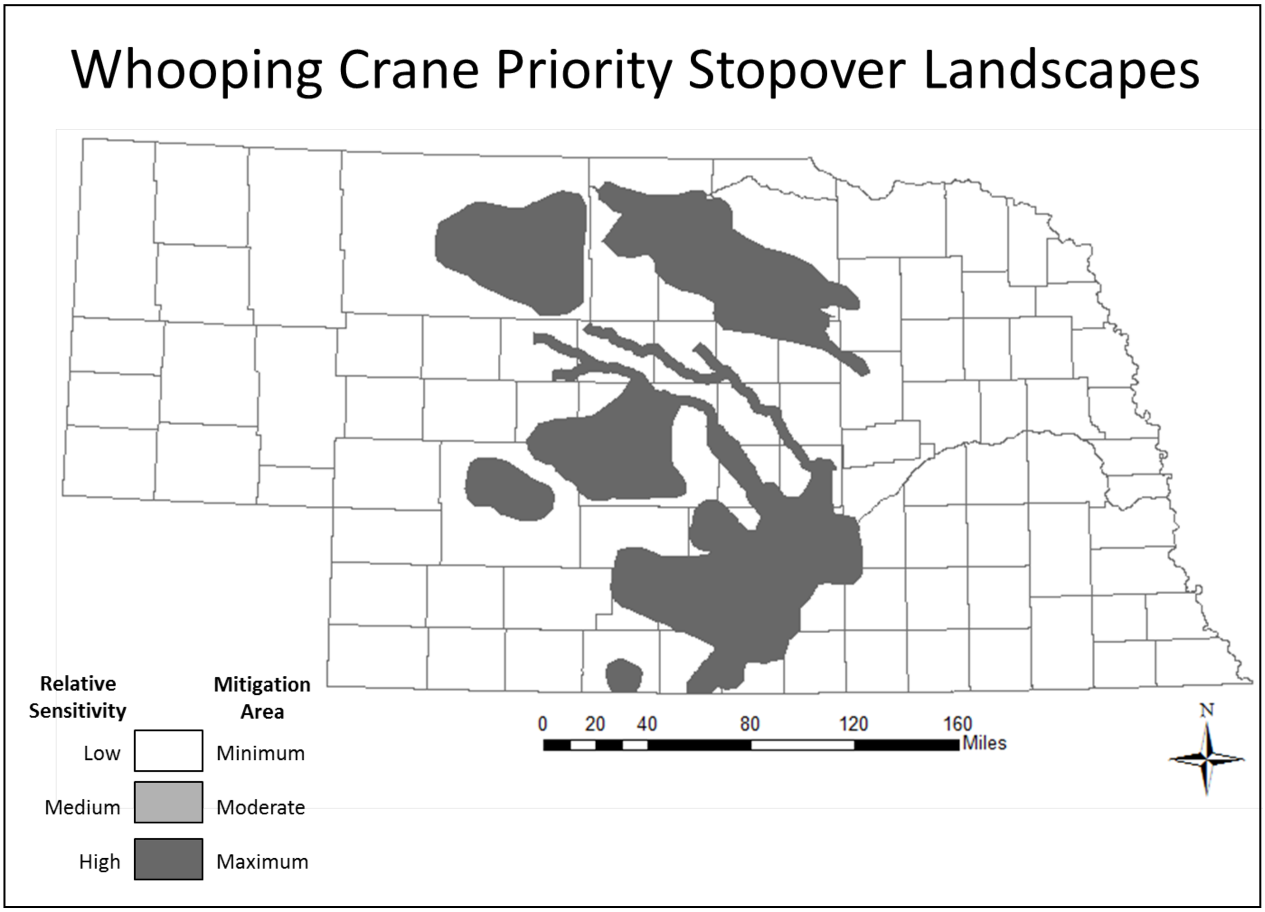
How this map was used: Playas in the Rainwater Basin were classified as Maximum Mitigation Areas. All other playas were classified as Moderate Mitigation Areas.

Whooping Crane Priority Stopover Landscapes

The Whooping Crane Priority Stopover Landscapes map illustrates areas or regions where there is a history of whooping crane (*Grus americana*) use and/or habitat likely used by the species. Whooping crane priority stopover landscapes were based on confirmed whooping crane records (1940 to spring 2010), USFWS designated critical habitat, and various sources describing landscape, land-use and habitat features. The delineated landscapes as a whole have no legal or formal designation, but the federally designated critical habitat within the landscapes does. These landscapes were identified using existing information. Additional information from on-going whooping crane research and criteria may alter the boundary locations of these landscapes in the future. Currently, the best information consists of confirmed whooping crane records which represent approximately four percent of all whooping crane migratory stopovers based on information from the U.S. Fish and Wildlife Service.



Due to the critically low number of whooping cranes in the Aransas-Wood Buffalo population, it is advised to avoid developing wind energy within and near areas of known use, such as illustrated in this map. As previously stated in this document, additional recommendations, buffers, and mitigation may be necessary depending on a site-specific evaluation.



How this map was used: All of the whooping crane priority stopover landscapes were classified as High Relative Sensitivity and Maximum Mitigation Areas.

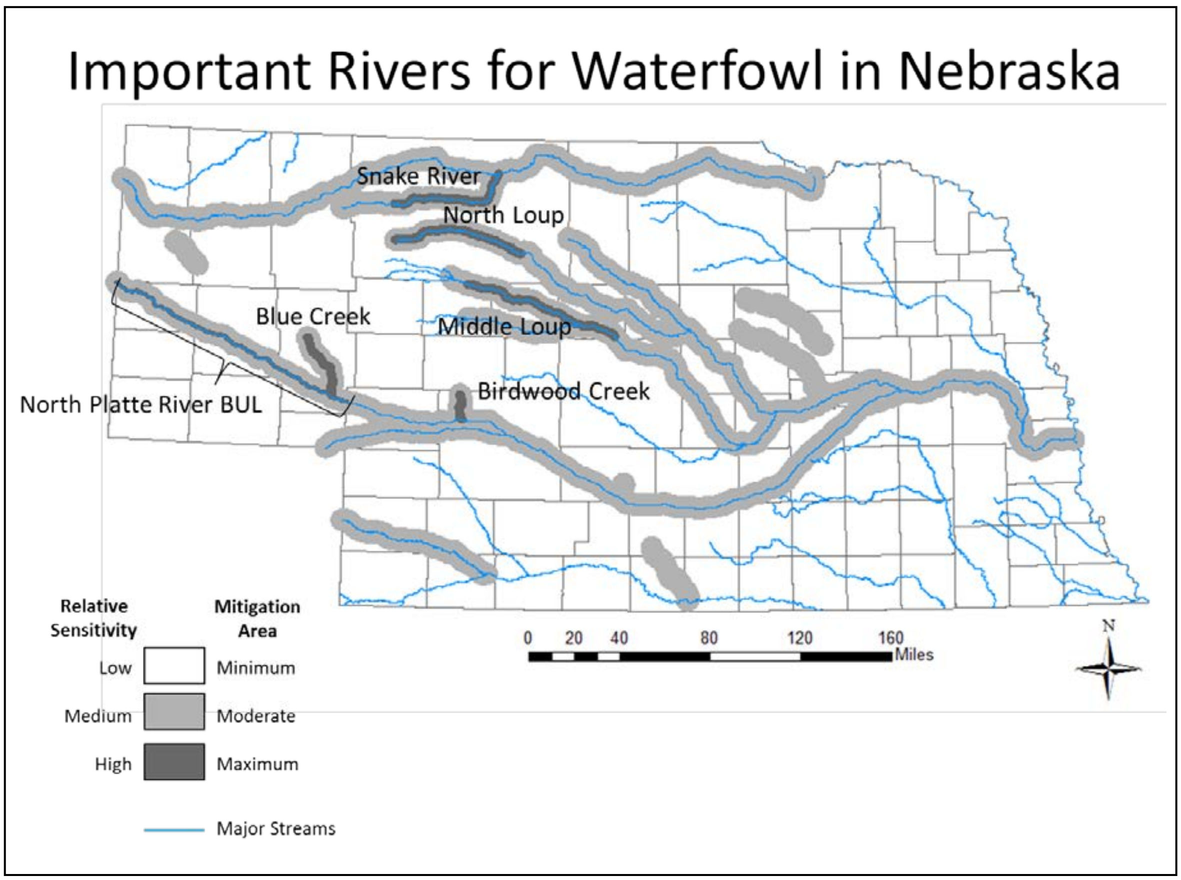
Important Rivers for Waterfowl in Nebraska

Many of Nebraska's rivers are important for populations of waterfowl during the winter months. These rivers and the surrounding habitats provide open water and food for waterfowl. Rivers important for waterfowl were identified based on aerial surveys conducted at regular intervals.

North Platte River BUL: The most important area in the Panhandle for migratory waterfowl and is important at a statewide scale as well.

Snake River: Three-fourths of Nebraska's wintering population of Trumpeter Swan (Tier 1, G4/S2, and ranked as imperiled or vulnerable in all states in its range) occurs along the Snake River. The Snake River downstream from Highway 61 and the reservoir are of particular importance.

Middle Loup, North Loup, Blue Creek, Birdwood Creek: Portions of these streams and rivers are important for over-wintering Trumpeter Swan. The portions of the North Loup and Middle Loup are two areas which stand out among the rest as having repeated use by large numbers of wintering Trumpeter Swans.

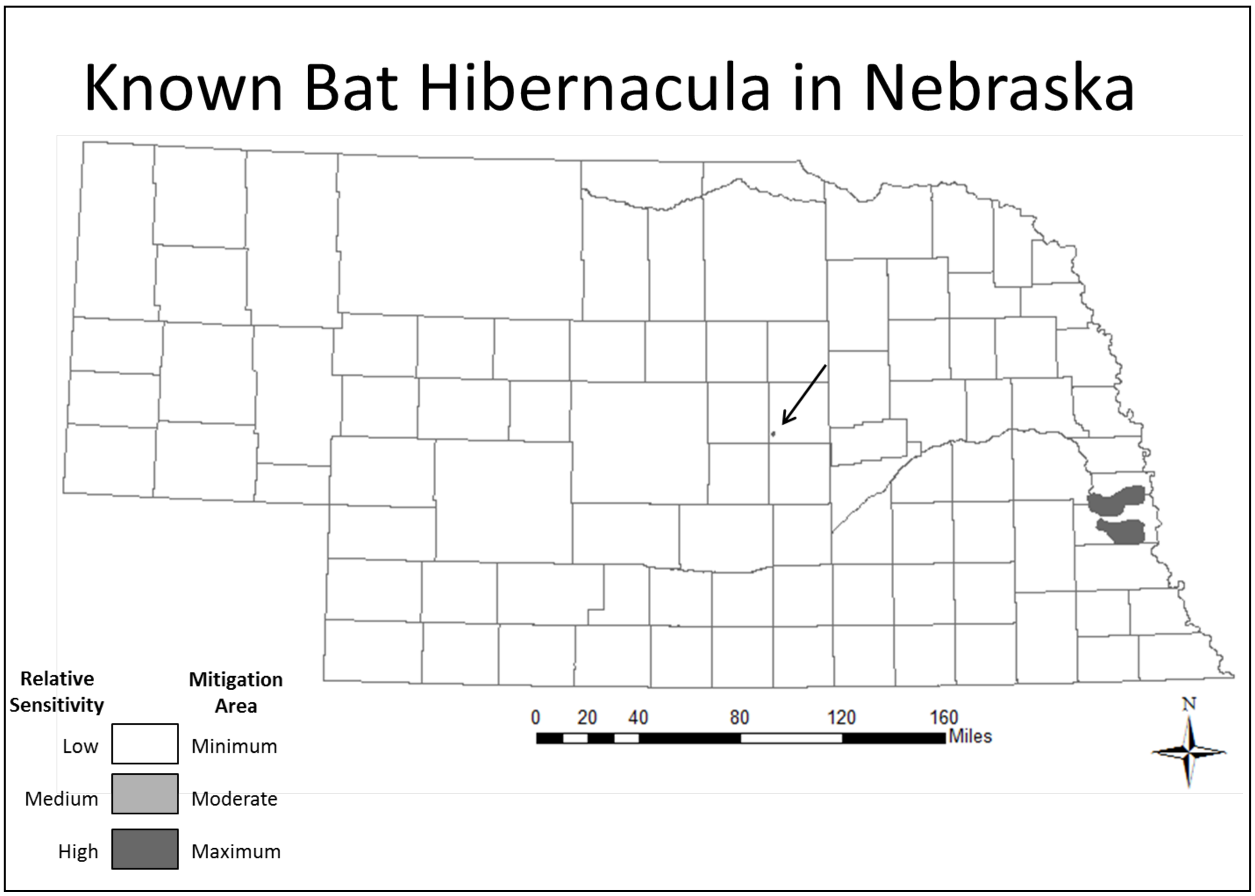


How this map was used: Buffers on the rivers important to waterfowl were classified as Medium Relative Sensitivity and Moderate Mitigation Areas. Portions of the streams and rivers that are particularly important to waterfowl, including Trumpeter Swans were classified as High Relative Sensitivity and Maximum Mitigation Areas.

Known Bat Hibernacula in Nebraska

Nebraska has a diverse mix of resident and migratory bat species. Because of the diversity of habitats found throughout Nebraska, there is no place in the state where all 13 bat species occur together. In the Nebraska Natural Legacy Project State Wildlife Action Plan (Schneider et al. 2011), there are seven bat species listed as either Tier I or Tier II At-Risk Species.

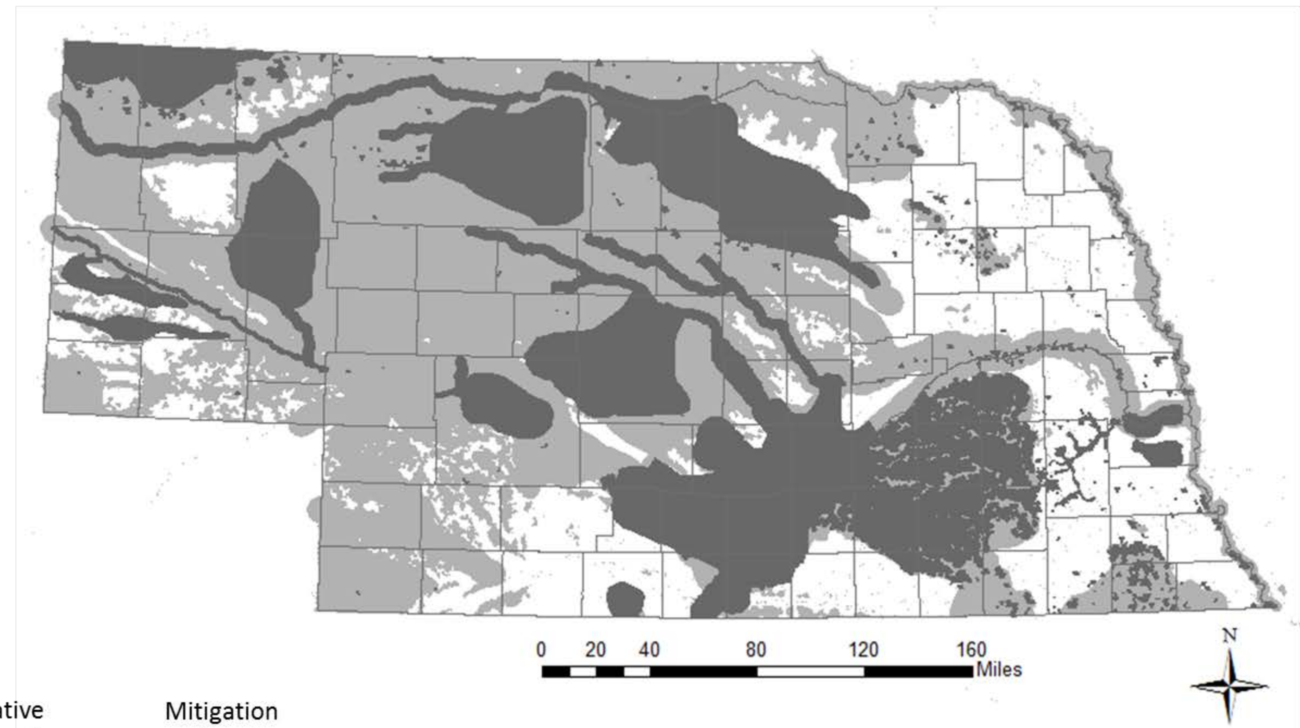
There are three areas in Nebraska with known hibernacula and other areas, such as old quarries and geological features that may be used as hibernacula. These areas are also known to have maternity roosts and summer roost sites. The primary species of concern are tricolored bat (*Perimyotis subflavus*, G3, Tier 1) and little brown bat (*Myotis lucifugus*, G3, Tier 1 Provisional), both of which may be considered for listing in the near future, and the northern long-eared bat (*Myotis septentrionalis*, federally and state-listed as threatened, G2G3, Tier 1 Provisional).



How this map was used: All known bat hibernacula areas were classified as High Relative Sensitivity and Maximum Mitigation Areas.

APPENDIX B: NEBRASKA'S BIODIVERSITY AND WIND ENERGY SITING AND MITIGATION MAP

Nebraska's Biodiversity and Wind Energy Siting and Mitigation Map



Relative Sensitivity		Mitigation Area
Low	(white)	Minimum
Medium	(light gray)	Moderate
High	(dark gray)	Maximum

This map is part of the voluntary guidance for wind energy development in Nebraska.

Projects will be reviewed site-by-site.

This map was developed to accompany the document *Guidelines for Avoiding, Minimizing, and Mitigating Impacts of Wind Energy on Biodiversity in Nebraska* (http://snr.unl.edu/renewableenergy/wind/tools.asp#stateguidelines).

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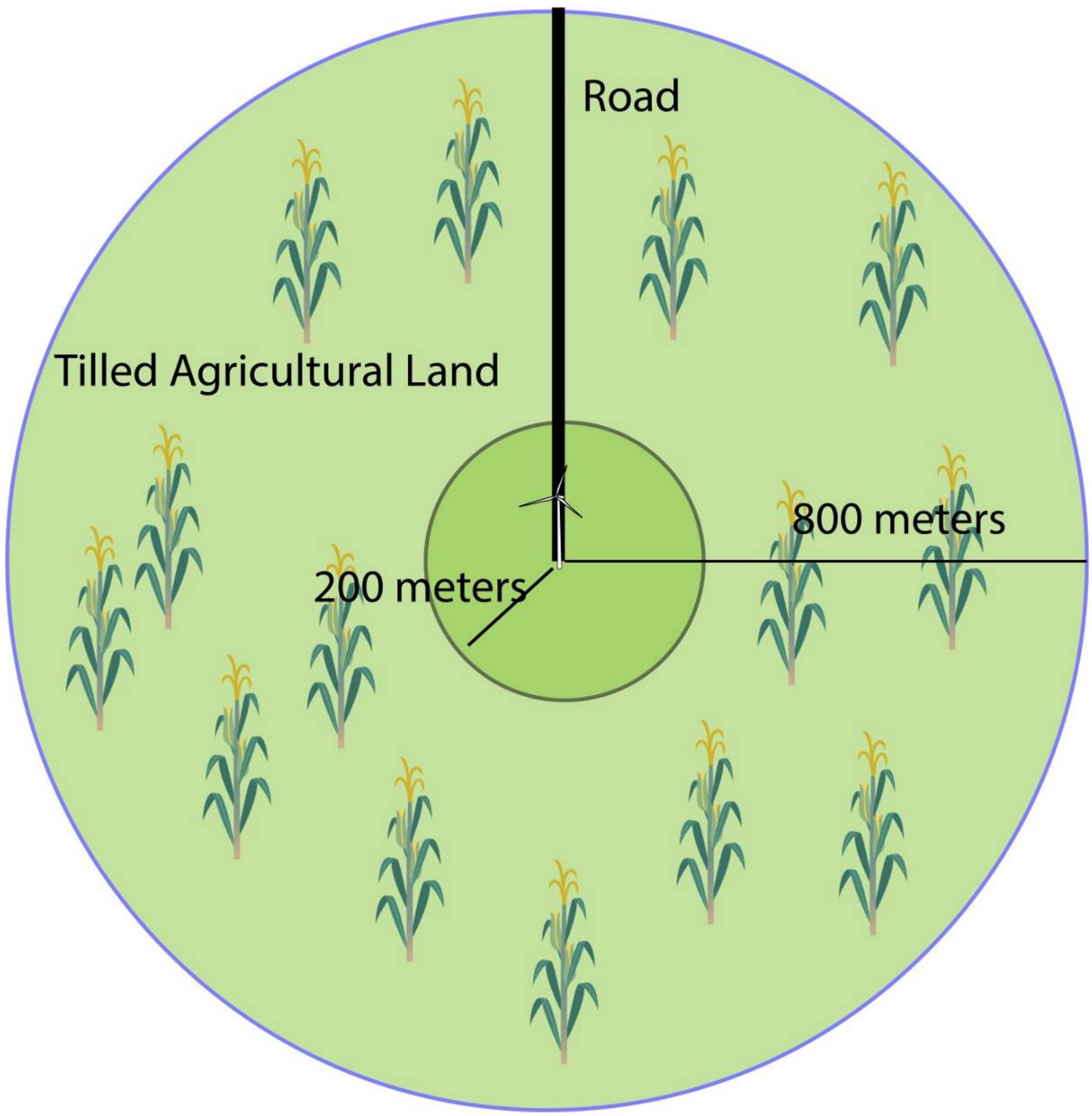
APPENDIX D: MITIGATION EXAMPLES

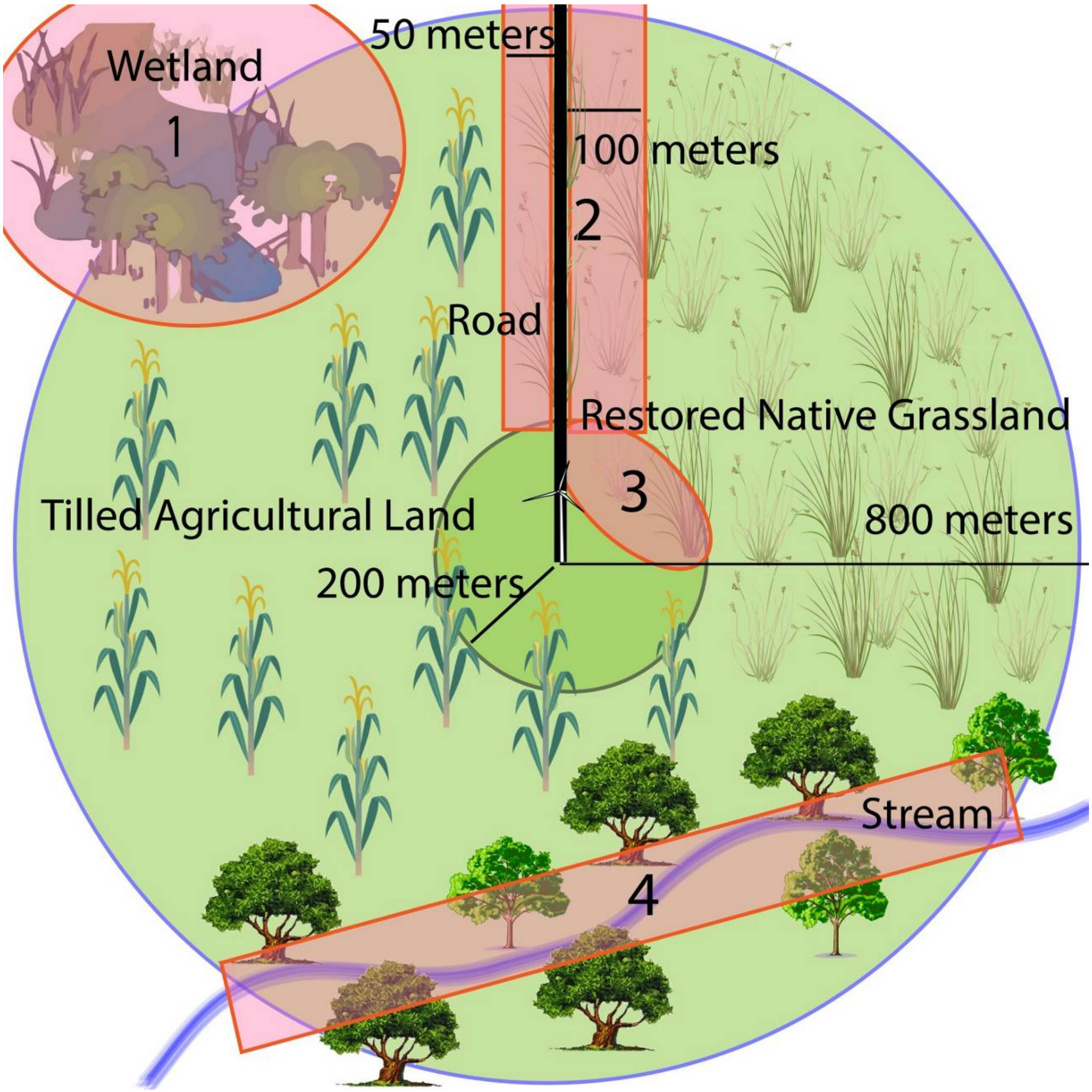
Mitigation Example 1

The wind turbine and pad were placed on tilled agricultural lands; therefore, there are no direct impacts associated with the wind turbine. Within 800 meters of the wind turbine, there are no wetlands or streams suitable for Whooping Crane or other water or shorebirds. Within 200 meters of the wind turbine, there are no grasslands, wetlands, streams, or rivers. Within 100 meters (not depicted), there are no forests or woodlands. The road was already established and transects tilled agricultural lands. **No mitigation would be recommended for this example for Minimum or Moderate Mitigation Areas**; this is the most ideal scenario for wildlife habitat and as a means to minimize mitigation costs. Mitigation would be determined for Maximum Mitigation Areas.



Mitigation Example 2

The wind turbine was placed on tilled agricultural land; therefore, there are no direct impacts associated with the wind turbine. Within 800 meters of the wind turbine, there is a wetland (1) and a stream (4), both suitable for Whooping Crane or other water or shorebirds. The road was built on Restored Native Grassland (2) and therefore, has both direct and indirect impacts to the grassland. Within 200 meters of the wind turbine, there is a patch of grassland (3).

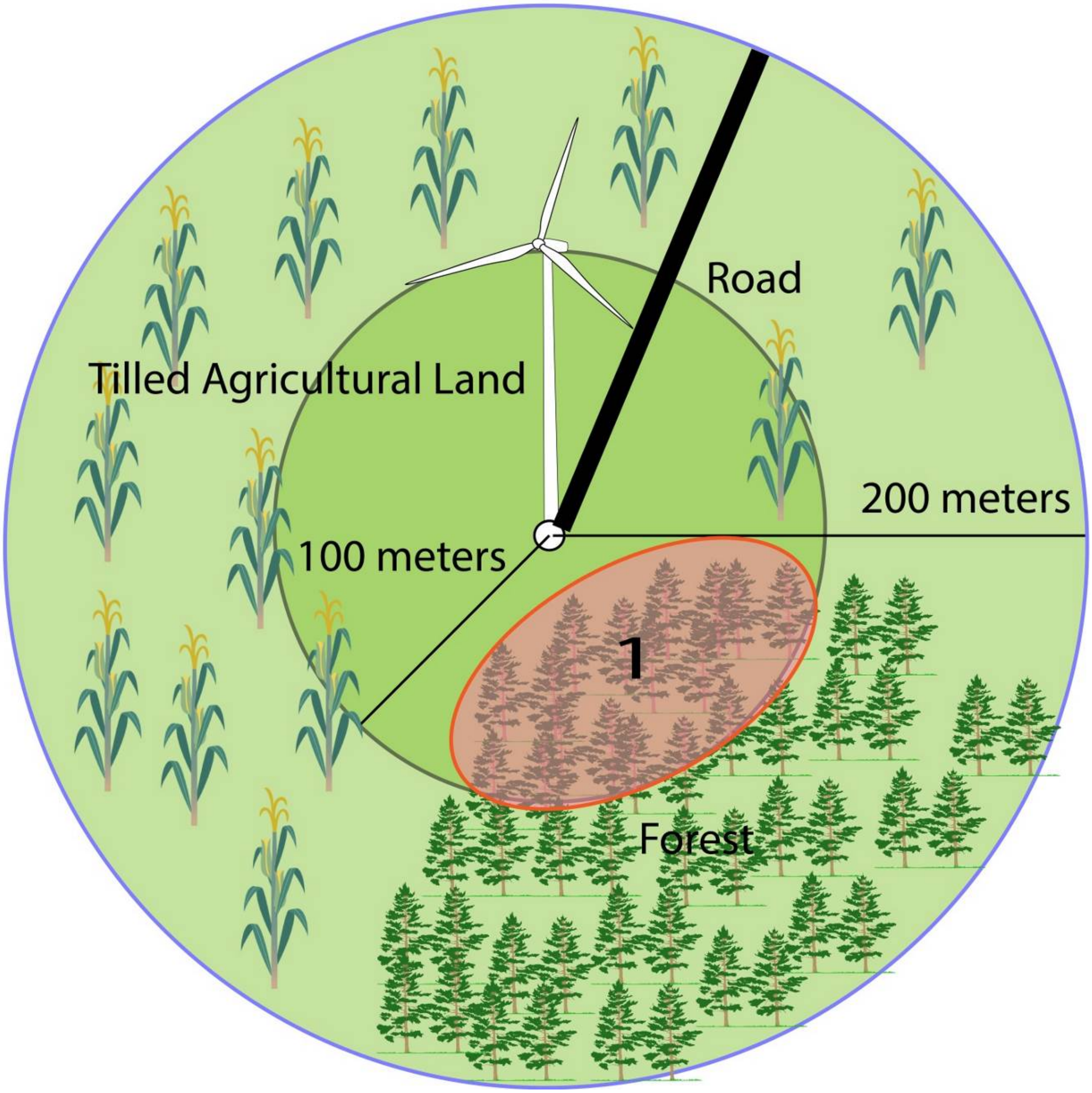


How mitigation would be configured for each section in this example:

1. Because the 800 meter buffer circle transects part of the wetland, the entire wetland would be mitigated for. The oval represented in the graphic would be approximately the area included in mitigation. The mitigation ratio for Minimum Mitigation Areas would be 1:1 (1.5:1 for the Moderate Mitigation Areas); these are the ratio values for indirect impacts. For Maximum Mitigation Areas, the mitigation would be determined for the site.
2. The road constructed as part of the wind energy development was built on the Restored Native Grassland and is bordered on both sides by the grassland. The direct impacts (or habitat lost) of the road would be the width and length of the road that transects the grassland. The mitigation ratio for the direct impacts of the road would be 1:1 for Minimum Mitigation Areas (2:1 for Moderate Mitigation Areas). A 100 meter buffer along the entire portion of the road that is bordered by the grassland would be mitigated for, even outside of the 800 meter radius shown in the graphic. In the graphic, the portion on the right side of the road would be mitigated for out to 100 meters. For the left side, the grassland only extends 50 meters out from the road, so only this portion would be mitigated for. Because it is a Restored Native Grassland, the mitigation ratio for the buffer would be 0.5:1 for Minimum Mitigation Areas and 1:1 for Moderate Mitigation Areas; these are the ratio values for indirect impacts. For Maximum Mitigation Areas, the mitigation would be determined for the site
3. Within 200 meters of the wind turbine, there is a patch of Restored Native Grassland. For the portion of the grassland within this buffer radius, the mitigation ratio for Minimum Mitigation Areas would be 0.5:1 (1:1 for Moderate Mitigation Areas); these are the ratio values for indirect impacts. For Maximum Mitigation Areas, the mitigation would be determined for the site.
4. Within 800 meter of the wind turbine, is a stream. The stream and its banks (unlike the box on the graphic) would be mitigated at a 1:1 ratio in Minimum Mitigation Areas (1.5:1 ratio in Moderate Mitigation Areas); these are the ratio values for indirect impacts. For Maximum Mitigation Areas, the mitigation would be determined for the site.

Mitigation Example 3

The wind turbine and road were placed on tilled agricultural land; therefore, there are no direct impacts associated with the wind turbine.   Within 100 meters of the wind turbine, there is forested land (1).

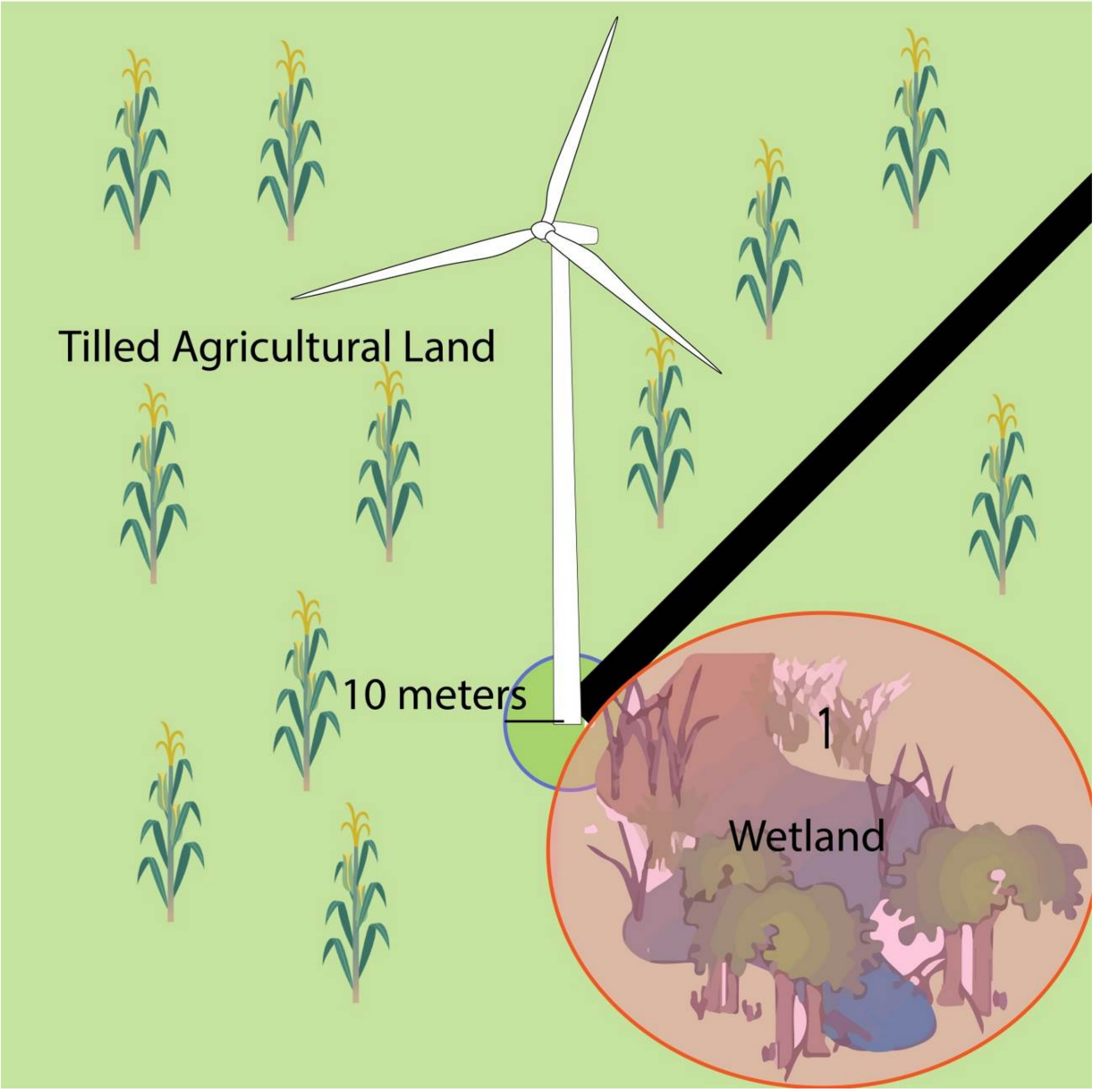


How mitigation would be configured for this example:

Because the 100 meter buffer circle transects a forest, the portion of the forest within the buffer would be mitigated for. The oval represented in the graphic would be approximately the area included in mitigation. The mitigation ratio for Minimum Mitigation Areas would be 1:1 (1.5:1 for the Moderate Mitigation Areas); these are the ratio values for indirect impacts. For Maximum Mitigation Areas, the mitigation would be determined for the site.

Mitigation Example 4

The wind turbine and road were placed on tilled agricultural land, but both within 10 meters a wetland (1).

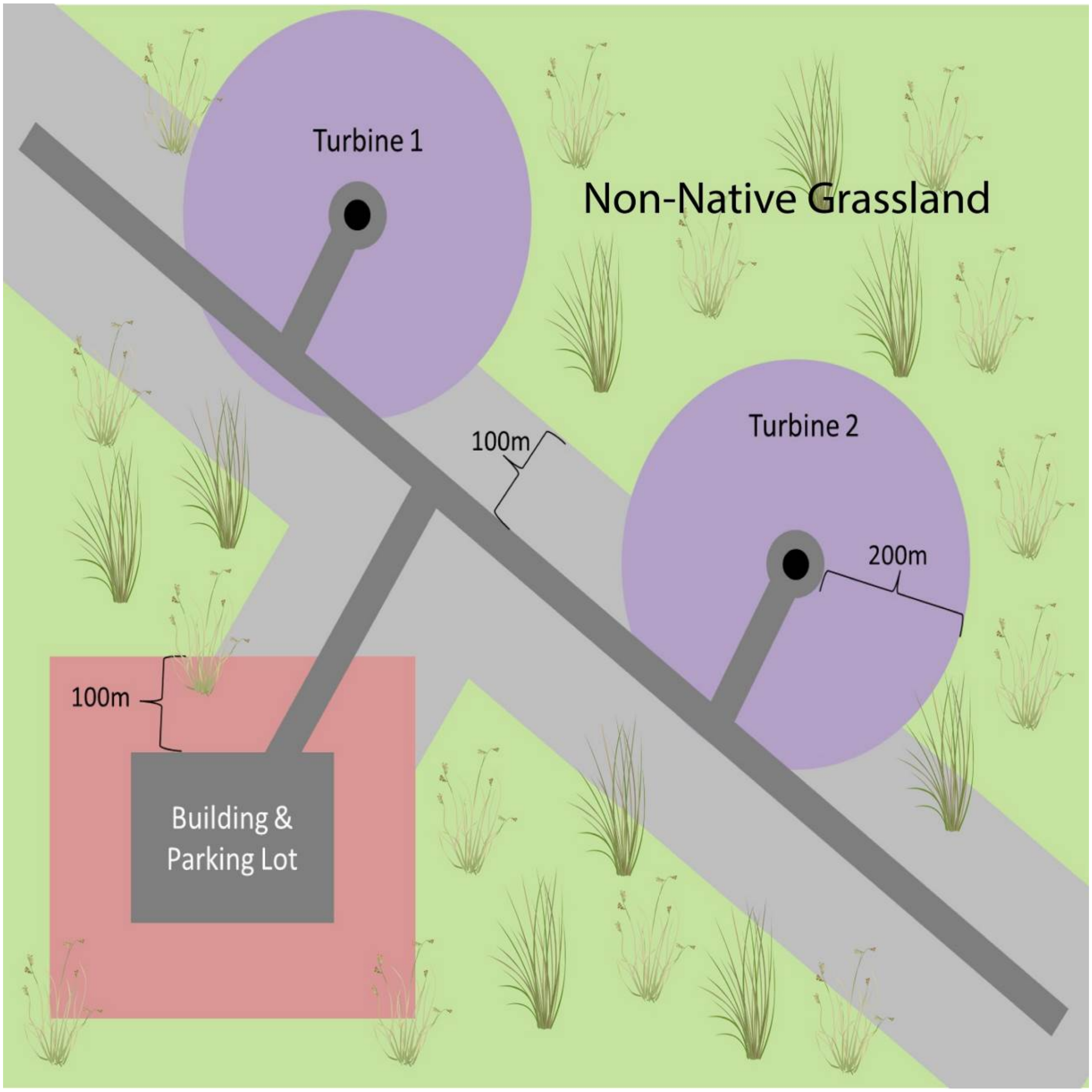


How mitigation would be configured for this example:

Because the wind turbine and road were placed within 10 meters of a wetland, the entire wetland would be mitigated for. The oval represented in the graphic would be approximately the area included in mitigation. The mitigation ratio for Minimum Mitigation Areas would be 2:1 (3:1 for the Moderate Mitigation Areas); these are the ratio values for direct impacts. For Maximum Mitigation Areas, the mitigation would be determined for the site.

Mitigation Example 5

The wind turbine, building, and road were placed on Non-Native Grassland and, therefore, both direct and indirect impacts to the grassland would be mitigated for.



How mitigation would be configured for this example:

The mitigation ratio for Non-Native Grasslands is 0.5:1 for direct and 0.25:1 for indirect impacts for both Minimum and Moderate Mitigation Areas. The buffer for the road and wind turbines or building overlap. Where the overlap occurs, double mitigation is not needed. If you use the Mitigation Worksheet, calculate the wind turbine buffers first and then calculate how much road buffer is outside of the wind turbine buffers.

APPENDIX D: NEBRASKA MITIGATION WORKSHEET EXAMPLE

Below is an example of how a mitigation worksheet would be used to estimate mitigation cost for a project.

To use the worksheet to calculate mitigation costs, access the Excel Workbook at: https://wind-energy-wildlife.unl.edu/nebraska-guidelines. Enter values into the open boxes. The mitigation cost is based on the value entered in the cost per acre box at the top of the worksheet. If, for example, there are multiple wind turbine pad sizes within one category, the calculation table for that category can be copied and inserted into the spreadsheet. If this is done, ensure the final mitigation cost includes all categories.

To determine indirect impacts, buffer distances have been included in the worksheets. It is possible that a wind turbine placed in one category may have a buffer that extends into another category. In this example, the direct impact (cells with blue text) would be figured for the category where the wind turbine was placed. The indirect impacts (buffer, cells with red text) would be determined by what percentage of the buffer is within each category.

Nebraska Mitigation Worksheet for Wind Energy Impacts

Minimum Mitigation Areas

Project Name:	Windy Estates	**Date:**	Jul-14
Company Name:		**Contact Person:**	Caroline Jezierski
Cost Per Acre:	$300		
Cost Per Acre Plus 20%:	$360		

Unbroken Grasslands

Mitigation Ratio - 2:1

Turbine Numbers:	1,3,4,6	Building Pad Length 1 (m):	10
Number of Turbines:	4	Building Pad Width 1 (m):	10

Turbine Pad Radius (m):	10	Building Pad Length 2 (m):	10
Turbine Pad Area (m^2):	314	Building Pad Width 2 (m):	10
% of Category in 200 m Buffer:	10	Building Pad Area (m^2):	100
		% of Category in 100 m Buffer:	15
Buffer Radius Area (m^2):	13816		
Turbine Direct Impacts (acres)*:	**0.31**	Buffer Area** (m^2):	6600
Turbine Indirect Impacts (acres)*:	**13.66**	Building Direct Impacts (acres):	**0.02**
		Building Indirect Impacts (acres):	**1.63**
Road length (m):	100		
Road Width (m):	10	*Calculate different pad sizes separately.	
		** If buffer is needed on all 4 sides	
Road Area (m^2):	1000		
% of Category in 100 m Buffer:	25		
Buffer Area (m^2):	5000		
Road Direct Impacts (acres):	**0.25**		
Road Indirect Impacts (acres):	**1.24**		

	Acres	Basic Cost	Mitigation Ratio	Weighted Cost
Direct Impacts (2:1)	**0.58**	$210	2.00	$419
Indirect Impacts (1:1)	**16.52**	$5,948	1.00	$5,948
			Mitigation Subtotal	$6,367

Wetlands (Hydrological Function)

Mitigation Ratio - 2:1

Turbine Numbers:	1,2
Number of Turbines:	2
Total Area of Wetland (m2):	600
Buffer Area (m^2):	600
Turbine Direct Impacts (acres)*:	**0.15**

# of Buildings within 10 m Buffer	0
Total Area of Wetlands (m2):	0
Buffer Area (m^2):	0
Building Direct Impacts (acres):	**0.00**

# of Roads within 10 m Buffer:	1
Total Area of Wetlands (m2):	500
Buffer Area (m^2):	500
Road Direct Impacts (acres):	**0.12**

	Acres	Basic Cost	Mitigation Ratio	Weighted Cost
Direct Impacts (2:1)	**0.27**	$98	2.00	$196
			Mitigation Subtotal	$196

Administrative Fee		$10,000
Total Mitigation Cost		$16,563
Total Direct Acres	**0.85**	
Total Indirect Acres	**16.52**	