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September 24, 2017

NextEra Energy Resources, LLC
Attention: Clay Cameron, Project Developer for Burke County, ND,
Subject: Environmental concerns over wind turbines in Burke County
P.O. Box 14000
Juno Beach, FL 33408-0420

To Whom This Concerns,

I live in southern Burke County, North Dakota. I live on a geological feature known as the Missouri Coteau, a spring and fall migratory corridor used by many migratory bird species, including the whooping crane.

The Missouri Coteau, formed by the Wisconsin Glacier, is a narrow band of hills with numerous wetlands that starts in southeastern Alberta, Canada and traverses southeast across USA to northwestern Iowa. The east side of this long, narrow band of hills is recognized by a feature called the Escarpment, a rise in topography from the flatten farmland to the east. In southern Burke County, this formation is well defined by a steep rise in topography that creates a strong uplift, likely the reason your company is interested in establishing a wind turbine field in southern Burke County.

Much of the Missouri Coteau in North Dakota is composed of hilly native grasslands, some areas are exceptionally large, intact open grassland ecosystems with little fragmentation by roads and vertical structures. The Missouri Coteau in North Dakota is exceptionally unique because of its abundant wetlands, attractive to many wildlife species. The amount of remaining, intact, native grassland areas in Burke County other than on the Coteau are rare.

To fragment these remaining grassland areas with turbines and roads will adversely affect many nesting grassland birds, such as Baird's sparrow and Sprague's pipit, both considered for listing in the ESA. The resident native sharp-tailed grouse also is adversely affected by tall, vertical structures. The Coteau is also a major migratory corridor route for raptors, shorebirds, cranes, passerines, waterfowl, and bats, species that will be killed during their spring and fall migration when they encounter the wind turbines, day or night.

If these wind turbines would be placed east of the Missouri Coteau and escarpment, the negative effect on migratory wildlife would be reduced, and almost eliminated in the case of grassland nesting avian species. This area is flat, intensely farmed with roads on many section lines. Building a wind field here would not fragment native grassland habitats and would reduce the negative impact on migratory birds.

116 PU-18-344 Filed 03/08/2019 Pages: 111
Exhibit I - Testimony. and Info. - K. Smith, Coteau, letter from R. Warhurst, and ND Wildlife Society
Karen Smith

76 PU-18-302 Filed 03/08/2019 Pages: 111
Exhibit I - Testimony. and Info. - K. Smith, Coteau, letter from R. Warhurst, and ND Wildlife Society
Karen Smith

Wind and solar energy are "green energy" sources however placement is equally important if a company wants to claim they are a green energy source. The Missouri Coteau and its escarpment is NOT a site that can be called a green location!!

Please consider not placing wind turbines on the Missouri Coteau and its escarpment, but instead on the intensely farmed land to the east.

Ms. Julie Fedorchak
Public Service Commissioner

Mr. Brian Kroshus
Public Service Commissioner

Mr. Randy Christmann
Public Service Commissioner

Re: Proposed Burke Wind, LLC

Dear Commissioners:

We, Coteau Preservation Alliance, are presenting information to Public Service Commission on this day, March 8, 2019 at the Bowbells' Memorial Hall regarding Burke Wind LLC Project Area's location and effect to the natural resources found on the Coteau. This project was actually disapproved by the Burke Planning and Zoning Commission with a 5 to 1 vote in 2018. The three Burke County commissioners decided, after a two week delay following the Zoning and Planning vote, to approve it.

We are here at the public hearing to provide two items to each PSC member: 1) copy of our revised Package and, 2) a copy of this 33-page paper containing additional natural resource information, and better ways to select wind field areas that reduces adverse affects to the natural resources.

The area selected for this wind field is centered in Burke County on the Coteau, a geological feature highly valued for its natural resources with intact native grasslands, numerous wetlands and abundant associated wildlife.

Smith and Dwyer (2016) states in their Abstract "Although renewable energy sources may offer a 'greener alternative' to traditional extractive energy sources, mounting evidence suggests that renewable energy infrastructure, and the transmission lines needed to convert energy from renewable energy facilities to users, may impact birds." – it is not MAY, but instead the correct word is WILL. In the following pages we will present information that proves this.

I am verbally giving highlights from this paper but please study this paper. It has a lot of additional information about the resources of the Coteau and the likely affects this project will have on the indigenous wildlife.

Our discussion about the Burke Wind Project Area begins by listing 115 species of wildlife identified by the North Dakota Game and Fish Department as having a Conservation Priority due to their **rarity, declining populations, or uniqueness** in North Dakota. They are categorized in three levels as "Level of Conservation Priority" (North Dakota Draft Guidelines):

"1" as high level conservation priority, "2" as moderate level of conservation priority, and "3" as moderate level of conservation priority but believed to be peripheral or non-breeding in North Dakota

Below are 49 of these species that use the Coteau's habitat for reproduction and/or for spring and fall migrations! Some of species identified by the state are also identified by the U. S. Fish and Wildlife Service (USFWS) under the Endangered Species Act (ESA).

Grassland Bird Species
American Kestrel (2)
Burrowing Owl (2)
Short-eared Owl (2)
Ferruginous Hawk (1)
Golden Eagle (2)
Swainson's Hawk (1)
Prairie Falcon (2)
Peregrine Falcon (3)
Northern Harrier (2)
Upland Sandpiper (2)
Western Meadowlark (2)
Baird's Sparrow (1)
Bobolink (2)
Chestnut-collared Longspur (1)
Grasshopper sparrow (1)
Le Conte's Sparrow (2)
Loggerhead Shrike (2)
Sharp-tailed Grouse (2)
Sprague's Pipit (1)

Grassland/Wetland Bird Species
Nelson's Sparrow (1)
Northern Pintail (2)

Wetland/Grassland Bird Species
Marbled Godwit (1)
Willet (2)
Wilson's Phalarope (1)
Lesser Scaup (2)

Grassland/ Woodland Species
Moose (ESA Status: Petitioned)

Wetland/Woodland Bird Species
Bald Eagle (2)

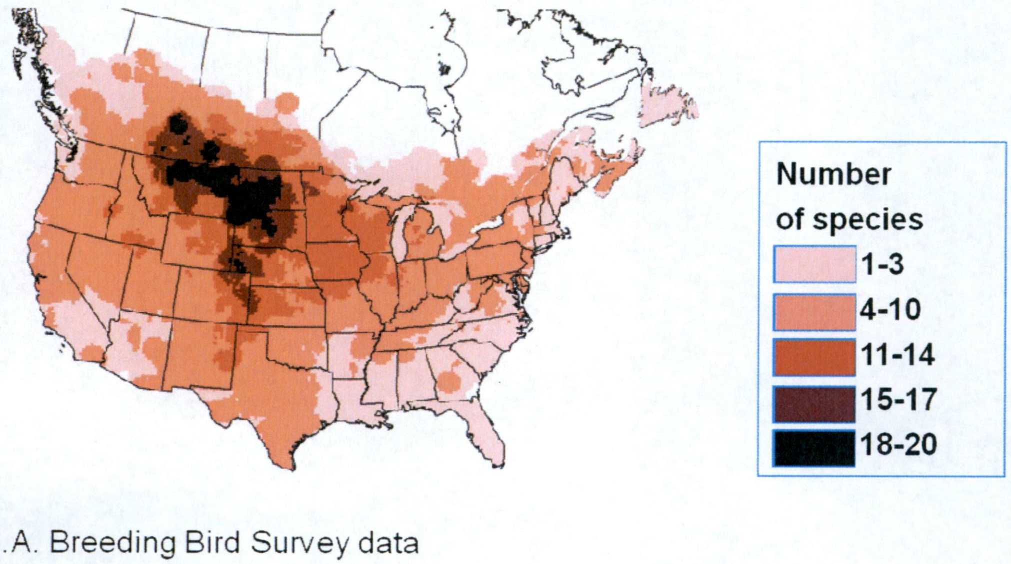
Wetland Bird Species
American Avocet (2)
American Bittern (1)
American White Pelican (2)
Black Tern (1)
Canvasback (2)
Franklin's Gull (1)
Horned Grebe (1)
Piping Plover (2) (ESA Status: Threatened)
Whooping Crane (3) (ESA Status Endangered)
Red Knot (3) (ESA Status: Threatened)
Yellow Rail (1)

Grassland Insects and Reptiles Species
Yellow Banded Bumble Bee (ESA Status: Petitioned)
Regal Fritillary (1) (ESA Status: Petitioned)
Rusty Patched Bumble Bee (ESA Status: Endangered)
Dakota Skipper (2) (ESA Status: Threatened)
Monarch (1) (ESA Status: Petitioned)
Smooth Green Snake (1)

Mammal Species
Grassland: Pygmy Shrew (2)
Grassland: Richardson's Ground Squirrel (2)
Wetland: Arctic Shrew (3)
Woodland: Big Brown Bat (1)
Woodland: Little Brown Bat (1) (ESA Status: Under Review)

From this list, there are 49 wildlife species found on the Coteau. People from all over the world come to view these species, such species as the Baird's sparrow, grasshopper sparrow, LeConte's sparrow, Nelson's sparrow, bobolink, chestnut-collared longspur, Sprague's pipit, western meadowlark, Ferruginous hawk, Swanson's hawk, northern harrier, and plus the remaining 38 not just stated. These species are here because their critical habitat needs are met on the large blocks of intact, native and tame grasslands and abundant wetlands found on the Coteau (see Figure 1 below). Many of these species have restricted breeding ranges, many concentrated on the Coteau, see Appendix 1 at end of this paper. This critical habitat is also in a major bird migration corridor for the Conservation Priority species as well as many others species of birds and bats.

Figure 1: Northern Great Plains has highest richness of grassland bird species in North America



The Conservation Priority list grouped by habitat type reveals how truly diverse the habitats are with associated wildlife species. On the Coteau there are 30 grassland or grassland/wetland bird, bumblebee, butterfly and reptile (the tiny, smooth green snake) species, 12 wetland bird species, and six mammals found in a variety of the habitat types. [Surprisingly, the moose is also on this list because this species in other areas of its Midwest eastern ranges is declining significantly.]

Not identified on this list is the diversity of native plants found on the Coteau's northern mixed-grass prairie; we have not provided plant information of common or unique and rare plants found on the Northern mixed-grass prairie of the Coteau, such as the yellow lady's slipper and pincushion cactus.

Another surprising species on the priority list is the sharp-tailed grouse. In North Dakota, this species is abundant enough to be even hunted. But here is the reason why it is listed, 30.9% of the **GLOBAL** population of sharp-tailed grouse occurs in North Dakota (ND Draft Guidelines 2018)! Some of the highest population densities of sharp-tailed grouse are on the Coteau associated with the native grasslands and wetlands (Lostwood refuge files). You might wonder why wetlands – they provide a diversity of green vegetation along the shorelines and insects throughout the year, and at times a very important source of water when conditions are dry.

Although NextEra has not distributed their biological data they may have gathered, we did see a map showing where sharp-tailed grouse dancing grounds were located. Based on NextEra's July 11, 2018 map, NextEra must have agreed with the North Dakota Game and Fish Department to have a turbine setback of one half mile radius from known dancing grounds. We appreciate NextEra incorporating these setbacks in their Project Area, unfortunately not all dancing grounds may have been located.

Knowing where NextEra had located grounds, we searched in portions of the eastern three Townships of the Project Area prior to these Townships being dropped from the Burke Wind Project Area. We found three additional dancing grounds not shown on their maps that would have affected at least one of their wind turbine locations. Are there other dancing grounds that have not been found in the remaining portions of the Project Area?

We believe there is high probability that not all were found because of the difficulty locating dancing grounds across such a large area of rolling to steep topographies. To locate dancing grounds on the 23,000-acre Burke Wind Project Area would take considerable time to search, particularly without any prior knowledge of ground locations. For example, when I searched on the 27,000-acre Lostwood Refuge for dancing grounds, I had the help of historical refuge documents of known dancing ground locations. I used this information plus over two consecutive springs, drove refuge roads and walked transects on areas without roads to locate other dancing grounds and to validate the historical grounds. Most of the grounds where identified by the third spring, yet new grounds were found every couple of years.

Locating dancing grounds becomes even more difficult because of annual population fluctuations. Grouse populations are affected by extreme weather events in winter, and when there is too much rain in June (Lostwood Refuge files). These dynamics make locating grounds difficult from year to year. In high population years, established grounds are crowded and easier to find. In low population years there are fewer males, sometimes just two or three on an established ground making it harder to hear and locate them. In high population years, new ones are established close to historical grounds, and when the populations are really high, some males disperse from the established grounds and move to new locations further away. This can easily result in missed grounds.

Some of Burke Wind Project Area's turbine locations will likely affect potentially new grounds from becoming established. If there are numerous turbines, this will adversely affect the grouse population over time.

Causes of Habitat and Wildlife Losses from Wind Development

Wind industrial development impacts on grassland wildlife come from direct loss of grassland habitats, and indirect loss through affects on wildlife and grassland habitat. The direct is obvious, direct loss of habitat from turbine site construction, the turbines themselves, overhead transmission lines (birds striking the lines), many miles of underground collection corridors/trenches, roads – includes the wider road areas needed to accommodate tower parts – and wider disturbance where roads and underground collection corridors are side by side.

The direct "Footprint" of the industrial wind field is estimated about 5% of the project area (NextEra's estimate), which by itself amounts to about 1,150 acres, but there is a larger, indirect footprint affect as well. Some of these are:

- It is estimated by NextEra there will be 50 vehicle travel/days of increase traffic for wind turbine maintenance on existing township and county roads, and on their own new roads. This will be accompanied with considerable dust, and we all know how this affects crops and grasslands, things we have learned from the oil industry's traffic on our roads. Livestock operators know that dust adversely affects cattle, and not just next to roads because dust is blown by winds sometimes several hundred yards from roads. Dust effects cattle's respiratory health. This likely affects wildlife similarly.
- Many miles of newly constructed roads and underground collection lines are traversing across the interior of sections, often through undisturbed native grasslands. When native sod is disturbed, non-native plant species, such wormwood, will invade. Weed problems will also come from off-site gravel pits that may be infested with noxious weeds spread onto the new road systems across the interior of sections. This is an indirect loss of native habitat.
- Yet another major indirect affect beyond the immediate footprint of the turbines are the sounds, flickering shadows, and debris flung by the whirling blades either from the turbine itself or from frost or ice accumulation on the blades. This will be disturbing to ground nesting passerines, shorebirds, and raptors when debris is dropped beneath and/or flung away from the tower.
- Will turbine noises effect birds establishing territories under and near turbines? It is required there be 0.75 miles (1.2 km) turbine setback to achieve the 50 decibel limit at a human residence, although this distance, as some who live next to turbines have found, is not always enough (see Package's Health chapter). Bird life establishes their nesting territories by males singing to deter other males and attract a female. Noise from the wind turbines where birds will try to set up territories under and near the turbines could easily be one of the reasons why one study found seven of nine grassland bird species over a five year period being increasingly displaced in a radius up to 300 meters from turbines (Shaffer and Buhl 2016). Incidentally, NextEra helped fund this study.

All of these indirect habitat altercations can collectively be called habitat fragmentation. Fragmentation will likely cause greater long-term losses for indigenous grassland wildlife.

What is habitat fragmentation and how does it affect wildlife?

Habitat fragmentation is described as the process of dividing large tracts of contiguous native habitat into smaller, disconnected pieces. Habitat fragmentation results in an increased number of small habitat patches, isolated by a matrix of human altered land cover (Haddad, 2015).

Breaking habitat into smaller pieces increases the amount of habitat edge. Animal behavior can be influenced by these "edge effects" (Lidicker 1999; Ries et al., 2004; Batary and Baldi, 2004) that adversely affects many grassland species. This reduction of habitat and connectivity, and increase in edge effect leads to a loss in biodiversity (Wilcox and Murphy, 1985; Fletcher et al., 2007).

Fragmentation of grassland habitats comes automatically with wind development through construction and maintenance of roads, power lines, wind turbines, underground collection lines, all accompanied with invasive weedy species, fragmenting the intact grassland. The ever increasing edge affect from fragmenting of habitat will adversely affect native grassland habitats and associated indigenous wildlife.

Being More Specific About Indirect Affects to Grassland Birds

Examples of studies showing grassland fragmenting affects to indigenous grassland wildlife on the Coteau beyond the disturbed areas are:

- Generally, grassland birds and waterfowl exhibit avoidance of wind turbines in studies in the Dakotas within the Coteau (Loesch et al. 2013, Shaffer and Buhl 2016).
- In Alberta, Canada "Six species, including five obligate grassland species, were more prevalent at off-road sites; they included four species listed under the Canadian federal Species At Risk Act or listed by the Committee on the Status of Endangered Wildlife in Canada: Sprague's Pipit (*Anthus spragueii*), Baird's Sparrow (*Ammodramus bairdii*), the Chestnut-collared Longspur (*Calcarius ornatus*), and McCown's Longspur (*Rhynchophanes mccownii*). The six species were as much as four times more abundant on off-road sites. Species more prevalent along roadside routes included common species and those typical of farmland and other human-modified habitats, e.g., the European Starling (*Sturnus vulgaris*), the Black-billed Magpie (*Pica hudsonia*), and the House Sparrow (*Passer domesticus*)." (Wellicome et al. (2014).
- Other studies identify the same results for indigenous grassland birds expressing roads traversing through once intact grasslands adversely affect indigenous grassland bird species, for example:

- **Grasshopper sparrow display a strong avoidance of building nests in roadside edges cut through native prairies** (Patten et al. 2006, 2011). [Their song, an insectlike buzz of very high, hissing sound hard to hear if there is much background noise.]
- Baird's sparrow, seen in Figure 2 below, is **another species very sensitive to losing intact grasslands, and avoids roads** (Koper and Schmiegelow 2006, Sliwinski and Koper 2012, Ludlow et al. 2015, and Nenninger and Koper 2018). [They have a very soft territorial song that sounds like the beginning of Beethoven's fifth symphony. The Burke Wind Project Area is within this species restricted breeding range, a species that also is being considered for the ESA listing. Both the Baird's and grasshopper's soft, high pitched songs will be hard to hear anywhere near turbines. Will this be true for them to hear one another as well?]
- Bobolinks consistently avoided roads (Thompson et al. 2015). [There constant bubbling jangling warble fills the grassland air with a loud, happy song.]
- Thompson et al. (2015) study in oil development country in western North Dakota demonstrated indirect affects to grassland birds from road development. They found grassland birds combined avoided habitat within 150 m of roadways, including secondary roads. They expressed this avoidance zone may potentially reduce over-all bird density by about 33%, as compared to areas outside the avoidance zone.

  Thompson et al. (2015) identified the magnitude of losses, both direct and indirect, when stating "Secondary gravel roads commonly measured ~10 m wide and usually had an additional ~10 m of roadside habitat that differed from the interior (i.e. right-of-way or ditches) on each side of the road. [bold added] **The inclusion of 150 m on either side of the roadway increases the area affected 10-fold. Thus, any 1 km of secondary road can detrimentally affect up to 33 ha of habitat**."
- Sprague's pipit (see Figure 2, below) breeding range is within the Burke Wind Project Area, "…a species that is currently a candidate for listing under the U.S. Endangered Species Act (U.S. Fish and Wildlife Service, 2010). The species is also listed as threatened in Canada (COSEWIC, 2010)." [Thompson et al. 2015] **Of endemic grassland birds, this species is very sensitive to retaining large tracts of native grassland** (Davis et al. 2006, Thompson et al. 2015). The towering turbines and the indirect footprint they cause will likely affect the Sprague's pipit similar to an oil pad as described in Thompson et al. (2015).

  Another aspect of the indirect effect to the Sprague's pipit can be realized when understanding its courtship behavior. Throughout spring and early summer, Sprague's pipits skylark an impressive aerial display high in the sky. This bird appears as a tiny dark speck high overhead – if you can find it dipping and diving over its territory from the higher landscape elevations for over an hour while also singing its high pitched jingling whistle song.

Figure 2: Sprague's pipit, western meadowlark, and Baird's sparrow respectively, all species found on the Coteau and are important Conservation Priority species.

Wind Tower Turbulence

Another indirect aspect of wind turbines located on intact grasslands likely to adversely affect indigenous birds – although we have not found any publications addressing this issue – is air turbulences behind the towers. Wind turbines create strong air turbulence downwind of the tower, as shown in Figures 3A and 3B, at the end of this paper. The amount of air turbulence downwind of these towers will prevent aerial displaying behavior by grassland birds that use either calm days or days with steady, straight winds that lack the turbulence such as that found behind wind towers.

There are several species of grassland birds that use aerial displays for establishing and retaining breeding territories. Sprague's pipit has one of the highest displays, viewed only as a very small black speck against white clouds, as described above. Chestnut-collared longspurs and bobolinks are also aerial displayers, although at much lower altitude than the Sprague's. Other species groups using aerial displays at or slightly above the height of a wind turbine include shorebirds and raptors. Shorebirds in the project area with elaborate aerial displays are marbled godwit (a special of special concern), willet, piping plover (ESA threatened), common snipe, and upland sandpiper.

Grassland nesting raptors that use aerial displays with impressive heights and maneuvers are the northern harrier and short-eared owl. The northern harrier is a common nester on the Coteau each year however, the short-eared owl will only be attracted for nesting here in high vole years.

Other wildlife species that use other grassland types in the Project Area for nesting will still have the same problems from tower turbulences if their territories are near turbines. The nearness of the turbines, of course, depends on each species territory size.

Drawing Basic Conclusions for Upland Grassland Species

As just presented, the potential direct and indirect footprint of the industrial wind field development will have multiple adverse affects on indigenous grassland wildlife.

Others too have expressed concern about the direct and indirect adverse affects to wildlife with the 'green' energy development.

Kiesecker et al. (2011) expressed "Wind energy offers the potential to reduce carbon emissions while increasing energy independence and bolstering economic development. However, wind energy has a larger land footprint per Gigawatt (GW) than most other forms of energy production, making appropriate siting and mitigation particularly important. Species that require large unfragmented habitats and those known to avoid vertical structures are particularly at risk from wind development. Developing energy on disturbed lands rather than placing new developments within large and intact habitats would reduce cumulative impacts to wildlife…"

Zimmerling et al. (2013) also expressed the importance of avoiding highly sensitive or rare habitats when they said "…population level impacts are unlikely [with wind development], provided that highly sensitive or rare habitats, as well as concentration areas for species of risk, are avoided."

A study by Obermeyer (2011) completed in Kansas expressed "Wind energy, if improperly sited, can impact wildlife through direct mortality and habitat loss and fragmentation, in contrast to its environmental benefits in the areas of greenhouse gas, air quality, and water quality. Fortunately, risks to wildlife from wind energy may be alleviated through proper siting and mitigation offsets." They suggested that wind projects that avoid and offset impacts consistent with their analysis could be awarded "Green Certification." They concluded "Certification may help to expand and sustain the wind industry by facilitating the completion of individual projects sited to avoid sensitive areas and protecting the industry's reputation as an ecologically friendly source of electricity."

Quantifying the total environmental degradation caused by industrial wind fields is a critical step in understanding how to better mitigate harm to wildlife populations, but of course it is better to avoid these highly valued wildlife native resources in the first place.

<u>Wildlife Associated with Wetland</u>

We have not presented much information yet about specific wildlife species associated with wetlands, and how they might be affected by the wind energy development on the Coteau.

First, it is important to emphasis the significant abundance of wetlands in the Burke Wind Project Area. The proportion of sections in North Dakota with the number of wetland basins greater than 100 is 3.6 times higher in the Project Area than elsewhere in North Dakota (USFWS data).

This is an aerial view of the Missouri du Coteau in Burke County during spring, clearly showing native grassland habitat with its abundant wetlands.

The abundance of wetlands, and native and tame grasslands for nesting found in the Burke Wind Project Area has created one of the best duck breeding areas in North Dakota. On sections of land state-wide with greater than 100 duck pairs, five species of dabbling duck pairs occur 8 times higher in the Project Area (USFWS data) than elsewhere in the state. Pintail and lesser scaup pairs are also more likely to occur in greater numbers here than elsewhere in the state – both are species of concern on the Conservation Priority list.

As mentioned above, waterfowl exhibit avoidance of wind turbines in studies on the Dakotas. Loesch et al. (2013) found five species of dabbling ducks exhibited an average decline of 20% after the erection of turbines on one wind farm, and the estimated densities of duck pairs on wetlands in wind sites were reduced 4 to 56% for 25 of 30 sites, species, and year combinations in the Coteau. With the extreme abundance of wetlands and higher populations of duck pairs occurring on Burke County's Coteau, the decline of dabbling ducks in Loesch's (et al.) study just might be even greater on the Burke Wind Project Area.

Then there is the diversity of waterbirds, including the great blue heron, American bittern, black terns, American white pelican, Franklin's gull, horned grebe. Referring back to the list of Conservation Priority species, we see most of the species we just mentioned are on that list. All these birds fly about from wetland to wetland searching for food. Will these birds be killed directly, will they be displaced going somewhere else to nest, or will they no longer have somewhere else to go because what had been available has been destroyed by the wind turbine industrial fields either directly or indirectly?

"The millions of wetlands that define the Prairie Pothole Region (PPR) harbor large proportions of continental populations of several species of North American waterfowl, waterbirds, and shorebirds" (Niemuth et al. 2013). **The Coteau – also referred to as the Prairie Pothole Region** – is "…estimated to host greater than 50% of the North American breeding populations for Pied-billed Grebe (*Podilymbus podiceps*), American Bittern (*Botaurus lentiginosus*), Sora (*Porzana Carolina*), American Coot (*Fulica americana*), and Black Tern (*Chlidonias niger*) …, as well as **approximately 80% of the North American population of Marbled Godwit** (Limosa fedoa)…." (Niemuth et al. 2013) [bold added]

Adult marble godwit defending chicks that hatched on the northern mixed-grass prairie of the Coteau in Burke County, North Dakota.

There is one study in Belgium that addresses effects to terns. This study found significant effects to breeding tern colony from collisions (Everaert and Stienen 2007). Scattered across the various wetlands on the Coteau are breeding pairs of black tern that nest in small, loose colonies, and Forester tern that nest on floating platform over water usually as a single pair. These species fly from wetland to wetland, crossing over uplands to reach the next wetland where they search for minnows and other aquatic foods to feed their chicks. If terns are vulnerable to collision in Belgium, it is not a big leap to assume they will have collision occurrences here too.

There is another study that assessed effect just on **the occurrence** of waterbirds and shorebirds (Niemuth et al. 2013) on the Coteua of North and South Dakota: "Models characterizing occurrence of Willet (Catoptrophorus semipalmatus), Marbled Godwit (Limosa fedoa), Wilson's Phalarope (Phalaropus tricolor), and Black Tern (Chlidonias niger) indicated that occurrence varied with wetland characteristics and among sites and years, was not substantially reduced on either wind energy site, but was slightly and consistently lower on one of the wind energy sites for the three shorebirds species." They expressed their concern that "… additional sampling across time and space will be necessary to understand the effects of wind turbines on shorebird and waterbird presence, density, survival, and reproductive success."

There are few studies on the Coteau that determine the effect of wind fields to willets, marbled godwits, and Wilson's phalaropes. All three of these species have their breeding habitat needs met on the Coteau. The adults nest on native grassland uplands, sometimes over 100 yards from their selected wetland habitats (Lostwood Refuge files). The adults will eventually guide their brood from the upland nesting and chick rearing area to a wetland shoreline where chicks finish their growth.

Godwits and willets, in particular, have elaborate aerial courtship displays each spring and early summer. Turbine turbulence, as previously presented above, may adversely affect their ability to perform their important aerial courtship displays.

There is one study that analyses whooping crane data collected in the spring of 1990 through the spring of 2014 to determine their migration route through the Dakotas. This, published in 2018 (Niemuth et al. 2018), shows the most probable migration route whooping cranes will use through North Dakota and South Dakota. The Burke Wind Project Area is squarely in the middle of the most probable migration route (see Figures 1, 3A, and 3B in the attached Niemuth et al. 2018 publication).

Piping plover, an ESA threatened species, is a migrant and a nester on alkaline shorelines found throughout the Coteau. This species has been studied extensively. Their alkaline wetland shorelines are not common in the Project Area but they return each spring to fly about checking shoreline conditions for appropriate nesting and feeding conditions. These flights can occur across North Dakota, Montana, and southern Provinces of Canada checking out shorelines to locate appropriate nesting and feeding habitats. Once a territory has been selected, adults still fly about, sometimes visiting other feeding sights on other wetlands.

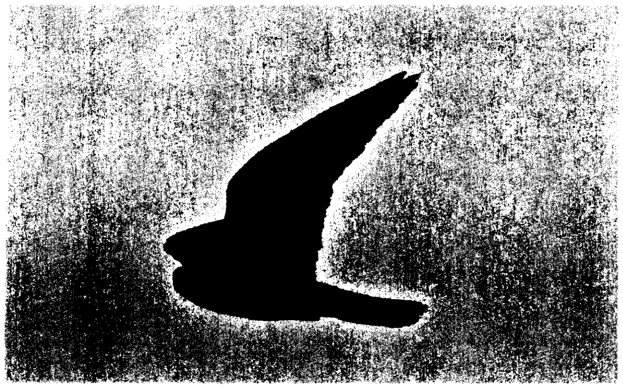
Nesting season flights, and spring and fall migrations to and from Canada, Montana, and North Dakota traverse through the Coteau in Burke County. Turbines located on the Coteau will increase their chances of turbine collisions.

A piping plover is keeping an eye on its' nearby nest on this alkaline wetland shoreline, a type of wetland habitat commonly found on Coteau within Burke County.

There are **not** a lot of studies available to evaluate how waterbirds and shorebirds will respond to wind development on the Coteau where wetland density is high, scattered within adjoining native and tame grasslands. It would be more appropriate for the wind industry to avoid these highly valued, intact grasslands with abundant wetlands than invade them with an industrial wind farm.

Valuable Migratory Corridor

The Coteau is a migration corridor! Of specific concern is that the Coteau has the highest elevations along this glacial feature both east and west for several miles. Towers will be placed on some of these highest elevations squarely in the middle of the migration path that will adversely affect migrating bats and such birds as whooping cranes, peregrine falcons, bald eagles, snow buntings, redpolls, longspurs, shorebirds, and the list can go on and on!



Immature peregrine falcon flying across the Coteau in Burke County during its' fall migration of 2011.

I believe Smith and Dwyer (2016) may have presented a summary of how setting a wind field in a migratory corridor, like the Coteau, will affect specific species. They said "Although both direct and indirect effects appear site-, species-, and infrastructure-specific, generalities across energy sectors are apparent. For example, large-bodied species with high wing loading and relatively low maneuverability appear to be especially susceptible to direct effects of tall structures, and the risk of collision is likely greater when structures are placed perpendicular to flight paths."

Whooping cranes with their large bodies fit this description, as well as some others just listed. The wind project is positioned on the Coteau, some of the highest elevations through central North Dakota squarely in the perpendicular flight path of this endangered crane.

Another aspect of importance is the spring and fall migration of migrating shorebirds through the Coteau and how turbines will affect these birds – we could not find published information about this effect. There is a tremendous diversity of shorebirds that migrate across the Coteau each spring and fall, utilizing the abundant and diverse wetlands for refueling during these migration flights. A few of species that fly through here include ruddy turnstone, Baird's sandpiper, long-billed dowitcher, and so many more. These species fly in mixed, small flocks zipping and diving about following the contour of the landscape at varying heights. We see this every spring and fall. The turbines will be right in the main migration pathway through the Coteau!

The flight behavior of these migrating shorebirds may well be very vulnerable to direct kill, or may result in avoidance, reducing their ability to access foods from wetlands that would have restored their energy reserves needed for migration.

There is so little known how these birds will be affected. Perhaps a significant degree of caution by the wind industry should be employed by not developing in these endangered habitats. This is the greatest assurance these critical habitats will be available for many sensitive species that depend upon grasslands and abundant wetlands characteristic of the Coteau in the proposed Burke Wind Project Area.

Wildlife species on the Conservation Priority list are declining across the Northern Great Plains which includes North Dakota. Realizing how many conservation priority wildlife species are present on the Coteau, it becomes easy to recognize why the Coteau's grasslands are so valued and important to retain intact!

The destruction and disturbance from direct and indirect 'footprints' onto wildlife caused by the Burke Wind Project will come from the increased human activities that will adversely affect the intact native grasslands and other grasslands, wetlands, and associated indigenous wildlife.

This is not a good place for constructing an industrial wind field! We wonder why was this unique geological feature so full of valuable, critical native resources selected for an industrial wind field! We believe the risk is too great to take the chance to allow this industrial wind project to be completed – particularly when there are alternatives, as will be shortly discussed.

Bats

Bat mortality associated with wind energy development has been recognized by many. Arnett et al. (2010) in their abstract "...All [wind] studies that addressed relationships between bat fatalities and weather patterns found that most bats were killed on nights with low wind speed (<6 m/sec) and that fatalities increased immediately before and after passage of storm fronts."

Barclay et al. (2007) expressed "...To assess the influence of turbine size on bird and bat fatalities, we analyzed data from North American wind energy facilities. Diameter of the turbine rotor did not influence the rate of bird or bat fatality. The height of the turbine tower had no effect on bird fatalities per turbine, but bat fatalities increased exponentially with tower height. This suggests that migrating bats fly at lower altitudes than nocturnally migrating birds and that newer, larger turbines are reaching that airspace. Minimizing tower height may help minimize bat fatalities. In addition, while replacing older, smaller turbines with fewer larger ones may reduce bird fatalities per megawatt, it may result in increased numbers of bat fatalities."

Many Recognize the Importance of Coteau's Native Grasslands and Associated Wetlands

Intact Northern Great Plains grasslands have been recognized as extremely important for wildlife in North Dakota by various organizations and federal and state agencies. Four of these sources are detailed in our Package. Below is a brief summary of these four, and below that is as summary of information from two alternative ways for selecting wind field locations.

1) The **North Dakota Game and Fish Department** (NDGFD) is required by stature authority to protect, conserve, and enhance fish and wildlife populations and their habitat for sustained public consumptive and non-consumptive use.

Information in the Package that **NDGFD** developed identifies Focus Areas (Figure 1 in Package) of High Impact for Native Wildlife and Habitat. Approximately 37% of the state has high impact areas. These areas are of most importance to the vast majority of Species on the Conservation Priority list. One of these prime Focus Areas is the "Missouri Coteau Breaks" (name applied by the state for the Missouri du Coteau). In the Package, Figure 2, there is a map of North Dakota that shows NDGFD's Focus Areas where larger tracts of intact grasslands are located. The Burke Wind Project Area is located in some of the largest blocks of intact grasslands on the Coteau.

2) The Nature Conservancy has identified important ecoregions throughout the United States that represents the top places where native species and plant communities should be conserved – Figure 4 in the Package. The Burke Wind Project Area is squarely in the middle of one of these important ecoregions!

3) The **Bird Life International** identified **Important Bird Areas**. They have identified over 12,000 areas of **global** importance. These sites represent some of the most important places for birds. Lostwood National Wildlife Refuge is one of those sites, shown in Figure 5 in the Package.

NextEra's original plan had the southeastern Project Area boundary one mile from the refuge's northern boundary. NextEra has withdrawn three Townships from the Burke Wind Project Area because of the proximity to the refuge. We thank NextEra for this decision. Whether landowners with wind leases in these Townships had their leases canceled is unknown.

The eastern edge of the Project Area's boundary is now six miles west of the refuge. This helps protect what the Burke Planning and Zoning Commissioners' Comprehensive Plan stressed, which was to protect and retain the characteristic of public land. This would represent the open grassland skyline of the Lostwood Wilderness Area for the visiting public to enjoy our widespread open grassland heritage.

4) The **U.S. Fish and Wildlife Service** (USFWS) is required to follow their mission of "...working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people." The agency stresses "As managing for listed species is far more restrictive, difficult, and expensive than preventing listings, it is vital that we maintain the key habitat resources needed to sustain healthy populations on the landscape."

The **USFWS** has developed detailed wetland information for North Dakota. One of the densest wetland areas shown on Figure 3 in the Package is the Focus Area of the Coteau where Burke Wind Project Area is located. These wetlands represent a vast array of wetlands large and small, fresh and saltier than the oceans intermingled in the intact native grasslands and other grassland areas.

Ways to Select Wind Field Locations

There are other ways to select wind field locations that will avoid sensitive areas and protect the industry's reputation as an ecologically friendly source of electricity. It is important to incorporate not only the amount of wind but also whether there are high impact areas that have wildlife populations **rare, declining, or unique** associated with critical and endangered habitats that need to be avoided.

Two organizations working together have incorporated these thoughts into two publications that can help make wind energy more ecologically friendly. The **World Wildlife Fund and The Nature Conservanc**y completed two studies cooperatively in 2012 and 2016 to identify locations that would assist the wind industry in selecting wind field locations that would reduce adverse affects to important critical wildlife and their habitats.

The 2012 Publication: Low Impact Areas

Authors of the 2012 publication entitled "Wind and wildlife in the Northern Great Plains: Identifying Low Impact areas for wind development" (Fargione et al. 2012: hard copy attached) . They expressed "Wind energy offers the potential to reduce carbon emissions while increasing energy independence and bolstering economic development. However, wind energy has a larger land footprint per Gigawatt (GW) than most other forms of energy production and has known and predicted adverse effects on wildlife. The Northern Great Plains (NGP) is home both to some of the world's best wind resources and to remaining temperate grasslands, the most converted and least protected ecological system on the planet. Thus, appropriate sighting and mitigation of wind development is particularly important in this region."

This publication offers another approach for selecting wind field locations using both wind and low wildlife impact area information. This 2012 publication developed several layers of previously known information from wind data, disturbed land surfaces, and state- and provincial-level wildlife data from Alberta, Saskatchewan, Montana, Nebraska, South Dakota, North Dakota, and Wyoming (how the data was gathered is detailed in the attached 2012 publication).

Briefly, they used High Resolution Wind Data at websites for United States and Canada for wind power class modeled at 50 meters (*wind data is found at web sites for both countries shown in literature cited*). They considered wind power class 3 through 7 to be economically viable. They expressed "Although newer wind turbines commonly have a hub height of 80–100 meters, wind speed data at this height is not publically available as a GIS data layer. Since wind speed increases with height, our use of the 50-meter wind speed data is conservative…."

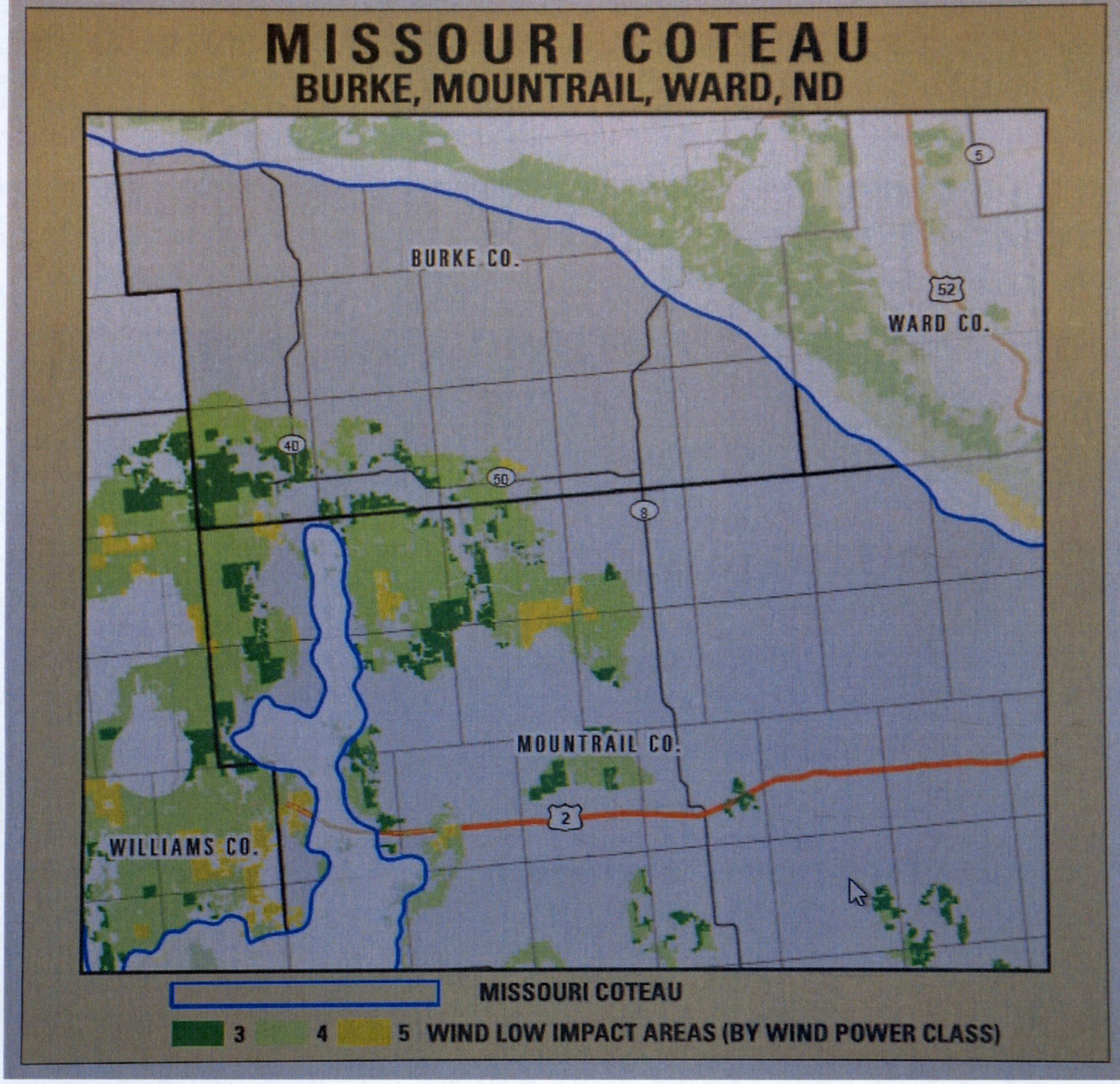
They "…compiled spatial data on the footprint of human disturbance, including developed areas, cropland, roads and other impervious surfaces, oil and gas development, and surface mines." The classes used in this data set considered to be disturbed lands were Cultivated Crops, Developed-High Intensity, Developed-Low Intensity, Developed-Medium Intensity, Developed-Open Space, and Hay/Pasture. **They identified the Hay/Pasture class to be planted forage grasses, "…but did not include [these as] natural (i.e. unplanted) grasslands used for grazing**." [bold added]

One of the data sources was the 2001 National Land Cover Dataset. They found that of all the areas on the Great Plains, the one area of **primary concern was the Northern Great Plains**. The authors expressed "…globally, the temperate grasslands biome is the most converted and least protected (Hoekstra et al. 2005) and the Northern Great Plains is home to much of North America's remaining temperate grasslands." And as we have already described the extreme importance for grassland wildlife!

What is extremely helpful is they combined data and developed maps to identify **Low Impact** areas with good wind, verses **High Impact** intact native grassland/wildlife areas that should be discouraged or avoided for use by the wind industry. There are ample areas with low impact and enough wind to meet the goals established by the U.S, Department of Energy that 20% of United States electrical needs come from wind energy by year 2030 (Department of Energy 2008).

Let us give a little more detail. From the 2012 publication, **"Goals for wind energy development in the NGP are roughly 30 GW of nameplate capacity by 2030** [bold added]. Our analyses demonstrate that there are large areas where wind development would likely have few additional impacts on wildlife. We estimate there are, 1,056 GW of potential wind energy available across the NGP on areas likely to have Low Impact for biodiversity, **over 35 times development goals**. New policies and approaches will be required to guide wind energy development to Low Impact areas." (Fargione et al. 2012)

To stress the significance of the 1,056 GW of potential wind energy available across the NGP on areas likely to have low impact, the **total** capacity of United States electricity generating plants is approximately equal to 1,100 GW – one gigawatt equal to 1,000 megawatts equal to one billion watts. The U.S. Department of Energy set a goal of producing 20% from wind energy can be met without using High Impact areas, like that found on the Burke Wind Project Area on the Coteau. Map 1, below, shows where there is Low Impact areas yet wind value classes of 3, 4, and 5 in Burke, Mountrail, and parts of Williams Counties.



Map 1: Areas of the Missouri Coteau that are Low Impact that have wind power classes 3, 4, and 5. All of the Coteau is located within **high impact** intact native grassland/wildlife areas that should be discouraged or avoided for use by the wind industry.

The entire Coteau in Burke County is **not** within the Low Impact areas for wind development as seen on Map 1. The Coteau is recognized as a High Impact area, an area that should be avoided by the wind industry because there is too much valued, intact native grassland and its associated grassland wildlife.

I think it is important to include two other paragraphs from this publication.

We mentioned earlier about "Green Certification" for encouraging the wind industry to seek low impact areas for wind development. The 2012 publication offers this suggestion:

> 1) "Perhaps more importantly, compliance with guidelines or certification could serve as a basis for power purchase decisions by **utilities**. Utilities could indicate in their requests for proposals for new power generation that projects meeting wildlife guidelines would be given preference. Because wind development typically cannot be financed without a long term power purchase agreement, this would provide strong incentive for wind developers to comply with any guidelines so endorsed. Such guidelines should not only identify low impact areas, but should also identify avoidance areas where wind development could not be certified. In addition to low impact and avoidance areas, there are intermediate areas that would incur moderate impacts that could be mitigated with compensatory offsite mitigation.... For example, impacts to moderately fragmented grasslands could be offset with grassland restoration or with protection of existing intact grasslands. Our work provides a substantial starting point for such conservation strategies, compiling many of the data layers that would be needed to construct comprehensive guidelines including avoidance areas and mitigation costs. These data are available at http:// LowImpactWind.tnc.org. (p13)"

A conclusion they have drawn:

> 2) "In places where extensive wind development may conflict with the preservation of large intact landscapes and the wildlife that depend upon them, strategies that can balance the needs of development and conservation are required. Targeting wind energy development to areas with low impacts to wildlife can help society simultaneously achieve goals for clean renewable energy production and wildlife conservation. Encouragingly, our analysis demonstrates that is possible to meet all of our demand for wind energy on lands that are likely to have low impacts to wildlife. In the Northern Great Plains, wind energy production on low-impact disturbed lands could exceed 1,056 GW, over 35 times the projected demand for wind energy. New policies and approaches are needed to guide wind energy development to low impact areas.(Fargione et al. 2012: 13)"

The approach proposed by the 2012 publication offers a much simpler and less costly solution to reduce or eliminate conflicts with industrial wind development and High Impact habitats of critical importance for our native heritage of native grasslands and associated wildlife.

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[To take the next step in making wind projects significantly less invasive and offensive to the open landscape and greater protection for wildlife, is to convert to wind towers without blades, as an example are those called Vortex.

Vortex structures have no exterior blades (see Figure 4 at end of this paper), less expensive to manufacture, totally silent, and safer for birds since there are no blades and support system. A structure that has a much smaller footprint and far less concrete base because it does not have to support the huge, whirling blades, making them safer for people and wildlife.]

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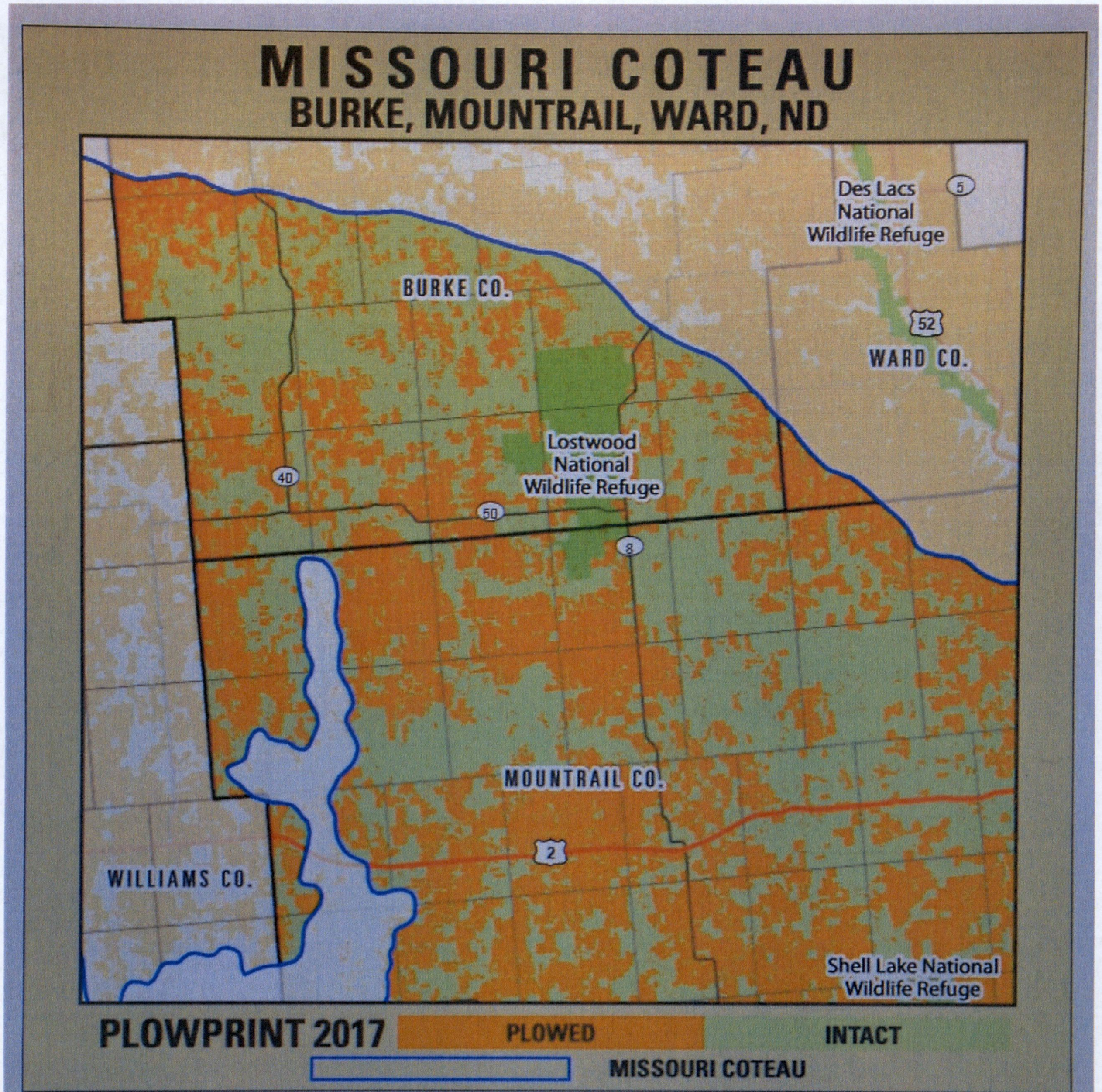
Plowprint: the 2016 Publication

I will briefly describe the 2016 information (Gage et al. 2016: hard copy attached). One of their main goals was to identify the locations of intact habitats to hopefully guide wind and other industrial development that would reduce the loss of valuable natural resources.

The authors in the 2016 publication entitled "Plowprint" were interested in documenting the footprint change in lands cropped. They "...gathered information from USDA National Agricultural Statistics Service Cropland Data layer, Canada Agricultural and Agri-Food Canada Annual Crop, Landsat imageries and other sources. They "...mapped additions of cropland to the plowprint annually, thus tracking the footprint of crop agriculture on the landscape as it expanded annually between 2009 (2010 in Canada) and 2013." (p 110)

They defined their study area by four different names that included all or part of seven states and three southern provinces. Landcover types used were explained on pages 111-112. Part of that information says "...we grouped crops and other landcover types into the following categories: cropland/fallow, **alfalfa/other hay, grassland/pasture/shrubland/wetland**, barren/developed, open water, and forest. Using this information, we can track different categories of land-cover types within the plowprint, which is of interest because **restored lands [grassland/hayland] can provide suitable habitat for some wildlife and avian species of conservation interest ....**" [bold added]

The outcome of this work is shown in Map 2, below. It presents two color groups: 1) grassland/pasture/shrubland/wetland and alfalfa/other hay called INTACT and 2) others that include cropland and other disturbed sites called PLOWED for parts of Burke and Mountrail counties on the Missouri Coteau.



Map 2: Plowprint map with two color groups representing: grassland/pasture/shrubland/wetland, and alfalfa/other hay in light green called **INTACT;** and others that include cropland and other disturbed sites in orange called **PLOWED** for parts of Burke and Mountrail counties on the Missouri Coteau.

They expressed that "While the tallgrass prairie of North America has largely been converted from its native state to cropland, shortgrass and mixed-grass prairies located along the western portion of the Great Plains still contain large, intact blocks of habitat."

Intact grasslands are a valuable resource because they provide a wealth of services to our country that includes storing carbon (grassland store at least as much as a forest); water filtration; reduced erosion that keeps the moisture on the land; avoids the addition of nitrogen, phosphorous, and sediment into our freshwater systems of the United States; and, of course, maintains the tremendous diversity of habitat for the tremendous diversity of wildlife, those of which cannot survive on cropland.

Getting Back to the Burke Wind Project.

Knowing what we have just presented and understanding the guidelines that USFWS and the NDGFD developed to help the wind industry select sites with low impact to wildlife, the Burke Wind Project should never have been started. In the USFWS step process, it should have never gotten past Tier 1 (this process is introduced in more detail in the Package). NDGFD guidelines also stressed the importance of the Coteau when they identified it as a Focus Area!

If NextEra began USFWS's tiered step approach to evaluate the site, then there were steps to collect additional wildlife information. Whether NextEra gathered data needed for the different tiers is not known by us. We asked the Burke County Planning and Zoning Commissioners if they have ever seen natural resource data that NextEra collected. The two members contacted were unaware or did not recall of such information. We did accidently get maps showing grouse dancing ground locations, as previously discussed, but the Coteau Preservation Alliance has not asked NextEra directly what other biological data they gathered nor if we could receive a copy of that data. To that extent, we perhaps made an error in not asking for that biological information.

Regardless, the information we have just provided about the habitat and wildlife that occurs within this project area is enough information that NextEra should have recognized the Burke Wind Project Area was in a deplorable location and should have been abandoned. Plus, if they would have followed the NDGFD's and USFWS's guidelines, they would have stopped studying Burke's Coteau for use as an industrial wind farm site!

Summary

The Coteau Preservation Alliance would first like to express our sincere appreciation that the NextEra company dropped three townships closest to Lostwood National Wildlife Refuge from their Project Area.

We also appreciate them having a setback from sharp-tailed dancing grounds by a half mile.

We believe there are more native grasslands in the project area than shown on NextEra's November 6, 2018 Figure 15 (a-f) entitled *Sharp-tailed Grouse Lek Habitat and Native Prairie Map*, where yellow represent's native prairie habitats. Based on the "Plowprint" map, excluding that portion of Harmonious Township in the Project Area, there are a lot of INTACT areas in the Burke Wind Project Area. Based on the quality imagery of the grouse map, and based on someone's own experience in reading aerial photographs, there appears to be more native grassland than indicated in yellow.

We have compared the Plowprint map to NextEra's maps to estimate the number of turbines on PLOWED and INTACT categories. If our calculations from these maps are correct, the number of turbines on Plowed and Intact by Townships are:

- Based on NextEra's July 11, 2018 map, the three Townships NextEra dropped from the Project Area had approximately 16 turbines adjacent to or located in Plowed and about 11 in Intact areas. Will NextEra – or any other wind industry – cancel existing wind leases on the three dropped Townships? Or, will they – or another wind company – construct wind turbines on these leases sometime in the future?
- Using the Plowprint map and NextEra's November 6, 2018 map, Figure 5:
  - Keller Township has approximately 17 turbines all in Plowed [four alternatives also in Plowed areas].
  - Harmonious Township has all 21 turbines and one alternative directly associated with Plowed. [Comparing the November map to their July 11, 2018 map, 15 turbines were dropped, of which only two or three were in Intact areas. Will NextEra or another wind industry cancel these leases, or construct these wind turbines at a later date?].
  - Leaf Mountain Township has approximately 14 associated with Plowed and 4 in Intact areas.
  - Foothills Township has approximately eight in Plowed and 12 in Intact.

NextEra has made an effort to put many of the turbines in PLOWED areas. But where there are larger INTACT areas, as found on the Foothills Township, there were 12 of the total 20 turbines placed in Intact areas. Regardless, the turbines are still in the migration corridor that will adversely affect migrating birds and bats every spring and fall, and species that fly about during the reproductive season.

NextEra has buried electric collection lines to reduce bird collisions. This decision reduces adverse affects. Unfortunately, the trenches dug for the collection lines traverse across several miles of native grassland, one stretch is approximately six miles through a lot of native sod without any turbines near. So there is a gain in having no bird collisions from overhead lines within the Wind Energy Center/Burke Wind Project Area, but the trench lines through native sod ripped apart by heavy equipment will fragment the tracts of grassland causing weed invasion that ultimately creates the adverse 'edge effect' detrimental to indigenous grassland wildlife. There is, however, the Transmission Line where it traverses through southwest Burke County and northwestern Mountrail County that will be a source of bird collisions.

The other unfortunate design of the project is not only are there roads where there never were roads, but the trenches for the underground lines do not necessarily follow the new roads but traverse instead across an adjacent area to go from turbine to turbine. This increased disturbance will increase weed species invasions, and as previously discussed, will adversely affect wildlife, and landowners.

We believe very strongly that NextEra has selected the wrong location for this wind field. We believe they should locate their wind fields in low impact areas shown in the study of 2012, "*Wind and wildlife in the Northern Great Plains: Identifying low-impact areas for wind development.*" There are ample areas to meet the U.S. Department of Energy's requirements without touching high impact areas such as the Coteau!

We have presented that the Coteau:

- is extremely important because of its intact native grasslands and other grassland types
- has one of North Dakota's highest wetland densities
- is a critical, endangered resource in great decline across the Northern Great Plains
- is associated with a diversity of indigenous grassland and wetland wildlife that need intact grasslands for survival
- is associated with grassland birds with a restricted breeding range
- is an important migratory corridor for many species, some of which, like the whooping crane, have a greater chance of striking turbine blades
- is so strongly recognized by many organizations and federal and state agencies as a highly valuable natural resource that needs to be excluded from wind development

All of this is evidence strongly against selection of the Burke Wind Project Area for wind development!

We have presented alternatives for wind site selections that have sufficient wind and low impact resources that will produce wind energy 35 times greater than needed to meet the 2030 goals established by the U.S. Department of Energy.

We have presented a couple of possibilities of how to encourage the wind industry to utilize low impact areas:

- one is the 'Green Certification' by Obermeyer et al. (2011), concluding certification "…may help to expand and sustain the wind industry by facilitating the completion of individual projects sited to avoid sensitive areas and protecting the industry's reputation as an ecologically friendly source of electricity."
- The second is what Fargione et al. 2012 suggested by having utilities give preference to wind projects that meet wildlife guidelines.

The Coteau Preservation Alliance is opposed to the Burke Wind LLC Project! We ask the North Dakota Public Service Commissioners to please deny NextEra's request for the Burke Wind LLC wind project based on the harm it will cause the natural resources found across the Coteau!

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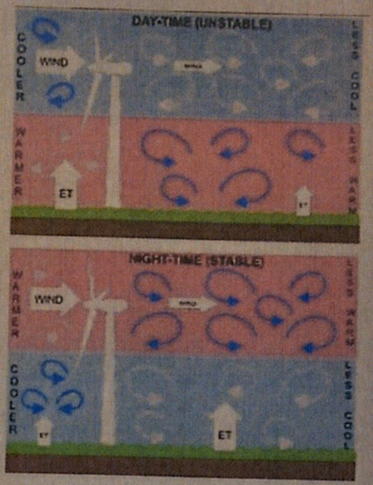
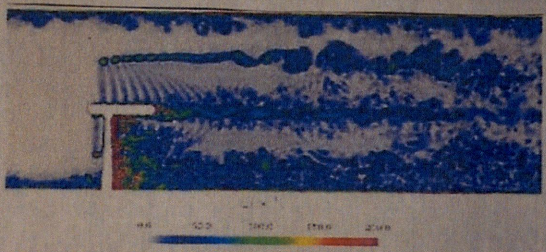




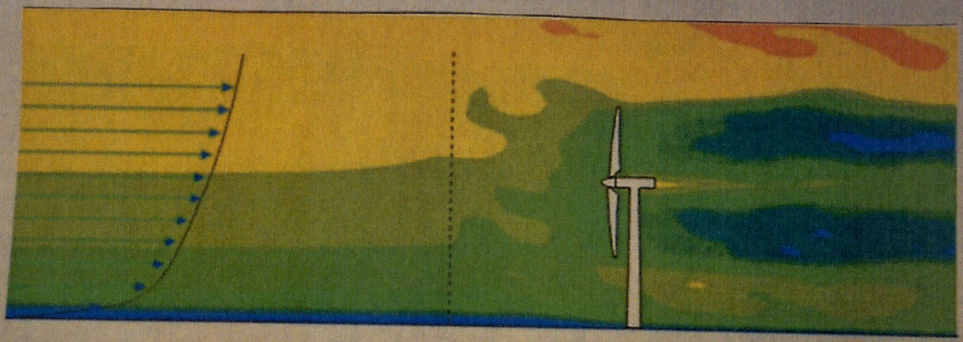


Figure 3A: Side view of wind turbulence behind a turbine

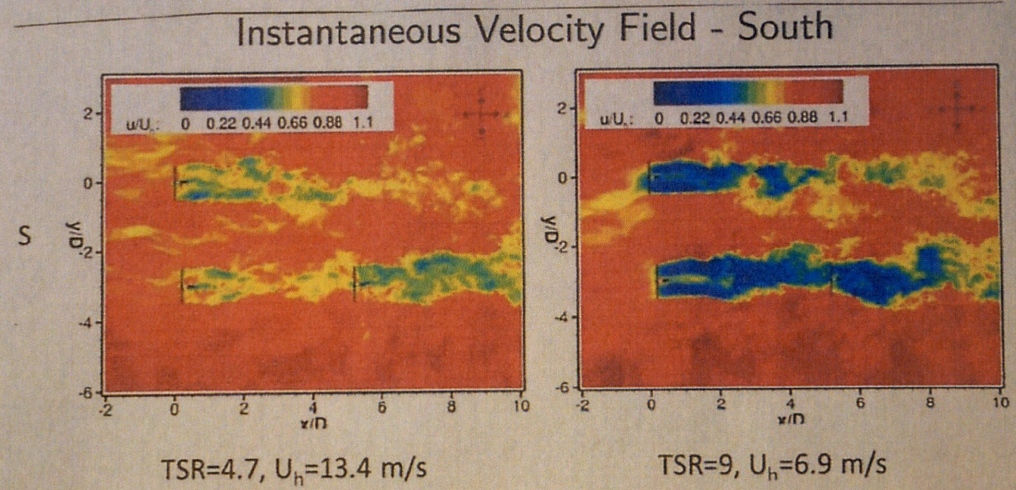
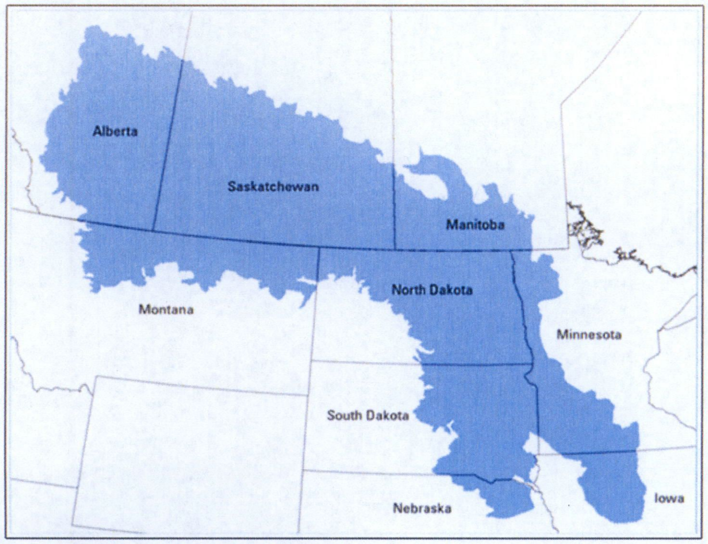


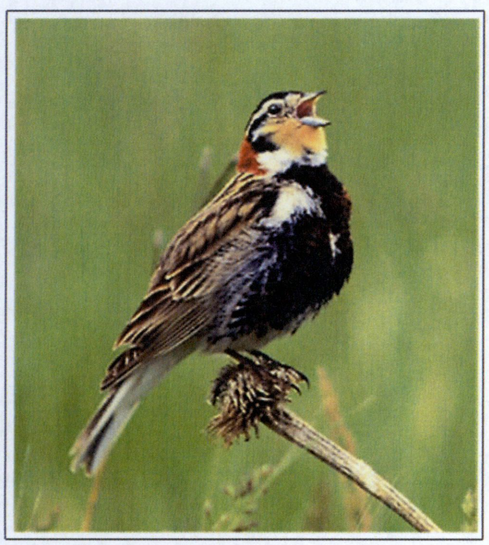
Figure 3B: Aerial view of wind turbulence behind a turbine

Figure 4: One Vortex structure, a wind turbine that has no exterior blades.

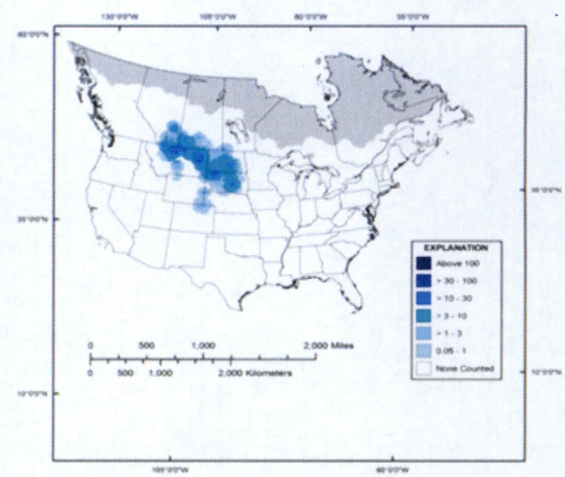
Appendix 1. This is an example of grassland avian species that reproduce on the Coteau. Note how restricted their breeding range is, similar to others on the Conservation Priority list (ND Game and Fish Department). Note also that each of these species, similar to others that use this restricted breeding range, are declining over the 1966 through 2015 period. [data from Pardieck et al. 2018]



The Coteau is part of the Prairie Pothole Region so valuable for many species of grassland and wetland wildlife and associated native plant communities.

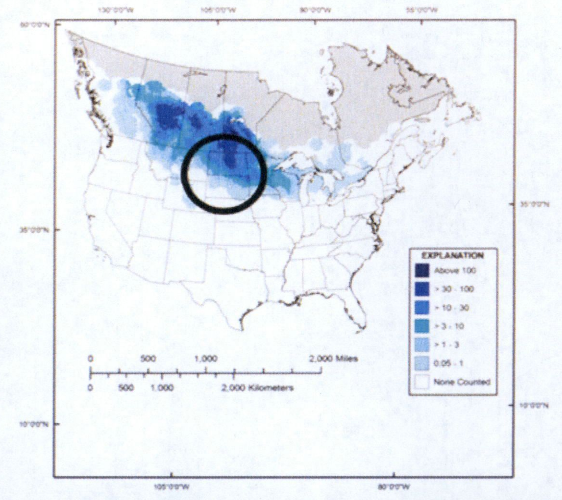


Chestnut-collared Longspur
Calcarius ornatus



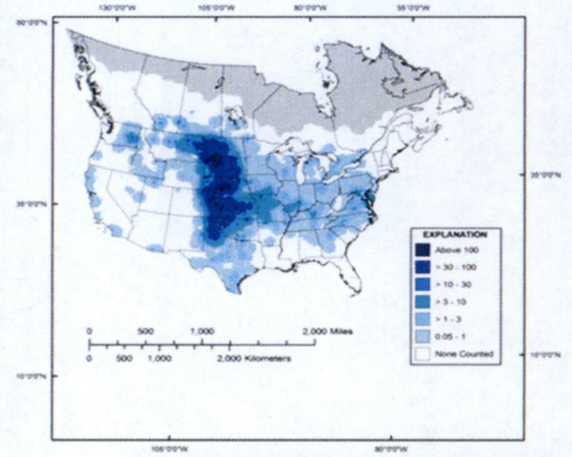
In the prairie pothole region, the longspur has declined 4.32%/year from 1966 to 2015.

Clay-colored Sparrow
Spizella pallida

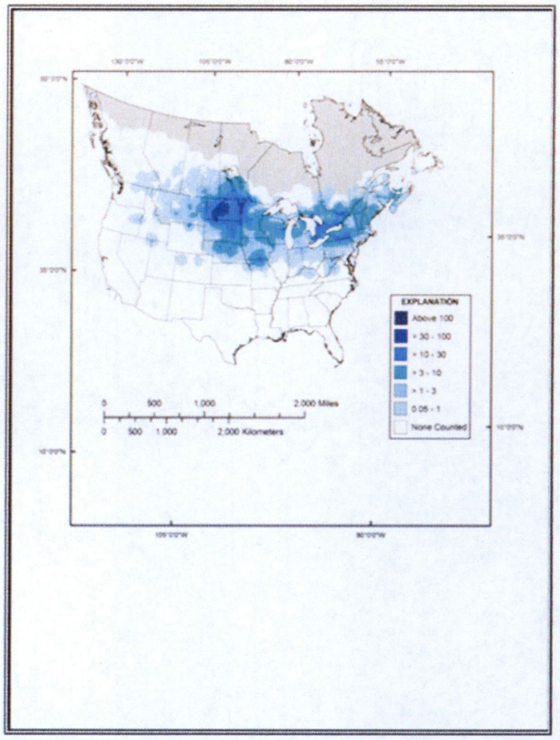


In the Prairie Pothole Region, the clay-colored sparrow has declined 0.69%/year from 1966 to 2015.

Grasshopper Sparrow
Ammodramus savannarum



In the Prairie Pothole Region, the grasshopper sparrow has declined 1.95%/year from 1966 to 2015.



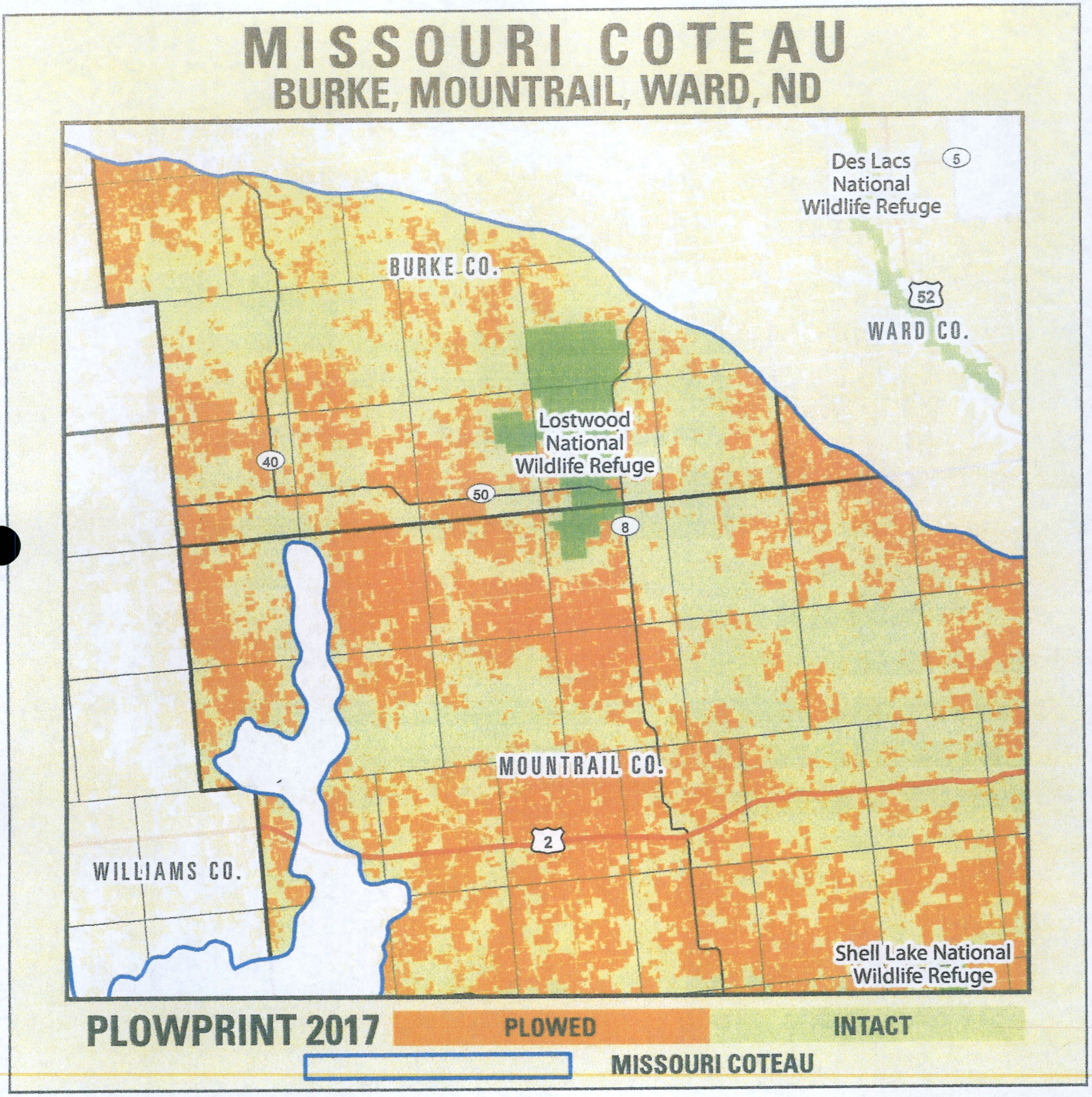
Boblink
Dolichonyx oryzivorus

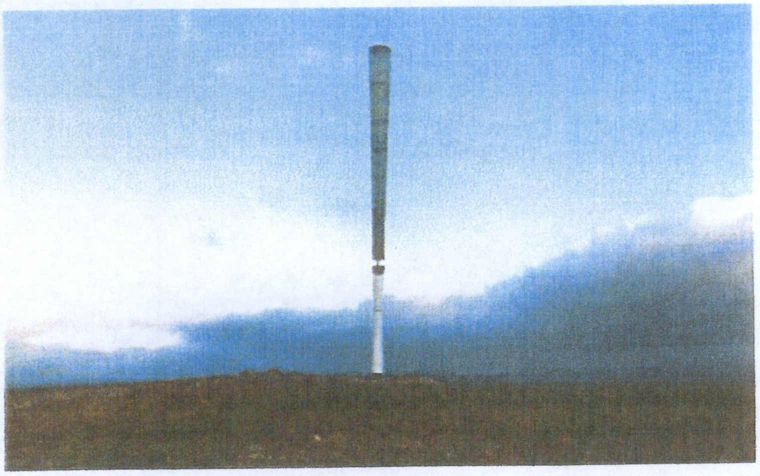
In the Prairie Pothole Region, the bobolink has declined 0.49%/year from 1966 to 2015.

MAP 1


MISSOURI COTEAU
BURKE, MOUNTRAIL, WARD, ND
5
BURKE CO.
52
WARD CO.
40
50
8
MOUNTRAIL CO.
2
WILLIAMS CO.
MISSOURI COTEAU
3
4
5
WIND LOW IMPACT AREAS (BY WIND POWER CLASS)

MAP 2


MISSOURI COTEAU
BURKE, MOUNTRAIL, WARD, ND
Des Lacs National Wildlife Refuge
5
BURKE CO.
52
WARD CO.
Lostwood National Wildlife Refuge
40
50
8
MOUNTRAIL CO.
2
WILLIAMS CO.
Shell Lake National Wildlife Refuge
PLOWPRINT 2017
PLOWED
INTACT
MISSOURI COTEAU



SAMPLE OF
VORTEX WIND
TURBINE

THE CONDOR
Ornithological Applications
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RESEARCH ARTICLE

Opportunistically collected data reveal habitat selection by migrating Whooping Cranes in the U.S. Northern Plains

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ABSTRACT

The Whooping Crane (*Grus americana*) is a federally endangered species in the United States and Canada that relies on wetland, grassland, and cropland habitat during its long migration between wintering grounds in coastal Texas, USA, and breeding sites in Alberta and Northwest Territories, Canada. We combined opportunistic Whooping Crane sightings with landscape data to identify correlates of Whooping Crane occurrence along the migration corridor in North Dakota and South Dakota, USA. Whooping Cranes selected landscapes characterized by diverse wetland communities and upland foraging opportunities. Model performance substantially improved when variables related to detection were included, emphasizing the importance of accounting for biases associated with detection and reporting of birds in opportunistic datasets. We created a predictive map showing relative probability of occurrence across the study region by applying our model to GIS data layers; validation using independent, unbiased locations from birds equipped with platform transmitting terminals indicated that our final model adequately predicted habitat use by migrant Whooping Cranes. The probability map demonstrated that existing conservation efforts have protected much top-tier Whooping Crane habitat, especially in the portions of North Dakota and South Dakota that lie east of the Missouri River. Our results can support species recovery by informing prioritization for acquisition and restoration of landscapes that provide safe roosting and foraging habitats. Our results can also guide the siting of structures such as wind towers and electrical transmission and distribution lines, which pose a strike and mortality risk to migrating Whooping Cranes.

Keywords: migration, observation bias, spatial model, species conservation

Datos observacionales colectados de modo oportunista revelan selección de hábitat por parte de individuos migratorios de *Grus americana* en las Planicies del Norte de EEUU

RESUMEN

Grus americana es una especie en peligro a nivel federal en los Estados Unidos y Canadá que depende de hábitat migratorio en su largo pasaje entre los sitios de invernada en la costa de Texas, EEUU y los sitios reproductivos en Alberta y los Territorios del Noroeste, Canadá. Combinamos observaciones oportunistas de *Grus americana* con datos del paisaje para identificar correlaciones de la ocurrencia de *G. americana* a lo largo del corredor migratorio de Dakota del Norte y Dakota del Sur, EEUU. Los individuos de *G. americana* seleccionaron paisajes caracterizados por diversas comunidades de humedales y oportunidades de forrajeo en las tierras altas. El desempeño del modelo mejoró sustancialmente cuando se incluyeron variables relacionadas con la detección, enfatizando la importancia de contabilizar los sesgos asociados con la detección y los informes de aves en bases de datos oportunistas. Creamos un mapa predictivo que muestra la probabilidad relativa de ocurrencia a través de la región de estudio, mediante la aplicación de nuestro modelo a las capas de datos de SIG; la validación usando ubicaciones independientes no sesgadas a partir de aves equipadas con terminales de transmisión de plataforma indicó que nuestro modelo final predijo adecuadamente el uso por parte de los individuos migratorios de *G. americana*. El mapa de probabilidad demuestra que los esfuerzos actuales de conservación han protegido mucho hábitat de primer nivel para *G. americana*, especialmente en las porciones de Dakota del Norte y Dakota del Sur al este del Río Missouri. Nuestros resultados pueden apoyar la recuperación de especies al permitir priorizar la compra y la restauración de paisajes que brindan hábitats seguros para dormidero y forrajeo. Nuestros resultados también pueden guiar la instalación de estructuras tales como torres eólicas y líneas de transmisión y distribución eléctrica que pueden poner en riesgo a los individuos migratorios de *G. americana*.

Palabras clave: conservación de especies, migración, modelo espacial, sesgo de observación

INTRODUCTION

The Whooping Crane (*Grus americana*) is a federally endangered species in the United States and Canada whose only self-sustaining wild population breeds in and near Wood Buffalo National Park in Alberta and Northwest Territories, Canada, and winters 4,000 km to the south along the Texas Gulf Coast, USA, in the vicinity of Aransas National Wildlife Refuge (Kuyt 1992). The Aransas–Wood Buffalo population has increased in number from a low of <20 adults in 1941 (CWS & USFWS 2007) to an estimated 431 birds on the wintering grounds in the winter of 2016–2017 (Butler and Harrell 2017).

The 4,000-km-long corridor along which Whooping Cranes migrate is critical to the species' annual life cycle and long-term viability. Migrants roost in palustrine, lacustrine, and riverine wetlands and use a variety of croplands, grasslands, and wetlands for foraging (Johns et al. 1997, Austin and Richert 2005, Urbanek and Lewis 2015), which occupies ~40% of their daily time budget (Howe 1989). Little is known about the nutritional and energetic needs of migrating Whooping Cranes (CWS & USFWS 2007). However, active foraging by Whooping Cranes during migration (Howe 1989), weight gain and fat deposition by the congeneric Sandhill Crane (*Antigone canadensis*) along a similar migration corridor (Krapu et al. 1985, Pearse et al. 2010), and the importance of nutritional condition to avian reproductive success (Sandberg and Moore 1996) all reinforce the importance of habitat along the migration corridor to meet the energetic requirements of migration and eventual reproduction (Calvert et al. 2009, Butler et al. 2014a). Causes of mortality during migration include predation, shooting, and collisions with fences and power lines (Howe 1989, Kuyt 1992, CWS & USFWS 2007, Stehn and Haralson-Strobel 2014). For these reasons, identifying and protecting migration and stopover habitat is a priority action for Whooping Crane conservation (Lingle 1987, Beyersbergen et al. 2004, CWS & USFWS 2007, Butler et al. 2014a).

Potential habitat in the Whooping Crane migration corridor is being lost and degraded at increasing rates in the Northern Plains. Conversion of grassland, particularly native prairie, to cropland in the region is extensive and ongoing (Stephens et al. 2008, Rashford et al. 2011, Lark et al. 2015), which reduces upland foraging opportunities in a landscape where grass is increasingly scarce. Waste grain in crop fields provides food for Whooping Cranes (Howe 1989), and the area of cropland and associated foraging opportunities in the region are increasing. However, the increase in cropland is causing a reduction in the ecological functioning of wetlands in crop fields relative to those in grasslands (Euliss and Mushet 1999). In addition, wetlands in crop fields continue to be drained, especially during times of high commodity prices (Dahl 2011, Johnston 2013, Lark et al. 2015). Large numbers of wind turbines are planned or have been erected in the Northern Plains to take advantage of high wind potential in the area (U.S. Department of Energy 2008, Kiesecker et al. 2011). Oil and gas development can lead to degradation of wetlands in which Whooping Cranes roost and feed (Lingle 1987, Gleason et al. 2011, Preston et al. 2014) and may cause direct disturbance from activity and traffic associated with drilling. Oil and gas drilling in northwestern North Dakota, USA, has increased dramatically in recent years as hydraulic fracturing has made petroleum extraction from the Bakken Formation economically viable; an estimated 40,000 to 70,000 additional wells are expected to be drilled in the next 20 yr (North Dakota Department of Mineral Resources 2014). Wind energy development and oil and gas extraction often require the erection of electricity transmission and distribution lines, which increases the potential for Whooping Crane collisions with power lines, a known source of mortality in the Aransas–Wood Buffalo population (Stehn and Haralson-Strobel 2014, Smith and Dwyer 2016).

These threats reinforce the importance of habitat conservation along the Whooping Crane migration corridor. However, identifying and protecting Whooping Crane migration habitat is not a simple matter. Some stopover and staging sites, which have been identified as critical habitat, are regularly used by Whooping Cranes (Urbanek and Lewis 2015), but habitat throughout much of the migration corridor is widespread, dispersed, and irregularly used (Lingle 1987, Howe 1989, Pearse et al. 2015). Consequently, there are few regularly used and easily identified sites for Whooping Crane conservation across much of the migration corridor.

Whooping Crane use of habitat along the migration corridor is poorly understood, as early studies of telemetered birds (e.g., Howe 1989) predated the widespread availability of digital land cover data and geographic information systems (GIS), and therefore lacked quantitative data on habitat use relative to availability. Recent attempts to identify Whooping Crane habitat within the migration corridor have used opportunistic data (Tacha et al. 2010) to identify sites that have been previously used, either by recording the occurrence of sightings in counties (e.g., USFWS 2014b), identifying spatial corridors defined by the distribution of crane sightings (e.g., Tacha et al. 2010), or buffering repeated stopover sites (e.g., Fargione et al. 2012). Using opportunistic sightings imposes limitations, though, as it is estimated that as few as 4% of Whooping Crane stopovers are confirmed annually (T. Stehn cited in Tacha et al. 2010). In addition, such analyses have limited capacity to guide management because they suffer from extremely coarse spatial resolution and do not identify relationships between Whooping Cranes and their habitat (Niemuth et al. 2009). Finally, opportunistic data

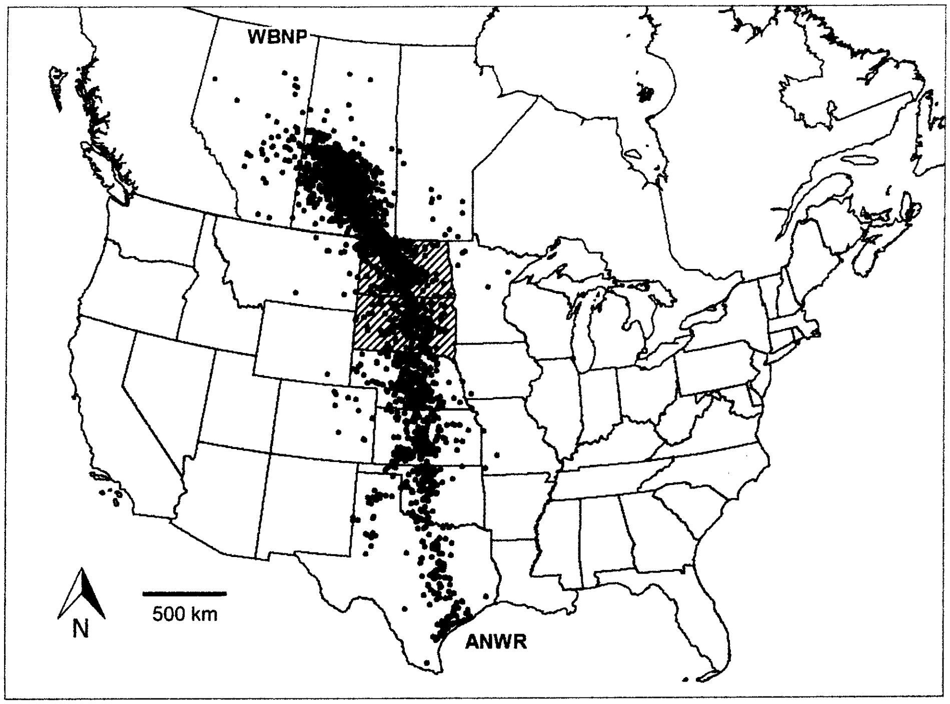

FIGURE 1. Whooping Crane sightings (black dots) in the Cooperative Whooping Crane Tracking Project database (Tacha et al. 2010) showing the migration corridor between Wood Buffalo National Park (WBNP) in west-central Canada and the Texas coast around Aransas National Wildlife Refuge (ANWR) in the southern United States. Diagonal hatching shows our North Dakota and South Dakota, USA, study region.

likely contain bias based on the presence of observers and other factors influencing detection (Anderson 2001, Niemuth et al. 2009, Hefley et al. 2013). However, some of the shortcomings of opportunistic data can be resolved by using model-based approaches that explicitly address biases in the data (Barry and Elith 2006, Mateo et al. 2010, Warton et al. 2013, Hefley and Hooten 2016).

We used Whooping Crane sightings, landscape data, and statistical models to provide insights into Whooping Crane habitat use along the migration corridor in North Dakota and South Dakota, USA. Our primary goal was to develop and evaluate habitat models characterizing the selection of stopover sites by Whooping Cranes in North Dakota and South Dakota. We used a model-based approach to account for biases that likely were present in the opportunistic dataset, particularly factors related to the detection of Whooping Cranes through space and time that could influence estimates of habitat relationships. These models were developed at a scale of hundreds of hectares, which is consistent with the scale of extensive and ongoing conservation programs in the region. We then implemented the best-supported model in a GIS framework to create predictive maps that can be used to guide conservation actions such as the acquisition of perpetual easements and restoration of wetlands, as well as to provide guidance for the siting of wind turbines and electrical transmission and distribution lines.

METHODS

Study Area

We modeled Whooping Crane sightings reported across the entire states of North Dakota and South Dakota, approximately midway between Wood Buffalo National Park and Aransas National Wildlife Refuge (Figure 1). Our study region is part of the Great Plains, which, prior to settlement by Europeans, was dominated by native grasslands (Samson et al. 2004, Licht 1997). Conversion of grassland, particularly native prairie, to cropland is stimulated by agricultural subsidies, new crop varieties, and altered climate that enable the planting of lands that were previously considered unsuitable for crop production (Stephens et al. 2008, Rashford et al. 2011, Lark et al. 2015). The portions of North Dakota and South Dakota that are east and north of the Missouri River are part of the Prairie Pothole Region, which is noted for high densities of wetlands that are also greatly diminished from historical levels due to agricultural intensification (Dahl 2011, Johnston 2013, Lark et al. 2015). The climate in the study region is continental, with high interannual variation in precipitation (Woodhouse and Overpeck 1998).

Whooping Crane Data

We used sightings from the Cooperative Whooping Crane Tracking Project that were entered into a GIS to facilitate spatial analysis of migration data (Tacha et al. 2010). The Cooperative Whooping Crane Tracking Project is coordinated by the U.S. Fish and Wildlife Service and relies on principal contacts within state and federal agencies to evaluate and submit reported sightings of migrant Whooping Cranes in each state in the Central Flyway (Tacha et al. 2010). The resulting database contains sightings from as early as 1942 and is updated annually; we used 478 confirmed sightings of Whooping Cranes using wetlands and uplands in North Dakota and South Dakota collected from spring of 1990 through spring of 2014. We chose this time period because its 2002 midpoint approximately coincided with 2001 land cover data derived from satellite imagery that we used to characterize upland habitat composition. Locations were variously reported using global positioning system (GPS) coordinates, cadastral descriptions, latitude and longitude, and distances from landmarks such as towns. The accuracy of locations varied, and in many cases points were assigned to the center of a legal section of 1.6 km × 1.6 km. Consequently, the data were only appropriate for coarse-grained analysis and were not suitable for measures such as distance to the nearest road (Tacha et al. 2010). Sightings in the Whooping Crane database show biases toward urban centers and national wildlife refuges (Howe 1989, Tacha et al. 2010). However, collection of Whooping Crane location data without detection biases has been limited, highlighting the need to address biases in analyses. Extensive field surveys are infeasible due to the rarity of Whooping Cranes over a large migration area, and telemetry-based research has been scant and difficult to conduct due to technological limitations (Howe 1989, Kuyt 1992) and perceived risks of capturing and marking birds.

Following the guidelines of Nielson et al. (2004), Pearce and Boyce (2006), and Northrup et al. (2013), we generated 10,000 random points throughout the entire study region to describe available habitat. We used points with known Whooping Crane use in conjunction with available (pseudoabsence) points to develop a resource selection function, which estimated relative probability of occurrence following a used–available design (Manly et al. 2002, Johnson et al. 2006). Although resource selection functions developed with a used–available design are generally robust to contamination where available points were in fact used (Johnson et al. 2006), we only used random points >1,600 m from reported crane sightings to reduce contamination. All random points were assigned a year value from a uniform distribution of years 1990–2014.

Predictor Variables

Predictor variables in our modeling effort fit into 3 general categories related to geographic location, landscape-level habitat characteristics, and detection (Table 1). The fundamental determinant of Whooping Crane presence in North Dakota and South Dakota is a migration path between Aransas National Wildlife Refuge and Wood Buffalo National Park (Howe 1989, Kuyt 1992). Therefore, we included distance to the centerline of the migration corridor to describe spatial positon within the migration corridor, similar to the directional bearing variable used by Belaire et al. (2014) and analogous to the first-order selection of Johnson (1980). We calculated the migration centerline following the methodology of Tacha et al. (2010), using 478 ground sightings for our selected time period in the Dakotas, as well as 339 sightings from Nebraska, USA, and 1,660 sightings from Alberta, Saskatchewan, and Manitoba, Canada, to more precisely estimate the southern and northern ends of the migration corridor in the Dakotas. In addition to increasing the predictive power of the model, incorporating covariates that account for spatial patterns of distribution helps to reduce biases in parameter estimates and nonindependence of errors caused by positive spatial autocorrelation (Lennon 2000, Beale et al. 2010).

We assessed the composition and configuration of landscapes around data points (used and available) within circular moving windows with radii of 800, 1,200, and 1,600 m, which coincided with distances commonly used for land protection and management in the region. The 1,200- and 1,600-m radii included the majority of observed distances between roosting and feeding sites (Howe 1989, Austin and Richert 2005), which accommodated the "landscape" that birds were using, rather than the point at which they roosted or fed, analogous to the second-order selection of Johnson (1980). In addition, using large sampling windows helped to reduce any effects of location error resulting from inexact geographic locations of many of the Whooping Crane sightings (Tacha et al. 2010, Hefley et al. 2014).

Landscape attributes were selected for their potential importance to Whooping Crane ecology (Howe 1989, Johns et al. 1997, Austin and Richert 2005; Table 1). Because wetlands are thought to be the primary prerequisite for stopover sites (Howe 1989), we used the National Wetlands Inventory (NWI) digital database processed to basins to identify area, variety, and number of wetlands across our study area. The NWI is based on the Cowardin et al. (1979) wetland classification system and provides water regimes (e.g., temporary, seasonal, semipermanent, permanent) identified for wetlands at the time of mapping. Even though most of the NWI data in our region were collected in the 1980s, we chose to use the NWI because its completeness, fine spatial resolution, and determination

TABLE 1. Predictor variables considered in the development of models relating sightings of Whooping Cranes in North Dakota and South Dakota, USA, to geographic location, landscape-level habitat characteristics, and factors influencing detection. Characteristics within buffers were calculated using circular moving windows with radii of 800, 1,200, and 1,600 m.

Predictor variable	Definition	Justification
Distance to centerline	Distance (km) from centerline of Whooping Crane migration corridor calculated from data	Whooping Cranes generally follow a narrow migration corridor (Howe 1989, Tacha et al. 2010)
Wetland area	Proportion of area within the buffer comprised of all temporary, seasonal, semipermanent, permanent, and lacustrine wetlands as identified by the National Wetlands Inventory (Wilen and Bates 1995)	Whooping Cranes use wetlands for roosting and foraging (Howe 1989, Johns et al. 1997, Austin and Richert 2005)
Wetland variety	Number of different wetland water regimes (temporary, seasonal, semipermanent, permanent or lake, riverine) as identified by the National Wetlands Inventory (Wilen and Bates 1995) processed to basins (Cowardin et al. 1995) within buffer	Seasonal shifts in wetland use and presence of multiple wetlands in the vicinity of Whooping Crane stopover sites (Howe 1989, Johns et al. 1997, Austin and Richert 2005) suggest that wetland complexes might be important to Whooping Cranes
Wetland number	Number of wetland basins as identified by the National Wetlands Inventory (Wilen and Bates 1995) processed to basins (Cowardin et al. 1995) within buffer	Wetlands used for roosting are generally large (Johns et al. 1997), but most prairie potholes and stock ponds are small (Kantrud et al. 1989); this variable evaluated whether multiple small wetlands of a given area were as attractive to Whooping Cranes as fewer large wetlands of the same area
Perennial cover	Proportion of buffer comprised of grassland, hay fields, and shrubs as identified by the 2001 National Land Cover Database (NLCD; Homer et al. 2007) cover classes 71, 81, and 52	Perennial cover is common at or adjacent to roosting and feeding sites (Howe 1989, Johns et al. 1997, Austin and Richert 2005)
Cropland	Proportion of buffer comprised of cultivated crops as identified by the 2001 NLCD (Homer et al. 2007) cover class 82	Whooping Cranes use agricultural fields for foraging (Howe 1989, Johns et al. 1997, Austin and Richert 2005)
Forest	Proportion of buffer comprised of forest cover as identified by the 2001 NLCD (Homer et al. 2007) cover classes 41, 42, and 43	Whooping Cranes use sites with few trees (Johns et al 1997, Austin and Richert 2005)
Distance to increased survey effort	Distance (km) from 24 areas of known intensive Whooping Crane observation effort, including district offices of wildlife management agencies and wildlife refuges and fish hatcheries with permanent staff	Disproportionate numbers of Whooping Crane sightings are in proximity to refuges or other sites with knowledgeable observers (Howe 1989, Tacha et al. 2010)
Human population density	Number of people per 2.6 km^2, derived from U.S. Census Bureau data (Seirup and Yetman 2006)	Human observers are necessary to detect and report Whooping Cranes; sightings are biased toward urban centers (Howe 1989)
Roads	Length (km) of roads (maintained gravel or better) identified by topologically integrated geographic encoding and referencing (TIGER) data (U.S. Census Bureau 2011) within each buffer	Whooping Cranes avoid roads (Johns et al. 1997, Belaire et al. 2014), but roads may enable increased detection of Whooping Cranes
Terrain roughness	Standard deviation of cells within buffer of digital elevation model with 30-m spatial resolution	Whooping Cranes use wetlands with shallow shoreline slopes (Johns et al. 1997, Austin and Richert 2005); detection of Whooping Cranes may be influenced by topographic variation
Whooping Crane population size	Number of birds estimated to be in the Aransas–Wood Buffalo flock each year	Number of Whooping Cranes detected annually increased as population size increased during the analysis period

of water regimes provided better insight into wetland community composition than datasets with coarser spatial and thematic resolution. We integrated digital polygons, some of which represented complex wetlands with more than one wetland zone identified by the NWI, into individual depressional wetland basins classified by the most permanent water regime associated with each basin (Cowardin et al. 1995). We did not discriminate among water regimes in our models for 2 reasons. First, water conditions in our study area varied greatly among years and basins could function under different water regimes depending on the year of observation (Niemuth et al. 2010). Second, our analysis included sightings from spring, when Whooping Cranes heavily use shallow, temporary, and seasonal wetlands, as well as from fall, when temporary and seasonal wetlands are generally dry and Whooping Cranes shift to semipermanent and permanent wetlands (Howe 1989, Johns et al. 1997). Finally, Whooping Cranes may use shallow perimeters of semipermanent and permanent wetland basins.

The seasonal shift in wetland use along with the presence of multiple wetlands in the vicinity of Whooping Crane stopover sites (Howe 1989, Johns et al. 1997, Austin and Richert 2005) suggest that wetland complexes may be important to Whooping Cranes. Therefore, we included a variable describing wetland variety and derived it by summing the number of different wetland water regimes in the windows surrounding use and pseudoabsence points. In addition, we included a variable that reported the number of wetland basins within windows surrounding use and pseudoabsence points to evaluate the response of Whooping Cranes to many small wetlands as opposed to few large wetlands (Howe 1989, Johns et al. 1997).

Crop fields and upland perennial cover such as pasture, wet meadows, and hay meadows are common components of Whooping Crane stopover habitat, and Whooping Cranes appear to avoid trees (Howe 1989, Johns et al. 1997, Austin and Richert 2005). We used the 2001 National Land Cover Database (NLCD; Homer et al. 2007), which was roughly centered in our analysis period, to estimate the amount of perennial cover, cropland, and forest in windows surrounding use and pseudoabsence points. Formal accuracy assessment of the 2001 NLCD is lacking, but average classification accuracy of the NLCD was 84% in 10-fold cross validation used during NLCD development (Homer et al. 2007). Estimated change in land cover composition from 1991 to 2001 varied throughout our study area, but ranged from <1% to 9% (Fry et al. 2009); changes in land cover composition from 2001 to 2014 have not been quantified. Because the amounts of cropland and perennial cover were strongly negatively correlated with each other in our study area, we did not include both variables in the same model, even though previous research has indicated that Whooping Cranes use both cover types (Table 1). Therefore, we evaluated models with each of the 2 cover variables individually and chose the combination that best explained Whooping Crane presence. In each case, we included a quadratic term to determine whether Whooping Cranes selected areas with moderate levels of one variable, which would suggest a preference for >1 cover class and is generally consistent with the "ecotone" variable of Belaire et al. (2014).

Data describing locations of Whooping Cranes were opportunistic with known biases; thus, we considered variables that might have influenced detection, assuming that variables related to detection were independent of habitat variables that influenced Whooping Crane use (Warton et al. 2013). First, we included distance to 24 sites likely to have increased observation effort, including district offices of wildlife management agencies and wildlife refuges and fish hatcheries with permanent staff. Second, we included human population density to account for increased detections reported by the general public. Finally, we included road density and digital elevation data to determine whether the probability of observing Whooping Cranes was positively related to ease of vehicular access, which could facilitate sightings, or negatively related to topographic variation, which could reduce the ability to see birds.

Sample size (i.e. the number of Whooping Crane observations) varied among years, likely influenced by weather and human activity during migration and possibly by interannual variation in water conditions (Howe 1989, Kuyt 1992). Therefore, we included the year of observation as a random intercept in a mixed effects model, as random effects can correct for unbalanced designs (Gillies et al. 2006). All other variables were treated as fixed effects.

Model Development and Validation

We used logistic regression (Hosmer and Lemeshow 2000, Agresti 2007) to estimate a resource selection function based on characteristics of predictor variables at locations used by and available to Whooping Cranes (Manly et al. 2002, Johnson et al. 2006). We treated each sighting of Whooping Cranes as one occurrence, regardless of stopover length or the number of individuals present, as the latter are likely influenced by weather and behavior rather than habitat (Howe 1989, Kuyt 1992). Prior to developing models, we used scatter plots and Pearson's correlations to assess collinearity among predictor variables to ensure that highly correlated ($|r| > 0.7$) predictors were not considered simultaneously. In an attempt to develop a parsimonious model and avoid spurious correlations with Whooping Crane observations, we initially evaluated main effects of linear relationships except for the previously mentioned quadratic relationship with the amount of cropland or perennial cover in the landscape. After assessing main effects, we evaluated several interaction terms, specifically wetland area*wetland number, distance to centerline of the migration corridor* distance to area of increased survey effort, and wetland area*cropland area*distance to centerline of the migration corridor. We used model selection to balance bias and variance, discriminating among reduced versions of the full model using Akaike's information criterion (AIC), beginning with the full model and holding out one parameter or set of parameters at a time and assessing improvements in AIC values (Burnham and Anderson

2002, Crawley 2007, Beale et al. 2010). We also calculated Akaike weights (w_i) for each model within 4 AIC units of the model with the lowest AIC value, which is a useful rule of thumb for identifying the set of models plausibly supported by the data (Burnham and Anderson 2002). Akaike weights provide an indication of the relative likelihood of competing models best fitting the data, which enabled us to evaluate the relative strength of evidence for models relating Whooping Crane sightings to predictor variables. We conducted statistical analyses in the R environment (R Core Team 2013), specifically the generalized linear mixed models capacity of the lme4 package (Bates et al. 2014, 2015), using a binomial error distribution with a logit link.

We created a map showing the predicted probability of occurrence across the 2 states by incorporating corresponding GIS data layers into the logistic response equation for the final model, using a constant for fixed effects that were associated with detection across space (i.e. road density and distance to areas of increased survey effort) or time (i.e. Whooping Crane population size). By using a constant, predictions across the study area were set to the same value for each variable that may cause bias, thereby correcting for effects of bias across the study area (Warton et al. 2013). The random year effect accounted for interannual variation in detection; the probability map therefore reflected predicted habitat use across all years of the analysis period. Because we followed a used–available design and the proportion of Whooping Crane stopovers that was confirmed is unknown, mapped values represent relative probabilities of use (Manly et al. 2002, Johnson et al. 2006). To aid interpretation of the mapped output for conservation planning, we used an equal-area slice to divide the probability map for the 2 states into 10 equal-area bins, or deciles, with decile values of 1 indicating the highest probability of occurrence by Whooping Cranes and decile values of 10 indicating the lowest probability of occurrence. Deciles provide a simple structure with clear thresholds that field personnel can use to identify and rank land parcels for conservation, particularly acquisition of perpetual easements. In addition, dividing the region into deciles provided the foundation for validation of the final model using independent data, which we performed by calculating the rank correlation between frequencies of occurrence from the validation data in each of the 10 equal-area slices of the final model (Boyce et al. 2002).

We validated the final model using unbiased location data collected from 46 Whooping Cranes outfitted with platform transmitting terminals (PTTs) that collected GPS coordinates during 2010–2013 (see Pearse et al. (2015) for capture, marking, and data handling procedures). Validation data included one randomly selected daytime location from multiple locations collected at each stopover site to simulate situations in which cranes may be observed.

Assessing Effectiveness of Conservation Programs

We assessed the predicted value of existing land conservation efforts for migrating Whooping Cranes by quantifying the area of protected lands by habitat decile. We used GIS data layers to summarize 4 categories of protected lands: (1) federal fee-title lands, which included national forests, national grasslands, national parks, national wildlife refuges, and waterfowl production areas; (2) state fee-title lands, which included wildlife management areas and school trust lands; (3) wetland easements held by the U.S. Fish and Wildlife Service, wherein land remains in private ownership but specified wetlands are protected from draining, filling, leveling, or burning; and (4) grassland easements held by the U.S. Fish and Wildlife Service, wherein land remains in private ownership and grassland may not be cultivated at any time or mowed prior to July 15 each year. We did not include tribal lands because of the large, varying, and unknown amounts of private inholdings on reservations. The area of wetlands protected under easements may differ from that observed in databases such as the NWI or NLCD due to annual variation or differences in data acquisition. Not all fee-title public lands that we considered are dedicated to conservation, but we included them as they are subject to public policy that generally requires that conservation or wildlife management at least be considered in management decisions. Because the portions of the 2 states east of the Missouri River have a long history of wetland and waterfowl conservation that is largely absent west of the Missouri River, we divided our assessments by areas east and west of the river as well as by land protection categories to evaluate patterns of land protection relative to potential use by Whooping Cranes. We used Spearman's rank correlation to evaluate relationships between area of protected land, by land protection category and location (east vs. west of the Missouri River), and habitat decile.

RESULTS

Models of Landscape-level Habitat Selection

The number of confirmed Whooping Crane sightings varied among years ($\bar{x} = 19.1$, range = 8–37) and tracked the size of the Aransas–Wood Buffalo flock, which increased during our analysis timeframe; however, reported sightings showed substantial interannual variation (Figure 2). Areas of cropland and perennial cover within moving windows were negatively correlated ($r = -0.87$ at all 3 scales), so we evaluated models separately, one with cropland and the other with perennial cover. The model with cropland and other covariates had an AIC value 7.4 points lower than the same model with perennial cover replacing cropland, so we no longer considered perennial cover during model selection. No other pairs of continuous variables were strongly ($|r| > 0.6$) correlated.

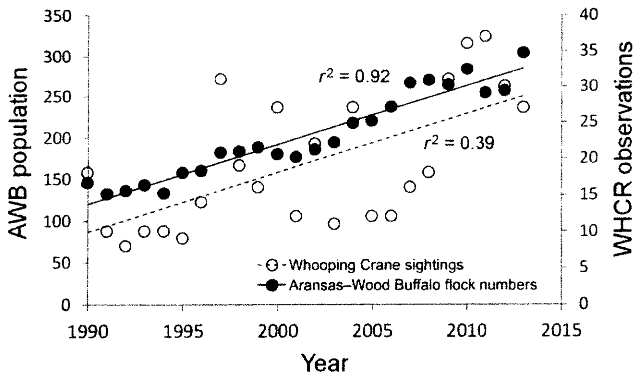

FIGURE 2. The number of Whooping Crane (WHCR) sightings available for analysis each year (open circles, dashed trend line) tracked the increasing population size of the Aransas–Wood Buffalo (AWB) flock (solid circles, solid trend line) in 1990–2013, but showed greater interannual variation. Aransas–Wood Buffalo flock numbers are from Butler et al. (2014b), USFWS (2014a), and W. Harrell (personal communication).

Models were best supported using data from the moving window with a 1,200-m radius; AIC values increased ≥5.0 points when full models were developed using data from the 800- and 1,600-m windows relative to the full model developed using data from the 1,200-m window. The best-supported model indicated that Whooping Crane occurrence was positively associated with wetland area, wetland variety, cropland area, road density, and Whooping Crane population size; negatively associated with distance to centerline of the migration corridor, wetland number, distance to area of increased survey effort, and terrain roughness; and also positively influenced by the interactions of wetland area*wetland number, distance to centerline of the migration corridor*distance to area of increased survey effort, and wetland area*cropland area*distance to centerline of the migration corridor (Tables 2 and 3). The best-supported model had an Akaike weight of 0.45; the 3 models within 4 units of the best-supported model had Akaike weights of 0.27 to 0.11 and differed from the best-supported model due to the inclusion or exclusion of one variable and/or one interaction term (Table 3). A model including forest cover was not treated as competitive even though its AIC value was just 2 points higher than that of the best-supported model, as the forest cover parameter was uninformative and did not improve the model (Arnold 2010).

We considered 2 variables in the final model (road density and distance to increased survey effort) to be related to detection of Whooping Cranes. Removing these 2 variables from the best model resulted in a ΔAIC = 97.1, indicating that detection was an important component of the best-approximating model. Removing the terrain roughness variable, which could be associated with selection of flat, open landscapes by Whooping Cranes or reduced detection of Whooping Cranes in hilly terrain, caused a further increase of 10.1 AIC points.

TABLE 2. Parameter estimates ± standard error (SE) for variables included in the best-supported model relating sightings of migrant Whooping Cranes in North Dakota and South Dakota, USA, to geographic location, landscape characteristics within 1,200 m of analysis points, and factors influencing detection, 1990–2014. 95% confidence intervals for all parameter estimates exclude 0, except for the wetland area*cropland area*distance to centerline interaction term.

Variable	Parameter estimate ± SE
Intercept	−2.93 ± 0.52
Distance to centerline	$-3.1 \times 10^{-2} \pm 2.4 \times 10^{-3}$
Wetland area	1.72 ± 0.45
Wetland variety	0.44 ± 0.08
Wetland number	−0.019 ± 0.003
Wetland area*Wetland number	0.09 ± 0.02
Cropland area	1.69 ± 0.24
Distance to increased survey effort	$-2.3 \times 10^{-2} \pm 2.9 \times 10^{-3}$
Road density	0.12 ± 0.05
Terrain roughness	−0.07 ± 0.02
Whooping Crane population size	0.006 ± 0.001
Distance to increased survey effort*Distance to centerline	$1.1 \times 10^{-4} \pm 3.6 \times 10^{-5}$
Wetland area*Cropland area*Distance to centerline	0.032 ± 0.017

The relative probability map created by applying the final model to data layers suggested habitat selection within a north–south corridor bisecting the 2 states (Figure 3). The top 3 deciles of the relative probability map contained 89% of the Whooping Crane sightings used to develop the model and 79% of the independent validation observations (Table 4). The number of independent validation locations derived from telemetered Whooping Cranes in each decile was strongly correlated with decile rank (Spearman's rho = 1.0), with a strong differential between high and low deciles, indicating that the model performed well (Boyce et al. 2002).

Distribution of Protected Lands

Protected lands in the study region totaled 3.8 million ha, or ~10% of the 38.5-million-ha study area (Figure 4). The area of protected land was ~1.9 million ha on each side of the Missouri River; however, the distribution of protected lands among deciles differed greatly between those portions of the study area east and west of the Missouri River (Figure 4). Protected lands east of the Missouri River were more evenly distributed among ownership classes than lands west of the Missouri River, which were dominated by national forests and national grasslands (Figure 4) and where U.S. Fish and Wildlife Service

TABLE 3. Constituent variables (with sign indicating direction of relationship), Akaike's information criterion (AIC) values, AIC differences (Δ_i), and Akaike weights (w_i) for candidate models with $\Delta_i < 4$ relating sightings of migrant Whooping Cranes in North Dakota and South Dakota, USA, to geographic location, landscape-level habitat characteristics, and factors influencing detection, 1990–2014.

	Model 1	Model 2	Model 3	Model 4
Variable				
Distance to centerline	−	−	−	−
Wetland area	+	+	+	+
Wetland variety	+	+	+	+
Wetland number	−	−	−	−
Cropland area	+	+	+	+
Cropland area^2			−	−
Distance to increased survey effort	−	−	−	−
Road density	+	+	+	+
Terrain roughness	−	−	−	−
Whooping Crane population size	+	+	+	+
Distance to centerline*Distance to increased survey effort	+	+		+
Wetland area*Wetland number	+	+	+	+
Wetland area*Cropland area*Distance to centerline	+		+	
Log-likelihood	−1300.7	−1302.2	−1300.7	−1302.2
AIC value	2629.4	2630.4	2631.3	2632.3
Δ_i	0.0	1.0	1.9	2.9
w_i	0.45	0.27	0.17	0.11

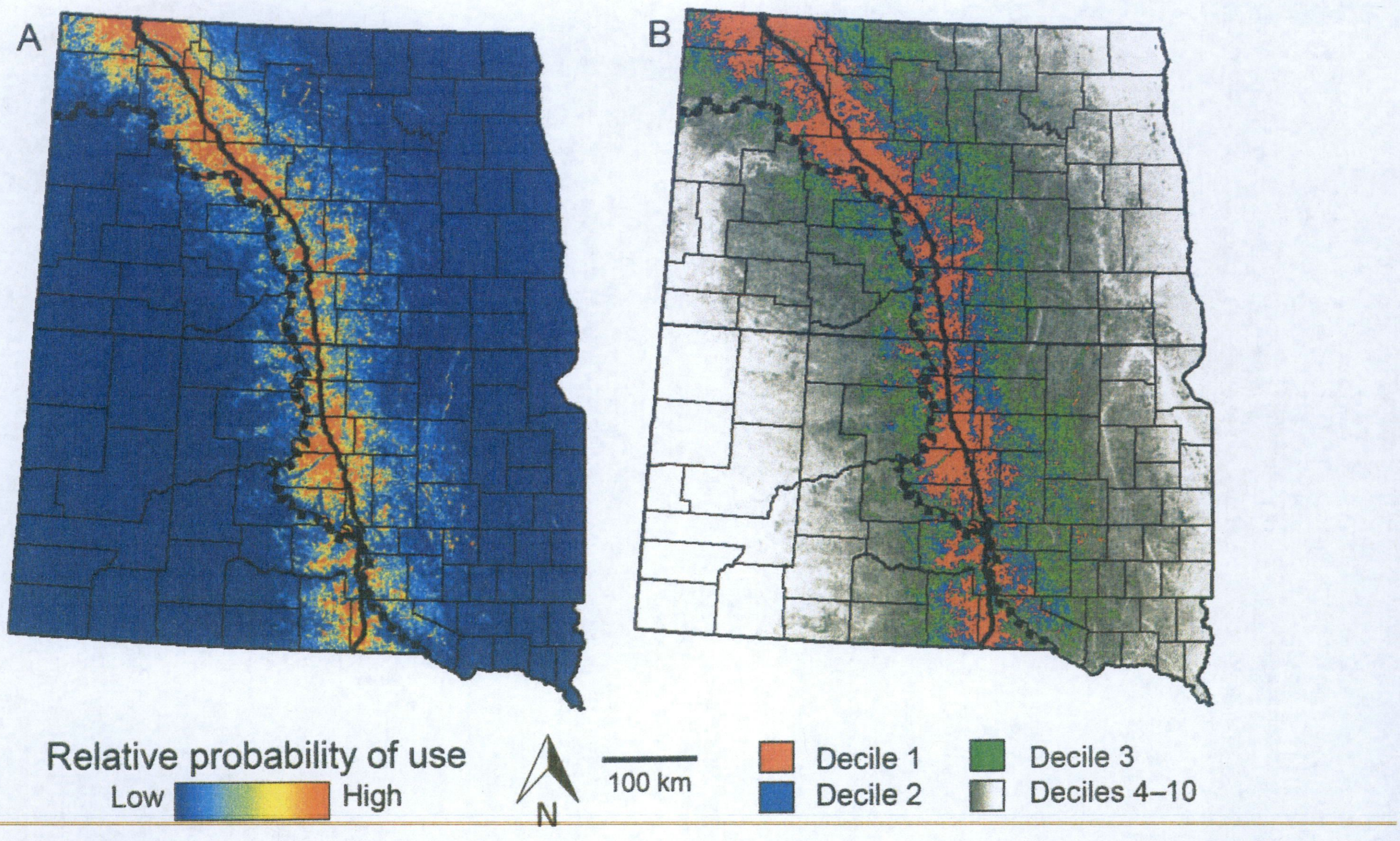

FIGURE 3. (**A**) Predicted relative probability of landscape-level habitat use by migrant Whooping Cranes in North Dakota and South Dakota, USA; and (**B**) ranked probability of landscape-level habitat use by migrant Whooping Cranes in North Dakota and South Dakota classified by equal-area deciles. The top 3 deciles (colored) contained 336 (79%) of 427 validation points. The heavy black line represents the centerline of the migration corridor for sightings used in developing the model, and the thick dotted line represents the Missouri River.

TABLE 4. Number of Whooping Crane sightings and percentage of sightings in each decile included in the probability map indicating ranked probability of use for Whooping Crane model building (MB) and validation (VAL) datasets.

	Sightings (*n*)		Percentage of sightings	
Decile	MB	VAL	MB	VAL
1	306	167	64.0	39.1
2	84	98	17.6	23.0
3	34	71	7.1	16.6
4	22	53	4.6	12.4
5	21	18	4.4	4.2
6	1	12	0.2	2.8
7	7	4	1.5	0.9
8	2	2	0.4	0.5
9	0	2	0.0	0.5
10	1	0	0.2	0.0

easements totaled <47 ha. The 2 largest ownership classes east of the Missouri River were grassland and wetland easements, each of which totaled >500,000 ha. East of the Missouri River, the area of federal fee-title lands was positively correlated with Whooping Crane habitat decile ($r = 0.95$), as was the area of state fee-title lands ($r = 1.00$), area of wetland easements ($r = 0.99$), and area of grassland easements ($r = 0.84$). West of the Missouri River, the area of state and federal fee-title lands was negatively correlated with Whooping Crane habitat decile ($r = -0.99$ and -1.00, respectively; Figure 4).

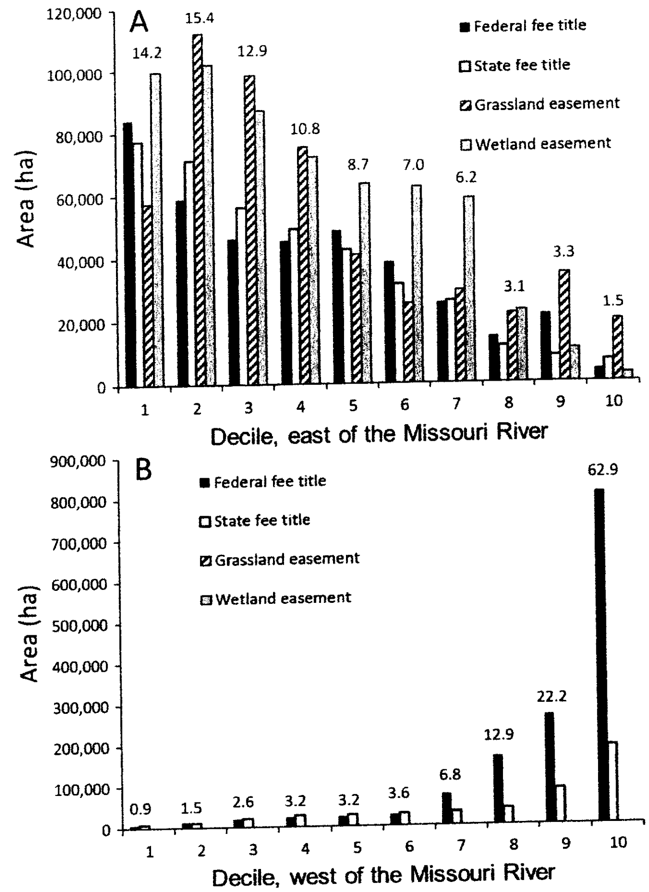

FIGURE 4. The area of land under multiple land protection categories within each Whooping Crane habitat decile differed between (**A**) the portion of the study region east of the Missouri River, USA, where ongoing waterfowl and wetland conservation efforts have protected land in upper Whooping Crane habitat deciles, and (**B**) the portion of the study region west of the Missouri River, where U.S. Fish and Wildlife Service easements totaled <47 ha. Numbers above each decile cluster of bars represent the percentage of that decile that is protected. Note the different *y*-axis scale between graphs.

DISCUSSION

Our results indicate that Whooping Cranes migrating through North Dakota and South Dakota select landscapes characterized by diverse wetland communities and upland foraging opportunities within a corridor linking breeding and wintering grounds. These findings are consistent with many observational studies (Howe 1989, Johns et al. 1997, Austin and Richert 2005, Tacha et al. 2010) as well as quantitative analyses for other portions of the migration corridor (Belaire et al. 2014, Hefley et al. 2015). The habitat model and associated predictive map that we developed are not definitive, but provide a positive step toward identifying important areas for conservation as part of an effective management strategy for Whooping Cranes (Howe 1989, Beyersbergen et al. 2004, CWS & USFWS 2007, Butler et al. 2014a).

The retention of 9 of the 11 candidate variables in the best-supported model suggests that our data were sufficient to develop a relatively well-parameterized model and that the candidate variables that we identified were appropriate to the question and scales that we addressed. Even though the best-supported model did not include the quadratic term for area of cropland, it was included in 2 of the 3 competitive models, indicating support for its effect. Inclusion of the quadratic term supports the idea that a positive linear relationship with cropland cannot be applied across the landscape, as perennial cover and multiple upland habitat types are important to migrating Whooping Cranes (Howe 1989, Johns et al. 1997, Austin and Richert 2005, Belaire et al. 2014) and continuing loss of wetlands associated with agricultural conversion (Dahl 2011, Johnston 2013, Lark et al. 2015) will reduce opportunities for roosting and foraging. Absence of the quadratic term for cropland from the best-supported model may have resulted from more detections in cropland than perennial cover, given the intensity and number of visits required by farmers for crop production relative to other uses and a general absence of standing vegetation in crop fields during spring and fall migration, thereby increasing Whooping Crane visibility and detection. In addition, cropland was positively correlated (r = 0.31) with roads and negatively correlated (r = –0.49) with terrain roughness, both of which also could have contributed to detection. Likewise, apparent selection of cropland might reflect a diurnal detection bias, as Whooping Cranes use croplands heavily during the day, when most opportunistic sightings of Whooping Cranes are likely to occur, but telemetered Whooping Cranes were regularly found in wetlands at night (Pearse et al. 2017). Finally, availability of cropland for foraging is unlikely to be limiting, as the amount of cropland in the study area is increasing as wetlands and grasslands that are also used by Whooping Cranes are being lost (Rashford et al. 2011, Johnston 2013, Niemuth et al. 2014, Lark et al. 2015).

The strength of the positive interaction between wetland area and wetland number indicates that wetland area influenced Whooping Crane use differently depending on the number of wetland basins in the area, where one large basin of a given area was more attractive than many small basins totaling the same area. Lower use of areas with many small basins might be caused by selection of wetlands with large, unobstructed views and widths (Pearse et al. 2017) or the higher likelihood of larger wetlands containing water, especially in fall (Howe 1989, Niemuth et al. 2010). This interaction, along with the positive relationship with the variety of wetland water regimes, reinforces the importance of wetland complexes to Whooping Cranes in our study region.

Our out-of-sample validation provided stronger inference and predictive power than the within-sample validation, and indicated that, in this case, opportunistic data can be used to develop biologically sound models when appropriate adjustments are applied. Our results have implications for citizen science and monitoring activities, as opportunistic data must be used with caution and an awareness of potential biases and shortcomings (see also McKelvey et al. 2008, Hefley et al. 2013, Belaire et al. 2014). Model selection results indicated that models that did not include variables related to detectability performed poorly at describing data relative to models that contained these variables. These results show the importance of using covariates to adjust for bias rather than simply ignoring bias in opportunistic data, although interpretation of detection covariates may be difficult. For example, the negative relationship with topographic roughness could be a function of reduced detectability in hilly terrain or might suggest that Whooping Cranes selected flat landscapes with high visibility, or perhaps a combination of the 2 explanations. Similarly, it is possible that Whooping Cranes selected areas of high road density, although increased detection along roads is a more plausible explanation, especially as road density was correlated with human population density (r = 0.53). Detection and environmental variables are often correlated; although this reduces the effectiveness of including variables to account for detection bias, model performance is generally higher when correlated variables are included in models relative to when they are not (Warton et al. 2013). Data from birds outfitted with GPS-enabled PTTs can provide unbiased data with precise locations; these data, along with emerging analytical techniques, will likely enable the development of more readily interpreted models in the future. In addition, precise locations from marked birds enable determination of habitat relationships at much finer scales than what is possible with opportunistic data. Nonetheless, the opportunistic dataset has provided locations for decades, providing opportunities for assessing habitat use over a range of environmental conditions, whereas monitoring using telemetered birds would be limited temporally based on funding, staffing, and other logistical challenges.

The distribution of protected lands in North Dakota and South Dakota relative to predicted Whooping Crane use demonstrated substantial benefits of existing conservation lands. Patterns were strikingly different between the portions of the 2 states east of the Missouri River (i.e. the Prairie Pothole Region), where extensive waterfowl conservation efforts occur, and the portions of the states west of the Missouri River, where public lands were acquired without a specific wildlife conservation goal. However, the 1.9 million hectares of protected lands in the Prairie Pothole Region constituted only ~8% of the area of all lands east of the Missouri River, and wetland loss in the region has accelerated with intensified agricultural production in recent years (Dahl 2011, Johnston 2013, Lark et al. 2015), reinforcing the need for additional conservation. The U.S. Fish and Wildlife Service is presently spending ~$50 million annually on the acquisition of perpetual wetland and grassland easements in the eastern portions of North Dakota and South Dakota, with funding primarily coming from Migratory Bird Hunting Stamp ("Duck Stamp") sales, the Land and Water Conservation Fund, and the North American Wetlands Conservation Act, in combination with nonfederal matching funds from state wildlife management agencies or nongovernmental organizations such as Ducks Unlimited (USFWS 2015). The value of land parcels to endangered species is one of the criteria for assessing candidate land parcels for easement acquisition (USFWS 2010); the model presented here will be valuable for ensuring benefits to Whooping Cranes by protecting grassland and wetland complexes in areas of high predicted Whooping Crane use from conversion to other uses.

Unfortunately, Whooping Cranes are subject to a variety of additional threats, including disturbance from oil and gas development and related degradation of wetlands in which Whooping Cranes roost and feed (Lingle 1987, Gleason et al. 2011, Preston et al. 2014), as well as direct mortality from power lines (Stehn and Haralson-Strobel 2014). Our spatial model can help to guide the siting of new wind, oil, and electrical transmission infrastructure to minimize potential conflicts with Whooping Cranes, and also to identify threats and associated opportunities for mitigation such as transmission line marking and wetland restoration. How these threats affect Whooping Crane habitat selection, energetics, duration of stay, and survival is poorly known, but our spatial model can help to ensure that conservation and mitigation actions intended to benefit Whooping Cranes are located in areas with the greatest likelihood of use by Whooping Cranes.

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Wind and Wildlife in the Northern Great Plains: Identifying Low-Impact Areas for Wind Development

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Abstract

Wind energy offers the potential to reduce carbon emissions while increasing energy independence and bolstering economic development. However, wind energy has a larger land footprint per Gigawatt (GW) than most other forms of energy production and has known and predicted adverse effects on wildlife. The Northern Great Plains (NGP) is home both to some of the world's best wind resources and to remaining temperate grasslands, the most converted and least protected ecological system on the planet. Thus, appropriate siting and mitigation of wind development is particularly important in this region. Steering energy development to disturbed lands with low wildlife value rather than placing new developments within large and intact habitats would reduce impacts to wildlife. Goals for wind energy development in the NGP are roughly 30 GW of nameplate capacity by 2030. Our analyses demonstrate that there are large areas where wind development would likely have few additional impacts on wildlife. We estimate there are ~1,056 GW of potential wind energy available across the NGP on areas likely to have low-impact for biodiversity, over 35 times development goals. New policies and approaches will be required to guide wind energy development to low-impact areas.

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Introduction

The winds on the Northern Great Plains (NGP) are strong and consistent, making this one of the most desirable areas for wind development (Fig. 1). As of January 2012, 5.2 GW of wind energy (all GW numbers refer to nameplate capacity) was in operation in the NGP (including the southern portions of Alberta and Saskatchewan and all of five states: Montana, Nebraska, North Dakota, South Dakota, and Wyoming), and there were 32 GW of proposed wind energy development [1]. The U.S. Department of Energy (DOE) set a goal of producing 20% of U.S. electricity from wind energy by the year 2030 [2]. Nationwide, DOE estimates that this would require 241 GW of on-shore (terrestrial) wind development. In the NGP states, DOE estimates that this would require 25 GW of wind energy. Similar goals in Canada add another 5 GW, for a total of 30 GW of expected development.

Per unit energy, wind energy production requires a much larger area than fossil energy, such that expected wind development is likely to cover large areas of the NGP. The DOE estimates that, with expected continued substantial increases in efficiency, additional capacity will require about 1 km^2 of land to site 5 MW of wind energy, depending on the quality of the wind resource. Thus, wind energy development is expected to grow to require approximately 5,000 km^2 across the five United States that compose the NGP. Analogous goals in Alberta and Saskatchewan would require at least 1,000 km^2 to be developed for wind. It is important to note that the ecological footprint of wind development is likely to be even larger, because many species of wildlife tend to avoid human infrastructure such as wind turbines. For example, sage grouse experience reduced nesting success up to 6.4 km away from oil and gas development [3,4]. Thus, wind development will impact many thousands of square kilometers in the Northern Great Plains.

Wind energy may have several impacts on wildlife. Direct mortality of birds and bats from wind turbines has been the focus of a growing body of research [5,6]. Northern Great Plains species of particular concern for direct mortality include whooping cranes (*Grus americana*), golden eagles (*Aquila chrysaetos*), ferruginous hawks (*Buteo regalis*), burrowing owl (*Athene cunicularia*), and several species of bat. Although there is no recorded instance of a whooping crane being killed by a wind turbine, because fewer than 400 individuals remain, any increased mortality would be a significant population concern [7,8]. Raptors may be particularly vulnerable to wind farm development [9,10,11,12]. Golden eagles are of particular conservation and regulatory concern, due to population declines and their protected status under the Bald and Golden Eagle Protection Act [13,14]. In places where both bird and bat mortality have been monitored, bat mortality rates can be over an order of magnitude higher than birds, with migratory tree dwelling species being particularly at risk [6,15].

The large spatial extent of wind development poses conservation concerns in addition to those posed by direct mortality, namely habitat loss and fragmentation. Although direct habitat losses from turbine footings and roads typically comprise less than five percent of a wind energy project area, the habitat values of adjacent lands may be significantly diminished. Habitat loss and fragmentation are considered the most significant threat to threatened and endangered species [16]. Moreover, globally, the

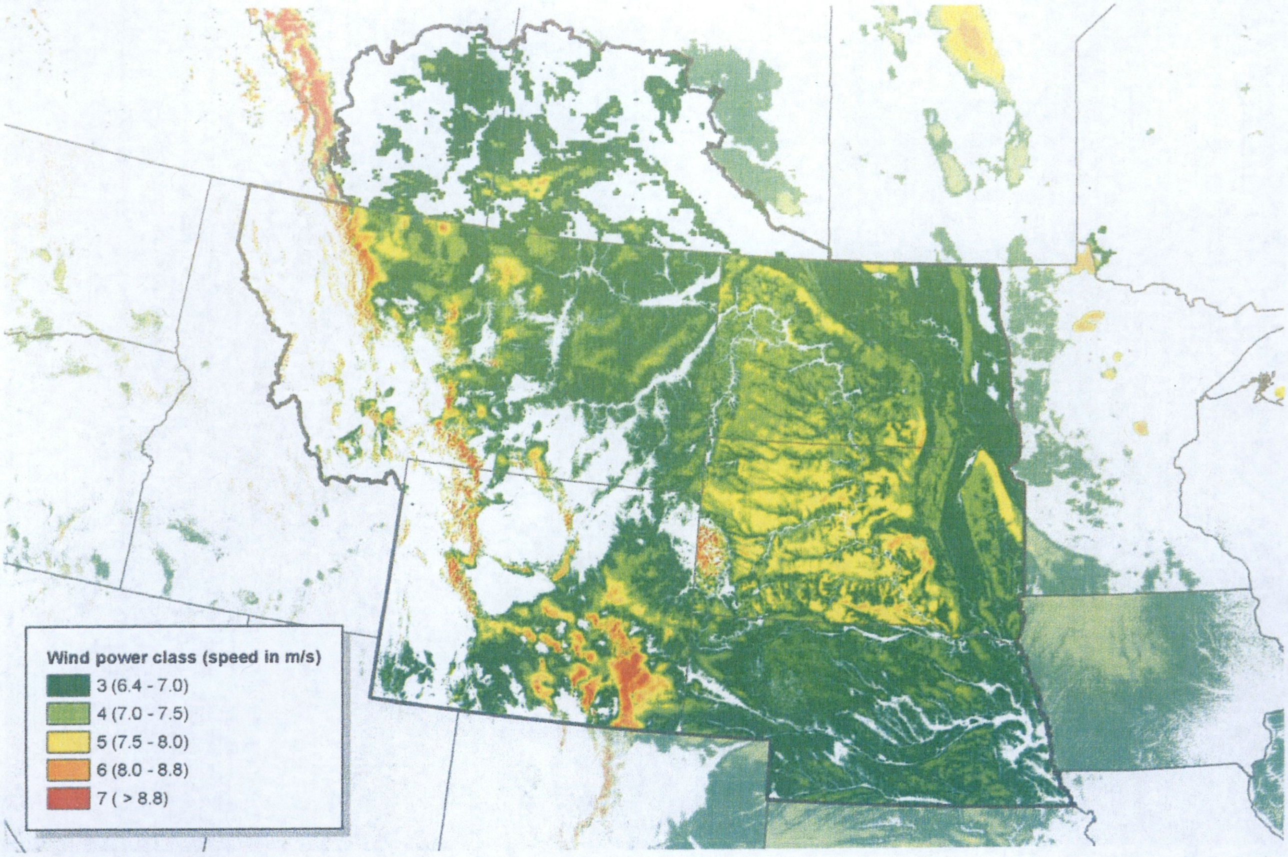

Figure 1. Wind potential in the Northern Great Plains [30,31].
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temperate grasslands biome is the most converted and least protected [17] and the Northern Great Plains is home to much of North America's remaining temperate grasslands. In the Northern Great Plains, grassland and shrubland nesting birds, such as the greater sage grouse (*Centrocercus urophasianus*) and the greater prairie-chicken (*Tympanuchus cupido*) are of particular concern because they require large intact areas to maintain viable populations and are likely to avoid use of habitat near roads or turbines [18,19,20]. Similarly, large game species depend on crucial summer and winter ranges and migratory corridors that may be impacted by wind and other energy development [21].

Many of the concerns about the impact of wind energy to wildlife can be addressed through appropriate siting. A recent paper suggests that, nationally, over 14 times DOE's goal for wind energy can be met simply by placing wind turbines on lands that are already disturbed or fragmented [22]. However, this national overview did not attempt to identify the specific locations best suited for low-impact wind development. Here we identify areas in the Northern Great Plains where wind development would have low impact to wildlife by selecting the subset of disturbed lands that have high wind energy potential and are not identified as wildlife priority areas by the best available state-level wildlife data. For each state, we used the best available wildlife and conservation data provided by local and federal agencies and non-profits, focusing on the species, habitats, migration corridors, and stopover sites most likely to be sensitive to wind development. Our approach is not intended to identify all areas suitable for wind development, but rather the subset of areas that, if developed, can be predicted with relative confidence to have low impacts to wildlife.

Methods

Based on data availability, we defined a study area based on political boundaries in the United States and ecological boundaries in Canada. Our Canadian analysis was constrained to the Northern Great Plains ecoregion, defined to include Northern mixed and short grassland ecoregions [23,24].

Disturbance Data

We created a binary disturbed/undisturbed classification that considers areas with any of several human impacts to be disturbed. Specifically, we compiled spatial data on the footprint of human disturbance, including developed areas, cropland, roads and other impervious surfaces, oil and gas development, and surface mines.

For the United States, we used the disturbance data compiled by Jeffrey Evans [22]. This compilation includes data from four sources: 1) 2001 National Land Cover Dataset, 2) USGS impervious surfaces dataset, 3) USGS topographic change dataset, and 4) a national oil and gas field dataset. The National Land Cover Dataset (NLCD) is a federal multi-agency effort that applies standard class schemas, methodologies, and error assessments to quantify land cover patterns across the entire lower 48 United States [25]. The following NLCD classes were considered to be disturbed lands: Cultivated Crops, Developed-High Intensity, Developed-Low Intensity, Developed-Medium Intensity, Devel-

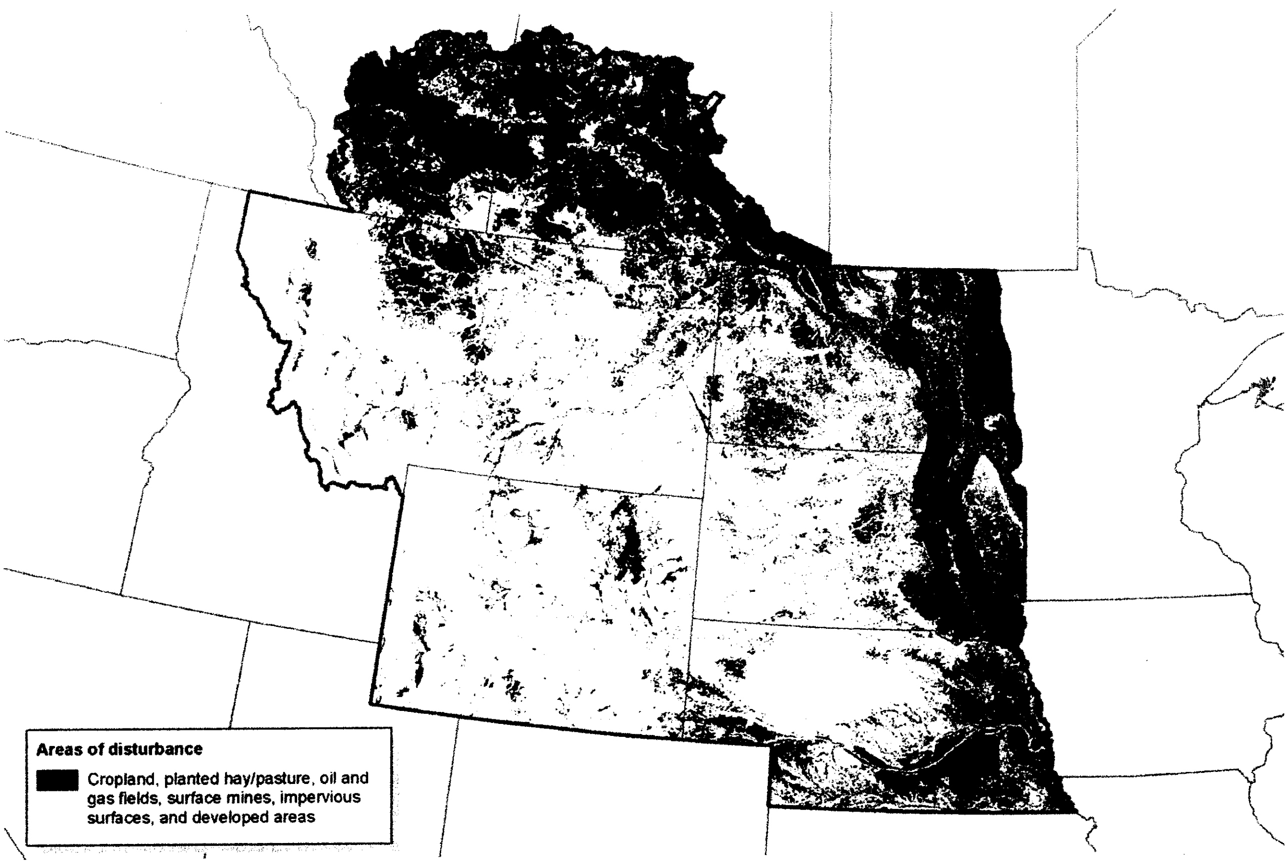

Figure 2. Disturbed areas in the Northern Great Plains [22,29].
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oped-Open Space, and Hay/Pasture. The Hay/Pasture class included planted forage grasses, but did not include natural (i.e. unplanted) grasslands used for grazing. We used a Landsat derived impervious surface classification produced by USGS [26] to identify areas with reduced percolation such as pavement. The USGS topographic change data was used to identify significant topographic change, representing surface mines and other major human-based changes in topography [27]. The USGS used a threshold for identifying significant topographic change of 10.21–17.57 meters, depending on the land cover type. Oil and gas fields were identified with a kernel density analysis of well locations using IHS energy© data [28].

We compiled disturbance data for Canada, including the following datasets: 1) A land cover database from Agriculture and Agri-Food Canada, classified circa 2000 Landsat imagery [29]. The following land cover classes were considered to be disturbed lands: Developed, Cultivated Agricultural Land, Annual Cropland, Perennial Cropland, and Pasture; 2) Active oil and gas fields based on a kernel density analysis of existing oil and gas wells; 3) Pipelines, roads, railways and transmission lines, rasterized at 30 meters. To identify urban areas, we used data on hamlets, villages, towns and cities. We converted point data on hamlets to raster data by buffering each hamlet by 300 meters and rasterizing at 30 meters.

Wind Resource and Development Goals

For wind power in the United States, we used wind power class modeled at 50 meters above the ground [30]. These data are available at a resolution of 200×200 meter pixels. For wind power in Canada, we used wind power class at 50 meters above the ground as estimated in the Canadian Wind Energy Atlas [31]. These data are available at a resolution of 5 km x 5 km pixels. We considered wind power class 3 and higher (≥6.4 m/s) to be economically viable [2]. Although newer wind turbines commonly have a hub height of 80–100 meters, wind speed data at this height is not publically available as a GIS data layer. Since wind speed increases with height, our use of the 50-meter wind speed data is conservative in two respects. First, all of the areas that we identify as low-impact areas for development have wind power classes as good or better than assumed for our analysis. Second, our estimates of the amount of low-impact areas available for wind development are conservative, because some areas that our analysis considers to have insufficient wind resource may actually be viable for development.

We obtained wind development goals for U.S. states from the DOE [2]. We are not aware of comparable governmental goals for southern Alberta or Saskatchewan. Therefore we used the amount of proposed wind energy development in the connection queue of the Alberta Electric System Operator as of December 2011 [32] as an estimate of the magnitude of additional wind development in Alberta that could be targeted to low-impact areas. For Saskatchewan, we used a wind development goal of 20% of the projected total nameplate capacity for all electricity generation by 2030 [33].

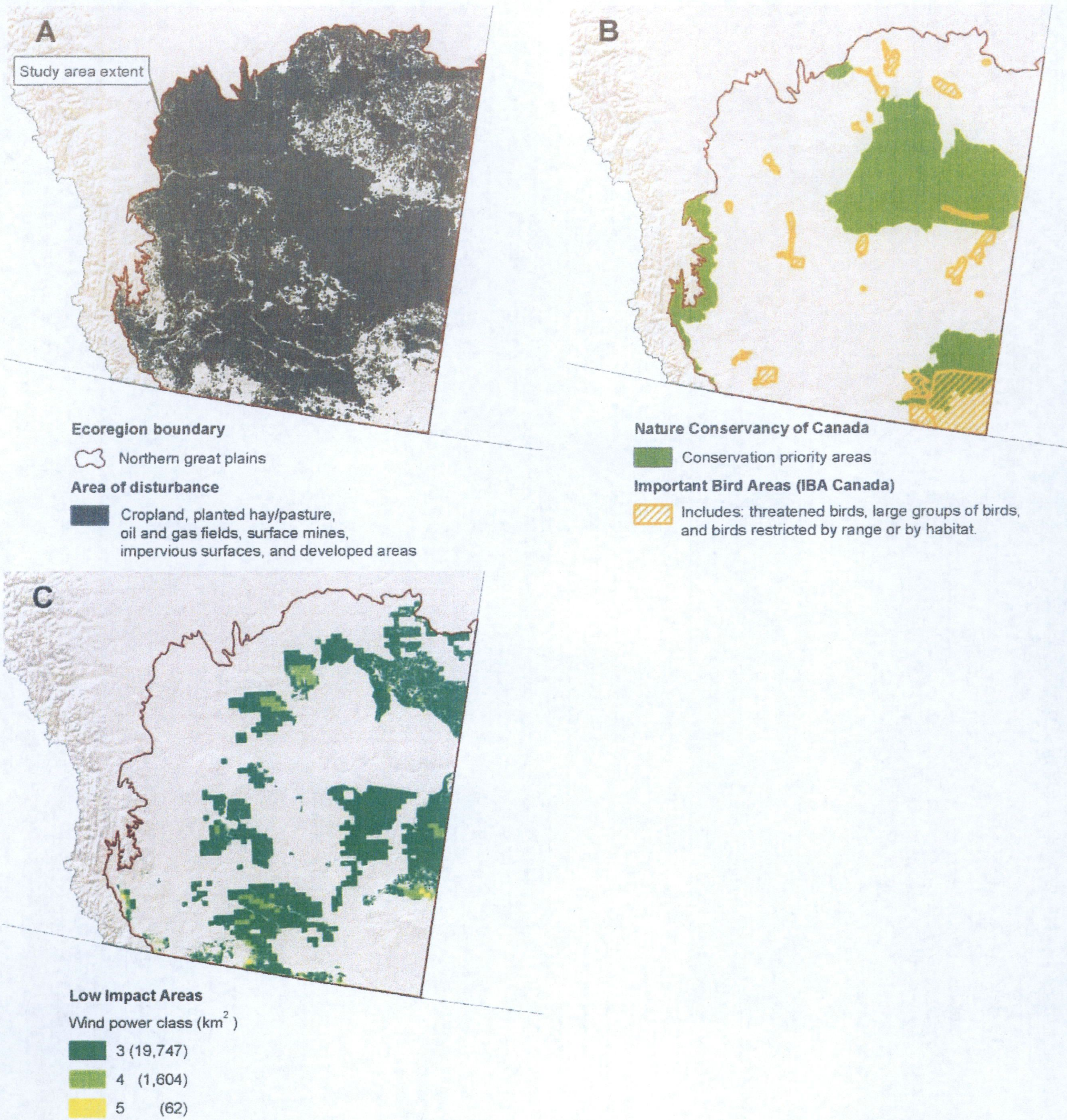

Figure 3. Low-impact areas for wind development in Alberta. (A) Disturbed areas [29] within the Northern Great Plains ecoregion [23]. (B) Conservation priority areas [40] and important bird areas [38,39]. (C) Low impact areas for wind development are the subset of disturbed areas where wind is viable and wildlife sensitivity is low.
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State-Level Wildlife Data

The disturbed areas used in this analysis represent low-quality habitats that we expect are altered to the point that they no longer support natural community assemblages or populations of species of conservation concern [34]. Disturbance is consistently associated with increased probability of extirpation for many species, such that areas of high disturbance generally have low value for biodiversity [34,35,36,37].We recognize, however, the limitations of our disturbance dataset to fully capture and represent local-scale biodiversity values. To more fully capture biodiversity values within each state/province, we assembled local data layers that identify areas with significant conservation values within each state. These areas were then excluded from designation as low-impact areas for wind development, even if they were already disturbed. We obtained the best available state-level data for wildlife priority areas in Montana, Nebraska, North Dakota, South Dakota, Wyoming, and southern Alberta and Saskatchewan.

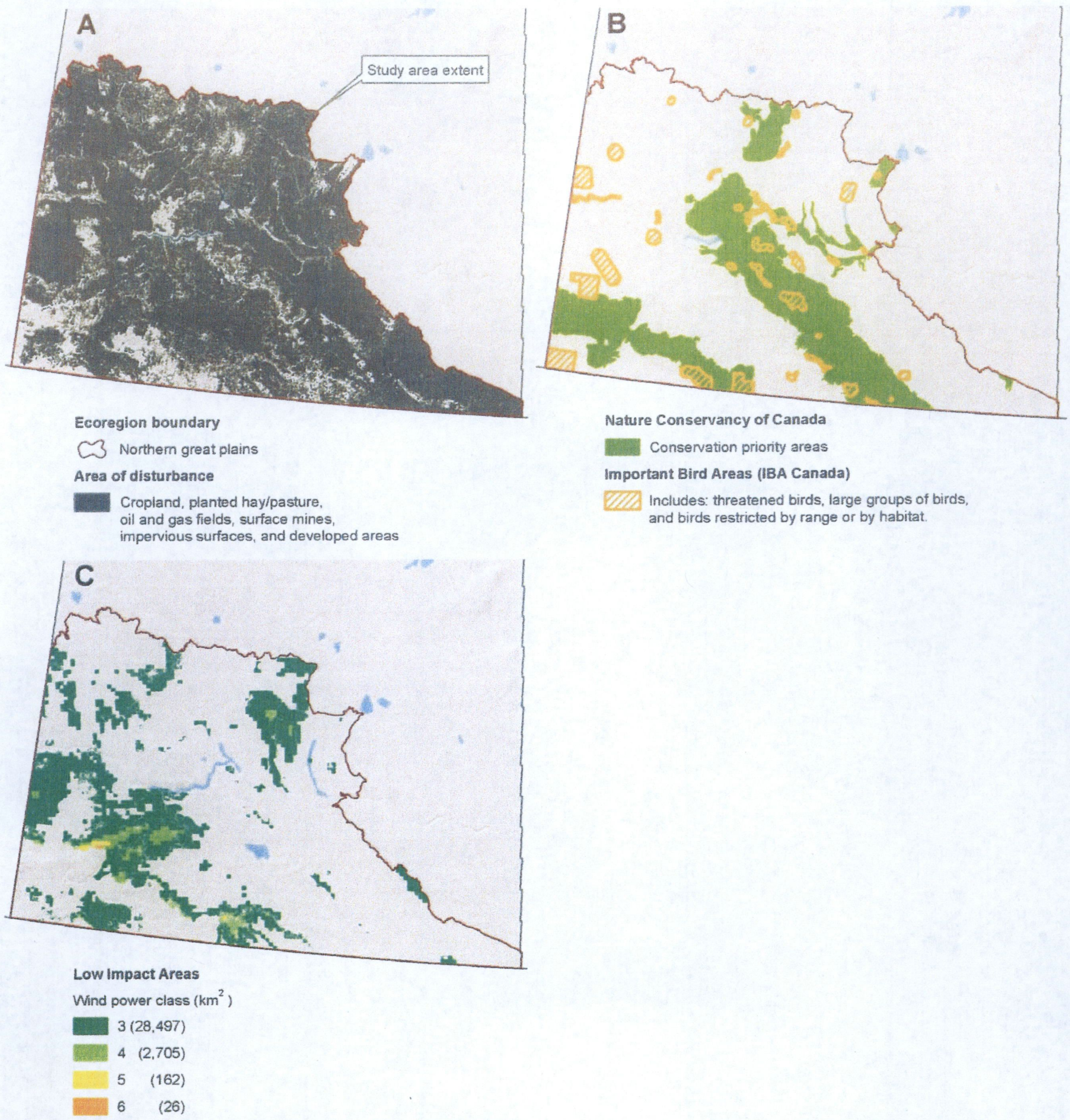

Figure 4. Low-impact areas for wind development in Saskatchewan. (A) Disturbed areas [29] within the Northern Great Plains ecoregion [24]. (B) Conservation priority areas [40] and important bird areas [38,39]. (C) Low impact areas for wind development are the subset of disturbed areas where wind is viable and wildlife sensitivity is low.
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Alberta and Saskatchewan

Alberta and Saskatchewan had similar species of concern and data availability, allowing a consistent methodology across these provinces. We excluded Important Bird Areas in Canada [38]. Important Bird Areas in Canada are home to threatened birds, large groups of birds, and birds restricted by range, and were identified as a part of an international effort to identify important bird areas using consistent criteria [39]. We also excluded Priority Natural Areas identified by the Nature Conservancy of Canada to represent the best examples of the diversity of the provinces' natural heritage and key habitat for many species [40].

Montana

Montana Fish, Wildlife & Parks has created a Crucial Areas Planning System to identify areas that may be relatively more sensitive to development [41]. They generated several data layers, including a terrestrial species richness layer, a terrestrial conservation species layer, and a wetlands layer. Each data layer was

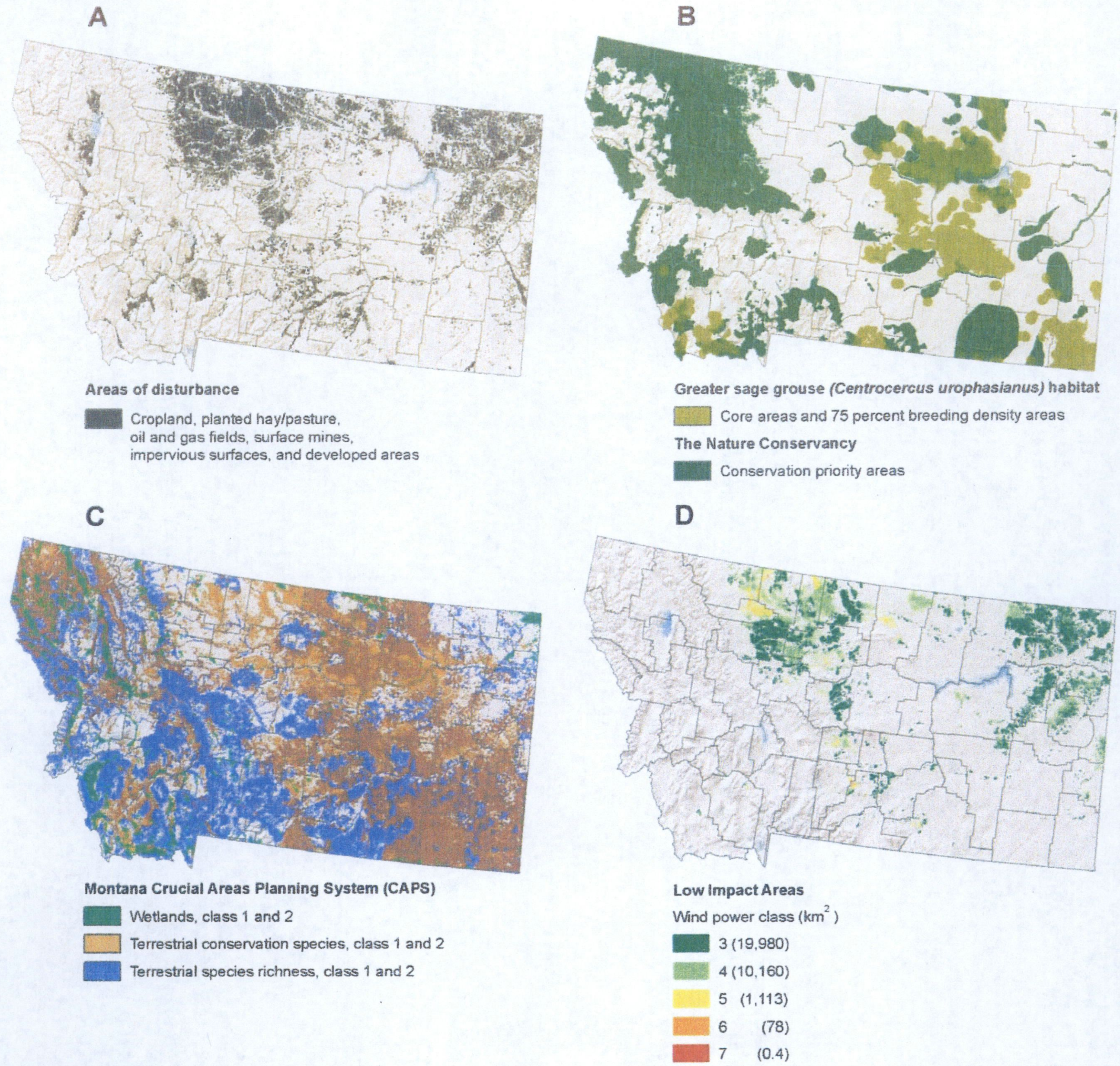

Figure 5. Low-impact areas for wind development in Montana. (A) Disturbed areas [22]. (B) Greater sage grouse (*Centrocercus urophasianus*) habitat [42,43] and conservation priority areas [44]. (C) Montana Crucial Areas Planning System priority areas for wetlands, terrestrial species, and terrestrial species richness [41]. (D) Low impact areas for wind development are the subset of disturbed areas where wind is viable and wildlife sensitivity is low.
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categorized into four classes. For each of these three data layers we excluded the two categories of highest conservation concern. For sage grouse, we excluded both the range-wide 75% core breeding areas [42] and Montana core areas map [43]. We also excluded The Nature Conservancy's conservation priority areas [44].

Nebraska

The Nebraska Game and Parks Commission has conducted a wind and wildlife analysis that identifies areas of relative sensitivity for species of conservation concern that may be impacted by wind energy development [45]. Their analysis considered the following species: bald eagle (*Haliaeetus leucocephalus*), golden eagle (*Aquila chrysaetos*), bighorn sheep (*Ovis canadensis*), ferruginous hawk (*Buteo regalis*), greater prairie-chicken (*Tympanuchus cupido*), interior least tern (*Sternula antillarum athalassos*), long-billed curlew (*Numenius americanus*), mountain plover (*Charadrius montanus*), piping plover (*Charadrius melodus*), sharp-tailed grouse (*Tympanuchus phasianellus*), whooping crane (*Grus americana*), and three species of bats. Their analysis ranked the relative sensitivity of all areas within the state of Nebraska on a scale of 1–6. To identify low-impact areas for wildlife, we excluded the areas within the four most sensitive categories. We also excluded playa lakes identified as high or very high quality by the Playa Lakes Joint Venture [46].

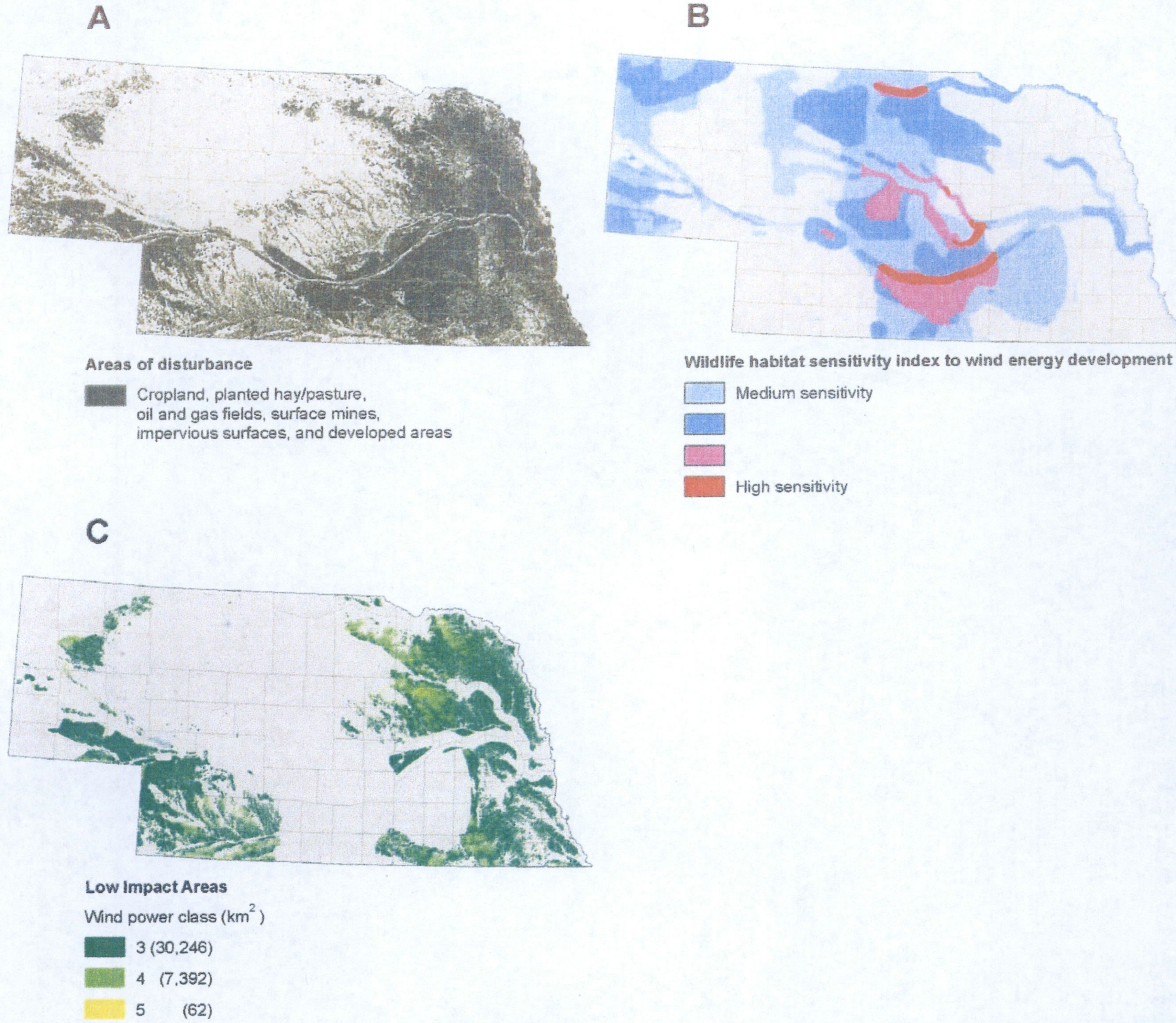

Figure 6. Low-impact areas for wind development in Nebraska. (A) Disturbed areas [22]. (B) Areas with medium to high wildlife sensitivity to wind energy development [45]. (C) Low impact areas for wind development are the subset of disturbed areas where wind is viable and wildlife sensitivity is low.
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North Dakota and South Dakota

North Dakota and South Dakota had similar species of concern and data availability, allowing a consistent methodology across these states. We excluded areas with a predicted waterfowl breeding pair density of 104 pairs per km^2 (40 pairs per mile^2) or greater, based on US Fish and Wildlife Service Habitat And Population Evaluation Team data [47,48]. This represents crucial habitat for many species of wetland-dependent birds in North America [47,48]. We excluded The Nature Conservancy's conservation priority areas [44]. We also excluded repeated whooping crane stopover sites, buffered by 3.2 km [49]. To identify repeated whooping crane stopover sites, we included any site with whooping crane observations in multiple years or on three or more days in the same year, based on U.S. Fish and Wildlife Service observation data. We also excluded a 1.6 km buffer area around the Missouri and Red Rivers that are important migratory corridors for birds and bats.

Wyoming

We excluded wildlife priority areas identified by the Wyoming State Wildlife Action Plan [50]. For big game ungulates (pronghorn, *Antilocapra americana*; elk, *Cervus canadensis*; and mule deer, *Odocoileus hemionus*) we excluded migration corridors and crucial winter and summer ranges [51]. For sage grouse, we excluded both the range-wide 75% core breeding areas [42] and the Wyoming Governor's core areas [52]. We also excluded priority wetland complexes [53].

Analysis

We identified lands potentially suitable for wind development by excluding lands known to be unsuitable for wind development based on wind speeds, protected status, urbanization, or standing water. We excluded lands with average annual wind speeds of less than 6.4 meters per second (i.e., wind power classes 1 and 2 in the NREL data). We excluded protected areas where wind de-

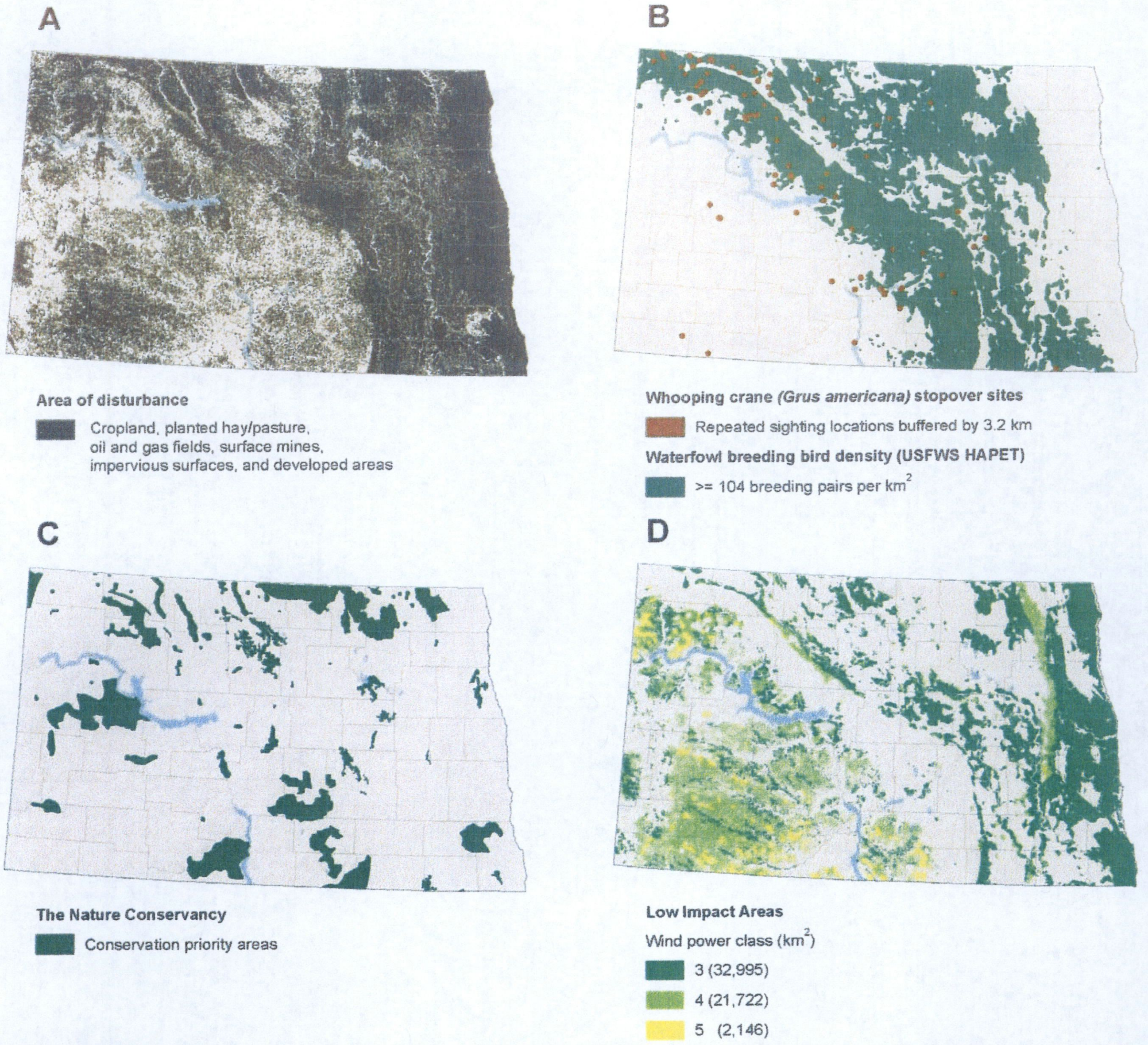

Figure 7. Low-impact areas for wind development in North Dakota. (A) Disturbed areas [22]. (B) Whooping crane (*Grus americana*) stopover sites and waterfowl breeding bird density [47,48]. (C) conservation priority areas [44]. (D) Low impact areas for wind development are the subset of disturbed areas where wind is viable and wildlife sensitivity is low.
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velopment would likely be prohibited based on areas with a Gap Analysis Program code 1 or 2 (i.e., permanent protection that excludes development), based on the Protected Area Database of the United States [54]. We used updated protected areas data for Wyoming [55] and Montana [56]. We excluded urban-core areas [57]. We also excluded wetlands and water bodies identified in the NLCD. To exclude disturbed areas that are too small to support wind development, we removed all patches of disturbed areas that were smaller than 1 km^2 and greater than 800 m away from patches of disturbed areas greater than 1 km^2.

We quantified the GW of wind energy in each state/province that could be produced on suitable low-impact disturbed lands. We accounted for the fact that areas with higher wind speeds will generate more electricity on the same amount of land as follows. We estimated the amount of MW per unit area, following DOE [2], by assuming that projected average nameplate capacity (44.5%) is installed at 5 MW/km^2 and adjusting turbine nameplate capacity based on capacity factors specific to each wind power class. The relationship between production capacity and area is predicted to vary by wind power class as follows: WPC $3 = 4.3$ MW/km^2; WPC $4 = 4.8$ MW/km^2; WPC $5 = 5.2$ MW/km^2; WPC $6 = 5.5$ MW/km^2; WPC $7 = 6.0$ MW/km^2. In addition, we evaluated whether wind turbines, current and proposed, as of early 2012 [1,58] are inside or outside of the low impact disturbed lands that we identified.

Results

Disturbed areas in the study region comprised 447,778 km^2 (Figure 2). We find that there are large areas where wind could be

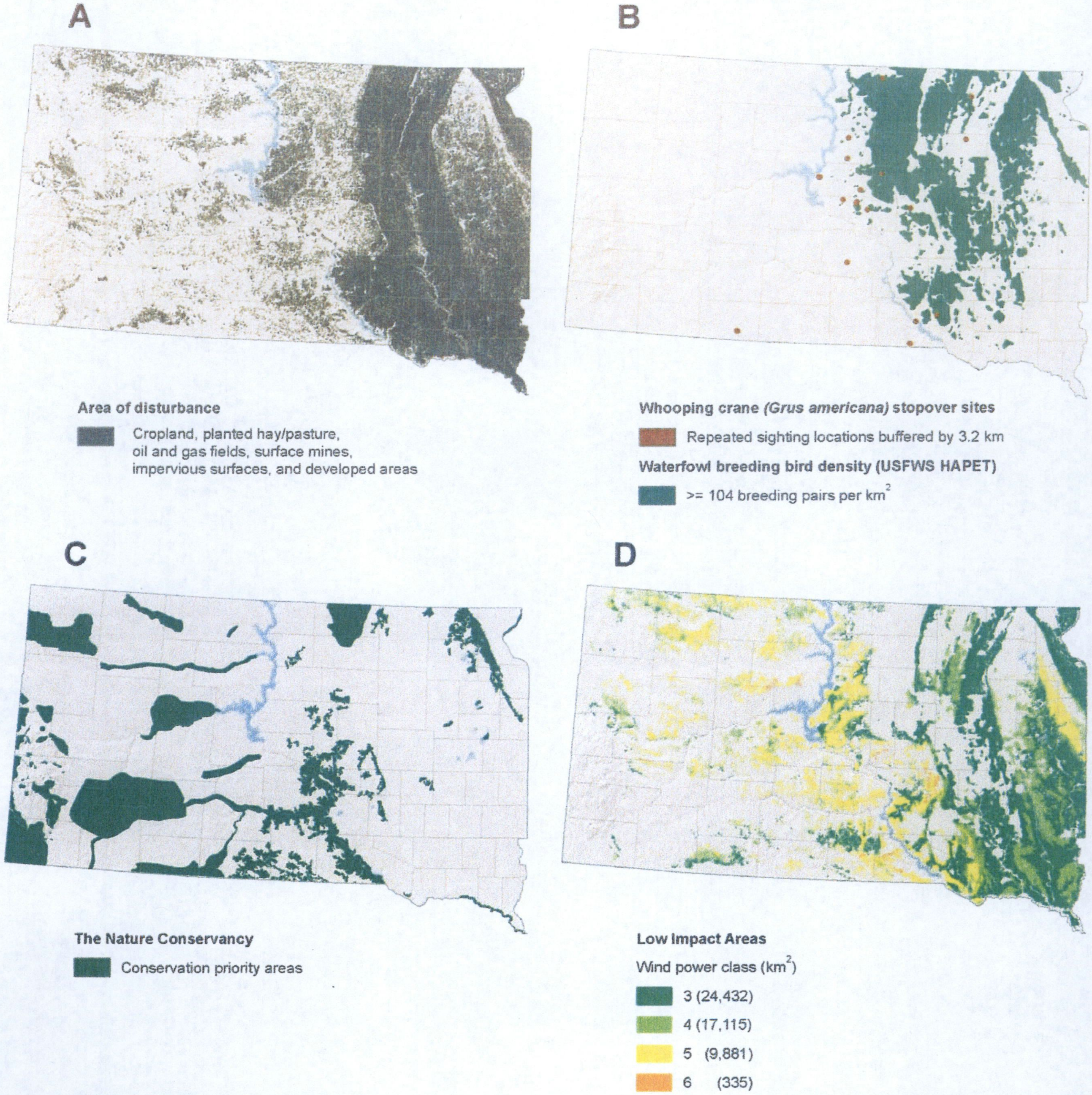

Figure 8. Low-impact areas for wind development in South Dakota. (A) Disturbed areas [22]. (B) Whooping crane (*Grus americana*) stopover sites and waterfowl breeding bird density [47,48]. (C) conservation priority areas [44]. (D) Low impact areas for wind development are the subset of disturbed areas where wind is viable and wildlife sensitivity is low.
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prioritized that would likely have little impact to wildlife (Figures 3, 4, 5, 6, 7, 8, 9 and 10). Across all states/provinces in the Northern Great Plains, there is enough wind resource on low-impact disturbed land to produce over 35 times the projected wind development goals (Table 1). Most (78%) of the low-impact lands that we identified were cropland. Current wind turbines in the Northern Great Plains are sited within our identified low impact areas 34% of the time, compared with 30% of the time for proposed turbines (Figure 11; Table 2).

Discussion

Our results indicate that there is ample opportunity in the Northern Great Plains (NGP) to target wind development to lands that are already disturbed and would likely have low impact to wildlife. We estimate that 1,056 GW of wind energy could be produced on these low-impact lands. This is over 35 times the goal for wind energy development in this region. The majority of the low-impact areas that we identified were located on cropland, indicating the benefit of co-locating wind facilities on existing cropland. The fact that the availability of wind energy far exceeds

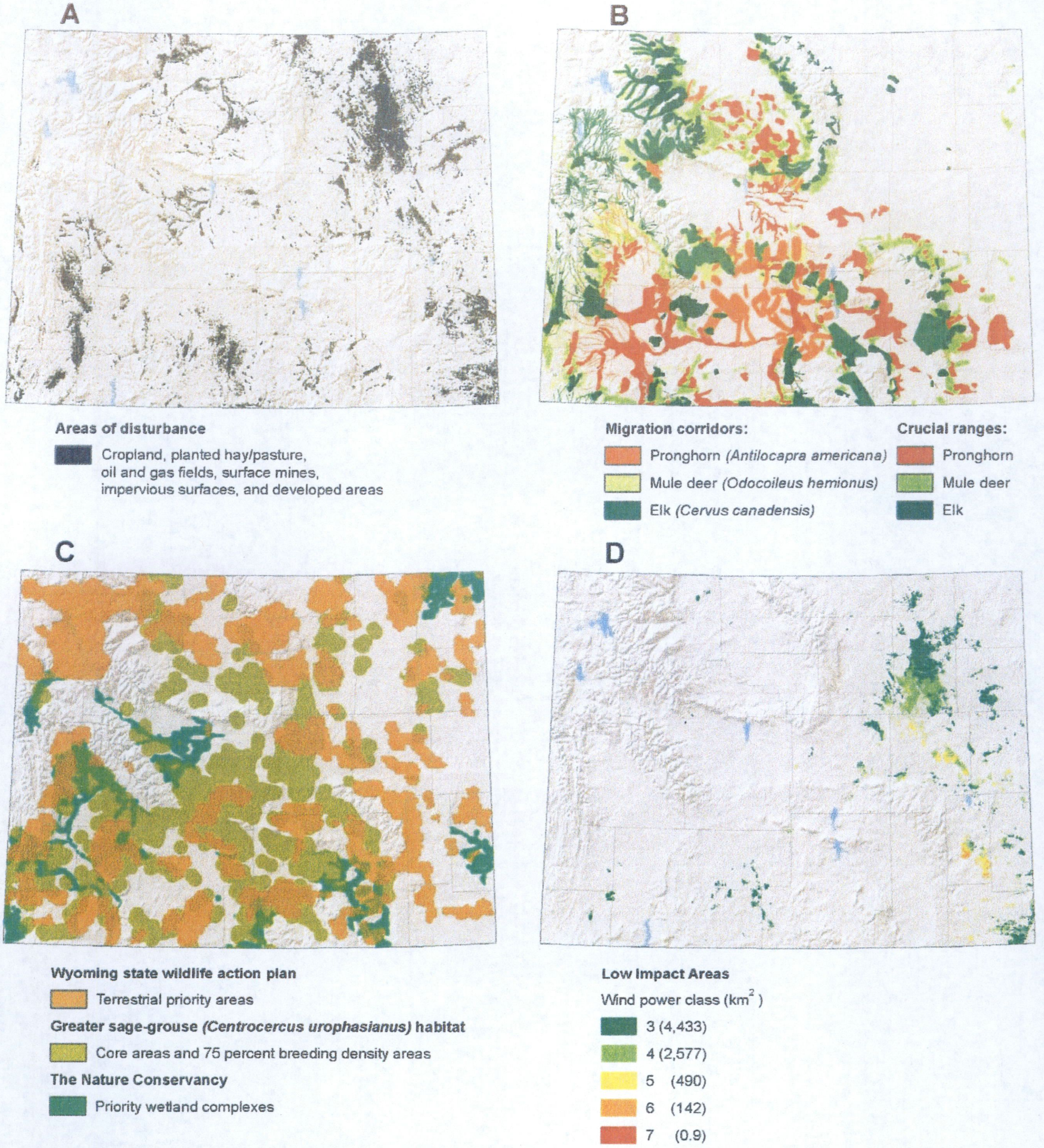

Figure 9. Low-impact areas for wind development in Wyoming. (A) Disturbed areas [22]. (B) Ungulate migration corridors and crucial ranges [51]. (C) Wyoming state wildlife action plan terrestrial priority areas [50], Greater sage grouse (*Centrocercus urophasianus*) core areas [42,52], and priority wetland complexes [53]. (D) Low impact areas for wind development are the subset of disturbed areas where wind is viable and wildlife sensitivity is low.
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development goals indicates that our results are not dependent on the particular development goals that we have used, but would be applicable for any reasonable goal.

We recommend that wind energy be targeted toward these areas with relatively low impact to wildlife. We recognize that wildlife impacts are only one consideration associated with wind energy development, and we have not attempted to address other issues, such as areas of cultural significance, in this analysis. We note that this analysis is not intended to be exhaustive, and that there are places outside of the areas that we have identified where

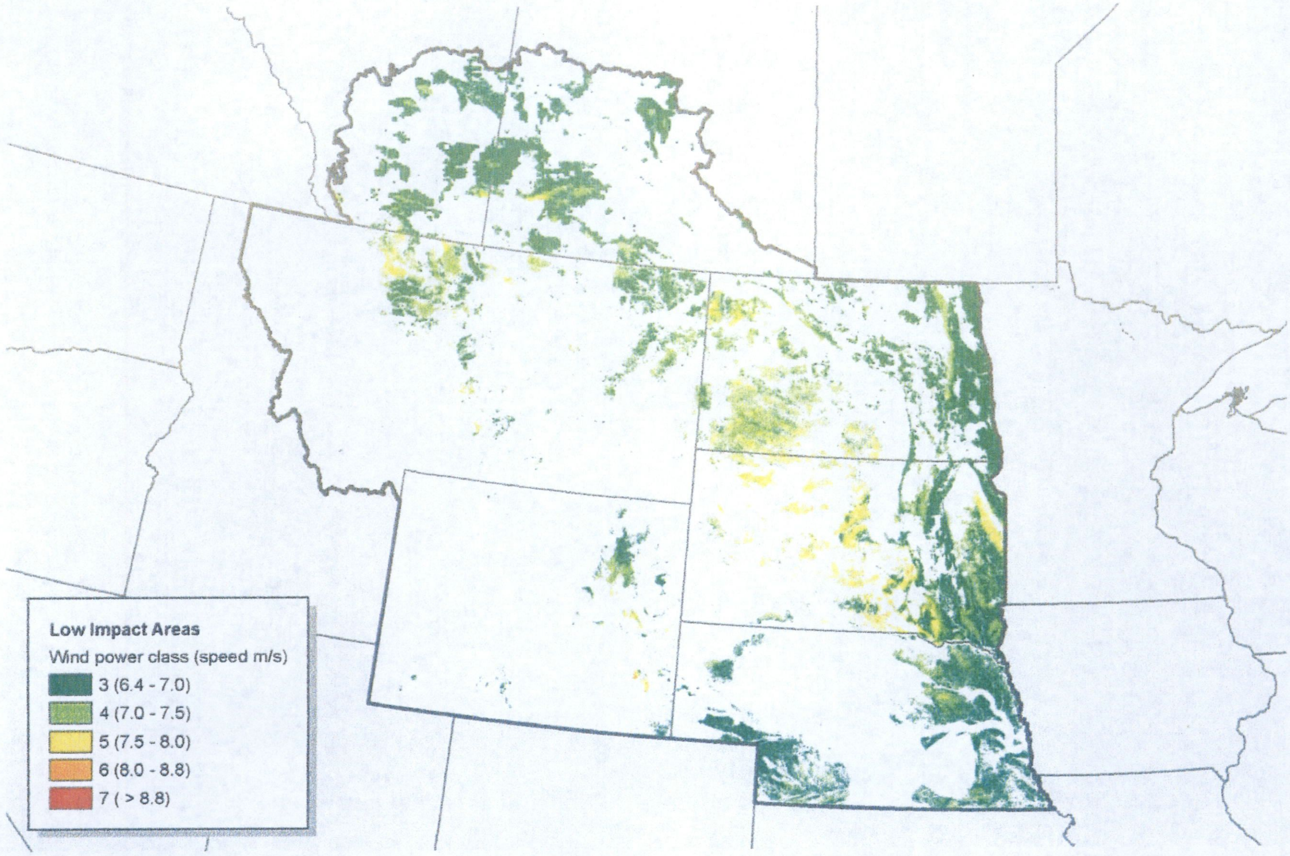

Figure 10. Low-impact areas for wind development in the Northern Great Plains. Low impact areas for wind development are the subset of disturbed areas where wind is viable and wildlife sensitivity is low.
doi:10.1371/journal.pone.0041468.g010

low-impact wind development is possible. Additional research is necessary to identify these areas. Similarly, even within the areas we have identified, there may be wildlife resources that need to be avoided through proper micro-siting and best management practices, which may include curtailment of wind turbines at low wind speeds to reduce bat mortality [59]. While it is clear that wind turbines have little additional impact on habitat and fragmentation in places that are already converted and fragmented, the relationship between disturbance and direct mortality is less clear. Numerous studies have noted that bird species of conservation concern are less abundant in areas that are converted and fragmented, suggesting that mortality for species of conservation concern are likely to be lower in disturbed areas [34]. However, additional research is needed to quantify the relationship between bird and bat mortality and landscape features, including land cover/uses such as croplands and oil and gas fields. Finally, we note that these recommendations are based on the best available wildlife data, but for some species these data are poor. For example, additional data on the migratory patterns of at-risk bat and bird species would be particularly useful for refining our recommendations.

Table 1. Wind energy production capacity on disturbed lands with low predicted impact to wildlife in the Northern Great Plains.

State	GW Goal	GW on low-impact lands	% of DOE goal
Alberta	4.11	91	2215%
Montana	5.26	139	2643%
Nebraska	7.88	163	2069%
North Dakota	2.26	254	11239%
Saskatchewan	1.10	137	12455%
South Dakota	8.06	238	2953%
Wyoming	1.28	34	2662%
Total	29.95	1,056	3526%

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Our analysis finds that the majority (70%) of proposed development in the Northern Great Plains is outside of the low-impact areas we have identified, suggesting that the current regulatory framework is generally insufficient to ensure low-impact wind development. Currently, conscientious developers who avoid a site that has substantial wildlife impacts may be at a competitive disadvantage because a competitor could subsequently develop the site. Consequently, relying on individual developers to voluntarily improve siting practices is unlikely to achieve desired conservation outcomes, because sensitive areas avoided by one project can be easily impacted by subsequent development. Also unlikely, for political reasons, is significant additional regulation in the NGP that restricts the development of wind resources on private lands based on wildlife concerns. Rather, improved incentives such that conscientious developers receive a competitive advantage will likely

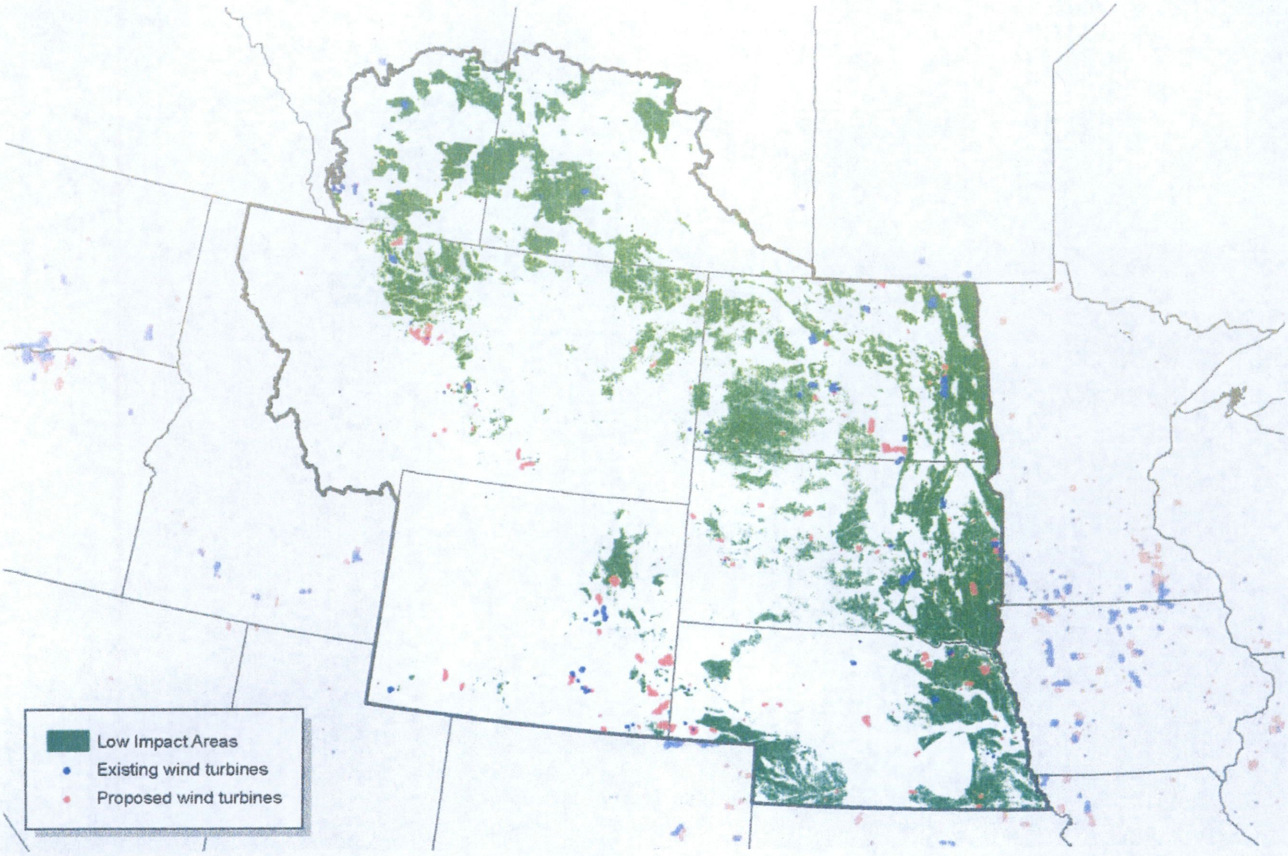

Figure 11. Current and proposed wind turbine locations in relation to low-impact areas in the Northern Great Plains.
doi:10.1371/journal.pone.0041468.g011

be necessary for widespread adoption of wildlife-friendly development practices. We identify four areas where action to help change incentives is needed: 1) transmission line siting; 2) formal guidelines and certification; 3) utility power purchase decisions; and 4) appropriate compensatory offsite mitigation for unavoidable impacts.

Wind development is limited by the availability of transmission to bring generated power to market. Consequently, the development of new transmission lines can strongly influence where new wind energy facilities will be developed. We suggest that transmission line siting target the disturbed, low-impact areas identified in this analysis.

Formal guidelines and certification would benefit industry by providing transparent guidelines that reduce risks for developers. Environmental issues can cause costly project delays or abandonment. Avoiding such costs could serve as an incentive for voluntary

Table 2. Distribution of current and proposed wind turbines in the Northern Great Plains in relationship to low-impact disturbed areas.

State	Existing			Proposed		
	# wind turbines	# Low impact wind turbines	% low impact	# wind turbines	# Low impact wind turbines	% low impact
Alberta	312	73	23%	1413	632	45%
Montana	264	128	48%	998	260	26%
Nebraska	148	52	35%	1208	500	41%
North Dakota	885	392	44%	1085	233	21%
South Dakota	351	147	42%	892	442	50%
Saskatchewan	115	100	87%	189	16	8%
Wyoming	571	1	0%	1316	41	3%
Total	2646	893	34%	7101	2124	30%

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adoption of guidelines by wind project developers. Perhaps more importantly, compliance with guidelines or certification could serve as a basis for power purchase decisions by utilities. Utilities could indicate in their requests for proposals for new power generation that projects meeting wildlife guidelines would be given preference. Because wind development typically cannot be financed without a long term power purchase agreement, this would provide strong incentive for wind developers to comply with any guidelines so endorsed. Such guidelines should not only identify low-impact areas, but should also identify avoidance areas where wind development could not be certified. In addition to low-impact and avoidance areas, there are intermediate areas that would incur moderate impacts that could be mitigated with compensatory offsite mitigation [60]. For example, impacts to moderately fragmented grasslands could be offset with grassland restoration or with protection of existing intact grasslands. Our work provides a substantial starting point for such conservation strategies, compiling many of the data layers that would be needed to construct comprehensive guidelines including avoidance areas and mitigation costs. These data are available at http://LowImpactWind.tnc.org.

Conclusion

In places where extensive wind development may conflict with the preservation of large intact landscapes and the wildlife that depend upon them, strategies that can balance the needs of development and conservation are required. Targeting wind energy development to areas with low impacts to wildlife can help society simultaneously achieve goals for clean renewable energy production and wildlife conservation. Encouragingly, our analysis demonstrates that is possible to meet all of our demand for wind energy on lands that are likely to have low impacts to wildlife. In the Northern Great Plains, wind energy production on low-impact disturbed lands could exceed 1,056 GW, over 35 times the projected demand for wind energy. New policies and approaches are needed to guide wind energy development to low impact areas.

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Author Contributions

Conceived and designed the experiments: JF JK SO. Analyzed the data: MJS. Wrote the paper: JF.

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Plowprint

Tracking Cumulative Cropland Expansion to Target Grassland Conservation

Anne M. Gage, Sarah K. Olimb, and Jeff Nelson

ABSTRACT—Conversion of grassland to cropland has accelerated over the past decade due to high crop prices, government incentives, and a growing global human population. Conversion of grasslands leads to loss of habitat and threatens the ability of the land to provide ecosystem services, such as carbon sequestration, water filtration, and reduced erosion. We developed a method for identifying remaining intact habitat across the Mississippi River Basin–Great Plains area by stacking subsequent years of the Cropland Data Layer (United States) and Annual Crop Inventory (Canada). We call the resulting cumulative plowed lands the "plowprint." The total size of the plowprint increased by 27,159,278 ha from 2009 to 2013. As of 2013, approximately one-third of the study area had been plowed. We conclude that developing the ability to monitor cumulative change over time will allow disparate agencies and organizations to align their goals, strategies, and activities, and to measure progress in a uniform way.

Key Words: agricultural expansion, cropland, grassland conversion, intact habitat, land-cover change

Introduction

Temperate grasslands are among the most modified ecosystems on the planet due to productive soils and the absence of extreme topography, which lend them to being easily modified with modern technology to produce food and fuel for the burgeoning global human population. Recent studies suggest that rates of conversion of grasslands to cropland in the United States vary from about 1% to 5% annually, with many areas of the tallgrass prairie already almost completely converted (Goldewijk 2001; Rashford et al. 2011; Claassen et al. 2012; Faber et al. 2012; Sylvester et al. 2013; Wright and Wimberly 2013; Lark et al. 2015). The temperate grassland biome is the least protected on the planet (Hoekstra et al. 2005), and the modification of these grasslands impacts their ability to store carbon, filter water, reduce erosion, and provide habitat for important wildlife species (Sustainable Rangelands Roundtable 2008).

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The United States is one of the top producers of agricultural commodities at the global scale, leading the world in the production and exportation of corn and soy (USDA-ERS 2016a, 2016b). Most of the major commodity crops, including corn, wheat, and soy, are grown across the central grasslands of the United States, and current and past crop production has led to increased eutrophication of freshwater resources and inputs to the Gulf of Mexico hypoxia zone (Costello et al. 2009). Coarse-level analyses show, however, that avoiding continued conversion of remaining grasslands could save substantial quantities of water and avoid inputs of nitrogen, phosphorous, and sediment to the freshwater systems of the United States (Flynn and Redder 2014).

While the tallgrass prairie of North America has largely been converted from its native state to cropland, shortgrass and mixed-grass prairies located along the western portion of the Great Plains still contain large, intact blocks of habitat. Some estimates suggest that up to 50% of the central shortgrass prairie remains intact (Landscope America 2016). This remaining habitat generally has lower soil quality and receives lower amounts of annual precipitation than the tallgrass prairie, but it is still under threat due to technological innovations, government incentives to plow up land, and the influence of high crop prices on landowner decision making (Rashford et al. 2011; Claassen et al. 2012).

Tracking the loss of grassland through time has proven to be complicated, with researchers using various methods for refining estimates of annual loss during recent decades and tying those losses to changes in crop prices, government payments or federal policies (Goldewijk 2001; Rashford et al. 2011; Claassen et al. 2012; Faber et al. 2012; Sylvester et al. 2013; Wright and Wimberly 2013; Lark et al. 2015). Most of these studies rely on the accuracy of datasets developed by the US Department of Agriculture (USDA) to track land-use change over time (Boryan et al. 2011). However, distinguishing between some categories, such as grassland versus hay, can be difficult using satellite data, with producer's and user's accuracy rates for the "other hay/non-alfalfa" category falling in the 50% to 80% range (USDA-NASS 2014b).

We sought to develop a methodology for tracking change in grasslands over time, with the goal of identifying remaining habitat that is largely intact and has not recently been plowed. For the purposes of this study, we use the term "grasslands" to refer to all grasslands (shortgrass, mixed-grass, tallgrass), vegetated wetlands, and shrubland-steppe habitats. To accomplish our goal of locating remaining intact habitat, we developed a method of stacking a time series of cropland data and then subtracting that crop footprint from the remaining habitat across the Mississippi River Basin–Great Plains (MRB-GP; Fig. 1) geographic area. The result is a baseline against which to monitor further incursions into remaining habitat by cropland agriculture, and an intact habitat layer for use in prioritizing conservation actions.

Methods

The MRB-GP region encompasses 2.7 million km^2 and stretches from the Rocky Mountains in the west to the Appalachians in the east. The region contains a mix of habitats, including grasslands, shrub-steppe, wetlands, and forests, as well as numerous large natural and artificial lakes (Forrest et al. 2004). This region has long been the agricultural heart of the country, with nearly half the US cropland contained within the Corn Belt and Northern Plains regions (NRCS 2007). Lands that are not cropland, developed land, or open water are generally forested or used as pastureland or rangeland throughout the region (NRCS 2007). Throughout this paper, we also reference two subregions: the Northern Great Plains (NGP) ecoregion, as defined by World Wildlife Fund (Forrest et al. 2004), and the Plains and Prairie Potholes Landscape Conservation Cooperative (PPP LCC), as defined by the US Fish and Wildlife Service (Fig. 1; Landscape Conservation Cooperative Network 2016).

Due to data availability, we used five years of data in Canada and six years of data in the United States to develop the baseline map of plowed lands in the MRB-GP region. Data for Canada spanned 2009–2013, and data for the United States covered the years 2008–2013 (USDA-NASS 2014). Data for the US portion of the study area was derived from the USDA National Agricultural Statistics Service Cropland Data Layer (CDL; USDA NASS 2014), and data for the Canadian portion of the study area is from the Agriculture and Agri-Food Canada Annual Crop Inventory (AAFC 2013). CDL data is derived from the Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS) and supplemented with Landsat 5 TM and Landsat 7 ETM+ data. Annual Crop Inventory data is derived from Landsat 7, AWiFS, and Disaster Monitoring Constellation sources. CDL data is available at 56 m resolution prior to 2010, and 30 m resolution since 2010. Similarly, Annual Crop Inventory data is available at 56 m resolution prior to 2011, and 30 m resolution since 2011. Both datasets were resampled to 56 m resolution to account for this change (AAFC 2013; USDA-NASS 2014).

Plowprint

For this analysis, cropland was defined as any annually planted agricultural commodity (e.g., corn, soybeans, wheat, etc.) or fallow agricultural land. Because alfalfa is a perennial crop that is periodically planted in rotation with annual crops, we chose not to define it as cropland. To circumvent the issue of misclassifications due to, for example, fallow land being identified as grassland and very wet or very dry years causing misclassification of some cover types, we developed a methodology that aggregates crop pixels from six subsequent years (five in Canada) by stacking datasets across years and allowing cropland/fallow pixels to be added to the dataset, but never removed. We call the resulting layer the plowprint, and it represents a footprint of cropland throughout the study area over the time period of the datasets.

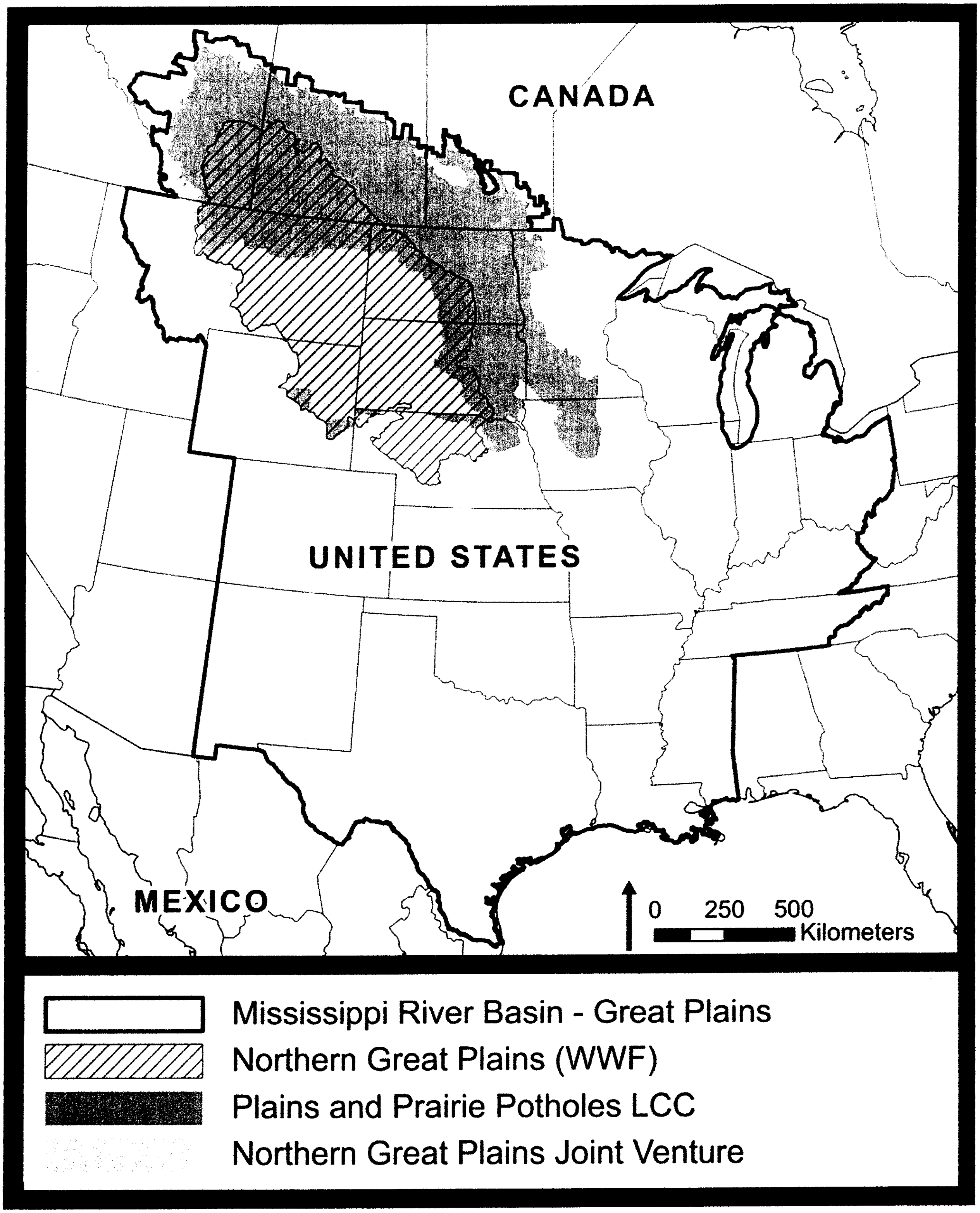

Figure 1. Study area, including the sub-boundaries of the Northern Great Plains (World Wildlife Fund), the Plains and Prairie Potholes Landscape Conservation Cooperative, and the Northern Great Plains Joint Venture.

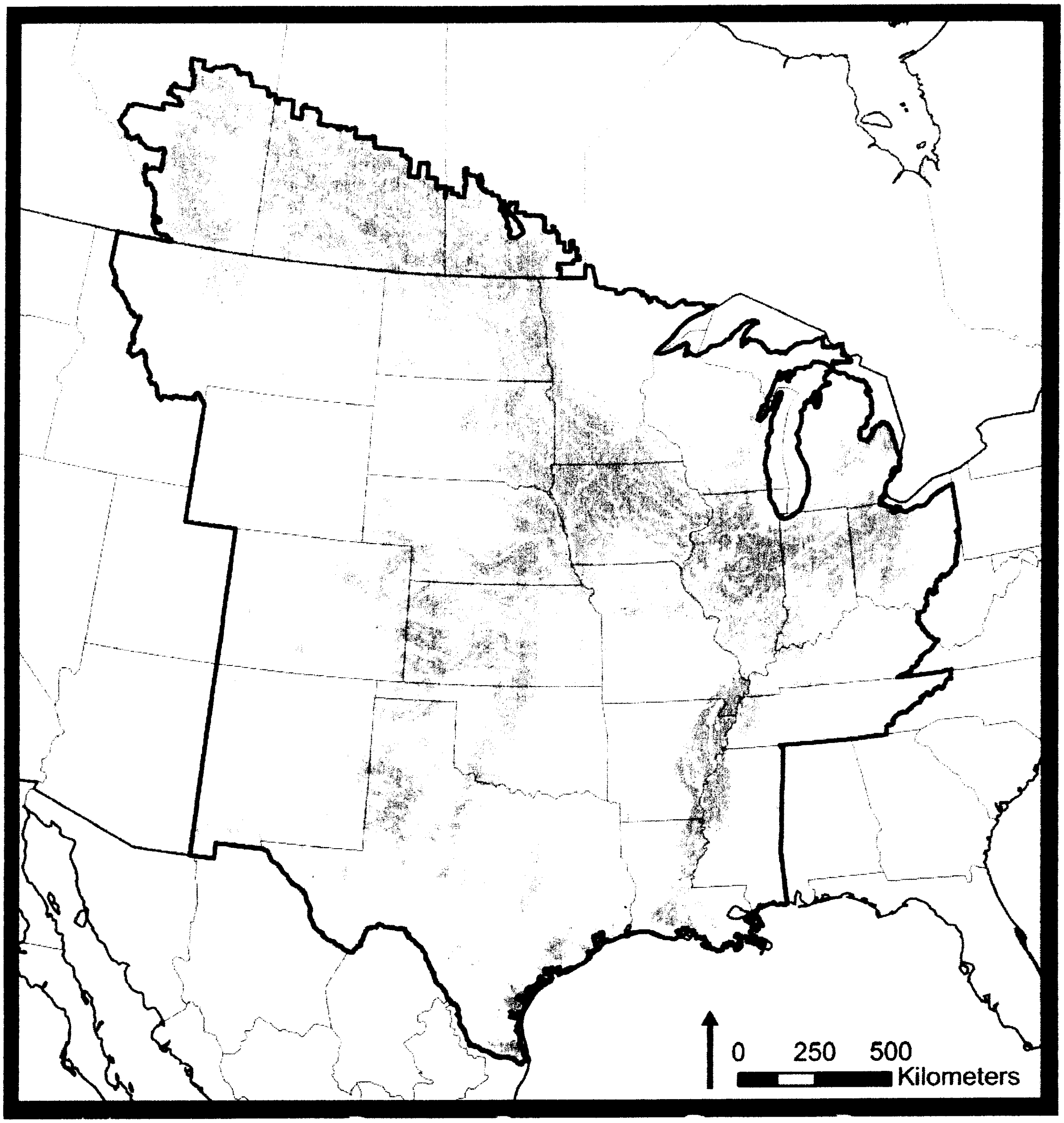

Figure 2. Extent of plowprint across the study area in 2013.

Conversion Rates and Plowprint Composition

Due to changes in the interpretation and resolution of the imagery (e.g., grassland) between 2008 and 2009 in the United States, we chose 2009 as our starting point against which to measure increases in cropland and decreases in remaining intact habitat. Changes in Canada were tracked starting in 2010 for the same reasons. We mapped additions of cropland to the plowprint annually, thus tracking the footprint of crop agriculture on the landscape as it expanded annually between 2009 (2010 in Canada) and 2013. Within the Northern Great Plains ecoregion, our area of conservation focus, we calculated the average rate of change for three county types (i.e., focal, buffer, other), which were classified according to the amount of remaining intact habitat and relative species

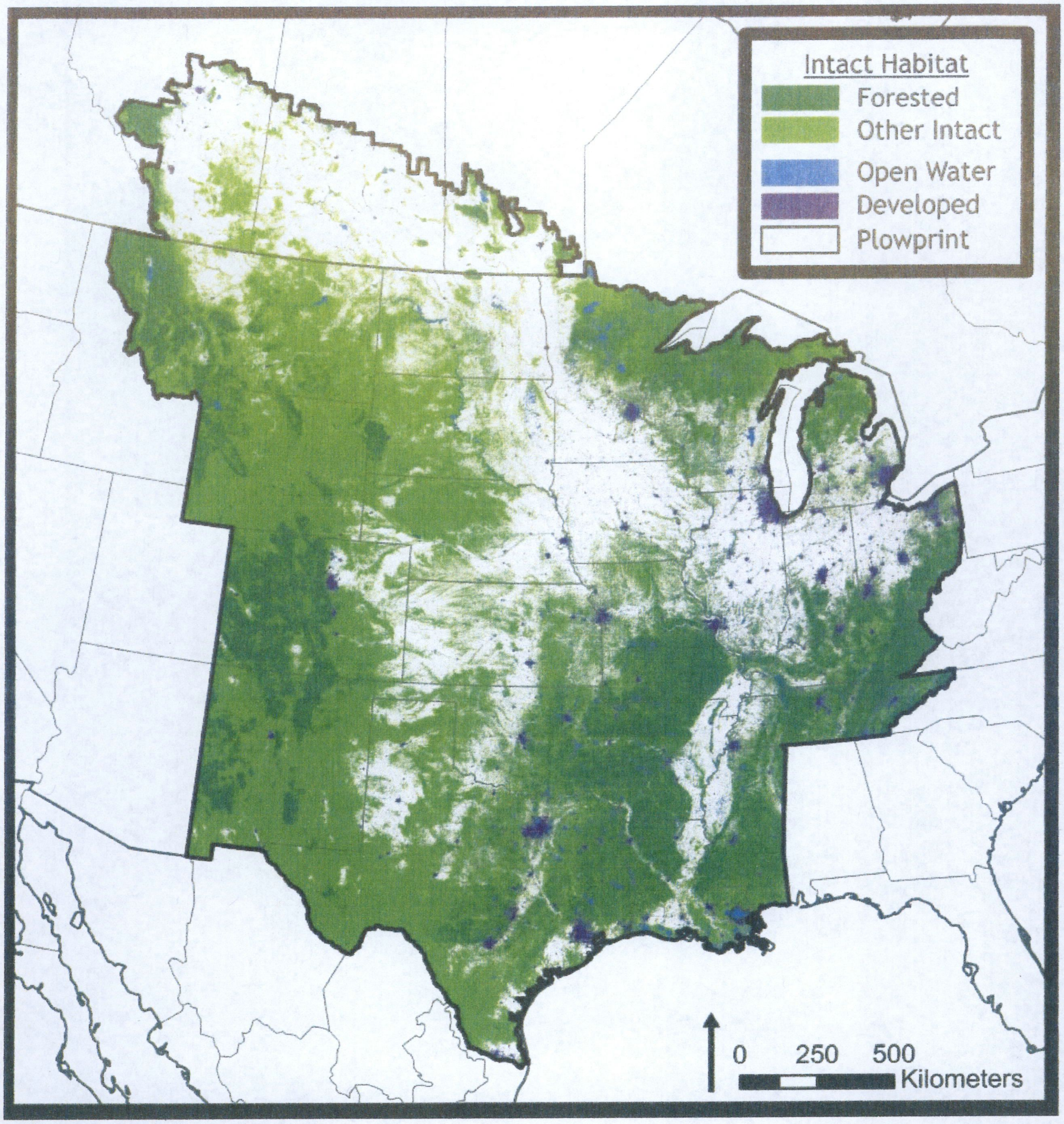

Figure 3. Intact habitat remaining in the MRB-GP study area in 2013. Dark green represents forested intact habitat. Light green represents all other remaining intact habitat, mostly grassland. Open water and developed lands are also shown.

diversity for the purpose of directing organizational resources. We then calculated the deviation from this average rate of change for each county type, scaled to the size of the county, to depict those counties that are experiencing faster and slower than average rates of conversion.

Within the plowprint, we grouped land-cover classes to provide an annual snapshot of the composition of the converted land footprint as it changes over time. For example, lands that were converted in the past could be restored back to grasslands or shifted to a different use. Previous research has shown that consolidation of similar classes within the CDL leads to decreased error rates associated with those classes (Lark 2015). Thus, we grouped crops and other land-cover types into the following categories: cropland/fallow, alfalfa/other hay,grassland/pasture/shrubland/wetland, barren/developed, open water, and forest. Using this information, we can track different categories of land-cover types within the plowprint, which is of interest because restored lands can provide suitable habitat for some wildlife and avian species of conservation interest (Gebhart et al. 1994; Reynolds et al. 1994; US Geological Survey 2015).

Intact Habitat Layer

Our intact habitat layer was developed by subtracting the plowprint, open water, and developed layers from all habitat within the study area. We used the most recent National Land Cover Dataset (NLCD) from 2011 (Homer et al. 2015) as the baseline land cover for noncropland cover types in the US portion of the study area and, similarly, the Land Cover Data from 2000 (Government of Canada 2000) for the baseline land cover for the Canadian portion of the study area. An open water category was developed for the US portion of the study area by redefining pixels classified as water to correct for annual variation. Thus, any pixel in the NLCD layer that was defined as "water" in 2001, 2006, or 2011 (the most recent land-cover classifications available) was included in the open water category. We used this process to account for pixels that might be impacted by wet and dry years and therefore might switch back and forth between water and a nonwater land-cover class (e.g., grass), depending on the year. Because only one year of recent data was available for Canada, we did not perform this correction for the Canadian portion of the ecoregion. Developed lands were defined using the developed categories from both the NLCD and Land Cover Data.

Once the open water, developed, and plowprint layers were defined as outlined above, we subtracted them from the base land-cover layers for Canada and the United States. The remaining pixels were classified as intact habitat. We assumed that any pixel that had not been converted, developed, or classified as open water was intact. Within this intact layer, we used the NLCD or Land Cover Data to show forested versus other intact habitat (grassland, shrubland, or wetland) across the study area. In the same manner that we tracked increases in the plowprint over the study period, we also tracked decreases in intact habitat over time.

Validation

We used two methodologies to validate our process for identifying tracts of land that have not been plowed since 2008 in the United States and since 2009 in Canada. First, we identified three types of classifications across the years of the study: (1) persistent cropland was defined as those pixels that were classified as cropland in two or more subsequent years or in the last year of the dataset; (2) intermittent cropland was defined as pixels that alternate between cropland and noncrop status, never with two subsequent years classified as cropland; and (3) probable misclassification was defined as those pixels that were classified as cropland in only one year, not including the final year of data. We calculated the percentage of each of these pixel types across the entire study area.

Our second assessment compared our plowprint data to a dataset compiled by Bauman et al. (2014) that primarily uses the USDA Farm Service Agency Common Land Unit data to delineate tracts of land with no cropping history, through 2012. This dataset covers a small portion of our MRB-GP study area, in the Prairie Coteau region of eastern South Dakota. We compared our dataset of plowed and intact habitat with this dataset and developed an error matrix that allowed us to identify those pixels that were classified as plowed in our dataset and intact in the Bauman et al. (2014) dataset and vice versa. We then compared those cells that were included in the 2012 plowprint, but identified as intact by Bauman et al. (2014), with land-cover classifications from the CDL for 2012.

Results

Plowprint and Intact Habitat Layers

As expected, the extent of the plowprint continues to grow over the study period, and intact habitat declines. Figure 2 shows the cumulative extent of the plowprint as of 2013. The extent of the plowprint across the MRB-GP study area in 2013 was 157,748,507 ha. The extent of the intact habitat in 2013 was 333,021,231 ha (Fig. 3). Thus, approximately 32% of the study area had been plowed as of 2013, not including the developed areas or open water. The majority of the remaining intact habitat is privately owned, including both forested lands and grasslands (Table 1).

Conversion Rates and Plowprint Composition

The total size of the plowprint increased by 27,159,278 ha over the time period from 2009–10 to 2013, roughly 10% of the study area, not including open water and already developed lands. The annual increase in acreage

TABLE 1. Percentage of total intact acreage (2013) that is publicly and privately owned within the study area.

	Forest	Grassland
Public	8.4	14.2
Private	19.8	57.6

of the plowprint was much larger at the beginning of the study period, likely due to the change in the resolution of the dataset (from 56 m to 30 m) and the improvement in crop classifications as years were added to the dataset. The annual conversion rate for the Northern Great Plains focal geography was 1.5% during the 2009–2013 time period. The counties showing the fastest and slowest rates of change, by county type within the Northern Great Plains, are shown in Figure 4. We calculated these rates of change for the 2011–2013 time period to show the most recent change in conversion in this focal region. The percentage of the plowprint classified as grassland/pasture/shrubland/wetland in 2013 was 9.8%, while the percentage classified as alfalfa/other hay was 6.5%. Active cropland/fallow land made up 81.5% of the plowprint. The remaining 2.2% was split between forest and barren/developed lands.

Validation

Our within-dataset validation methodology yielded a probable misclassification rate of 11% within the plowprint. Persistent cropland represented 86% of the study area, and intermittent cropland encompassed 3% of the study area.

Our across-dataset validation methodology suggests that most of the pixels classified as cropland (70%) and intact (15%) are classified the same way in the Bauman et al. (2014) dataset. The error matrix is shown in Table 2. Thus, 15% of the cells were classified differently between the two datasets. The cells that our analysis identified as intact and Bauman et al. (2014) identified as plowed (10%) were likely plowed prior to 2008, the first year of our data, since their dataset extends back to the early 1900s. The cells that our analysis identified as plowed and that Bauman et al. (2014) identified as intact (5%), however, are likely misclassifications in our dataset. When we examined the 2012 plowprint classification data, most of these cells were classified as some type of hay or other grasslike cover, which are the classifications that are most likely to be confused with intact habitat.

TABLE 2. Error matrix showing the percentage of the total number of pixels that fall within each category.

	Intact acreage (this study)	Plowed acreage (this study)
Intact acreage (Bauman et al.)	15%	5%
Plowed acreage (Bauman et al.)	10%	70%

Note: Across-dataset validation of plowed versus intact pixels.

In fact, only 7% of the cells that we classified as plowed and Bauman et al. (2014) classified as intact, or 0.3% of the total cells in this validation dataset, were in active cropland in 2012.

Discussion

Developing metrics for tracking conversion of grasslands and other intact ecosystems to cropland over time can provide clarity for agencies and organizations that are working toward conservation of these important habitats as to how much is being lost and where. The results of our study mirror those of similar studies from the past decade: cropland expansion is increasing. The size of the plowprint in 2013 was over twice the size of the state of Texas, or equivalent to four times the size of Montana. Much of the remaining untilled lands in the study area are forested and publicly owned. We conclude that privately owned grasslands in this region are at high risk of conversion because publicly owned lands are largely protected from this type of land-use change.

Our study improves on the ability to monitor cumulative change over time, thus allowing disparate agencies and organizations to align their goals, strategies, and activities, and measure progress in a uniform way. Stacking subsequent years of data allows us to circumvent many of the common issues associated with using satellite-derived data to track annual change in cropland extent, and our validation efforts suggest that we are capturing most of the converted lands using our methodology. Previous studies reported conversion rates of 1% to 5% annually (Goldewijk 2001; Rashford et al. 2011; Claassen et al. 2012; Faber et al. 2012; Sylvester et al. 2013; Wright and Wimberly 2013; Lark et al. 2015); our calculated rates of conversion fit within this range, which further suggests that our methodology is doing an accurate job of monitoring conversion of intact habitat to cropland over time.

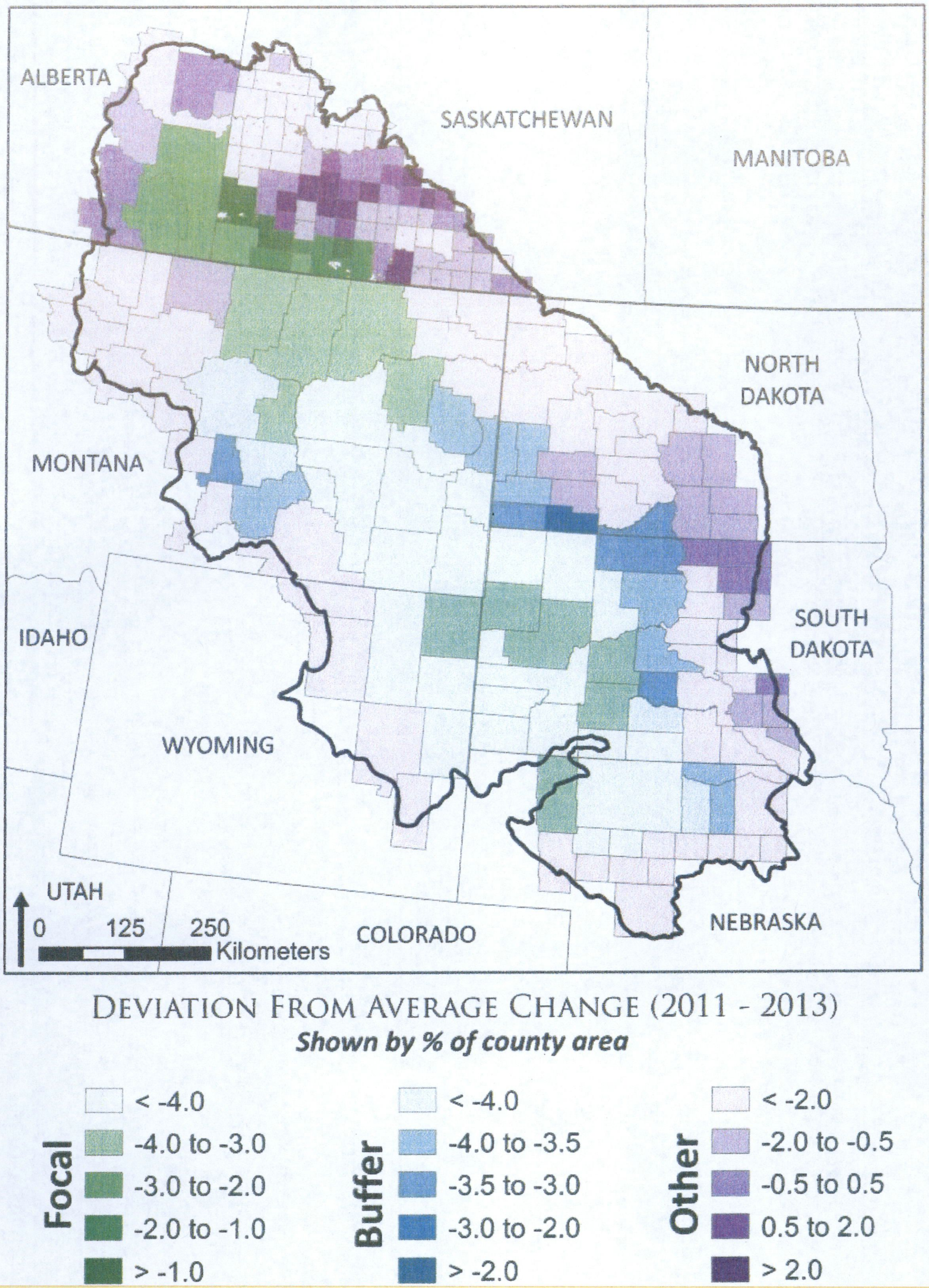

Figure 4. The deviation from average of conversion from grassland to cropland, as a percentage of county size, 2011–2013. Focal counties are shown in green; buffer counties in blue; and other counties in purple. Darker shades represent higher rates of conversion and lighter shades represent lower rates of conversion.

The broader implications of the conversion of intact lands to cropland, including decreased habitat for wildlife and declining ecosystem services, are significant and will require the attention of policy makers, as well as other conservation stakeholders. Previous coarse-scale analysis in the Northern Great Plains region suggests that, depending on the soil type, avoided conversion could lead to savings of hundreds of thousands of gallons of water per acre (Flynn and Redder 2014). Conserving intact grassland ecosystems into the future will have lasting impacts on water availability while also improving water quality for downstream users.

Conclusions

The implementation of regional monitoring programs can help identify remaining intact habitat so that resources may be directed to those areas. In areas that are not currently experiencing high rates of conversion, working with landowners to find incentives for keeping land intact could be a potential avenue forward. In addition, government policies that seek to reduce the motivation to convert should be implemented. Working together, we can maintain the remaining intact grasslands to provide habitat, ecosystem services, and other benefits to communities and wildlife across this region.

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Acknowledgments

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Coteau Preservation Alliance

We, Coteau Preservation Alliance, are presenting information – slightly revised – about why we believe the Burke Wind Project Area should be abandoned. This wind project, in fact, after reviewing how this Coteau area has been recognized as a very valuable resource for its native grasslands, wetlands, and wildlife, should have been abandoned before any planning began.

An outline of the topics in the attached package[1] is:

I. Grasslands, Wetlands, and Wildlife (pages 2 - 19)
II. Health (pages 20 - 23)
III. Land Values (pages 24 - 25)
IV. Liabilities (pages 26 - 27)
V. Reclamation (page 28)
VI. Local Comments and Thoughts (page 28 - 31)
VII. Issues to Contemplate (pages 31 - 32)

The Missouri Coteau is one area remaining that still has significant amounts of grasslands, wetlands, and wildlife compared to intensively farmed areas in other parts of North Dakota. A quote by Tom Dickson in July-August 2018 Montana Outdoors magazine fits very well with what may happen to our very valuable North Dakota natural resources on the Coteau.

> "To enrich our lives, we humans have tinkered a lot with the natural world. The food we eat, the electricity we use, the wood and metal that build our homes and vehicles--all that and more comes from altering the environment to meet our needs. We can't turn back time and not plow the prairies, log forests, build dams, or mine copper.... But we can value and conserve the shiners, sparrow, and other seemingly insignificant species still out there. Not out of moral duty or guilt, but because it's the wise thing to do.
>
> We still don't fully understand how the natural world works, and may never get there. But we should still retain all the parts.... Once they're gone, they're gone for good."

The Burke Wind LLC Project Area will adversely affect our health and property values, and increase problems with liability, reclamation and so much more, all at the landowner's expense. Important to us as well is the loss of our way of life.

This project will adversely affect our lives in so many ways for those who live in and around the Burke Wind LLC Project Area.

Please reject the application that would allow NexEra to complete the Burke Wind LLC Project Area!

I. Grasslands, Wetlands, and Wildlife

We, Coteau Preservation Alliance, are providing information about the valuable natural resources in the Coteau where the Burke Wind Project Area is proposed. Our information includes:

- description of the Missouri du Coteau,
- valuable landscapes within,
- wildlife diversity in the grassland/wetland landscape,
- adverse effects of Burke Wind Project Area to these natural resources,
- many organizations and government agencies that recognize the value and importance of this unique resource.

Description of the Missouri du Coteau and its Valuable Resources

The Burke Wind proposal is located on the Missouri Coteau Breaks (Coteau). The Coteau, a glacially formed terminal moraine of the Wisconsin glacier that traverses from the southeast Alberta through southwest Saskatchewan entering in the northwest corner of North Dakota to the south-southeast boundary (light green area in Figure 1) and continues southeast across South Dakota and into northwest Iowa. This very unique feature has many important natural resources for North Dakota.

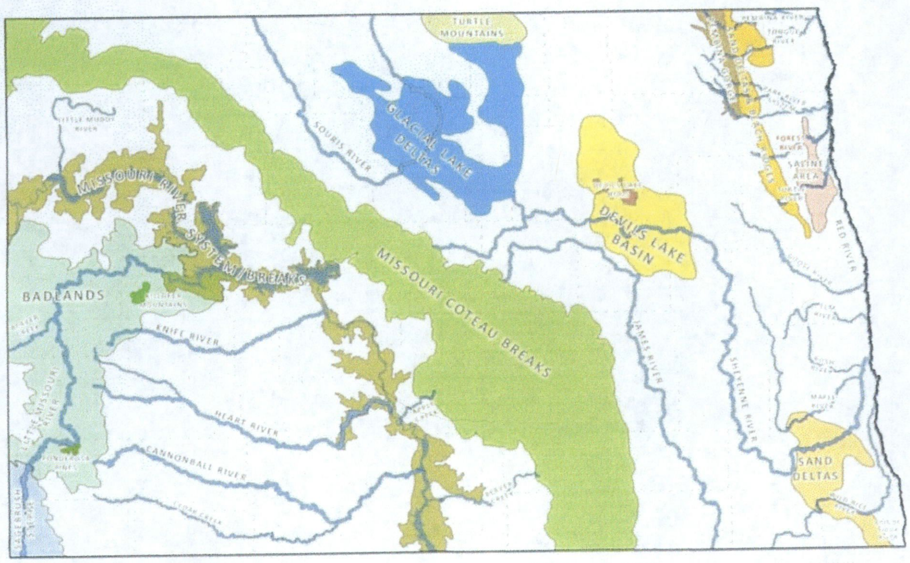

Figure 1. This is a copy of Figure B1 from draft guidelines developed by North Dakota Game and Fish Department (hereafter referred to as "ND Draft Guidelines"). This map is used to identify North Dakota's current draft recognition of Focus Areas most important to the vast majority of Species of Conservation Priority. Due to the high value of these areas, all Focus Areas are categorized as High Impact to Native Wildlife and Habitat.

The native grasslands found in the Burke Wind project area (located on the Coteau straight above the olive green extension northward from the Missouri River) are composed of northern mixed-grass prairie plant species, different from the tallgrass and shortgrass prairie grassland ecosystems elsewhere in North Dakota. Prairie plant communities thrive in North Dakota because of their deep rooted systems allowing them to survive in extreme climatic variability's common here. It is estimated 75% of these native grasslands have been converted (NDGF, unpublished data).

The areas in Figure 1 with color are the Focus Areas. These are of most importance to the vast majority of Species of Conservation Priority by NDGFD. In subsequent figures these areas are grayed in the background of the overlay colors for different land features presented.

North Dakota's remaining native grassland areas have been categorized using a 4 square mile area equal to or greater than 40% remaining in native grasslands (Figure 2). The Burke Wind Project Area is within one of the prized native grassland areas composed of the northern mixed-grass prairie plant species. This project is squarely in a High importance Focus Area in the Coteau.

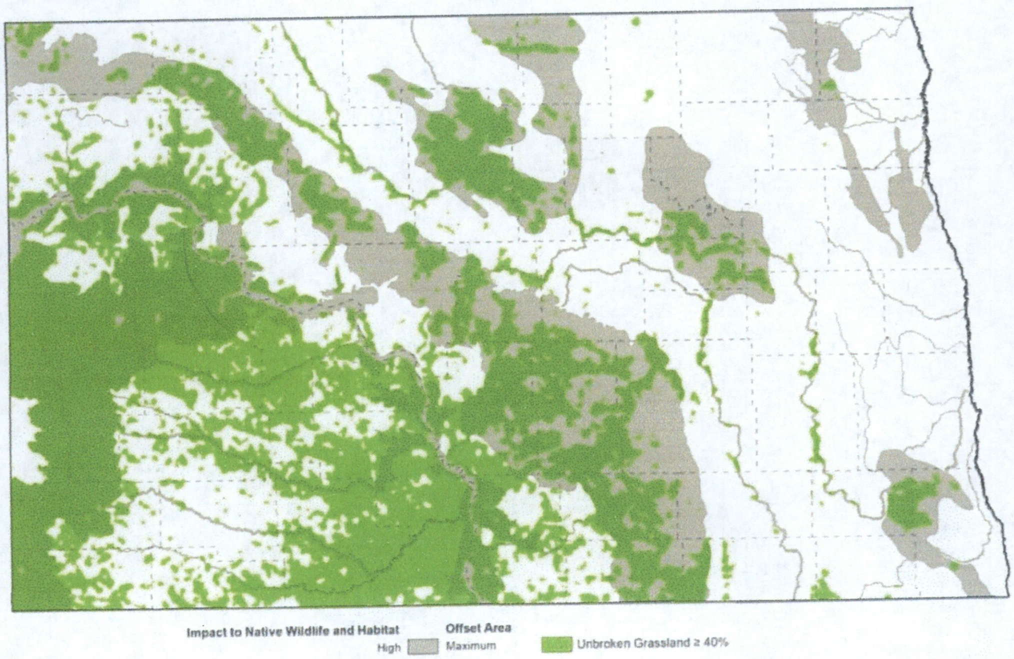

Figure 2. The light green overlay on the Focus Areas are areas of higher portions of native grasslands remaining. This is a copy of Figure B4 from the ND Draft Guidelines. The criteria used to identify these areas was any 4 square mile area that contained equal to or greater than 40% native grasslands.

Intermingled in the grasslands is a vast array of wetlands large and small, fresh and saltier than the oceans. It is estimated 50% of wetlands have been lost from an estimated 4.9 million acres that once existed to 2.5 million (Dahl 2014). In Figure 3, copied from ND Draft Guidelines, is data from U.S. Fish and Wildlife Service's wetland inventories. Burke County's Coteau is composed of abundant wetlands. Data pulled together by USFWS in Bismarck, North Dakota found that the Burke Wind Project Area has proportions of sections with wetland basins greater than 100 is 3.6 times higher in the project area than elsewhere in the state. Again, as you can see, Burke Wind project is right in one of the highest densities of wetlands in North Dakota.

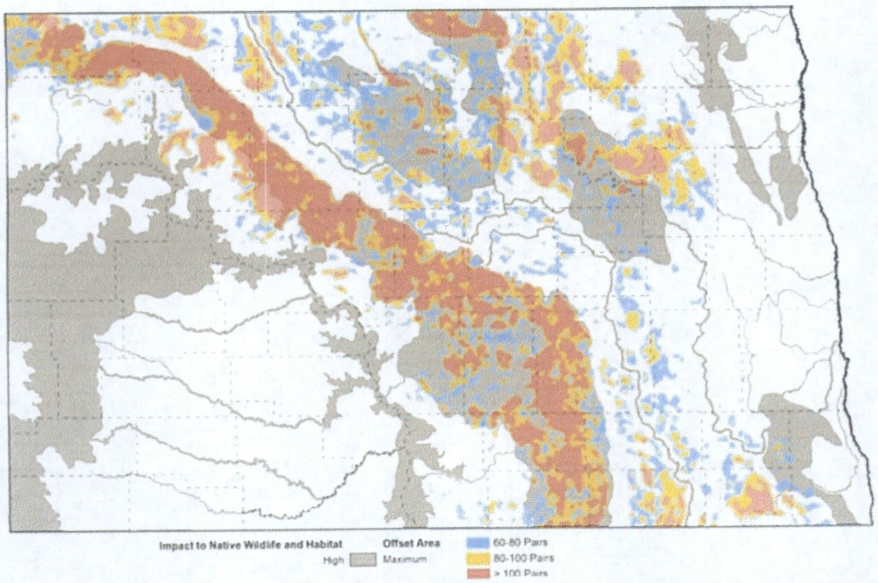

Figure B9. Intersection of the wetland dense areas and the SWAP Focus Areas/High Impact to Native Wildlife and Habitat..

Wetland areas that fall within the Focus Areas is classified as High Impact to Native Wildlife and Habitat. Wetland areas that fall outside the Focus Areas is classified as Medium Impact to Native Wildlife and Habitat.

Figure 3. Overlay of wetland density areas over Focus Areas with High Impact to Native Wildlife and Habitat.

The Nature Conservancy has recognized important ecoregions in United States. These areas represent the top U.S. places where native species and plant communities should be conserved. Figure 4 shows where The Nature Conservancy has identified in North Dakota where these important ecoregions are. Note that the Burke Wind project is squarely in one of the priority conservation areas in the northern portion of the Coteau.

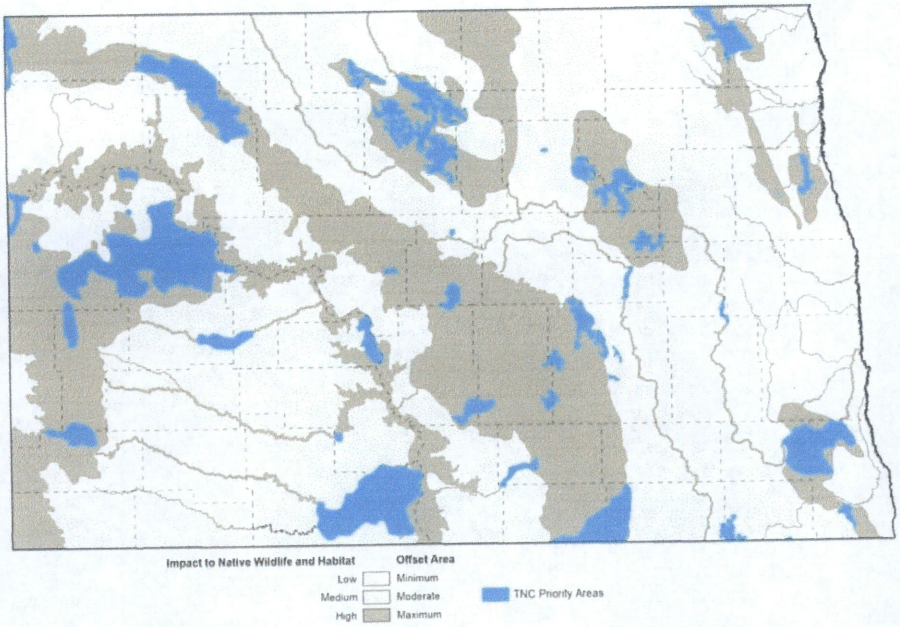

Figure 4. The Nature Conservancy identified areas in ecoregions throughout the United States that represent the top places where native species and plant communities should be conserved. This figure shows the top places in North Dakota. Spatial layers available: http://www.uspriorityareas.tnc.org

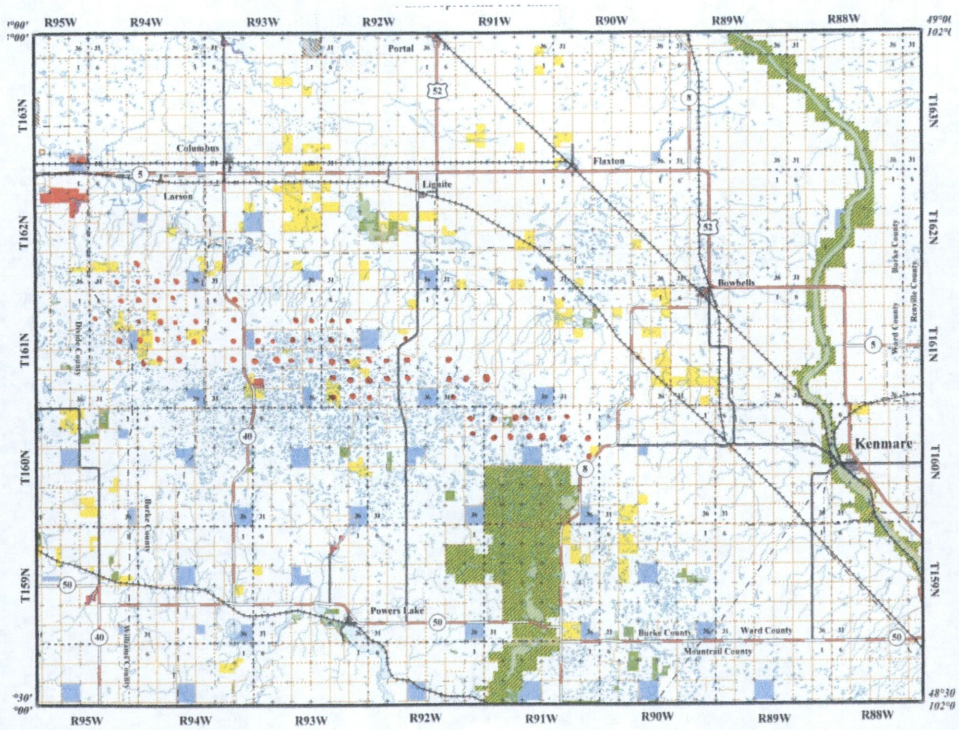

Figure 4. The Burke Wind project boundary goes from one township west of State Highway 8 west to Divide County. The red dots are section within the project's boundary identified by Burke Wind LLC, however, NextEra has dropped from the Project Area everything east of the blacktop road – road between Powers Lake north to Lignite. Subsidiary of NextEra Energy Resources LLC (Juno Beach, Florida). The large green area in the lower center of this figure is Lostwood National Wildlife Refuge.

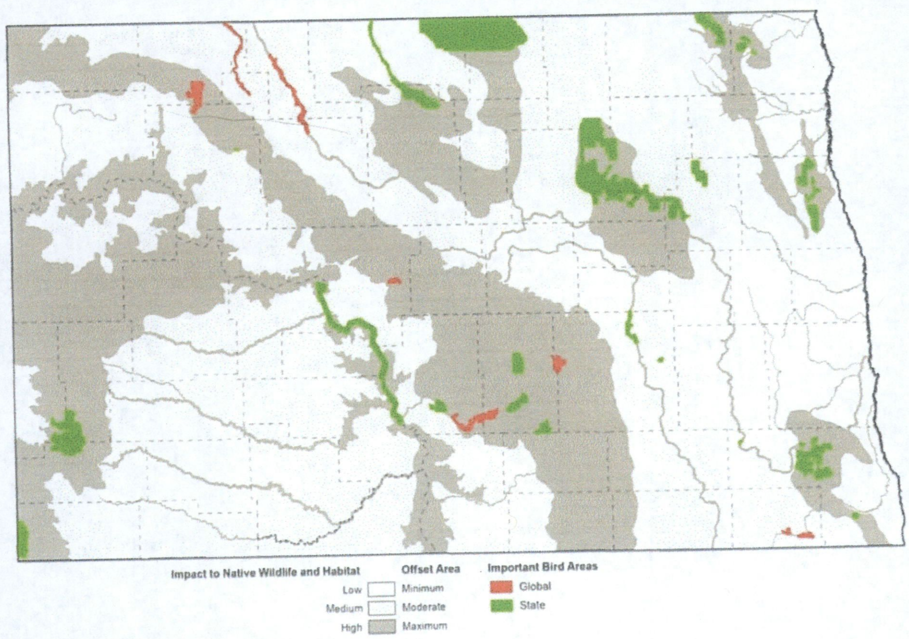

Figure 5. BirdLife International has identified over 12,000 Important Bird Areas. These sites represent some of the most important places for birds at the global or regional level. Lostwood is one of Global importance. (http://www.arcgis.com/home/item.html?d=af5fe0b13bae4f8297700345d27201fa).

The Burke Planning and Zoning Commission's 2016 Plan stresses on page 17 page, Goal G:

> "Public lands are generally existing lands established and sited for a variety of environmental, historical or cultural reasons. They may include parks, wildlife refuges, state-owned land, recreational areas such as golf courses, and the like. **When considering development near public lands, it is important to protect from loss of the characteristics which made the site originally desirable as a public land.**"

Not only will Lostwood character be compromised, there is the Lostwood Wilderness Area on the north side of Lostwood. Even though NextEra has moved the east boundary of the Project area six miles west of Lostwood and its 5,000-acre wilderness area, the towers will still be seen. The standing towers above the topography of the landscape will lose the CHARACTER of the desirable public land when viewing north into a spinning industry of turbines. Our own Burke County Planning and Zoning Commission recognized the importance of these public lands and their character. The character of a wide open prairie landscape will be lost.

Natural resource government agencies that have high regard for the Coteau's natural resource are North Dakota Game and Fish, and U.S. Fish and Wildlife Service.

- The **North Dakota Game and Fish Department** (NDGFD) is required by stature authority to protect, conserve, and enhance fish and wildlife populations and their habitat for sustained public consumptive and non-consumptive use.
- The **U.S. Fish and Wildlife Service** is required to follow their mission of "…working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people."

Each agency developed voluntary guidelines for wind projects to reduce impacts to wildlife and their habitats. Neither agency is politically allowed to oppose wind projects. NDGFD has identified in their ND Draft Guidelines for wind projects, species of conservation priority. A three tier Level of concern was developed: Level I-High, Level II-Moderate, and Level III-Low. Many species found in the Coteau are in Levels I and II (details of specific species are in the ND Draft Guideline).

USFWS guidelines express: "As the United States moves to expand wind energy production, it also must maintain and protect the Nation's wildlife and their habitats, which wind energy production can negatively affect" (USFWS Guidelines, p 1). USFWS guideline uses "tiered approach" for assessing potential adverse effects to species of concern and their habitats…. During the pre-construction tiers (Tiers 1, 2, and 3), developers are working to identify, avoid and minimize risks to species of concern….The tiered approach provides the opportunity for evaluation and decision-making at each stage, enabling a developer to abandon or proceed with project development…."

Coteau Landscape Importance:

- North Dakota's crucial habitat core areas are essential to sustain wildlife and species of conservation priority for the future (ND Draft Guidelines p.45). The Missouri Coteau is one of the more intact remaining endangered grassland ecosystems.
- These are valuable resources not only for wildlife but for the ranching community in Burke County.
- The Project Area in central Burke County has been highly prized as extremely important to native grassland wildlife by many natural resource interested people and organizations.
- North Dakotans and non-resident people come to hunt, bird watch, and enjoy the open, rolling grasslands dotted with wetlands in North Dakota. These resources are a very important economical asset to North Dakota's ecotourism.

The Burke Wind Project Area is squarely in the middle of some of the larger remaining native grassland tracts found on the Coteau! *This project needs to be abandoned.*

Wildlife Species of Concern in Burke Wind Project Area

The Coteau's grassland wildlife diversity is stunning. NDGFD conservation priority listing contains species that are unique to this region's northern mixed-grass prairie. Many are the little brown birds that are seen flitting about in the grasses, their songs often the best way to identify them.

These seemingly insignificant species sought by people all over the world to see include Baird's sparrow, grasshopper sparrow, LeConte's sparrow, Nelson's sparrow, bobolink, chestnut-collared longspur, Sprague's pipit, western meadowlark, and others. Birds of prey include Ferruginous hawk, Swanson's hawk, and northern harrier. Sharp-tailed grouse population in the Coteau is some of the highest in North Dakota. Grouse are sought after during the hunting season by North Dakota hunters, and hunters from other states. There are more species of concern, just not all listed right here but can be found in the ND Draft Guidelines.

All of these species are species of conservation concern due to depleting habitat either by direct loss of habitat or by fragmenting what is left.

The abundance of these species on the Burke Wind Project Area will be similar to what has been documented on Lostwood because Lostwood is in the same Coteau six miles southeast of the Project Area. Various studies on Lostwood had all the species of conservation concern present.

> Six of the species of conservation concern shown above—Baird's sparrow, grasshopper sparrow, bobolink, Sprague's pipit, western meadowlark, and Le Conte's sparrow—are well represented on Lostwood (Green 1992, Madden 1999, Madden 2000, Winter 1999, Murphy and Smith 2007).

Each species selected their preferred grassland habitat, habitats like that found on the Burke Wind Project Area.

Livestock operators in the project area maintain these grasslands for their livestock. Ranchers keep these grasslands healthy for their livestock through their management which also promotes quality grasslands for wildlife (Messmer 1990, Buskness et al. 2001, Danley et al. 2004). Defoliating the grasslands creates habitat diversity, critical for these grassland passerines and maintenance of grasslands (Kerns et al. 2010). For example, Sprague's pipits decline quickly as visual obstruction increase while Baird's and grasshopper sparrows prefer a little more visual obstruction. On the other end of the visual obstruction spectrum is the Le Conte's sparrow who selects the tallest and densest grassy habitat (Madden et al. 2000). All of these habitat conditions are present and maintained with defoliations conducted by private livestock operators on their rangelands found in the Burke Wind Project Area.

One species, the Baird's sparrow, has a very restricted range that includes most of North Dakota, northeastern Montana and portions of southern Alberta, Saskatchewan, and Manitoba. That is it, nowhere else does it breed. The Burke Wind Project Area is within this species breeding range. This species does move about within its range based on vegetative conditions and amounts of precipitation to find its preferred and yet varied breeding habitat structure (Dechant et al. 2003). Baird's sparrow where defoliation was frequent on Lostwood had a density from 6.9 males/100 ha to 20 males/100 ha (Winter 1994, Winter 1999), some of the higher densities recorded.

Other species of concern with similar restricted breeding ranges is Nelson's sparrow and Le Conte's sparrow, both species found on Lostwood and currently on private lands within the project area.

The Burke Wind Project Area also harbors one of the best duck breeding habitats in North Dakota. From the U.S. Fish and Wildlife duck pair data calculated each year, this project area has one of the highest breeding pair numbers.

The proportions of sections with pair values > 100 pairs is 8 times higher than proportion of sections with the same pair values elsewhere in North Dakota.

Within the Burke Wind Project Area, using the same duck data, pintails—a species of concern—has pairs numbers about 3.8 times greater in the Project Area compared to the sum of all count areas in North Dakota.

The late summer and fall use by ducks is important in the Coteau, including the Burke Wind area. As the young of the year mature and begin flying about, they move from wetland to wetland and to stubble grain fields. Wind turbines will be in their flight paths as they fly about up over hills into the next wetland.

The Burke Wind Project Area also harbors a diversity of nesting shorebirds and other wetland birds, as documented in the same habitat type on Lostwood (Lostwood's 1981 Annual Refuge Narrative and refuge files, Smith *in draft*). Wetlands are predominately the reason most of these birds are here. Many of these species use the uplands for nesting and wetland edges to raise their young. These include American avocet, Wilson's phalarope, yellow rail, marbled godwit, willet, and upland sandpiper. Birds more directly dependent on wetlands are American white pelican, Franklin's gull, black tern, horned grebe, northern pintail, and American bittern. All of these species are of concern and all present in the Burke Wind Project Area.

There are piping plovers, a threatened species, that move through the Burke Wind Project Area in the spring and fall migration to arrive and depart their breeding habitat of alkaline wetlands. These birds nest both in North Dakota—including Lostwood— and into Canada. The Coteau is a very important migration corridor for these birds.

There are whooping cranes that use the wind's project area as their main migration route (Figure 6). This general map shown in Figure 6 has been further detailed for the most probable migration route these birds are taking. In a figure in Niemuth et al (2018)(Figure 3), the Burke Wind Project Area is centered in the landscape-level habitat used by migrant whooping cranes. *In fact, the centerline of the migration corridor from sightings is centered through the Burke Wind Project Area*!

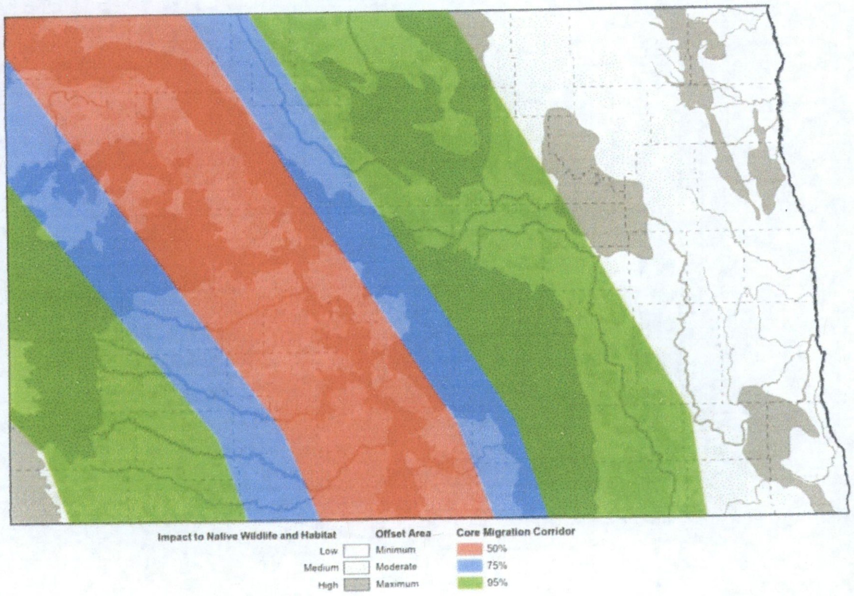

Figure 6. Whooping crane migration corridors were delineated using opportunistic sightings and location data from telemetered birds. The migration corridors are well defined and include 50%, 75%, and 95% core corridors (Pearse et al. 2018). Spatial layer available: https://www.sciencebase.gov/catalog/item/5a314a72e4b08e6a89d707e0

There are also golden and bald eagles that migrate along the Coteau, following the waterfowl migration path. Even reptiles, such as the smooth green snake, are a concerned species that lives in the Coteau's grasslands. It is on Lostwood it will be in the wind Project Area.

There are also moose, mule deer, and white-tailed deer that are throughout the Burke Wind Project Area. Moose are a species of concern in United States.

Of specific concern is that this stretch of the Coteau has some of the highest elevations along this glacial feature. Towers will be placed on some of these highest elevations square in the middle of the migration path that will adversely affect migrating birds and bats.

One of the remaining states to retain sharp-tailed grouse in good numbers is North Dakota, a core area with 30.9% of the global population (ND Draft Guidelines).

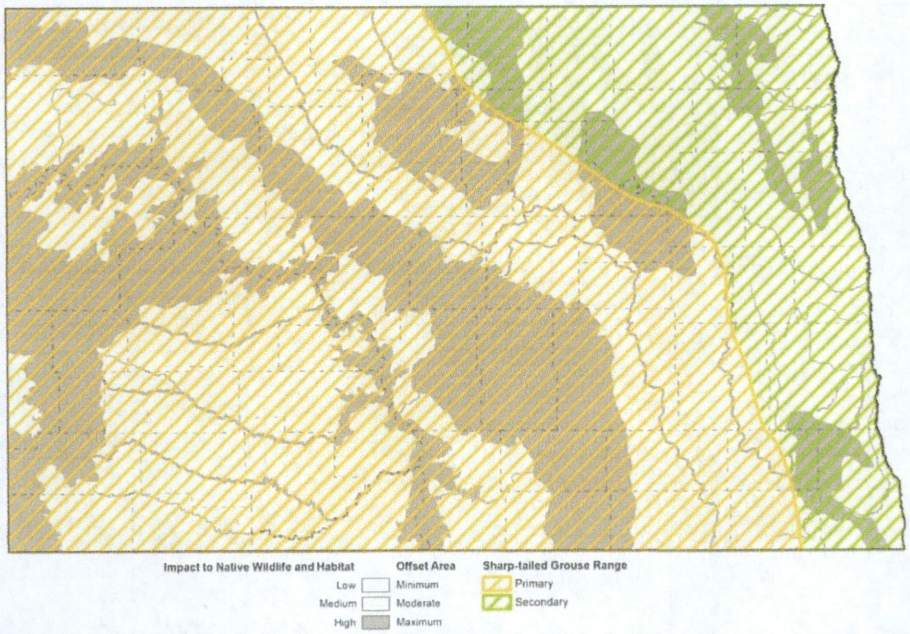

Figure 7 (copied from Figure C8 of ND Draft Guidelines). The sharp-tailed grouse is found across North Dakota, but abundance increases from east to west. The majority of leks will be found on grasslands within Medium and High Impact to Native Wildlife areas that includes the Coteau. Spatial layers available: https://gf.nd.gov/maps/data

The Burke Wind Project Area has not identified all dancing grounds within the project area. On Lostwood's 26,900 acres during years 1978 to 1992 when annual precipitation average about 16.5 inches, the range of dancing grounds was from 32 to 44 that averaged 36/year. In years 1993 through 2001, the average annual precipitation increased significantly to 21.93 inches. This increase adversely affected the number of leks each year by 4 to 6, averaging about 4 fewer leks compared to the previous normal annual precipitation. The number of males on leks also decreased but minimally, averaging about 3 fewer males.

Table 1. The number of sharp-tailed grouse dancing grounds (leks) and males/lek on Lostwood National Wildlife Refuge from 1978 through 2001 (Lostwood files). The 1978 through 1992 represents years with the average precipitation records that began in the mid-1930s of 16.5 inches, while the 1993 through 2001 represents significant annual increases in average annual precipitation to 21.93 inches (Smith *in draft*).

1978 though 1992	1993 through 2001

# of leks		# of males/lek		# of leks		# of males/lek	
range	ave.	range	ave.	range	ave.	range	ave.
32 - 44	36	10 - 27	18	26 - 40	32	12 - 19	15

What significance does this information have regarding the Burke Wind Project Area. The Project Area, based on information given at the Public Hearing Zoning Change on July 10, 2018, this Project Area encompasses approximately 50,560 acres. The project map given at a July 17 Burke Planning and Zoning Commission meeting shows only 24 leks.

We know all the leks have not been found on the Project Area.

We know it is hard to find all dancing grounds, taking 2 or more springs to find them. Most leks remain in at one site for several years but they do move about based on land use. On sections with annual crops present, there will be fewer leks, and leks with smaller number of males, often only 2 to 6 (based on experience from a member of the Coteau Preservation Alliance when searching for and counting males on leks in croplands for NDGFD).

A couple of accusation:

- has there not been enough time spent to find all the grouse leks?
- NextEra may not want to find all leks because of the ½ mile radius around each lek without turbines--a protection for grouse NextEra chose to follow although ND Guidelines suggests a 2 mile buffer.

The northern mixed-grass prairie and its wetlands provide valuable grassland resources. This prairie—a large part of the state's valuable natural heritage and culture—contributes significantly to ecotourism that includes hunting by locals and non-residents bringing in revenue for local town communities.

The Burke Wind LLC Project Area harbors all these habitats and wildlife species in abundance. The Coteau provides all who live here or visit with abundant grassland, wetlands, and its wildlife. We live in some of the best of the best that has survived. This future loss is very concerning to us and others.

Potential Adverse Effects to Coteau's Grassland, Wetlands and its Wildlife with Burke Wind LLC Project Area.

When the diversity of grassland habitats and wildlife on the Coteau is fully realized, the grassland and wetlands that remain are some of the best of the best! The Coteau has some of the most grassland blocks across North Dakota's landscapes. The Coteau has the largest intact wetland densities across such a large landscape of anywhere else in North Dakota, thus the reason why NDGFD recognized this landscape as a Focus Area of High value!

Habitat fragmentation is described as the process of dividing large tracts of contiguous native habitat into smaller, disconnected pieces. Habitat fragmentation results in an increased number of small habitat patches, isolated by a matrix of human altered land cover (Haddad, 2015). Breaking habitat into smaller pieces also increases the amount of edge, and animal behavior can be influenced by these "edge effects" (Lidicker 1999; Ries et al., 2004; Batary and Baldi, 2004). This reduction of habitat and connectivity and increase in edge effect has been shown to lead to a loss in biodiversity (Wilcox and Murphy, 1985; Fletcher et al., 2007). This is especially concerning when coupled with the fact that there is still substantial wind potential desired developed by the wind industry in North Dakota.

The Missouri Coteau has been identified as a Focus Area of High value. In the Burke Wind Project Area there are large tracts of land without significant roads (2011 Burke County Plat Book & Directory www.greatplainsdirectory.com). Townships that have four or more sections without marked roads are Harmonious, Clayton, Dimond, and Foothills. There are fewer and fewer large tracts of native mixed-grass rangelands left on the Coteau. These large, rural tracts need to be protected from further **fragmentation and destruction**.

There is direct loss to this valuable habitat due to new and widening roads to 38 feet (stated at the August 1, 2018 application request to the Burke Planning and Zoning Commission), but likely wider in some locations. Destruction will occur with concrete pads for wind towers, other infrastructure needs, and so called temporary loss when roads are widened to accommodate the tower parts to arrive at their locations. (Once the native grassland is torn in this way, this is a permanent loss, not temporary.) *This valuable grassland resource with such large tracts and other native grassland areas just cannot be lost*!

It is commendable that NextEra is proposing collection lines underground. This greatly reduces overhead line wildlife collisions on these open grasslands, although there are above ground transmission lines transporting power from the Project Area. Unfortunately, native sod will be torn apart from heavy equipment pulling the trencher across the landscape.

The Project Area is within prime ranching country. When trenching activities split open and tear the sod apart for line placement, there will also be rocks pulled up, leaving sod upturned and holes in their place. Holes left where rocks once were is of grave concern for livestock operators because livestock can step into these small, hard to see areas, injuring their legs, hips and shoulders.

The trenching across the landscape increases weed infestation which the land owner will end up having to control over several years, if it is ever totally resolved. Additional land disturbance that will increase weed problems include gravel—brought in from gravel sites that likely will have such weeds as leafy spurge— for roads and for tower sites. Equipment brought to construction sites can have weeds on the equipment itself, bringing in other weeds to pristine areas. Additional pesticide use will likely be used to reduce invasive weeds brought in by these invasive activities. All of these activities add additional disturbance to wildlife and cost to the landowner that would not happen if the wind project was abandoned.

There will be dust from construction and maintenance of turbines and other facilities, and chemical spills during construction. NextEra estimated on August 1st Burke Planning and Zoning Commission meeting that there will be 50 vehicle travel/days of increase traffic on the roads due to the Burke Wind maintenance. All of these activities will increase dust accumulation that will reduce grassland and habitat quality for wildlife and for livestock.

NextEra has located some of the grouse dancing grounds. All leks need to be found in the Project Area. They have put a ½ mile buffer from turbines around leks, although ND Guidelines suggest a 2 mile buffer. The buffer is helpful but their upland habitat will still be fragmented by roads and the turbines themselves, vertical structures that grouse are not very tolerant of.

There is direct loss of grouse habitat from road building, turbine construction sites, and collection line trenching, and the disturbance during construction and maintenance activities. There also is indirect loss that happens over time by a trend of increasing avoidance.

> For eight grassland birds in a North and South Dakota study of mixed-grass prairies, of significant turbine effects indicted displacement at 100m, 100-200 m, and 200-300 m. Shaffer and Buhl (2016) found that *the first year post-construction displacement was relatively low, but reached up to an average of 55% at 5 years for certain bird species* (Shaffer, J.A., Loesch, C.R., and Buhl, D.A., *in prep.*).
>
> Grassland birds and waterfowl exhibit avoidance of wind turbines in studies in the Dakotas within the Prairie Pothole Region (Loesch et al. 2013, Shaffer and Buhl 2016). Loesch et al. (2013) demonstrated that five species of dabbling ducks exhibited an average decline of 20% after the erection of turbines on one wind farm.
>
> A species very sensitive to having large tracts of native grassland, the Sprague's pipit (Davis et al. 2006), likely will decline with fragmentation of the native grassland tracts.
>
> Roads exacerbate habitat loss, affecting grassland birds (Wellicome et al. 2014).
>
> Bairds sparrow are even more sensitive and a Species of Conservation Concern. This is a species with an extremely restricted breeding range in North America that occurs in the Project Area. This species avoids roads (Koper and Schmiegelow 2006, Sliwinski and Koper 2012, Wellicome et al. 2014, Ludlow et al. 2015, and Nenninger and Koper 2018). Baird's sparrow abundance was over 16 times lower on roadside point counts than on off-road point counts (800 meters from the nearest roadside count) (Wellicome et al. 2014).
>
> Bobolinks avoided roads within 150 meters (Thompson et al. 2015). Grasshopper sparrows displayed a strong avoidance of building nests in roadside edges cut through native prairies (Patten et al. 2006, 2011). Western Meadowlarks were also negatively related to distance to roads (Koper and Schmiegelow 2006).

Noise is another concern. There is a buffer of 1.2 km as setback to the rural residencies for protection from noise and health affects to people for a maximum sound of 50 decibels. There is no protection for wildlife at and around where the turbine for noise disturbance, which does not include the inaudible low-frequency and infra sounds the turbines produce—this is also not taken into consideration for people!

The turbines themselves are of grave concern for flying wildlife. For example, one turbine site we are aware of is immediately above a wetland used each late summer and fall by hundreds of ducks. Where the turbine is being proposed is directly in the flight path for these ducks as they fly about from wetland to wetland and to harvested grain fields adjacent to this wetland.

There are other areas that will be similar or even worse. Turbines intermingled with the abundant wetlands in the Coteau is a disaster waiting to happen—whooping cranes, waterfowl, shorebirds, and other water depend birds such as white pelican, bald eagles following the waterfowl migration—all species and more that follow the Coteau during spring and fall migration. This does not include the breeding bird life in the Project Area that will have to maneuver around, through, over turbines, or eventually abandon the Coteau as a breeding site due to these obstacles (scientific citing in section above).

NextEra has completed some wildlife inventories and surveys, although we have only seen their dancing ground locations and raptor nesting sites shown on their issued map dated July 11, 2018 but nothing else. Each year's wildlife surveys will vary from year to year due to precipitation, defoliation events, temperatures, cold springs and much more. Completing only one or two years of breeding bird transects may not reveal all species presence. Not all these species may be seen every year because changes in temperature and precipitation from abundant to scarce that alters the vegetation habitat structure from year to year. Grassland bird species are nomadic and go where the condition are right but they will occur somewhere in the ecoregion where their preferred grassland habitat needs are met.

We, the Coteau Preservation Alliance, are proud of what we have and do not want this destroyed!

The Coteau: off limits to Wind Projects

What is being proposed by NextEra Energy will have negative impacts on the Coteau in Burke County. Negative impacts, both direct and indirect, that comes from fragmenting these large grassland tracts with turbines, roads, transmission lines, and increased human activities.

The entire stretch of the Missouri Coteau is likely targeted for additional wind projects by perhaps NextEra and other wind companies. Thus, these projects should not be evaluated individually but instead evaluated for those existing, proposed and those in the future. If this project is completed as planned, this could set a precedent for the remaining portions of the Coteau where large tracts of native grasslands still remain, **a valuable endangered ecosystems.**

The Coteau's native grasslands, wetlands and associated wildlife found here are way too valuable to destroy by allowing the Burke Wind Project Area to continue. Please stop this wind project to prevent destruction of our beloved Coteau and its native grasslands and wetlands!

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II. Adverse Health Effects to People Living Near Industrial Wind Turbines

In the Burke County Roadmap to the Future Comprehensive Plan, Goal B (page16) states "Protect Existing Development from Nuisances/Conflicts."

The World Health Organization (WHO) defines health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity."[2]

Some proponents to industrial wind turbines (IWTs) say that there just are not that many health complaints from people living near IWTs. Although opponents argue to the contrary, if true, one reason for that may be because people who have entered into a lease agreement with a wind company have to abide by a confidentiality agreement, also known as a "gag order" which does not allow them to talk about certain things[3] which may include health problems. The other reason may be that proponents just don't want to listen.

So who better to know about the health effects of the IWTs than the people who actually live or have lived by them? What follows is information gathered from just a few of many, many people who have had to endure living by industrial wind turbines.

The sounds produced by IWTs are: (a) the audible components; and (b) the inaudible components, known as infrasound, low-frequency sound and vibrations. Of the sounds that can be heard, people who have lived near IWTs complain about the actual noises made by the turbines, but especially the whooshing. "The pulsating noise, characteristic of wind turbines, can be more intrusive than other types of noise...."[4] People who live by IWTs talk about how the whooshing never seems to stop and when it does they are always anticipating when it will start up again.

There are many health issues which include, but are not limited to dizziness, nausea, tinnitus, bad headaches/migraines, depression, anxiety, racing pulse, heart palpitations, difficulty with memory and concentration. "Sleep disturbance is by far the most common complaint of families living near wind turbines. Prolonged lack of sleep affects our capacity to learn and negatively affects our memory, temperament, heart health, stress levels, and hormones that regulate growth, puberty and fertility. It can also lead to high blood pressure, changes in heart rate, and an increase in heart disease, as well as weight gain and lowered immunity to disease. These symptoms have regularly been reported by individuals who live near IWTs."[5]

This family's experience was similar to others living by IWTs:

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[2] Constitution of World Health Organization, *Basic Documents*, Forty-fifth edition, Supplement, October 2006 [http://www.who.int/governance/eb/who_constitution_en.pdf]

[3] Better Plan, Wisconsin, Badgers for a Better Renewable Energy Plan [http://betterplan.squarespace.com/todays-special/2011/5/28/52911-oh-thats-what-a-wind-lease-gag-order-looks-like-and-co.html]

[4] Frey, B.J., and Hadden, P.J., January 2012. Wind Turbines and Proximity to Homes; The Impact of Wind Turbine Noise on Health, a review of literature and discussion of the issues

[5] Punch, J. and James, R., November 11, 2014, The Negative Health Impact of Noise from Industrial Wind Turbines: The Evidence [https://hearinghealthmatters.org/hearingviews/2014/wind-turbine-noise-evidence-health-problems]

"They were noisy immediately, blades 'whooshing' around ... if the wind is from the East, or the South, the noise is horrendous. You can't get away from the noise, where can you go? It's all around outside and you get it inside the house as well. It's worst during the night, I have to "bed hop" to get any sleep ... but it doesn't work ... This noise is like a washing machine that's gone wrong. It's whooshing, drumming, constant drumming, noise. It is agitating. It is frustrating. It is annoying. It wears you down. You can't sleep at night and you can't concentrate during the day ... It just goes on and on ... It's torture ... [4 years later] *You just don't get a full night's sleep and when you drop off it is always disturbed and only like 'cat napping.' You then get up, tired, agitated and depressed and it makes you short-tempered ... Our lives are hell."*[6]

One of NextEra's representatives at a zoning meeting indicated that 47 to 50 decibels was not a cause for concern; however, the World Health Organization in its 2009 Night Noise Guidelines for Europe study[7] stated:

"30 to 40 dB	A number of effects on sleep are observed from this range: body movements, awakening, self-reported sleep disturbance, arousals.... Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible....
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with the noise at night. Vulnerable groups are more severely affected...

For the primary prevention of subclinical adverse health effects related to night noise in the population, it is recommended that the population should not be exposed to night noise levels greater than 40 dB of $L_{night,outside}$ during the part of the night when most people are in bed. The LOAEL [lowest observed adverse effect level] of night noise, 40 dB $L_{night,outside}$, can be considered a health-based limit value of the night noise guidelines (NNG) necessary to protect the public, including most of the vulnerable groups such as children, the chronically ill and the elderly, from the adverse health effects of night noise."

To be able to better understand infrasound and how it affects us, the following is quoted from Nina Pierpont, M.D. and Ph.D.:

"The explanation may be tucked away in the inner ear in a cluster of tiny, interconnected organs with a remarkable evolutionary pedigree. The vestibular organs--the semicircular

[6]Frey, B.J. and Hadden, P.J., February 2007. Noise Radiation from Wind Turbines Installed Near Homes: Effects on Health, With an annotated review of research and related issues

[7] World Health Organization Night Noise Guidelines for Europe www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf

canals, saccule, and utricle–function as Mother Nature's gyroscope, controlling our sense of motion, position, and balance, including our spatial thinking. (Remember when you got carsick as a kid? Or seasick?)

Humans share these enigmatic organs with a host of other backboned species, including fish and amphibians. Some scientists indeed see them as a kind of pan-species master key for an extraordinarily broad range of brain function–amounting to a sixth sense.

One of those functions, it now appears, is to register and respond to the sounds and vibrations (infrasound) we don't consciously hear, but feel–as from wind turbines. For many people, the response is swift and disastrous.

Sometimes it's advantageous being a country doctor. Six years ago I began hearing health complaints from people living in the shadow of these gigantic turbines. At first it was merely local and regional, then global. Tellingly, virtually everyone described the same constellation of symptoms. Symptoms that were being triggered, I began to suspect, by vestibular dysregulation.

(1) Sleep disturbance. Not simply awakened, but awakening in a panic ("flight or fight" response).
(2) Headache
(3) Tinnitus
(4) Ear pressure
(5) Dizziness
(6) Vertigo
(7) Nausea
(8) Visual blurring
(9) Tachycardia
(10) Irritability
(11) Problems with concentration and memory
(12) Panic episodes associated with sensations of internal pulsation or quivering, which arise while awake or asleep. (This latter involving other, non-vestibular organs of balance, motion, and position sense.)

None of these people had experienced these symptoms to any appreciable degree before the turbines became operational. All said their symptoms disappeared rapidly whenever they spent several days away from home. All said the symptoms reappeared when they returned home.

Many had supported the wind farm project before all this happened. Now, some became so ill, they literally abandoned their homes–locked the door and left [emphasis added].

Taking my cue from a British country doctor who was reporting identical 'wind turbine' symptoms among her patients, I did what clinicians call a case series. I interviewed 10 families (38 people) both here and abroad, who had either left their homes or were about to leave. I found a statistically significant correlation between the telltale symptoms and pre-existing motion sensitivity, inner ear damage, and migraine disorder. Each is a risk factor for what I now christened Wind Turbine Syndrome. My data suggest, further, that young children and adults beyond age 50 are also at substantial risk.

The response from ear, nose, throat clinicians (otolaryngologists and neuro-otologists) was immediate and encouraging. One was Dr. F. Owen Black, a highly regarded neuro-otologist who consults for the US Navy and NASA on vestibular dysregulation.

Another was Dr. Alec Salt at the Washington University School of Medicine, who recently published an NIH-funded, peer-reviewed study demonstrating that the cochlea (which links to the vestibular organs) responds to infrasound without registering it as sound. Infrasound, in fact, increases pressure inside both the cochlea and vestibular organs, distorting both balance and hearing.

Salt thus effectively shatters the dogma that '*what you can't hear, can't hurt you.*' It can indeed hurt you. The growing uproar among wind turbine neighbors testifies to this inconvenient truth."[8]

http://en.friends-against-wind.org/testimonies/sick-since-a-wind-park-was-installed?fbclid=IwAR33nJS_JFx9L16xBwMPj15p98kg_b59e8jfL_xtfKzB39buQ-j9Wp-5Kqw

Sick since a wind park was installed

Unexplained medical emergencies and illness. As in the case of increased medical emergencies, accidents, and psychological symptoms with foehn (hot southerly winds on the northern slopes of the Alps), the same is true for residents near wind turbines.

en.friends-against-wind.org

"The adverse health effects of audible and inaudible noise are substantial. Their effects are underestimated and underappreciated…."[9] [emphasis added]

The industrial development proposal of wind turbines in the Coteau from the Burke Wind Project does not fulfill Goal B in the Burke County Comprehensive Plan: "Protect Existing Development from Nuisances/Conflicts."

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[8]Pierpont, N., MD, PhD, CounterPunch Magazine (10/31/10) "Inconvenient Truths: Wind Turbine Syndrome"
[9]Jeffrey, R.D., Krough C. and Horner, B., Adverse health effects of industrial wind turbines [https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3771715]

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Punch, J. and James, R., November 11, 2014, The Negative Health Impact of Noise from Industrial Wind Turbines: The Evidence [https://hearinghealthmatters.org/hearingviews/2014/wind-turbine-noise-evidence-health-problems]

World Health Organization Night Noise Guidelines for Europe [www.euro.who.int/__data/assets/pdf_file/0017/43316/E92845.pdf]

III. Industrial Wind Turbines Adversely Affect Property Values

In the Burke County Roadmap to the Future Comprehensive Plan, Goal A (page16) states "Protect Property Values."

Reporting on the decrease in property values due to industrial wind turbines is varied, but most do agree that there is definitely a decrease to some degree, depending on the proximity, as follows:

"Real estate and appraisal businesses maintain that wind power does affect property values. Michael McCann of McCann Appraisal, LLC out of Chicago said that 'residential property values are adversely and measurably impacted by close-proximity of industrial-scale wind energy turbine projects to the residential properties,' if they are up to 3.2 km [almost 2 miles] away. They decrease a property's value by 35 to 40 per cent."

"According to the London School of Economics, wind farms decrease property value by up to 12 per cent if the home is within a two km radius and can even affect a property's value up to 14 km [over 8.5 miles] away from the home."

"In fact, the Ontario Superior Court ruled in 2013 that landowners living near large wind farms suffer from lower property values. That court said it decreased property values by 22 to 55 per cent."[10]

[10] Joy, Lisa, Stettler Independent, Apr. 3, 2018, Wind turbines affect property values

"Once a lender gets wind of [the fact that there are windmills visible or adjacent to the project] (forgive the pun), they will not fund a mortgage," said Angela Jenkins, a mortgage agent at Dominion Lending Centres...."

"John Leonard Goodwin, who has been a real estate broker for more than 10 years in the Grand Bend, Ont. market, asserted that wind turbines absolutely do affect property values. 'Turbines complicate your property enjoyment, period,' he said. 'That alone spells depreciated value(s).'"

"Turbines should be in remote, unpopulated locations. To all the folks who have turbines on their property: Enjoy your $18,000 per turbine per year, because you will be giving most of the lease payments back (in much lower property value) when you sell."[11]

"SCOTS homeowners are seeing up to 50 per cent slashed from the value of their houses because of wind turbines, estate agents have warned.... It comes as the Scottish Government launches a study into the link between house prices and turbines, which experts say will show homes near wind farms are almost impossible to sell....Families across the country also claim they have been trapped in their homes for years because noisy wind farms put off potential buyers." (Allen, Victoria, Scotland Against Spin, Dec. 31, 2013, Windfarms make homes unsellable)

Even property which has high-voltage transmission lines could be affected by a decrease of 2.1% to 3.4% in property values.[12]

"Put simply, if you were to buy your future home, given the choice, would you buy where you would have noise, shadow flicker, an industrial view, potential health issues caused by the turbines, and the possibility of a very difficult resale, or would you spend your money elsewhere?"[13]

The industrial development proposal of wind turbines in the Coteau from the Burke Wind Project does not fulfill Goal A in the Burke County Comprehensive Plan: "Protect Property Values."

[11] Paterson, Jennifer, 18 Dec 2014, Industry criticizes wind turbine report
[12] Chalmers, J.A., The Appraisal Journal, Winter 2012, High-Voltage Transmission Lines and Rural, Western and Real Estate Values
[13] Paterson, Jennifer, 18 Dec 2014, Industry criticizes wind turbine report

IV. Liability Concerns for Landowners

Farmers' Guide to Wind Energy[1]

Page 5-8: "…any person who suffers harm caused by a wind facility will likely sue both the landowner and the turbine owner….the farmer should require that…the developer include a provision requiring the developer to carry sufficient liability insurance, to defend the farmer….[18]"

Page 5-13: "Tall objects on the landscape can cause interference with television, telecommunications, and radio reception by blocking or reflecting the signals. Commercial-scale wind turbines have been known to interfere with television reception…." [Nexrad radar used by the National Weather Service may lose accuracy for forecasting dangerous weather events.]

Page 5-23: "…if wetlands are damaged during the construction or operation of a wind project, even accidentally, it can have serious consequences for the farmer's future eligibility for federal farm programs…."

Page 5-24 through 26: Under various federal farm programs—Conservation Security Program (CSP), Environmental Quality Incentive Programs (EQIP), Wildlife Habitat Incentives Program (WHIP), Farmland Protection Program (EPP), Grassland Reserve Program (GRP), and Wetlands Reserve Program (WRP)—risks that a farmer might face as a result of using enrolled land for a wind project could include:

- "…loss of eligibility for future payments…
- … demand for return of all payments…
- …fines…
- …and ineligibility for other farm programs."

NDSU Extension Service, 2009 "Wind Turbine Lease Considerations for Landowners"[2]

"**U.S. Department of Agriculture's** Farm Service Agency **mortgage restrictions**: Any land with a FSA mortgage needs an extensive approval process." Page 7

"U.S. Department of Agriculture programs: Approval may be needed from the U.S. Department of Agriculture if the land or landowner is involved in …: Wetlands, CRP, Commodity program payments, Swampbuster provisions, CSP, EQUIP, WHIP, FPP. GRP, and WRP." Page 7

Forensic Appraisal Group, Ltd. puts it this way:

"Through our research **we've interviewed dozens of Realtors** because they have nothing to gain by taking sides on this debate, making them perfect barometers of the public's perception of wind turbines and their effect on property values. After all, a Realtor's job is to sell. If the market says a house with polka dots sells less than a house with a single color scheme, **a good Realtor adapts to the public's perception of value** and discounts the polka dot house accordingly **to make the sale.**

So what do most Realtors think of a property that once had an attractive viewshed but now looks at wind turbines? According to our research, **an overwhelming majority of Realtors says that wind turbines negatively impact property value**. They estimate the range of impact to be **from a 10% price reduction to being completely unsellable**."14[1]

Morrison, L. 2012. National Wind Watch: Five Questions to ask before signing a wind…

Affect to farm operations: "The lease clearly state your rights to use the land for farming, grazing, development of subsurface minerals, hunting or other uses…."

Affect to farm operations, efficiency and production: turbines and access roads soil compaction and changes field configurations, field-drainage patterns may be altered, grazing land fences, gates may have to change, aerial crop spraying will be an issue, and winter snow removal on access roads may pile snow delaying or preventing planting, or access to pasture with fences destroyed by the snow piles.

Types of wind-power property agreements that can harm a farming/ranching operation when easements in the contract are not carefully reviewed, understood, and stated: access, construction, transmission, wind non-obstruction, overhang or encroachment, noise, covenant, and leases. Some of these provisions can end up giving exclusive property rights to the tenant— the wind developer.

Landowner fears about developer will default or dissolve leaving reclamation to landowner. North Dakota has a relatively weak reclamation law …"permits turbines to stand idle so long that the company could be long gone."

Problems with wind lease renewal because landowners may not have a say.

[1]Shoemaker, J.A. 2007. Farmers' Guide to Wind Energy, Legal Issues in Farming the Wind. Farmers' Legal Action Group, Inc.
Farmers' Legal Action Group, Inc. (FLAG)
360 North Robert Street, Suite 500
Saint Paul, Minnesota 55101-1589
Phone: 651.223.5400 Email: lawyers@flaginc.org Web site: www.flaginc.org

[2]Aakre, D, and R. Haugen. 2009. Wind Turbine Lease Considerations for Landowners. NDSU Extension Service, North Dakota State University: 8 pages.

14[1] Forensic Appraisal Group. Ltd., Do Wind Turbines Affect Property Values? [https://www.forensic-appraisal.com/wind-turbines]

V. Reclamation

We in Burke County have had experience living with the aftermath of a coal mine located 4 miles south of Columbus without reclamation. In 1930 the Baukol-Noonan coal mine opened as one of the first to develop strip mining. The mining operation covered 1040 acres and the vein which was 7-9 feet thick was beneath 30 feet of soil.

Huge hills of earth was tossed up by the giant steam shovels, spreading man made hills and valleys in a fan like design. The dragline created depths often exceeding 40-50 feet which radically changed the topography.

This land was not reclaimed until 1978 following the Improvement in reclamation practices as a result of the 1977 Federal legislation.

The original contract stated reclamation can be accomplished. However it is recognized a good reclamation plan must be developed and implemented for complete success.

This wording could be accurate today related to the Wind Farm planned for Burke County. Where are we going to be in 20 years when it comes time for decommissioning the wind turbines. One big question is how much money is being set aside for the inevitable decommissioning with removing aging, unprofitable and just plan warn out turbines. Are we going to see our country side full of rusty, teetering and fallen wind turbines?

VI. Local Comments and Thoughts

Comment from a resident living in the Project Area: Burke County Planning and Zoning Commission and/or Burke County Commissioners and/or officials did not follow their own December 2016 approved plan. What happened? Highly likely money and gifts were presented to the town and county people who buckled under, betraying their rural residents.

The "Burke County Roadmap to the Future Comprehensive Plan of December 2016" expresses concerns for retaining the rural stature: page 14

> "Rural Lands are lands located throughout the County which have very low density development and are used primarily as open space or for agricultural purposes. They are typically located outside of existing residential developments or subdivisions. **These lands should be encouraged to remain rural in character. Uses which promote increased levels of traffic or need increased levels of government support should be encouraged not to develop in rural areas."**

WHAT HAPPENED AFTER THE COMPLETION OF THIS PLAN? Our county leadership decided to change what they wrote in 2016 and decided for development of rural areas without rural resident input. This is betrayed of—keep the rural character with limited traffic and to not encourage develop in rural areas--by our Burke County leadership to their rural neighbors!

There are fewer than a dozen county leaders making decisions for rural people who live in the project area. This is poor representation for the affected people. How many people who were supportive of the wind project actually reside in the Project Area?

One county in North Dakota recognizes and values their rural residents. Divide County has established a 3-mile setback of turbines for residencies (Ordinance 7.13.5a).

The unfortunate thing that has happened to rural western North Dakotans who live on the land is it has become common for commercial industries to push their way through because rural is not populated as cities and towns. We are being taken advantage of because we do not have the numbers of people. The agriculture community is what created and keeps North Dakota going economically. To abandon this community and give in to political moves and pushes from industries is abusive to many farmers and ranchers whom may, and have been, adversely affected by such development.

Comment from another resident living in the Project Area: I went online and read the Burke County Roadmap to the Future Comprehensive Plan of December 2016 that expresses concern for retaining rural stature. This is the plan you use as a guideline before you make your decisions. It states:

> "Rural Lands are lands located throughout the County which have a very low density development and are used primarily as open space or for agricultural purposes. They are typically located outside of existing residential developments or subdivisions. These lands should be encouraged to remain rural in character. Uses which promote increased levels of traffic or need increased levels of government support should be encouraged NOT to develop in rural areas."

By allowing a wind farm to be built in Burke County it will definitely increase traffic especially during the construction phase of the project. It will also add to the need increased levels of government support. Examples are increased law enforcement, adding to the work load of our volunteer fire departments and ambulance squads. It may also have a huge affect on our county road crews. If NextEra are to be tax payers in Burke County I assume they would have the right to ask for snow removal to get access to their turbines. Some of the roads they will be using are minimum maintenance roads that are never opened from the first snowfall to the thaw in the spring. Will the county and townships be forced to keep these roads open? I have lived near the hills for 52 years and I can tell you that it is a whole new ball game when dealing with snow removal during years when we have had excessive amounts of snow and wind. And I might add, very costly!

Because we are a sparsely populated community we are being taken advantage of by a commercial industry that in my opinion does not care how it will affect our way of life. Several of the people that signed leases with this company don't actually live in the project area. Many of them live out of the county and even out of the state. Agriculture is the backbone of the economy in this state. It has been in the past and it will be in the future. We need to protect the land and our rural community.

On page 16 of your comprehensive plan under Goals, Objectives and Policies: Goal A is to protect property values. Real estate and appraisal businesses maintain that landowners living near wind farms suffer from lower property values. They may see a decrease of 35 to 40 % in property value.

Also in the Burke County Comprehensive Plan on page 17 it states:

> "Public lands are generally existing lands established and sited for a variety of environmental, historical or cultural reasons. They may include parks, wildlife refuges, state-owned land, recreational areas such as golf courses and the like. When considering development near public land, it is important to protect from loss of the CHARACTERISTICS which made the site originally desirable as a public land."

We have waterfowl production areas, a National wildlife refuge, state school lands and state game management areas within the project boundary. If a wind farm is built near these public lands it will change the characteristics of the landscape. People will not be able to enjoy the beauty of a prairie vista without viewing an industrial field of wind turbines.

What this all boils down to is QUALITY OF LIFE VS MONEY. There are 9 or 10 people making this life changing decision for everyone in the county— as well as for future generations. This is a tremendous responsibility. I ask that before you make this decision that you take your time and think it through and not let NextEra push you into making a snap decision. If you were to take a poll or have a vote of the people I believe the citizens of Burke County would choose quality of life over any monetary benefit they may or may not receive.

A yes vote is contrary to everything in your comprehensive plan. Therefore I urge you to vote no on the construction of a wind farm in our county.

Comment from yet another resident living in the Project Area ....As far as I know, wind does not take precedence over the surface owner's rights. People seem to think the wind energy has the same rights as the oil and cannot be told "no," but the surface owner can say "no" to a turbine on the land they own....The other thing I thought of is that the natural resources and wildlife protection are the ideas that have to be emphasized heavily. If we can get across that it is important to protect this area as if it is as valuable as a national park or a state park....The county and the state have to think about being good stewards to preserve our native grasslands, our wildlife, our teepee rings and the history of this area.

Other thoughts

Damage to lands when trenching for the collection lines occurs. When these trenching machines split open the soils for line placement, there will be rocks hit. This leaves upturned topsoil and even holes where the rocks once were. This increases the weed infestation problems and increases the chances of cattle and horses getting injured by stepping into one of these holes. It will also cost the ranching community time and money to overcome damages.

VII. Issues to Contemplate

Fire Danger

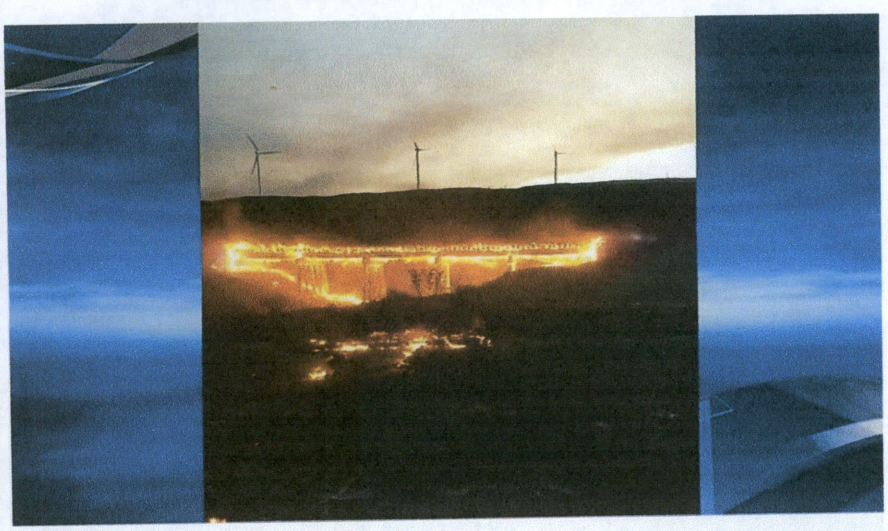
This happened in Arlington, Oregon on August 2, 2018. A wind turbine caught fire, sparking a 2,000-acre wildfire. Two railroad bridges burned before it could be put out. Article by KATU.com Staff, Friday 3rd 2018.

.RLINGTON, Ore. — A wind turbine caught fire Thursday, August 2, 2018 sparking a 2,000-acre wildfire, ccording to the North Gilliam Rural Fire Protection District.

he turbine was on Rattlesnake Road and, according to firefighters, the fire jumped Highway 19, closing the oad.

irefighters got the fire out but not before two railroad bridges were burned.

lo evacuations were needed.



A railroad bridge burns Thursday night, Aug. 2, 2018 in Arlington, Oregon. Firefighters said a wind turbine caught fire, sparking a

Jobs

How many construction and/or permanent jobs will actually be awarded to "locals", or will NextEra bring in all their "own" people or people from a different state or local?

Please consider reading this website: http://gatehousenews.con/windfarm/home/

It contains information on all aspects of wind farm industries tactics and health effects. Basic headings are:

WIND INDUSTRY DENIES CLAIMS

A BOOMING INDUSTRY

INCENTIVES AND MANDATES
Two factors fueled the boom.

FORCED TO MOVE
Hundreds of residents nationwide have claimed industrial wind turbines make them sick. Several families say the structures have forced them from their homes….As the wind industry continues to expand, so do its critics.

SHADOW FLICKER
She developed nausea, headaches and vertigo from the persistent shadow flicker infiltrating nearly every room in the house.

VIBRATIONS
At first it was the noise – loud whistling and whooshing sounds. But soon they could feel thumping vibrations that resonated through the walls of their home like bass-heavy music from a distant, passing car….

HEALTH IMPACT DEBATE
That annoyance is "statistically related" to reports of migraines, tinnitus, dizziness and high blood pressure.

LIKE MOTION SICKNESS
these acoustic impulses – or low-frequency sound waves – stimulate parts of the inner ear responsible for balance, motion and spatial orientation and that they provoke symptoms similar to motion sickness

DRAGGED THROUGH THE MUD
But some wind farm residents who spoke out about their problems said the industry belittles them. It dismisses their complaints as unfounded or labels them troublemakers, multiple people said. …It has silenced many of their neighbors whom they said suffer the same symptoms but fear the consequences of speaking out.

MISLEADING TACTICS

Some landowners solicited by wind farm developers claim the companies used misleading statements in their bids to secure land rights for the projects. …Among the statements these landowners cited: That they should sign agreements because their neighbors already did; that the wind turbines would be quiet and unobtrusive; that they could exit the agreement at any time. Several of those who signed said they now regret doing so.

WHO THE CONTRACTS FAVOR

The agreements work in the favor of companies in almost every sense, according to several attorneys who have reviewed these types of documents.

WIND INDUSTRY DENIES CLAIMS

• Wind industry officials have denounced people who complain about these symptoms, calling them misinformed or "anti-wind." Some wind companies offer money or other concessions to frequent complainers, often in exchange for silence and a waiver for turbine-related claims. "I call it a shut-up clause," said Jim Miller of South Dakota, who refused to sign such an agreement with Florida-based NextEra….Forced to move ….As the wind industry continues to expand, so do its critics. … Hundreds of residents nationwide have claimed industrial wind turbines make them sick. Several families say the structures have forced them from their homes.

North Dakota Chapter of the Wildlife Society
PO Box 1442
Bismarck, ND 58501

March 5, 2019

Brian Kroshus, Chairman
North Dakota Public Service Commission
600 E. Boulevard, Dept. 408
Bismarck, ND 58505-0480

Chairman Kroshus:

This letter is intended as a filing for inclusion in the public record for the public hearing on the siting application for the Burke Wind, LLC proposed Burke County Wind Energy Center, PU-18-344, and associated transmission line, PU-18-302. The North Dakota Chapter of The Wildlife Society (Chapter) is generally supportive of the wind industry as a renewable source of energy that can be produced locally. The Chapter has been monitoring the growth of the industry in the state since the industry's inception in North Dakota, as well as staying apprised of research that has evaluated the impact of wind facilities on wildlife. When the wind industry first moved into North Dakota in 2003, very little research had been conducted that could guide turbine siting with respect to environmental impacts, but that has changed. A growing body of scientific evidence indicates that wind facilities have detrimental impacts to wildlife, particularly in areas containing high-quality natural resources and associated wildlife, such as the relatively unfragmented grasslands and high density of wetlands located within the project area of the Burke County Wind Energy Center.

The U.S. Fish and Wildlife Service voluntarily worked with the wind industry to create the Land-based Wind Energy Guidelines, commonly referred to as the WEGs. NextEra Energy (NEE) cooperated in this endeavor. The intent of this venture was that, to ward off involuntary regulations, wind companies would work through the tiered levels to determine areas best suited for wind facilities that did not imperil vital or declining natural resources. Had NEE worked through the tiered process in good faith, with the spirit and intention of the WEGs paramount, the location of the Burke County Wind Energy Center would not be located in its current physical location. At the public hearing on the Wind Energy Center's application, the Chapter would like to hear NEE explain how it worked through the WEGs, yet still came to the conclusion that this location would not have serious detrimental harm to the environment.

A ten-year study conducted by the U.S. Geological Survey's Northern Prairie Wildlife Research Center in Jamestown, ND, clearly showed that grassland breeding birds avoid wind facilities. The population numbers for all of the species of birds exhibiting avoidance behavior have been plummeting for decades, including species like North Dakota's state bird, the Western Meadowlark. The research, partially funded by NEE, occurred on Acciona's Tatanka Wind Facility in Dickey County, North Dakota, NEE's Oliver Wind Energy Center in Oliver County, North Dakota, and at NEE's South Dakota Wind Energy Center in Hyde County, South Dakota. This research, published in 2016 in the highly regarded international scientific journal *Conservation Biology*, was exemplary in terms of the duration of the study and the strength of the study design. The research clearly shows that 7 of 9 grassland bird species avoided wind facilities in North Dakota.

Two other studies that occurred on Tatanka and NEE's Kulm/Edgeley wind farm further showed detrimental impacts to wildlife. This research, conducted by the U.S. Fish and Wildlife Service's Habitat and Population Evaluation Team in Bismarck, ND, showed that waterbirds like the Black Tern and Marbled Godwit showed a tendency to decline near these two wind farms. Furthermore, five species of dabbling ducks exhibited an average decline of 20% after the erection of turbines on the Tatanka and Kulm/Edgeley wind farms. These species include the Mallard, Northern Pintail, Northern Shoveler, Blue-winged Teal, and Gadwall, all species important to North Dakota's reputation as the "duck factory of North America." Imagine these species being reduced by 20% in Burke County and surrounding counties -- and what that would mean for the quality of North Dakotans' hunting opportunities, as well as the impact on tourism as out-of-state hunters seek other hunting grounds. Given the high density of wetlands in the proposed project area—densities unrivaled nearly anywhere else in North Dakota!! — we again say that it defies logic that NEE concluded that the Burke County Wind Energy Center is a benign location for wildlife.

We cannot overemphasize that the area encompassed by the Burke County Wind Energy Center is located in an area **vital** to a diverse array of wildlife species, including grassland birds and waterfowl as mentioned in the studies highlighted above, but also pheasants, small-game, deer, and potentially federally listed threatened and endangered species such as the Whooping Crane, Piping Plover, and Northern Long-eared Bat. Deaths to these species from transmission line and turbine strikes and barotrauma are subject to formal federal government "take" proceedings. Unauthorized "take" of any migratory bird is prohibited under federal law, unless such anticipated take has been coordinated in advance with the U.S. Fish and Wildlife Service. The Chapter wonders if the company has coordinated their proposal with the U.S. Fish and Wildlife Service to ensure that unauthorized "take" of these species does not occur and, if such a discussion did occur, what the outcome of the discussion was? We will say it again: it defies logic that NEE is not aware that by placing this wind facility in this location, that it is putting itself in a position of defiance against several federal regulations.

In addition to the threat posed to North Dakotan's wildlife, the Burke County Wind Energy Center would be located in one of the last stands of contiguous northern mixed-grass prairie, **a highly endangered ecosystem**. From 2008-2012, North Dakota and South Dakota experienced the greatest amount of new cultivation, primarily for corn and soybean production, out of all other states in the U.S. Corn Belt. The greatest source of land for this new cultivation was grasslands that were native mixed-grass prairie and grasslands that were part of the USDA's Conservation Reserve Program that were removed from the program. Thus, the placement of the wind facility contributes to this downward spiral in the loss of our natural heritage. Native prairie in Burke County is an endangered mixed-grass prairie ecosystem! Nature created it: man cannot replace it. Once lost, the biodiversity and ecosystem services are gone forever.

Ranchers are already feeling the economic hit as pasture (in most cases, native mixed-grass prairie) and hayland become ever more scarce. An annual survey funded by the ND Department of Trust Lands revealed that the average rent for pasture in Burke County during the five-year period 2011-2015 was $10.90 per acre; that number increased to $11.60 per acre for the five-year period 2013-2017. Factoring in the current economic stability of the cattle market, one might expect that number to keep climbing as pasture continues to be converted to cropland and other non-pasture uses.

Burke County Wind Energy Center is an example of a pattern we suspected would come and are now seeing in other areas such as the Dickey-Emmons-Logan county area. That is the pattern of several "small" projects in the same vicinity becoming, in essence, one giant wind industrial complex, but because of current state regulations, the combined facilities' biological effects accumulate without the benefit of regulatory review. The Chapter strongly believes that each new wind facility should be considered in the context of other existing and planned projects in the region. The projects of Lindahl Wind and the proposed Aurora Wind combine to form a contiguous 198-tower industrial complex, with Burke County Wind Energy Center adding an additional 76 turbines, for a total of 274 turbines in the Williams-Mountrail-Burke tri-county area. Also associated with these projects are a minimum of 57 miles of transmission line. The consideration of cumulative effects should include a cumulative impact analysis that includes *all* anthropogenic impacts in the area, including such things as additional transmission lines, roads, and other types of infrastructure that may or may not be unrelated to wind facilities, such as oil and gas wells. Whereas one wind facility may have a relatively moderate negative influence on wildlife, the accumulation of numerous wind facilities in concert with other forms of energy development and associated roads may begin to break down wildlife species' thresholds of tolerance to disturbances and result in significant population declines.

For the reasons stated above, the Chapter is most supportive of wind facilities that are placed in habitats of limited conservation value to wildlife, such as cropland in predominantly agricultural landscapes. In areas where turbine placement on grasslands is unavoidable, the Chapter urges mitigation in ratios exceeding 1:1. That is to say, for every acre of grassland destroyed, more than an acre should be recreated, restored, or protected. Native prairie should receive the highest mitigation ratio, followed by planted grasslands. The Chapter realizes that there is no established system in North Dakota for grassland mitigation for wind facilities. Although no mitigation has been provided to date for grassland impacts, there are, however, examples of voluntary conservation measures for impacts to endangered Whooping Cranes. Basin Electric Power, BP Alternative Energy and Clipper WindPower Development (for a jointly owned South Dakota project), and NEE have already committed to voluntary conservation measures for impacts to Whooping Cranes. The Chapter applauds these efforts. The USGS team in Jamestown that discovered the avoidance of grassland birds in Dickey and Oliver counties on the Tatanka and Oliver wind farms, as well as the USFWS team in Bismarck that discovered avoidance of breeding waterfowl and waterbirds, have jointly developed mitigation tools that allow wind developers to assess the impact of their facilities with a mind toward compensation of impacts. We would be happy to connect wind developers with these entities so that compensatory measures can be discussed.

Because the Chapter's members are wildlife professionals, the Chapter would be happy to engage wind developers in discussions about our concerns, as well as serving in an advisory capacity.

Sincerely,

Rick Warhurst

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The Wildlife Society is an international, nonprofit, scientific and educational organization composed of professionals, students, and laypersons active and interested in wildlife research, management, education and administration. The NDCTWS is an active affiliate. It is specifically concerned with approaches to effective management of North Dakota's plant and animal communities. The Chapter provides expertise in advising legislative and judicial processes surrounding the controversial management of many natural resource assets. It advocates the holistic treatment of environmental questions. The Chapter was founded in 1963 and incorporated in 1981 under the laws of North Dakota. The NDCTWS would be very willing to engage the PSC in issues concerning wildlife impacts from wind facilities, as well as offer advice based on member's expertise in matters of wildlife management and impacts of human-derived disturbances.