BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY NORTH BEND WIND PROJECT, LLC FOR A PERMIT TO CONSTRUCT AND OPERATE THE NORTH BEND WIND PROJECT IN HYDE COUNTY AND HUGHES COUNTY, SOUTH DAKOTA	**MS. JUDI BOLLWEG'S RESPONSES TO STAFF'S FIRST SET OF DATA REQUESTS TO MS. JUDI BOLLWEG** **EL21-018**

Below, please find Judi Bollweg's Responses to Staff's First Set of Data Requests to Ms. Judi Bollweg, individually, and on behalf of Bollweg Family, LLLP.

1-1) Provide copies of all data requests submitted to Ms. Bollweg or by Ms. Bollweg and copies of all responses provided to those data requests. Provide this information to date and on an ongoing basis.

1-2) Refer to SDCL 49-41B-22, Applicant's burden of proof:

The applicant has the burden of proof to establish by a preponderance of the evidence that:

(1) The proposed facility will comply with all applicable laws and rules;

(2) The facility will not pose a threat of serious injury to the environment nor to the social and economic condition of inhabitants or expected inhabitants in the siting area. An applicant for an electric transmission line, a solar energy facility, or a wind energy facility that holds a conditional use permit from the applicable local units of government is determined not to threaten the social and economic condition of inhabitants or expected inhabitants in the siting area;

(3) The facility will not substantially impair the health, safety or welfare of the inhabitants; and

(4) The facility will not unduly interfere with the orderly development of the region with due consideration having been given the views of governing bodies of affected local units of government. An applicant for an electric transmission line, a solar energy facility, or a wind energy facility that holds a conditional use permit from the applicable local units of government is in compliance with this subdivision.

(a) Please specify particular aspect(s) of the Applicant's burden that Ms. Bollweg intends to personally testify on.

Response: Michael Bollweg will testify on his mother's behalf, as an expert witness in agronomy/farming and in running a hunting lodge. He will testify concerning numerous aspects, and most of them are discussed in his letters to the commission dated 8/9/21, 8/12/21, 8/26/21, and 9/7-8/21. Ms. Bollweg also submitted a letter to the commission on 8/10/21. Specifically, he will address the probable loss of revenue to the farming operation due to the location of the towers preventing aerial application which will place crops at risk. He will base his testimony on his background in farming, working for Bollweg Spraying, and his education in agronomy. He will also testify concerning the effects of the turbines upon the family hunting lodge, Tumbleweed Lodge.

There are two grounds for the Bollweg objections. The first is that the layout of the proposed towers will prevent fields from being sprayed by aerial applicators. Planes that spray a field need both a safe entrance and exit. The proposed towers that cause a danger are: 8, 9, 14, 15 and any towers that are adjacent such as 20-22. In addition to Michael Bollweg testifying, the below listed witnesses will also be called.

Tower 6 is east of the Lodge and will interfere with its operation both on the basis of shadow flicker and noise, driving game away.

(b) Please specify particular aspect(s) of the Applicant's burden of proof that Ms. Bollweg intends to call a witness to testify on.

Response: Ms. Bollweg intends to call witnesses that will testify regarding the importance/necessity of spraying fungicide/pesticides on crops. Ms. Bollweg intends to call Agronomists who will speak about the need for two separate crop protection product applications and how they must be applied by air. Ms. Bollweg will call witnesses to testify as to the rates charged for aerial applications and for the products sprayed. Ms. Bollweg intends to call aviation witnesses, including an expert witness who is a faculty member at South Dakota State University.

Brandon Haag, agronomist and employee of Corteva chemical company will testify concerning the importance and necessity to spray red sunflower seed weevils. He's going to spell out the economic impact if not sprayed and the damage impact on the sunflower plant if applied by ground vs. aerial.

Wally West, agronomist and employee of Syngenta chemical company, will testify regarding the importance and necessity to spray a fungicide on wheat at heading. He will spell out the economic gain when sprayed and state the acres of damage that occurs when a ground sprayer drives over the crop as opposed to aerial application.

Dr. Adam Varenhorst, South Dakota State University, will testify about the general impact red sunflower seed weevils have on a sunflower crop if not controlled. A letter from him is also attached.

Jonathan Kleinjan, South Dakota State University, will testify regarding the general impact weeds have on a crop in the event a ground rig is unable to spray, and the field is not suitable for air application.

Ryan Thompson will testify that sunflowers are just too tall to spray using a ground rig; it would completely destroy the crop where the sprayer drove. Also, the timing is so critical that there is no way it would be possible to get across all the acres in a timely manner. As far as the wheat and fungicide at heading, it follows the same impacts as the flowers by not being able to use aerial application. The tracks from the ground rig will cause probably at a 90-95% loss, once the wheat is jointed and the stalk breaks it will not come back or stand back up. Once again, agriculture is about timing and the efficacy of a head treatment at flowering is even more precise, just not enough ground sprayers to do. The impact of not putting on a head treatment could result in a 5-35% decrease in yield depending on pressure.

Dr. Cody Christensen will testify regarding the safety of aerial spraying in the vicinity of the proposed wind towers. Also, he will testify concerning the performance of ag sprayers and the dangers the wind towers pose. A report he has written is also enclosed.

Curt Korzan also owns a hunting lodge in South Dakota – Grand Slam Pheasants Hunt Lodge. He will testify concerning the fact that he owned prime hunting ground for his pheasant ground. It operated successfully for years. Turbines were put up and he immediately observed that the pheasants left his grounds when the turbines were operating. He also observed that other wildlife fled the grounds. His grounds were in a predator study before and during the installation of the turbines and found that his predator numbers were low. He also had additional land, away from the turbines and the wildlife in those areas remained constant. The effect was so bad that he sold the property.

Terry Barber will testify that wind towers either make ag spraying very dangerous or complicated. The airflow off the turbines disrupts the spray patterns off the aircraft, making the spray less effective. Mr. Barber sprays the Bollweg farm properties. He will testify that proposed tower locations 19, 27 and permanent met tower 2 impede the ability to spray the 240 acres in the northeast quarter of section 21 and the south half of the southeast quarter of section 16 in a north-south direction. It will be limited to spraying in an east-west direction limiting efficiency and the ability to utilize all wind with an aircraft.

The evidence will show that the inability to use aerial applicators will substantially reduce the yield to both sunflowers and wheat.

There will also be evidence showing the proximity of wind towers to Tumbleweed Lodge will cause sharp-tail grouse to stop using their land for habitat. In addition, evidence will be offered that shows that both wild and planted pheasants will leave the areas adjacent to the turbines. The Tumbleweed Lodge has had success in promoting sharp-tail hunting and various studies have discovered adverse effects of turbines upon sharp-tail nesting. In addition, there will be evidence that the presence of turbines close to hunting facilities drive away both wild and released pheasants. These same concerns also apply to prairie chickens.

1-3) Refer to SDCL 49-41B-2, permit for wind or solar energy facility:

Within nine months of receipt of the initial application for a permit for the construction of a wind energy facility or solar energy facility, the commission shall make complete findings, and render a decision, regarding whether a permit should be granted, denied, or granted upon such terms, conditions, or modifications of the construction, operation, or maintenance as the commission determines are appropriate. In the decision, the commission shall find that the construction of the facility meets all requirements of this chapter. Notice of the commission's decision shall be given to the applicant and to parties to the hearing within ten days following the decision.

(a) Identify any “terms, conditions, or modifications of construction, operation, or maintenance” that you would recommend the Commission order. Please provide support and explanation for any recommendations.
(b) Specifically, what mitigations efforts would you like to see taken if this Project is constructed?

Response: The applicants are applying for permission to build/install many turbines. If turbines #8, 9, 14, 15, 20, 21, and 22 were not put up farming could continue without interference. If 6 was not built it would permit the lodge to operate as it has.

1-4) Please list with specificity the witnesses that Ms. Bollweg intend to call. Please include name, address, phone number, credentials and area of expertise.

Response: 1) Wally West, Agronomist, Syngenta, (605) 659-4394

2) Dr. Adam Varenhoust, Assistant Professor and Extension Field Crop Entomologist, South Dakota State University, 1451 Stadium Rd, Brookings, SD 57007 (credentials attached)

3) Ryan Thompson, Agronomist, 2921 Sussex Rd, Pierre, SD 57501 (credentials attached)

4) Brandon Haag, Agronomist, 20449 Augusta Road, Pierre, SD 57501 (credentials attached)

5) Dr. Cody Christensen, 143 Wagner Hall Box 2275A Brookings, SD 57007 (credentials attached)

6) Terry Barber, Brett's Spray Service, 18531 303rd Ave, Onida, SD 57564 (credentials attached)

7) Jonathan Kleinjan, Extension Agronomist, South Dakota State University, 1451 Stadium Rd, Brookings, SD 57007

8) Michael Bollweg, 20152 321st Avenue, Harrold, South Dakota 57536 (credentials attached)

9) Curt Korzan, 25425 361 Ave, Kimball, SD 57355

1-5) Does Ms. Bollweg intend to take depositions? If so, of whom?

Response: As of today's date, no depositions have been taken.

1-6) Please identify every concern Ms. Bollweg has with the proposed project that Ms. Bollweg intends to address at the evidentiary hearing. For each concern identified, please provide support for the concern.

Response: Most of them are discussed in the letters submitted to the commission dated 8/9/21, 8/10/21, 8/12/21, 8/26/21, and 9/7-8/21. Specifically, Michael Bollweg will address the probable loss of revenue to the farming operation due to the location of the towers preventing aerial application which will place crops at risk. He will base his testimony on his background in farming, working for Bollweg Spraying, and his education in agronomy. He will also testify concerning the effects of the turbines upon the family hunting lodge, Tumbleweed Lodge.

There are two grounds for the Bollweg objections. The first is that the layout of the proposed towers will prevent fields from being sprayed by aerial applicators. Planes that spray a field need both a safe entrance and exit. The proposed towers that cause a danger are: 8, 9, 14, 15 and any towers that are adjacent such as 20-22. In addition to Michael Bollweg testifying, the below listed witnesses will also be called.

1-7) Other than intervening in this docket, has Ms. Bollweg pursued any legal action with respect to this Project?

Response: No.

/s James E. Malters
JAMES E. MALTERS
For: MALTERS, SHEPHERD & VON HOLTUM
Attorneys for Michael Bollweg, Judi Bollweg, Tumbleweed Lodge and the Bollweg Family, LLP
727 Oxford Street - P. O. Box 517
Worthington, MN 56187-0517
jmalters@msvlawoffice.com
(507) 376-4166
Fax: (507) 376-6359

Public Utilities Commission
Capitol Building, 1st floor
500 E. Capitol Ave.
Pierre, SD 57501-5070

RE: EL21-018 North Bend Wind Project in Hughes/Hyde Counties

PUC Commissioners:

I'm writing in regards to my concerns about specific locations of industrial wind turbines (IWT) proposed in the North Bend Wind Project footprint and the significant impact they will have on an aerial applicator's ability to safely and effectively apply crop protection products.

I am a retired aerial applicator pilot with more the 42 years of experience. Through the years I've experienced flying near IWT's; in particular in southwest Minnesota. Considerably smaller than these being proposed and not as densely populated, I learned in a real hurry even ¾ of a mile away the turbulence and sheer magnitude of their size prevented me to safely and effectively fly.

Two locations of concern:

Cropland Location: SW ¼ Section 11 – 111-74: Proposed IWT location 08 is to the north, 15 to the east, 22 to the south and 14 to the west. Each of the IWT's look to be within 800-1000' from the property line.

Cropland Location: NE ¼ Section 10 – 111-74: Proposed IWT location 08 is to the east and location 14 is to the south. These two IWT locations look to be within 1000' from the property line. Location 09 to the east and location 21 to the south look to be within 2/3 of a mile of the property line.

At a 140 mph, an aerial applicator is traveling at more than 205 feet/second. This allows only 4-5 seconds to either fly around it, or navigate the impossible task of starting at 10' AGL (above ground level) and climbing more than 700' to pass over the tip of a blade with a mere 100' buffer. A number of inputs make this not only extremely dangerous but physically impossible to safely and effectively apply crop protection products. Adding a multitude of additional IWT's in the same area only amplifies this complexity.

As a result of the weight of a loaded (or half loaded) airplane, aerial applicators are limited in the height of their turns to 300'-400' before re-entering a field. You can't simply pull up out of a field border, fly over an IWT, and safely reduce your altitude to 10' AGL.

It's naïve to think aerial applicators can simply fly around or over multiple IWT's located in large sections. It's also naïve to believe there is no "dirty air" and turbulence associated with IWT's. This same turbulence that significantly impacts an aircraft's flying ability also creates additional problems with drift as the vortices from the massive blades can carry these products to non-target locations.

Aerial applicators are essential to agriculture. When conditions are too wet to apply products by ground rigs, we're called upon. When dangerous pesticides need to be applied for insect control, aerial is the answer. When products need applied that ground rigs will destroy by driving on or over the top, aerial remedy's that. Without responsible placements of IWT's, significant negative economic impacts are inevitable. Thank you for your time.

Sincerely,

Mike Bollweg
Owner – Custom Air Inc. (Ret)

Public Utilities Commission
Capitol Building, 1st floor
500 E. Capitol Ave.
Pierre, SD 57501-5070

RECEIVED
AUG 12 2021
SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

RE: Docket EL21-018 North Bend Wind Farm Project

PUC Commissioners:

Per Commissioner Fiegen's request during the PUC meeting on 11 August 2021, I have listed the following proposed locations of Industrial Wind Towers (IWT) that will have a significant economic and social impact on our established upland bird hunting lodge (Tumbleweed Lodge) and farm operations (Bollweg Farms).

Exhibit 1 shows the outline of each of our preserves. Tumbleweed Lodge North (TWL N) consists of 2400 acres. Proposed towers 06, 08, 09, 14, 19, and 20 directly impact TWL N via shadow flicker, noise, and loss of aesthetics.

Exhibit 1 also shows two quarters of land that have multiple tower locations extremely close to their borders, eliminating the ability to safely and effectively apply crop protection products via aerial application from any direction:

SW ¼ Section 11 – 111-74 (160 acres): Proposed IWT location 08 is to the north, 15 to the east, 22 to the south and 14 to the west.

NE ¼ Section 10 – 111-74 (160 acres): Proposed IWT locations 08 and 09 are to the east and location 14 and 21 are to the south.

In order to at least be able to utilize an aerial applicator in an east/west flight pattern on both quarters, proposed locations 08, 09, 14, and 15 need to be removed from consideration. Once these four locations would be removed, locations 21 and 22 would not have an impact.

As I mentioned in the PUC meeting last night, Engie representatives conceded during a Hughes county commissioner meeting shadow flicker and noise are negative effects directly associated wind turbines. Their Indemnity clause echoes these concerns by requiring landowners to waive claims against them for damage or injury directly suffered as a result of any audible, electromagnetic noise or shadow flicker to name a few. The same clause also supports my argument view shed has value or they wouldn't include visual impacts. My family operation, staff, and guests that we entertain should not be exposed.

In summary, the greatest negative impacts on our entire operation are proposed towers 06, 08, 09, 14, and 15. These would be my highest priority to have removed from consideration. The next level of negative impact would derive from proposed locations 19 and 20.

I am confident the PUC and Engie would recognize this as an equitable solution. Engie has already stated they are only pursing the building of 71 of the 78 proposed locations; leaving 7 locations to be withdrawn.

If you have any questions please give me a call. Thank you for your consideration.

Sincerely,

Michael J Bollweg
Bollweg Farms
Bollweg Family LLLP
Tumbleweed Lodge
Agronomist – '96 graduate SDSU
[redacted]
Harrold, SD 57536
[redacted]

ENGIE

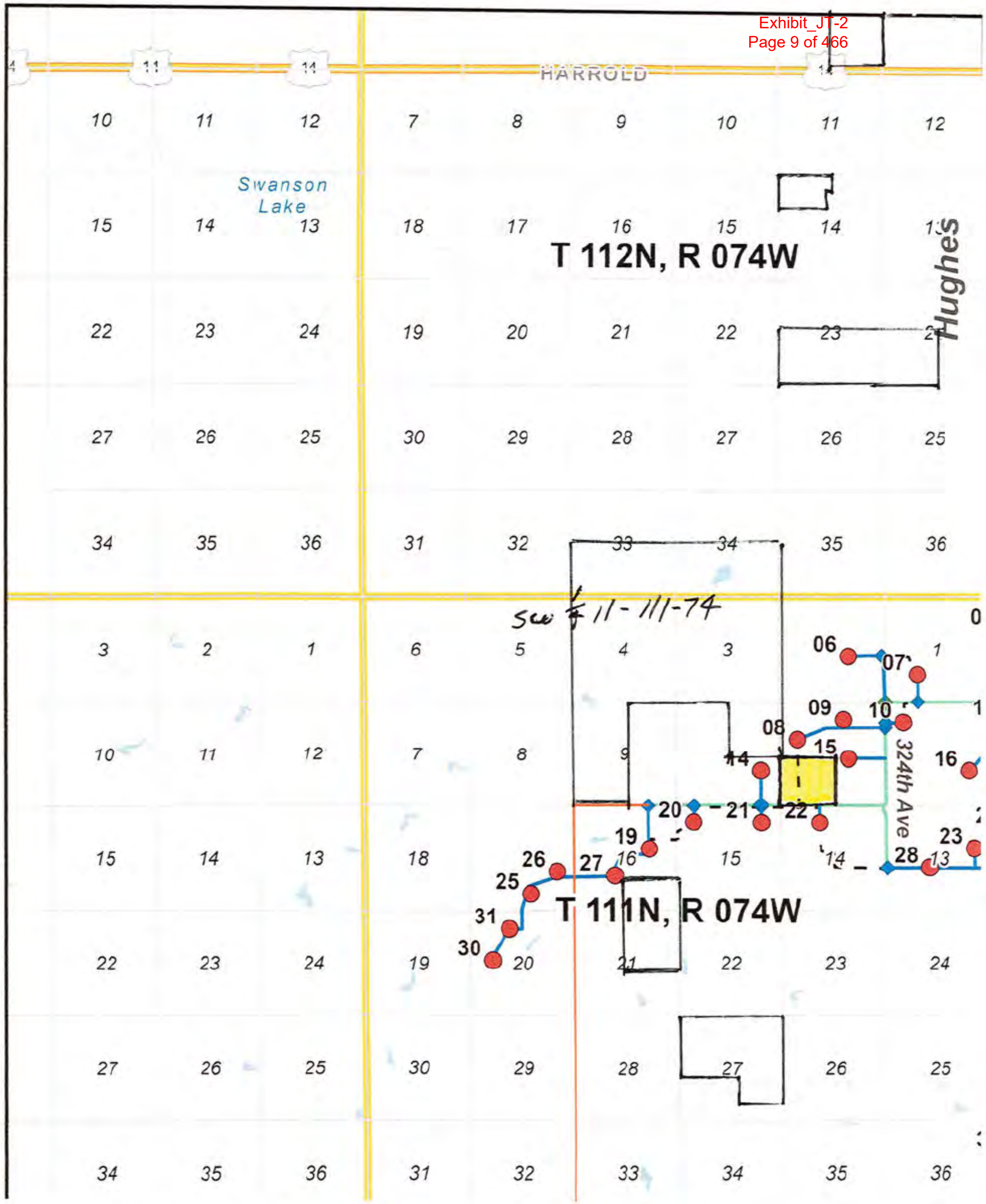
North Bend Wind Project

06/04/2021

Legend

- Turbine Locations
- New Entrance
- Intersection Modification & Improvement
- Potential County Roads
- Gravel Road Upgrades
- Access Roads
- Crane Path ~ ACROSS OUR PROPERTY
- Township & Range
- County

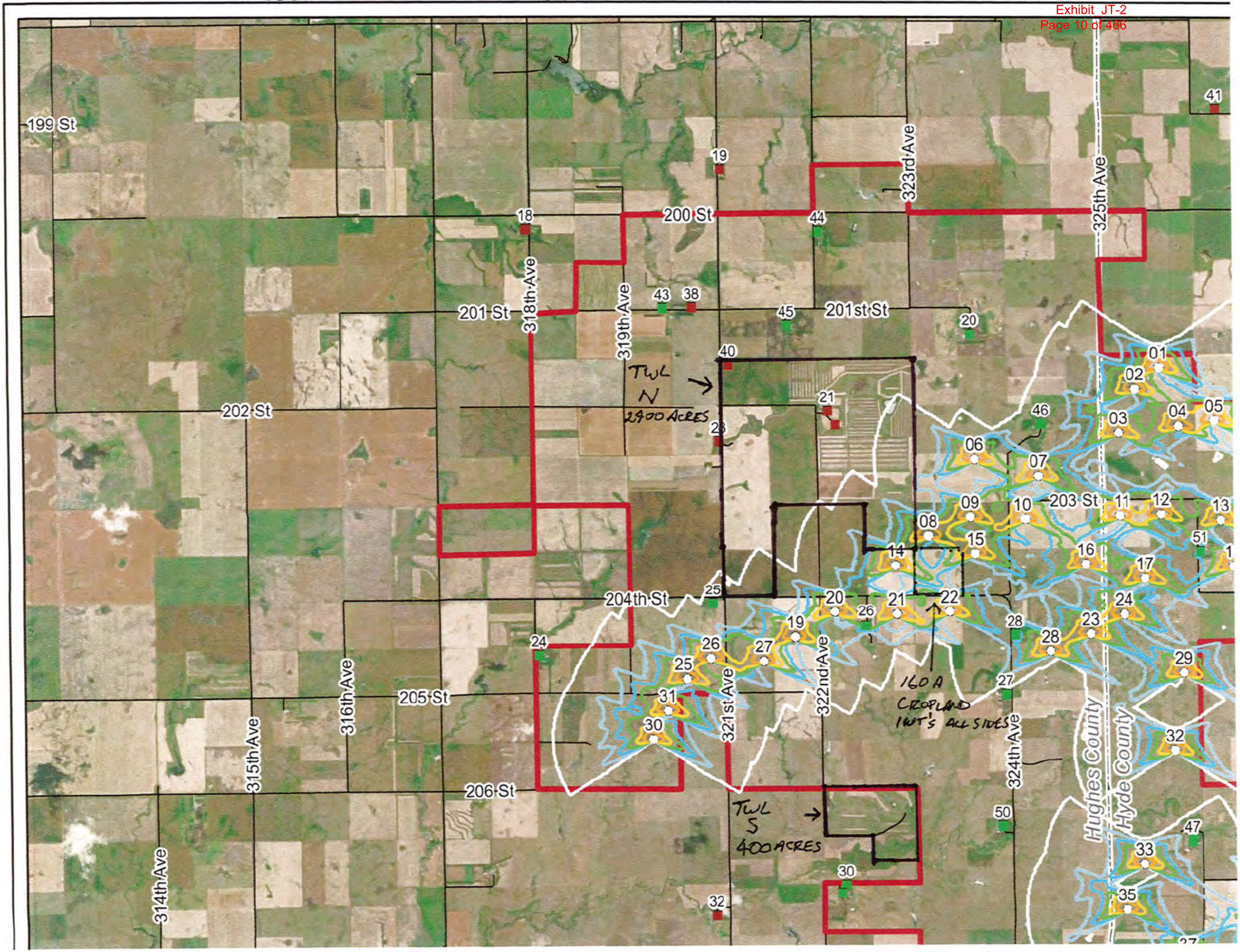
EXHIBIT 2



Project Location

TUMBLEWEED LODGE - PRESERVES

EXHIBIT 1



From: Michael Bollweg [redacted]
Sent: Thursday, August 26, 2021 9:03 AM
To: PUC-PUC <PUC@state.sd.us>
Subject: [EXT] Docket: EL21-018 North Bend Wind Project

PUC Commissioners:

Please find my attached letter of concern including supportive exhibits and permission to reprint letter pertaining to the docket: EL21-018 North Bend Wind Project in Hughes/Hyde Counties.

Thank you.

Michael J Bollweg
Bollweg Farms
Bollweg Family LLLP
Tumbleweed Lodge
[redacted]
Harrold, SD 57536
[redacted]

South Dakota's Upland Game Birds

A group consisting of representatives from Iowa DNR's Wildlife Bureau and Energy Section, US Fish & Wildlife Service, several non-governmental conservation organizations, energy companies, and the Iowa Renewable Energy Association put together siting recommendations with regard to industrial wind projects and their distance from sensitive wildlife and plant populations. EXHIBIT 1. Significant findings published include:

* "Avoid placing turbines at locations where any species of fish, wildlife or plants protected under the federal Endangered Species Act have been documented."

* "Avoid placing turbines in or near recognized bird concentration areas or migration pathways, including lakes, wetlands, forests, river valleys, ridge tops or bluff tops, large grasslands, known bird roosting areas, public wildlife areas, parks, and areas with frequent incidence of fog mist or low clouds."

* "Consider possible cumulative regional effects of multiple wind energy projects. While one project alone may result in few concerns for wildlife, multiple projects across one landscape could significantly multiply adverse effects."

* "Avoid placement of turbines in or near areas where highly "area-sensitive" wildlife species, such as prairie-chickens, are known. Area-sensitive species require expansive, unfragmented habitat. For prairie-chickens in particular, a separation distance of <u>at least 5 miles from all known leks</u> (breeding grounds) is strongly recommended."

A three year study recently completed in 2018 as a thesis "Ring-necked Pheasant responses to wind energy in Iowa" by Iowa State University graduate student James Norman Dupuie Jr. with program study committee professors Stephen J. Dinsmore and Julie A. Blanchong provides some interesting insight.

The study concluded a linear regression showed <u>statistically significant effects</u> of the presence of wind turbines on pheasant counts. Pheasant counts increased with increasing distance from the nearest wind turbine. Furthermore they showed a population decrease as the density of wind turbines near the survey point increased. South Dakota has a significantly higher population of pheasants than Iowa. Can you imagine how much more significant the negative impacts would be if you transferred South Dakota's pheasant population data into their statistical formulas?

In December 2013 at the SD Pheasant Summit, the South Dakota Game, Fish and Parks Dept. data showed pheasant hunters spend about $219 million each year. In total, South Dakota hunting has generated almost $100 million in salaries, wages and business owners' income and created 4,500 jobs. – *Capital Journal* 10 Dec 2013. It seems evident the SD Office of Economic Development has overlooked this significant information with their carefree actions of supporting every wind development project without completely comprehending the negative repercussions other major facets of our state's economy will endure. The PUC's discretion to deny or amend a project in the event the "project will not pose a threat to the social and economic condition of the inhabitants" is significant. As the state continues to be blanketed with industrial wind facilities, the economic and social impacts linked to our beloved wildlife will become more and more stressed and must be taken into serious consideration.

The agricultural splendor, wildlife, natural habitat, and great people who have made this region their home for generations do not deserve the life altering negative impacts associated with the proposed transition of agricultural lands into industrial wind parks without serious oversight. Thank you for your consideration.

Sincerely,

Michael J Bollweg
Agronomist – '96 Graduate SDSU
Bollweg Farms
Tumbleweed Lodge
[redacted]
Harrold, SD 57536

Exhibit 1-1

Wind Energy and Wildlife Resource Management in Iowa:
Avoiding Potential Conflicts

Introduction

Iowa is on its way to ranking among the world's leading producers of wind-generated electrical energy. In our efforts to become less dependent upon fossil fuels, nuclear power, hydropower and other sources with frequent environmental concerns, the possibility of this "green" energy has caused much excitement. Many Iowans eagerly await expansion of this low-cost (after initial infrastructure investments) source of electricity as one step towards energy independence.

The Governor, General Assembly, and Department of Natural Resources all consider wind energy development in Iowa a high priority. With much open farmland upon which wind generators might be placed, and in a region of nation realizing relatively high average wind velocities, Iowa seems destined to be a national focal point for wind energy development. Many state and national conservation organizations also support increasing wind energy production.

No energy source has yet been found to be without some degree of environmental costs, however, and wind energy is no exception. It has been demonstrated that if proper siting of wind turbines is not carefully planned, certain locations may result in collisions with, and death of, both wild birds and bats. In one or two noteworthy instances, excessive mortality of hawks, eagles and other birds of prey has resulted in major modifications to both design and placement of wind turbines, or even periodic shut-downs of large facilities. Additional costs involved with such measures can reduce cost-effectiveness of energy production.

Iowa currently exercises minimal regulation on locating wind farms. Nevertheless, some energy companies recognize the benefits of consulting with wildlife resource managers *before* final decisions are made on siting of new facilities. Such actions will result in greater trust and cooperation between energy producers and those charged with protecting our wildlife resources This can lead to an orderly and beneficial development of Iowa's wind energy.

An *ad hoc* Iowa wind energy and wildlife discussion group has met infrequently to review current developments regarding wind energy and wildlife interactions. The group consists of representatives from Iowa DNR's Wildlife Bureau and Energy Section, US Fish & Wildlife Service, several non-governmental conservation organizations, energy companies, the Iowa Renewable Energy Association and other interested parties. The group has no rule-making or regulatory authority; rather it simply works cooperatively to discuss mutual concerns and to learn of the latest developments.

Wildlife Concerns

Just what are the problems wind turbines might pose to our wildlife and other natural resources? The most obvious is direct collisions of birds and bats with rotating blades. Fortunately for

birds, the annual mortality rate at most Midwestern wind farms appears to remain relatively low and probably insignificant. An exception occurs when turbines are placed in or very near major migration corridors and pathways, such as large river valleys and ridgetops or bluffs. Because birds tend to follow or congregate along these natural landscape features during their semi-annual migrations, wind turbines placed near these features have potential for causing significant bird kills in spring and fall. A few examples of such landscapes in Iowa include the Des Moines River, Little Sioux River, Wapsipinicon River, Loess Hills, and Mississippi River blufflands. Still, with Iowa's mostly open landscape, birds generally are widely dispersed throughout much of the year and chance of interaction with turbines is small.

Bats present an entirely different situation. For reasons still mostly unknown, bat collisions and mortality is much higher than for birds at many wind farms. Early efforts are underway to attempt a better understanding of the problem, but little is known at this time. However, bats usually are associated with trees or wooded areas and wetlands, where the insects on which they feed are abundant. Wind turbines placed near woodlands and wetlands thus might reasonably be expected to result in more bat deaths than turbines situated in open farmlands.

An emerging concern for birds is wind turbines placed within or very near large expanses of grassland. In some western states, ground-nesting lesser prairie-chickens have been found to abandon their nesting grounds when wind turbines were erected and operated nearby. It is quite likely that Iowa's greater prairie-chickens, a state endangered species requiring large expanses of unbroken habitat, would exhibit similar behavior. Many other ground-nesting grassland birds have yet to be studied, but some of these species already are in steep decline nationwide and cannot risk another factor that might potentially threaten their survival. A leading cause of much bird decline is related to fragmentation, or "parcelization", of their remaining habitat, breaking it into parcels too small to meet certain birds' survival or reproductive needs. It has been suggested that wind turbines placed in the middle of a large grassland may similarly fragment habitat and greatly reduce its value. This is a question in need of much additional research.

In summary, adverse effects of wind turbines on birds and bats have been documented in some locations, but much remains to be learned. A few energy companies or developers have collaborated with wildlife researchers to conduct some desperately needed studies. They are to be recognized for their commitment to better conservation of all our natural resources. Nevertheless, much more research is needed, especially in comparing "before and after" effects upon wildlife where wind farms are constructed. Information garnered would be invaluable in helping with future wind farm siting decisions.

Wind Turbine Siting Recommendations and Guidelines

Until we more fully understand how wildlife interacts with wind turbines, interim guidelines have been prepared to help wind energy developers and producers do a better job of designing and siting their wind farms. The list of recommendations below will serve as a starting point for things that *should* be considered when planning wind energy developments. These have been collected from a variety of sources, chief among them the US Fish & Wildlife Service Interim Guidelines for siting and construction of wind energy facilities, and recommendations from the

National Wind Coordinating Committee. Keep in mind that this list is a *work in progress*, subject to change as new information is gained.

Siting Recommendations:

- Avoid placing turbines at locations where any species of fish, wildlife or plants protected under the federal Endangered Species Act have been documented. Information may be obtained by contacting the Iowa Department of Natural Resources Endangered Species Coordinator or Wildlife Bureau staff. Any action resulting in losses to federally-listed species could result in substantial fines or other penalties.
- Avoid placing turbines in or near recognized bird concentration areas or migration pathways, including lakes, wetlands, forests, river valleys, ridge tops or bluff tops, large grasslands, known bird roosting areas, public wildlife areas, parks, and areas with frequent incidence of fog mist or low clouds. While there is no firm information on the amount of buffer zone needed between turbines and these habitats, a separation distance of at least one mile might be considered an absolute minimum (more for prairie-chickens—see below).
- Avoid placement of turbines in or near areas where highly "area-sensitive" wildlife species, such as prairie-chickens, are known. Area-sensitive species *require* expansive, unfragmented habitat. For prairie-chickens in particular, a separation distance of at least 5 miles from all known leks (breeding grounds) is *strongly* recommended.
- Avoid placing turbines near documented bat hibernation, breeding or nursery colonies and in migration corridors (see bird recommendation above) or between known colonies and feeding areas.
- Avoid placement of multiple turbines in close proximity to one another or perpendicular to known migration pathways (typically north-south). Widely spaced turbines, in arrays parallel to normal bird migration routes, can reduce collisions.
- Reduce or eliminate availability of carrion within wind farms, to reduce chances of attracting eagles, vultures and other raptors colliding with turbine blades. Neither dead livestock nor wildlife should be left within or near wind farm boundaries.
- Place wind turbines in areas already fully developed for agriculture, especially row-crop farming, where there is minimal extant wildlife habitat—Iowa is especially rich in such lands, and it has been estimated that as much as 80% of Iowa's landscape might be considered suitable for wind energy development with few adverse effects upon wildlife.
- If wildlife habitat losses or fragmentation must be mitigated, develop a plan to create or restore habitat *away* from the wind farm site. This will serve to attract birds, bats and other wildlife away from the development and reduce collisions. Wherever possible, coordinate habitat mitigation sites with other public or private wildlife lands, to connect, enlarge or enhance those areas.
- Certain landscapes, such as the Loess Hills in western Iowa and the "Iowa Great Lakes Region" in northwest Iowa, are known for their beauty, rarity *and* for extensive wildlife breeding and migrating activities. Such landscapes should be avoided entirely both for biological and aesthetic reasons.
- Consider possible *cumulative* regional effects of multiple wind energy projects. While one project alone may result in few concerns for wildlife, multiple projects across one landscape could significantly multiply adverse effects.

- A map of Iowa, denoting areas of particular concern for possible adverse effects by wind turbines upon wildlife and habitat, has been developed and is updated periodically. Construction within these areas may not necessarily result in wildlife conflicts, and consultation with DNR wildlife biologists can assist developers in finding suitable sites within these potentially sensitive landscapes, or in suggesting plan modifications to minimize adverse effects.

Turbine Design and Operation Recommendations:

- Tubular support towers with pointed tops, rather than lattice supports, greatly reduce opportunities for birds to perch or nest upon the structures. Avoiding placement of permanent external ladders or platforms on tubular towers also reduces nesting and perching.
- Avoid use of guy wires for turbine or meteorological tower supports. Any existing guy wires should be marked with recommended bird deterrent devices (Avian Power Line Interaction Committee 1994).
- Taller turbines, having a top-of-rotor sweep exceeding 199 ft., may require lights for aviation safety. The minimum amount of pilot warning and avoidance lighting necessary should be used, and unless otherwise required by the Federal Aviation Administration, only white strobe lights should be used at night. These should be minimized in number, intensity, and number of flashes per minute. Solid red or pulsating red lights should *not* be used, as they appear to attract more night-migrating birds than do white strobes.
- Electric power lines should be placed underground wherever possible, or should utilize insulated, shielded wire when placed above ground, in order to reduce bird perching and electrocution.
- Where the height of rotor-sweep area produces high wildlife collision risks, tower heights should be adjusted to lower risks.
- If wind turbine facilities absolutely must be located in areas known for high seasonal concentration of birds, it is essential that a bird monitoring program be established, with at least three years of data collected to determine peak use periods. Data may be collected by direct observation, radar, infrared or acoustic methods. When birds are highly concentrated in or near the site, turbines should be shut down until birds have dispersed.
- When older facilities must be upgraded or retrofitted, the guidelines above should be employed as closely as possible.

Ideally, a site study plan and description of turbine structural and lighting design should be submitted to Iowa DNR well in advance of final siting decisions, for review by staff wildlife experts and advisements on acceptability or suggestions for modifications and/or monitoring. Hiring a reputable environmental consultant with a strong background in bat and bird ecology is strongly recommended. A baseline inventory of wildlife and evaluation of habitat should be considered for every site under serious consideration for windfarm development. Use of National Wind Coordinating Committee study guidelines will allow for comparison with other studies. Special attention should be paid to Spring and Fall migration seasons, reviewing

migrational use of the proposed site by raptors, waterfowl, shorebirds, gulls, songbirds and bats. Upon completion and startup of wind energy generation, monitoring wildlife populations and migrations should be conducted for at least 2-3 years.

Related Links

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

http://www.fws.gov/habitatconservation/wind.pdf
http://www.nationalwind.org/publications/siting.htm
http://www.dnr.wi.gov/org/es//science/energy/wind/guidelines.pdf
http://www.aplic.org

Michael Bollweg

PERMISSION TO REPRINT

From: "Murphy, Alex" <alex.murphy@dnr.iowa.gov>
Date: Wednesday, April 04, 2018 5:27 PM
To: "Michael Bollweg" [redacted]>
Attach: wind_wildliferecs_Current2018.pdf
Subject: Re: wind_wildliferecs.pdf

Michael,

Here is the updated document, feel free to use this in place of the old one.

Thanks,
AM

ALEX MURPHY | *Director of Communications*
Director's Office
Iowa Department of Natural Resources
P 515-725-8219 | C 515-729-7533 | 502 E. 9th St., Des Moines, IA 50319
www.iowadnr.gov

On Wed, Apr 4, 2018 at 3:28 PM, Michael Bollweg <tumbleweed@venturecomm.net> wrote:

Alex,

Please find the attached document. If you could grant me permission (in writing) to reprint, cite, use the material that would be greatly appreciated. Thank you!

http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwiIrNaCuqHaAhXk6IMKHU74D7UQFggnMAA&url=http%3A%2F%2Fwww.iowadnr.gov%2FPortals%2Fidnr%2Fuploads%2Fwildlife%2Fwind_wildliferecs.pdf&usg=AOvVaw1aHBd0_VehwHpYZGMz02_m

Michael J. Bollweg
Bollweg Farms
[redacted]
Harrold, SD 57536
[redacted]

09/02/2021

James Malters
727 Oxford St.
Worthington, MN 56187

Mr. Malters,

My name is Dr. Cody Christensen, I serve in a professional capacity as the only tenured aviation faculty member in South Dakota wherein my role at South Dakota State University, I am tasked with teaching, service, and research related to aviation education. My primary role within the university is teaching new pilots, commercial pilots, and advanced systems in aviation operations. I have been a licensed pilot for over twenty years, a FAA Goal Seal flight instructor for 15 years, and hold certificates in both single and multiengine aircraft including an Air Transport Pilot (ATP) certificate. I am answering your questions as a former airline captain for a small regional airline operating into and out of the Midwest, including South Dakota and the area depicted in Hughes County.

This letter is in request to addressing agricultural flight operations around wind turbines, specifically around T112N, R074W section 10, and 11 in Hughes County, SD. Three main considerations must be factored when addressing the pilot perspective of operations around obstacles. Those three factors include margin of safety, operation of aircraft, and aircraft performance factors associated with the flight.

The first main consideration when evaluating an operating area, whether that be a field to spray or a ground-based maneuver designated by the Federal Aviation Administration (FAA) for training such as an Eight on Pylon, is the margin of safety. The margin of safety when obstacles are present in a field decreases options in the event of an emergency such as a powerplant failure or stall/spin situation. From personal experience I know that operating directly behind or in between wind turbines creates considerable turbulence that can lead to loss of control events- a leading cause of aircraft accidents in the United States. Additionally, flying with known obstacles increases workload because the pilot must evaluate the proper course of action with little to no room for error. The margin of safety decreases as the height and number of obstacles increases.

The second consideration when operating around obstacles that are unavoidable is that of operation of aircraft including pilot training and pilot response. Professional agricultural pilots knowingly take considerable, calculated risks related to obstacles other pilots do not take. They are responsible for flying between 3-12 feet above the ground, making multiple low passes, multiple takeoff and landings, and operating to the max capacity of the aircraft. Doing this operation on a zero wind, cool day, with no elevation or obstacles take precision and professional skills few possess. Adding additional obstacles that decrease the margin of safety and decrease the reaction time a pilot has to react to unforeseen situations such as mechanical issues, bird strikes, wire strikes, wind changes, and product issues decreases the safety of the operation.

The final major concern when operating around obstacles is the aircraft performance, including climb rate, turn radius, and environmental conditions. The climb rate of a standard Air Tractor 502, a common midlevel agricultural application aircraft, is 664 feet per minute and a typical working speed of 135mph. Every second the airplane is traveling approximately 198 feet per second while on target. At the end of a field the pilot would turn off the spray and begin a climb, followed shortly by a climbing turn usually away from the spray pass to complete a course reversal to realign for the next spray pass. In a normal situation with no obstacles, ending the spray and the initial climb out might all occur within five to eight seconds, resulting in a straight-line distance of almost ¼ mile. The turnaround for ag operators, generally considered a 45° downwind turn, followed by a 225-course reversal to come back on target requires a 30-45° turn to do a back-to-back turn. The time of the course reversal is approximately 25 seconds, resulting in close to one mile of total distance traveled per swath. Assuming a 30° bank, the calculated turn radius of an aircraft going 135mph is 2,119 feet and the diameter of the turn is 0.8 miles. It should be noted that for an Air Tractor 502, it is close to one mile to make a turn, but for an Air Tractor 802, currently the largest single engine commercially used ag application airplane, that distance increases to 1.82 miles to complete a turn.

As early discussed, an Air Tractor 502 climb rate is 664 feet per minute or approximately 11 feet per second (fps) climb rate. Considering at the end of the field, an applicator pulls up into a climb, it would take 18 seconds (200ft/ 11fps) to clear a 200 feet obstacle located at the end of a field. Using a working speed of 135MPH or 198fps the aircraft would travel forward 3,564ft (198fps*18 sec to climb) to clear a 200ft obstacle. If a 600-foot obstacle was considered, it would take 54 seconds to outclimb the obstacle and would travel forward over two miles (198fps *54sec= 10,800ft). Even assuming the pilot slowed to 111mph (best rate of climb at max weight) the distance covered is still 1.6 miles (162fps *54 sec). This assumes the pilot adds max power, performs a perfect climb, the airplane performs perfect, and the field conditions were conducive to a climb (sea level, standard atmosphere, low humidity, calm or head winds prevailing). Anything less than perfect conditions would decrease the climb rate and make the field in question non flyable.

The other option would be instead of pulling up to climb over an obstacle to fly around it, below it, or through the blade arc or guy-wire, all of which are not prudent options, especially considering any abnormal operations. Additionally, the turbulence created by the wind turbines would have a direct and immediate impact on the pilot operating downwind of the turbine.

In reviewing the plat map of 112N, R 074W, section 10 and 11 in Hughes County, SD I am most concerned about the placement of towers 8, 9, 14, &15 within the sections and any towers that are adjacent such as #20-22 as they are well within a normal margin of safety for a typical pilot to safety spray that area. Based on the map and field layout, an east/west swath pattern would prevail and the presence of wind turbines or any obstacle at the end of those fields, especially on two sides, would be detrimental to safety. In my opinion, I would advise against a pilot maneuvering in the field presented with obstacles in the placement suggested.

Respectfully,

Cody Christensen, Ed.D
Airline Transport Pilot
FAA Gold seal flight instructor

From: Michael Bollweg
Sent: Tuesday, 07 September 2021 17:51:40 (UTC-06:00) Central Time (US & Canada)
To: PUC-PUC
Cc: PUC Docket Filings
Subject: [EXT] Docket: EL21-018 North Bend Wind Project

RE: Docket: EL21-018 North Bend Wind Project

PUC Commissioners:

The existing Triple H Wind project, located in western Hyde county includes 92 industrial wind turbines with a total capacity of 250 MWs. The proposed North Bend Wind Project including more than 70 towers is planned to be located directly west and south with a total capacity of 200 MWs.

With 162 towers and capacity of 450 MWs in such a small area, one must give serious consideration on the entire **cumulative impact** family farms, businesses, homes and wildlife will face from the exponential exposure. Simply view ENGIE's indemnity clause and note the list of exposures resulting from audible noise, electromagnetic noise, electrical interference, vibration, visual impacts, and shadow flicker to name a few. Inaudible noise and infrasound must also be taken into consideration. Compounding effects are inevitable.

Each project has shown studies on their own. Has an independent study determining the compounding effects to be associated with such a massive footprint been considered or in the works? It should be.

Sincerely,

Michael J Bollweg
Bollweg Farms
Bollweg Family LLLP
Tumbleweed Lodge
[redacted]
Harrold, SD 57536
[redacted]

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With 162 towers and capacity of 450 MWs in such a small area, one must give serious consideration on the entire **cumulative impact** family farms, businesses, homes and wildlife will face from the exponential exposure. Simply view ENGIE's indemnity clause and note the list of exposures resulting from audible noise, electromagnetic noise, electrical interference, vibration, visual impacts, and shadow flicker to name a few. Inaudible noise and infrasound must also be taken into consideration. Compounding effects are inevitable.

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Sincerely,

Michael J Bollweg
Bollweg Farms
Bollweg Family LLLP
Tumbleweed Lodge
[redacted]
Harrold, SD 57536
[redacted]

Adam J. Varenhorst
Curriculum Vitae

Assistant Professor, Extension Field Crop Entomologist, IPM Director
(75% Extension: 25% Research)
Agronomy, Horticulture and Plant Science Department
South Dakota State University
Brookings, SD 57007
Office Phone (605) 688-6854
Cell Phone (712) 540-7173
Adam.Varenhorst@sdstate.edu

Education:

Ph.D. 2015. Entomology, Iowa State University, Ames, IA
M.S. 2011. Entomology, Iowa State University, Ames, IA
B.S. 2009. Biology, Briar Cliff University, Sioux City, IA

Professional Experience:

2/16 to present

Assistant Professor and Extension Field Crop Entomologist, Agronomy, Horticulture and Plant Science Department, South Dakota State University.
Department Head: Dr. David Wright

8/15 to 2/16

Extension Entomology Specialist II, Agronomy, Horticulture and Plant Science Department, South Dakota State University.
Department Head: Dr. David Wright.

4/15 to 8/15

Postdoctoral Research Associate, Iowa State University.
Supervisor: Dr. Erin Hodgson,

- Skills developed:
  - Creating research-based extension handouts
  - Author and co-author extension articles
  - Public speaking to diverse audiences

5/11 to 4/15

Graduate Research Assistant. Soybean Entomology, Iowa State University. Dr. Matthew O'Neal, Advisor. Ph.D. Dissertation, entitled, "Beyond biotypes: *Aphis glycines* (Hemiptera: Aphididae) biology and the durability of aphid-resistant soybean".

- Skills developed:
  - Aphid species identification
  - Aphid rearing
  - Supervising, training and managing a total of eleven hourly employees

- Designing and implementing field and laboratory experiments

6/09 to 5/11

Graduate Research Assistant. Soybean Entomology, Iowa State University. Dr. Matthew O'Neal, Advisor. M.S. Thesis: "Selective insecticides: the potential for improved control of the soybean aphid as a result of a bioresidual".

- Skills developed:
  - Insect identification
  - Designing and implement small-plot field crop experiments
  - Supervising, training and managing hourly employees
  - Iowa Insecticide applicators license; endorsements to apply herbicides, insecticides, and fungicides; endorsements for demo and research pest control
  - Statistical analysis, interpretation of data

8/08 to 5/09

Collection Curator. Briar Cliff University and Dorothy Pecaut Nature Center, Sioux City, IA. Dr. Ted. Wilson, Advisor.

- Skills developed:
  - Insect identification with dichotomous keys
  - Insect specimen collection, curation, and management

3/08 to 12/08

Research Assistant. Briar Cliff University Sioux City, IA. Dr. Ted Wilson, Advisor. Research Project: Survey of the insects in the Sioux City Prairie, Woodbury County.

- Skills developed:
  - Understanding of the scientific method
  - Insect collection and curating

12/00 to 8/15

Farm Consultant. Jerry Varenhorst Farms, LeMars, IA. Jerry Varenhorst, Owner.

- Skills obtained:
  - Maintenance and repair of machinery
  - Operation of farm machinery
  - Marketing of commodities
  - Interpersonal communication

Grants:

Funded (total = $3,096,962):
2018: ($110,524)

Research Grant 2018, South Dakota Soybean Research and Promotion Council Grant. "Evaluating foliar insecticide efficacies for the soybean aphid and the impact of tillage and cover crops on seed treatment efficacies and insect populations".
Amount awarded: $97,080

PI: **Adam J. Varenhorst**
Co-PI: B. Fuller (South Dakota State University), J. Kleinjan (South Dakota State University), P. J. Johnson (South Dakota State University)

Research Grant 2018, South Dakota Oilseeds Council. "Evaluating the susceptibility of red sunflower seed weevil to pyrethroid insecticides in South Dakota".
Amount requested: $13,444
PI: **Adam J. Varenhorst**
Co-PI: A. Bachmann (South Dakota State University), P. Wagner (South Dakota State University)

<u>2017:</u> ($958,772)
Extension Implementation Program Grant 2017, United States Department of Agriculture, National Institute of Food and Agriculture. "SDSU Integrated Pest Management: Agronomic Crops, Specialty Crops, Pollinator Health, Pesticide Applicators, Public Health, and Diagnostic Clinics."
Amount awarded: $358,000
PI: **Adam J. Varenhorst**
Co-PI: A. Bachmann, P. O. Johnson, E. Byamukama

Research Grant 2017, United Soybean Board. "Evaluation of precision zone management in soybean fields to increase profit and reduce product inputs."
Amount awarded: $99,745
PI: D. Mueller (Iowa State University)
Co-PI: **A. Varenhorst**, S. Conley (University of Wisconsin)

Research Grant 2017, South Dakota Soybean Research and Promotion Council Grant. "Evaluating foliar insecticide efficacies for the soybean aphid and the impact of tillage and cover crops on seed treatment efficacies and insect populations".
Amount awarded: $79,272
PI: **Adam J. Varenhorst**
Co-PI: B. Fuller (South Dakota State University), J. Kleinjan (South Dakota State University), P. J. Johnson (South Dakota State University)

Research Grant 2017, South Dakota Soybean Research and Promotion Council Grant. "Developing management recommendations for the use of fungicide and insecticide seed treatments for soybeans in South Dakota".
Amount awarded: $50,000
PI: **Adam J. Varenhorst**
Co-PI: F. Mathew (South Dakota State University), J. Kleinjan (South Dakota State University)

Research Grant 2017, South Dakota Soybean Research and Promotion Council Grant. "Association of soybean cyst nematode with biotic stress factors (Fusarium and soybean aphid) and management".
Amount awarded: $90,000
PI: Febina Mathew (South Dakota State University)

Co-PI: **A. Varenhorst**, M. Nepal (South Dakota State University), J. Kleinjan (South Dakota State University), E. Byamukama (South Dakota State University)

Research Grant 2017, National Sunflower Association. "Efficacy and economics of insecticide seed treatments for management of wireworms and seed corn maggots in sunflowers".
Amount awarded: $40,000
PI: **Adam J. Varenhorst**
Co-PI: Janet Knodel (North Dakota State University), J. P. Michaud (Kansas State University)

Research Grant 2017, National Sunflower Association. "Benefits of insect pollination to confection sunflowers".
Amount awarded: $16,500
PI: Jarrad Prasifka (USDA-ARS)
Co-PI: Rachel E. Mallinger (USDA-ARS), **A. Varenhorst**, J. Bradshaw (University of Nebraska-Lincoln)

Research Grant 2017, South Dakota Wheat Commission (7/1/17-6/30/18). "Determining the importance of insecticide seed treatments for managing aphids and *Barley yellow dwarf virus* in winter wheat".
Amount awarded: $25,000
PI: **Adam J. Varenhorst**.
Co-PI: Emmanuel Byamukama (South Dakota State University)

Research Grant 2017, United States Department of Agriculture, National Institute of Food and Agriculture (3/15/2017-3/14/2020). "Improving disease management in sunflower."
Amount Awarded: $300,000
PI. Febina Mathew (South Dakota State Univeristy)
Co-PI: S. Markell (North Dakota State Univeristy), B. Harveson (University of Nebraska-Lincoln), **A. Varenhorst**, A. Severin (Iowa State Univeristy), A. Seethraram (Iowa State University).

<u>2016:</u> ($525,533)

Research Grant 2016, South Dakota Department of Agriculture Specialty Crop Block Grant. "Determining the importance of pollinators to confection sunflower production in South Dakota".
Amount requested: $48,351.
PI: **Adam J. Varenhorst**
Co-PI: M. Dunbar (South Dakota State University), A. Bachmann (South Dakota State University), R. Beck (South Dakota State University), F. Mathew (South Dakota State University)

Research Grant 2016, South Dakota Oilseeds Council. "Determining the pollinator diversity present in South Dakota sunflowers and their impact on yield".
Amount requested: $10,640 (50%)
PI: **Adam J. Varenhorst**
Co-PI: A. Bachmann (South Dakota State University)

Research Grant 2016, Sun Grant Program North Central Region (USDA-NIFA funded). "Development of best management practices for the production of *Brassica carinata* (L.) in the Dakotas."
Amount requested: $150,000
PI: Thandiwe Nleya
Co-PI: F. Mathew (South Dakota State University), **A. Varenhorst**, B. Johnson (North Dakota State University)

Research Grant 2016, South Dakota Soybean Research and Promotion Council Grant. "Association of soybean cyst nematode with biotic stress factors (Fusarium and soybean aphid) and management".
Amount requested: $90,000
PI: Febina Mathew (South Dakota State University)
Co-PI: **A. Varenhorst**, M. Nepal (South Dakota State University), J. Kleinjan (South Dakota State University), E. Byamukama (South Dakota State University)

Research Grant 2016, South Dakota Soybean Research and Promotion Council Grant. "Developing management recommendations for the use of fungicide and insecticide seed treatments for soybeans in South Dakota".
Amount requested: $50,000
PI: **Adam J. Varenhorst**
Co-PI: F. Mathew (South Dakota State University), J. Kleinjan (South Dakota State University)

Research Grant 2016, South Dakota Soybean Research and Promotion Council Grant. "Effect of fungicide seed treatments on soybean disease caused by *Fusarium* species".
Amount requested: $20,505
PI: Febina Mathew (South Dakota State University)
Co-PI: **A. Varenhorst**, J. Kleinjan (South Dakota State University)

Research Grant 2016, National Science Foundation (2013-9/2016). "Broad implementation of the lost ladybug project".
Amount awarded: $99,624
PI: John Losey (Cornell University).
Co-PI: **A. J. Varenhorst**, Louis Hesler (USDA-ARS).

Research Grant 2016, South Dakota Pulse Council. "Monitoring dry pea for diseases and insect pests in South Dakota".
Amount requested: $4,000
PI: Febina Mathew
Co-PI: **A. J. Varenhorst**, C. Graham, R. Beck

Research Grant 2016, National Sunflower Association. "Efficacy and economics of insecticide seed treatments for management of wireworms and seed corn maggots in sunflowers".
Amount requested: $35,913
PI: **Adam J. Varenhorst**

Co-PI: Janet Knodel (North Dakota State University), J. P. Michaud (Kansas State University)

Research Grant 2016, National Sunflower Association. "Benefits of insect pollination to confection sunflowers".
Amount requested: $16,500
PI: Jarrad Prasifka (USDA-ARS)
Co-PI: Rachel E. Mallinger (USDA-ARS), **A. Varenhorst**, J. Bradshaw (University of Nebraska-Lincoln)

<u>2015:</u> ($1,502,133)

Extension Grant 2015, South Dakota SARE Professional Development Program State Level Mini-Grant. "Pollinator Identification and Conservation Workshop". Amount awarded: $5,500.
PI: **Adam J. Varenhorst**
Co-PI: Amanda Bachmann.

Extension Grant 2015, South Dakota SARE Professional Development Program State Level Mini-Grant. "Providing integrated pest management training opportunities for crop managers"
Amount awarded: $5,500.
PI: Emmanuel Byamukama
Co-PI: **Adam J. Varenhorst**, Amanda Bachmann, and Paul Johnson

Research Grant 2015, South Dakota Wheat Commission (7/1/16-6/30/17). "Cost and benefit analysis of the use of seed treatments and timing of planting against aphids in winter wheat and tactics for sustainable management of wheat stem sawfly in South Dakota". Amount awarded: $20,000
PI: **Adam J. Varenhorst.**
Co-PI: Karl Glover (South Dakota State University)

Research Grant 2015, North Central Soybean Research Program (10/1/15-9/30/18). "Soybean entomology in the north central region: management and outreach for new and existing pests".
Amount awarded: $1,471,133 (5.5%)
PI: Kelley J. Tilmon (Ohio State University).
Co-PI: B. Diers (University of Illinois), G. Hartman (University of Illinois), C. Krupke (Purdue University), P. Nachappa (Indiana University-Purdue University Fort Wayne), M. O'Neal (Iowa State University), E. Hodgson (Iowa State University), B. McCornack (Kansas State University), D. Finke (University of Missouri), G. Heimpel (University of Minnesota), B. Potter (University of Minnesota), R. Koch (University of Minnesota), T. Hunt (University of Nebraska-Lincoln), R. Wright (University of Nebraska-Lincoln), D. Prischmann (North Dakota State University), J. Knodel (North Dakota State University), A. Michel (Ohio State University), **A. Varenhorst**.

Proposed (total = $1,203,262):

<u>2017:</u> ($120,000)

Research Grant 2017, North Central Region Sustainable Agriculture Research and Education. "Evaluating the impact of insecticide and fungicide applications on pollinators in confection and oilseed sunflowers."

Amount requested: $120,000
PI: **Adam J. Varenhorst**
Co-PI: P. Wagner, (South Dakota State University) and A. Bachmann (South Dakota State University)

<u>2016:</u> ($285,266)

Research Grant 2016, North Central Soybean Research Program Grant. "Determining when seed treatments in soybean really pay off".
Amount requested: $225,000
PI: **Adam J. Varenhorst**
Co-PI: D. Mueller (Iowa State University), S. Conley (University of Wisconsin), F. Mathew (South Dakota State University), J. Kleinjan (South Dakota State University), M. Dunbar (South Dakota State University)

Research Grant 2016, South Dakota Department of Agriculture Specialty Crop Block Grant. "Developing best management practices for dry pea production in South Dakota".
PI: Febina Mathew (South Dakota State University)
Co-PI: **A. J. Varenhorst**, C. Graham (South Dakota State University), R. Beck (South Dakota State University), A. Bachmann (South Dakota State University)
Amount requested: $37,856

Research Grant 2016, South Dakota Oilseeds Council. "Developing management recommendations for the use of seed treatments in sunflower in South Dakota".
Amount requested: $12,410
PI: **Adam J. Varenhorst**
Co-PI: F. Mathew (South Dakota State University)

Research Grant 2016, South Dakota Oilseeds Council Grant. "Managing Phomopsis stem canker of sunflower using genetic resistance".
Amount requested: $10,000
PI: Febina Mathew (South Dakota State University)
Co-PI: **A. Varenhorst**

<u>2015:</u> ($797,996)

Research Grant 2015, USDA Multi-State Specialty Crop Block Grant. "Genetic improvement of sustainable pea production in the United States".
Amount requested: $797,906
PI: Dipak Santra (University of Nebraska-Lincoln)
Co-PI: R. Harveson (University of Nebraska-Lincoln), J. Bradshaw (University of Nebraska-Lincoln), C. Coyne (Washington State University), F. Mathew (South Dakota State University), **A. Varenhorst**, K. McPhee (North Dakota State University), J. Pasche (North Dakota State University)

Publications and Book Chapters

Peer reviewed

Google Scholar: https://scholar.google.com/citations?hl=en&user=7wU4mecAAAAJ
ORCID ID: http://orcid.org/0000-0001-6239-9860

2018

Dunbar, M. W., A. Bachmann, and **A. J. Varenhorst.** 2018. Reduced insecticide susceptibility in *Aedes vexans* (Diptera: Culicidae) where agricultural pest management overlaps with mosquito abatement. Journal of Medical Entomology.

O'Neal, M. E., **A. J. Varenhorst,** M. C. Kaiser. 2018. Rapid evolution to host plant resistance by an invasive herbivore: soybean aphid (Aphis glycines) virulence in North America to aphid resistant cultivars. Current Opinion in Insect Science 26: 1-7.

2017

Clay, S. A. and **A. Varenhorst**. 2017. Estimating weed and insect development, in-season yield losses, and economic thresholds. *In* Clay, D. E., S. A. Clay, and S. A. Bruggeman (eds). American Society of Agronomy.

Varenhorst, A. J., S. R. Pritchard, E. W. Hodgson, M. E. O'Neal, and A. Singh. 2017. Determining the effectiveness of three-gene pyramids against *Aphis glycines* (Hemiptera: Aphididae) biotypes. J. Econ. Entomol.

Dunbar, M., A. Adhikari, B. Kontz, **A. Varenhorst**, T. Nleya, E. Byamukama, and F. Mathew. 2017. First report of Alternaria Black Spot caused by *Alternaria alternata* on Brassicae carinata in South Dakota. Plant Disease. DOI: 10.1094/PDIS-02-17-0222-PDN

Koch, R., B. Potter, P. Glogoza, E. Hodgson, C. Krupke, J. Tooker, C. DiFonzo, A. Michel, K. Tilmon, T. Prochaska, J. Knodel, R. Wright, T. Hunt, B. Jensen, **A. Varenhorst**, B. McCornack, K. Estes, and J. Spencer. In review. Biology and economics of recommendations for insecticide-based management of soybean aphid. Plant Health Progress.

2015

Varenhorst, A. J., and M. E. O'Neal. 2015. The effect of an interspersed refuge on *Aphis glycines* (Hemiptera: Aphididae) and natural enemy populations. J. Econ. Entomol. DOI: 10.1093/jee/tov302

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Reduced fitness of virulent *Aphis glycines* (Hemiptera: Aphididae) biotypes may influence the longevity of resistance genes in soybean. PLoS One. DOI: 10.1371/journal.pone.0138252.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Determining the duration of *Aphis glycines* (Hemiptera: Aphididae) induced susceptibility effects in soybean. Arthropod-Plant Inter. 9: 457-464. DOI: 10.1007/s11829-015-9395-7.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. An induced susceptibility response in soybean promotes avirulent *Aphis glycines* (Hemiptera: Aphididae) populations on resistant soybean. Environ. Entomol. 44: 658-667. DOI: 10.1093/ee/nvv051.

2012

Varenhorst, A. J., and M. E. O'Neal. 2012. The response of natural enemies to selective insecticides applied to soybean. Environ. Entomol. 41: 1565-1574.

In preparation

Varenhorst, A. J., M. T. McCarville, J. A. Wenger, M. E. O'Neal, and A. P. Michel. How does virulence spread within a field? Soybean aphids, host-plant resistance, and interspersed refuges. J. Econ. Entomol.

Pritchard, S. R., M. E. O'Neal, A. Singh, A. K. Singh, and **A. J. Varenhorst**. Effect of soybean trichome density on *Aphis glycines* Matsumura (Hemiptera: Aphididae).

Extension Fact Sheets

Dunbar, M., B. Fuller, B. McManus, and **A. J. Varenhorst**. 2017. Corn rootworm in South Dakota. iGrow, South Dakota State University Extension. Publication:

Fiedler, D., F. Mathew, R. Beck, and **A. Varenhorst**. 2016. Phoma black stem of sunflower. iGrow, South Dakota State University Extension. Publication: 03-2004-2016.

Fiedler, D., F. Mathew, R. Beck, and **A. Varenhorst**. 2016. Phomopsis stem canker of sunflower. iGrow, South Dakota State University Extension. Publication 03-2005-2016.

Fiedler, D., F. Mathew. R. Beck, and **A. Varenhorst**. 2016. Stem weevils of sunflowers in South Dakota. iGrow, South Dakota State University Extension. Publication: 03-2006-2016.

Welch, K. D., K. J. Tilmon, and **A. J. Varenhorst**. 2016. Bean leaf beetle in South Dakota. iGrow, South Dakota State University Extension. Publication: 03-2002-2016.

Welch, K. D., K. J. Tilmon, and **A. J. Varenhorst**. 2016. Green cloverworm and other caterpillars in South Dakota soybeans. iGrow, South Dakota State University Extension. Publication: 03-2001-2016.

Welch, K. D., K. J. Tilmon, and **A. J. Varenhorst**. 2016. Japanese beetles in South Dakota. iGrow, South Dakota State University Extension. Publication: 03-2000-2016.

Extension Articles

2017: 83

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Varenhorst, A. J., P. M. Wagner, P. B. Beauzay, S. D. Eigenbrode, J. J. Knodel, T. J. Prochaska, G. V. P Reddy and K. W. Wanner. **2018.** Grasshoppers. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Knodel, J. J., P. B. Beauzay, S. D. Eigenbrode, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner, and K. W. Wanner. **2018.** Tarnished plant bug. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Reddy, G. V. P., P. B. Beauzay, S. D. Eigenbrode, J. J. Knodel, T. J. Prochaska, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018**. Pea weevil. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Eigenbrode, S. D., P. B. Beauzay, J. J. Knodel, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018.** Pea aphid. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Prochaska, T. J., P. B. Beauzay, S. D. Eigenbrode, J. J. Knodel, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018.** Lady beetles or ladybugs. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Prochaska, T. J., P. B. Beauzay, S. D. Eigenbrode, J. J. Knodel, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018.** Lacewings or aphid lions. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Wagner, P. M., P. B. Beauzay, S. D. Eigenbrode, J. J. Knodel, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst** and K. W. Wanner. **2018.** Minute pirate bugs. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Knodel, J. J., P. B. Beauzay, S. D. Eigenbrode, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018.** Syrphid flies or hoverflies. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Beauzay, P. B., S. D. Eigenbrode, J. J. Knodel, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018**. Parasitic wasps or parasitoids. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Beauzay, P. B., S. D. Eigenbrode, J. J. Knodel, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018**. Entomopathogenic fungi. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Varenhorst, A. J. and P. M. Wagner. **2018.** Soil and foliar insecticides in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. and P. M. Wagner. **2018.** Foliar insecticides in alfalfa. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. and P. M. Wagner. **2018.** Foliar insecticides in oilseeds. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. and P. M. Wagner. **2018.** Foliar insecticides in soybean. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Soybean: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. and P. M. Wagner. **2018.** Foliar insecticides in wheat. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, P. M. Wagner, and **A. J. Varenhorst. 2018.** Seed treatments in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, P. M. Wagner, and **A. J. Varenhorst. 2018.** Seed treatments in soybean. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Soybean: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, P. M. Wagner, and **A. J. Varenhorst. 2018.** Seed treatments in wheat. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, P. M. Wagner, and **A. J. Varenhorst. 2018.** Seed treatments in sunflower. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

2017:

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Soil and foliar insecticides in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Foliar insecticides in alfalfa. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Foliar insecticides in oilseeds. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Sunflower & Oilseeds/Alfalfa & Range: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Foliar insecticides in soybean. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Soybean: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Foliar insecticides in wheat. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, M. W. Dunbar, P. M. Wagner, and **A. J. Varenhorst. 2017.** Seed treatments in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, M. W. Dunbar, P. M. Wagner, and **A. J. Varenhorst. 2017.** Seed treatments in soybean. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Soybean: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, M. W. Dunbar, P. M. Wagner, and **A. J. Varenhorst. 2017.** Seed treatments in wheat. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, M. W. Dunbar, P. M. Wagner, and **A. J. Varenhorst. 2017.** Seed treatments in sunflower. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

2016:

Beck, D., R. Beck, A. Chirumamilla, **A. Varenhorst. 2016.** Production and utilization of field peas in South Dakota. iGrow.

Varenhorst, A. J. 2016. Soil and foliar insecticides in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. 2016. Foliar insecticides in alfalfa. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. 2016. Foliar insecticides in oilseeds. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. 2016. Foliar insecticides in soybean. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Soybean: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. 2016. Foliar insecticides in wheat. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

Byamukama, E., and **A. J. Varenhorst. 2016.** Seed treatments in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Byamukama, E., and **A. J. Varenhorst. 2016.** Seed treatments in soybean. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Soybean: A guide to managing weeds, insects, and diseases.

Byamukama, E., and **A. J. Varenhorst. 2016.** Seed treatments in wheat. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Byamukama, E., and **A. J. Varenhorst. 2016.** Seed treatments in sunflower. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

Refereed:

Wright, R. and **A. J. Varenhorst**. 2016. Sorghum insect pests.

Varenhorst, A. J., B. W. Fuller, and B. W. French. 2016. Corn insect pests. *In* Clay, D.E., C.G. Carlson, S.A. Clay, and E. Byamukama (eds). iGrow Corn: Best Management Practices. South Dakota State University.

Varenhorst, A. J., and B. W. Fuller. 2016. Stored grain pests of corn. *In* Clay, D.E., C.G. Carlson, S.A. Clay, and E. Byamukama (eds). iGrow Corn: Best Management Practices. South Dakota State University.

Invited Presentations

2018:

Varenhorst, A., and B. Hauswedell. 2018. Planting populations and seed treatments. Soy100: Growing 100-Bushel Soybeans. 14 March 2018. Brookings, SD.

Varenhorst, A., J. Knodel, E. Bynum, and J. P. Michaud. 2018. 2018 Sunflower special topics: Insects of the sunflower root and stalk. 40th Annual NSA Research Forum. 10 January 2018. Fargo, ND.

2017:

Varenhorst, A. J., B. Hauswedell, J. P. Michaud, and J. Knodel. 2017. Evaluating early season belowground pest management in sunflowers. 65th Annual Meeting of the Entomological Society of America. 8 November 2017. Denver, CO.

Varenhorst, A. J. 2017. Integrated pest management: Insects. American Society of Agronomy Cultivating Sustainability: A Training Curriculum for Agronomy Professionals: Concepts in Integrated Pest Management: Insects and Plant Pathology Webinar Series.

Varenhorst, A., B. Hauswedell, P. Rozeboom, P. Wagner, and A. Bachmann. 2017. Managing pests in South Dakota's Major Crops. 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/4/2017.

Varenhorst, A. and M. O'Neal. 2017. Interspersed refuges: How do they impact soybean aphid natural enemies? 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/7/2017.

Varenhorst, A. J. 2017. Insect issues facing farmers in South Dakota. PS 390 Junior Seminar. Instructor Dr. Thandiwe Nleya. 28 February 2017. Brookings, South Dakota. Presented to 40 students.

Varenhorst, A. J., B. Hauswedell, M. Mattern and P. Rozeboom. 2017. Insect pests and pollinators of sunflower in South Dakota. NuSeed, Legend Seeds Sunflower Training. Alison Stone. Pierre, SD. Presented to 122 stakeholders.

Varenhorst, A. J. 2017. Belligerent bugs –How resistance affects insect management. American Society of Agronomy Resistance Management Webinar Series.

Varenhorst, A., M. Mattern, B. Hauswedell, and P. Rozeboom. 2017. 2017 Insect Pest and Research Update. Brown County Crops Clinic. Aberdeen, SD. 1/6/2017.

2016:

Varenhorst, A. J. 2016. From a B.S. in biology to a Ph.D. in entomology: How did I get here? Briar Cliff University STEM Seminar. Briar Cliff University, Sioux City, IA. 11 November 2016.

Varenhorst, A. J. and M. E. O'Neal. 2016. The effect of an interspersed refuge on soybean aphid management. Symposium: Research Update from the North Central Soybean Research Program (NCSRP). 71st Annual North Central Branch of the Entomological Society of America. 5 June 2016.

Varenhorst, A. J. 2016. Insect pollinators. Hinton Community Elementary School, Hinton, IA. 23 May 2016. Presented to a total of 60 first grade students.

Varenhorst, A. J. 2016. Seed treatments: do they provide economic benefits to South Dakota farmers? PS 333. Instructor Dr. Febina Mathew. 4 April 2016. Brookings, SD. Presented to 58 students.

Varenhorst, A. J. 2016. Insecticide seed treatments in soybeans. Soy100. Stephanie Bruggeman. 11 March 2016. Brookings, SD. Presented to 80 stakeholders.

Varenhorst, A. J. 2016. Insect pests of sunflower in South Dakota. NuSeed, Legend Seeds Sunflower Training. Alison Stone. 23 February 2016. Chamberlain, SD. Presented to 55 stakeholders.

Varenhorst, A. J. 2016. Major insect issues in South Dakota. PS 380 Junior Seminar. Instructor Dr. Thandiwe Nleya. 16 February 2016. Brookings, SD. Presented to 20 students.

Varenhorst, A. J. 2016. Review of 2015 insect pests and what to watch for in 2016. Faulkton Crop Improvement Meeting. 29 January 2016. Faulkton, SD. Presented to nine stakeholders.

Varenhorst, A. J. 2016. 2015 insect pest summary and current research update. 8 January 2016. Aberdeen, SD. Presented to 19 stakeholders.

2015:

Varenhorst, A. J. 2015. Climate and insect pests: How are they related? Climate & Agriculture Workshop. 15 December 2015. Mitchell, SD. Presented to seven stakeholders.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Induced susceptibility affects *Aphis glycines* virulence on resistant soybean: Implications for managing this pest in the future. 63rd Annual Meeting of the Entomological Society of America. 15 November 2015. Minneapolis, MN.

Varenhorst, A. J. 2015. Insect issues facing farmers in South Dakota. PS 390 Junior Seminar. Instructor Dr. Thandiwe Nleya. 22 October 2015. Brookings, South Dakota. Presented to 30 students.

Research Presentations

2018:

Koch, R., J. Menger, I. MacRae, J. Knodel, B. Potter, P. Glogoza, E. Hodgson, **A. Varenhorst**, A. Chirumamilla, and J. Gavloski. 2018. Insecticide resistance in soybean aphid: An emerging challenge in soybean production. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Pezzini, D., P. Mittapelly, C. DiFonzo, D. Finke, T. hunt, J. Knodel, C. Krupke, B. McCornack, A. Michel, C. R. Philips, **A. Varenhorst**, R. Wright, and R. Koch. 2018. Emerging stink bugs on soybean – Where are they and what do they like to eat? 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Hauswedell, B., C. Dierks, P. Rozeboom, F. Mathew, J. Kleinjan, and **A. Varenhorst**. 2018. Does planting date, location and seeding rate affect the efficacy of seed treatments in soybean? 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Dunbar, M., A. Bachmann, and **A. Varenhorst**. 2018. Reduced insecticide susceptibility in *Aedes vexans* (Diptera: Culicidae) where agricultural pest management overlaps with mosquito abatement. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Hohenstein, J., M. Kaiser, K. Tilmon, **A. Varenhorst**, E. Hodgson, and M. O'Neal. 2018. "Refuge-in-a-bag" approach for sustainable management of virulent soybean aphids (*Aphis glycines*, Hemiptera: Aphididae) in the field. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Conzemius, S., L. Hesler, **A. Varenhorst**, and K. Tilmon. 2018. Eat, drink and be varied: Soybean aphid intrabiotypic variants on soybean ascensions. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Dierks, C., B. Hauswedell, P. Rozeboom, and **A. Varenhorst**. 2018. Do cover crops and tillage affect the efficacy of soybean insecticide seed treatments? 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Varenhorst, A. and B. Hauswedell. 2018. Determining the efficacy of insecticide seed treatments and in-furrow insecticides for wireworm management. 40th Annual NSA Research Forum. 10 January 2018. Fargo, ND.

Prasifka, J., R. Mallinger, **A. Varenhorst**, and J. Bradshaw. 2018. Benefits of insect pollination to confection sunflowers in the Northern and Central Plains. 40th Annual NSA Research Forum. 10 January 2018. Fargo, ND.

2017:

Dierks, C., P. Rozeboom, B. Hauswedell, and **A. Varenhorst**. 2017. Evaluating the efficacy of foliar insecticides for soybean aphids in South Dakota. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. Denver, CO.

Conzemius, S., L. Hesler, **A. Varenhorst**, and K. Tilmon. 2017. Mind your elders: Wild soybean's contribution to soybean aphid resistance. 65th Annual Meeting of the Entomological Society of America. 6 November 2017. Denver, CO.

Pezzini, D., D. Finke, T. Hunt, J. Knodel, C. Krupke, B. McCornack, A. Michel, C. R. Philips, **A. Varenhorst**, R. Wright, and R. Koch. 2017. Influence of field and landscape factors on stink bug (Hemiptera: Pentatomidae) community in North Central soybean. 65th Annual Meeting of the Entomological Society of America. 5 November 2017. Denver, CO.

Hauswedell, B., P. Rozeboom, J. P. Michaud, J. Knodel, and **A. Varenhorst**. 2017. Evaluation of seed and in-furrow treatments for sunflower in South Dakota. 65th Annual Meeting of the Entomological Society of America. 5 November 2017. Denver, CO.

Mallinger, R., J. Prasifka, J. Bradshaw, and **A. Varenhorst**. 2017. How do pollination services to sunflowers vary across plant genotypes, environements, and pollinator taxa? 65th Annual Meeting of the Entomological Society of America. 5 November 2017. Denver, CO.

Varenhorst, A., M. W. Dunbar, and A. Bachmann. 2017. Agricultural pest management in South Dakota: Does it affect mosquito insecticide resistance? 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/6/2017

Hauswedell, B., M. W. Dunbar, F. Mathew, J. Kleinjan, and **A. Varenhorst**. 2017. Developing management recommendations for soybean seed treatments in South Dakota. 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/5/2017

Pezzini, D., D. Finke, T. Hunt, J. Knodel, C. Krupke, B. McCornack, A. Michel, C. R. Philips, **A. Varenhorst**, R. Wright, and R. Koch. 2017. Influence of field and landscape factors on stink bug (Hemiptera: Pentatomidae) community in North Central soybean. North Central Branch of the Entomological Society of America. Indianapolis, IN. 6/5/2017.

Varenhorst, A., B. Hauswedell, J. Knodel, and J. P. Michaud. 2017. Determining the impact of seed treatments on sunflower yield. National Sunflower Association Forum. Fargo, ND. 1/10/2017.

Dunbar, M. W., A. Bachmann, F. Mathew, and **A. Varenhorst**. 2017. Mosquito insecticide resistance affected by agricultural pest management. Adult Control I, American Mosquito Control Association, Annual Meeting, San Diego, CA.

2016:

Varenhorst, A., B. Hauswedell, M. Mattern, and F. Mathew. 2016. Sunflower Update: Insects and diseases. Ag Horizons. Pierre, SD. 11/30/2016.

Okello, P., A. Adhikari, **A. Varenhorst**, S. Osborne, E. Byamukama, and F. Mathew. 2016. Interaction between Fusarium and soybean cyst nematode on soybean. American Phytopathology Society Annual Meeting. 31 July 2016. Tampa FL.

Posch, J. P., **A. J. Varenhorst**, F. M. Mathew. 2016. Exploring interactions of soybean cyst nematode with stem canker pathogens on soybean. American Phytopathological Society North Central Meeting. 8 June 2016. Minneapolis, MN.

Pritchard, S., M. O'Neal, A. Singh, A. Singh, **A. Varenhorst**. 2016. Effect of soybean trichome density on biotype-1 soybean aphid (*Aphis glycines*) and its natural enemies. 71st Annual North Central Branch of the Entomological Society of America. 6 June 2016. 3rd place in PIE student competition.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Exploring factors that may promote the longevity of *Rag* genes. 70th Annual North Central Branch of the Entomological Society of America. 1 June 2015. Manhattan, Kansas.

Nutter, F., M. T. McCarville, and **A. J. Varenhorst**. 2014. Defoliation.Pro: A new training tool for improving the accuracy and precision of defoliation ratings. 62nd Annual Meeting of the Entomological Society of America. 19 November 2014. Portland, Oregon.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2014. Does induced susceptibility occur between virulent and avirulent soybean aphids on resistant soybean? 62nd Annual Meeting of the Entomological Society of America. 17 November 2014. Portland, Oregon. (Received 1st place in PIE student competition)

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2014. Do biotype-1 soybean aphids benefit from the presence of biotype-2 on resistant soybean. 1st Annual ISU Graduate and Professional Student Research Conference. 5 April 2014. Ames, Iowa (Received Best in Session).

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2014. Do biotype-1 soybean aphids benefit from the presence of biotype-2 on resistant soybean? 69th Annual North Central Branch of the Entomological Society of America. 10 March 2014. Des Moines, Iowa. (Received 2nd place in the Ph.D. PIE student competition)

Wagner, P., M. E. O'Neal, and **A. J. Varenhorst**. 2014. Varying the timing of insecticide application limits non-target impacts in soybean. 69th Annual North Central Branch of the Entomological Society of America. 10 March 2014. Des Moines, Iowa.

Varenhorst, A. J., and M. E. O'Neal. 2013. Induced susceptibility: a density dependent response that explains *Aphis glycines* populations on resistant soybean in field research plots. 68th Annual North Central Branch of the Entomological Society of America. 17 June 2013. Rapid City, South Dakota. (Received 2nd place in the Ph.D. PIE student competition)

Varenhorst, A. J., and M. E. O'Neal. 2013. Density-dependent induced susceptibility: a non-genetic explanation of soybean aphid biotypes on aphid resistant soybean. 4th Biennial ISU Hemipteran Research Symposium. 26 March 2013. Ames, Iowa.

Varenhorst, A. J., and M. E. O'Neal. 2012. Which aphids are important vectors of *Soybean mosaic virus*? 60th Annual Meeting of the Entomological Society of America. 12 November 2012. Knoxville, Tennessee.

Varenhorst, A. J., and M. E. O'Neal. 2012. What role do alate soybean aphids (*Aphis glycines*) play in the spread of Soybean mosaic virus? 67th Annual North Central Branch of the Entomological Society of America. 4 June 2012. Lincoln, Nebraska. (Received 2nd in the Ph.D. PIE student competition)

Varenhorst, A. J., and M. E. O'Neal. 2011. Managing soybean aphids with selective insecticides results in a bioresidual. 59th Annual Meeting of the Entomological Society of America. 14 November 2011. Reno, Nevada.

Varenhorst, A. J., and M. E. O'Neal. 2011. The natural enemy community of the soybean aphid, and the effects that selective insecticides have on its populations. 66th Annual North Central Branch of the Entomological Society of America. 14 March 2011. Minneapolis, Minnesota. (Received 3rd place in the M.S. PIE student competition)

Varenhorst, A. J., and M. E. O'Neal. 2010. Can selective insecticides control soybean aphid populations without harming natural enemies? 58th Annual Meeting of the Entomological Society of America. 13 December 2010. San Diego, California.

Varenhorst, A. J., and M. E. O'Neal. 2010. Can selective insecticides control soybean aphid populations without harming natural enemies? Midwest Ecology & Evolution Conference 2010. 27 March 2010. Ames, Iowa.

Varenhorst, A. and T. Wilson. 2008. Survey of the insects in the Sioux City Prairie, Woodbury County. 18th Annual Prairie Invertebrate Conference. 25 October 2008. Newburg, Wisconsin.

Extension Presentations

2017

Varenhorst, A., A. Bachmann and M. Dunbar. 2017. Insecticide resistance in South Dakota mosquitos. Mosquito Control and West Nile Conference. Aberdeen, SD.

Varenhorst, A. 2017. Forage insect pests: what to watch for. Forage Fiesta. Beresford, SD.

Varenhorst, A., P. Wagner and A. Bachmann. 2017. Corn, Soybean, and Alfalfa insect pest management. East River IPM Field School. Beresford, SD.

Varenhorst, A. J. 2017. Current and potential insect pests. Northeast Research Farm Field Day.

Varenhorst, A. J. 2017. Current and potential insect pests. Southeast Research Farm Field Day.

Varenhorst, A. J. 2017. Current and potential insect pests. Volga Farm Field Day.

Varenhorst, A. J. and P. Wagner. 2017. 2017 insect pests in field peas. Field Pea Tours.

Varenhorst, A. J. and P. Wagner. 2017. Alfalfa and Range insect pest management. West River Field School. Rapid City, SD.

Varenhorst, A., J. 2017. Current and potential wheat insect pests. Pierre and Wall Wheat Walks.

Varenhorst, A., J. 2017. Current and potential wheat insect pests. Watertown Wheat Walks.

Varenhorst, A. J. and P. M. Wagner. 2017. Commercial Agriculture Recertification: Category 1B. Presented at 10 locations to 1,826 stakeholders.

Varenhorst, A. J. and P. M. Wagner. 2017. Private Agriculture Recertification. Presented at 13 locations.

2016

Varenhorst, A., P. Wagner, A. Bachmann. 2016. Extension Entomology Booth. South Dakota State Fair, Huron, SD. Attended 9/1/16 – 9/5/16. Contacted approximately 5,000 stakeholders.

Varenhorst, A. 2016. Scouting for late season insect pests. DakotaFest, Mitchell, SD. 8/16/16. Presented to approximately 12 stakeholders.

Varenhorst, A., and A. Bachmann. Extension Entomology Booth. DakotaFest. DakotaFest, Mitchell, SD. Attended 8/16/16 - 8/18/16. Contacted approximately 1,000 stakeholders.

Varenhorst, A. 2016. Corn and soybean insect pests. Volga Research Farm Field Day. Volga, SD. 7/27/16. Presented to 8 stakeholders.

Varenhorst, A. 2016. Insects in South Dakota Crops. IPM Field School. Volga, SD. Attended 7/20/16 - 7/21/16. 66 attendees.

Varenhorst, A. 2016. Insecticides and pollinators. Pollinator Workshop. Pierre, SD. 7/15/16. Presented to 11 attendees.

Varenhorst, A. 2016. Soybean insect pests. Southeast Research Farm Field Day. Beresford, SD. 7/12/16. Presented to approximately 40 stakeholders.

Varenhorst, A. 2016. Soybean insect pests. Northeast Research Farm Field Day. 7/6/16. Presented to approximately 40 stakeholders.

Varenhorst, A. 2016. South Dakota insect pests. West River IPM Field School. Pierre, SD. 6/28/16. Presented to 40 attendees.

Posch, J. P., P. Alberti, T. Olson, P. Okello, **A. Varenhorst**, A. Bachmann, E. Byamukama, and F. Mathew. 2016. Common garden diseases and pests. SDSU Extension Day. 6/22/16. Rosebud Indian Reservation.

Varenhorst, A. 2016. Insect pests of field peas in South Dakota. Field Pea Tours. 6/21/16-6/22/16. Presented at two locations to a total of 15 stakeholders.

Varenhorst, A. 2016. Insect pests of wheat in South Dakota. Wheat Walks. 25 May 2016. Presented at three locations to a total of 20 stakeholders.

Varenhorst, A. 2016. Insect pests in South Dakota. South Dakota Independent Crop Consultants Workshop. 1 April 2016. Presented to a total of 45 stakeholders.

Varenhorst, A. and A. Bachmann. 2016. Integrated pest management of insects and pesticide safety. South Dakota State University Winter IPM School. 15 March 2016. Presented to a total of 14 stakeholders.

Varenhorst, A. J. 2016. Insect updates on major crops in South Dakota. Commercial Agriculture Recertification: Category 1B. Presented at ten locations to a total of 1,924 stakeholders.

Varenhorst, A. J. 2016. Insect pest issues in South Dakota. South Dakota Private Applicator Training. Presented at nine locations to a total of 503 stakeholders.

Posters

2018

Dierks, C., B. Hauswedell, P. Rozeboom and **A. Varenhorst**. 2018. Developing an efficacy study for foliar insecticidal management of soybean aphids in South Dakota. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Rozeboom, P., B. Hauswedell, C. Dierks, and **A. Varenhorst**. 2018. Evaluating the efficacy of seed treatments and planting dates against aphid pests in South Dakota winter wheat. 73rd Annual

Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Wagner, P. and **A. Varenhorst**. 2018. Do dung beetles provide services in grazed cover crops. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Hauswedell, B., P. Rozeboom, J. P. Michaud, J. Knodel and **A. Varenhorst**. 2018. Efficacy of seed and in-furrow treatments in sunflower for early season insect pests. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Anderson, E., B. Fuller, P. Wagner, and **A. Varenhorst**. 2018. Grasshoppers of Eastern South Dakota: A species diversity survey. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Wagner, P., A. Bachmann, R. Beck, B. Hauswedell, E. Byamukama, and **A. Varenhorst.** 2018. South Dakota State University Extension Efforts in Sunflower. 40th Annual NSA Research Forum. 10 January 2018. Fargo, ND.

2017

Wagner, P., E. Anderson, A. Bachmann, and **A. Varenhorst**. 2017. Grasshoppers of western South Dakota: A species diversity survey. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. Denver, CO.

Hauswedell, B., P. Rozeboom, F. Mathew, J. Kleinjan, and **A. Varenhorst**. 2017. Developing soybean seed treatment recommendations in South Dakota. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. Denver, CO.

Dierks, C. P. Rozeboom, and A. Varenhorst. 2017. Evaluating the impacts of seed treatment and cover crop on soybean. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. 7 November 2017. Denver, CO.

Rozeboom, P. and **A. Varenhorst**. 2017. Evaluating the efficacy of seed treatments in South Dakota winter wheat. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. Denver, CO.

Mattern, M., P. Rozeboom, A. Bachmann, and **A. Varenhorst**. 2017. Determining the species of pollinators visiting South Dakota sunflower. 65th Annual Meeting of the Entomological Society of America. 6 November 2017. Denver, CO.

Conzemius, S., L. Hesler, **A. Varenhorst**, and K. Tilmon. 2017. No-Choice but to find plant resistance to soybean aphid biotype 4. 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/5/2017

Hauswedell, B., P. Rozeboom, and **A. Varenhorst**. 2017. Efficacy of insecticide seed treatments for sunflowers in South Dakota. 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/6/2017

Dunbar, M. W., A. Bachmann, F. Mathew, and **A. J. Varenhorst**. 2016. Mosquito insecticide resistance affected by agricultural pest management. American Society of Tropical Medicine and Hygiene, Annual Meeting, Atlanta, GA.

Hauswedell, B., M. W. Dunbar, F. M. Mathew, J. Kleinjan, and **A. J. Varenhorst**. 2016. Developing management recommendations for the use of seed treatments for soybean in South Dakota. AgOutlook. Sioux Falls, SD.

Posch, J. P., **A. J. Varenhorst**, P. A. Rozeboom, and F. M. Mathew. 2016. Determining the impact of co-infestations of Diaporthe longicolla and soybean aphid on soybean. AgOutlook. Sioux Falls, SD.

Neupane, S., Q. Ma, F. Mathew, **A. Varenhorst**, E. J. Andersen, and M. P. Nepal. 2016. Characterization of induced susceptibility effects on soybean-soybean aphid and soybean-soybean aphid-soybean cyst nematode interactions. AgOutlook. Sioux Falls, SD.

2016

Dunbar, M. W., B. Hauswedell, F. M. Mathew, J. Kleinjan, and **A. J. Varenhorst**. 2016. Developing management recommendations for the use of fungicide and insecticide seed treatments for soybeans in South Dakota. International Congress of Entomology. 26 September 2016. Orlando, FL.

Olson, T., F. Mathew, A. Adhikari, B. Kontz, **A. Varenhorst**, and L. Marek. 2016. Development of a quantitative PCR assay to quantify resistance to *Diaporthe helianthi* and *Diaporthe gulyae* in sunflower. American Phytopathological Society Annual Meeting. 30 July 2016.

Adhikari, A., P. Okello, B. Kontz, M. Dunbar, **A. Varenhorst**, and F. Mathew. 2016. Characterizing Fusarium species infecting corn roots in South Dakota. American Phytopathological Society Annual Meeting. 30 July 2016.

Olson, T., B. Kontz, K. Kirby, P. Okello, A. Adhikari, J. Kleinjan, **A. Varenhorst**, and F. Mathew. 2016. Efficacy of commercial fungicide seed treatments on soybean. South Dakota State University Northeast Research Farm Field Day. July 6, 2016. Southshore, SD.

Hauswedell, B., M. W. Dunbar, F. M. Mathew, J. Kleinjan, and **A. J. Varenhorst**. 2016. Developing management recommendations for the use of seed treatments for soybeans in South Dakota. South Dakota State University Northeast Farm Field Day. 6 July 2016. Southshore, SD.

Posch, J. P., **A. J. Varenhorst**, F. M. Mathew. 2016. Determining the interaction between the stem canker fungus, *Diaporthe longicolla*, and the soybean aphid, *Aphis glycines,* on soybean. American Phytopathological Society North Central Meeting. 8 June 2016. Minneapolis, MN.

Dunbar, M. W., B. Hauswedell, F. Mathew, J. Kleinjan, and **A. J. Varenhorst**. 2016. Developing management recommendations for the use of seed treatments for soybeans in South Dakota. 71st Annual North Central Branch of the Entomological Society of America. 7 June 2016.

Pritchard, S. R., M. E. O'Neal, A. Singh, A. K. Singh, **A. J. Varenhorst**, and I. Valmorbida. 2016. Effect of soybean trichome density on Aphis glycines and its natural enemies. 3rd Annual Graduate and Professional Student's Research Conference. 12 April 2016. Ames, IA.

Nepal, M., S. Neupane, Q. Ma, F. Mathew, **A. Varenhorst,** and E. J. Andersen, R. N. Reese. 2016. Comparative genomics of disease resistance genes in soybean (*Glycine max*) and common bean (*Phaseolus vulgaris*). 2016 Botany Conference. 30 July through 3 August 2016. Savannah, GA.

Varenhorst, A., K. Grady, R. Beck, C. Graham, T. Nleya, E. Byamukama, A. Bachmann, P. O. Johnson, C. Tande, and F. Mathew. 2016. Sunflowers in South Dakota: A summary of the South Dakota State University extension efforts for 2015. 2016 National Sunflower Association Research Forum. 12 January 2016. Fargo, ND.

Knodel, J., J. P. Michaud, P. Beauzay, and **A. Varenhorst**. 2016. Efficacy of insecticide seed treatments and soil insecticides for management of wireworms in sunflowers. 2016 National Sunflower Association Research Forum. 12 January 2016. Fargo, ND.

Posch, J. P., **A. J. Varenhorst**, and F. M. Mathew. 2015. Interaction between soybean cyst nematode and stem canker pathogens. 11th Annual AgOutlook. 10 December 2015. Sioux Falls, SD.

Dunbar, M. W., **A. J. Varenhorst**, E. W. Hodgson, M. E. O'Neal, A. J. Gassmann. 2015. True armyworm, rye cover, and no-till: An unfortunate combination in 2015. 63rd Annual Meeting of the Entomological Society of America. 17 November 2015. Minneapolis, MN.

Pritchard, S. R., **A. J. Varenhorst**, A. Singh, A. Singh, I. Valmorbida, M. E. O'Neal. 2015. Effect of soybean trichome density on soybean aphid and its natural enemies. 63rd Annual Meeting of the Entomological Society of America. 16 November 2015. Minneapolis, MN.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Fitness costs associated with virulent soybean aphids. 2015 Soybean Breeders Workshop: Entomology and Agronomy. 17 February 2015. St. Louis, Missouri.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2014. Fitness costs associated with virulent soybean aphids. Soybean Aphid Field Day. 14 August 2014. Iowa State University Field Extension Education Laboratory Boone, Iowa.

McCarville, M. T., **A. J. Varenhorst**, M. E. O'Neal. 2014. Tougher than we all thought? Re-evaluating the surprisingly durable *Rag* genes. Soybean Aphid Field Day. 14 August 2014. Iowa State University Field Extension Education Laboratory Boone, Iowa.

Varenhorst, A. J. and M. E. O'Neal. 2009. Can reduced-risk insecticides prevent soybean aphid outbreaks? 57th Annual Meeting of the Entomological Society of America. 14 December 2009. Indianapolis, Indiana.

Photo Credits

Environmental Entomology. 2015. Environ. Entomol. 44. Front cover.

United Soybean Board. 2015. Leading experts stress need for cooperation on honey bee health. News from the Checkoff. 16 June 2015.

United Soybean Board. 2015. Checkoff studies soybean-honey bee relationship. News from the Checkoff. 16 June 2015.

Gill, K. 2015. Everyone can play a role in pollinator conservation. Ecological Landscape Alliance.
http://www.ecolandscaping.org/01/beneficials/everyone-can-play-a-role-in-pollinator-conservation/

Pearce, R. Researchers abuzz about soybean yields. Country Guide.
http://www.country-guide.ca/2014/11/07/researchers-abuzz-about-soybean-yields/45085/

Adamson, N. L., B. Borders, J. Cruz, S. Foltz-Jordan, K. Gill, J. Hopwood, E. Lee-Mäder, A. Minnerath, and M. Vaughn. 2014. Pollinator plants mid-Atlantic region. Cover, picture 15.

Vaughn, M. 2014. USDA NRCS Honey bee monitoring training. USDA NRCS West National Technology Support Center and Pollinator Program. Webinar 29 May 2014 picture C.

Jesse, L., D. Lewis, J. Coats, and M. Shour. 2013. Protecting bees from pesticides. Iowa State University Extension and Outreach. Pub SP 455.

O'Neal, M., and E. Hodgson. 2013. Best practices to promote pollinator habitat. Integrated Crop Management News. 15 August 2013

Heidel-Baker, T., E. Hodgson, and M. O'Neal. Conserving Bees in Iowa Field Crops. Iowa State University Extension and Outreach. Pub 293-13.

Hodgson, E., and T. Heidel-Baker. 2013. Soybean aphid field guide. North Central Soybean Research Program. P. 46. Pub CSI 0060.

O'Neal, M., and E. Hodgson. 2013. Bee health in the news. Iowa State University Extension and Outreach. Integrated Crop Management News. 9 May 2013.

Leopold Center. 2013. Conserving beneficial insects with native plants. Front, Back (pp. 4, 6, 8).

Practical Farmers of Iowa. 2012. The buzz about best pollinator practices. http://practicalfarmers.org/blog/2012/the-buzz-about-best-pollinator-practices.

Hodgson, E., A. Sisson, D. Mueller, L. Jesse, E. Saalau-Rojas, and A. Duster. 2012. Field crop insects. Iowa State University Extension and Outreach. Pg. 37 top. Pub CSI 0014.

McCarville, M., E. Hodgson, and M. O'Neal. 2012. Soybean-aphid resistant soybean varieties for Iowa. Iowa State University Extension and Outreach. Integrated Crop Management News. Pub PM 3023

Teaching Experience

Teaching Assistant
Fundamentals of Entomology and Pest Management (Entomology 376), Iowa State University
Lab Teaching Assistant, Spring 2015, 2014 (two sections), 2013, 2012
Lab Teaching Assistant Coordinator, Spring 2015

Insect Biology (Entomology 370), Iowa State University
Lab Teaching Assistant, Fall 2013, 2012, 2011

Entomology (Entomology 300), Briar Cliff University
Lab Teaching Assistant, Fall 2008

Mentoring Experience

Graduate Student Advisor

Ph.D. Students:

Student: Surendra Neupane
Status: In progress

M.S. Students:

Student: Cole Dierks
Status: In progress

Student: John Posch

Status: Graduated

Student: Brady Hauswedell
Status: In progress

Student: Sophia Conzemius
Status: In progress

Graduate Student Committee
Ph.D. students

Student: Biyi Chen
Status: In progress
Student: Paul Okello
Status: In progress

M.S. students

Student: Taylor Hanson
Status: Graduated
Student: Bret Owen
Status: Graduated

Graduate Student Mentor

Student Mentored: Shelby Pritchard (M.S.)
Status: Graduated

Undergraduate Student Mentor

Student: Mackenzie Mattern
Project title:
Affiliation: South Dakota State University
Duration: 2016-2018

Student: Patrick Wagner
Project title: Examining the effect of insecticide application timing.
Affiliation: Iowa State University
Duration: 2012-2013

George Washington Carver Student Advisor/Mentor

Student Mentored: Danaisa Green
Project title: Determining the presence of fitness costs associated with biotype-4 soybean aphids.
Affiliation: Iowa State University

Duration: Summer 2014

Tutoring

Introduction to Microbiology (Biology 239), Briar Cliff University
Tutor, Fall 2008. Three students.

Environmental Science (Environmental Science 110), Briar Cliff University
Tutor, Winter 2008. One student.

Awards and Scholarships:

2017	International IPM Award of Excellence: Soybean Entomology for North Central Soybean Research Project
2017	National Association of County Agricultural Agents Communication Award: Newsletter by a Team Regional Winner
2017	Curtis Stern Memorial Scholarship from National Sunflower Association, student: Brady Hauswedell
2016	Griffith Undergraduate Research Award, student: Mackenzie Mattern
2015	ISU Teaching Excellence Award
2014	ISU Department of Entomology, Jim Oleson Scholarship in Entomology
2014	1st Place Plant-Insect Ecosystems Session 19. 62nd Annual ESA National Meeting, Student Ten-Minute Presentation (TMP), Portland, OR
2014	Best in Section Award. Student Talk Competition at 1st Graduate and Professional Student Research Conference – ISU, Ames, IA
2014	2nd Place Plant-Insect Ecosystems Session II Ph.D. Competition at 69th Annual ESA NCB meeting, Student Ten-Minute Presentation (TMP), Des Moines, IA.
2013	ISU Department of Entomology, Jim Oleson Scholarship in Entomology
2013	2nd Place Plant-Insect Ecosystems Session II Ph.D. Competition at 68th Annual ESA NCB meeting, Student Ten-Minute Presentation (TMP), Lincoln, NE
2012	ISU Department of Entomology Alumni Scholarship

2012	2nd Place Plant-Insect Ecosystems Session II Ph.D. Competition at 67th Annual ESA NCB Meeting, Student Ten-Minute Presentation (TMP), Minneapolis, MN
2012	North Central Branch of the Entomological Society of America, 2012 Presidential Student Travel Scholarship, Rapid City, SD
2011	ISU Department of Entomology, Wayne A. Rowley Scholarship
2011	3rd Place Plant-Insect Ecosystems Session II M.S. 66th Annual ESA NCB Meeting, Student Ten-Minute Presentation (TMP), Minneapolis, MN
2009-2011	ISU Department of Entomology, Miller Graduate Fellowship
2008-2009	Briar Cliff University, BCU Grant Briar Cliff University, National Smart Grant
2008-2009	Briar Cliff University, Academic Scholarship Briar Cliff University, Leadership Scholarship
2007-2008	Briar Cliff University, Academic Award Scholarship Briar Cliff University, Leadership Scholarship Briar Cliff University, Academic Competitiveness Grant
2006-2007	Briar Cliff University, Academic Award Scholarship Briar Cliff University, Leadership Scholarship Briar Cliff University, BCU Grant

Service and Society:

Organizations

Agronomy, Horticulture, and Plant Science Department, South Dakota State University
- Department Search Committees
  - Lecturer Positions
- Extension Committees
  - DakotaFest Planning Committee 2016-present
  - Roadside Working Group 2015-present
  - Monarch and Pollinator Planning Summit 2017-present
- Department Committees
  - Greenhouse committee 2016-present
  - Seminar committee 2016-present

Entomology Graduate Student Organization, Iowa State University

Member, 2009-2015
Student Chair of the Social Committee 2009-2015
Student Chair of the Newsletter Committee 2013-2015
Treasurer, 2010-2011, 2012-2013
President, 2011-2012
Volunteer at:
Annual EGSO Film Festival 2009, 2010, 2011, 2012, 2013, 2014
Edwards Elementary School Science Night 2010, 2011
EGSO participation in VEISHEA 2010, 2011, 2012, 2013

Briar Cliff Science Club, Briar Cliff University
Member 2006-2009
Vice President 2008-2009

Professional Societies
Entomological Society of America
Member, 2008 to present

Roles as a faculty member:
North Central Branch Student Awards Committee Chair 2017 to present
North Central Branch Students Awards Committee 2016 to present
North Central Branch
2016: Ph.D. student presentation competition judge
2017: M.S. student poster competition judge

Roles as a graduate student:
North Central Branch Student Affairs Committee Representative 2012-2014
National Student Affairs Committee Representative 2012-2014
Treasurer of the North Central Branch Student Affairs Committee 2013-2014
North Central Branch Local Arrangements Student Representative 2013-2014
ESA and Foundations Awards Committee Member 2012-2013

National Association of County Agricultural Agents
Member, 2016 to present

Honor Societies
Gamma Sigma Delta: The Honor Society of Agriculture
Member Iowa State University Branch 2011 to 2015
Member South Dakota State University Branch 2015 to present

Community and Other
Pheasants Forever, Member 2008 to present

The National Audubon Society, Member 2008-2012

The Nature Conservancy, Member 2008-2012

The Sierra Club, Member 2008-2012

Reviewer for:

Biological Control
The Journal of Arthropod-Plant Interactions

Technical Skills

Designed and implemented a complete randomized design and also randomized complete block design for field research.

Computer: Microsoft Office (Word, Excel, Power Point, Access), Photoshop, SAS statistical software

Farm machinery operator, equipment repair and maintenance.

Training Programs/Short Courses

Hosted:
Winter IPM Short Course. 2016. Hosted by: Emmanuel Byamukama, Adam Varenhorst,

Pollinator Workshop Short Course. 2016. Hosted by: Adam Varenhorst and Amanda Bachmann. 11 attendees.

Participant:

Bridges: Building a Supportive Community (South Dakota State University). Title IX training. Completed 04/10/17.

SDSU Extension Fall Conference. Mini Workshop: Conflict management. Completed.

SDSU Extension Fall Conference. Mini Workshop: Working with public figures. Completed.

Faculty Inquiry Group (FIG). 2015-2016. What the best college teacher's do. Presented by South Dakota State University Center for the Enhancement of Teaching and Learning. Completed.

Active Shooter Training Class. Presented by Division of Technology and Security. 10/29/15.

Building Research Teams. Presented by Dianne Nagy. South Dakota State University. Completed 10/27/15.

Bridges: Building a Supportive Community (South Dakota State University). Title IX training. Completed 10/6/15.

Federal Required Training: Responsible Conduct of Research. Presented by Norm Braaten. South Dakota State University. Completed 9/24/15.

Prospecting for Funding Opportunities. Presented by Dianne Nagy. South Dakota State University. Completed 9/24/15.

Graduate Assistants: Employee vs. Student. Presented by Tracy Greene, Kinchel Doerner, and David Hanson. South Dakota State University. Completed 9/15/15.

Federal Requirements for Data Management Plans & Public Access. Presented by Jim Doolittle and Kristi Tornquist. South Dakota State University. Completed 9/15/15.

Research at SDSU Workshop for New Faculty. Presented by Kevin Kephart, Jim Doolittle, Dianne Nagy, Kay Scheibe, Michelle Mucciante, and Will Aylor.

Preventing Discrimination and Sexual Violence: Title IX, VAWA and Clery Act for Faculty and Staff. Iowa State University. Completed 8/5/15.

Unlawful Harassment Prevention for Higher Education Staff. Iowa State University. Completed 2/14/14.

Title IX Awareness and Violence Prevention for Higher Education Students. Iowa State University. Completed 2/14/14

Aphid Identification Program

Attended a five-day mentoring program presented by Dr. David Voegtlin from the University of Illinois at the University of Illinois.

NAME: Brandon Haag

EDUCATIONAL BACKGROUND:BS in Business Econ, BS in Agriculture from South Dakota State University

ADDRESS:
20449 Augusta Road
Pierre, SD 57501

WORK EXPERIENCE AS IT APPLIES TO THE ISSUE AT HAND:
18 years in the Ag industry ranging from retail, crop consultant, to manufacturing roles. Former certified crop advisor.

ANTICIPATED TESTIMONY:
The importance of aerial applications as it pertains to our row crops. Also the need for aerial application on small grains in wet years where ground application is not an option.

CODY CHRISTENSEN

Cody.Christensen@sdstate.edu
143 Wagner Hall Box 2275A Brookings, SD 57007
Ph: 605-688-4983

EDUCATION

- University of South Dakota (USD) Vermillion, SD May 2013
  - *Doctorate of Education; Educational Administration; Adult and Higher Education*

- South Dakota State University (SDSU) Brookings, SD December 2006
  - *Masters of Education; Curriculum and Instruction*

- South Dakota State University (SDSU) Brookings, SD May 2005
  - *Bachelor of Science in Education; Career and Technical Education*

AVIATION LICENSES AND CERTIFICATIONS

- FAA Airline Transport Pilot Certificate (AMEL)
  - Type Rating: Beechcraft 1900D
- Medical: Second Class- no restrictions
- FCC Restricted Radiotelephone Operator Permit
- FAA Gold Seal Instructor ratings
  - CFI, CFII, MEI, IGI

AVIATION EXPERIENCE

Assistant Professor/Program Coordinator -South Dakota State University Brookings, SD 01/09-Present

- Oversee Aviation Program including five full time staff and 15 part time staff
- Teach multiple aviation related courses in accordance with regulations
- Advise students within the aviation program
- Publish articles and conduct peer reviewed research
- Secure grants and funding to continue supporting aviation program mission
- Oversee Aviation Accreditation Board International specialized accreditation
- Coordinate, secure funding, and organize summer aviation ACE (Aerospace Career and Education) Camp for high school aged students

Captain- Great Lakes Airlines Cheyenne, WY 01/07- 12/08

- Act as Pilot in Command of a 19 seat Beechcraft 1900 airliner
- Ultimately responsible for the safe and efficient operation of the aircraft and crew
- Utilize Crew Resource Management techniques to create a positive cockpit environment
- Supervise fueling, baggage handling, deicing procedures to ensure compliance with company policies
- Effectively communicate with ground, flight and support staff to ensure a safe, on time flight

Ground Instructor- Great Lakes Airlines Cheyenne, WY 05/08-12/08

- Instruct captains/first officers in aircraft systems, emergency procedures, company policies and procedures
- Qualify former pilots who were rehired to the company
- Conducted emergency drills including evaluation, fire detection and prevention, and hijacking
- Advised pilots on proper procedures during emergency operations

PEER REVIEWED ARTICLES

Adjekum, D. K., Walala, M., Keller, J., Christensen, C., DeMik, R. J., Young, J. P., & Northam, G. (2016). An Analysis of the Effects of Demographic Variables and Perceptions on the Safety Reporting Behavior in Collegiate Flight Programs. International Journal of Aviation Sciences. http://commons.erau.edu/cgi/viewcontent.cgi?article=1134&context=ijaaa

Bjerke, Elizabeth; Smith, Guy; Smith, MaryJo; Christensen, Cody; Carney, Thomas; Craig, Paul; and Niemczyk, Mary (2016). Pilot Source Study 2015: US Regional Airline Pilot Hiring Background Characteristic Changes Consequent to Public Law 111-216 and the FAA First Officer Qualifications Rule. *Journal of Aviation Technology and Engineering*: Vol. 5: Iss. 2, Article 1. Available at: http://dx.doi.org/10.7771/2159-6670.1133

Smith, Guy; Bjerke, Elizabeth; Smith, MaryJo; Christensen, Cody; Carney, Thomas; Craig, Paul; and Niemczyk, Mary. (IN REVIEW) Pilot Source Study 2015: An Analysis of FAR Part 121 Pilots Hired after Public Law-111-216 – Their Backgrounds and Subsequent Successes in US Regional Airline Training and Operating Experience. *Journal of Aviation Technology and Engineering:* Vol. XX: Iss. XX, Article XX.

Smith, MaryJo; Smith, Guy; Bjerke, Elizabeth; Carney, Thomas; Christensen, Cody; Craig, Paul; and Niemczyk, Mary. (IN REVIEW). Pilot Source Study 2015: A Comparison of Performance at Part 121 Regional Airlines between Pilots Hired before the US Congress Passed Public Law-111-216 and Pilots Hired after the Law's Effective Date. *Journal of Aviation Technology and Engineering:* Vol. XX: Iss. XX, Article XX.

Adjekum, D. K., Keller, J., Walala, M., Young, J. P., Christensen, C., & DeMik, R. J. (2015). Cross-Sectional Assessment of Safety Culture Perceptions and Safety Behavior in Collegiate Aviation Programs in the United States. International Journal of Aviation, Aeronautics, and Aerospace, 2(4). http://dx.doi.org/10.15394/ijaaa.2015.1074

Christensen, C. & Card, K. A. (2014). *Specialized Aviation Flight Accreditation Under Public Law 111-216 Aviation Program Administrators' Perceptions*. Collegiate Aviation Review.32 (2).

Christensen, C. & Dunn, B. (2011) Fleet characteristics of collegiate aviation flight programs. *Collegiate Aviation Review,* 29 (2), 13-20

MAGAZINE ARTICLE (EDITOR REVIEWED)

Christensen, C. (2011) *The art of professionalism*. CFI to CFI. 2(1).

PRESENTATIONS

Christensen, C. (2016) *Pilot Source Study Updates and Aviation in South Dakota*. South Dakota Aeronautics Commission Meeting. Deadwood, SD.

Bjerke, Elizabeth; Smith, Guy; Smith, MaryJo; Christensen, Cody; Carney, Thomas; Craig, Paul; and Niemczyk, Mary (February 2016). Pilot Source Study 2015: US Regional Airline Pilot Hiring Background Characteristic Changes Consequent to Public Law 111-216 and the FAA First Officer Qualifications Rule. AABI Town hall Atlanta, GA.

Dow, A., Christensen, C., & Marshall, S. (2015). Reaching New Heights in Recruitment for Smaller Aviation Programs. University Aviation Association Conference in Snowbird, UT.

Christensen, C. & Leonard, A. (2014). Benefits of Early Alerts on Flight Training. University Aviation Association Conference in Daytona Beach, FL.

Christensen, C. (2014). Specialized Aviation Flight Accreditation Under Public Law 111-216 Aviation Program Administrators' Perceptions. University Aviation Association Conference in Daytona Beach, FL.

Christensen, C. (2014). FAA Airspace Review. Presented at the East River Aviation Symposium. Brookings, SD.

Christensen, C. & Leonard, A. (2013). *Integrating a Mobile Training Lab into an Aviation Curriculum.* Presentation at the International University Aviation Association Conference, San Juan, PR.

Christensen, C. (2013). *Influence of military service on student success in an aviation program.* Abstract presentation at the International University Aviation Association Conference, San Juan, PR.

Christensen, C. & Leonard, A. (2012). *Integrating Aviation Concepts into Curriculum.* Presentation at the SD STEM Initiative, Sioux Falls, SD.

Christensen, C. (2011). *Implications of Public Law 111-216 and outcomes based accreditation on specialized aviation accreditation.* Presentation at the International University Aviation Association Conference, Indianapolis, IN.

Christensen, C. (2011). *South Dakota Aviation Safety Initiative*. South Dakota Aeronautics Commission. Pierre, SD.

Christensen, C. and Dunn, B. (2011). *Fleet characteristics of collegiate aviation flight programs.* Presentation at the International University Aviation Association Conference. Indianapolis, IN.

Christensen, C. (2011). *Perfecting the preflight.* FAA national safety-stand down event. Brookings, SD.

Christensen, C., Hovland, W., Kelm, W., Hoogerhyde, S., Leonard, A., & Kwasniewski, G. (2011) *Setting Personal Minimums*. Federal Aviation Administration Safety Seminar. Brookings, SD.

Christensen, C. (2011). *Energizing PowerPoint's using Prezi's in the classroom and conference environments*. Faculty Showcase presented by the Teaching Learning Center. Brookings, SD

CONFERENCE PUBLISHED ABSTRACT (COMMITTEE CHAIR REVIEWED):

Christensen, C. & Leonard, A. (2015). Needs Based Assessment of Agricultural Pilots in the Upper Midwest. University Aviation Association Conference in Snowbird, UT.

Christensen, C. & Leonard, A. (2013). *Integrating a Mobile Training Lab into an Aviation Curriculum.* Conference proceedings at the International University Aviation Association Conference, San Juan, PR.

Christensen, C. (2013) *Influence of military service on student success in an aviation program.* Abstract conference proceedings at the International University Aviation Association Conference. San Juan, PR.

Christensen, C. (2011). *Implications of Public Law 111-216 and outcomes based accreditation on specialized aviation accreditation.* University Aviation Association Conference, Indianapolis, IN.

DISSERTATION

Christensen, C. (2013). *Aviation program administrators' perceptions of specialized aviation accreditation under public law 111-216*. (Doctoral dissertation), University of South Dakota, Vermillion, SD.

GRANTS:

Aerospace Career and Education Camp. $5,000. South Dakota Aeronautics Commission. 2016. (PI: C. Christensen)

SDSU Mobile Aviation Simulator. $75,000. South Dakota Aeronautics Commission. 2016. (PI: C. Christensen)

SDSU Mobile Aviation Simulator. $42,000. Brookings School District. 2016. (PI: C. Christensen)

Aerospace Career and Education Camp. $5,000. South Dakota Aeronautics Commission. 2015. (PI: C. Christensen)

Scholarly Travel Grant. $1,000. SDSU Office of Academic Affairs and Department of Consumer Sciences. 2013. (PI: C. Christensen)

Aerospace Career and Education Camp. $5,000. South Dakota Aeronautics Commission. 2014. (PI: K. Dalsted, Co-PI: C. Christensen)

Accreditation Self-Study Funding. $6,400. SDSU Office of Academic Affairs, 2012. (Co-PI: C. Christensen, Co-PI: A, Leonard, Co-PI: J. Boulware).

Increasing Aviation Activity in South Dakota. $2,500. South Dakota Space Grant Consortium. 2011-2012.

Assessment and development plan for aviation program accreditation. $5,400. SDSU Office of Academic Affairs, 2011 (PI: C. Christensen, Co-PI: A, Leonard).

Online course redevelopment for Advanced Flight Principles. $1,500. College of EHS Academic Excellence funds, 2011.

Capital utilization among aviation flight programs. $1,000. College of EHS Academic Excellence funds. 2011 (PI: C. Christensen, Co-PI: B. Dunn).

Female mentor in the SDSU Aviation program. $2,400 SDSU Foundation-Women in Giving, 2009-2011.

MEMBERSHIPS & AFFILIATIONS

- FAASTeam safety counselor (2010-current)
  - 2016 SD FAASTeam Rep of the Year
- SDSU Flying Jacks-Advisor (2012-current)
- University Aviation Association (2009-current)
- Alpha Eta Rho Aviation Fraternity-Advisor (2009-2012)
- Aircraft Owners and Pilots Association (2001-current)
- Brookings County Youth Mentor (2012-2016)
- South Dakota Pilots Association (2009-current)
- South Dakota Aviation Association (2014-current)
- Women in Aviation member (2011-current)

Michael J Bollweg 09/25/1973
South Dakota State University - Bachelor of Science in Agriculture
Graduated: December 1996
34 years farming experience -
SD Dept of Agriculture Commercial Applicator License holder for 30 years: #AP1607

Manager/Executive Director of Tumbleweed Lodge – overseeing all aspects
Judi Bollweg – owner (sole proprietor) of Tumbleweed Lodge

Tumbleweed Lodge has held a South Dakota Hunting Preserve permit since 1988. I began as a bird cleaner/guide.

NAME: Ryan Thompson

EDUCATIONAL BACKGROUND: Agronomy Degree from Fort hays State University
ADDRESS: 2921 Sussex Rd, Pierre, SD 57501

WORK EXPERIENCE AS IT APPLIES TO THE ISSUE AT HAND
2 yrs interning with Servi –Tech agronomy
3 years Crop quest out Dodge City scouting 20,000 ac/year of multiple crops
And 15 years with Helena, in multiple rolls, Retail salesman and now Branch Manager for western 2/3 of North and South Dakota

ANTICIPATED TESTIMONY (providing an expert perspective why aerial application of pesticides on sunflowers at bloom and fungicides at heading are necessary and cannot be applied by ground without extreme economic loss)
Sunflowers is the easy one, Simply they are just too tall and rank to drive a ground rig through it would completely destroy where the sprayer drove. Also the timing is so critical that there is no way it would be possible to get across all the acres in a timely manner. The economic impact of either one is critical for sunflower production

As far as the wheat and fungicide at heading, It follows the same impacts as the flowers by not being able to use aerial application. There tracks from the ground rig our probadly at a 90-95% loss, once the wheat is jointed and the stalk breaks it will not come back or stand back up. And once a again agriculture is about timing and the efficacy of a head treatment at flowering is even more precise, just not enough ground sprayers to do. The impact of not putting on a head treatment could result 5-35% decrease in yield depending on pressure

NAME: Terry Barber

EDUCATIONAL BACKGROUND: Agronomy Degree from South Dakota State University

WORK EXPERIENCE AS IT APPLIES TO THE ISSUE AT HAND
22 years in the family ag spraying business

ANTICIPATED TESTIMONY (providing an expert perspective why aerial application of pesticides on sunflowers at bloom and fungicides at heading are necessary and cannot be applied by ground without extreme economic loss)
He sprays the Bollweg farm properties. The towers either make spraying very dangerous or complicated. The airflow off the turbines disrupts the spray patterns off the aircraft, making the spray less effective.

28 September 2021

Michael Bollweg
Bollweg Farms
Tumbleweed Lodge
20210 322nd Ave.
Harrold, SD 57536

RE: RED SUNFLOWER SEED WEEVILS

Dear Michael Bollweg,

The red sunflower seed weevil is a native pest of sunflower in South Dakota. When left unmanaged, the red sunflower seed weevil is capable of infesting approximately 80% of the developing seeds in a sunflower head. Since 2016, populations of red sunflower seed weevils have been observed in South Dakota that are 10-100x over the economic threshold of 4-6 weevils per sunflower head. In addition, SDSU Extension entomologists have received reports of insecticide application failures for red sunflower seed weevils since 2017. These reports were for the pyrethroid class active ingredient lambda-cyhalothrin. Since 2017, research from South Dakota State University has concluded that there are populations of red sunflower seed weevils with reduced susceptibility to pyrethroid class insecticides. On-going research is aimed at determining the level of reduced susceptibility and compare the populations tested in South Dakota to those from neighboring states. Our observations of red sunflower seed weevils in several counties in South Dakota during 2021 indicate that very large populations are present within fields. We are continuing to test populations using laboratory assays.

At this time, we recommend that all sunflower fields be scouted, and insecticides be applied when the threshold for red sunflower seed weevils is exceeded. Due to the numerous field failures, we are recommending that lambda-cyhalothrin not be used for management of the red sunflower seed weevil. We also are recommending that fields are scouted 24-48 hours after insecticide application to determine if the treatment successfully reduced the red sunflower seed weevil populations. To prevent additional issues with labeled insecticide products we recommend tank mixing two insecticides with different modes of action (not including lambda-cyhalothrin) or using a product that is not from the pyrethroid insecticide class.

Sincerely,

Dr. Adam Varenhorst

Assistant Professor and Extension Field Crop Entomologist

South Dakota State University

syngenta

Michael Bollweg tumbleweed@venturecomm.net
The importance of aerial spraying to timely product applications

Michael:

Following up on our recent conversation, I've been involved in production agriculture and the crop input supply business, heavily weighted to agronomy for over 40 years. Here are my thoughts on the importance of timely applications using 3 local crop production examples and situations.

The first is control of what can be a devastating disease pathogen in central South Dakota. Fusarium graminearum is the fungal pathogen that causes Head Blight in wheat. As recent as 2019 in South Dakota, Fusarium head blight (FHB) can and has reduced wheat yields up to 50%. Additionally, FHB typically produces a mycotoxin, deoxynivalenol (DON). DON is toxic to mammals at very low levels. If DON levels are over the acceptable threshold, the harvested wheat will be rejected and disposed of as unsaleable at the elevator. It's important to understand the threat from an FHB infection and not take it lightly.

With reference to managing FHB in Wheat, there are fungicides available to help control the pathogen. We know from field research that the spores produced by the pathogen enter the wheat plant through the flowers. The critical timing to make a fungicide application is Feekes growth stage 10.5.1. That is when the wheat begins to flower. In a practical sense the fungicide application window is generally around 3 days. That may seem like an ample amount of time to make an application to control FHB. Unfortunately knowing the plant physiology of winter wheat, fields generally all flowers at the same time over a very large geography. It's very common for 10's of thousands of acres to require an FHB fungicide application at the same time over a narrow geography in central SD.

Syngenta produces and markets a fungicide, Miravis Ace. The active ingredients in Miravis Ace are well positioned to manage FHB. We know from experience that aerial application is well suited for the application of Miravis Ace. Aerial application can accurately and efficiently cover thousands of acres in a narrow time window. Anything that can cause an application delay can and will cause a yield and quality loss from the pathogen. There are factors like wind and rain that are out of our control and put pressure on the application window. That's why it's even more important to manage things that are in our control like the placement of wind turbines.

The disease threat in central SD isn't limited to wheat. Plant disease management has grown exponentially as disease threats in South Dakota have increased and as the performance of fungicides like Miravis Ace and Miravis Neo has grown, so has the use of fungicides. Specific to corn, tassel applications of fungicides like Miravis Neo and Trivapro have clearly demonstrated yield and quality improvements. One of the key application timings on corn is the growth stage VT – R1, tassel and silk emergence. On an average year, the corn in central SD at VT-R1 is from 6 to 10 feet tall. Due to crop clearance issues that make it challenging if not impossible for a ground rig sprayer to make the timely application. Once again making aerial the primary application method of choice.

The pest threat isn't isolated to plant pathogens, it unfortunately extends to insect pests also. A specific example is the management of seed weevils and head moths in Sunflowers. Similar to the examples above, proper application timing is important for management of these two insects in sunflowers. The threat is the early flowering stage of the sunflowers. Similar to corn, aerial application is preferred over ground application due to the height and physical spacing of the target crop.

I've addressed key pest threats in three important crops that cover a high percentage of the crop acres in central South Dakota. Knowing the bigger picture, there are crop protection products and product labels that support aerial application on virtually all crops, including pastures in South Dakota.

I trust you will agree that we have an obligation to understand and mitigate the threats to South Dakota producers that can negatively impact our ability to produce a safe, wholesome and bountiful harvest.

Wally West
Agronomy Services Representative
Wally.West@syngenta.com

syngenta *Bringing plant potential to life*

BEFORE THE PUBLIC UTILITIES COMMISSION OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY NORTH BEND WIND PROJECT, LLC FOR A PERMIT TO CONSTRUCT AND OPERATE THE NORTH BEND WIND PROJECT IN HYDE COUNTY AND HUGHES COUNTY, SOUTH DAKOTA	* * * * * * * *	**JUDI BOLLWEG'S RESPONSE TO STAFF'S SECOND SET OF DATA REQUESTS TO MS. JUDI BOLLWEG** **EL21-018**

Below, please find Judi Bollweg's Response to Staff's Second Set of Data Requests to Ms. Bollweg, individually, and on behalf of Tumbleweed Lodge and on behalf of Bollweg Family, LLLP.

2-1) Refer to Ms. Bollweg's response to staff data request 1-2(b) and 1-3. In response to staff data request 1-2(b), Ms. Bollweg stated "Mr. Barber sprays the Bolweg farm properties. He will testify that proposed tower locations 19, 27 and permanent met tower 2 impede the ability to spray the 240 acres ….". In response to staff data request 1-3, Ms. Bollweg states "if turbines #8, 9, 14, 15, 20, 21, and 22 were not put up farming could continue without interference." Turbine locations 19 and 27, and permanent met tower 2 were not referenced in response to staff data request 1-3. Is Ms. Bollweg recommending any terms, conditions, or modifications regarding turbines 19 and 27, and permanent met tower 2? Please explain.

Response: Towers 19, 27 and Permanent met tower 2 impede the ability to apply crop protection products the most efficient way on that property. The property consists of approximately 240 acres that is 3/4 mile long, north/south and a 1/2 mile wide, east/west. Aerial application may still occur with the proposed locations in question; however, eliminating the ability to spray it north/south. As such, the negative results are as follows:

1. Aerial applicators, including Brett's Spray Service, will charge an additional fee for having to make more passes across the field, burning more aviation fuel and putting more hours on their aircraft which is passed on to the consumer. EX: This field is approximately 3,960' long by 2640' wide. An aircraft swath of 66' would only require 40 passes when products are applied the long way, north/south. However, with the impediment of towers 19, 27 and met 2, aircraft would be restricted to fly it the short way requiring 60 passes. Another thing to consider with regard to ag pilots applying crop protection products on a property is regardless of the initial direction they choose to spray the field; they still need to do a "clean up" pass on all sides. "Cleaning up" involves flying along all outside edges of the fields.

2. Professional bee keepers place beehives on private properties throughout the region. Bees are susceptible to pesticide applications required to control harmful seed weevils in sunflowers. Bees tend to go back to their hives in the evenings in which aerial applicators choose to spray sunflowers in the evenings to minimize the loss of beneficial pollinators. An east/west spray pattern puts the sun, now lower in the skyline right in view of the pilot adding another element of distraction. Compound this with 500-600' wind turbines, 320' met towers, and turbulence created by the wind turbines, a pilot has added extreme safety risks to his/her welfare while still trying to effectively, efficiently apply crop protection products.

Terry Barber noted an applicator in Nebraska charges a flat $2/acre more if the field is near a wind tower and many times will not make an attempt to spray it if deemed too dangerous.

Dated this 26th day of October, 2021.

/s James E. Malters
JAMES E. MALTERS
For: MALTERS, SHEPHERD & VON HOLTUM
Attorneys for Michael Bollweg, Judi Bollweg, Tumbleweed Lodge and the Bollweg Family, LLP
727 Oxford Street - P. O. Box 517
Worthington, MN 56187-0517
jmalters@msvlawoffice.com
(507) 376-4166
Fax: (507) 376-6359

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

IN THE MATTER OF THE APPLICATION BY NORTH BEND WIND PROJECT, LLC FOR A PERMIT TO CONSTRUCT AND OPERATE THE NORTH BEND WIND PROJECT IN HYDE COUNTY AND HUGHES COUNTY, SOUTH DAKOTA	* * * * * * * *	**MICHAEL BOLLWEG'S RESPONSES TO STAFF'S FIRST SET OF DATA REQUESTS TO MR. MICHAEL BOLLWEG** **EL21-018**

Below, please find Michael Bollweg's Responses to Staff's First Set of Data Requests to Mr. Bollweg, individually, and on behalf of Bollweg Family, LLLP.

1-1) Provide copies of all data requests submitted to Mr. Bollweg or by Mr. Bollweg and copies of all responses provided to those data requests. Provide this information to date and on an ongoing basis.

1-2) Refer to SDCL 49-41B-22, Applicant's burden of proof:

The applicant has the burden of proof to establish by a preponderance of the evidence that:

(1) The proposed facility will comply with all applicable laws and rules;

(2) The facility will not pose a threat of serious injury to the environment nor to the social and economic condition of inhabitants or expected inhabitants in the siting area. An applicant for an electric transmission line, a solar energy facility, or a wind energy facility that holds a conditional use permit from the applicable local units of government is determined not to threaten the social and economic condition of inhabitants or expected inhabitants in the siting area;

(3) The facility will not substantially impair the health, safety or welfare of the inhabitants; and

(4) The facility will not unduly interfere with the orderly development of the region with due consideration having been given the views of governing bodies of affected local units of government. An applicant for an electric transmission line, a solar energy facility, or a wind energy facility that holds a conditional use permit from the applicable local units of government is in compliance with this subdivision.

(a) Please specify particular aspect(s) of the Applicant's burden that Mr. Bollweg intends to personally testify on.

Response: Michael Bollweg will testify as an expert witness in agronomy/farming and in running a hunting lodge. He will testify concerning numerous aspects, and most of them are discussed in his letters to the commission dated 8/9/21, 8/12/21, 8/26/21, and 9/7-9/8/21. Specifically, he will address the probable loss of revenue to the farming operation due to the location of the towers preventing aerial application which will place crops at risk. He will base his testimony on his background in farming, working for Bollweg Spraying, and his education in agronomy. He will also testify concerning the effects of the turbines upon the family hunting lodge, Tumbleweed Lodge.

There are two grounds for the Bollweg objections. The first is that the layout of the proposed towers will prevent fields from being sprayed by aerial applicators. Planes that spray a field need both a safe entrance and exit. The proposed towers that cause a danger are: 8, 9, 14, 15 and any towers that are adjacent such as 20-22. In addition to Michael Bollweg testifying, the below listed witnesses will also be called.

Tower 6 is east of the Lodge and will interfere with its operation both on the basis of shadow flicker and noise, driving game away.

(b) Please specify particular aspect(s) of the Applicant's burden of proof that Mr. Bollweg intends to call a witness to testify on.

Response: Mr. Bollweg intends to call witnesses that will testify regarding the importance/necessity of spraying fungicide/pesticides on crops. Mr. Bollweg intends to call agronomists who will speak about the need for two separate crop protection product applications and how they must be applied by air. Mr. Bollweg will call witnesses to testify as to the rates charged for aerial applications and for the products sprayed. Mr. Bollweg intends to call aviation witnesses, including an expert witness who is a faculty member at South Dakota State University.

Brandon Haag, agronomist and employee of Corteva chemical company, will testify concerning the importance and necessity to spray red sunflower seed weevils. He will discuss the economic impact if not sprayed and the damage impact on the sunflower plant if applied by ground vs. aerial.

Wally West, agronomist and employee of Syngenta chemical company, will testify regarding the importance and necessity to spray a fungicide on wheat at heading. He will discuss the economic gain when sprayed and state the acres of damage that occurs when a ground sprayer drives over the crop as opposed to aerial application.

Dr. Adam Varenhorst, South Dakota State University, will testify about the general impact red sunflower seed weevils have on a sunflower crop if not controlled. A letter from him is also attached.

Jonathan Kleinjan, South Dakota State University, will testify regarding the general impact weeds have on a crop in the event a ground rig is unable to spray and the field is not suitable for air application.

Ryan Thompson will testify that sunflowers are too tall to spray using a ground rig; spraying with a ground rig would completely destroy the crop where the sprayer drove. He will also testify that the timing is so critical that it would not be possible to get across all the acres done in a timely manner. As far as the wheat and fungicide at heading, it follows the same impacts as the flowers by not being able to use aerial application. The tracks from the ground rig would cause approximately a 90-95% loss, once the wheat is jointed and the stalk breaks it will not come back or stand back up. He will testify that agriculture is about timing and the efficacy of a head treatment at flowering is even more precise, just not enough ground sprayers to do. The impact of not putting on a head treatment could result in a 5-35% decrease in yield depending on pressure.

Dr. Cody Christensen will testify regarding the safety of aerial spraying in the vicinity of the proposed wind towers. Also, he will testify concerning the performance of ag sprayers and the dangers the wind towers pose. A report he has written is also enclosed.

Curt Korzan, owner of a hunting lodge in South Dakota Grand Slam Pheasants Hunt Lodge, will testify concerning the fact that he has owned prime hunting ground for his pheasant ground and operated successfully for years. He will testify that turbines were put up and he immediately observed that the pheasants left his grounds when the turbines were operating. He also observed that other wildlife fled the grounds. His grounds were in a predator study before and during the installation of the turbines and found that his predator numbers were low. He also had additional land, away from the turbines, and the wildlife in those areas remained constant. The effect was so bad that he sold the property.

Terry Barber will testify that wind towers either make ag spraying very dangerous or complicated. The airflow off the turbines disrupts the spray patterns off the aircraft, making the spray less effective. Mr. Barber sprays the Bollweg farm properties.

The evidence will show that the inability to use aerial applicators will substantially reduce the yield to both sunflowers and wheat.

There will also be evidence showing the proximity of wind towers to Tumbleweed Lodge will cause sharp-tail grouse to stop using their land for habitat. In addition, evidence will be offered that shows that both wild and planted pheasants will leave the areas adjacent to the turbines. The Tumbleweed Lodge has had success in promoting sharp-tail hunting and various studies have discovered adverse effects of turbines upon sharp-tail nesting. In addition, there will be evidence that the presence of turbines close to hunting facilities drive away both wild and released pheasants. These same concerns also apply to prairie chickens.

1-3) Refer to SDCL 49-41B-2, permit for wind or solar energy facility:

Within nine months of receipt of the initial application for a permit for the construction of a wind energy facility or solar energy facility, the commission shall make complete findings, and render a decision, regarding whether a permit should be granted, denied, or granted upon such terms, conditions, or modifications of the construction, operation, or maintenance as the commission determines are appropriate. In the decision, the commission shall find that the construction of the facility meets all requirements of this chapter. Notice of the commission's decision shall be given to the applicant and to parties to the hearing within ten days following the decision.

(a) Identify any "terms, conditions, or modifications of construction, operation, or maintenance" that you would recommend the Commission order. Please provide support and explanation for any recommendations.
(b) Specifically, what mitigations efforts would you like to see taken if this Project is constructed?

Response: The applicants are applying for permission to build/install many turbines. If turbines 8, 9, 14, 15, 20, 21, 22 were not put up, he could continue is farming without interference. If six was not built, it would permit the lodge to operate as it has.

1-4) Please list with specificity the witnesses that Mr. Bollweg intend to call. Please include name, address, phone number, credentials and area of expertise.

Response: 1) Wally West, Agronomist, Syngenta, (605) 659-4394

2) Dr. Adam Varenhoust, Assistant Professor and Extension Field Crop Entomologist, South Dakota State University, 1451 Stadium Rd, Brookings, SD 57007 (credentials attached)

3) Ryan Thompson, Agronomist, 2921 Sussex Rd, Pierre, SD 57501 (credentials attached)

4) Brandon Haag, Agronomist, 20449 Augusta Road, Pierre, SD 57501 (credentials attached)

5) Dr. Cody Christensen, 143 Wagner Hall Box 2275A Brookings, SD 57007 (credentials attached)

6) Terry Barber, Brett's Spray Service, 18531 303rd Ave, Onida, SD 57564 (credentials attached)

7) Jonathan Kleinjan, Extension Agronomist, South Dakota State University, 1451 Stadium Rd, Brookings, SD 57007

8) Michael Bollweg, 20152 321st Avenue, Harrold, South Dakota 57536 (credentials attached)

9) Curt Korzan, 25425 361 Ave, Kimball, SD 57355

1-5) Does Mr. Bollweg intend to take depositions? If so, of whom?

Response: As of today's date, no depositions have been taken.

1-6) Please identify every concern Mr. Bollweg has with the proposed project that Mr. Bollweg intends to address at the evidentiary hearing. For each concern identified, please provide support for the concern.

Response: Most of the concerns are discussed in his letters to the commission dated 8/9/21, 8/12/21, 8/26/21, and 9/7-9/8/21. Specifically, he will address the probable loss of revenue to the farming operation due to the location of the towers preventing aerial application which will place crops at risk. He will base his testimony on his background in farming, working for Bollweg Spraying, and his education in agronomy. He will also testify concerning the effects of the turbines upon the family hunting lodge, Tumbleweed Lodge.

There are two grounds for the Bollweg objections. The first is that the layout of the proposed towers will prevent fields from being sprayed by aerial applicators. Planes that spray a field need both a safe entrance and exit. The proposed towers that cause a danger are: 8, 9, 14, 15 and any towers that are adjacent such as 20-22. In addition to Michael Bollweg testifying, the below listed witnesses will also be called.

1-7) Other than intervening in this docket, has Mr. Bollweg pursued any legal action with respect to this Project?

Response: No.

1-8) Who does Mr. Bollweg contract for aerial spraying? Please provide the name, contact information for the vendor, and applicable financial rate(s).

Response: Brett's Spray Service, Inc. Terry Barber. 18531 303rd Ave – Onida, SD 57564 605-258-2743. Rates for Miravus Ace fungicide application on wheat: $26.66/acre (13.7 oz Miravis Ace @ $19.47 + Dyne-Amic adjuvant @ $.44 + 3 gallons/acre application @ $6.75/A) Rates for control of red sunflower seed weevils in sunflowers: $15.03/acre (21 oz Cobalt Advanced @ $7.74, Dyne-Amic adjuvant @ $.46 + 1 oz. Lamda-Cy @ $.33 + 2 gallons/acre application @ $6.50/acre).

Dated this 5th day of October, 2021.

/s James E. Malters
JAMES E. MALTERS
For: MALTERS, SHEPHERD & VON HOLTUM
Attorneys for Michael Bollweg, Judi Bollweg, Tumbleweed Lodge and the Bollweg Family, LLP
727 Oxford Street - P. O. Box 517
Worthington, MN 56187-0517
jmalters@msvlawoffice.com
(507) 376-4166
Fax: (507) 376-6359

Public Utilities Commission
Capitol Building, 1st floor
500 E. Capitol Ave.
Pierre, SD 57501-5070

RE: EL21-018 North Bend Wind Project in Hughes/Hyde Counties

PUC Commissioners:

I'm writing in regards to my concerns about specific locations of industrial wind turbines (IWT) proposed in the North Bend Wind Project footprint and the significant impact they will have on an aerial applicator's ability to safely and effectively apply crop protection products.

I am a retired aerial applicator pilot with more the 42 years of experience. Through the years I've experienced flying near IWT's; in particular in southwest Minnesota. Considerably smaller than these being proposed and not as densely populated, I learned in a real hurry even ¾ of a mile away the turbulence and sheer magnitude of their size prevented me to safely and effectively fly.

Two locations of concern:

Cropland Location: SW ¼ Section 11 – 111-74: Proposed IWT location 08 is to the north, 15 to the east, 22 to the south and 14 to the west. Each of the IWT's look to be within 800-1000' from the property line.

Cropland Location: NE ¼ Section 10 – 111-74: Proposed IWT location 08 is to the east and location 14 is to the south. These two IWT locations look to be within 1000' from the property line. Location 09 to the east and location 21 to the south look to be within 2/3 of a mile of the property line.

At a 140 mph, an aerial applicator is traveling at more than 205 feet/second. This allows only 4-5 seconds to either fly around it, or navigate the impossible task of starting at 10' AGL (above ground level) and climbing more than 700' to pass over the tip of a blade with a mere 100' buffer. A number of inputs make this not only extremely dangerous but physically impossible to safely and effectively apply crop protection products. Adding a multitude of additional IWT's in the same area only amplifies this complexity.

As a result of the weight of a loaded (or half loaded) airplane, aerial applicators are limited in the height of their turns to 300'-400' before re-entering a field. You can't simply pull up out of a field border, fly over an IWT, and safely reduce your altitude to 10' AGL.

It's naïve to think aerial applicators can simply fly around or over multiple IWT's located in large sections. It's also naïve to believe there is no "dirty air" and turbulence associated with IWT's. This same turbulence that significantly impacts an aircraft's flying ability also creates additional problems with drift as the vortices from the massive blades can carry these products to non-target locations.

Aerial applicators are essential to agriculture. When conditions are too wet to apply products by ground rigs, we're called upon. When dangerous pesticides need to be applied for insect control, aerial is the answer. When products need applied that ground rigs will destroy by driving on or over the top, aerial remedy's that. Without responsible placements of IWT's, significant negative economic impacts are inevitable. Thank you for your time.

Sincerely,

Mike Bollweg
Owner – Custom Air Inc. (Ret)

RECEIVED

AUG 12 2021

SOUTH DAKOTA PUBLIC
UTILITIES COMMISSION

Public Utilities Commission
Capitol Building, 1st floor
500 E. Capitol Ave.
Pierre, SD 57501-5070

RE: Docket EL21-018 North Bend Wind Farm Project

PUC Commissioners:

Per Commissioner Fiegen's request during the PUC meeting on 11 August 2021, I have listed the following proposed locations of Industrial Wind Towers (IWT) that will have a significant economic and social impact on our established upland bird hunting lodge (Tumbleweed Lodge) and farm operations (Bollweg Farms).

Exhibit 1 shows the outline of each of our preserves. Tumbleweed Lodge North (TWL N) consists of 2400 acres. Proposed towers 06, 08, 09, 14, 19, and 20 directly impact TWL N via shadow flicker, noise, and loss of aesthetics.

Exhibit 1 also shows two quarters of land that have multiple tower locations extremely close to their borders, eliminating the ability to safely and effectively apply crop protection products via aerial application from any direction:

SW ¼ Section 11 – 111-74 (160 acres): Proposed IWT location 08 is to the north, 15 to the east, 22 to the south and 14 to the west.

NE ¼ Section 10 – 111-74 (160 acres): Proposed IWT locations 08 and 09 are to the east and location 14 and 21 are to the south.

In order to at least be able to utilize an aerial applicator in an east/west flight pattern on both quarters, proposed locations 08, 09, 14, and 15 need to be removed from consideration. Once these four locations would be removed, locations 21 and 22 would not have an impact.

As I mentioned in the PUC meeting last night, Engie representatives conceded during a Hughes county commissioner meeting shadow flicker and noise are negative effects directly associated wind turbines. Their Indemnity clause echoes these concerns by requiring landowners to waive claims against them for damage or injury directly suffered as a result of any audible, electromagnetic noise or shadow flicker to name a few. The same clause also supports my argument view shed has value or they wouldn't include visual impacts. My family operation, staff, and guests that we entertain should not be exposed.

In summary, the greatest negative impacts on our entire operation are proposed towers 06, 08, 09, 14, and 15. These would be my highest priority to have removed from consideration. The next level of negative impact would derive from proposed locations 19 and 20.

I am confident the PUC and Engie would recognize this as an equitable solution. Engie has already stated they are only pursing the building of 71 of the 78 proposed locations; leaving 7 locations to be withdrawn.

If you have any questions please give me a call. Thank you for your consideration.

Sincerely,

Michael J Bollweg
Bollweg Farms
Bollweg Family LLLP
Tumbleweed Lodge
Agronomist – '96 graduate SDSU
[redacted]
Harrold, SD 57536
[redacted]

North Bend Wind Project

06/04/2021

Legend

Turbine Locations

New Entrance

Intersection Modification & Improvement

Potential County Roads

Gravel Road Upgrades

Access Roads

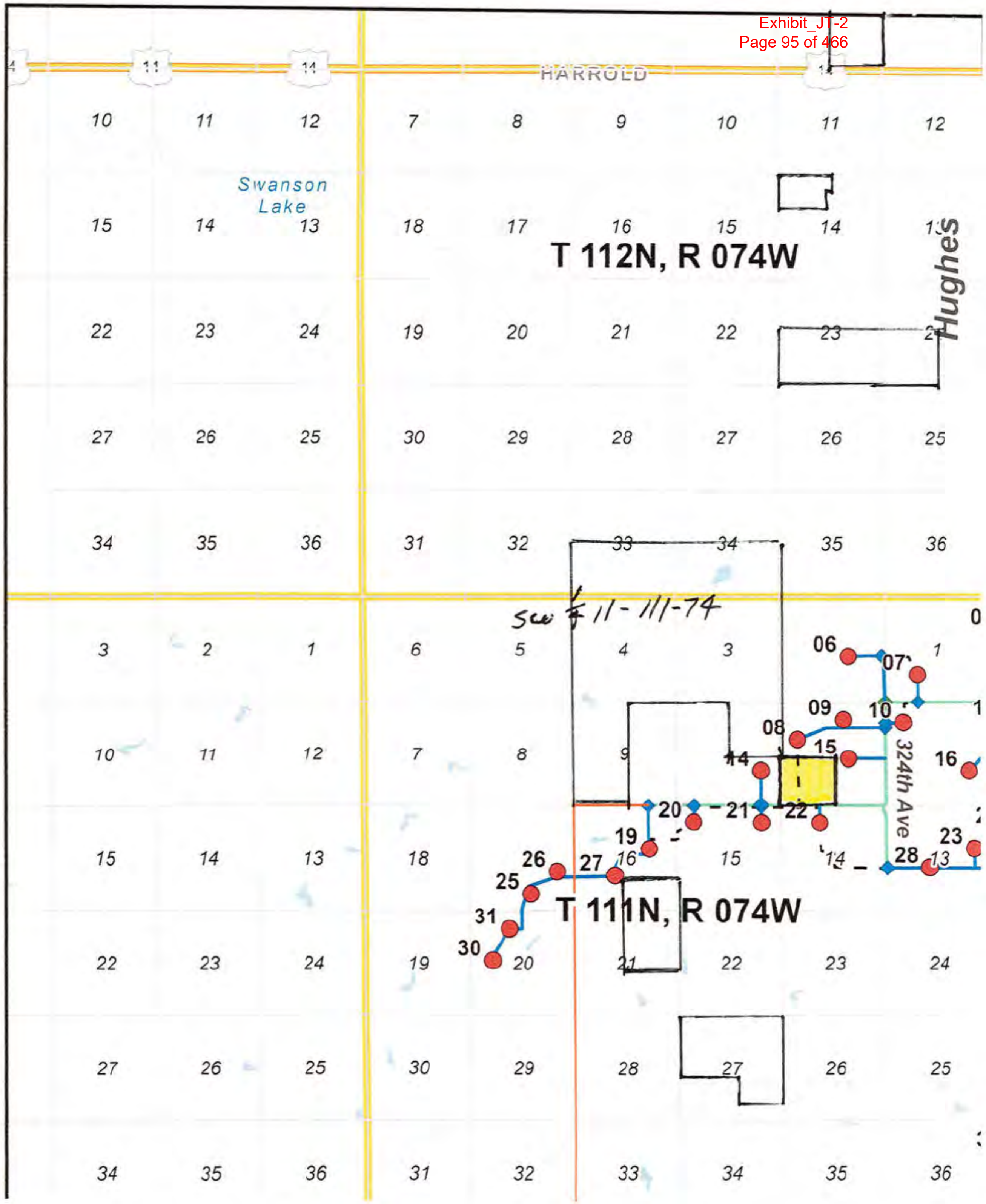
EXHIBIT 2

Crane Path – ACROSS OUR PROPERTY

Township & Range

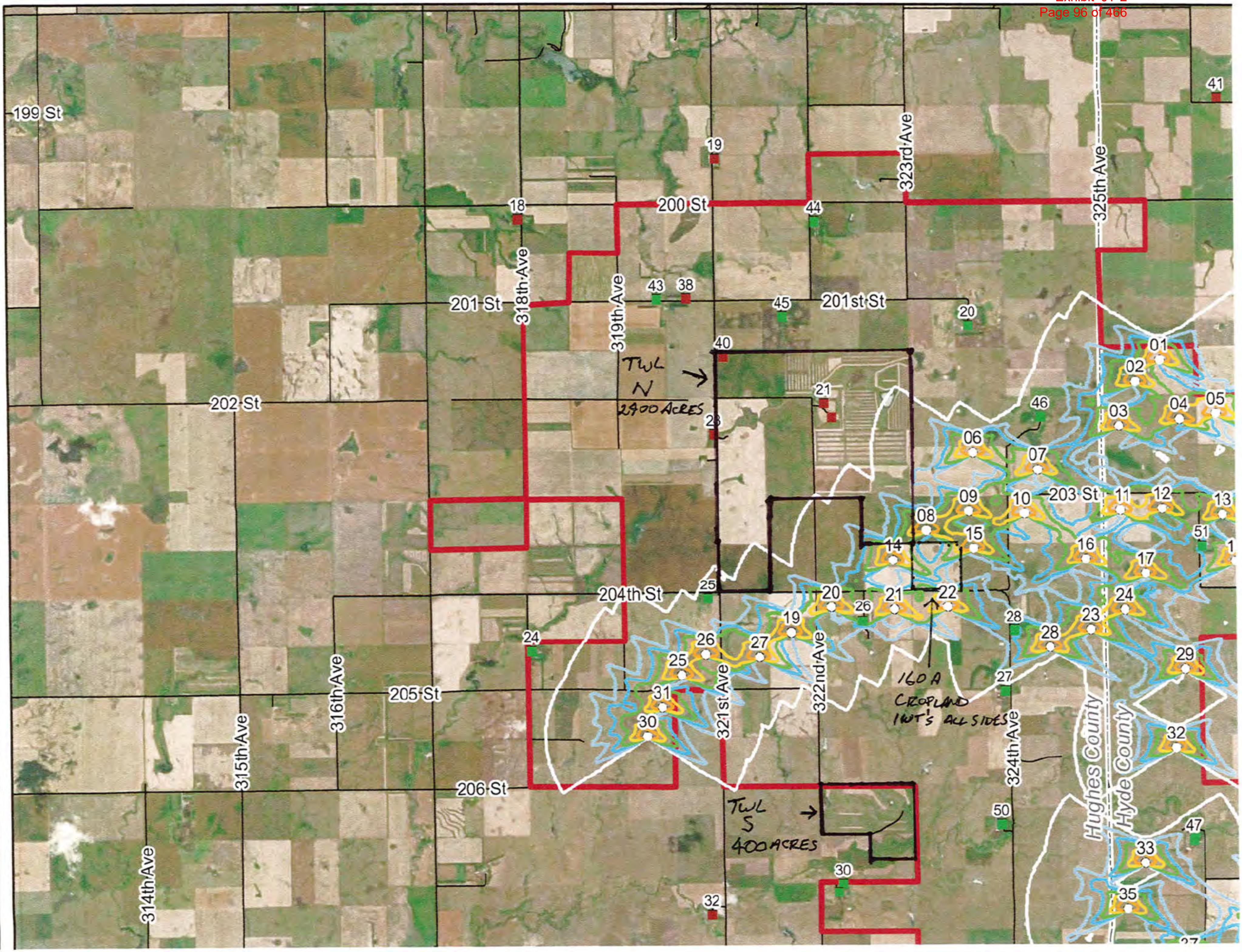
County

Project Location



TUMBLEWEED LODGE - PRESERVES

EXHIBIT 1



From: Michael Bollweg [redacted]
Sent: Thursday, August 26, 2021 9:03 AM
To: PUC-PUC <PUC@state.sd.us>
Subject: [EXT] Docket: EL21-018 North Bend Wind Project

PUC Commissioners:

Please find my attached letter of concern including supportive exhibits and permission to reprint letter pertaining to the docket: EL21-018 North Bend Wind Project in Hughes/Hyde Counties.

Thank you.

Michael J Bollweg
Bollweg Farms
Bollweg Family LLLP
Tumbleweed Lodge
[redacted]
Harrold, SD 57536
[redacted]

South Dakota's Upland Game Birds

A group consisting of representatives from Iowa DNR's Wildlife Bureau and Energy Section, US Fish & Wildlife Service, several non-governmental conservation organizations, energy companies, and the Iowa Renewable Energy Association put together siting recommendations with regard to industrial wind projects and their distance from sensitive wildlife and plant populations. EXHIBIT 1. Significant findings published include:

* "Avoid placing turbines at locations where any species of fish, wildlife or plants protected under the federal Endangered Species Act have been documented."

* "Avoid placing turbines in or near recognized bird concentration areas or migration pathways, including lakes, wetlands, forests, river valleys, ridge tops or bluff tops, large grasslands, known bird roosting areas, public wildlife areas, parks, and areas with frequent incidence of fog mist or low clouds."

* "Consider possible cumulative regional effects of multiple wind energy projects. While one project alone may result in few concerns for wildlife, multiple projects across one landscape could significantly multiply adverse effects."

* "Avoid placement of turbines in or near areas where highly "area-sensitive" wildlife species, such as prairie-chickens, are known. Area-sensitive species require expansive, unfragmented habitat. For prairie-chickens in particular, a separation distance of at least 5 miles from all known leks (breeding grounds) is strongly recommended."

A three year study recently completed in 2018 as a thesis "Ring-necked Pheasant responses to wind energy in Iowa" by Iowa State University graduate student James Norman Dupuie Jr. with program study committee professors Stephen J. Dinsmore and Julie A. Blanchong provides some interesting insight.

The study concluded a linear regression showed statistically significant effects of the presence of wind turbines on pheasant counts. Pheasant counts increased with increasing distance from the nearest wind turbine. Furthermore they showed a population decrease as the density of wind turbines near the survey point increased. South Dakota has a significantly higher population of pheasants than Iowa. Can you imagine how much more significant the negative impacts would be if you transferred South Dakota's pheasant population data into their statistical formulas?

In December 2013 at the SD Pheasant Summit, the South Dakota Game, Fish and Parks Dept. data showed pheasant hunters spend about $219 million each year. In total, South Dakota hunting has generated almost $100 million in salaries, wages and business owners' income and created 4,500 jobs. – *Capital Journal* 10 Dec 2013. It seems evident the SD Office of Economic Development has overlooked this significant information with their carefree actions of supporting every wind development project without completely comprehending the negative repercussions other major facets of our state's economy will endure. The PUC's discretion to deny or amend a project in the event the "project will not pose a threat to the social and economic condition of the inhabitants" is significant. As the state continues to be blanketed with industrial wind facilities, the economic and social impacts linked to our beloved wildlife will become more and more stressed and must be taken into serious consideration.

The agricultural splendor, wildlife, natural habitat, and great people who have made this region their home for generations do not deserve the life altering negative impacts associated with the proposed transition of agricultural lands into industrial wind parks without serious oversight. Thank you for your consideration.

Sincerely,

Michael J Bollweg
Agronomist – '96 Graduate SDSU
Bollweg Farms
Tumbleweed Lodge
[redacted]
Harrold, SD 57536

Wind Energy and Wildlife Resource Management in Iowa:
Avoiding Potential Conflicts

Introduction

Iowa is on its way to ranking among the world's leading producers of wind-generated electrical energy. In our efforts to become less dependent upon fossil fuels, nuclear power, hydropower and other sources with frequent environmental concerns, the possibility of this "green" energy has caused much excitement. Many Iowans eagerly await expansion of this low-cost (after initial infrastructure investments) source of electricity as one step towards energy independence.

The Governor, General Assembly, and Department of Natural Resources all consider wind energy development in Iowa a high priority. With much open farmland upon which wind generators might be placed, and in a region of nation realizing relatively high average wind velocities, Iowa seems destined to be a national focal point for wind energy development. Many state and national conservation organizations also support increasing wind energy production.

No energy source has yet been found to be without some degree of environmental costs, however, and wind energy is no exception. It has been demonstrated that if proper siting of wind turbines is not carefully planned, certain locations may result in collisions with, and death of, both wild birds and bats. In one or two noteworthy instances, excessive mortality of hawks, eagles and other birds of prey has resulted in major modifications to both design and placement of wind turbines, or even periodic shut-downs of large facilities. Additional costs involved with such measures can reduce cost-effectiveness of energy production.

Iowa currently exercises minimal regulation on locating wind farms. Nevertheless, some energy companies recognize the benefits of consulting with wildlife resource managers *before* final decisions are made on siting of new facilities. Such actions will result in greater trust and cooperation between energy producers and those charged with protecting our wildlife resources This can lead to an orderly and beneficial development of Iowa's wind energy.

An *ad hoc* Iowa wind energy and wildlife discussion group has met infrequently to review current developments regarding wind energy and wildlife interactions. The group consists of representatives from Iowa DNR's Wildlife Bureau and Energy Section, US Fish & Wildlife Service, several non-governmental conservation organizations, energy companies, the Iowa Renewable Energy Association and other interested parties. The group has no rule-making or regulatory authority; rather it simply works cooperatively to discuss mutual concerns and to learn of the latest developments.

Wildlife Concerns

Just what are the problems wind turbines might pose to our wildlife and other natural resources? The most obvious is direct collisions of birds and bats with rotating blades. Fortunately for

birds, the annual mortality rate at most Midwestern wind farms appears to remain relatively low and probably insignificant. An exception occurs when turbines are placed in or very near major migration corridors and pathways, such as large river valleys and ridgetops or bluffs. Because birds tend to follow or congregate along these natural landscape features during their semi-annual migrations, wind turbines placed near these features have potential for causing significant bird kills in spring and fall. A few examples of such landscapes in Iowa include the Des Moines River, Little Sioux River, Wapsipinicon River, Loess Hills, and Mississippi River blufflands. Still, with Iowa's mostly open landscape, birds generally are widely dispersed throughout much of the year and chance of interaction with turbines is small.

Bats present an entirely different situation. For reasons still mostly unknown, bat collisions and mortality is much higher than for birds at many wind farms. Early efforts are underway to attempt a better understanding of the problem, but little is known at this time. However, bats usually are associated with trees or wooded areas and wetlands, where the insects on which they feed are abundant. Wind turbines placed near woodlands and wetlands thus might reasonably be expected to result in more bat deaths than turbines situated in open farmlands.

An emerging concern for birds is wind turbines placed within or very near large expanses of grassland. In some western states, ground-nesting lesser prairie-chickens have been found to abandon their nesting grounds when wind turbines were erected and operated nearby. It is quite likely that Iowa's greater prairie-chickens, a state endangered species requiring large expanses of unbroken habitat, would exhibit similar behavior. Many other ground-nesting grassland birds have yet to be studied, but some of these species already are in steep decline nationwide and cannot risk another factor that might potentially threaten their survival. A leading cause of much bird decline is related to fragmentation, or "parcelization", of their remaining habitat, breaking it into parcels too small to meet certain birds' survival or reproductive needs. It has been suggested that wind turbines placed in the middle of a large grassland may similarly fragment habitat and greatly reduce its value. This is a question in need of much additional research.

In summary, adverse effects of wind turbines on birds and bats have been documented in some locations, but much remains to be learned. A few energy companies or developers have collaborated with wildlife researchers to conduct some desperately needed studies. They are to be recognized for their commitment to better conservation of all our natural resources. Nevertheless, much more research is needed, especially in comparing "before and after" effects upon wildlife where wind farms are constructed. Information garnered would be invaluable in helping with future wind farm siting decisions.

Wind Turbine Siting Recommendations and Guidelines

Until we more fully understand how wildlife interacts with wind turbines, interim guidelines have been prepared to help wind energy developers and producers do a better job of designing and siting their wind farms. The list of recommendations below will serve as a starting point for things that *should* be considered when planning wind energy developments. These have been collected from a variety of sources, chief among them the US Fish & Wildlife Service Interim Guidelines for siting and construction of wind energy facilities, and recommendations from the

National Wind Coordinating Committee. Keep in mind that this list is a *work in progress*, subject to change as new information is gained.

Siting Recommendations:

- Avoid placing turbines at locations where any species of fish, wildlife or plants protected under the federal Endangered Species Act have been documented. Information may be obtained by contacting the Iowa Department of Natural Resources Endangered Species Coordinator or Wildlife Bureau staff. Any action resulting in losses to federally-listed species could result in substantial fines or other penalties.
- Avoid placing turbines in or near recognized bird concentration areas or migration pathways, including lakes, wetlands, forests, river valleys, ridge tops or bluff tops, large grasslands, known bird roosting areas, public wildlife areas, parks, and areas with frequent incidence of fog mist or low clouds. While there is no firm information on the amount of buffer zone needed between turbines and these habitats, a separation distance of at least one mile might be considered an absolute minimum (more for prairie-chickens—see below).
- Avoid placement of turbines in or near areas where highly "area-sensitive" wildlife species, such as prairie-chickens, are known. Area-sensitive species *require* expansive, unfragmented habitat. For prairie-chickens in particular, a separation distance of at least 5 miles from all known leks (breeding grounds) is *strongly* recommended.
- Avoid placing turbines near documented bat hibernation, breeding or nursery colonies and in migration corridors (see bird recommendation above) or between known colonies and feeding areas.
- Avoid placement of multiple turbines in close proximity to one another or perpendicular to known migration pathways (typically north-south). Widely spaced turbines, in arrays parallel to normal bird migration routes, can reduce collisions.
- Reduce or eliminate availability of carrion within wind farms, to reduce chances of attracting eagles, vultures and other raptors colliding with turbine blades. Neither dead livestock nor wildlife should be left within or near wind farm boundaries.
- Place wind turbines in areas already fully developed for agriculture, especially row-crop farming, where there is minimal extant wildlife habitat—Iowa is especially rich in such lands, and it has been estimated that as much as 80% of Iowa's landscape might be considered suitable for wind energy development with few adverse effects upon wildlife.
- If wildlife habitat losses or fragmentation must be mitigated, develop a plan to create or restore habitat *away* from the wind farm site. This will serve to attract birds, bats and other wildlife away from the development and reduce collisions. Wherever possible, coordinate habitat mitigation sites with other public or private wildlife lands, to connect, enlarge or enhance those areas.
- Certain landscapes, such as the Loess Hills in western Iowa and the "Iowa Great Lakes Region" in northwest Iowa, are known for their beauty, rarity *and* for extensive wildlife breeding and migrating activities. Such landscapes should be avoided entirely both for biological and aesthetic reasons.
- Consider possible *cumulative* regional effects of multiple wind energy projects. While one project alone may result in few concerns for wildlife, multiple projects across one landscape could significantly multiply adverse effects.

- A map of Iowa, denoting areas of particular concern for possible adverse effects by wind turbines upon wildlife and habitat, has been developed and is updated periodically. Construction within these areas may not necessarily result in wildlife conflicts, and consultation with DNR wildlife biologists can assist developers in finding suitable sites within these potentially sensitive landscapes, or in suggesting plan modifications to minimize adverse effects.

Turbine Design and Operation Recommendations:

- Tubular support towers with pointed tops, rather than lattice supports, greatly reduce opportunities for birds to perch or nest upon the structures. Avoiding placement of permanent external ladders or platforms on tubular towers also reduces nesting and perching.
- Avoid use of guy wires for turbine or meteorological tower supports. Any existing guy wires should be marked with recommended bird deterrent devices (Avian Power Line Interaction Committee 1994).
- Taller turbines, having a top-of-rotor sweep exceeding 199 ft., may require lights for aviation safety. The minimum amount of pilot warning and avoidance lighting necessary should be used, and unless otherwise required by the Federal Aviation Administration, only white strobe lights should be used at night. These should be minimized in number, intensity, and number of flashes per minute. Solid red or pulsating red lights should *not* be used, as they appear to attract more night-migrating birds than do white strobes.
- Electric power lines should be placed underground wherever possible, or should utilize insulated, shielded wire when placed above ground, in order to reduce bird perching and electrocution.
- Where the height of rotor-sweep area produces high wildlife collision risks, tower heights should be adjusted to lower risks.
- If wind turbine facilities absolutely must be located in areas known for high seasonal concentration of birds, it is essential that a bird monitoring program be established, with at least three years of data collected to determine peak use periods. Data may be collected by direct observation, radar, infrared or acoustic methods. When birds are highly concentrated in or near the site, turbines should be shut down until birds have dispersed.
- When older facilities must be upgraded or retrofitted, the guidelines above should be employed as closely as possible.

Ideally, a site study plan and description of turbine structural and lighting design should be submitted to Iowa DNR well in advance of final siting decisions, for review by staff wildlife experts and advisements on acceptability or suggestions for modifications and/or monitoring. Hiring a reputable environmental consultant with a strong background in bat and bird ecology is strongly recommended. A baseline inventory of wildlife and evaluation of habitat should be considered for every site under serious consideration for windfarm development. Use of National Wind Coordinating Committee study guidelines will allow for comparison with other studies. Special attention should be paid to Spring and Fall migration seasons, reviewing

migrational use of the proposed site by raptors, waterfowl, shorebirds, gulls, songbirds and bats. Upon completion and startup of wind energy generation, monitoring wildlife populations and migrations should be conducted for at least 2-3 years.

Related Links

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

http://www.fws.gov/habitatconservation/wind.pdf
http://www.nationalwind.org/publications/siting.htm
http://www.dnr.wi.gov/org/es//science/energy/wind/guidelines.pdf
http://www.aplic.org

Michael Bollweg PERMISSION TO REPRINT

From: "Murphy, Alex" <alex.murphy@dnr.iowa.gov>
Date: Wednesday, April 04, 2018 5:27 PM
To: "Michael Bollweg"[redacted]>
Attach: wind wildliferecs Current2018.pdf
Subject: Re: wind_wildliferecs.pdf

Michael,

Here is the updated document, feel free to use this in place of the old one.

Thanks,
AM

ALEX MURPHY | *Director of Communications*
Director's Office
Iowa Department of Natural Resources
P 515-725-8219 | C 515-729-7533 | 502 E. 9th St., Des Moines, IA 50319
www.iowadnr.gov

On Wed, Apr 4, 2018 at 3:28 PM, Michael Bollweg <tumbleweed@venturecomm.net> wrote:

Alex,

Please find the attached document. If you could grant me permission (in writing) to reprint, cite, use the material that would be greatly appreciated. Thank you!

http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwiIrNaCuqHaAhXk6IMKHU74D7UQFggnMAA&url=http%3A%2F%2Fwww.iowadnr.gov%2FPortals%2Fidnr%2Fuploads%2Fwildlife%2Fwind_wildliferecs.pdf&usg=AOvVaw1aHBd0_VehwHpYZGMz02_m

Michael J. Bollweg
Bollweg Farms
[redacted]
Harrold, SD 57536
[redacted]

09/02/2021

James Malters
727 Oxford St.
Worthington, MN 56187

Mr. Malters,

My name is Dr. Cody Christensen, I serve in a professional capacity as the only tenured aviation faculty member in South Dakota wherein my role at South Dakota State University, I am tasked with teaching, service, and research related to aviation education. My primary role within the university is teaching new pilots, commercial pilots, and advanced systems in aviation operations. I have been a licensed pilot for over twenty years, a FAA Goal Seal flight instructor for 15 years, and hold certificates in both single and multiengine aircraft including an Air Transport Pilot (ATP) certificate. I am answering your questions as a former airline captain for a small regional airline operating into and out of the Midwest, including South Dakota and the area depicted in Hughes County.

This letter is in request to addressing agricultural flight operations around wind turbines, specifically around T112N, R074W section 10, and 11 in Hughes County, SD. Three main considerations must be factored when addressing the pilot perspective of operations around obstacles. Those three factors include margin of safety, operation of aircraft, and aircraft performance factors associated with the flight.

The first main consideration when evaluating an operating area, whether that be a field to spray or a ground-based maneuver designated by the Federal Aviation Administration (FAA) for training such as an Eight on Pylon, is the margin of safety. The margin of safety when obstacles are present in a field decreases options in the event of an emergency such as a powerplant failure or stall/spin situation. From personal experience I know that operating directly behind or in between wind turbines creates considerable turbulence that can lead to loss of control events- a leading cause of aircraft accidents in the United States. Additionally, flying with known obstacles increases workload because the pilot must evaluate the proper course of action with little to no room for error. The margin of safety decreases as the height and number of obstacles increases.

The second consideration when operating around obstacles that are unavoidable is that of operation of aircraft including pilot training and pilot response. Professional agricultural pilots knowingly take considerable, calculated risks related to obstacles other pilots do not take. They are responsible for flying between 3-12 feet above the ground, making multiple low passes, multiple takeoff and landings, and operating to the max capacity of the aircraft. Doing this operation on a zero wind, cool day, with no elevation or obstacles take precision and professional skills few possess. Adding additional obstacles that decrease the margin of safety and decrease the reaction time a pilot has to react to unforeseen situations such as mechanical issues, bird strikes, wire strikes, wind changes, and product issues decreases the safety of the operation.

The final major concern when operating around obstacles is the aircraft performance, including climb rate, turn radius, and environmental conditions. The climb rate of a standard Air Tractor 502, a common midlevel agricultural application aircraft, is 664 feet per minute and a typical working speed of 135mph. Every second the airplane is traveling approximately 198 feet per second while on target. At the end of a field the pilot would turn off the spray and begin a climb, followed shortly by a climbing turn usually away from the spray pass to complete a course reversal to realign for the next spray pass. In a normal situation with no obstacles, ending the spray and the initial climb out might all occur within five to eight seconds, resulting in a straight-line distance of almost ¼ mile. The turnaround for ag operators, generally considered a 45° downwind turn, followed by a 225-course reversal to come back on target requires a 30-45° turn to do a back-to-back turn. The time of the course reversal is approximately 25 seconds, resulting in close to one mile of total distance traveled per swath. Assuming a 30° bank, the calculated turn radius of an aircraft going 135mph is 2,119 feet and the diameter of the turn is 0.8 miles. It should be noted that for an Air Tractor 502, it is close to one mile to make a turn, but for an Air Tractor 802, currently the largest single engine commercially used ag application airplane, that distance increases to 1.82 miles to complete a turn.

As early discussed, an Air Tractor 502 climb rate is 664 feet per minute or approximately 11 feet per second (fps) climb rate. Considering at the end of the field, an applicator pulls up into a climb, it would take 18 seconds (200ft/ 11fps) to clear a 200 feet obstacle located at the end of a field. Using a working speed of 135MPH or 198fps the aircraft would travel forward 3,564ft (198fps*18 sec to climb) to clear a 200ft obstacle. If a 600-foot obstacle was considered, it would take 54 seconds to outclimb the obstacle and would travel forward over two miles (198fps *54sec= 10,800ft). Even assuming the pilot slowed to 111mph (best rate of climb at max weight) the distance covered is still 1.6 miles (162fps *54 sec). This assumes the pilot adds max power, performs a perfect climb, the airplane performs perfect, and the field conditions were conducive to a climb (sea level, standard atmosphere, low humidity, calm or head winds prevailing). Anything less than perfect conditions would decrease the climb rate and make the field in question non flyable.

The other option would be instead of pulling up to climb over an obstacle to fly around it, below it, or through the blade arc or guy-wire, all of which are not prudent options, especially considering any abnormal operations. Additionally, the turbulence created by the wind turbines would have a direct and immediate impact on the pilot operating downwind of the turbine.

In reviewing the plat map of 112N, R 074W, section 10 and 11 in Hughes County, SD I am most concerned about the placement of towers 8, 9, 14, &15 within the sections and any towers that are adjacent such as #20-22 as they are well within a normal margin of safety for a typical pilot to safety spray that area. Based on the map and field layout, an east/west swath pattern would prevail and the presence of wind turbines or any obstacle at the end of those fields, especially on two sides, would be detrimental to safety. In my opinion, I would advise against a pilot maneuvering in the field presented with obstacles in the placement suggested.

Respectfully,

Cody Christensen, Ed.D
Airline Transport Pilot
FAA Gold seal flight instructor

From: Michael Bollweg
Sent: Tuesday, 07 September 2021 17:51:40 (UTC-06:00) Central Time (US & Canada)
To: PUC-PUC
Cc: PUC Docket Filings
Subject: [EXT] Docket: EL21-018 North Bend Wind Project

RE: Docket: EL21-018 North Bend Wind Project

PUC Commissioners:

The existing Triple H Wind project, located in western Hyde county includes 92 industrial wind turbines with a total capacity of 250 MWs. The proposed North Bend Wind Project including more than 70 towers is planned to be located directly west and south with a total capacity of 200 MWs.

With 162 towers and capacity of 450 MWs in such a small area, one must give serious consideration on the entire **cumulative impact** family farms, businesses, homes and wildlife will face from the exponential exposure. Simply view ENGIE's indemnity clause and note the list of exposures resulting from audible noise, electromagnetic noise, electrical interference, vibration, visual impacts, and shadow flicker to name a few. Inaudible noise and infrasound must also be taken into consideration. Compounding effects are inevitable.

Each project has shown studies on their own. Has an independent study determining the compounding effects to be associated with such a massive footprint been considered or in the works? It should be.

Sincerely,

Michael J Bollweg
Bollweg Farms
Bollweg Family LLLP
Tumbleweed Lodge
[redacted]
Harrold, SD 57536
[redacted]

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Sent: Tuesday, 07 September 2021 17:51:40 (UTC-06:00) Central Time (US & Canada)
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Sincerely,

Michael J Bollweg
Bollweg Farms
Bollweg Family LLLP
Tumbleweed Lodge
[redacted]
Harrold, SD 57536
[redacted]

Adam J. Varenhorst
Curriculum Vitae

Assistant Professor, Extension Field Crop Entomologist, IPM Director
(75% Extension: 25% Research)
Agronomy, Horticulture and Plant Science Department
South Dakota State University
Brookings, SD 57007
Office Phone (605) 688-6854
Cell Phone (712) 540-7173
Adam.Varenhorst@sdstate.edu

Education:

Ph.D. 2015. Entomology, Iowa State University, Ames, IA
M.S. 2011. Entomology, Iowa State University, Ames, IA
B.S. 2009. Biology, Briar Cliff University, Sioux City, IA

Professional Experience:

2/16 to present
Assistant Professor and Extension Field Crop Entomologist, Agronomy, Horticulture and Plant Science Department, South Dakota State University.
Department Head: Dr. David Wright

8/15 to 2/16
Extension Entomology Specialist II, Agronomy, Horticulture and Plant Science Department, South Dakota State University.
Department Head: Dr. David Wright.

4/15 to 8/15
Postdoctoral Research Associate, Iowa State University.
Supervisor: Dr. Erin Hodgson,

- Skills developed:
  - Creating research-based extension handouts
  - Author and co-author extension articles
  - Public speaking to diverse audiences

5/11 to 4/15
Graduate Research Assistant. Soybean Entomology, Iowa State University. Dr. Matthew O'Neal, Advisor. Ph.D. Dissertation, entitled, "Beyond biotypes: *Aphis glycines* (Hemiptera: Aphididae) biology and the durability of aphid-resistant soybean".

- Skills developed:
  - Aphid species identification
  - Aphid rearing
  - Supervising, training and managing a total of eleven hourly employees

- Designing and implementing field and laboratory experiments

6/09 to 5/11

Graduate Research Assistant. Soybean Entomology, Iowa State University. Dr. Matthew O'Neal, Advisor. M.S. Thesis: "Selective insecticides: the potential for improved control of the soybean aphid as a result of a bioresidual".

- Skills developed:
  - Insect identification
  - Designing and implement small-plot field crop experiments
  - Supervising, training and managing hourly employees
  - Iowa Insecticide applicators license; endorsements to apply herbicides, insecticides, and fungicides; endorsements for demo and research pest control
  - Statistical analysis, interpretation of data

8/08 to 5/09

Collection Curator. Briar Cliff University and Dorothy Pecaut Nature Center, Sioux City, IA. Dr. Ted. Wilson, Advisor.

- Skills developed:
  - Insect identification with dichotomous keys
  - Insect specimen collection, curation, and management

3/08 to 12/08

Research Assistant. Briar Cliff University Sioux City, IA. Dr. Ted Wilson, Advisor. Research Project: Survey of the insects in the Sioux City Prairie, Woodbury County.

- Skills developed:
  - Understanding of the scientific method
  - Insect collection and curating

12/00 to 8/15

Farm Consultant. Jerry Varenhorst Farms, LeMars, IA. Jerry Varenhorst, Owner.

- Skills obtained:
  - Maintenance and repair of machinery
  - Operation of farm machinery
  - Marketing of commodities
  - Interpersonal communication

Grants:

Funded (total = $3,096,962):

<u>2018:</u> ($110,524)

Research Grant 2018, South Dakota Soybean Research and Promotion Council Grant. "Evaluating foliar insecticide efficacies for the soybean aphid and the impact of tillage and cover crops on seed treatment efficacies and insect populations".
Amount awarded: $97,080

PI: **Adam J. Varenhorst**
Co-PI: B. Fuller (South Dakota State University), J. Kleinjan (South Dakota State University), P. J. Johnson (South Dakota State University)

Research Grant 2018, South Dakota Oilseeds Council. "Evaluating the susceptibility of red sunflower seed weevil to pyrethroid insecticides in South Dakota".
Amount requested: $13,444
PI: **Adam J. Varenhorst**
Co-PI: A. Bachmann (South Dakota State University), P. Wagner (South Dakota State University)

<u>2017:</u> ($958,772)
Extension Implementation Program Grant 2017, United States Department of Agriculture, National Institute of Food and Agriculture. "SDSU Integrated Pest Management: Agronomic Crops, Specialty Crops, Pollinator Health, Pesticide Applicators, Public Health, and Diagnostic Clinics."
Amount awarded: $358,000
PI: **Adam J. Varenhorst**
Co-PI: A. Bachmann, P. O. Johnson, E. Byamukama

Research Grant 2017, United Soybean Board. "Evaluation of precision zone management in soybean fields to increase profit and reduce product inputs."
Amount awarded: $99,745
PI: D. Mueller (Iowa State University)
Co-PI: **A. Varenhorst**, S. Conley (University of Wisconsin)

Research Grant 2017, South Dakota Soybean Research and Promotion Council Grant. "Evaluating foliar insecticide efficacies for the soybean aphid and the impact of tillage and cover crops on seed treatment efficacies and insect populations".
Amount awarded: $79,272
PI: **Adam J. Varenhorst**
Co-PI: B. Fuller (South Dakota State University), J. Kleinjan (South Dakota State University), P. J. Johnson (South Dakota State University)

Research Grant 2017, South Dakota Soybean Research and Promotion Council Grant. "Developing management recommendations for the use of fungicide and insecticide seed treatments for soybeans in South Dakota".
Amount awarded: $50,000
PI: **Adam J. Varenhorst**
Co-PI: F. Mathew (South Dakota State University), J. Kleinjan (South Dakota State University)

Research Grant 2017, South Dakota Soybean Research and Promotion Council Grant. "Association of soybean cyst nematode with biotic stress factors (Fusarium and soybean aphid) and management".
Amount awarded: $90,000
PI: Febina Mathew (South Dakota State University)

Co-PI: **A. Varenhorst**, M. Nepal (South Dakota State University), J. Kleinjan (South Dakota State University), E. Byamukama (South Dakota State University)

Research Grant 2017, National Sunflower Association. "Efficacy and economics of insecticide seed treatments for management of wireworms and seed corn maggots in sunflowers".
Amount awarded: $40,000
PI: **Adam J. Varenhorst**
Co-PI: Janet Knodel (North Dakota State University), J. P. Michaud (Kansas State University)

Research Grant 2017, National Sunflower Association. "Benefits of insect pollination to confection sunflowers".
Amount awarded: $16,500
PI: Jarrad Prasifka (USDA-ARS)
Co-PI: Rachel E. Mallinger (USDA-ARS), **A. Varenhorst**, J. Bradshaw (University of Nebraska-Lincoln)

Research Grant 2017, South Dakota Wheat Commission (7/1/17-6/30/18). "Determining the importance of insecticide seed treatments for managing aphids and *Barley yellow dwarf virus* in winter wheat".
Amount awarded: $25,000
PI: **Adam J. Varenhorst**.
Co-PI: Emmanuel Byamukama (South Dakota State University)

Research Grant 2017, United States Department of Agriculture, National Institute of Food and Agriculture (3/15/2017-3/14/2020). "Improving disease management in sunflower."
Amount Awarded: $300,000
PI. Febina Mathew (South Dakota State Univeristy)
Co-PI: S. Markell (North Dakota State Univeristy), B. Harveson (University of Nebraska-Lincoln), **A. Varenhorst**, A. Severin (Iowa State Univeristy), A. Seethraram (Iowa State University).

<u>2016:</u> ($525,533)

Research Grant 2016, South Dakota Department of Agriculture Specialty Crop Block Grant. "Determining the importance of pollinators to confection sunflower production in South Dakota".
Amount requested: $48,351.
PI: **Adam J. Varenhorst**
Co-PI: M. Dunbar (South Dakota State University), A. Bachmann (South Dakota State University), R. Beck (South Dakota State University), F. Mathew (South Dakota State University)

Research Grant 2016, South Dakota Oilseeds Council. "Determining the pollinator diversity present in South Dakota sunflowers and their impact on yield".
Amount requested: $10,640 (50%)
PI: **Adam J. Varenhorst**
Co-PI: A. Bachmann (South Dakota State University)

Research Grant 2016, Sun Grant Program North Central Region (USDA-NIFA funded). "Development of best management practices for the production of *Brassica carinata* (L.) in the Dakotas."
Amount requested: $150,000
PI: Thandiwe Nleya
Co-PI: F. Mathew (South Dakota State University), **A. Varenhorst**, B. Johnson (North Dakota State University)

Research Grant 2016, South Dakota Soybean Research and Promotion Council Grant. "Association of soybean cyst nematode with biotic stress factors (Fusarium and soybean aphid) and management".
Amount requested: $90,000
PI: Febina Mathew (South Dakota State University)
Co-PI: **A. Varenhorst**, M. Nepal (South Dakota State University), J. Kleinjan (South Dakota State University), E. Byamukama (South Dakota State University)

Research Grant 2016, South Dakota Soybean Research and Promotion Council Grant. "Developing management recommendations for the use of fungicide and insecticide seed treatments for soybeans in South Dakota".
Amount requested: $50,000
PI: **Adam J. Varenhorst**
Co-PI: F. Mathew (South Dakota State University), J. Kleinjan (South Dakota State University)

Research Grant 2016, South Dakota Soybean Research and Promotion Council Grant. "Effect of fungicide seed treatments on soybean disease caused by *Fusarium* species".
Amount requested: $20,505
PI: Febina Mathew (South Dakota State University)
Co-PI: **A. Varenhorst**, J. Kleinjan (South Dakota State University)

Research Grant 2016, National Science Foundation (2013-9/2016). "Broad implementation of the lost ladybug project".
Amount awarded: $99,624
PI: John Losey (Cornell University).
Co-PI: **A. J. Varenhorst**, Louis Hesler (USDA-ARS).

Research Grant 2016, South Dakota Pulse Council. "Monitoring dry pea for diseases and insect pests in South Dakota".
Amount requested: $4,000
PI: Febina Mathew
Co-PI: **A. J. Varenhorst**, C. Graham, R. Beck

Research Grant 2016, National Sunflower Association. "Efficacy and economics of insecticide seed treatments for management of wireworms and seed corn maggots in sunflowers".
Amount requested: $35,913
PI: **Adam J. Varenhorst**

Co-PI: Janet Knodel (North Dakota State University), J. P. Michaud (Kansas State University)

Research Grant 2016, National Sunflower Association. "Benefits of insect pollination to confection sunflowers".
Amount requested: $16,500
PI: Jarrad Prasifka (USDA-ARS)
Co-PI: Rachel E. Mallinger (USDA-ARS), **A. Varenhorst**, J. Bradshaw (University of Nebraska-Lincoln)

<u>2015:</u> ($1,502,133)

Extension Grant 2015, South Dakota SARE Professional Development Program State Level Mini-Grant. "Pollinator Identification and Conservation Workshop". Amount awarded: $5,500.
PI: **Adam J. Varenhorst**
Co-PI: Amanda Bachmann.

Extension Grant 2015, South Dakota SARE Professional Development Program State Level Mini-Grant. "Providing integrated pest management training opportunities for crop managers"
Amount awarded: $5,500.
PI: Emmanuel Byamukama
Co-PI: **Adam J. Varenhorst**, Amanda Bachmann, and Paul Johnson

Research Grant 2015, South Dakota Wheat Commission (7/1/16-6/30/17). "Cost and benefit analysis of the use of seed treatments and timing of planting against aphids in winter wheat and tactics for sustainable management of wheat stem sawfly in South Dakota". Amount awarded: $20,000
PI: **Adam J. Varenhorst.**
Co-PI: Karl Glover (South Dakota State University)

Research Grant 2015, North Central Soybean Research Program (10/1/15-9/30/18). "Soybean entomology in the north central region: management and outreach for new and existing pests".
Amount awarded: $1,471,133 (5.5%)
PI: Kelley J. Tilmon (Ohio State University).
Co-PI: B. Diers (University of Illinois), G. Hartman (University of Illinois), C. Krupke (Purdue University), P. Nachappa (Indiana University-Purdue University Fort Wayne), M. O'Neal (Iowa State University), E. Hodgson (Iowa State University), B. McCornack (Kansas State University), D. Finke (University of Missouri), G. Heimpel (University of Minnesota), B. Potter (University of Minnesota), R. Koch (University of Minnesota), T. Hunt (University of Nebraska-Lincoln), R. Wright (University of Nebraska-Lincoln), D. Prischmann (North Dakota State University), J. Knodel (North Dakota State University), A. Michel (Ohio State University), **A. Varenhorst**.

Proposed (total = $1,203,262):

<u>2017:</u> ($120,000)

Research Grant 2017, North Central Region Sustainable Agriculture Research and Education. "Evaluating the impact of insecticide and fungicide applications on pollinators in confection and oilseed sunflowers."

Amount requested: $120,000
PI: **Adam J. Varenhorst**
Co-PI: P. Wagner, (South Dakota State University) and A. Bachmann (South Dakota State University)

<u>2016:</u> ($285,266)
Research Grant 2016, North Central Soybean Research Program Grant. "Determining when seed treatments in soybean really pay off".
Amount requested: $225,000
PI: **Adam J. Varenhorst**
Co-PI: D. Mueller (Iowa State University), S. Conley (University of Wisconsin), F. Mathew (South Dakota State University), J. Kleinjan (South Dakota State University), M. Dunbar (South Dakota State University)

Research Grant 2016, South Dakota Department of Agriculture Specialty Crop Block Grant. "Developing best management practices for dry pea production in South Dakota".
PI: Febina Mathew (South Dakota State University)
Co-PI: **A. J. Varenhorst**, C. Graham (South Dakota State University), R. Beck (South Dakota State University), A. Bachmann (South Dakota State University)
Amount requested: $37,856

Research Grant 2016, South Dakota Oilseeds Council. "Developing management recommendations for the use of seed treatments in sunflower in South Dakota".
Amount requested: $12,410
PI: **Adam J. Varenhorst**
Co-PI: F. Mathew (South Dakota State University)

Research Grant 2016, South Dakota Oilseeds Council Grant. "Managing Phomopsis stem canker of sunflower using genetic resistance".
Amount requested: $10,000
PI: Febina Mathew (South Dakota State University)
Co-PI: **A. Varenhorst**

<u>2015:</u> ($797,996)
Research Grant 2015, USDA Multi-State Specialty Crop Block Grant. "Genetic improvement of sustainable pea production in the United States".
Amount requested: $797,906
PI: Dipak Santra (University of Nebraska-Lincoln)
Co-PI: R. Harveson (University of Nebraska-Lincoln), J. Bradshaw (University of Nebraska-Lincoln), C. Coyne (Washington State University), F. Mathew (South Dakota State University), **A. Varenhorst**, K. McPhee (North Dakota State University), J. Pasche (North Dakota State University)

Publications and Book Chapters

Peer reviewed

Google Scholar: https://scholar.google.com/citations?hl=en&user=7wU4mecAAAAJ
ORCID ID: http://orcid.org/0000-0001-6239-9860

2018

Dunbar, M. W., A. Bachmann, and **A. J. Varenhorst.** 2018. Reduced insecticide susceptibility in *Aedes vexans* (Diptera: Culicidae) where agricultural pest management overlaps with mosquito abatement. Journal of Medical Entomology.

O'Neal, M. E., **A. J. Varenhorst,** M. C. Kaiser. 2018. Rapid evolution to host plant resistance by an invasive herbivore: soybean aphid (Aphis glycines) virulence in North America to aphid resistant cultivars. Current Opinion in Insect Science 26: 1-7.

2017

Clay, S. A. and **A. Varenhorst**. 2017. Estimating weed and insect development, in-season yield losses, and economic thresholds. *In* Clay, D. E., S. A. Clay, and S. A. Bruggeman (eds). American Society of Agronomy.

Varenhorst, A. J., S. R. Pritchard, E. W. Hodgson, M. E. O'Neal, and A. Singh. 2017. Determining the effectiveness of three-gene pyramids against *Aphis glycines* (Hemiptera: Aphididae) biotypes. J. Econ. Entomol.

Dunbar, M., A. Adhikari, B. Kontz, **A. Varenhorst**, T. Nleya, E. Byamukama, and F. Mathew. 2017. First report of Alternaria Black Spot caused by *Alternaria alternata* on Brassicae carinata in South Dakota. Plant Disease. DOI: 10.1094/PDIS-02-17-0222-PDN

Koch, R., B. Potter, P. Glogoza, E. Hodgson, C. Krupke, J. Tooker, C. DiFonzo, A. Michel, K. Tilmon, T. Prochaska, J. Knodel, R. Wright, T. Hunt, B. Jensen, **A. Varenhorst**, B. McCornack, K. Estes, and J. Spencer. In review. Biology and economics of recommendations for insecticide-based management of soybean aphid. Plant Health Progress.

2015

Varenhorst, A. J., and M. E. O'Neal. 2015. The effect of an interspersed refuge on *Aphis glycines* (Hemiptera: Aphididae) and natural enemy populations. J. Econ. Entomol. DOI: 10.1093/jee/tov302

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Reduced fitness of virulent *Aphis glycines* (Hemiptera: Aphididae) biotypes may influence the longevity of resistance genes in soybean. PLoS One. DOI: 10.1371/journal.pone.0138252.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Determining the duration of *Aphis glycines* (Hemiptera: Aphididae) induced susceptibility effects in soybean. Arthropod-Plant Inter. 9: 457-464. DOI: 10.1007/s11829-015-9395-7.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. An induced susceptibility response in soybean promotes avirulent *Aphis glycines* (Hemiptera: Aphididae) populations on resistant soybean. Environ. Entomol. 44: 658-667. DOI: 10.1093/ee/nvv051.

2012

Varenhorst, A. J., and M. E. O'Neal. 2012. The response of natural enemies to selective insecticides applied to soybean. Environ. Entomol. 41: 1565-1574.

In preparation

Varenhorst, A. J., M. T. McCarville, J. A. Wenger, M. E. O'Neal, and A. P. Michel. How does virulence spread within a field? Soybean aphids, host-plant resistance, and interspersed refuges. J. Econ. Entomol.

Pritchard, S. R., M. E. O'Neal, A. Singh, A. K. Singh, and **A. J. Varenhorst**. Effect of soybean trichome density on *Aphis glycines* Matsumura (Hemiptera: Aphididae).

Extension Fact Sheets

Dunbar, M., B. Fuller, B. McManus, and **A. J. Varenhorst**. 2017. Corn rootworm in South Dakota. iGrow, South Dakota State University Extension. Publication:

Fiedler, D., F. Mathew, R. Beck, and **A. Varenhorst**. 2016. Phoma black stem of sunflower. iGrow, South Dakota State University Extension. Publication: 03-2004-2016.

Fiedler, D., F. Mathew, R. Beck, and **A. Varenhorst**. 2016. Phomopsis stem canker of sunflower. iGrow, South Dakota State University Extension. Publication 03-2005-2016.

Fiedler, D., F. Mathew. R. Beck, and **A. Varenhorst**. 2016. Stem weevils of sunflowers in South Dakota. iGrow, South Dakota State University Extension. Publication: 03-2006-2016.

Welch, K. D., K. J. Tilmon, and **A. J. Varenhorst**. 2016. Bean leaf beetle in South Dakota. iGrow, South Dakota State University Extension. Publication: 03-2002-2016.

Welch, K. D., K. J. Tilmon, and **A. J. Varenhorst**. 2016. Green cloverworm and other caterpillars in South Dakota soybeans. iGrow, South Dakota State University Extension. Publication: 03-2001-2016.

Welch, K. D., K. J. Tilmon, and **A. J. Varenhorst**. 2016. Japanese beetles in South Dakota. iGrow, South Dakota State University Extension. Publication: 03-2000-2016.

Extension Articles

2017: 83

Byamukama, E., C. Tande, M. Langham, C. Strunk, and **A. Varenhorst**. 2017. Soybean vein necrosis virus detected in South Dakota soybeans. iGrow, South Dakota State University Extension. 9/21/2017.

http://igrow.org/agronomy/soybeans/soybean-vein-necrosis-virus-detected-in-south-dakota-soybeans/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. What should I do about the spider mites that I'm finding in corn? iGrow, South Dakota State University Extension. 9/20/2017. http://igrow.org/agronomy/corn/what-should-i-do-about-the-spider-mites-that-im-finding-in-corn/

Wagner, P., A. Bachmann, and **A. Varenhorst.** 2017. Managing cucumber beetles. iGrow, South Dakota State University Extension. 9/20/2017. http://igrow.org/gardens/home-and-garden-pests/managing-cucumber-beetles/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Aphid populations being observed in South Dakota corn. iGrow, South Dakota State University Extension. 9/13/2017. http://igrow.org/agronomy/corn/aphid-populations-being-observed-in-south-dakota-corn/

Wagner, P., A. Bachmann, and **A. Varenhorst**. 2017. Protecting your garden from squash bugs. iGrow, South Dakota State University Extension. 9/7/2017. http://igrow.org/gardens/home-and-garden-pests/protecting-your-garden-from-squash-bugs/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. What were SDSU Extension entomologists doing at Dakotafest? iGrow, South Dakota State University Extension. 8/31/2017. http://igrow.org/agronomy/soybeans/what-were-sdsu-extension-entomologists-doing-at-dakotafest/

Varenhorst, A., P. Wagner, A. Bachmann, C. Dierks, B. Hauswedell, and P. Rozeboom. 2017. Pyrethroid resistant soybean aphids detected in South Dakota. iGrow, South Dakota State University Extension. 8/31/2017. http://igrow.org/agronomy/soybeans/pyrethroid-resistant-soybean-aphids-detected-in-south-dakota/

Byamukama, E., C. Strunk, and **A. Varenhorst**. 2017. Soybean field day planned for September 12. iGrow, South Dakota State University Extension. 8/31/2017. http://igrow.org/agronomy/soybeans/soybean-field-day-planned-for-september-12/

Varenhorst, A., P. Wagner, A. Bachmann, and R. Beck. 2017. Red and gray beetles on sunflower heads: What are they? iGrow, South Dakota State University Extension. 8/31/2017. http://igrow.org/agronomy/other-crops/red-gray-beetles-on-sunflower-heads-what-are-they/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Thistle caterpillars chewing up soybeans: Round 2! iGrow, South Dakota State University Extension. 8/28/2017. http://igrow.org/agronomy/soybeans/thistle-caterpillars-chewing-up-soybeans-round-2/

Varenhorst, A., P. Wagner, A. Bachmann, and C. Strunk. 2017. Small red maggots under your soybean plants' epidermis? We have answers. iGrow, South Dakota State University Extension. 8/24/2017.

http://igrow.org/agronomy/soybeans/small-red-maggots-under-your-soybean-plants-epidermis-we-have-answers/

Varenhorst, A., P. Wagner, A. Bachmann, C. Dierks, B. Hauswedell, and P. Rozeboom. 2017. Grasshoppers chewing up soybean in Southeast South Dakota. iGrow, South Dakota State University Extension. 8/24/2017. http://igrow.org/agronomy/soybeans/grasshoppers-chewing-up-soybean-in-southeast-south-dakota/

Varenhorst, A., P. Wagner, A. Bachmann, and P. O. Johnson. 2017. What's eating the Canada thistle? iGrow, South Dakota State University Extension. 8/24/2017. http://igrow.org/agronomy/soybeans/whats-eating-the-canada-thistle/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Soybean aphid populations reaching and exceeding thresholds. iGrow, South Dakota State University Extension. 8/18/2017. http://igrow.org/agronomy/soybeans/soybean-aphid-populations-reaching-and-exceeding-thresholds/

Varenhorst, A., P. Wagner, A. Bachmann, and R. Beck. 2017. Red sunflower seed weevils exceeding thresholds and then some. iGrow, South Dakota State University Extension. 8/16/2017. http://igrow.org/agronomy/other-crops/red-sunflower-seed-weevils-exceeding-thresholds-and-then-some/

Varenhorst, A., P. Wagner, A. Bachmann, R. Beck, and L. Edwards. 2017. Dectes stem borer in South Dakota sunflowers. iGrow, South Dakota State University Extension. 8/10/2017. http://igrow.org/agronomy/other-crops/dectes-stem-borer-in-south-dakota-sunflowers/

Varenhorst, A., P. Wagner, A. Bachmann, and R. Beck. 2017. Monitoring sunflower fields for sunflower moth. iGrow, South Dakota State University Extension. 8/10/2017. http://igrow.org/agronomy/other-crops/monitoring-sunflower-fields-for-sunflower-moth/

Varenhorst, A., P. Wagner, A. Bachmann, and C. Strunk. 2017. Are bean leaf beetles chewing holes in your soybean leaves? iGrow, South Dakota State University. 8/10/2017. http://igrow.org/agronomy/soybeans/are-bean-leaf-beetles-chewing-holes-in-your-soybean-leaves/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Where are the soybean aphid populations at now? iGrow, South Dakota State University Extension. 8/10/2017. http://igrow.org/agronomy/soybeans/where-are-the-soybean-aphid-populations-at-now/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Attendees learned about insects at the IPM Field School. iGrow, South Dakota State University. 8/10/2017. http://igrow.org/agronomy/soybeans/attendees-learned-about-insects-at-the-ipm-field-school/

Beck, R., **A. Varenhorst,** E. Byamukama, P. Wagner, P. O. Johnson, and D. Beck. 2017. Managing wheat residue to prevent a green bridge. 8/9/2017. http://igrow.org/agronomy/wheat/managing-wheat-residue-to-prevent-a-green-bridge/

Bachmann. A., P. Wagner, **A. Varenhorst**, and J. Ball. 2017. Root weevils and imported longhorned weevils finding their way inside. iGrow, South Dakota State University. 8/7/2017. http://igrow.org/gardens/home-and-garden-pests/root-weevils-imported-longhorned-weevils-finding-their-way-inside/

Bachmann, A., P. Wagner, and **A. Varenhorst**. 2017. Why are those big, scary wasps digging in my yard? iGrow, South Dakota State University Extension. 8/4/2017. http://igrow.org/gardens/home-and-garden-pests/why-are-those-big-scary-wasps-digging-in-my-yard/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. What to do about redheaded flea beetles in soybean? iGrow, South Dakota State University Extension. 8/3/2017. http://igrow.org/agronomy/soybeans/what-to-do-about-redheaded-flea-beetles-in-soybean/

Wagner, P., A. Bachmann, **A. Varenhorst.** 2017. What are those gigantic flies? iGrow, South Dakota State University Extension. 8/3/2017. http://igrow.org/livestock-land-water-wildlife/land-water-and-wildlife/what-are-those-gigantic-flies/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Grasshopper populations exceeding thresholds in Eastern South Dakota. iGrow, South Dakota State University Extension. 8/3/2017. http://igrow.org/agronomy/land-water-wildlife/grasshopper-populations-exceeding-thresholds-in-eastern-south-dakota/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Red sunflower seed weevil adults spotted. iGrow, South Dakota State University Extension. 8/3/2017. http://igrow.org/agronomy/other-crops/red-sunflower-seed-weevil-adults-spotted/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Green cloverworm, soybean looper and alfalfa caterpillars observed in S.D. soybeans. iGrow, South Dakota State University Extension. 7/31/2017. http://igrow.org/agronomy/soybeans/green-cloverworm-soybean-looper-and-alfalfa-caterpillars-observed-in-s.d.-s/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Earwigs: The good, the bad, and the ugly. iGrow, South Dakota State University. 7/27/2017. http://igrow.org/gardens/home-and-garden-pests/earwigs-the-good-the-bad-and-the-ugly/

Wagner, P., A. Bachmann, R. Beck, and **A. Varenhorst.** 2017. Banded sunflower moth in South Dakota. iGrow, South Dakota State University Extension. 7/26/2017. http://igrow.org/agronomy/other-crops/banded-sunflower-moth-in-south-dakota/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Dectes stem borer in Southeast South Dakota soybean. iGrow, South Dakota State University Extension. 7/26/2017. http://igrow.org/agronomy/soybeans/dectes-stem-borer-in-southeast-south-dakota-soybean/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Grasshopper populations increasing in Central and Southeast S.D. iGrow, South Dakota State University Extension. 7/26/2017. http://igrow.org/agronomy/corn/grasshopper-populations-increasing-in-central-and-southeast-s.d

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Imported longhorned weevils observed in South Dakota. iGrow, South Dakota State University Extension. 7/26/2017. http://igrow.org/agronomy/soybeans/imported-longhorned-weevils-observed-in-south-dakota/

Varenhorst, A., P. Wagner, and A. Bachmann. 2017. Thistle caterpillar infestation symptoms: Rolled leaves, defoliation and webbing. iGrow, South Dakota State University Extension. 7/20/2017. http://igrow.org/agronomy/soybeans/thistle-caterpillar-infestation-symptoms-rolled-leaves-defoliation-and-webb/

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http://igrow.org/agronomy/other-crops/alfalfa-plant-bugs/

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Varenhorst, A., E. Byamukama, C. Strunk, P. Wagner, and A. Bachmann. 2017. Wheat stem maggots observed in S.D. wheat. iGrow, South Dakota State University Extension. 6/30/2017.
http://igrow.org/agronomy/wheat/wheat-stem-maggots-observed-in-s.d.-wheat/

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Reddy, G. V. P., P. B. Beauzay, S. D. Eigenbrode, J. J. Knodel, T. J. Prochaska, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018**. Pea weevil. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Eigenbrode, S. D., P. B. Beauzay, J. J. Knodel, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018.** Pea aphid. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Prochaska, T. J., P. B. Beauzay, S. D. Eigenbrode, J. J. Knodel, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018.** Lady beetles or ladybugs. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

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Wagner, P. M., P. B. Beauzay, S. D. Eigenbrode, J. J. Knodel, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst** and K. W. Wanner. **2018.** Minute pirate bugs. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Knodel, J. J., P. B. Beauzay, S. D. Eigenbrode, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018.** Syrphid flies or hoverflies. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

Beauzay, P. B., S. D. Eigenbrode, J. J. Knodel, T. J. Prochaska, G. V. P. Reddy, **A. J. Varenhorst**, P. M. Wagner and K. W. Wanner. **2018**. Parasitic wasps or parasitoids. *In* Knodel, J., T. J. Prochaska and J. S. Pasche. (eds.). Pulse Crop Insect Diagnostic Series: Field Pea, Lentil and Chickpea.

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Varenhorst, A. J. and P. M. Wagner. **2018.** Soil and foliar insecticides in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

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Byamukama, E., D. Yabwalo, P. M. Wagner, and **A. J. Varenhorst. 2018.** Seed treatments in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, P. M. Wagner, and **A. J. Varenhorst. 2018.** Seed treatments in soybean. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Soybean: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, P. M. Wagner, and **A. J. Varenhorst. 2018.** Seed treatments in wheat. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Byamukama, E., D. Yabwalo, P. M. Wagner, and **A. J. Varenhorst. 2018.** Seed treatments in sunflower. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

2017:

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Soil and foliar insecticides in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Foliar insecticides in alfalfa. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Foliar insecticides in oilseeds. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Sunflower & Oilseeds/Alfalfa & Range: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Foliar insecticides in soybean. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Soybean: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J., M. W. Dunbar, and P. M. Wagner. **2017.** Foliar insecticides in wheat. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

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Byamukama, E., D. Yabwalo, M. W. Dunbar, P. M. Wagner, and **A. J. Varenhorst. 2017.** Seed treatments in sunflower. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

2016:

Beck, D., R. Beck, A. Chirumamilla, **A. Varenhorst. 2016.** Production and utilization of field peas in South Dakota. iGrow.

Varenhorst, A. J. 2016. Soil and foliar insecticides in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

Varenhorst, A. J. 2016. Foliar insecticides in alfalfa. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Alfalfa and Oilseeds: A guide to managing weeds, insects, and diseases.

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Byamukama, E., and **A. J. Varenhorst. 2016.** Seed treatments in corn. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Corn: A guide to managing weeds, insects, and diseases.

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Byamukama, E., and **A. J. Varenhorst. 2016.** Seed treatments in sunflower. *In* Bachmann, A. (ed). South Dakota Pest Management Guide, Wheat: A guide to managing weeds, insects, and diseases.

Refereed:

Wright, R. and **A. J. Varenhorst**. 2016. Sorghum insect pests.

Varenhorst, A. J., B. W. Fuller, and B. W. French. 2016. Corn insect pests. *In* Clay, D.E., C.G. Carlson, S.A. Clay, and E. Byamukama (eds). iGrow Corn: Best Management Practices. South Dakota State University.

Varenhorst, A. J., and B. W. Fuller. 2016. Stored grain pests of corn. *In* Clay, D.E., C.G. Carlson, S.A. Clay, and E. Byamukama (eds). iGrow Corn: Best Management Practices. South Dakota State University.

Invited Presentations

2018:

Varenhorst, A., and B. Hauswedell. 2018. Planting populations and seed treatments. Soy100: Growing 100-Bushel Soybeans. 14 March 2018. Brookings, SD.

Varenhorst, A., J. Knodel, E. Bynum, and J. P. Michaud. 2018. 2018 Sunflower special topics: Insects of the sunflower root and stalk. 40th Annual NSA Research Forum. 10 January 2018. Fargo, ND.

2017:

Varenhorst, A. J., B. Hauswedell, J. P. Michaud, and J. Knodel. 2017. Evaluating early season belowground pest management in sunflowers. 65th Annual Meeting of the Entomological Society of America. 8 November 2017. Denver, CO.

Varenhorst, A. J. 2017. Integrated pest management: Insects. American Society of Agronomy Cultivating Sustainability: A Training Curriculum for Agronomy Professionals: Concepts in Integrated Pest Management: Insects and Plant Pathology Webinar Series.

Varenhorst, A., B. Hauswedell, P. Rozeboom, P. Wagner, and A. Bachmann. 2017. Managing pests in South Dakota's Major Crops. 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/4/2017.

Varenhorst, A. and M. O'Neal. 2017. Interspersed refuges: How do they impact soybean aphid natural enemies? 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/7/2017.

Varenhorst, A. J. 2017. Insect issues facing farmers in South Dakota. PS 390 Junior Seminar. Instructor Dr. Thandiwe Nleya. 28 February 2017. Brookings, South Dakota. Presented to 40 students.

Varenhorst, A. J., B. Hauswedell, M. Mattern and P. Rozeboom. 2017. Insect pests and pollinators of sunflower in South Dakota. NuSeed, Legend Seeds Sunflower Training. Alison Stone. Pierre, SD. Presented to 122 stakeholders.

Varenhorst, A. J. 2017. Belligerent bugs –How resistance affects insect management. American Society of Agronomy Resistance Management Webinar Series.

Varenhorst, A., M. Mattern, B. Hauswedell, and P. Rozeboom. 2017. 2017 Insect Pest and Research Update. Brown County Crops Clinic. Aberdeen, SD. 1/6/2017.

2016:

Varenhorst, A. J. 2016. From a B.S. in biology to a Ph.D. in entomology: How did I get here? Briar Cliff University STEM Seminar. Briar Cliff University, Sioux City, IA. 11 November 2016.

Varenhorst, A. J. and M. E. O'Neal. 2016. The effect of an interspersed refuge on soybean aphid management. Symposium: Research Update from the North Central Soybean Research Program (NCSRP). 71st Annual North Central Branch of the Entomological Society of America. 5 June 2016.

Varenhorst, A. J. 2016. Insect pollinators. Hinton Community Elementary School, Hinton, IA. 23 May 2016. Presented to a total of 60 first grade students.

Varenhorst, A. J. 2016. Seed treatments: do they provide economic benefits to South Dakota farmers? PS 333. Instructor Dr. Febina Mathew. 4 April 2016. Brookings, SD. Presented to 58 students.

Varenhorst, A. J. 2016. Insecticide seed treatments in soybeans. Soy100. Stephanie Bruggeman. 11 March 2016. Brookings, SD. Presented to 80 stakeholders.

Varenhorst, A. J. 2016. Insect pests of sunflower in South Dakota. NuSeed, Legend Seeds Sunflower Training. Alison Stone. 23 February 2016. Chamberlain, SD. Presented to 55 stakeholders.

Varenhorst, A. J. 2016. Major insect issues in South Dakota. PS 380 Junior Seminar. Instructor Dr. Thandiwe Nleya. 16 February 2016. Brookings, SD. Presented to 20 students.

Varenhorst, A. J. 2016. Review of 2015 insect pests and what to watch for in 2016. Faulkton Crop Improvement Meeting. 29 January 2016. Faulkton, SD. Presented to nine stakeholders.

Varenhorst, A. J. 2016. 2015 insect pest summary and current research update. 8 January 2016. Aberdeen, SD. Presented to 19 stakeholders.

2015:

Varenhorst, A. J. 2015. Climate and insect pests: How are they related? Climate & Agriculture Workshop. 15 December 2015. Mitchell, SD. Presented to seven stakeholders.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Induced susceptibility affects *Aphis glycines* virulence on resistant soybean: Implications for managing this pest in the future. 63rd Annual Meeting of the Entomological Society of America. 15 November 2015. Minneapolis, MN.

Varenhorst, A. J. 2015. Insect issues facing farmers in South Dakota. PS 390 Junior Seminar. Instructor Dr. Thandiwe Nleya. 22 October 2015. Brookings, South Dakota. Presented to 30 students.

Research Presentations

2018:

Koch, R., J. Menger, I. MacRae, J. Knodel, B. Potter, P. Glogoza, E. Hodgson, **A. Varenhorst**, A. Chirumamilla, and J. Gavloski. 2018. Insecticide resistance in soybean aphid: An emerging challenge in soybean production. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Pezzini, D., P. Mittapelly, C. DiFonzo, D. Finke, T. hunt, J. Knodel, C. Krupke, B. McCornack, A. Michel, C. R. Philips, **A. Varenhorst**, R. Wright, and R. Koch. 2018. Emerging stink bugs on soybean – Where are they and what do they like to eat? 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Hauswedell, B., C. Dierks, P. Rozeboom, F. Mathew, J. Kleinjan, and **A. Varenhorst**. 2018. Does planting date, location and seeding rate affect the efficacy of seed treatments in soybean? 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Dunbar, M., A. Bachmann, and **A. Varenhorst**. 2018. Reduced insecticide susceptibility in *Aedes vexans* (Diptera: Culicidae) where agricultural pest management overlaps with mosquito abatement. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Hohenstein, J., M. Kaiser, K. Tilmon, **A. Varenhorst**, E. Hodgson, and M. O'Neal. 2018. "Refuge-in-a-bag" approach for sustainable management of virulent soybean aphids (*Aphis glycines*, Hemiptera: Aphididae) in the field. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Conzemius, S., L. Hesler, **A. Varenhorst**, and K. Tilmon. 2018. Eat, drink and be varied: Soybean aphid intrabiotypic variants on soybean ascensions. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Dierks, C., B. Hauswedell, P. Rozeboom, and **A. Varenhorst**. 2018. Do cover crops and tillage affect the efficacy of soybean insecticide seed treatments? 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Varenhorst, A. and B. Hauswedell. 2018. Determining the efficacy of insecticide seed treatments and in-furrow insecticides for wireworm management. 40th Annual NSA Research Forum. 10 January 2018. Fargo, ND.

Prasifka, J., R. Mallinger, **A. Varenhorst**, and J. Bradshaw. 2018. Benefits of insect pollination to confection sunflowers in the Northern and Central Plains. 40th Annual NSA Research Forum. 10 January 2018. Fargo, ND.

2017:

Dierks, C., P. Rozeboom, B. Hauswedell, and **A. Varenhorst**. 2017. Evaluating the efficacy of foliar insecticides for soybean aphids in South Dakota. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. Denver, CO.

Conzemius, S., L. Hesler, **A. Varenhorst**, and K. Tilmon. 2017. Mind your elders: Wild soybean's contribution to soybean aphid resistance. 65th Annual Meeting of the Entomological Society of America. 6 November 2017. Denver, CO.

Pezzini, D., D. Finke, T. Hunt, J. Knodel, C. Krupke, B. McCornack, A. Michel, C. R. Philips, **A. Varenhorst**, R. Wright, and R. Koch. 2017. Influence of field and landscape factors on stink bug (Hemiptera: Pentatomidae) community in North Central soybean. 65th Annual Meeting of the Entomological Society of America. 5 November 2017. Denver, CO.

Hauswedell, B., P. Rozeboom, J. P. Michaud, J. Knodel, and **A. Varenhorst**. 2017. Evaluation of seed and in-furrow treatments for sunflower in South Dakota. 65th Annual Meeting of the Entomological Society of America. 5 November 2017. Denver, CO.

Mallinger, R., J. Prasifka, J. Bradshaw, and **A. Varenhorst**. 2017. How do pollination services to sunflowers vary across plant genotypes, environements, and pollinator taxa? 65th Annual Meeting of the Entomological Society of America. 5 November 2017. Denver, CO.

Varenhorst, A., M. W. Dunbar, and A. Bachmann. 2017. Agricultural pest management in South Dakota: Does it affect mosquito insecticide resistance? 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/6/2017

Hauswedell, B., M. W. Dunbar, F. Mathew, J. Kleinjan, and **A. Varenhorst**. 2017. Developing management recommendations for soybean seed treatments in South Dakota. 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/5/2017

Pezzini, D., D. Finke, T. Hunt, J. Knodel, C. Krupke, B. McCornack, A. Michel, C. R. Philips, **A. Varenhorst**, R. Wright, and R. Koch. 2017. Influence of field and landscape factors on stink bug (Hemiptera: Pentatomidae) community in North Central soybean. North Central Branch of the Entomological Society of America. Indianapolis, IN. 6/5/2017.

Varenhorst, A., B. Hauswedell, J. Knodel, and J. P. Michaud. 2017. Determining the impact of seed treatments on sunflower yield. National Sunflower Association Forum. Fargo, ND. 1/10/2017.

Dunbar, M. W., A. Bachmann, F. Mathew, and **A. Varenhorst**. 2017. Mosquito insecticide resistance affected by agricultural pest management. Adult Control I, American Mosquito Control Association, Annual Meeting, San Diego, CA.

2016:

Varenhorst, A., B. Hauswedell, M. Mattern, and F. Mathew. 2016. Sunflower Update: Insects and diseases. Ag Horizons. Pierre, SD. 11/30/2016.

Okello, P., A. Adhikari, **A. Varenhorst**, S. Osborne, E. Byamukama, and F. Mathew. 2016. Interaction between Fusarium and soybean cyst nematode on soybean. American Phytopathology Society Annual Meeting. 31 July 2016. Tampa FL.

Posch, J. P., **A. J. Varenhorst**, F. M. Mathew. 2016. Exploring interactions of soybean cyst nematode with stem canker pathogens on soybean. American Phytopathological Society North Central Meeting. 8 June 2016. Minneapolis, MN.

Pritchard, S., M. O'Neal, A. Singh, A. Singh, **A. Varenhorst**. 2016. Effect of soybean trichome density on biotype-1 soybean aphid (*Aphis glycines*) and its natural enemies. 71st Annual North Central Branch of the Entomological Society of America. 6 June 2016. 3rd place in PIE student competition.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Exploring factors that may promote the longevity of *Rag* genes. 70th Annual North Central Branch of the Entomological Society of America. 1 June 2015. Manhattan, Kansas.

Nutter, F., M. T. McCarville, and **A. J. Varenhorst**. 2014. Defoliation.Pro: A new training tool for improving the accuracy and precision of defoliation ratings. 62nd Annual Meeting of the Entomological Society of America. 19 November 2014. Portland, Oregon.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2014. Does induced susceptibility occur between virulent and avirulent soybean aphids on resistant soybean? 62nd Annual Meeting of the Entomological Society of America. 17 November 2014. Portland, Oregon. (Received 1st place in PIE student competition)

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2014. Do biotype-1 soybean aphids benefit from the presence of biotype-2 on resistant soybean. 1st Annual ISU Graduate and Professional Student Research Conference. 5 April 2014. Ames, Iowa (Received Best in Session).

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2014. Do biotype-1 soybean aphids benefit from the presence of biotype-2 on resistant soybean? 69th Annual North Central Branch of the Entomological Society of America. 10 March 2014. Des Moines, Iowa. (Received 2nd place in the Ph.D. PIE student competition)

Wagner, P., M. E. O'Neal, and **A. J. Varenhorst**. 2014. Varying the timing of insecticide application limits non-target impacts in soybean. 69th Annual North Central Branch of the Entomological Society of America. 10 March 2014. Des Moines, Iowa.

Varenhorst, A. J., and M. E. O'Neal. 2013. Induced susceptibility: a density dependent response that explains *Aphis glycines* populations on resistant soybean in field research plots. 68th Annual North Central Branch of the Entomological Society of America. 17 June 2013. Rapid City, South Dakota. (Received 2nd place in the Ph.D. PIE student competition)

Varenhorst, A. J., and M. E. O'Neal. 2013. Density-dependent induced susceptibility: a non-genetic explanation of soybean aphid biotypes on aphid resistant soybean. 4th Biennial ISU Hemipteran Research Symposium. 26 March 2013. Ames, Iowa.

Varenhorst, A. J., and M. E. O'Neal. 2012. Which aphids are important vectors of *Soybean mosaic virus*? 60th Annual Meeting of the Entomological Society of America. 12 November 2012. Knoxville, Tennessee.

Varenhorst, A. J., and M. E. O'Neal. 2012. What role do alate soybean aphids (*Aphis glycines*) play in the spread of Soybean mosaic virus? 67th Annual North Central Branch of the Entomological Society of America. 4 June 2012. Lincoln, Nebraska. (Received 2nd in the Ph.D. PIE student competition)

Varenhorst, A. J., and M. E. O'Neal. 2011. Managing soybean aphids with selective insecticides results in a bioresidual. 59th Annual Meeting of the Entomological Society of America. 14 November 2011. Reno, Nevada.

Varenhorst, A. J., and M. E. O'Neal. 2011. The natural enemy community of the soybean aphid, and the effects that selective insecticides have on its populations. 66th Annual North Central Branch of the Entomological Society of America. 14 March 2011. Minneapolis, Minnesota. (Received 3rd place in the M.S. PIE student competition)

Varenhorst, A. J., and M. E. O'Neal. 2010. Can selective insecticides control soybean aphid populations without harming natural enemies? 58th Annual Meeting of the Entomological Society of America. 13 December 2010. San Diego, California.

Varenhorst, A. J., and M. E. O'Neal. 2010. Can selective insecticides control soybean aphid populations without harming natural enemies? Midwest Ecology & Evolution Conference 2010. 27 March 2010. Ames, Iowa.

Varenhorst, A. and T. Wilson. 2008. Survey of the insects in the Sioux City Prairie, Woodbury County. 18th Annual Prairie Invertebrate Conference. 25 October 2008. Newburg, Wisconsin.

Extension Presentations

2017

Varenhorst, A., A. Bachmann and M. Dunbar. 2017. Insecticide resistance in South Dakota mosquitos. Mosquito Control and West Nile Conference. Aberdeen, SD.

Varenhorst, A. 2017. Forage insect pests: what to watch for. Forage Fiesta. Beresford, SD.

Varenhorst, A., P. Wagner and A. Bachmann. 2017. Corn, Soybean, and Alfalfa insect pest management. East River IPM Field School. Beresford, SD.

Varenhorst, A. J. 2017. Current and potential insect pests. Northeast Research Farm Field Day.

Varenhorst, A. J. 2017. Current and potential insect pests. Southeast Research Farm Field Day.

Varenhorst, A. J. 2017. Current and potential insect pests. Volga Farm Field Day.

Varenhorst, A. J. and P. Wagner. 2017. 2017 insect pests in field peas. Field Pea Tours.

Varenhorst, A. J. and P. Wagner. 2017. Alfalfa and Range insect pest management. West River Field School. Rapid City, SD.

Varenhorst, A., J. 2017. Current and potential wheat insect pests. Pierre and Wall Wheat Walks.

Varenhorst, A., J. 2017. Current and potential wheat insect pests. Watertown Wheat Walks.

Varenhorst, A. J. and P. M. Wagner. 2017. Commercial Agriculture Recertification: Category 1B. Presented at 10 locations to 1,826 stakeholders.

Varenhorst, A. J. and P. M. Wagner. 2017. Private Agriculture Recertification. Presented at 13 locations.

2016

Varenhorst, A., P. Wagner, A. Bachmann. 2016. Extension Entomology Booth. South Dakota State Fair, Huron, SD. Attended 9/1/16 – 9/5/16. Contacted approximately 5,000 stakeholders.

Varenhorst, A. 2016. Scouting for late season insect pests. DakotaFest, Mitchell, SD. 8/16/16. Presented to approximately 12 stakeholders.

Varenhorst, A., and A. Bachmann. Extension Entomology Booth. DakotaFest. DakotaFest, Mitchell, SD. Attended 8/16/16 - 8/18/16. Contacted approximately 1,000 stakeholders.

Varenhorst, A. 2016. Corn and soybean insect pests. Volga Research Farm Field Day. Volga, SD. 7/27/16. Presented to 8 stakeholders.

Varenhorst, A. 2016. Insects in South Dakota Crops. IPM Field School. Volga, SD. Attended 7/20/16 - 7/21/16. 66 attendees.

Varenhorst, A. 2016. Insecticides and pollinators. Pollinator Workshop. Pierre, SD. 7/15/16. Presented to 11 attendees.

Varenhorst, A. 2016. Soybean insect pests. Southeast Research Farm Field Day. Beresford, SD. 7/12/16. Presented to approximately 40 stakeholders.

Varenhorst, A. 2016. Soybean insect pests. Northeast Research Farm Field Day. 7/6/16. Presented to approximately 40 stakeholders.

Varenhorst, A. 2016. South Dakota insect pests. West River IPM Field School. Pierre, SD. 6/28/16. Presented to 40 attendees.

Posch, J. P., P. Alberti, T. Olson, P. Okello, **A. Varenhorst**, A. Bachmann, E. Byamukama, and F. Mathew. 2016. Common garden diseases and pests. SDSU Extension Day. 6/22/16. Rosebud Indian Reservation.

Varenhorst, A. 2016. Insect pests of field peas in South Dakota. Field Pea Tours. 6/21/16-6/22/16. Presented at two locations to a total of 15 stakeholders.

Varenhorst, A. 2016. Insect pests of wheat in South Dakota. Wheat Walks. 25 May 2016. Presented at three locations to a total of 20 stakeholders.

Varenhorst, A. 2016. Insect pests in South Dakota. South Dakota Independent Crop Consultants Workshop. 1 April 2016. Presented to a total of 45 stakeholders.

Varenhorst, A. and A. Bachmann. 2016. Integrated pest management of insects and pesticide safety. South Dakota State University Winter IPM School. 15 March 2016. Presented to a total of 14 stakeholders.

Varenhorst, A. J. 2016. Insect updates on major crops in South Dakota. Commercial Agriculture Recertification: Category 1B. Presented at ten locations to a total of 1,924 stakeholders.

Varenhorst, A. J. 2016. Insect pest issues in South Dakota. South Dakota Private Applicator Training. Presented at nine locations to a total of 503 stakeholders.

Posters

2018

Dierks, C., B. Hauswedell, P. Rozeboom and **A. Varenhorst**. 2018. Developing an efficacy study for foliar insecticidal management of soybean aphids in South Dakota. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Rozeboom, P., B. Hauswedell, C. Dierks, and **A. Varenhorst**. 2018. Evaluating the efficacy of seed treatments and planting dates against aphid pests in South Dakota winter wheat. 73rd Annual

Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Wagner, P. and **A. Varenhorst**. 2018. Do dung beetles provide services in grazed cover crops. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 20 March 2018. Madison, WI.

Hauswedell, B., P. Rozeboom, J. P. Michaud, J. Knodel and **A. Varenhorst**. 2018. Efficacy of seed and in-furrow treatments in sunflower for early season insect pests. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Anderson, E., B. Fuller, P. Wagner, and **A. Varenhorst**. 2018. Grasshoppers of Eastern South Dakota: A species diversity survey. 73rd Annual Meeting of the North Central Branch of the Entomological Society of America. 19 March 2018. Madison, WI.

Wagner, P., A. Bachmann, R. Beck, B. Hauswedell, E. Byamukama, and **A. Varenhorst.** 2018. South Dakota State University Extension Efforts in Sunflower. 40th Annual NSA Research Forum. 10 January 2018. Fargo, ND.

2017

Wagner, P., E. Anderson, A. Bachmann, and **A. Varenhorst**. 2017. Grasshoppers of western South Dakota: A species diversity survey. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. Denver, CO.

Hauswedell, B., P. Rozeboom, F. Mathew, J. Kleinjan, and **A. Varenhorst**. 2017. Developing soybean seed treatment recommendations in South Dakota. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. Denver, CO.

Dierks, C. P. Rozeboom, and A. Varenhorst. 2017. Evaluating the impacts of seed treatment and cover crop on soybean. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. 7 November 2017. Denver, CO.

Rozeboom, P. and **A. Varenhorst**. 2017. Evaluating the efficacy of seed treatments in South Dakota winter wheat. 65th Annual Meeting of the Entomological Society of America. 7 November 2017. Denver, CO.

Mattern, M., P. Rozeboom, A. Bachmann, and **A. Varenhorst**. 2017. Determining the species of pollinators visiting South Dakota sunflower. 65th Annual Meeting of the Entomological Society of America. 6 November 2017. Denver, CO.

Conzemius, S., L. Hesler, **A. Varenhorst**, and K. Tilmon. 2017. No-Choice but to find plant resistance to soybean aphid biotype 4. 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/5/2017

Hauswedell, B., P. Rozeboom, and **A. Varenhorst**. 2017. Efficacy of insecticide seed treatments for sunflowers in South Dakota. 72nd Annual Meeting of the North Central Branch of the Entomological Society of America. 6/6/2017

Dunbar, M. W., A. Bachmann, F. Mathew, and **A. J. Varenhorst**. 2016. Mosquito insecticide resistance affected by agricultural pest management. American Society of Tropical Medicine and Hygiene, Annual Meeting, Atlanta, GA.

Hauswedell, B., M. W. Dunbar, F. M. Mathew, J. Kleinjan, and **A. J. Varenhorst**. 2016. Developing management recommendations for the use of seed treatments for soybean in South Dakota. AgOutlook. Sioux Falls, SD.

Posch, J. P., **A. J. Varenhorst**, P. A. Rozeboom, and F. M. Mathew. 2016. Determining the impact of co-infestations of Diaporthe longicolla and soybean aphid on soybean. AgOutlook. Sioux Falls, SD.

Neupane, S., Q. Ma, F. Mathew, **A. Varenhorst**, E. J. Andersen, and M. P. Nepal. 2016. Characterization of induced susceptibility effects on soybean-soybean aphid and soybean-soybean aphid-soybean cyst nematode interactions. AgOutlook. Sioux Falls, SD.

2016

Dunbar, M. W., B. Hauswedell, F. M. Mathew, J. Kleinjan, and **A. J. Varenhorst**. 2016. Developing management recommendations for the use of fungicide and insecticide seed treatments for soybeans in South Dakota. International Congress of Entomology. 26 September 2016. Orlando, FL.

Olson, T., F. Mathew, A. Adhikari, B. Kontz, **A. Varenhorst**, and L. Marek. 2016. Development of a quantitative PCR assay to quantify resistance to *Diaporthe helianthi* and *Diaporthe gulyae* in sunflower. American Phytopathological Society Annual Meeting. 30 July 2016.

Adhikari, A., P. Okello, B. Kontz, M. Dunbar, **A. Varenhorst**, and F. Mathew. 2016. Characterizing Fusarium species infecting corn roots in South Dakota. American Phytopathological Society Annual Meeting. 30 July 2016.

Olson, T., B. Kontz, K. Kirby, P. Okello, A. Adhikari, J. Kleinjan, **A. Varenhorst**, and F. Mathew. 2016. Efficacy of commercial fungicide seed treatments on soybean. South Dakota State University Northeast Research Farm Field Day. July 6, 2016. Southshore, SD.

Hauswedell, B., M. W. Dunbar, F. M. Mathew, J. Kleinjan, and **A. J. Varenhorst**. 2016. Developing management recommendations for the use of seed treatments for soybeans in South Dakota. South Dakota State University Northeast Farm Field Day. 6 July 2016. Southshore, SD.

Posch, J. P., **A. J. Varenhorst**, F. M. Mathew. 2016. Determining the interaction between the stem canker fungus, *Diaporthe longicolla*, and the soybean aphid, *Aphis glycines,* on soybean. American Phytopathological Society North Central Meeting. 8 June 2016. Minneapolis, MN.

Dunbar, M. W., B. Hauswedell, F. Mathew, J. Kleinjan, and **A. J. Varenhorst**. 2016. Developing management recommendations for the use of seed treatments for soybeans in South Dakota. 71st Annual North Central Branch of the Entomological Society of America. 7 June 2016.

Pritchard, S. R., M. E. O'Neal, A. Singh, A. K. Singh, **A. J. Varenhorst**, and I. Valmorbida. 2016. Effect of soybean trichome density on Aphis glycines and its natural enemies. 3rd Annual Graduate and Professional Student's Research Conference. 12 April 2016. Ames, IA.

Nepal, M., S. Neupane, Q. Ma, F. Mathew, **A. Varenhorst,** and E. J. Andersen, R. N. Reese. 2016. Comparative genomics of disease resistance genes in soybean (*Glycine max*) and common bean (*Phaseolus vulgaris*). 2016 Botany Conference. 30 July through 3 August 2016. Savannah, GA.

Varenhorst, A., K. Grady, R. Beck, C. Graham, T. Nleya, E. Byamukama, A. Bachmann, P. O. Johnson, C. Tande, and F. Mathew. 2016. Sunflowers in South Dakota: A summary of the South Dakota State University extension efforts for 2015. 2016 National Sunflower Association Research Forum. 12 January 2016. Fargo, ND.

Knodel, J., J. P. Michaud, P. Beauzay, and **A. Varenhorst**. 2016. Efficacy of insecticide seed treatments and soil insecticides for management of wireworms in sunflowers. 2016 National Sunflower Association Research Forum. 12 January 2016. Fargo, ND.

Posch, J. P., **A. J. Varenhorst**, and F. M. Mathew. 2015. Interaction between soybean cyst nematode and stem canker pathogens. 11th Annual AgOutlook. 10 December 2015. Sioux Falls, SD.

Dunbar, M. W., **A. J. Varenhorst**, E. W. Hodgson, M. E. O'Neal, A. J. Gassmann. 2015. True armyworm, rye cover, and no-till: An unfortunate combination in 2015. 63rd Annual Meeting of the Entomological Society of America. 17 November 2015. Minneapolis, MN.

Pritchard, S. R., **A. J. Varenhorst**, A. Singh, A. Singh, I. Valmorbida, M. E. O'Neal. 2015. Effect of soybean trichome density on soybean aphid and its natural enemies. 63rd Annual Meeting of the Entomological Society of America. 16 November 2015. Minneapolis, MN.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2015. Fitness costs associated with virulent soybean aphids. 2015 Soybean Breeders Workshop: Entomology and Agronomy. 17 February 2015. St. Louis, Missouri.

Varenhorst, A. J., M. T. McCarville, and M. E. O'Neal. 2014. Fitness costs associated with virulent soybean aphids. Soybean Aphid Field Day. 14 August 2014. Iowa State University Field Extension Education Laboratory Boone, Iowa.

McCarville, M. T., **A. J. Varenhorst**, M. E. O'Neal. 2014. Tougher than we all thought? Re-evaluating the surprisingly durable *Rag* genes. Soybean Aphid Field Day. 14 August 2014. Iowa State University Field Extension Education Laboratory Boone, Iowa.

Varenhorst, A. J. and M. E. O'Neal. 2009. Can reduced-risk insecticides prevent soybean aphid outbreaks? 57th Annual Meeting of the Entomological Society of America. 14 December 2009. Indianapolis, Indiana.

Photo Credits

Environmental Entomology. 2015. Environ. Entomol. 44. Front cover.

United Soybean Board. 2015. Leading experts stress need for cooperation on honey bee health. News from the Checkoff. 16 June 2015.

United Soybean Board. 2015. Checkoff studies soybean-honey bee relationship. News from the Checkoff. 16 June 2015.

Gill, K. 2015. Everyone can play a role in pollinator conservation. Ecological Landscape Alliance.
http://www.ecolandscaping.org/01/beneficials/everyone-can-play-a-role-in-pollinator-conservation/

Pearce, R. Researchers abuzz about soybean yields. Country Guide.
http://www.country-guide.ca/2014/11/07/researchers-abuzz-about-soybean-yields/45085/

Adamson, N. L., B. Borders, J. Cruz, S. Foltz-Jordan, K. Gill, J. Hopwood, E. Lee-Mäder, A. Minnerath, and M. Vaughn. 2014. Pollinator plants mid-Atlantic region. Cover, picture 15.

Vaughn, M. 2014. USDA NRCS Honey bee monitoring training. USDA NRCS West National Technology Support Center and Pollinator Program. Webinar 29 May 2014 picture C.

Jesse, L., D. Lewis, J. Coats, and M. Shour. 2013. Protecting bees from pesticides. Iowa State University Extension and Outreach. Pub SP 455.

O'Neal, M., and E. Hodgson. 2013. Best practices to promote pollinator habitat. Integrated Crop Management News. 15 August 2013

Heidel-Baker, T., E. Hodgson, and M. O'Neal. Conserving Bees in Iowa Field Crops. Iowa State University Extension and Outreach. Pub 293-13.

Hodgson, E., and T. Heidel-Baker. 2013. Soybean aphid field guide. North Central Soybean Research Program. P. 46. Pub CSI 0060.

O'Neal, M., and E. Hodgson. 2013. Bee health in the news. Iowa State University Extension and Outreach. Integrated Crop Management News. 9 May 2013.

Leopold Center. 2013. Conserving beneficial insects with native plants. Front, Back (pp. 4, 6, 8).

Practical Farmers of Iowa. 2012. The buzz about best pollinator practices. http://practicalfarmers.org/blog/2012/the-buzz-about-best-pollinator-practices.

Hodgson, E., A. Sisson, D. Mueller, L. Jesse, E. Saalau-Rojas, and A. Duster. 2012. Field crop insects. Iowa State University Extension and Outreach. Pg. 37 top. Pub CSI 0014.

McCarville, M., E. Hodgson, and M. O'Neal. 2012. Soybean-aphid resistant soybean varieties for Iowa. Iowa State University Extension and Outreach. Integrated Crop Management News. Pub PM 3023

Teaching Experience

Teaching Assistant

Fundamentals of Entomology and Pest Management (Entomology 376), Iowa State University
Lab Teaching Assistant, Spring 2015, 2014 (two sections), 2013, 2012
Lab Teaching Assistant Coordinator, Spring 2015

Insect Biology (Entomology 370), Iowa State University
Lab Teaching Assistant, Fall 2013, 2012, 2011

Entomology (Entomology 300), Briar Cliff University
Lab Teaching Assistant, Fall 2008

Mentoring Experience

Graduate Student Advisor

Ph.D. Students:

Student: Surendra Neupane
Status: In progress

M.S. Students:

Student: Cole Dierks
Status: In progress

Student: John Posch

Status: Graduated

Student: Brady Hauswedell
Status: In progress

Student: Sophia Conzemius
Status: In progress

Graduate Student Committee
Ph.D. students

Student: Biyi Chen
Status: In progress
Student: Paul Okello
Status: In progress

M.S. students

Student: Taylor Hanson
Status: Graduated
Student: Bret Owen
Status: Graduated

Graduate Student Mentor

Student Mentored: Shelby Pritchard (M.S.)
Status: Graduated

Undergraduate Student Mentor

Student: Mackenzie Mattern
Project title:
Affiliation: South Dakota State University
Duration: 2016-2018

Student: Patrick Wagner
Project title: Examining the effect of insecticide application timing.
Affiliation: Iowa State University
Duration: 2012-2013

George Washington Carver Student Advisor/Mentor

Student Mentored: Danaisa Green
Project title: Determining the presence of fitness costs associated with biotype-4 soybean aphids.
Affiliation: Iowa State University

Duration: Summer 2014

Tutoring
Introduction to Microbiology (Biology 239), Briar Cliff University
Tutor, Fall 2008. Three students.

Environmental Science (Environmental Science 110), Briar Cliff University
Tutor, Winter 2008. One student.

Awards and Scholarships:

2017	International IPM Award of Excellence: Soybean Entomology for North Central Soybean Research Project
2017	National Association of County Agricultural Agents Communication Award: Newsletter by a Team Regional Winner
2017	Curtis Stern Memorial Scholarship from National Sunflower Association, student: Brady Hauswedell
2016	Griffith Undergraduate Research Award, student: Mackenzie Mattern
2015	ISU Teaching Excellence Award
2014	ISU Department of Entomology, Jim Oleson Scholarship in Entomology
2014	1st Place Plant-Insect Ecosystems Session 19. 62nd Annual ESA National Meeting, Student Ten-Minute Presentation (TMP), Portland, OR
2014	Best in Section Award. Student Talk Competition at 1st Graduate and Professional Student Research Conference – ISU, Ames, IA
2014	2nd Place Plant-Insect Ecosystems Session II Ph.D. Competition at 69th Annual ESA NCB meeting, Student Ten-Minute Presentation (TMP), Des Moines, IA.
2013	ISU Department of Entomology, Jim Oleson Scholarship in Entomology
2013	2nd Place Plant-Insect Ecosystems Session II Ph.D. Competition at 68th Annual ESA NCB meeting, Student Ten-Minute Presentation (TMP), Lincoln, NE
2012	ISU Department of Entomology Alumni Scholarship

2012	2nd Place Plant-Insect Ecosystems Session II Ph.D. Competition at 67th Annual ESA NCB Meeting, Student Ten-Minute Presentation (TMP), Minneapolis, MN
2012	North Central Branch of the Entomological Society of America, 2012 Presidential Student Travel Scholarship, Rapid City, SD
2011	ISU Department of Entomology, Wayne A. Rowley Scholarship
2011	3rd Place Plant-Insect Ecosystems Session II M.S. 66th Annual ESA NCB Meeting, Student Ten-Minute Presentation (TMP), Minneapolis, MN
2009-2011	ISU Department of Entomology, Miller Graduate Fellowship
2008-2009	Briar Cliff University, BCU Grant Briar Cliff University, National Smart Grant
2008-2009	Briar Cliff University, Academic Scholarship Briar Cliff University, Leadership Scholarship
2007-2008	Briar Cliff University, Academic Award Scholarship Briar Cliff University, Leadership Scholarship Briar Cliff University, Academic Competitiveness Grant
2006-2007	Briar Cliff University, Academic Award Scholarship Briar Cliff University, Leadership Scholarship Briar Cliff University, BCU Grant

Service and Society:

Organizations

Agronomy, Horticulture, and Plant Science Department, South Dakota State University
- Department Search Committees
  - Lecturer Positions
- Extension Committees
  - DakotaFest Planning Committee 2016-present
  - Roadside Working Group 2015-present
  - Monarch and Pollinator Planning Summit 2017-present
- Department Committees
  - Greenhouse committee 2016-present
  - Seminar committee 2016-present

Entomology Graduate Student Organization, Iowa State University

Member, 2009-2015
Student Chair of the Social Committee 2009-2015
Student Chair of the Newsletter Committee 2013-2015
Treasurer, 2010-2011, 2012-2013
President, 2011-2012
Volunteer at:
Annual EGSO Film Festival 2009, 2010, 2011, 2012, 2013, 2014
Edwards Elementary School Science Night 2010, 2011
EGSO participation in VEISHEA 2010, 2011, 2012, 2013

Briar Cliff Science Club, Briar Cliff University
Member 2006-2009
Vice President 2008-2009

Professional Societies
Entomological Society of America
Member, 2008 to present

Roles as a faculty member:
North Central Branch Student Awards Committee Chair 2017 to present
North Central Branch Students Awards Committee 2016 to present
North Central Branch
2016: Ph.D. student presentation competition judge
2017: M.S. student poster competition judge

Roles as a graduate student:
North Central Branch Student Affairs Committee Representative 2012-2014
National Student Affairs Committee Representative 2012-2014
Treasurer of the North Central Branch Student Affairs Committee 2013-2014
North Central Branch Local Arrangements Student Representative 2013-2014
ESA and Foundations Awards Committee Member 2012-2013

National Association of County Agricultural Agents
Member, 2016 to present

Honor Societies
Gamma Sigma Delta: The Honor Society of Agriculture
Member Iowa State University Branch 2011 to 2015
Member South Dakota State University Branch 2015 to present

Community and Other
Pheasants Forever, Member 2008 to present

The National Audubon Society, Member 2008-2012

The Nature Conservancy, Member 2008-2012

The Sierra Club, Member 2008-2012

Reviewer for:

Biological Control
The Journal of Arthropod-Plant Interactions

Technical Skills

Designed and implemented a complete randomized design and also randomized complete block design for field research.

Computer: Microsoft Office (Word, Excel, Power Point, Access), Photoshop, SAS statistical software

Farm machinery operator, equipment repair and maintenance.

Training Programs/Short Courses

Hosted:
Winter IPM Short Course. 2016. Hosted by: Emmanuel Byamukama, Adam Varenhorst,

Pollinator Workshop Short Course. 2016. Hosted by: Adam Varenhorst and Amanda Bachmann. 11 attendees.

Participant:

Bridges: Building a Supportive Community (South Dakota State University). Title IX training. Completed 04/10/17.

SDSU Extension Fall Conference. Mini Workshop: Conflict management. Completed.

SDSU Extension Fall Conference. Mini Workshop: Working with public figures. Completed.

Faculty Inquiry Group (FIG). 2015-2016. What the best college teacher's do. Presented by South Dakota State University Center for the Enhancement of Teaching and Learning. Completed.

Active Shooter Training Class. Presented by Division of Technology and Security. 10/29/15.

Building Research Teams. Presented by Dianne Nagy. South Dakota State University. Completed 10/27/15.

Bridges: Building a Supportive Community (South Dakota State University). Title IX training. Completed 10/6/15.

Federal Required Training: Responsible Conduct of Research. Presented by Norm Braaten. South Dakota State University. Completed 9/24/15.

Prospecting for Funding Opportunities. Presented by Dianne Nagy. South Dakota State University. Completed 9/24/15.

Graduate Assistants: Employee vs. Student. Presented by Tracy Greene, Kinchel Doerner, and David Hanson. South Dakota State University. Completed 9/15/15.

Federal Requirements for Data Management Plans & Public Access. Presented by Jim Doolittle and Kristi Tornquist. South Dakota State University. Completed 9/15/15.

Research at SDSU Workshop for New Faculty. Presented by Kevin Kephart, Jim Doolittle, Dianne Nagy, Kay Scheibe, Michelle Mucciante, and Will Aylor.

Preventing Discrimination and Sexual Violence: Title IX, VAWA and Clery Act for Faculty and Staff. Iowa State University. Completed 8/5/15.

Unlawful Harassment Prevention for Higher Education Staff. Iowa State University. Completed 2/14/14.

Title IX Awareness and Violence Prevention for Higher Education Students. Iowa State University. Completed 2/14/14

Aphid Identification Program

Attended a five-day mentoring program presented by Dr. David Voegtlin from the University of Illinois at the University of Illinois.

NAME: Brandon Haag

EDUCATIONAL BACKGROUND:BS in Business Econ, BS in Agriculture from South Dakota State University

ADDRESS:
20449 Augusta Road
Pierre, SD 57501

WORK EXPERIENCE AS IT APPLIES TO THE ISSUE AT HAND:
18 years in the Ag industry ranging from retail, crop consultant, to manufacturing roles. Former certified crop advisor.

ANTICIPATED TESTIMONY:
The importance of aerial applications as it pertains to our row crops. Also the need for aerial application on small grains in wet years where ground application is not an option.

CODY CHRISTENSEN
Cody.Christensen@sdstate.edu
143 Wagner Hall Box 2275A Brookings, SD 57007
Ph: 605-688-4983

EDUCATION

- University of South Dakota (USD) Vermillion, SD May 2013
  - *Doctorate of Education; Educational Administration; Adult and Higher Education*

- South Dakota State University (SDSU) Brookings, SD December 2006
  - *Masters of Education; Curriculum and Instruction*

- South Dakota State University (SDSU) Brookings, SD May 2005
  - *Bachelor of Science in Education; Career and Technical Education*

AVIATION LICENSES AND CERTIFICATIONS

- FAA Airline Transport Pilot Certificate (AMEL)
  - Type Rating: Beechcraft 1900D
- Medical: Second Class- no restrictions
- FCC Restricted Radiotelephone Operator Permit
- FAA Gold Seal Instructor ratings
  - CFI, CFII, MEI, IGI

AVIATION EXPERIENCE

Assistant Professor/Program Coordinator -South Dakota State University Brookings, SD 01/09-Present

- Oversee Aviation Program including five full time staff and 15 part time staff
- Teach multiple aviation related courses in accordance with regulations
- Advise students within the aviation program
- Publish articles and conduct peer reviewed research
- Secure grants and funding to continue supporting aviation program mission
- Oversee Aviation Accreditation Board International specialized accreditation
- Coordinate, secure funding, and organize summer aviation ACE (Aerospace Career and Education) Camp for high school aged students

Captain- Great Lakes Airlines Cheyenne, WY 01/07- 12/08

- Act as Pilot in Command of a 19 seat Beechcraft 1900 airliner
- Ultimately responsible for the safe and efficient operation of the aircraft and crew
- Utilize Crew Resource Management techniques to create a positive cockpit environment
- Supervise fueling, baggage handling, deicing procedures to ensure compliance with company policies
- Effectively communicate with ground, flight and support staff to ensure a safe, on time flight

Ground Instructor- Great Lakes Airlines Cheyenne, WY 05/08-12/08

- Instruct captains/first officers in aircraft systems, emergency procedures, company policies and procedures
- Qualify former pilots who were rehired to the company
- Conducted emergency drills including evaluation, fire detection and prevention, and hijacking
- Advised pilots on proper procedures during emergency operations

PEER REVIEWED ARTICLES

Adjekum, D. K., Walala, M., Keller, J., Christensen, C., DeMik, R. J., Young, J. P., & Northam, G. (2016). An Analysis of the Effects of Demographic Variables and Perceptions on the Safety Reporting Behavior in Collegiate Flight Programs. International Journal of Aviation Sciences. http://commons.erau.edu/cgi/viewcontent.cgi?article=1134&context=ijaaa

Bjerke, Elizabeth; Smith, Guy; Smith, MaryJo; Christensen, Cody; Carney, Thomas; Craig, Paul; and Niemczyk, Mary (2016). Pilot Source Study 2015: US Regional Airline Pilot Hiring Background Characteristic Changes Consequent to Public Law 111-216 and the FAA First Officer Qualifications Rule. *Journal of Aviation Technology and Engineering*: Vol. 5: Iss. 2, Article 1. Available at: http://dx.doi.org/10.7771/2159-6670.1133

Smith, Guy; Bjerke, Elizabeth; Smith, MaryJo; Christensen, Cody; Carney, Thomas; Craig, Paul; and Niemczyk, Mary. (IN REVIEW) Pilot Source Study 2015: An Analysis of FAR Part 121 Pilots Hired after Public Law-111-216 – Their Backgrounds and Subsequent Successes in US Regional Airline Training and Operating Experience. *Journal of Aviation Technology and Engineering:* Vol. XX: Iss. XX, Article XX.

Smith, MaryJo; Smith, Guy; Bjerke, Elizabeth; Carney, Thomas; Christensen, Cody; Craig, Paul; and Niemczyk, Mary. (IN REVIEW). Pilot Source Study 2015: A Comparison of Performance at Part 121 Regional Airlines between Pilots Hired before the US Congress Passed Public Law-111-216 and Pilots Hired after the Law's Effective Date. *Journal of Aviation Technology and Engineering:* Vol. XX: Iss. XX, Article XX.

Adjekum, D. K., Keller, J., Walala, M., Young, J. P., Christensen, C., & DeMik, R. J. (2015). Cross-Sectional Assessment of Safety Culture Perceptions and Safety Behavior in Collegiate Aviation Programs in the United States. International Journal of Aviation, Aeronautics, and Aerospace, 2(4). http://dx.doi.org/10.15394/ijaaa.2015.1074

Christensen, C. & Card, K. A. (2014). *Specialized Aviation Flight Accreditation Under Public Law 111-216 Aviation Program Administrators' Perceptions*. Collegiate Aviation Review.32 (2).

Christensen, C. & Dunn, B. (2011) Fleet characteristics of collegiate aviation flight programs. *Collegiate Aviation Review,* 29 (2), 13-20

MAGAZINE ARTICLE (EDITOR REVIEWED)
Christensen, C. (2011) *The art of professionalism*. CFI to CFI. 2(1).

PRESENTATIONS
Christensen, C. (2016) *Pilot Source Study Updates and Aviation in South Dakota*. South Dakota Aeronautics Commission Meeting. Deadwood, SD.

Bjerke, Elizabeth; Smith, Guy; Smith, MaryJo; Christensen, Cody; Carney, Thomas; Craig, Paul; and Niemczyk, Mary (February 2016). Pilot Source Study 2015: US Regional Airline Pilot Hiring Background Characteristic Changes Consequent to Public Law 111-216 and the FAA First Officer Qualifications Rule. AABI Town hall Atlanta, GA.

Dow, A., Christensen, C., & Marshall, S. (2015). Reaching New Heights in Recruitment for Smaller Aviation Programs. University Aviation Association Conference in Snowbird, UT.

Christensen, C. & Leonard, A. (2014). Benefits of Early Alerts on Flight Training. University Aviation Association Conference in Daytona Beach, FL.

Christensen, C. (2014). Specialized Aviation Flight Accreditation Under Public Law 111-216 Aviation Program Administrators' Perceptions. University Aviation Association Conference in Daytona Beach, FL.

Christensen, C. (2014). FAA Airspace Review. Presented at the East River Aviation Symposium. Brookings, SD.

Christensen, C. & Leonard, A. (2013). *Integrating a Mobile Training Lab into an Aviation Curriculum.* Presentation at the International University Aviation Association Conference, San Juan, PR.

Christensen, C. (2013). *Influence of military service on student success in an aviation program.* Abstract presentation at the International University Aviation Association Conference, San Juan, PR.

Christensen, C. & Leonard, A. (2012). *Integrating Aviation Concepts into Curriculum.* Presentation at the SD STEM Initiative, Sioux Falls, SD.

Christensen, C. (2011). *Implications of Public Law 111-216 and outcomes based accreditation on specialized aviation accreditation.* Presentation at the International University Aviation Association Conference, Indianapolis, IN.

Christensen, C. (2011). *South Dakota Aviation Safety Initiative*. South Dakota Aeronautics Commission. Pierre, SD.

Christensen, C. and Dunn, B. (2011). *Fleet characteristics of collegiate aviation flight programs.* Presentation at the International University Aviation Association Conference. Indianapolis, IN.

Christensen, C. (2011). *Perfecting the preflight.* FAA national safety-stand down event. Brookings, SD.

Christensen, C., Hovland, W., Kelm, W., Hoogerhyde, S., Leonard, A., & Kwasniewski, G. (2011) *Setting Personal Minimums*. Federal Aviation Administration Safety Seminar. Brookings, SD.

Christensen, C. (2011). *Energizing PowerPoint's using Prezi's in the classroom and conference environments*. Faculty Showcase presented by the Teaching Learning Center. Brookings, SD

CONFERENCE PUBLISHED ABSTRACT (COMMITTEE CHAIR REVIEWED):

Christensen, C. & Leonard, A. (2015). Needs Based Assessment of Agricultural Pilots in the Upper Midwest. University Aviation Association Conference in Snowbird, UT.

Christensen, C. & Leonard, A. (2013). *Integrating a Mobile Training Lab into an Aviation Curriculum.* Conference proceedings at the International University Aviation Association Conference, San Juan, PR.

Christensen, C. (2013) *Influence of military service on student success in an aviation program.* Abstract conference proceedings at the International University Aviation Association Conference. San Juan, PR.

Christensen, C. (2011). *Implications of Public Law 111-216 and outcomes based accreditation on specialized aviation accreditation.* University Aviation Association Conference, Indianapolis, IN.

DISSERTATION

Christensen, C. (2013). *Aviation program administrators' perceptions of specialized aviation accreditation under public law 111-216*. (Doctoral dissertation), University of South Dakota, Vermillion, SD.

GRANTS:

Aerospace Career and Education Camp. $5,000. South Dakota Aeronautics Commission. 2016. (PI: C. Christensen)

SDSU Mobile Aviation Simulator. $75,000. South Dakota Aeronautics Commission. 2016. (PI: C. Christensen)

SDSU Mobile Aviation Simulator. $42,000. Brookings School District. 2016. (PI: C. Christensen)

Aerospace Career and Education Camp. $5,000. South Dakota Aeronautics Commission. 2015. (PI: C. Christensen)

Scholarly Travel Grant. $1,000. SDSU Office of Academic Affairs and Department of Consumer Sciences. 2013. (PI: C. Christensen)

Aerospace Career and Education Camp. $5,000. South Dakota Aeronautics Commission. 2014. (PI: K. Dalsted, Co-PI: C. Christensen)

Accreditation Self-Study Funding. $6,400. SDSU Office of Academic Affairs, 2012. (Co-PI: C. Christensen, Co-PI: A, Leonard, Co-PI: J. Boulware).

Increasing Aviation Activity in South Dakota. $2,500. South Dakota Space Grant Consortium. 2011-2012.

Assessment and development plan for aviation program accreditation. $5,400. SDSU Office of Academic Affairs, 2011 (PI: C. Christensen, Co-PI: A, Leonard).

Online course redevelopment for Advanced Flight Principles. $1,500. College of EHS Academic Excellence funds, 2011.

Capital utilization among aviation flight programs. $1,000. College of EHS Academic Excellence funds. 2011 (PI: C. Christensen, Co-PI: B. Dunn).

Female mentor in the SDSU Aviation program. $2,400 SDSU Foundation-Women in Giving, 2009-2011.

MEMBERSHIPS & AFFILIATIONS

- FAASTeam safety counselor (2010-current)
  - 2016 SD FAASTeam Rep of the Year
- SDSU Flying Jacks-Advisor (2012-current)
- University Aviation Association (2009-current)
- Alpha Eta Rho Aviation Fraternity-Advisor (2009-2012)
- Aircraft Owners and Pilots Association (2001-current)
- Brookings County Youth Mentor (2012-2016)
- South Dakota Pilots Association (2009-current)
- South Dakota Aviation Association (2014-current)
- Women in Aviation member (2011-current)

Michael J Bollweg 09/25/1973
South Dakota State University - Bachelor of Science in Agriculture
Graduated: December 1996
34 years farming experience -
SD Dept of Agriculture Commercial Applicator License holder for 30 years: #AP1607

Manager/Executive Director of Tumbleweed Lodge – overseeing all aspects
Judi Bollweg – owner (sole proprietor) of Tumbleweed Lodge

Tumbleweed Lodge has held a South Dakota Hunting Preserve permit since 1988. I began as a bird cleaner/guide.

NAME: Ryan Thompson

EDUCATIONAL BACKGROUND: Agronomy Degree from Fort hays State University
ADDRESS: 2921 Sussex Rd, Pierre, SD 57501

WORK EXPERIENCE AS IT APPLIES TO THE ISSUE AT HAND
2 yrs interning with Servi –Tech agronomy
3 years Crop quest out Dodge City scouting 20,000 ac/year of multiple crops
And 15 years with Helena, in multiple rolls, Retail salesman and now Branch Manager for western 2/3 of North and South Dakota

ANTICIPATED TESTIMONY (providing an expert perspective why aerial application of pesticides on sunflowers at bloom and fungicides at heading are necessary and cannot be applied by ground without extreme economic loss)
Sunflowers is the easy one, Simply they are just too tall and rank to drive a ground rig through it would completely destroy where the sprayer drove. Also the timing is so critical that there is no way it would be possible to get across all the acres in a timely manner. The economic impact of either one is critical for sunflower production

As far as the wheat and fungicide at heading, It follows the same impacts as the flowers by not being able to use aerial application. There tracks from the ground rig our probadly at a 90-95% loss, once the wheat is jointed and the stalk breaks it will not come back or stand back up. And once a again agriculture is about timing and the efficacy of a head treatment at flowering is even more precise, just not enough ground sprayers to do. The impact of not putting on a head treatment could result 5-35% decrease in yield depending on pressure

NAME: Terry Barber

EDUCATIONAL BACKGROUND: Agronomy Degree from South Dakota State University

WORK EXPERIENCE AS IT APPLIES TO THE ISSUE AT HAND
22 years in the family ag spraying business

ANTICIPATED TESTIMONY (providing an expert perspective why aerial application of pesticides on sunflowers at bloom and fungicides at heading are necessary and cannot be applied by ground without extreme economic loss)
He sprays the Bollweg farm properties. The towers either make spraying very dangerous or complicated. The airflow off the turbines disrupts the spray patterns off the aircraft, making the spray less effective.

28 September 2021

Michael Bollweg
Bollweg Farms
Tumbleweed Lodge
20210 322nd Ave.
Harrold, SD 57536

RE: RED SUNFLOWER SEED WEEVILS

Dear Michael Bollweg,

The red sunflower seed weevil is a native pest of sunflower in South Dakota. When left unmanaged, the red sunflower seed weevil is capable of infesting approximately 80% of the developing seeds in a sunflower head. Since 2016, populations of red sunflower seed weevils have been observed in South Dakota that are 10-100x over the economic threshold of 4-6 weevils per sunflower head. In addition, SDSU Extension entomologists have received reports of insecticide application failures for red sunflower seed weevils since 2017. These reports were for the pyrethroid class active ingredient lambda-cyhalothrin. Since 2017, research from South Dakota State University has concluded that there are populations of red sunflower seed weevils with reduced susceptibility to pyrethroid class insecticides. On-going research is aimed at determining the level of reduced susceptibility and compare the populations tested in South Dakota to those from neighboring states. Our observations of red sunflower seed weevils in several counties in South Dakota during 2021 indicate that very large populations are present within fields. We are continuing to test populations using laboratory assays.

At this time, we recommend that all sunflower fields be scouted, and insecticides be applied when the threshold for red sunflower seed weevils is exceeded. Due to the numerous field failures, we are recommending that lambda-cyhalothrin not be used for management of the red sunflower seed weevil. We also are recommending that fields are scouted 24-48 hours after insecticide application to determine if the treatment successfully reduced the red sunflower seed weevil populations. To prevent additional issues with labeled insecticide products we recommend tank mixing two insecticides with different modes of action (not including lambda-cyhalothrin) or using a product that is not from the pyrethroid insecticide class.

Sincerely,

Dr. Adam Varenhorst

Assistant Professor and Extension Field Crop Entomologist

South Dakota State University

syngenta

Michael Bollweg tumbleweed@venturecomm.net
The importance of aerial spraying to timely product applications

Michael:

Following up on our recent conversation, I've been involved in production agriculture and the crop input supply business, heavily weighted to agronomy for over 40 years. Here are my thoughts on the importance of timely applications using 3 local crop production examples and situations.

The first is control of what can be a devastating disease pathogen in central South Dakota. Fusarium graminearum is the fungal pathogen that causes Head Blight in wheat. As recent as 2019 in South Dakota, Fusarium head blight (FHB) can and has reduced wheat yields up to 50%. Additionally, FHB typically produces a mycotoxin, deoxynivalenol (DON). DON is toxic to mammals at very low levels. If DON levels are over the acceptable threshold, the harvested wheat will be rejected and disposed of as unsaleable at the elevator. It's important to understand the threat from an FHB infection and not take it lightly.

With reference to managing FHB in Wheat, there are fungicides available to help control the pathogen. We know from field research that the spores produced by the pathogen enter the wheat plant through the flowers. The critical timing to make a fungicide application is Feekes growth stage 10.5.1. That is when the wheat begins to flower. In a practical sense the fungicide application window is generally around 3 days. That may seem like an ample amount of time to make an application to control FHB. Unfortunately knowing the plant physiology of winter wheat, fields generally all flowers at the same time over a very large geography. It's very common for 10's of thousands of acres to require an FHB fungicide application at the same time over a narrow geography in central SD.

Syngenta produces and markets a fungicide, Miravis Ace. The active ingredients in Miravis Ace are well positioned to manage FHB. We know from experience that aerial application is well suited for the application of Miravis Ace. Aerial application can accurately and efficiently cover thousands of acres in a narrow time window. Anything that can cause an application delay can and will cause a yield and quality loss from the pathogen. There are factors like wind and rain that are out of our control and put pressure on the application window. That's why it's even more important to manage things that are in our control like the placement of wind turbines.

The disease threat in central SD isn't limited to wheat. Plant disease management has grown exponentially as disease threats in South Dakota have increased and as the performance of fungicides like Miravis Ace and Miravis Neo has grown, so has the use of fungicides. Specific to corn, tassel applications of fungicides like Miravis Neo and Trivapro have clearly demonstrated yield and quality improvements. One of the key application timings on corn is the growth stage VT – R1, tassel and silk emergence. On an average year, the corn in central SD at VT-R1 is from 6 to 10 feet tall. Due to crop clearance issues that make it challenging if not impossible for a ground rig sprayer to make the timely application. Once again making aerial the primary application method of choice.

The pest threat isn't isolated to plant pathogens, it unfortunately extends to insect pests also. A specific example is the management of seed weevils and head moths in Sunflowers. Similar to the examples above, proper application timing is important for management of these two insects in sunflowers. The threat is the early flowering stage of the sunflowers. Similar to corn, aerial application is preferred over ground application due to the height and physical spacing of the target crop.

I've addressed key pest threats in three important crops that cover a high percentage of the crop acres in central South Dakota. Knowing the bigger picture, there are crop protection products and product labels that support aerial application on virtually all crops, including pastures in South Dakota.

I trust you will agree that we have an obligation to understand and mitigate the threats to South Dakota producers that can negatively impact our ability to produce a safe, wholesome and bountiful harvest.

Wally West
Agronomy Services Representative
Wally.West@syngenta.com

syngenta *Bringing plant potential to life*

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

IN THE MATTER OF THE APPLICATION BY NORTH BEND WIND PROJECT, LLC FOR A PERMIT TO CONSTRUCT AND OPERATE THE NORTH BEND WIND PROJECT IN HYDE COUNTY AND HUGHES COUNTY, SOUTH DAKOTA	* * * * * * * *	**MICHAEL BOLLWEG'S SUPPLEMENTAL RESPONSE TO STAFF'S SECOND SET OF DATA REQUESTS TO MR. MICHAEL BOLLWEG** **EL21-018**

Below, please find Michael Bollweg's Response to Staff's Second Set of Data Requests to Mr. Bollweg, individually, and on behalf of Bollweg Family, LLLP.

2-1) Refer to Mr. Bollweg's response to staff data request 1(a). Mr. Bollweg states that "tower 6 is east of the Lodge and will interfere with its operation both on the basis of shadow flicker and noise, driving game away."

(a) Is there a specific amount of shadow flicker (ie – hours per year) where exceedances will interfere with the Lodge's operation? Please explain and provide support for the assertion.

(b) What level of audible noise will interfere with the Lodge's operation? Please explain and provide support for the assertion.

Response: Our determination that tower #6 poses a threat to the operation is based on the following:

- Michael Bollweg is not aware of any studies that exist concerning tolerable amounts of either shadow flicker or audible noise operation to wildlife. Studies might be successful concerning how humans are affected but would not be transferable to the effects upon wildlife; wildlife have senses and abilities well beyond what humans possess. My objections are based upon real life, in the testimony of Curt Korzan and recommendations of various wildlife governmental organizations tasked with protecting our natural resources. Mr. Korzan's observations of the effect of the towers on his lodge operation are more fully discussed below.
- Michael Bollweg has been involved in the hunting lodge business for decades. He tries to pay attention to matters that might affect wild game. He spoke with Curt Korzan about his adverse experiences with wind turbines and looked at various studies, which are attached, including recommendations of the federal government, showing concern for the effects of turbines on prairie chickens and sharp tail grouse.

- Wind Energy and Wildlife Resource Management in Iowa: Avoiding Potential Conflicts (attached as Exhibit A). Relevant excerpts from this study are as follows:
  - An emerging concern for birds is wind turbines placed within or very near large expanses of grassland. In some western states, ground-nesting lesser prairie-chickens have been found to abandon their nesting grounds when wind turbines were erected and operated nearby. It is quite likely that Iowa's greater prairie-chickens, a state endangered species requiring large expanses of unbroken habitat, would exhibit similar behavior. Many other ground-nesting grassland birds have yet to be studied, but some of these species already are in steep decline nationwide and cannot risk another factor that might potentially threaten their survival. A leading cause of much bird decline is related to fragmentation, or "parcelization", of their remaining habitat, breaking it into parcels too small to meet certain birds' survival or reproductive needs. It has been suggested that wind turbines placed in the middle of a large grassland may similarly fragment habitat and greatly reduce its value. This is a question in need of much additional research.
  - Avoid placement of turbines in or near areas where highly "area-sensitive" wildlife species, such as prairie-chickens, are known. Area-sensitive species require expansive, unfragmented habitat. For prairie-chickens in particular, a separation distance of at least 5 miles from all known leks (breeding grounds) is strongly recommended.
- The Siting Guidelines for Wind Power Projects in South Dakota (attached as Exhibit B)
- The Prairie Grouse Management Plan for South Dakota 2017-2021 (attached as Exhibit C). Relevant excerpts from this study are as follows:
  - Avoid activities near (~ 2 mi) lek sites that could interrupt lekking and nesting activity from March 1–July 30. If disruptive activities cannot be avoided, limit disruptive activities to three hours after sunrise to one hour before sunset. Disruptive activities could include but are not limited to well drilling and operation (water or energy development), burying pipeline or other utilities, building roads, vehicle traffic, direct disruption by human presence, wind tower construction and operation, or low flights by air craft or drones. (p. 17)
  - Avoid development (e.g., roads, power lines, structures, energy development) in grasslands within occupied range, especially within 1 mi of lek sites. Where development occurs within occupied range, leks within 5 mi of development should be monitored indefinitely. (p. 17)

  - The impacts of wind energy on greater prairie-chickens are generally equivocal and the impacts on sharp-tailed grouse have not been studied. Greater prairie-chicken lek persistence was ~0.5 for leks <0.62 mi from a turbine, ~0.9 for leks 1.86 mi from a turbine, and >0.95 for leks ≥3.73 mi from a turbine during the 3-year post-construction period for a study in Kansas (Winder et al. 2015a). The rate of lek abandonment was 3× higher for leks <4.97 mi from a turbine compared to leks ≥4.97 mi from a turbine (22% vs 8%) supporting the USFWS's 4.97-mi buffer zone for wind energy development (Manville 2004). The increased rate of lek abandonment within 4.97 mi of wind turbines is concerning because female prairie-chicken activity centers are nearly always centered within 3.1 mi of active leks (Winder et al. 2015b). Although previous research found female greater prairie-chickens avoid turbines in their space use and movements, turbines did not negatively affect nest-site selection, nest survival, or adult survival (McNew et al. 2014, Winder et al. 2014a, Winder et al. 2014b). An unpublished study from a 36-turbine wind farm in an unfragmented Nebraska landscape found no influence of wind energy development on nesting, brood-rearing, or special ecology of greater prairie-chickens (Harrison 2015). (pp. 18-19)
  - There is also evidence that other forms of development within occupied habitat could have a negative impact on prairie grouse. Greater prairie-chickens were found to avoid power lines by 330 ft in Oklahoma (Pruett et al. 2009). A habitat-based greater prairie-chicken lek site model revealed a weak avoidance effect of roads at a 3.1-mi scale in Kansas (Gregory et al. 2011). A similar modeling effort in Minnesota suggests road density at a 2-mile scale was a negative predictor of lek presence (USFWS HAPET 2010). Significantly more roads occurred within 1,640 and 3,280 ft of inactive sharp-tailed grouse leks when compared to active leks in Minnesota (Hanowski et al. 2000). (p. 19)
- All three of the above describe displacement distances of nesting birds as well as recommendations.
- The testimony of Curt Korzan of Kimball, South Dakota. He experienced firsthand the negative impact on his property when wind turbines were placed close to his land. He was forced to sell when the pheasants/upland game disappeared.
- When Applicant's representatives were pressed at a Hughes County meeting what the purpose of the indemnity clause would be if no harm is claimed, Engie representatives Casey Willis and Brett Koeneke both conceded that noise and shadow flicker do indeed pose a negative harmful effect. This can be found in the enclosed transcript of the meeting held on

June 7, 2021 (Exhibit D). After being pressed for the truth by Commissioner Brown, Brett Koenecke and Casey Willis ultimately conceded in the public meeting there are indeed negative effects.

- There are lek locations on and near our property. They are discussed in the North Bend Wind Project Field Studies Summary 2016 – 2020 (Final Draft) pages 18-21 (attached as Exhibit E). Lek Location 21 is on Bollweg property. I believe it to be active. Lek Location 14 is only a 1/2 mile from our property that is in preserve. Towers 6, 8, and 10 appear to be within a 1/2 mile from it. Tower 9 is right on top of it, tower 15 a 1/4 mile from it. Lek Location 15 is within a few hundred feet of our farm property located in Section 16/21 (we hunt grouse on it). Tower 27 is located right on top of it.
- Manville, A. M., II. 2004. Prairie grouse leks and wind turbines: U.S. Fish and Wildlife Service justification for a 5-mi buffer from leks; additional grassland songbird recommendations. Division of Migratory Bird Management, USFWS, Arlington, VA, peer-reviewed briefing paper. 17 pp. This briefing paper is attached as Exhibit F. This briefing paper discusses notes the following:
    - Given continuing uncertainties about structural impacts on prairie grouse, especially the lack of data regarding impacts from wind facilities, and the clearly declining trends in prairie grouse populations, we urge a precautionary approach by industry and recommend a 5-mile buffer where feasible.
    - While we acknowledge that much research continues on prairie grouse and the impacts of tall structures, including wind turbines – and thus much of the data have yet to be peer reviewed and published – several studies and their recommendations have been published and are used as the basis for our 5-mile recommendation. Most compelling was the recommendation by Connelly et al. (2000:978) calling for protection of breeding habitats within 11.2 mi (18 km) of the leks of migratory populations of Sage-grouse (see discussion beyond). See also Giesen and Connelly (1993) beyond for a discussion of management guidelines for Columbian Sharp-tailed grouse.
    - We believe it is important to clarify that avoidance of vertical structures by grassland and sage-steppe-obligate wildlife is not a new issue, and the Service's recommendations are not merely reactive to current recommendations promoting wind power development nationwide. Concerns were brought to the Division of Migratory Bird Management as early as 2000 regarding the possible impacts of wind turbines on prairie grouse, including noise, habitat disruption, disturbance, fragmentation, and increased predator access (R. Reynolds and N. Niemuth, FWS Habitat and Population

Evaluation Team, Bismark, ND 2000 pers. comm.). Much research has also been conducted on the impacts of high-tension power transmission and electric distribution lines on prairie grouse, providing a detailed body of literature on a related structural issue (e.g., Connelly et al. 2000, Braun et al. 2002, Hagen 2003, Wolfe et al. 2003a and 2003b, Pitman 2003, Hagen et al. 2004, Patten et al. 2004, and Connelly et al. 2004).

- Because range wide, the majority of remaining LPCH populations are fragmented and isolated into "islands" of unfragmented, open prairie, thus we assert that a 5-mile buffer from a lek is recommended to protect the wind power industry from later determinations that construction activities could significantly impact important LPCH populations and habitat corridors needed for future recovery.
- Hagen et al. (2004:79), in "guidelines for managing lesser prairie-chicken populations and their habitats," recommended that wind turbines and other tall vertical structures be constructed >1.25 mi (2 km) from known or potentially occupied LPCH habitat, at a minimum. This recommended area represents a buffer beyond already existing LPCH home ranges (Figure 2). If wind facilities must be placed in known LPCH habitats, Hagen et al. (2004) suggested they be positioned along prairie edge or clustered in sites with other disturbances.
- Sage-Grouse. they recommended protecting sagebrush and herbaceous understory within 2 mi (3.2 km) of all occupied leks. For non-migratory populations, leks should be considered the center of year-round activity and treated as the focal points for management activities. For non-migratory populations where sagebrush is not uniformly distributed, suitable habitats should all be protected out to 3.1 mi (5 km) from all occupied leks.
- C. Braun (2004 pers. comm.) Wind generators, he indicated, were quite tall and could be seen and avoided by Sage-grouse for long distances. Noise (especially humming), motion, and height all may negatively affect Sage-grouse, although he indicated we still don't know the specific effects. Braun therefore felt that FWS could defend our 5-mile recommendation even though definitive data showing impacts are still being collected.
- Service's Recommendation for 5-Mile Buffer from Leks. The intent of the Service's recommendation for a 5-mile zone of protection is to buffer against increased mortality (both human-caused and natural), against habitat degradation and fragmentation, and against disturbance. In considering our recommendation, FWS recognizes major declines in populations and habitats of prairie grouse. All

species of prairie grouse are in varying stages of decline – some populations declining precipitously -- requiring a major focus on direct human impacts, disturbance from structures, and fragmentation of habitats. While wind plants are new additions to prairie grouse habitats in the Midwest and West, cumulative impacts from human development and exploitation must be assessed with great care and considerable detail. To reverse these declines will take significant commitment from industry, the Service, and other stakeholders. We view the voluntary nature of our guidance and specifically our 5-mile recommendation as a reasonable effort needed to conserve these important resources.

- In addition, the PUC's own witness, Tom Kirschenmann, testified on May 10, 2019 (a copy of which is enclosed as Exhibit G) concerning the effect of the wind turbines upon grouse and prairie chicken. Mr. Kirschenmann is the Director for the state Wildlife Division in the South Dakota Game, Fisher, and Parks Department. His directive was to study, evaluate, and assist in the management of all wildlife and associated habitats. When he testified, he was the Deputy Director of Wildlife Division and Chief of the Terrestrial Resources Section.
    - Mr. Kirschenmann provided testimony as to potential impact to wildlife as the result of the construction of a wind project. (pp.6-7). He testified that there was direct and indirect impact upon birds and bats. He referred to a study, Shaffer, J.A., and D.A. Buhl. 2016. Effects of wind-energy facilities on breeding grassland bird distributions. Conservation Biology 30:50-71 that showed that 7 of 9 species of grassland birds had reduced densities around wind turbines over time.
    - He noted that there was research into the effects of wind energy on habitat avoidance which has shown that some species will not use grassland or wetland habitat within a certain distance of a wind turbine (p. 8 citing Loesch, C.R. J.A. Walker, R.E. Reynolds, J.S. Gleason, N.D. Niemuth, S.E. Stephens, and M.A. Erickson. 2013. Effect of wind energy development on breeding duck densities in the Prairie Pothole Region. The Journal of Wildlife Management 77:587-598, and Shaffer and Buhl 2016).
    - Mr. Kirschenmann recommended that there was a need to monitor confirmed leks less than 1 mile from proposed turbines (p.20). This is certainly less restrictive than the 5 miles recommended by the A.M. Manville briefing paper discussed above, but regardless turbine 6 is within the 1 mile referenced by Mr. Kirschenmann.

Supplemental Response: **Curtis Korzan has passed away. His son, Corbin Korzan, who worked closely with his father, will be substituted for his father. His observations and**

testimony will be essentially the same. The Korzan attempts to rule out predators in the reduction of bird and wildlife numbers came with working with Mr. Dart (referenced below) and communicating with him concerning his findings while using their land. The Korzan property was included in the study of predator numbers.

2-2) Referring to Mr. Bollweg's response to question 1-2(b), please provide:

(a) Citations to the predator study referenced in the response and provide a copy of the study.
(b) The "evidence showing the proximity of wind towers to Tumbleweed Lodge will cause sharp-tail grouse to stop using their land for habitat."
(c) The evidence that "will be offered that shows that both wild and planted pheasants will leave the areas adjacent to the turbines."
(d) The studies that "have discovered adverse effects of turbines upon sharp-tail nesting."
(e) The "evidence that the presence of turbines close to hunting facilities drive away both wild and released pheasants."

Response: Please see the response to request 2-1.

Supplemental Response: Please see the attached article (Exhibit J): Dart, Marlin M., "Spatial and Temporal Patterns of Sympatric Bobcats (Lynx Rufus) and Coyotes (Canis Latrans) in an Agricultural Landscape" (2021). Electronic Theses and Dissertations. 5700.

Marlin Dart completed the above predator study, for the completion of his dissertation, in Charles Mix and Brule Counties, South Dakota, in 2019 and 2020. His study covered land owned by the Korzan family. He studied bobcats, coyotes, and racoons. He notes that there were low numbers of predators on Korzan land near the turbines when compared to the rest of Charles Mix and Brule Counties.

2-3) Refer to Page 8 of 84 of Mr. Bollweg's response to staff data request 1. Mr. Bollweg states that "in order to at least be able to utilize an aerial applicator in an east/west flight patten on both quarters, proposed locations 8, 9, 14, and 15 need to be removed from consideration. Once these four locations would be removed, locations 21 and 22 would not have an impact." If only turbines 14 and 15 were removed, would that provide a safe east/west flight patten on SW ¼ Section 11-111-74 and a safe north/south flight patten on NE ¼ Section 10-111-74? Please explain.

Response: Please see Cody Christensen's expert report regarding concerns with regard to proposed towers 8, 9, 14, 15, 20-22. His report was provided after the initial assessment PUC is referencing on page 8 of 84. There is still a threat with a north/south pattern.

If north-south spraying patterns are blocked by neighboring turbines applicators will be forced to fly east-west. There are commercial bee keepers in the area who like to place their hives by sun flower fields. Applicators try to spray later in the day when the bees have returned to their hives so they are not killed. Flying east-west later in the day will cause the pilots to be looking into the sunset while flying.

Crop dusting is done close to the ground and flying looking into the sunset increases the chance of having a plane crash. The same goes for morning spraying when the bees are less active; flying into the sunrise is a concern as well.

Removing towers 14 and 15 would greatly reduce the dangers of an east/west flight pattern on the SW 1/4 section 11. Removing towers 14 and 15 will not eliminate the dangers to apply products in a north/south pattern on section 10. Tower 21 wouldn't affect an east/west application however it still poses a serious threat in a north/south application eliminating the ability to spray north/south.

I anticipate Tower 20 would be a threat with regard to being in the way of the turning radius.

These fields need to be sprayed in either direction or it poses a hardship. Terry Barber will testify that ag pilots still need to make a "clean up" pass on all edges of the field as previously mentioned.

In addition, Michael Bollweg belongs to the South Dakota Aerial Applicators. Enclosed is a study indicating that the safe distance form turbines to spray is 9,585 feet or 1.82 miles. (See Exhibit H).

2-4) Refer to Pages 19 through 21 of Mr. Bollweg's response to staff data request 1, which is a letter from Mr. Cody Christensen to Mr. James Malters, in order to accommodate a safe turn radius at the end of a field for an agricultural application aircraft, what is Mr. Christensen recommending as an appropriate setback for a wind turbine from the property line to safely spray that field? Please explain and provide supporting calculations.

Response: See attached letter report from Cody Christensen (Exhibit I).

Dated this 28th day of January, 2022.

/s James E. Malters
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2021

Spatial and Temporal Patterns of Sympatric Bobcats *(Lynx Rufus)* and Coyotes *(Canis Latrans)* in an Agricultural Landscape

Marlin M. Dart
South Dakota State University

SPATIAL AND TEMPORAL PATTERNS OF SYMPATRIC BOBCATS (*LYNX RUFUS*) AND COYOTES (*CANIS LATRANS*) IN AN AGRICULTURAL LANDSCAPE

BY

MARLIN M. DART

A thesis submitted in partial fulfillment of the requirements for the

Master of Science

Major in Wildlife and Fisheries Science

Specialization in Wildlife Sciences

South Dakota State University

2021

THESIS ACCEPTANCE PAGE

Marlin M. Dart

This thesis is approved as a creditable and independent investigation by a candidate for the master's degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Robert C. Lonsinger
Advisor Date

Michele R. Dudash
Department Head Date

Nicole Lounsbery, PhD
Director, Graduate School Date

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ABSTRACT

SPATIAL AND TEMPORAL PATTERNS OF SYMPATRIC BOBCATS (*LYNX RUFUS*) AND COYOTES (*CANIS LATRANS*) IN AN AGRICULTURAL LANDSCAPE

MARLIN M. DART

2021

Bobcat (*Lynx rufus*) populations experienced declines in the Midwest during the 20th century due to land conversion for agriculture and overexploitation and were practically nonexistent in areas by the 1970-80s. Populations have been recovering following changes in land-use practices and habitat improvement. Eastern South Dakota was closed to bobcat harvest in 1977 but reopened in 2012 to select counties. Bobcats are elusive, have large home ranges, and occur at low densities, making monitoring their populations difficult. Camera trapping is an effective tool for monitoring elusive carnivores but can be burdened by low detection rates. Researchers often employ attractants to increase detection, but attractants can unequally influence detection of species among different trophic levels. We ran a pilot season in 2019 to evaluate the efficacy of an olfactory lure, a non-consumable attractant, as a means of increasing detection of bobcats. We expanded our species of interest to include additional species (coyote [*Canis latrans*], raccoon [*Procyon lotor*], and eastern cottontail [*Sylvilagus floridanus*]) that represented a range of foraging guilds. We evaluated the influence of the lure at three temporal scales (i.e., daily probability of detection, sequences per detection, and triggers per sequence). The influence of the lure varied between the two most-carnivorous species, bobcat and coyote. The lure positively influenced detection of coyote and raccoon, an intermediate omnivore, and negatively influenced detection of bobcat and eastern cottontail, an herbivorous prey. Bobcats are of management interest in South Dakota that are potentially vulnerable to land conversion and may be influenced by coyotes. We used occupancy modeling to evaluate the influences of landscape features on space use of bobcats and coyotes and generated activity curves to quantify temporal overlap between species using remote camera data collected in the summers of 2019 and 2020. Coyote space use was positively associated with slope, small-scale percent agriculture, and edge density. Bobcat space use was limited and positively associated with coyote activity, distance to roads, and large-scale percent woodland/shrubland. Our results indicate that bobcats are using smaller, less-disturbed woodland/shrubland patches, which are associated with higher coyote activity levels. Bobcat and coyote temporal activity had high overlap.

CHAPTER 1: THE IMPACT OF SCENT LURES ON DETECTION IS NOT EQUITABLE AMONG SYMPATRIC SPECIES

Abstract

Camera trapping is an effective tool for cost-effective monitoring of rare and elusive species over large temporal and spatial scales and is becoming an increasingly popular method for investigating wildlife communities or species across trophic levels. Camera trapping research targeting rare and elusive species can still be hampered by low detection rates. Consequently, researchers often employ attractants in an effort to increase detection without accounting for how attractants may differentially influence detection of species across trophic levels. Therefore, we evaluated the influence of a non-species-specific olfactory lure (i.e., a non-consumable attractant; sardines) and sampling design on detection of four species (i.e., bobcat [*Lynx rufus*], coyote [*Canis latrans*], raccoon [*Procyon lotor*], and eastern cottontail [*Sylvilagus floridanus*]) that represented a range of foraging guilds in an agricultural landscape in southcentral South Dakota. We evaluated the influence of the lure at three temporal scales of detection (i.e., daily probability of detection, independent sequences per detection, and triggers per sequence). The influence of the lure on detection varied among trophic levels, including between the two most carnivorous species. The lure generally positively influenced detection of coyotes and negatively influenced detection of bobcats. The lure also generally positively influenced detection of raccoon, an intermediate omnivore, and negatively influenced detection of eastern cottontail, an herbivorous prey. We also demonstrated that the influence of the lure can vary across temporal scales.

Introduction

Early efforts to use camera traps for mammal research largely centered on documenting the presence and distribution of rare and elusive carnivores (Kucera and Barrett 1993, Zielinski and Kucera 1995). Advancements in analytical techniques employing detection data expanded the role of camera trapping, which has been used to evaluate patterns of occurrence (MacKenzie et al. 2002, 2018), quantify patterns of reproduction (Fisher et al. 2014), estimate abundance with (Karanth 1995, Heilbrun et al. 2006, Rich et al. 2019) and without (Moeller et al. 2018) individual identification, and evaluate temporal activity patterns (Ridout and Linkie 2009, Wang et al. 2015). Recent advancements in approaches for jointly analyzing data from multiple species (Richmond et al. 2010, Rota et al. 2016) and the ability to non-invasively monitor a wide range of species over large spatial and temporal scales at reduced costs compared to traditional monitoring methods (Lesmeister et al. 2015) has made camera trapping an effective tool for evaluating communities or species across trophic levels.

One challenge associated with camera trapping, particularly with rare and elusive species, is obtaining a sufficient number of detections; the accuracy and precision of estimates from occupancy and capture-recapture methods require a sufficient number of detections (White et al. 1982, MacKenzie et al. 2002). The accuracy of occupancy estimates is influenced by the number of detections (MacKenzie et al. 2002) and capture-recapture methods require a sufficient sample size (White et al. 1982). Studies targeting species that are rare or occur in low densities often employ baits (i.e., a consumable attractant) or lures (i.e., a non-consumable attractant) to increase their probability of detection (p; Burton et al. 2015). Some capture-recapture methods also require recaptures of some known individuals (Karanth 1995, du Preez et al. 2014, Braczkowski et al. 2016). Attractants can entice the animal to remain in front of the camera longer and increase the potential for identifying individuals through unique physical features (e.g., pelage patterns; du Preez et al. 2014) or applied marks (e.g., ear tags; Jordan et al. 2011). Commonly used carnivore attractants include canned fish (Cove et al. 2013, Lesmeister et al. 2015, Rocha et al. 2016), carcasses (du Preez et al. 2014, Robinson et al. 2017), predator gland or musk scent lures (Holinda et al. 2020), and fatty acid tablets (Lesmeister et al. 2015). Studies evaluating the effect of attractants on carnivore detection have yielded mixed results, with some finding positive effects (e.g., Thorn et al. 2009, du Preez et al. 2014, Mills et al. 2019), whereas others found no effect (Braczkowski et al. 2016, Rocha et al. 2016). Studies evaluating the influence of attractants on the detection of species within and among different trophic levels are limited. For example, olfactory attractants specific to carnivores (e.g., scent lures) increased detection of some carnivores without impacting prey detection (Holinda et al. 2020). Conversely, a more general olfactory attractant (e.g., sardines and egg mixture) did not increase carnivore detections, but decreased detection of prey (Rocha et al. 2016). The influence of olfactory attractants may change over time as well (Mills et al. 2019).

The influence of an attractant in an agricultural landscape has not been formally assessed and may differ from other systems due to differences in human disturbance and pressure from harvest. We evaluated the influence of sardines, a commonly used non-species-specific attractant, as a non-consumable olfactory attractant (i.e., a lure) on the detection of four sympatric mammals including bobcat (*Lynx rufus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), and eastern cottontail (*Sylvilagus floridanus*) in an agricultural landscape. We selected species that represented a range of foraging guilds in southcentral South Dakota. Bobcats are strictly carnivorous (Nomsen 1982, Anderson and Lovallo 2003) and a species of management interest due to their value as a furbearer. Coyotes are more omnivorous (Kamler et al. 2002, Cepek 2004), are potentially dominant to bobcats (Henke and Bryant 1999, Wilson et al. 2010), and are often managed through lethal control (Knowlton et al. 1999). Raccoons are mesocarnivores and intermediate omnivores with broad and opportunistic diets (Greenwood 1982). Eastern cottontails are herbivorous (Chapman and Litvaitis 2003) and are important prey for bobcats (Nomsen 1982, Rolley and Warde 1985) and coyotes (Kamler et al. 2002, Cepek 2004).

Detection data from camera trapping can be used at multiple scales. For instance, studies have used the number of independent photos of a prey species as an index of prey availability (Díaz-Ruiz et al. 2016, Santos et al. 2019), however, camera trapping data could be used at other temporal scales, such as daily (e.g., days with detection per days surveyed). The influence of an attractant could potentially vary across scales. For example, an attractant may entice an animal to stay in front of a camera longer, increasing the number of photos captured within a 24-hour period, without influencing detection at a daily level. Understanding whether or not the influence of an attractant varies across different temporal scales would be an important step towards understanding how to properly apply or collect camera trapping detection data, particularly for studies using cameras to simultaneously survey predators and their prey.

We quantified the rates of camera-based detections using three approaches: (i) daily p given an area is used; (ii) number of independent photo sequences per daily detection (hereafter, sequences), and (iii) number of triggers per sequence (hereafter, triggers). Fidino et al. (2020) found that attractants can decrease daily *p* and the number of triggers of eastern cottontail, so we predicted that the attractant would decrease eastern cottontail daily *p*, sequences, and triggers. Attractants have been shown to positively influence detection of carnivores at multiple scales (Holinda et al. 2020, Fidino et al. 2020), so we predicted that the attractant would increase daily *p*, sequences, and triggers for bobcat, coyote, and raccoon.

Methods

Study Area

The study area was located along the Missouri River in Charles Mix and Brule counties in southcentral South Dakota. The study area was ~4,275 km^2 and was bound by the borders of Charles Mix and Brule counties and by Interstate 90 to the north. The majority of the area was dominated by flat, privately-owned rangelands used for domestic cattle (*Bos taurus*) grazing and croplands (primarily corn [*Zea mays*] and soybean [*Glycine max*]) interspersed with woodland shelterbelts. Conversely, the western extent of the study area along the river was characterized by rugged drainages that had been impacted by eastern red cedar (*Juniperus virginiana*) encroachment. Dominant plant species included smooth bromegrass (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), big bluestem (*Andropogon gerardii*), porcupine grass (*Hesperostipa spartea*), eastern red cedar, and green ash (*Fraxinus pennsylvanica*). The study area experienced cold winters and moderate summers with the coldest month being January (average = -

6.5°C) and the warmest month being July (average = 23.8°C). Average monthly precipitation, defined as the liquid equivalent of precipitation not including snowfall (Arguez et al. 2012), ranged from 12.7 mm (December) to 98.8 mm (June). Average annual precipitation and snowfall of 609 mm and 1054 mm, respectively (National Oceanic and Atmospheric Administration [NOAA] 2020).

Camera Trapping Design

Our sampling design was intended for evaluating occupancy of bobcats. We divided our study area into 25 km^2 sites (5 km x 5 km), which approximated the home range size of female bobcats in South Dakota (Mosby 2011). We randomly selected 60 sites for surveying, excluding sites where land-access permissions could not be obtained. Single cameras within a site can fail to produce reliable assessments of occupancy and spatial replication within sites has been recommended (O'Connor et al. 2017, Kolowski et al. 2021). We used three cameras (hereafter, stations) to survey each site, which ensured that we surveyed a range of conditions within each site. We set stations ≥1.2 km from one another (both within and among sites), which represented the approximate home range diameter of eastern spotted skunks (*Spilogale putorius*) reported in the Midwest (Lesmeister et al. 2015). Eastern spotted skunks were of management interest in South Dakota and were a secondary target species of our initial survey efforts. We developed the sampling design to evaluate patterns of occupancy of species with larger home ranges (e.g., bobcats, coyote) at the site level and smaller home ranges (e.g., eastern spotted skunk, eastern cottontail) at the station level. We surveyed selected sites during a single summer season from May to September 2019. Each station within a site was surveyed concurrently.

We set stations near habitat features frequented by carnivores (e.g., edge habitat, fence lines). We set all stations within a site with one of three passive infrared game camera models (Browning model BTC-6HDP, Bushnell Trophy Cam No Glow, or Moultrie model M-880), keeping models consistent within a site. We set cameras ~1 m high with a slight downward angle. We trimmed vegetation within 4 meters in front of each camera to increase species detectability, maximize visibility of smaller species, and minimize false triggers (Si et al. 2014, Moll et al. 2020). We hung a quarter of an aluminum pie tin ~1 m high and ~4 m in front of each camera as a visual lure. Within each site, we randomly assigned one of three olfactory lure treatments to each station without replacement. Treatments included (i) an olfactory lure, (ii) no olfactory lure, or (iii) an olfactory lure only during the latter half of the survey. For treatments including an olfactory lure, we used 3.75 ounces of sardines in soybean oil enclosed in a perforated polyvinyl chloride pipe (5” length x 2” diameter) to prevent consumption and secured to the ground with a rebar stake ~4 m in front of the camera. We set cameras to operate 24 hours a day and capture 3 photos per trigger with a one-minute delay between triggers. Stations were set for ~28 nights. We checked cameras after ~14 nights to replace memory cards and batteries (if necessary) and replace or add attractants for sites receiving an attractant during the entire survey or the latter half of the survey, respectively.

Data Analysis

To characterize how an olfactory lure influenced the detection of sympatric species with disparate life-history strategies, we identified four target species. Bobcats represented a hypercarnivorous predator. Coyotes represented an omnivorous predator with more carnivorous tendencies. Raccoons represented an omnivore and eastern cottontails represented an herbivorous prey species. For each species, we generated daily encounter histories for each camera station with detection (1) or non-detection (0) being coded as a binary response. We analyzed encounter histories within an occupancy modeling framework to estimate species-specific daily *p* and evaluate factors influencing detection (MacKenzie et al. 2002). We used two covariates to evaluate the influence of an olfactory lure on detection: (i) lure, which indicated if the olfactory lure was present at the time of the survey; and (ii) lure age, which indicated the number of days since the lure was applied or refreshed.

Cameras set near game trails may influence detection (Tobler et al. 2015, Kolowski and Forrester 2017). To account for the influence of game trails, we included a covariate for game trail (hereafter, trail) that characterized if the camera was set adjacent to a game trail or not. Precipitation and temperature may also influence *p* (Lesmeister et al. 2015). We obtained daily precipitation totals (mm) and maximum temperatures (ºC) for 5 NOAA weather stations near the study area (NOAA 2021a) and characterized each camera station with data from the nearest reporting weather station. Both predator and prey species may alter their nocturnal movement patterns with changes in lunar illumination (Rockhill et al. 2013, Prugh and Golden 2014, Melville et al. 2020). We generated a daily illumination covariate from recorded moon phase data (NOAA 2021b) by scaling illumination from a range of 0 (new moon) to 100 (full moon). To account for unmodeled heterogeneity in detection that resulted from temporal variation, we included a covariate for time based on Julian day.

We tested for correlation (Kendall's $\tau \geq 0.7$; Dormann et al. 2013) between all covariate combinations using a Kendall's rank correlation test (Robinson et al. 2014, Lonsinger et al. 2017). We hypothesized that the effect of time may change over the season (i.e., detection increases, then decreases), so we also considered time with a quadratic effect (i.e., time + time^2). To identify which characterization of time was most supported by the data, we fit two global detection models (i.e., including all detection covariates) while holding the occupancy submodel as the null model. Each model varied only by how time was characterized: time versus quadratic effect of time. We retained the most parsimonious characterization of time for each species for subsequent analyses.

For each species, we developed a candidate model set for detection that included all possible additive combinations of detection covariates (Doherty et al. 2012), while holding the occupancy model constant at the null (Mills et al. 2019). Relative support for competing models was ranked by Akaike's Information Criterion (AIC) values (Burnham and Anderson 2002). We evaluated the importance of covariates on detection by considering the structure of the most-supported models, beta coefficients of predictors, and cumulative model weights (a measure of relative predictor importance; Burnham and Anderson 2002, Arnold 2010, Lonsinger et al. 2017). Covariates with cumulative model weights >0.5 were considered significant predictors (Erb et al. 2012). All analyses were completed in program MARK (White and Burnham 1999).

We estimated the daily p in the presence and absence of the lure from the most-supported detection model containing the lure covariate for each species; this was the most-supported model for all species but coyote (*see* Results). Daily p was estimated at the mean value for continuous covariates and the mode for categorical covariates (trail = set adjacent to trail; camera type = Browning). We used daily p estimates to generate daily p^* curves ($p^* = 1 - [1 - p]^K$), where p^* was defined as the cumulative probability of detecting the species at least once during K surveys given the station was used (MacKenzie and Royle 2005).

For each target species, we defined a trigger as an event leading to the photo capture (i.e., observation) of the species in at least one of the three photos taken per trigger. We defined an independent photo sequence as ≥1 trigger that captured the presence of a specific species and was separated from the next trigger capturing the same species by ≥30 minutes (Wang et al. 2015, Iannarilli et al. 2021). A photo containing multiple individuals of the same species was recorded as a single observation. A daily detection recorded in an encounter history could be the result of a single sequence or multiple independent sequences over a 24-hour period. Similarly, a sequence could be the result of a single trigger (e.g., an animal quickly passing in front of the camera) or multiple triggers (e.g., from an animal remaining in front of the camera for an extended period). The presence of an attractant may increase (or decrease) the number of triggers per sequence, number of sequences per detection, or both. For each species, we tested (i) if the number of triggers per sequence was different when a lure was applied or not, (ii) and if the number of sequences per daily detection was different when a lure was applied or not. Data were not normally distributed for all comparisons and, therefore, comparisons were completed with nonparametric Mann-Whitney U tests (Mann and Whitney 1947).

Results

From May to September 2019, we surveyed 180 stations for a total of 5,514 camera days (mean = 30.6 ± 7.5 SD), consisting of 2,692 with a lure and 2,822 days without a lure. Time characterized as a linear covariate was more supported than a quadratic effect of time for all species except raccoon. However, the raccoon detection model with a quadratic effect of time had estimation issues and was not a significant improvement over the linear time model (ΔAIC = 0.54). Consequently, we used the linear time covariate to model detection for all species.

We detected bobcats at 24 stations and had more independent photo sequences without a lure than with one (Table 1). The most-supported bobcat detection model structure included lure and precipitation. Bobcat detection was negatively associated with lure ($\hat{\beta} = -0.96$, $\widehat{SE} = 0.36$, 95% CI = −1.66, −0.25) and precipitation ($\hat{\beta} = -0.03$, $\widehat{SE} = 0.03$, 95% CI = −0.09, 0.02), although the effect of precipitation was not as strong with confidence intervals overlapping 0. When considering the full candidate model set, the two covariates in the most-supported model, lure and precipitation, and temperature had the highest relative importance (Table 2). Lure had the highest relative importance followed by precipitation and temperature. Other covariates had lower relative importance values (cumulative model weights < 0.5; Table 2). Daily *p* was lower with a lure (0.025, $\widehat{SE} = 0.008$, 95% CI = 0.014, 0.046) than without one (0.063, $\widehat{SE} = 0.014$, 95% CI = 0.040, 0.098; Fig. 1A). Daily p estimates indicated that 63 survey days were required to achieve a $p^* \geq 0.8$ with a lure compared to 25 days at a station without a lure (Fig. 1A). The lure did not significantly influence the number of sequences per detection for bobcat, but stations with lure never had >1 sequence for a daily detection (Table 1). The number of triggers per sequence was marginally lower when a lure was applied (Table 1).

We detected coyotes at 111 stations and had more independent photo sequences with a lure than without (Table 1). Lure age and time were important predictors of coyote detection (Table 2) and were the only covariates in the most-supported model of coyote detection. Coyote daily p increased with lure age ($\hat{\beta} = 0.017$, $\widehat{SE} = 0.008$, 95% CI = 0.001, 0.032; Fig. 2) and time ($\hat{\beta} = 0.003$, $\widehat{SE} = 0.002$, 95% CI = −0.001, 0.007), although the effect of time was weak with the confidence intervals overlapping 0. Only covariates in the most-supported model had cumulative model weights >0.5 (Table 2). The presence of a lure did not meaningfully impact the survey effort required to achieve a $p^* \geq 0.8$ (Fig. 1B). For coyotes, sequences per detection and triggers per sequence were both significantly higher when a lure was applied (Table 1).

We detected raccoons at 159 stations and had more independent photo sequences with a lure than without one (Table 1). The most-supported raccoon detection model included lure, camera model, trail, temperature, and time covariates. Daily p of raccoon was positively associated with lure ($\hat{\beta} = 0.35$, $\widehat{SE} = 0.07$, 95% CI = 0.21, 0.48). Daily p of raccoons was higher when stations were set by game trails ($\hat{\beta} = 0.31$, $\widehat{SE} = 0.08$, 95% CI = 0.15, 0.47). Detection increased over time ($\hat{\beta} = 0.007$, $\widehat{SE} = 0.001$, 95% CI = 0.005, 0.009), and decreased with increasing temperature ($\hat{\beta} = -0.02$, $\widehat{SE} = 0.01$, 95% CI =

−0.03, −0.01). Relative to Moultrie cameras (represented by the intercept), raccoon detection was higher for Browning ($\hat{\beta}$ = 0.28, $\widehat{SE}$ = 0.09, 95% CI = 0.10, 0.46) and Bushnell ($\hat{\beta}$ = 0.92, $\widehat{SE}$ = 0.12, 95% CI = 0.68, 1.15) camera models (Fig. 3). Only covariates in the most-supported model had cumulative model weights >0.5 (Table 2). Daily *p* of raccoon was higher with a lure than without one (Fig. 1C). However, *p* was sufficiently high for both treatments that lure did not meaningfully impact the survey effort required to achieve $p^* \geq 0.8$ (Fig. 1C). Lure did not significantly influence sequences per detection or triggers per sequence for raccoons (Table 1).

We detected eastern cottontails at 121 stations and had more independent photo sequences without a lure than with one (Table 1). The most-supported detection model included lure, lure age, camera model, temperature, and illumination. Eastern cottontail detection was negatively associated with lure ($\hat{\beta}$ = −0.20, $\widehat{SE}$ = 0.11, 95% CI = −0.41, 0.01), although 95% confidence intervals slightly overlapped 0. Detection was negatively associated with lure age ($\hat{\beta}$ = −0.02, $\widehat{SE}$ = 0.01, 95% CI = −0.04, −0.01) and temperature ($\hat{\beta}$ = −0.02, $\widehat{SE}$ = 0.01, 95% CI = −0.03, −0.005) and positively related to illumination ($\hat{\beta}$ = 0.002, $\widehat{SE}$ = 0.001, 95% CI = 0.00, 0.005), although confidence intervals for illumination included 0. Relative to Moultrie cameras, eastern cottontail detection was comparable with Browning cameras ($\hat{\beta}$ = 0.04, $\widehat{SE}$ = 0.10, 95% CI = −0.16, 0.23) and higher for Bushnell ($\hat{\beta}$ = 0.52, $\widehat{SE}$ = 0.13, 95% CI = 0.27, 0.77) camera models (Fig. 3). Only covariates in the most-supported model had cumulative model weights >0.5 (Table 2). Daily *p* of eastern cottontail was lower with a lure than without one (Fig. 1D). The presence of the lure increased the effort required to achieve a $p^* \geq 0.8$ from 4 days without the lure to 6 days (Fig. 1D). For eastern cottontails, the number of sequences was not significantly different for stations with and without a lure, but triggers were significantly lower when a lure was applied (Table 1).

Discussion

The use of an olfactory attractant to increase species-specific detection rates can be problematic for multi-species monitoring when the direction and magnitude of the effect differs among target species (Holinda et al. 2020). Holdinda et al. (2020) focused on guilds (i.e., all predators, large carnivores, small carnivores, all prey, small mammals, and ungulates) and four target species and found that lure increased predator detections but did not influence prey. We found that the influence of an olfactory lure varied across the focal species, even between the two most carnivorous species. The presence of a lure largely positively influenced detection of coyotes and generally had a negative influence on detection of bobcats. Our results suggest that evaluating the influence of attractants on groups or guilds of species can mask differences in detection among species. Studies investigating the influence of an olfactory attractant on species-specific detection rates focused largely on testing differences in the number of sequences (i.e., presumably independent observations; Tobler et al. 2008, Wellington et al. 2014, Holinda et al. 2020) or differences in detection probability over a defined sampling occasion (e.g., 1-week sampling occasion). The temporal scale at which camera trap data is applied may alter the resulting inferences but has received little attention (Fidino et al. 2020). Fidino et al. (2020) investigated the influence of a lure on the number of triggers and daily p for multiple species, including three species we investigated, and found that the temporal scale of inquiry influenced conclusions related to the influence of lure on detection. In addition to triggers and daily *p*, we also considered the influence of a lure on the commonly used scale of sequences. Similar to our results, Fidino et al. (2020) found that lure decreased detection of eastern cottontails at both temporal scales but influenced coyote detection only at the scale of triggers (not daily *p*). For raccoons, our results indicating no effect of lure aligned with those of Fidino et al. (2020) at the scale of triggers, whereas our finding that lure increased daily *p* was in contrast to the patterns reported by Fidino et al. (2020). The different results for raccoons emphasize that species-specific responses are context dependent and, therefore, caution should be used when extrapolating results from one system to another.

The most relevant temporal scale of detection depends on the research objectives. For occupancy-based studies, the *p* at the scale of temporal replication (e.g., daily or weekly) is often most relevant. In our system, lure influenced the daily *p* for bobcats, raccoons, and eastern cottontails, but only bobcats had a daily *p* that was low enough (with or without a lure) for it to significantly impact the sampling design or survey intensity required for occupancy modeling. Studies using cameras to investigate the spatial ecology of predators have used the number of prey observations (triggers or sequences) detected from the same cameras as a predictor of predator occupancy (Díaz-Ruiz et al. 2016, Van der Weyde et al. 2018). Although this may be appropriate when all camera sets are the same, our results demonstrated that the number of prey triggers may be influenced by lures (or camera type) and that careful consideration should be used to either select the appropriate scale for prey detections where differences in treatment do not influence results or explicitly account for differences in the analyses (e.g., co-occurrence modeling; Richmond et al. 2010). For camera-based studies interested in identification of individuals through unique pelage markings or tags (Jordan et al. 2011, du Preez et al. 2014), the scale of triggers or sequences may be important, as increasing the number of images per daily detection may increase the probability of identifying distinguishing markings. The presence of an attractant, a carcass, aided in individual identification of leopards (*Panthera pardus*) based on spot patterns by increasing the time spent at the camera (du Preez et al. 2014). Similarly, we found lures increased triggers per sequence, a measure of time spent at the camera, of coyotes, the most dominant carnivore, but had no effect or decreased triggers for subordinate carnivores and prey. Results may differ for subordinate carnivores and prey due to increased activity or scent making by dominant carnivores because the presence of dominant carnivores has been shown to suppress the detection of subordinate carnivores (Lazenby and Dickman 2013, Ramesh et al. 2017) and prey (Murphy et al. 2019). Bobcat densities have been estimated using cameras and unique pelage markings (Clare et al. 2015, Jacques et al. 2019) and our results suggest that an olfactory lure may decrease the number of photos per sequence, decreasing the probability of individual identification.

When developing occupancy studies, researchers are challenged with balancing the number of sites surveyed and the duration of the surveys while maximizing detection at a site in order to have a sufficient sample size and have the ability to generate accurate and precise results (MacKenzie and Royle 2005). Consequentially, researchers often employ attractants to increase detection (Burton et al. 2015). We identified two scenarios where an olfactory lure did not sufficiently increase detection at the daily detection scale to meaningfully reduce effort and facilitate surveying of additional sites. First, when the target species did not respond to (i.e., coyote), or negatively responded to (i.e., bobcat), the lure. Second, when the effort required to achieve the desired probability of detecting the target species is only marginally reduced because *p* was sufficiently high with or without a lure (i.e., raccoon).

Camera trapping results may be influenced by the size of target species, the type of camera and settings employed, or both (Tobler et al. 2008, Rowcliffe et al. 2011, Wellington et al. 2014). Using a single camera type, Tobler et al. (2008) found that smaller-bodied mammals had lower detection rates (i.e., photos/1000 days) than larger-bodied mammals. Similarly, Rowcliffe et al. (2011) suggested smaller mammals (≤4 kg) were less likely to be detected than larger mammals (≥8 kg) due to camera sensitivity. Wellington et al. (2014) compared the performance of two camera types (i.e., Reconyx and Cuddeback) and found that detection rates were significantly different between the camera types for smaller- and medium-bodied mammals, but not for larger-bodied mammals. We observed similar patterns, with camera model influencing daily *p* for smaller-bodied raccoons (average mass ~ 6 kg; Lotze and Anderson 1979) and eastern cottontail (average mass ~ 1 kg; Chapman and Ceballos 1990), but not for larger-bodied bobcats (average mass ~10 kg; Tycz 2016) and coyotes (average mass ~ 16 kg; Way 2007). Failure to account for variation in camera model performance and difference in detectability by body mass can bias estimates and lead to erroneous conclusions (Meek et al. 2015, Anile and Devillard 2016). These patterns highlight the importance of using caution when interpreting indices of relative abundance (e.g., among species, for prey of a target predator, or across studies employing different cameras for the same species). Minimizing variation among cameras (e.g., using a single camera type) could alleviate concerns for single species monitoring (Meek et al. 2015), but practitioners often have an assortment of camera models due to limited funding (e.g., borrowing equipment) or changing camera availability (e.g., replacing damaged cameras with newer models). Alternatively, explicit consideration of camera model in the analyses, as we have done here, can produce more robust inferences regarding species-specific detection rates.

In recent years, camera-based community/citizen science projects have been developed for large-scale monitoring of wildlife communities (e.g., Snapshot Wisconsin, Locke et al. 2019; Snapshot USA, Cove et al. 2021). Data collected through community science camera trapping projects have contributed to peer-reviewed research in recent years (Kays et al. 2017, Parsons et al. 2018), highlighting the emerging role of large-scale camera trapping in wildlife management and conservation. Furthermore, data generated from species-specific camera trapping sampling designs are often used to make inferences about prey (e.g., index of prey availability) or wildlife communities. The growing prevalence of large-scale community science projects and multi-species analyses underscore the importance of understanding how variation in sampling strategies influences detection of species at different trophic levels.

This study is limited in that camera trapping was only conducted during summer months when resource availability was presumably the highest. The influence of an olfactory attractant may be stronger during winter when resources are more limited. The factors that influence detection are likely to vary throughout the year including changes in precipitation, weather, and anthropogenic disturbance. Similarly, the factors that drive the intensity of interspecific interactions may change with temporal or spatial variability in resource availability, reproduction, and rearing of young. Furthermore, we only tested an olfactory attractant consisting of sardines in an enclosed container that prevented consumption. A consumable bait that has a reward may have a stronger effect on detection.

Management Implications

Camera trapping is increasing in popularity as a tool for multi-species, wildlife community, and large-scale community/citizen science research. In our study system, the factors that could be controlled for in the sampling design (e.g., lure, camera model, trail) tended to influence detection more than environmental factors (e.g., precipitation, temperature, illumination). We suggest that multi-species camera trapping research minimize variation in camera sets, account for camera-set variation in analyses, or both. We suggest that multi-species camera trapping research use caution when employing attractants and consider potential variation in response among trophic levels or species of the same guild (i.e., bobcat and coyote). For occupancy studies, the attractant had limited efficacy as a method for increasing detection of carnivores and thus, reducing the survey effort. If attractants are used, we recommend pilot studies to evaluate attractant efficacy. We stress the importance of identifying the resolution that data will be used at and identifying sources of variation at the appropriate temporal scale.

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Figure 1. Estimated daily probability of detection (*p*) with 95% confidence intervals (left column) and daily *p** curves (right column; the cumulative probability of detecting a species at least once during *K* surveys of a used station) with (solid line) and without (dotted line) an olfactory lure from 180 camera stations surveyed for (A) bobcat (*Lynx rufus*), (B) coyote (*Canis latrans*), (C) raccoon (*Procyon lotor*), and (D) eastern cottontail rabbit (*Sylvilagus floridanus*) in southcentral South Dakota during summer, 2019.

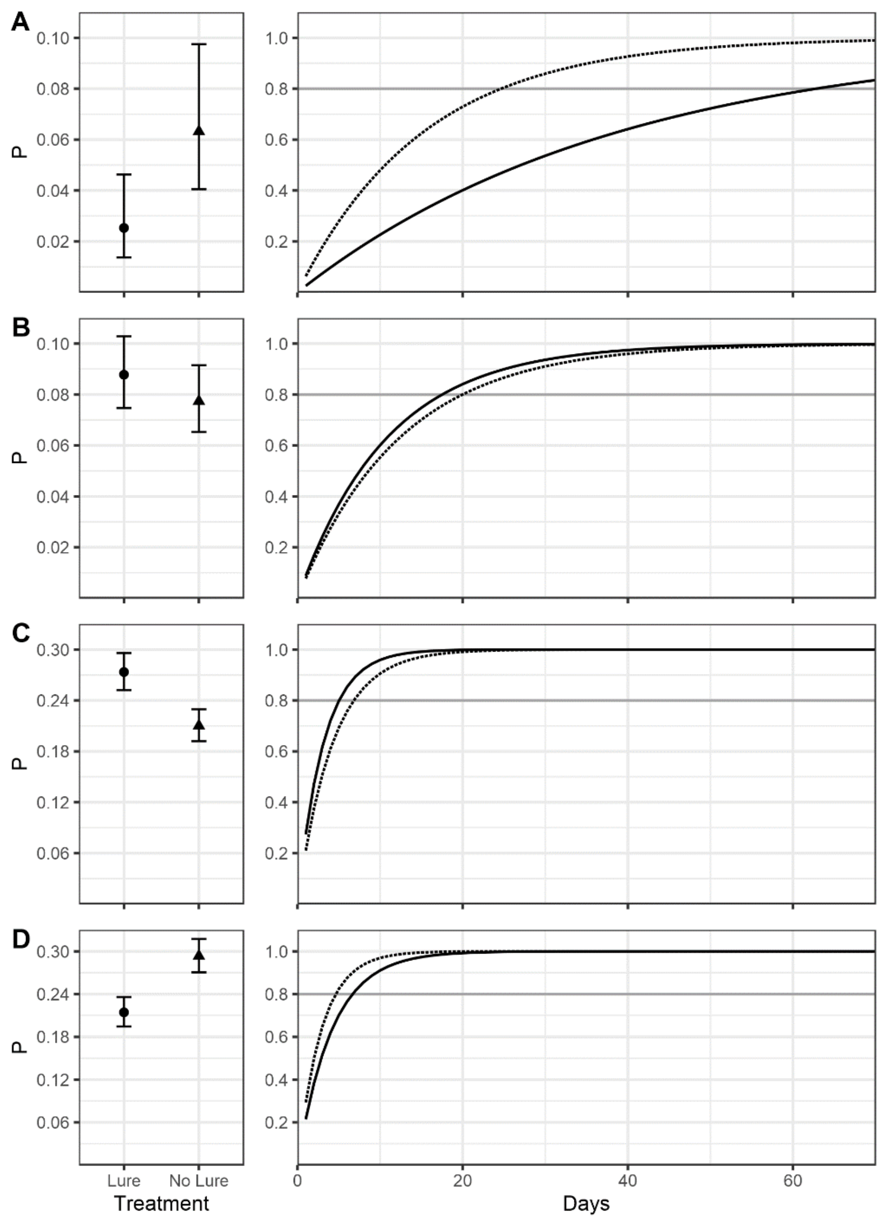

Figure 2: Estimated daily probability of detection of coyote (*Canis latrans*) as a function of lure age with 95% confidence interval band from 180 camera stations surveyed in southcentral South Dakota during summer, 2019.

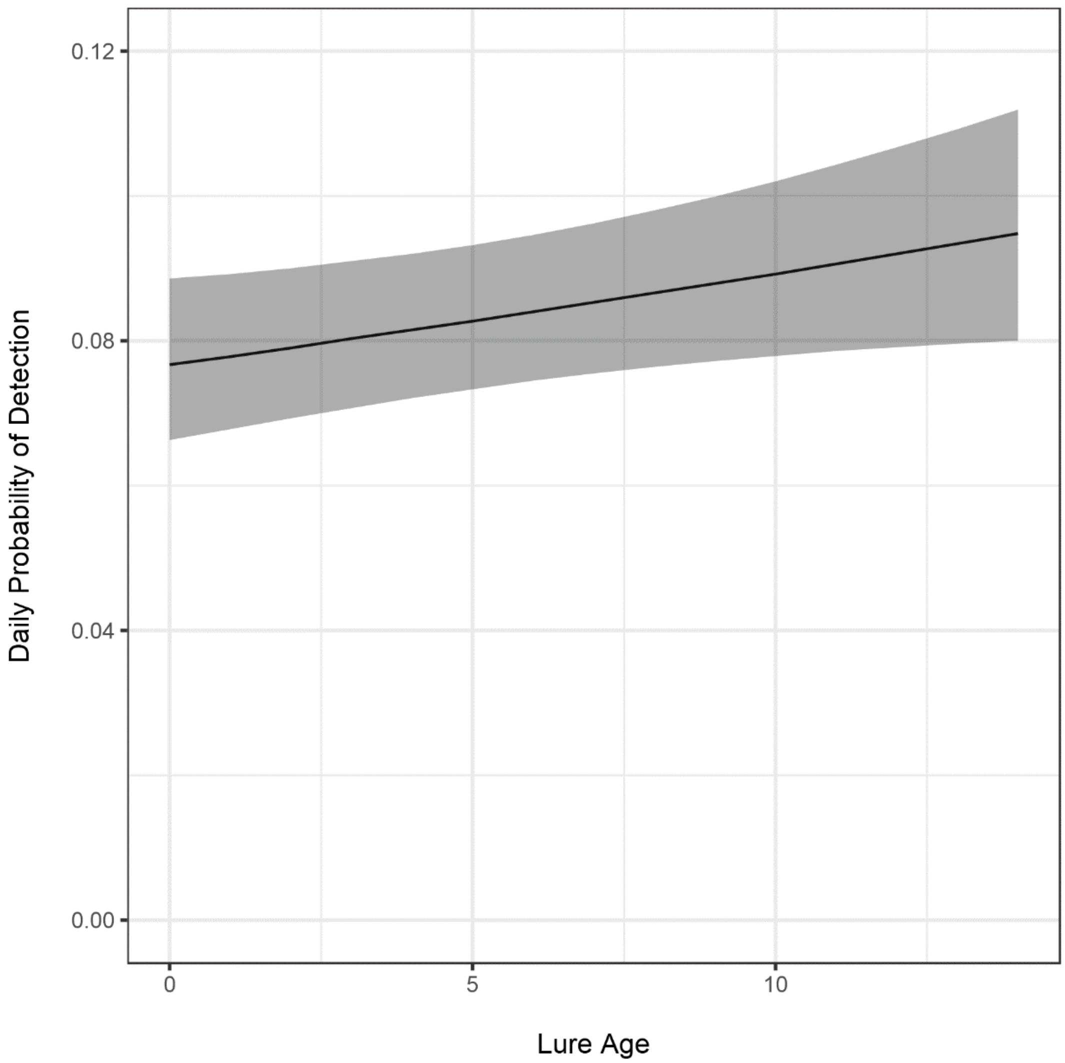

Figure 3: Daily probability of detection of raccoon (*Procyon lotor*) and eastern cottontail rabbit (*Sylvilagus floridanus*) by camera model with (●) and without (▲) lure applied from 180 camera stations surveyed in southcentral South Dakota during summer, 2019.

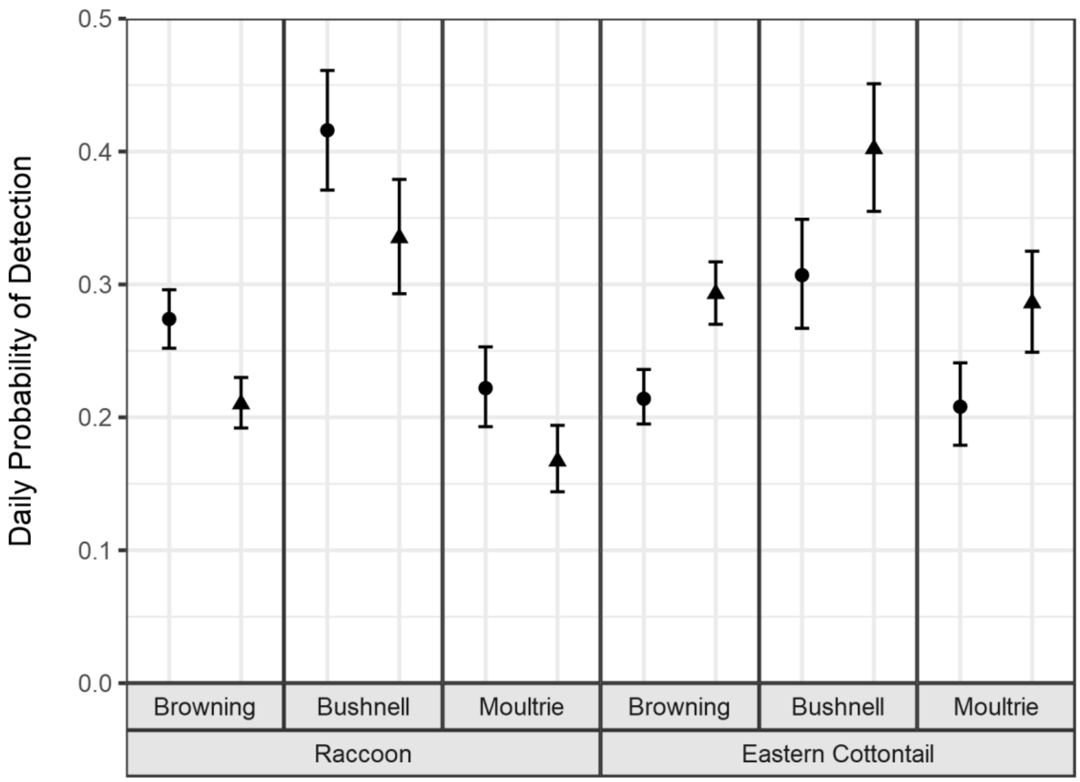

Table 1: Number of independent photo sequences, mean number of sequences (± SE) per detection, mean number of triggers (± SE) per sequence, and *p*-values for Mann-Whitney U tests at camera stations with and without a sardine lure applied for bobcat (*Lynx rufus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), and eastern cottontail (*Sylvilagus floridanus*) surveyed in southcentral South Dakota during summer, 2019.

	Independent Sequences			**Sequences**			**Triggers**		
Species	**Lure**	**No lure**	**Total**	**Lure**	**No lure**	***P*-value**	**Lure**	**No lure**	***P*-value**
Bobcat	14	38	52	1.00 ± 0.00	1.23 ± 0.12	0.172	1.07 ± 0.07	1.58 ± 0.27	0.098
Coyote	229	174	403	1.34 ± 0.06	1.12 ± 0.04	0.003	1.39 ± 0.06	1.09 ± 0.03	<0.001
Raccoon	878	708	1,586	1.32 ± 0.02	1.35 ± 0.03	0.771	1.41 ± 0.04	1.44 ± 0.06	0.121
Eastern Cottontail	743	999	1,742	1.71 ± 0.06	1.79 ± 0.06	0.196	1.35 ± 0.04	1.50 ± 0.04	<0.001

Table 2: Detection covariate predictor importance based on cumulative model weights from single-species, single-season occupancy modeling for bobcat (*Lynx rufus*), coyote (*Canis latrans*), raccoon (*Procyon lotor*), and eastern cottontail (*Sylvilagus floridanus*) surveyed in southcentral South Dakota during summer, 2019. Bold indicates predictors in the most-supported detection model.

	Species			
Covariate	**Bobcat**	**Coyote**	**Raccoon**	**Eastern cottontail**
Lure	**0.87**	0.31	**0.98**	**0.71**
Lure age	0.32	**0.77**	0.36	**0.93**
Trail	0.26	0.27	**1.00**	0.43
Camera model	0.27	0.32	**1.00**	**1.00**
Precipitation	**0.51**	0.36	0.25	0.44
Temperature	0.51	0.27	**0.96**	**0.92**
Illumination	0.27	0.27	0.40	**0.66**
Time	0.39	**0.65**	**1.00**	0.27

Notes: Predictors: Lure = lure applied at time of survey; lure age = days since lure applied; Trail = camera set adjacent to game trail; Camera Model = categorical identification of camera model; Precipitation = daily precipitation total (mm) from nearest weather station; Temperature = daily max temperature (ºC) from nearest weather station; Illumination = scaled range of moon phase; 0 (new moon) to 100 (full moon); Time = Julian day during survey.

CHAPTER 2: SPATIAL AND TEMPORAL PATTERNS OF SYMPATRIC BOBCATS (*LYNX RUFUS*) AND COYOTES (*CANIS LATRANS*) IN AN AGRICULTURAL LANDSCAPE

Abstract

In the Northern Great Plains, habitat loss and fragmentation are driven by the conversion of grasslands to agricultural land. Bobcats (*Lynx rufus*) are a species of management interest in South Dakota that are potentially vulnerable to habitat loss and fragmentation due to their large home ranges, low densities, and low reproductive rates. Additionally, bobcats may be influenced by interspecific interactions with coyotes (*Canis latrans*). Coexistence of sympatric carnivores can be facilitated through spatial, temporal, or dietary niche partitioning. We evaluated the influences of landscape features on space use of bobcats and coyotes using occupancy modeling and generated activity curves to quantify species temporal overlap using detection data collected from motion-activated cameras during the summers of 2019 and 2020. Coyote space use was high and positively related to slope and small-scale percent agriculture in 2019 and positively related to edge density in 2020. Bobcat space use was limited and positively associated with coyote activity in both years, and distance to roads and large-scale percent woodland/shrubland in 2020. We did not find evidence of temporal partitioning. Our results indicate that bobcats are using smaller, less-disturbed patches of woodland/shrubland, which are also associated with higher levels of coyote activity.

Introduction

Habitat loss and degradation are among the leading causes of mammalian biodiversity loss (Schipper et al. 2008, Newbold et al. 2015) and are projected to be the primary drivers of biodiversity loss in the future (Sala et al. 2000). Temperate grassland ecosystems, including grasslands of the Northern Great Plains, are threatened by high levels of conversion coupled with the lowest levels of protection (Hoekstra et al. 2005). In the Northern Great Plains, habitat loss is driven by conversion of grasslands to agricultural lands (Stephens et al. 2008). The life history characteristics of mammalian carnivores including low densities, large home ranges, and low reproductive rates relative to other terrestrial mammalian orders and persecution by humans can make them susceptible to habitat loss and fragmentation (Woodroffe and Ginsberg 1998, Crooks 2002). Consequently, carnivore population declines have resulted in the largest range contractions among mammalian biodiversity (Di Minin et al. 2016).

Carnivores are an essential component of the environment that influences ecosystem structure and function through regulating prey and their impact on vegetative communities (Ripple et al. 2014). Declines in populations of large carnivores can result in mesocarnivore population growth (i.e., “mesopredator release”), which can impact prey and vegetative communities through trophic cascades (Crooks and Soulé 1999, Berger et al. 2008, Prugh et al. 2009). Sympatric carnivore coexistence can be facilitated through spatial, temporal, or dietary niche partitioning (Schoener 1974). Habitat loss and fragmentation can reduce the potential for spatial partitioning by restricting movement and use to smaller, more-isolated patches of habitat (Hanski 2008, Šálek et al. 2014). With reduced opportunity for spatial partitioning, coexistence of carnivores may be facilitated through temporal partitioning (Schoener 1974). Temporal partitioning may be more restricted in landscapes with greater anthropogenic disturbances as carnivores decrease diurnal activity in response to anthropogenic disturbance (Riley et al. 2003, George and Crooks 2006, Wang et al. 2015).

Bobcats (*Lynx rufus*) are a species of management interest in South Dakota due to their value as a furbearer and vulnerability to overharvest (Knick 1990). Bobcats are listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES), which requires that management agencies demonstrate that harvest and exportation is not detrimental to the survival of the species (Anderson and Lovallo 2003). Bobcats may be influenced by sympatric coyotes (*Canis latrans*) through interference competition including interspecific killing (Knick 1990, Fedriani et al. 2000, Gipson and Kamler 2002) or exploitative competition (Litvaitis and Harrison 1989, Henke and Bryant 1999). Bobcats have relatively large home ranges, tend to be solitary as adults, and are elusive, making monitoring their populations difficult (Sargeant et al. 1998, Ruell and Crooks 2007). Motion-activated camera traps have improved monitoring of elusive carnivores by enabling monitoring over large spatial and temporal scales and can be used to evaluate patterns of occurrence (Burton et al. 2015, Lesmeister et al. 2015).

Habitat conservation is improved through a better understanding of how habitat characteristics influence the spatial dynamics of species (Mackenzie et al. 2018). Evaluating patterns of use and occurrence without accounting for imperfect detection (Mackenzie et al. 2018), the influence of interspecific interactions (McLoughlin et al. 2010), or both can lead to biased inferences of factors associated with use. Occupancy modeling uses detection-nondetection data to estimate and examine the factors that influence probability of detection (*p*) and occupancy while accounting for imperfect detection (MacKenzie et al. 2002).

We combined detection data from camera traps with occupancy modeling (MacKenzie et al. 2002) and activity curves (Wang et al. 2015, Lashley et al. 2018) to investigate patterns of space use and temporal activity, respectively, for bobcats and coyotes (a potential intraguild predator) in an agriculturally-dominated landscape in southcentral South Dakota. Consistent with previous research (Tucker et al. 2008, Clare et al. 2015, Wait et al. 2018), we predicted that bobcat use would be positively associated with woodland/shrubland (WS) cover due to their reliance on cover as ambush predators (Rollings 1945, Anderson and Lovallo 2003). We also predicted that bobcat space use would be positively associated with terrain ruggedness (Mosby 2011, Reed et al. 2017) and positively associated with distance from paved roads due to sensitivity to anthropogenic disturbance (Poessel et al. 2014, Lesmeister et al. 2015). We also predicted that bobcat space use would be negatively associated with coyote activity because bobcat space use has been shown to be influenced by the intensity of coyote activity (Wilson et al. 2010). Consistent with previous research (Theberge and Wedeles 1989, Lesmeister et al. 2015, Ellington et al. 2020) and cursorial hunting techniques, we predicted that coyote space use would be positively associated with edge density and distance from paved roads due to increased persecution in an agriculturally-dominated landscape (Lesmeister et al. 2015). Lastly, we predicted that bobcats and coyotes would temporally partition resources if space use of both species was limited to the same areas.

Methods

Study Area

The study area was located along the Missouri River in Charles Mix and Brule counties in southcentral South Dakota. The study area was ~4,275 km^2 and was bound by the borders of Charles Mix and Brule counties and by Interstate 90 to the north. The majority of the area was dominated by flat, privately-owned rangelands used for domestic cattle (*Bos taurus*) grazing and croplands (primarily corn [*Zea mays*] and soybean [*Glycine max*]) interspersed with woodland shelterbelts. Conversely, the western extent of the study area along the river was characterized by rugged drainages that had been impacted by eastern red cedar (*Juniperus virginiana*) encroachment. Dominant plant species included smooth bromegrass (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), big bluestem (*Andropogon gerardii*), porcupine grass (*Hesperostipa spartea*), eastern red cedar, and green ash (*Fraxinus pennsylvanica*). The study area experienced cold winters and moderate summers with the coldest month being January (average = -6.5°C) and the warmest month being July (average = 23.8°C). Average monthly precipitation, defined as the liquid equivalent of precipitation not including snowfall (Arguez et al. 2012), ranged from 12.7 mm (December) to 98.8 mm (June). Average annual precipitation and snowfall of 609 mm and 1054 mm, respectively (National Oceanic and Atmospheric Administration [NOAA] 2020).

Camera Trapping Design

Our sampling design was primarily intended to evaluate occupancy of bobcats. We divided the study area into 25 km^2 sites (5 km x 5 km), which approximated the home range size of female bobcats in South Dakota (Mosby 2011). We randomly selected 60 sites for surveying, excluding sites where land-access permissions could not be obtained. Single cameras within a site can fail to produce reliable assessments of occupancy and spatial replication within sites has been recommended (O'Connor et al. 2017, Kolowski et al. 2021). We used three cameras (hereafter, stations) to survey each site, which ensured that we surveyed a range of conditions within each site. We set stations ≥1.2 km from one another (both within and among sites), which represented the approximate home range diameter of eastern spotted skunks (*Spilogale putorius*) in the Midwest (Lesmeister et al. 2015). Eastern spotted skunks were of management interest in South Dakota and were a secondary target of our broader survey efforts. We surveyed selected sites over two summer field seasons from May to September in 2019 and May to August in 2020. Each station within a site was surveyed concurrently.

We set stations near habitat features frequented by carnivores (e.g., edge habitat, fence lines). We set all stations within a site with one of three passive infrared game camera models (Browning model BTC-6HDP, Bushnell Trophy Cam No Glow, or Moultrie model M-880), keeping models consistent within a site. We set cameras ~1 m high with a slight downward angle and trimmed vegetation within 4 m in front of each camera to increase visibility of smaller species and minimize false triggers (Si et al. 2014). We hung a quarter of an aluminum pie tin ~1 m high and ~4 m in front of each camera as a visual lure. In 2019, we ran a pilot study to test the influence of an olfactory lure on *p* of bobcats by randomly assigning one of three olfactory lure treatments to each station within a site without replacement; details of this pilot study are described in Chapter 1. Briefly, treatments included (i) an olfactory lure, (ii) no olfactory lure, or (iii) an olfactory lure only during only the latter half of the survey. For treatments with an olfactory lure, we used 3.75 ounces of sardines in soybean oil enclosed in a perforated polyvinyl chloride pipe (5" length x 2" diameter) to prevent consumption and secured to the ground with a rebar stake ~4 m in front of the camera. Based on our pilot study (*see* Chapter 1), olfactory lures were not applied in 2020. We set cameras to operate 24 hours a day and capture three photos per trigger with a one-minute delay between triggers. Stations were set for ~28 nights. In 2019, we checked cameras after ~14 nights to replace memory cards and batteries (if necessary) and replace or add attractants for sites receiving an attractant during the entire survey or latter half of the survey, respectively. Cameras were not checked in 2020.

Habitat Sampling

We used line-point intercept sampling to characterize vegetation cover at each station (Herrick et al. 2005). We cleared vegetation and selected camera locations to maximize visibility; therefore, habitat sampling was conducted at randomly generated sampling cores using random bearings (0−359°) and distances (<100 m) from which three 100 m transects were conducted at randomly generated angles spaced equally apart by 120°. We used sampling core distances <100 m to ensure that the circular area sampled by the transects included the camera. We dropped a pin at 5 m increments along the transect and recorded the functional group (i.e., grass, forbs, sub-shrub [height <1 m], shrub [1 m – 2 m], and tree [>2 m]) of every species that intercepted a line extending vertically from the pin (Herrick et al. 2005). We recorded four measurements of both visual obstruction (VO) using a Robel Pole (Harris et al. 2020) and concealment using a concealment board (Camp et al. 2012, McMahon et al. 2017) from a viewing height of 1 m and distance of 4 m in the four cardinal directions from the sampling core. Concealment was measured using a 39 x 30 cm concealment board with 3 x 3 cm checkerboarded squares and was recorded as the percentage of squares concealed by vegetation (Camp et al. 2012). We averaged the four directional measures to get a single measurement for both visual obstruction and concealment for each station.

Occupancy Modeling Covariates

We identified covariates expected to influence detection of carnivores. Cameras set near game trails may influence detection (Tobler et al. 2015, Kolowski and Forrester 2017), so we included a covariate (trail) to indicate if the camera was set adjacent to a game trail or not. Detection can be influenced by precipitation and temperature (Lesmeister et al. 2015). We obtained daily precipitation totals (mm) and maximum temperatures (ºC) for 5 NOAA weather stations near the study area (NOAA 2021a) and characterized each camera station with weather data from the nearest reporting weather station. Predators may alter movement patterns with changes in lunar illumination (Rockhill et al. 2013, Prugh and Golden 2014, Melville et al. 2020). We generated a daily illumination covariate from recorded moon phase data (NOAA 2021b) by scaling illumination from a range of 0 (new moon) to 100 (full moon). We included a covariate for time based on Julian day to account for temporal variation in detection. The effect that time has on detection may change within a season (i.e., detection increases, then decreases), so we also considered time with a quadratic effect (i.e., time + $time^2$). For analysis of 2019 detection data, we included two covariates, lure and lure age, to characterize the influence of the olfactory lure on detection. Lure indicated if a lure was present at the time of the survey and lure age characterized the number of days since the lure was applied or refreshed because the influence of an attractant can change over time (Mills et al. 2019).

We identified covariates expected to influence space use of bobcats and coyotes. Bobcats are ambush predators that rely on the dense cover and increased prey availability associated with WS cover (Rollings 1945). Previous research has found that bobcat space use and occupancy was positively associated with WS cover (Tucker et al. 2008, Clare et al. 2015, Wait et al. 2018), edge (Clare et al. 2015, Wait et al. 2018), and terrain ruggedness (Mosby 2011, Reed et al. 2017), and negatively associated with human disturbance (Lesmeister et al. 2015, Wang et al. 2015) and agriculture landcover (Reed et al. 2017). Similarly, coyotes have been found to be associated with WS habitats in some systems (Gese et al. 1988, Lonsinger et al. 2017), terrain ruggedness (Bender et al. 2017), edge density (Theberge and Wedeles 1989, Lesmeister et al. 2015) and may avoid areas with higher human disturbance in some systems (Lesmeister et al. 2015, Wait et al. 2018).

We used ArcMap 10.8 (Environmental System Research Institute [ESRI], Redlands, CA, USA) to calculate a distance to the nearest paved road, which tends to reflect areas with greater human activity. We also used ArcMap and a digital elevation model (https://www.landfire.gov, accessed 18 Nov 2020) to calculate two covariates that characterize terrain ruggedness at each station, slope and terrain ruggedness index (TRI), defined as the standard deviation of the slope (Riley et al. 1999). We used FRAGSTATS 4.2 (University of Massachusetts, Amherst, MA, USA) and a National Vegetation Classification (NVC) land cover layer (https://www.landfire.gov, accessed 17 Nov 2020) to calculate two covariates to characterize fragmentation for each station, mean patch size and edge density, and to calculate large-scale percent WS cover and percent agriculture (row crop). All FRAGSTATS landscape metrics were calculated within a 600-m buffer. We used line-point intercept habitat sampling data to calculate small-scale percent WS cover and percent agriculture by dividing the number of transect points with WS (tree, shrub, and sub-shrub) or agriculture functional groups by the total number of points (Lonsinger et al. 2015). We also used habitat sampling data to generate VO (Harris et al. 2020) and concealment (McMahon et al. 2017) covariates for each station. Because we were unable to use co-occurrence models, we characterized relative coyote activity at each camera station as the proportion of survey days with a coyote detection and included relative coyote activity as a covariate on bobcat space use (Lonsinger et al. 2017, Wait et al. 2018).

Occupancy Modeling

We intended to evaluate species-specific patterns of detection, occupancy, and spatial dynamics using multi-season single-species occupancy models for bobcats and coyotes, and then combine results of species-specific analyses into a multi-season conditional two-species analysis to investigate the influence of coyotes on bobcat patterns of occurrence (MacKenzie et al. 2002, 2003, Richmond et al. 2010). Preliminary site-level analyses revealed that coyote occupancy was high and prevented us from formally assessing patterns of co-occurrence. Insufficient variation in the occurrence of coyotes, the dominant species, limited our ability to evaluate their influence on patterns of occurrence of bobcat, the subordinate species. High occurrence of coyote at the site level also limited our ability to evaluate how environmental predictors influenced coyote occurrence. Station-level patterns of detection suggested coyote occurrence was lower at the station-level scale. Although we were unlikely to satisfy the closure assumption of occupancy modeling at the station level, occupancy results can be interpreted as the probability of use when the closure assumption is not met and movement between sites is random (Mackenzie 2006, Gould et al. 2019). Consequently, we performed the analyses at the station-level scale to facilitate identification of factors driving coyote space use and interpreted results as the probability of use. Very few stations that were used by bobcats in 2019 were not used in 2020. This limited our ability to generate reliable estimates of extinction which can lead to erroneous use estimates in year 2 and prevented multi-season occupancy modeling. Consequently, we evaluated the factors influencing space use of bobcats and coyotes separately for 2019 and 2020 using daily encounter histories and single-species, single-season occupancy models (MacKenzie et al. 2002).

We used a sequential-by-sub-model modeling approach (Lonsinger et al. 2017, Morin et al. 2020). We tested for correlations between all pairwise covariate combinations using a Kendall's rank correlation test (Robinson et al. 2014, Lonsinger et al. 2017). Covariates with a Kendall's $|\tau| \geq 0.7$ were not included in the same model (Dormann et al. 2013). For each species, we first identified the most-supported global models for detection and occupancy. We fit two global detection models (i.e., including all detection covariates), which varied only by how time was characterized (i.e., time versus quadratic effect of time), while holding the occupancy model for occupancy at the null model. We retained the most parsimonious characterization of time for each species for subsequent analyses. We fit eight competing global occupancy models that compared support for covariates that were correlated (i.e., slope vs. TRI, mean patch size vs. edge density, and VO vs. concealment), including all possible combinations of characterizations for these covariates along with all other occupancy covariates. We retained the characterization of each covariate in the most parsimonious global model for subsequent analyses. Finally, we developed a candidate model set for occupancy that included all possible additive combinations of occupancy covariates (Doherty et al. 2012), while holding the model for detection at the most-supported model (Lonsinger et al. 2017). Relative support for competing models was ranked using an information-theoretic approach with Akaike's Information Criterion (AIC; Burnham and Anderson 2002). We estimated daily *p* and use, and inferred the influence of covariates, based on the structure of the most-supported models. Detection and use were estimated at the mean value for continuous covariates and the mode for categorical covariates (i.e., trail = adjacent to trail; camera type = Browning). To account for model-selection uncertainty, we also reported covariate predictor importance based on cumulative model weights. Analyses were completed separately for each species and each year.

The influence of mean patch size on bobcat space use (*see* Results) contradicted patterns observed in other studies (Nielsen and Woolf 2002, Crooks 2002). Consequently, we conducted a post-hoc analysis to assess the relationship between patch size and WS cover using a Spearman's rank correlation test. Additionally, we replaced mean patch size with edge density in the top model to ensure that we had identified the most-parsimonious model.

Temporal Activity Curves

We evaluated temporal activity patterns separately for 2019 and 2020 using a non-parametric kernel density approach (Ridout and Linkie 2009). Photo sequences of the same species separated by ≥30 minutes were considered independent (Wang et al. 2015, Iannarilli et al. 2021). We converted detection times to radians, generated a probability density distribution using a kernel density estimation, and calculated a coefficient of overlap between bobcats and coyotes ($\hat{\Delta}$; Ridout and Linkie 2009, Wang et al. 2015, Lashley et al. 2018). Ridout and Linkie (2009) suggested using $\hat{\Delta}_1$ if the number of independent photo sequences of the smaller sample was <50 and $\hat{\Delta}_4$ if >75. We used $\hat{\Delta}_1$ because bobcat had <75 photo sequences for both years (2019: 52 and 2020: 45). Using program R (R Core Team 2020), we estimated $\hat{\Delta}$ 95% confidence intervals from 10,000 bootstrap samples with *overlap* package (Ridout and Linkie 2009; Wang et al. 2015, Lashley et al. 2018) and conducted a Watson's two-sample test of homogeneity in the *CircStats* package (Lund and Agostinelli 2018) to test for homogeneity between samples, (i.e., if the two samples come from the same population). We interpreted results to evaluate for evidence of temporal partitioning (Lashley et al. 2018).

Results

We surveyed 180 stations for a total of 5,514 camera days (mean = 30.6 ± 7.5 SD) from May to September 2019, and 174 stations for a total of 5000 camera days (mean = 27.8 ± 6.2 SD) from May to August 2020. Six stations from 2019 were not resurveyed in 2020 due to camera failure or changes in land-access permission. Coyotes had more independent photo sequences, days with ≥1 sequence, and were detected at more stations than bobcats (Table 1). Coyote independent photo sequences and days with ≥1 sequence decreased from 2019 and 2020, while those of bobcat were comparable between years (Table 1).

Time characterized as a linear covariate was more supported than a quadratic effect of time for bobcats and coyotes for both years. Only covariates that characterized the same habitat characteristics were correlated either year, including TRI and slope (Kendall's $|\tau| = 0.81$), VO and concealment ($|\tau| = 0.70$), and mean patch size and edge density ($|\tau| \geq 0.72$), which were not included in the same model.

Bobcat

The most-supported models of bobcat detection suggested that detection was negatively associated with lure in 2019 (Table 2). The most-supported models also suggested that bobcat detection may have been influenced by precipitation in 2019 and trail, illumination, and time in 2020, however, the influence of these predictors was not different from 0 (Table 2). When considering the full candidate model set, only lure, precipitation, and temperature in 2019 and only trail and time in 2020 had cumulative model weights >0.5, with lure having the highest relative importance (Table 3). Daily *p* was higher in 2019 (daily $\hat{p}$ without lure, 0.063, $\widehat{\text{SE}}$ = 0.014, 95% CI = 0.040, 0.097) than in 2020 (0.027, $\widehat{\text{SE}}$ = 0.007, 95% CI = 0.017, 0.044).

Eight of the 512 bobcat space use models for 2020 were removed from the model set due to convergence issues. The most-supported models of bobcat space use suggested space use was positively associated with coyote activity (Table 2; Fig. 1) and negatively associated with patch size in both years, but the influence of patch size was not different from 0 in 2020 (Table 2). Cumulative model weights supported the importance of coyote activity and patch size in both years (Table 3). Bobcat space use in 2020 was also positively associated with distance to the nearest paved road and the large-scale percent WS cover (Table 2), both of which had high cumulative model weights (Table 3). Although the most-supported models also suggested that bobcat space use may have been influenced by concealment in 2019 and the large-scale proportion of agriculture in 2020, the influence of these predictors was not different from 0 (Table 2) and both had relatively low cumulative model weights (Table 3). Estimates of bobcat space use were similar across years (Fig. 2).

A post-hoc analysis found that mean patch size was negatively correlated with large-scale percent WS (Spearman's rho = –0.69, $p < 0.001$). The model with mean patch size was more supported than the model with edge density, and the 95% confidence intervals for the estimated beta coefficient of edge density overlapped 0 in 2020.

Coyote

The most-supported models of coyote detection suggested that detection was positively associated with lure age in 2019 and precipitation and varied across camera models in 2020 (Table 2). Relative to Moultrie cameras (represented by the intercept), detection was higher for Browning and Bushnell camera models (Table 2). Cumulative model weights supported the importance of lure age in 2019 and camera model and precipitation in 2020 (Table 3). Although the most-supported models also suggested that coyote detection may have been influenced by time in 2019, the influence of this predictor was not different from 0 (Table 2) and had a lower cumulative model weight than lure age in 2019 (Table 3). Daily p was similar between 2019 (0.070, $\widehat{SE}$ = 0.005, 95% CI = 0.061, 0.080) and 2020 (0.074, $\widehat{SE}$ = 0.007, 95% CI = 0.062, 0.088).

The most-supported models of coyote occupancy suggested space use was positively associated with slope and small-scale percent agriculture in 2019 and edge density in 2020 (Table 2). The most-supported models also suggested that coyote space use may have been influenced by large-scale percent WS cover in 2019, however, the influence of this predictor was not different from 0 (Table 2). When considering the full candidate model set, only slope, small-scale percent agriculture, and large-scale percent WS cover in 2019 and edge density and concealment in 2020 had cumulative model weights >0.5, with slope and edge density having the highest relative importance in 2019 and 2020, respectively (Table 3). Estimates of coyote space use were similar across years and significantly higher than bobcat space use (Fig. 2).

Temporal overlap

Bobcats and coyotes had marginally higher levels of activity during nocturnal and crepuscular periods with more detections (bobcat: 2019 = 56%, 2020 = 58%; coyote: 2019 = 61%, 2020 = 62%) occurring between sunrise and sunset than during diurnal periods. Bobcat activity was similar between years ($\hat{\Delta}_1 = 0.89$, 95% CI = 0.77, 0.99) and was not significantly different (p-value > 0.10). Coyote activity was similar between years ($\hat{\Delta}_4 = 0.92$, 95% CI = 0.86, 0.96) and was not significantly different (p-value > 0.10). Seasonal bobcat activity had high temporal overlap with coyote activity in both years, $\hat{\Delta}_1 = 0.91$ (95% CI = 0.81, 0.98) in 2019 and $\hat{\Delta}_1 = 0.86$ (95% CI = 0.76, 0.94; Fig 3) in 2020. We did not find evidence of temporal partitioning between bobcats and coyotes in either year (2019: p-value > 0.10; 2020: p-value > 0.10).

Discussion

Previous research investigating bobcat space use in habitats similar to southcentral South Dakota (Iowa, Tucker et al. 2008; Wisconsin, Clare et al. 2015; Kansas, Wait et al. 2018) found that landcover type influenced bobcat space use. Bobcat space use is often positively associated with natural landcover types such as woodlands and shrublands (Tucker et al. 2008, Clare et al. 2015, Wait et al. 2018) and can be negatively associated with agricultural land (Tucker et al. 2008). Based on telemetry data and habitat selection ratios, Tucker et al. (2008) found that bobcats were almost twice as likely to select for woodland than other habitat types and avoided agricultural land. Clare et al. (2015) found that bobcat space use was positively associated with the proportion of wooded cover (forest, shrubland, and wooded wetland combined) and that neither the proportion of cropland or urban were significant predictors of space use. As we predicted, we found that large-scale percent WS was a significant predictor of bobcat space use in 2020. Percent agriculture was not a significant predictor either year. These results highlight the importance of WS cover to bobcats in an agricultural landscape.

Roads and anthropogenic disturbances can negatively influence the spatial dynamics of bobcats. Roads can be a direct source of mortality (Litvaitis et al. 1987, Knick 1990, Chamberlain et al. 1999, Riley et al. 2003) and can contribute to increased harvest mortality of carnivores (Basille et al. 2013). Bobcat home ranges in California had lower road densities than the overall road density in the study extent (Poessel et al. 2014). Likewise, Reed et al. (2017) found that collared bobcats avoided areas with high road densities. Riley et al. (2003) found that bobcat home ranges consisted primarily of natural areas, but most particularly adult females had the lowest percentage of urban landcover and hypothesized that females perceived disturbed areas as unsafe for rearing young. Occupancy of bobcat in southern Illinois was most influenced by anthropogenic disturbances, including negative associations with distance to paved roads and anthropogenetic structures (Lesmeister et al. 2015). We observed similar patterns. As we predicted, space use was greater in areas that were farther from roads, but only in 2020. These results highlight the importance of conserving undisturbed remote habitat. Undisturbed habitat may be important for females rearing young and may provide refugia from human-related disturbance and mortality.

Both edge density and patch size have been used to investigate bobcat space use or occupancy. Clare et al. (2015) found that bobcat use was positively associated with wetland edge density (but not forest edge density) and suggested that wetland edge density had increased foraging value. Similarly, Wait et al. (2018) found that bobcat occupancy was positively associated with edge density. Nielsen and Woolf (2002) found that bobcat core areas had similarly high levels of mean patch size in comparison to the rest of the study area. Crooks (2002) found that the probability of occurrence of bobcats was positively related to fragment area. Our results that bobcat space use was negatively associated with mean patch size contradicts previous results (Nielsen and Woolf 2002, Crooks 2002). However, this is likely a consequence of landcover patterns in our study area and the scale of our mean patch size covariate. In our study area, relatively small, and presumably higher-quality, WS patches were interspersed among larger agricultural patches. This highlights the importance of understanding how covariate selection can influence the interpretation of results and how covariates and their influence can be scale and context dependent.

Ubiquitous use of study areas by coyotes has been found in other regions (Lesmeister et al. 2015, Lonsinger et al. 2017). Despite being able to exploit anthropogenically-dominated landscapes (Grinder and Krausman 2001, Gehrt et al. 2009), coyote space use and occupancy can still be negatively influenced by anthropogenic disturbance (Lesmeister et al. 2015, Wait et al. 2018). Our results did not indicate that coyote space use was influenced by anthropogenic disturbance. Rather, coyote space use was positively associated with slope and large-scale percent agriculture in 2019 and edge density in 2020. Coyotes in North Carolina selected for agricultural fields over woodland but territories normally consisted of core areas dominated by agricultural land with woodland more prevalent on the periphery (Hinton et al. 2015). In

2019, we found that coyote space use was positively associated with small-scale percent agriculture with large-scale percent WS potentially having a weak effect on coyote space use. Similar to other studies examining coyote space use (Theberge and Wedeles 1989, Lesmeister et al. 2015, Ellington et al. 2020), we found that space use was positively associated with edge density, which has been attributed to their cursorial hunting technique and increased prey availability in edge habitats (Theberge and Wedeles 1989).

The competitive exclusion principle suggests that two sympatric species competing for the same resources cannot coexist (Hardin 1960). Coyotes have been shown to influence bobcat space use (Wilson et al. 2010), influence bobcats through interference competition (Knick 1990, Fedriani et al. 2000, Gipson and Kamler 2002), and suppress bobcat populations through exploitative competition (Litvaitis and Harrison 1989, Henke and Bryant 1999). Coexistence of sympatric carnivores can be facilitated through dietary, spatial, or temporal niche partitioning (Schoener 1974, Di Bitetti et al. 2010). Despite evidence of competition between bobcat and coyote, previous research examining the spatial dynamic of bobcats and coyotes has generated mixed results on spatial partitioning. Wilson et al. (2010) found that bobcat space use was most influenced by the intensity of coyote activity. Bobcats avoided areas with high coyote activity when prey was abundant, but were more likely to use areas with high coyote activity when prey availability was low (Wilson et al. 2010). Bobcat space use or occurrence has been shown to not be influenced by (Lesmeister et al. 2015, Wait et al. 2018) or even be positively associated with coyote occupancy (Wang et al. 2015, Bender et al. 2017, Lombardi et al. 2020). Wang et al. (2015) and Wait et al. (2018) did not account for prey availability. The spatial patterns that they observed may have been influenced by underlying resource availability that was not accounted for. Lombardi et al. (2020) did not include prey availability in analyses but suggested that prey availability in the study area was high due to no harvest and limited habitat manipulation. Bender et al. (2017) found that bobcat and coyote were more likely to co-occur than would be expected under a hypothesis of independence (Richmond et al. 2010) but that space use of each species was influenced by different-sized prey. Lesmeister et al. (2015) accounted for prey availability and found no effect for bobcat but found that coyote occupancy was higher in hardwood forest stands and suggested that hardwood forests had higher prey abundance than conifer stands. Contradicting our prediction, we found that bobcat space use was positively associated with coyote activity. These results suggest that bobcats are more likely to use areas that have more coyote activity. This may suggest that prey resources are sufficiently low in our study area (Wilson et al. 2010) or that landscape patterns in our agriculturally-dominated landscape concentrate prey in areas and results in increased interactions at the spatial scale between bobcats and coyotes. We were unable to include prey availability in our modeling of space use because detection of eastern cottontail, presumably one of the primary prey of bobcats in South Dakota (Nomsen 1982), was influenced by differences across camera sets (e.g., camera model and lure) that would have invalidated any relative measure of prey availability.

Consistent with our results that bobcats and coyotes do not spatially partition resources, our results aligned with previous research findings that activity of bobcats and coyotes have high levels of temporal overlap (Witmer and DeCalesta 1986, Neale and Sacks 2001, Lesmeister et al. 2015). This may be a consequence of decreased diurnal activity of carnivores in response to anthropogenic disturbance (Riley et al. 2003, George and Crooks 2006, Wang et al. 2015) in our agriculturally-dominated landscape. In the absence of spatial and temporal partitioning, co-occurrence can still be facilitated through dietary niche partitioning (Schoener 1974), but we were unable to evaluate dietary patterns between bobcats and coyotes in our study system. Neale and Sacks (2001) found slight differences in diets between bobcat and coyote and no evidence of spatial or temporal partitioning. Bobcat diets consisted primarily of small mammals, while coyotes diets consisted primarily of ungulates (Neale and Sacks 2001). Bender et al. (2017) found that bobcat and coyote space use was influenced by different-sized prey. Lesmeister et al. (2015) and Bender et al. (2017) suggested that despite high spatial overlap, that co-occurrence can be facilitated through differences in hunting techniques between cursorial predators and ambush predators. Beyond dietary niche partitioning, Lombardi et al. (2020) hypothesized that co-occurrence was facilitated by an abundance of suitable cover with high prey availability and fine-scale avoidance was facilitated through olfactory cues.

We found that the factors that influenced patterns of use varied between years. Our study area experienced major flooding before and during our 2019 field season. Flooding altered human activity by limiting farming and altering human movement and access. In our study area, most WS cover is adjacent to rivers, creeks, and drainages. Flooding may have altered prey availability or displaced bobcats in these areas. Our 2020 field season took place during the SARS-CoV-2 (coronavirus disease 2019) outbreak, which likely had impacts on human activity and road traffic around recreation areas and campgrounds in the study area.

Our study was restricted to spatial and temporal patterns of bobcats and coyotes during summer months. The factors that potentially influence space use and interspecific interactions (e.g., resource availability, weather, harvest, reproduction, and anthropogenic disturbance) are likely to vary throughout the year. Summer is important for understanding bobcat and coyote space use because abundance should be highest due to reproductive pulses. Harvest in winter months complicates using occupancy modeling to investigate space use because harvest mortality likely violates the closer assumption required for occupancy modeling. Furthermore, trapping activity is difficult to quantify and is likely to influence space use of bobcats and coyotes.

Management Implications

This research adds to the growing body of evidence of the importance of remnant, undisturbed WS cover for bobcat space use in an agricultural landscape. Eastern red cedar encroachment could benefit bobcat populations and management of encroachment is likely to influence bobcat populations in the Northern Great Plains. Managers should consider conserving and limiting the development of undisturbed WS habitats because it may provide refugia from human-related disturbance and mortality. Our results also provide insight into patterns of spatial and temporal resource partitioning between competing sympatric carnivores in agricultural landscapes. Agricultural landscapes may limit the availability of high-quality habitat, which may concentrate or suppress prey availability, and increase spatial overlap of sympatric carnivores. Wildlife managers should consider limiting further conversion of natural habitats to agriculture to limit further concentration or reduction of prey availability which could further decrease opportunities for resource partitioning between bobcats and coyotes.

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Figure 1. Estimated space use ($\widehat{\Psi}$) of bobcats (*Lynx rufus*) as a function of relative coyote (*Canis latrans*) activity (i.e., the proportion of survey days with a coyote detection) with 95% confidence intervals in southcentral South Dakota during summer, 2019 and 2020.

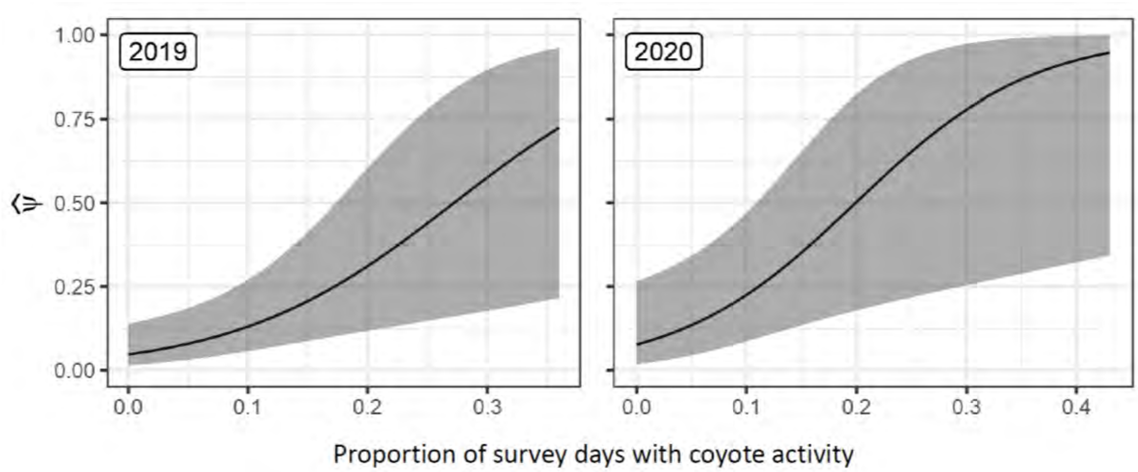


Figure 2. Estimated space use ($\widehat{\Psi}$) of bobcats (*Lynx rufus*) and coyotes (*Canis latrans*) with 95% confidence intervals for summer 2019 (●) and 2020 (▲) in southcentral South Dakota.

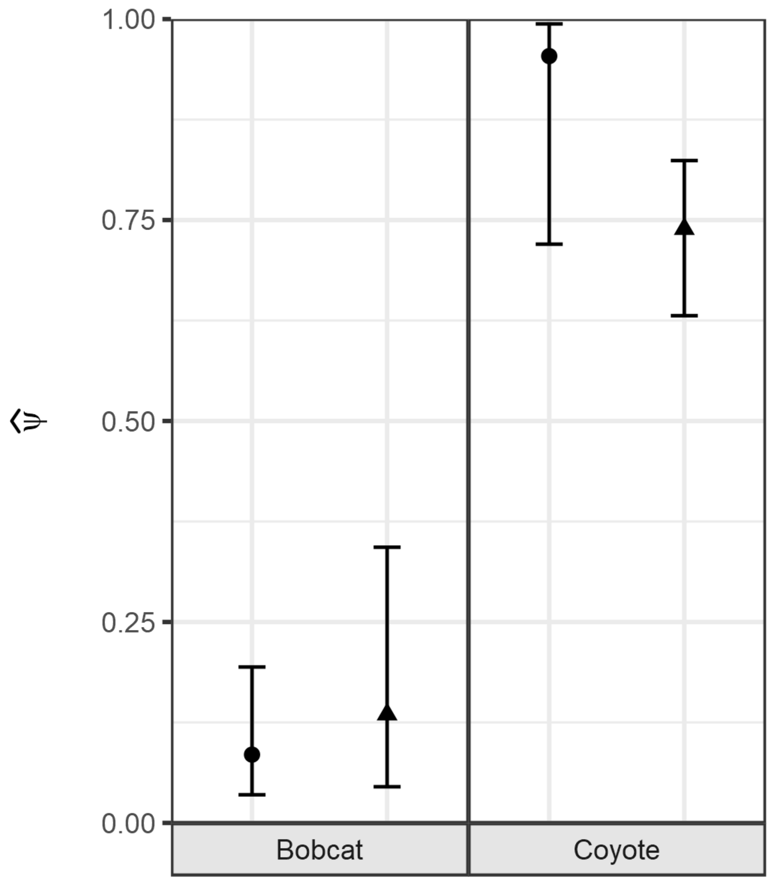
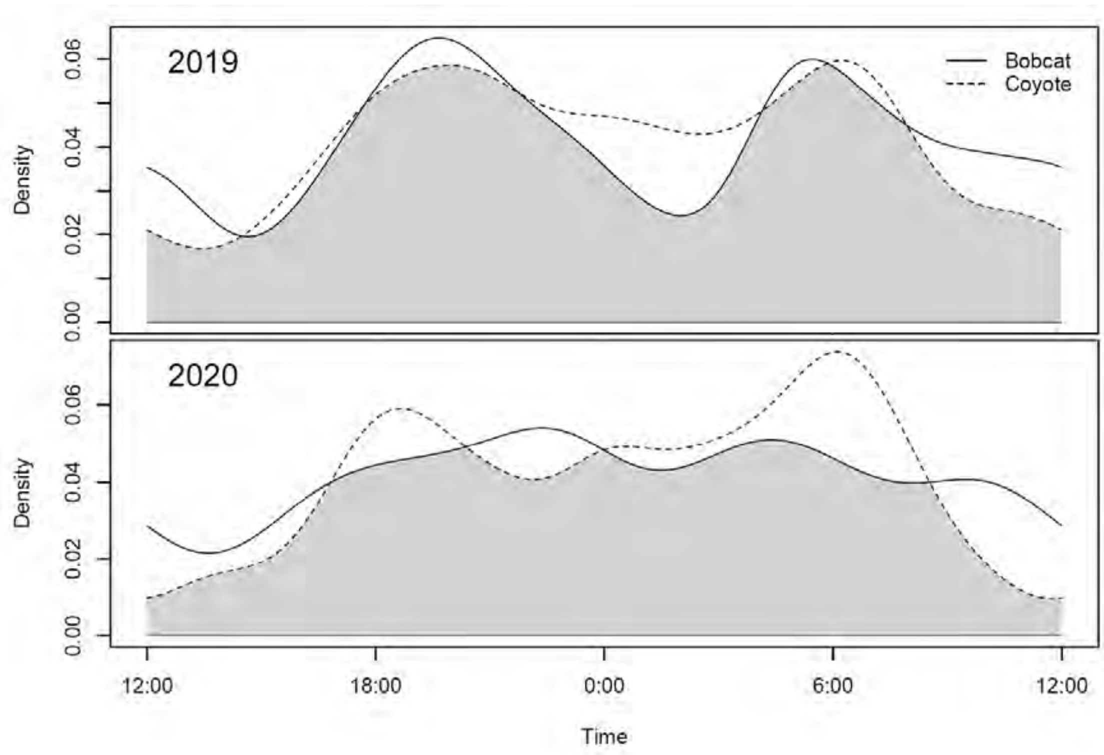


Figure 3. Kernel density estimates of summer daily activity patterns of bobcat (*Lynx rufus*) and coyote (*Canis latrans*) in southcentral South Dakota, 2019 and 2020.



Notes: independent photo sequence totals: 2019: bobcat = 52, coyote = 403; 2020: bobcat = 45; coyote = 302.

Table 1. The number of independent photo sequences, number of days with ≥1 photo sequence, and number of unique stations with detections of bobcat (*Lynx rufus*) and coyote (*Canis latrans*) surveyed in southcentral South Dakota during summer, 2019 and 2020.

	Independent sequences		**Days with ≥1 sequence**		**Unique stations**		
	2019	**2020**	**2019**	**2020**	**2019**	**2020**	**Both years**
Bobcat	52	45	45	44	24	30	43
Coyote	403	302	326	262	111	108	153

Table 2. Estimated beta coefficients ($\hat{\beta}$), standard error (SE), and 95% confidence interval lower (LCL) and upper (UCL) confidence limits for the most-supported models of detection (*p*) and space use (Ψ) for bobcats (*Lynx rufus*) and coyotes (*Canis latrans*) surveyed in southcentral South Dakota during summer, 2019 and 2020.

	Parameter	$\hat{\beta}$	SE	LCL	UCL		Parameter	$\hat{\beta}$	SE	LCL	UCL
Bobcat 2019						*Coyote 2019*					
p	Intercept	−2.548	0.243	−3.025	−2.071	*p*	Intercept	−3.080	0.376	−3.817	−2.343
	Lure	−1.011	0.357	−1.710	−0.311		Lure Age	0.022	0.008	0.006	0.037
	Precipitation	−0.033	0.027	−0.086	0.019		Time	0.003	0.002	−0.001	0.006
Ψ	Intercept	0.403	0.808	−1.180	1.987	Ψ	Intercept	−1.276	0.481	−2.218	−0.334
	Coyote Act.	10.989	3.995	3.158	18.820		Slope	0.594	0.237	0.129	1.058
	Concealment	−0.018	0.010	−0.037	0.001		LS_%WS	0.116	0.071	−0.023	0.255
	Patch	−0.374	0.162	−0.692	−0.056		SS_%Ag	0.019	0.008	0.003	0.035
Bobcat 2020						*Coyote 2020*					
p	Intercept	−1.306	1.769	−4.773	2.160	*p*	Intercept	−3.223	0.212	−3.639	−2.806
	Trail	0.896	0.686	−0.450	2.241		Cam Model				
	Illumination	−0.008	0.005	−0.019	0.002		Browning	0.629	0.229	0.179	1.079
	Time	−0.015	0.009	−0.033	0.002		Bushnell	0.818	0.243	0.342	1.293
Ψ	Intercept	−3.307	1.283	−5.821	−0.793		Precipitation	0.015	0.004	0.007	0.023
	Coyote Act.	12.442	5.083	2.480	22.404	Ψ	Intercept	−0.621	0.572	−1.742	0.500
	Patch	−0.415	0.218	−0.843	0.012		Edge Density	0.018	0.007	0.004	0.031
	Road Dist.	0.599	0.248	0.114	1.085						
	LS_%WS	0.108	0.033	0.044	0.173						
	LS_%Ag	0.031	0.018	−0.004	0.067						

Notes: Predictors: Lure = lure applied at time of survey; lure age = days since lure applied; Trail = camera set adjacent to game trail; Camera Model = categorical identification of camera model; Precipitation = daily precipitation total (mm) from nearest weather station; Temperature = daily max temperature (ºC) from nearest weather station; Illumination = scaled range of moon phase; 0 (new moon) to 100 (full moon); Time = Julian day during survey; Slope = slope at station; TRI = Terrain ruggedness index at station; concealment = visual cover measured as percent of 39 x 30 cm concealed by vegetation at ground level; VO = vertical density of vegetation measured from ground level (cm); Edge Density = total edge (m) per hectare within 600-m buffer; Patch = mean patch size within 600-m buffer; coyote act = proportion of survey days with a coyote detection; Road Dist = distance to nearest paved road (km); LS_%WS = percent woodland/shrubland cover within 600-m buffer; LS_%Ag = percent agriculture cover within 600-m buffer, SS_%WS = percent woodland/shrubland cover within 100-m buffer, SS_%Ag = percent agriculture cover within 600-m buffer.

Table 3. Detection (*p*) and space use (Ψ) covariate predictor importance based on cumulative model weights from single-species, single-season occupancy modeling for bobcat (*Lynx rufus*) and coyote (*Canis latrans*) surveyed in southcentral South Dakota during summer, 2019 and 2020. Bold indicates predictors in the most-supported detection model. Dash indicates that the covariate was not considered in the model set.

		Bobcat		Coyote	
	Covariate	2019	2020	2019	2020
p	Lure	**0.87**	-	0.31	-
	Lure Age	0.32	-	**0.77**	-
	Trail	0.26	**0.78**	0.27	0.42
	CamModel	0.27	0.15	0.32	**0.97**
	Illumination	0.27	**0.47**	0.27	0.29
	Precipitation	**0.51**	0.26	0.36	**0.99**
	Temperature	0.51	0.41	0.27	0.30
	Time	0.39	**0.85**	**0.65**	0.41
Ψ	Slope	0.26	-	**1.00**	-
	TRI	-	0.47	-	0.27
	Concealment	**0.61**	-	-	0.51
	VO	-	0.54	0.26	-
	Edge Density	-	-	0.36	**0.67**
	Patch	**0.88**	**0.87**	-	-
	Coyote Act.	**0.96**	**0.97**	-	-
	Road Dist	0.26	**0.97**	0.25	0.26
	LS_%WS	0.45	**1.00**	**0.74**	0.31
	LS_%Ag	0.26	**0.48**	0.27	0.27
	SS_%WS	0.31	0.53	0.34	0.38
	SS_%Ag	0.29	0.34	**0.76**	0.31

Notes: Predictors: Lure = lure applied at time of survey; lure age = days since lure applied; Trail = camera set adjacent to game trail; Camera Model = categorical identification of camera model; Precipitation = daily precipitation total (mm) from nearest weather station; Temperature = daily max temperature (ºC) from nearest weather station; Illumination = scaled range of moon phase; 0 (new moon) to 100 (full moon); Time = Julian day during survey; Slope = slope at station; TRI = Terrain ruggedness index at station; concealment = visual cover measured as percent of 39 x 30 cm concealed by vegetation at ground level; VO = vertical density of vegetation measured from ground level (cm); Edge Density = total edge (m) per hectare within 600-m buffer; Patch = mean patch size within 600-m buffer; coyote act = proportion of survey days with a coyote detection; Road Dist = distance to nearest paved road (km); LS_%WS = percent woodland/shrubland cover within 600-m buffer; LS_%Ag = percent agriculture cover within 600-m buffer, SS_%WS = percent woodland/shrubland cover within 100-m buffer, SS_%Ag = percent agriculture cover within 600-m .

**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

IN THE MATTER OF THE APPLICATION BY NORTH BEND WIND PROJECT, LLC FOR A PERMIT TO CONSTRUCT AND OPERATE THE NORTH BEND WIND PROJECT IN HYDE COUNTY AND HUGHES COUNTY, SOUTH DAKOTA	**CERTIFICATE OF SERVICE** EL21-018

I hereby certify that a true and correct copy of Michael Bollweg's Supplemental Response to Staff's Second Set of Data Requests and the Certificate of Service were served electronically on the Parties listed below, on the 28th day of January, 2022, addressed to:

Amanda M. Reiss
Staff Attorney
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/s James E. Malters
JAMES E. MALTERS

Wind Energy and Wildlife Resource Management in Iowa:
Avoiding Potential Conflicts

Introduction

Iowa is on its way to ranking among the world's leading producers of wind-generated electrical energy. In our efforts to become less dependent upon fossil fuels, nuclear power, hydropower and other sources with frequent environmental concerns, the possibility of this "green" energy has caused much excitement. Many Iowans eagerly await expansion of this low-cost (after initial infrastructure investments) source of electricity as one step towards energy independence.

The Governor, General Assembly, and Department of Natural Resources all consider wind energy development in Iowa a high priority. With much open farmland upon which wind generators might be placed, and in a region of nation realizing relatively high average wind velocities, Iowa seems destined to be a national focal point for wind energy development. Many state and national conservation organizations also support increasing wind energy production.

No energy source has yet been found to be without some degree of environmental costs, however, and wind energy is no exception. It has been demonstrated that if proper siting of wind turbines is not carefully planned, certain locations may result in collisions with, and death of, both wild birds and bats. In one or two noteworthy instances, excessive mortality of hawks, eagles and other birds of prey has resulted in major modifications to both design and placement of wind turbines, or even periodic shut-downs of large facilities. Additional costs involved with such measures can reduce cost-effectiveness of energy production.

Iowa currently exercises minimal regulation on locating wind farms. Nevertheless, some energy companies recognize the benefits of consulting with wildlife resource managers *before* final decisions are made on siting of new facilities. Such actions will result in greater trust and cooperation between energy producers and those charged with protecting our wildlife resources This can lead to an orderly and beneficial development of Iowa's wind energy.

An *ad hoc* Iowa wind energy and wildlife discussion group has met infrequently to review current developments regarding wind energy and wildlife interactions. The group consists of representatives from Iowa DNR's Wildlife Bureau and Energy Section, US Fish & Wildlife Service, several non-governmental conservation organizations, energy companies, the Iowa Renewable Energy Association and other interested parties. The group has no rule-making or regulatory authority; rather it simply works cooperatively to discuss mutual concerns and to learn of the latest developments.

Wildlife Concerns

Just what are the problems wind turbines might pose to our wildlife and other natural resources? The most obvious is direct collisions of birds and bats with rotating blades. Fortunately for

birds, the annual mortality rate at most Midwestern wind farms appears to remain relatively low and probably insignificant. An exception occurs when turbines are placed in or very near major migration corridors and pathways, such as large river valleys and ridgetops or bluffs. Because birds tend to follow or congregate along these natural landscape features during their semi-annual migrations, wind turbines placed near these features have potential for causing significant bird kills in spring and fall. A few examples of such landscapes in Iowa include the Des Moines River, Little Sioux River, Wapsipinicon River, Loess Hills, and Mississippi River blufflands. Still, with Iowa's mostly open landscape, birds generally are widely dispersed throughout much of the year and chance of interaction with turbines is small.

Bats present an entirely different situation. For reasons still mostly unknown, bat collisions and mortality is much higher than for birds at many wind farms. Early efforts are underway to attempt a better understanding of the problem, but little is known at this time. However, bats usually are associated with trees or wooded areas and wetlands, where the insects on which they feed are abundant. Wind turbines placed near woodlands and wetlands thus might reasonably be expected to result in more bat deaths than turbines situated in open farmlands.

An emerging concern for birds is wind turbines placed within or very near large expanses of grassland. In some western states, ground-nesting lesser prairie-chickens have been found to abandon their nesting grounds when wind turbines were erected and operated nearby. It is quite likely that Iowa's greater prairie-chickens, a state endangered species requiring large expanses of unbroken habitat, would exhibit similar behavior. Many other ground-nesting grassland birds have yet to be studied, but some of these species already are in steep decline nationwide and cannot risk another factor that might potentially threaten their survival. A leading cause of much bird decline is related to fragmentation, or "parcelization", of their remaining habitat, breaking it into parcels too small to meet certain birds' survival or reproductive needs. It has been suggested that wind turbines placed in the middle of a large grassland may similarly fragment habitat and greatly reduce its value. This is a question in need of much additional research.

In summary, adverse effects of wind turbines on birds and bats have been documented in some locations, but much remains to be learned. A few energy companies or developers have collaborated with wildlife researchers to conduct some desperately needed studies. They are to be recognized for their commitment to better conservation of all our natural resources. Nevertheless, much more research is needed, especially in comparing "before and after" effects upon wildlife where wind farms are constructed. Information garnered would be invaluable in helping with future wind farm siting decisions.

Wind Turbine Siting Recommendations and Guidelines

Until we more fully understand how wildlife interacts with wind turbines, interim guidelines have been prepared to help wind energy developers and producers do a better job of designing and siting their wind farms. The list of recommendations below will serve as a starting point for things that *should* be considered when planning wind energy developments. These have been collected from a variety of sources, chief among them the US Fish & Wildlife Service Interim Guidelines for siting and construction of wind energy facilities, and recommendations from the

National Wind Coordinating Committee. Keep in mind that this list is a *work in progress*, subject to change as new information is gained.

Siting Recommendations:

- Avoid placing turbines at locations where any species of fish, wildlife or plants protected under the federal Endangered Species Act have been documented. Information may be obtained by contacting the Iowa Department of Natural Resources Endangered Species Coordinator or Wildlife Bureau staff. Any action resulting in losses to federally-listed species could result in substantial fines or other penalties.
- Avoid placing turbines in or near recognized bird concentration areas or migration pathways, including lakes, wetlands, forests, river valleys, ridge tops or bluff tops, large grasslands, known bird roosting areas, public wildlife areas, parks, and areas with frequent incidence of fog mist or low clouds. While there is no firm information on the amount of buffer zone needed between turbines and these habitats, a separation distance of at least one mile might be considered an absolute minimum (more for prairie-chickens—see below).
- Avoid placement of turbines in or near areas where highly “area-sensitive” wildlife species, such as prairie-chickens, are known. Area-sensitive species *require* expansive, unfragmented habitat. For prairie-chickens in particular, a separation distance of at least 5 miles from all known leks (breeding grounds) is *strongly* recommended.
- Avoid placing turbines near documented bat hibernation, breeding or nursery colonies and in migration corridors (see bird recommendation above) or between known colonies and feeding areas.
- Avoid placement of multiple turbines in close proximity to one another or perpendicular to known migration pathways (typically north-south). Widely spaced turbines, in arrays parallel to normal bird migration routes, can reduce collisions.
- Reduce or eliminate availability of carrion within wind farms, to reduce chances of attracting eagles, vultures and other raptors colliding with turbine blades. Neither dead livestock nor wildlife should be left within or near wind farm boundaries.
- Place wind turbines in areas already fully developed for agriculture, especially row-crop farming, where there is minimal extant wildlife habitat—Iowa is especially rich in such lands, and it has been estimated that as much as 80% of Iowa’s landscape might be considered suitable for wind energy development with few adverse effects upon wildlife.
- If wildlife habitat losses or fragmentation must be mitigated, develop a plan to create or restore habitat *away* from the wind farm site. This will serve to attract birds, bats and other wildlife away from the development and reduce collisions. Wherever possible, coordinate habitat mitigation sites with other public or private wildlife lands, to connect, enlarge or enhance those areas.
- Certain landscapes, such as the Loess Hills in western Iowa and the “Iowa Great Lakes Region” in northwest Iowa, are known for their beauty, rarity *and* for extensive wildlife breeding and migrating activities. Such landscapes should be avoided entirely both for biological and aesthetic reasons.
- Consider possible *cumulative* regional effects of multiple wind energy projects. While one project alone may result in few concerns for wildlife, multiple projects across one landscape could significantly multiply adverse effects.

- A map of Iowa, denoting areas of particular concern for possible adverse effects by wind turbines upon wildlife and habitat, has been developed and is updated periodically. Construction within these areas may not necessarily result in wildlife conflicts, and consultation with DNR wildlife biologists can assist developers in finding suitable sites within these potentially sensitive landscapes, or in suggesting plan modifications to minimize adverse effects.

Turbine Design and Operation Recommendations:

- Tubular support towers with pointed tops, rather than lattice supports, greatly reduce opportunities for birds to perch or nest upon the structures. Avoiding placement of permanent external ladders or platforms on tubular towers also reduces nesting and perching.
- Avoid use of guy wires for turbine or meteorological tower supports. Any existing guy wires should be marked with recommended bird deterrent devices (Avian Power Line Interaction Committee 1994).
- Taller turbines, having a top-of-rotor sweep exceeding 199 ft., may require lights for aviation safety. The minimum amount of pilot warning and avoidance lighting necessary should be used, and unless otherwise required by the Federal Aviation Administration, only white strobe lights should be used at night. These should be minimized in number, intensity, and number of flashes per minute. Solid red or pulsating red lights should *not* be used, as they appear to attract more night-migrating birds than do white strobes.
- Electric power lines should be placed underground wherever possible, or should utilize insulated, shielded wire when placed above ground, in order to reduce bird perching and electrocution.
- Where the height of rotor-sweep area produces high wildlife collision risks, tower heights should be adjusted to lower risks.
- If wind turbine facilities absolutely must be located in areas known for high seasonal concentration of birds, it is essential that a bird monitoring program be established, with at least three years of data collected to determine peak use periods. Data may be collected by direct observation, radar, infrared or acoustic methods. When birds are highly concentrated in or near the site, turbines should be shut down until birds have dispersed.
- When older facilities must be upgraded or retrofitted, the guidelines above should be employed as closely as possible.

Ideally, a site study plan and description of turbine structural and lighting design should be submitted to Iowa DNR well in advance of final siting decisions, for review by staff wildlife experts and advisements on acceptability or suggestions for modifications and/or monitoring. Hiring a reputable environmental consultant with a strong background in bat and bird ecology is strongly recommended. A baseline inventory of wildlife and evaluation of habitat should be considered for every site under serious consideration for windfarm development. Use of National Wind Coordinating Committee study guidelines will allow for comparison with other studies. Special attention should be paid to Spring and Fall migration seasons, reviewing

migrational use of the proposed site by raptors, waterfowl, shorebirds, gulls, songbirds and bats. Upon completion and startup of wind energy generation, monitoring wildlife populations and migrations should be conducted for at least 2-3 years.

Related Links

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

http://www.fws.gov/habitatconservation/wind.pdf
http://www.nationalwind.org/publications/siting.htm
http://www.dnr.wi.gov/org/es//science/energy/wind/guidelines.pdf
http://www.aplic.org

Siting Guidelines for Wind Power Projects in South Dakota

Introduction

The South Dakota Bat Working Group in cooperation with the Department of South Dakota Game, Fish and Parks compiled these siting guidelines for wind power developers and other stakeholders to utilize as they consider potential wind power sites in South Dakota. Wind power siting and permitting processes vary by county and/or city. The Public Utilities Commission has agreed to distribute siting guidelines to all stakeholders involved in the development of wind power in South Dakota, since at this time no state environmental regulations exist in association with siting of wind turbines.

Wind siting guidelines relevant to South Dakota were adapted from the National Wind Coordinating Committee's (NWCC) Permitting of Wind Energy Facilities: A Handbook and the Kansas Renewable Energy Working Group (KREWG) Environmental and Siting Committee's Siting Guidelines for Windpower Projects in Kansas. The National Wind Coordinating Committee's guidelines are available online at the following website address: http://www.nationalwind.org/publications/siting.htm and the Kansas Renewable Energy Working Group's guidelines are available online at the following address: http://www.kansasenergy.org/krewg/reports/KREWGSitingGuidelines.pdf.

South Dakota's guidelines address activities and concerns associated with siting and permitting wind turbines. Successfully siting a wind power project often relies on trade-offs between community acceptability and economic viability, which relates to adequate communication.

Although wind power is considered "green energy," many concerns have been expressed about the effects of their presence on plants and animals native to South Dakota. Specific areas of South Dakota have been identified as potential sites for wind energy development, and these sites are located in, but not limited to, the Coteau des Prairies in eastern South Dakota and the Missouri River in central South Dakota, which are unique/rare in South Dakota. Additional areas in other regions of the state may be identified/added by ongoing studies or further infrastructure development (e.g., transmission lines and substations).

Wind energy issues in South Dakota are similar to those in other states. Most residents of South Dakota respect their local resources, wildlife, and environment, and have concerns regarding the exploitation and/or degradation of those resources. Developers, recognizing the opportunity to establish renewable energy generation facilities, may not be aware of concerns expressed by agencies, groups, or individuals regarding wind farm impacts. Each project should be evaluated on a case by case basis. Cumulative impacts will undoubtedly accrue as development proceeds within regions (e.g., Missouri River, Coteau des Prairies, Prairie Pothole) and across the state. These cumulative effects may differ in type and significance from those experienced at individual project sites. In particular, the cumulative effects on natural and biological resources, such as habitat (e.g., native prairie) and wildlife (e.g., birds and bats), require consideration from all stakeholders; however, impacts on other resources are also important. For further development and sustainability of the wind energy industry, it is important by all stakeholders to evaluate the context of the collective merits of all projects.

Most guidelines within this document are issues and concerns identified by other parties, e.g., NWCC and KREWG, which are shared in South Dakota, but some guidelines are tailored to address the concerns and issues specifically to this state. These guidelines address issues/concerns associated with the pre-construction, construction or post-construction of wind turbines and have been divided into eleven general categories:

1) Land Use
2) Natural and Biological Resources
3) Noise
4) Visual Resources
5) Public Interaction
6) Soil Erosion and/or Water Quality
7) Health and Safety
8) Cultural, Archaeological, and Paleontological Resources
9) Socioeconomic, Public Service, and Infrastructure
10) Solid and Hazardous Wastes
11) Air Quality and Climate.

The guidelines outlined in this document are neither mandates nor regulations. They have been compiled/developed: 1) to encourage developers to select potential wind sites using a process that is acceptable to all stakeholders (e.g., state agencies/departments, federal agencies, sportsmen/women groups, local communities, developers, landowners, wildlife advocacy groups, and/or tribal agencies); 2) to protect South Dakota rare/unique areas (e.g., Coteau des Prairies, Missouri River, and Prairie Potholes) and thus the state's natural beauty; 3) to minimize deleterious effects to wildlife; 4) to help provide information to all involved/interested parties; and 5) to promote a responsible, guided, uniform approach to the siting of wind power projects in South Dakota.

1) Land Use - Wind development may be compatible with a variety of other land uses, including agriculture, grazing, open space, and habitat conservation, depending on the site, size, and design of the project. Other land uses, such as hunting/fishing, bird watching, and wildlife photography as well as resource values need to be considered when siting large wind projects in remote areas of South Dakota. Stakeholders need to understand all the land use issues associated with a site before finalizing development plans, permit conditions, or other requirements.
   a) Contact resource agencies (Table 1), property-owners and other stakeholders early to identify potentially sensitive land uses and issues. Ensure that all the stakeholders fully understand the entire project in order to address and resolve potential land use issues.

   b) Look at all the land use relationships and objectives for an entire wind resource area. Land use concerns are specific to different regions of South Dakota thus early scoping and planning is crucial to reducing potentially incompatible uses. Contact appropriate experts (Table 2) and resource agencies to research and evaluate the issues prior to selecting a specific site within the respective region.

   c) Careful consideration should be given to the impact of wind power projects in areas that are unique/rare in South Dakota, such as the Coteau des Prairies, Missouri River, and Prairie Pothole regions (Figure 1), particularly in areas that are relatively unfragmented. Special care should be given to avoid damage to unfragmented landscapes and high quality remnants in wetland and prairie ecosystems (e.g., tall grass, mixed grass, and short grass prairie). If possible, wind energy development should be located on already altered landscapes, such as cultivated or developed lands. An undeveloped buffer adjacent to intact prairies is also desirable.

   d) Consider the potential impacts of both wind and non-wind (e.g., roads, transmission lines, substations) project development in the wind resource area before development projects are proposed, and develop a plan for the area that avoids or minimizes land use conflicts. Design the project site layout to limit the use of the land, consolidate necessary infrastructure requirements wherever possible, and evaluate current transmission lines and market access.

   e) Learn the rules that govern where and how a wind project may be developed in the project area. Become aware of potential conflicts between lease provisions and permitting agency (e.g., The Public Utilities Commission and/or local governments) conditions for project development.

2) Natural and Biological Resources - Bird and bat collision mortality and behavioral avoidance associated with wind energy facilities have been a controversial siting consideration. Typically, bats have a higher incidence of mortalities at wind energy sites than birds, though this depends on the site. Biological resource surveys at each potential wind power site in the early stages of planning can help determine whether serious conflicts are likely to occur at a particular site, but cumulative effects with multiple sites in a particular region/area must also be acknowledged and/or investigated and minimized/avoided. In some instances, the impact wind turbines have on birds, bats, and other sensitive biological resources can be adequately mitigated. However, wind development may be inappropriate in certain areas in South Dakota.

   a) Consider the biological setting early in project evaluation and planning. Use biological and environmental experts to conduct a preliminary biological reconnaissance of the likely site area. Communicate with personnel from wildlife agencies (e.g., South Dakota Game, Fish and Parks (SDGFP), U. S. Fish and Wildlife Service, U. S. Geological Survey, and Natural Resources Conservation Service; Table 1) and universities (e.g., South Dakota State University, University of South Dakota, Dakota State University, Black Hills State University, and Northern State University; Table 2). If a proposed turbine site has a large potential for biological conflicts and an alternate site is eventually deemed appropriate, the time and expense of detailed wind resource evaluation work may be lost.

   b) Contact the local resource management agency (e.g., local South Dakota Conservation District and SDGFP regional office, Appendix A) early in the planning process to determine if there are any resources of special concern in the area under consideration.

   c) Involve local environmental/natural resources groups (e.g., South Dakota Wildlife Federation, local chapters of Audubon Society, local chapters of The Wildlife Society, Izaak Walton League, The Nature Conservancy, South Dakota Bat Working Group, Ducks Unlimited, United Sportsmen for South Dakotans; Table 3) as soon as practicable. Early involvement of these organizations may provide additional resource information as well as minimize potential conflicts.

   d) Avoid unnecessary ecological impacts of wind power development through proper planning. Examine landscape levels of key wildlife habitats, migration corridors, staging/concentration area, and breeding/brood-rearing areas to help develop general siting strategies. Situate turbines so they do not interfere with important wildlife movement corridors and staging areas.

e) Avoid large, intact areas of native vegetation. Sites where native vegetation is scarce or absent will have substantially fewer biological resource concerns.

f) Careful review should be given to sites with legally protected wildlife (e.g., state or federal threatened or endangered species, migratory birds) present or potentially present. Recognize that other declining or vulnerable species (not legally protected) may also be present. Investigate wildlife issues associated with each potential wind energy site and determine the apparent impacts of each potential wind energy site on species of concern.

g) Avoid lattice-designed towers or other designs providing perches for avian predators. Avoid placing perches of any sort on the nacelles of turbines. Address potential adverse affects of turbine warning lights on migrating birds and bats. Minimize effects of meteorological towers when investigating wind energy potential by using tubular monopoles rather than lattice structures with guy wires and lighting systems, which could represent a hazard to birds.

h) Bury power lines and/or place turbines near existing transmission lines and substations, where possible. Infrastructure should be able to withstand periodic burning of vegetation, where prescribed burns are practiced. Minimize number of roads and fences.

i) Mitigate for habitat loss in areas where there is ecological damage in the siting of a wind power facility. Appropriate actions include but are not limited to ecological restoration, long-term management agreements, conservation easements, or fee title acquisitions to protect lands with similar or higher ecological quality as that of the wind power site.

j) Consider possible cumulative regional impacts from multiple wind energy projects when conducting environmental assessments and making mitigation decisions. Evaluation of these impacts could result in significant changes to project plans.

k) Consider turbine designs (e.g., wind turbines with tubular monopoles rather than lattice structures with guy wires) or deterrents, which minimize potential impacts on flying animals such as birds and bats.

l) Consider timing of construction and maintenance activities (including mowing) to minimize impacts on native flora (plants) and fauna (animals), including ground-nesting birds. Avoid construction and maintenance activities during breeding season (April to July) and, if possible, during migration (April – June and August – October).

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m) Develop a stringent plan for preventing the introduction or establishment of non-native/invasive flora (plants) in disturbed areas and establishing the financial means to do so the duration of the wind power project.

3) Noise - Noise emitted by wind turbines tends to be masked by the ambient (background) noise from the wind itself and tends to fall off sharply with increased distance, therefore noise-related concerns are likely to occur at residences closest to the site, particularly those sheltered from prevailing winds. Advanced turbine technology and preventive maintenance can help minimize noise during project operation.
   a) Design projects with adequate setbacks from dwelling units, especially where the dwelling unit is in a relatively less windy or quieter location than the turbine(s). Recognize that residents who object to noise created by wind energy may replace residents who support wind systems. Efforts should be made to place the turbines in disturbed areas (e.g., croplands) as stated above.

   b) Avoid locating marginally noisy turbines in projects with nearby residences. In areas potentially sensitive to acoustic levels, e.g., nearby residences or natural surroundings, consider taking efforts to prevent problems by upgrading turbines with sound reduction technology.

4) Visual Resources - There are ways to reduce the visual impact of wind projects, but there may be tradeoffs to consider. One of the best tools for assessing project impact is the use of visual simulations.
   a) Consider visual impact of wind power projects when siting turbines. Evaluate the impact of siting turbines on the quality of the surrounding landscape, especially in areas where aesthetic qualities and/or neighboring properties might be affected. Prepare and use visual simulations and/or viewshed analyses to provide information to landowners, the general public, and other key stakeholders to identify potential impacts to visual resources from wind power developments.

   b) Educate all stakeholders about what to expect from a wind project.

   c) Prepare to make impact tradeoffs and coordinate planning efforts in all jurisdictions and with all stakeholders.

   d) Listen to the communities and stakeholders in all project phases and be prepared to adapt design to minimize industrial characteristics and structures and minimize visual exposure from sensitive areas.

   e) Minimize the need for developed roads or cut and fill techniques. Consider possibilities and benefits of using roadless project designs or designs relying on current roads, especially in remote or sensitive visual areas.

f) Identify designated scenic byways and popular landscapes and avoid siting turbines in areas that are readily visible from those sites. Priority should be given to wind power projects in sites where the natural landscape has already experienced significant change from human-related causes.

5) Public Interaction - It is important to inform all stakeholders of the benefits and tradeoffs associated with each wind power project, therefore wind projects entail public involvement. This makes it easier for all stakeholders to communicate and cooperative with each other in order to make informed decisions in the best interest of all parties.

   a) Prepare and implement a public education program to discuss the benefits and tradeoffs involved in wind generation.

   b) Provide objective information or access to objective information that allows interested parties to make informed decisions. Decision making by all stakeholders is enhanced through accurate and comprehensive information sharing and opportunities for communication between stakeholders. Invite public input in regards to wind power projects through public meetings and public forums.

6) Soil Erosion and/or Water Quality - Temporary and permanent soil disturbance results from wind projects. Care must be taken to estimate and control both runoff and erosion from each wind power site, particularly in areas where access roads and facilities are located in steep terrain, especially near waterways (e.g., creeks and rivers) and wetlands.

   a) Minimize the footprint of the project and evaluate alternative turbine pad and access road siting and layouts. Minimize improved roads and construction staging areas and avoid sensitive habitats (e.g., native prairies and wetlands).

   b) Preferably conduct construction and maintenance of wind power sites when the ground is frozen or when soils are dry and the native vegetation is dormant. Conduct ongoing operation and maintenance activities, as practical, by using light conveyances in order to minimize habitat disturbance and the need for improved roads.

   c) Whenever possible, avoid road construction on steep slopes.

   d) When selecting the appropriate erosion control measures, be aware that although some measures may require greater initial expense, significant savings will occur over the life of the project in reduced maintenance and replacement costs. Furthermore, a well-developed erosion and sediment control plan may also reduce regulatory delays in approving and monitoring the project.

e) Use certified weed-free seed of local ecotypes of native vegetation when reseeding disturbed areas and consider revegetation re-growth and cover. Consider animal and plant compositions when determining the frequency and timing of mowing near turbines.

7) Health and Safety - Most of the safety issues associated with wind energy projects can be dealt with through adequate setbacks, security, safe work practices, and the implementation of a fire control plan.
   a) Consider safety setback distances from wind turbines and habitable dwellings, public highways, and property lines when evaluating specific parcels for development. Setbacks should provide adequate spacing from falling ice, blown turbine parts, and major structural failure, which can mitigate siting issues.

   b) Design facilities and turbine pads to prevent or avoid public and worker safety problems. Consider the benefits of underground wiring between turbines and project substation.

8) Cultural, Archaeological, and Paleontological Resources - During project design and site development, important cultural and fossil resource sites should be avoided and protected or else a mitigation plan should be developed. Special care should be taken to preserve the confidentiality as well as the integrity of certain sensitive resources or sites sacred to Native Americans.
   a) Identify and avoid potentially sensitive cultural, historical, or pre-historical resources and involve all stakeholders early on.

   b) Consult with the South Dakota State Historical Society (Table 1) and other qualified professional specialists familiar with cultural and fossil resources in the project development area.

   c) Some sensitive resources and sites may be confidential to Native Americans. Respect this confidentiality and work closely with tribal representatives to protect these resources by avoiding disruption to these sites.

   d) Design project site layout to avoid sensitive resources, if possible.

   e) Prepare a monitoring and mitigation plan for protection of sensitive resources during construction and operation of the project. Require appropriate mitigation of unavoidable impacts and monitor to ensure measures are implemented.

   f) Allow adequate time in the project schedule for data and specimen recovery, mapping, analysis, and reporting.

9) Socioeconomic, Public Services, and Infrastructure - Developers and other stakeholders should coordinate with local communities and/or agencies to determine how the project may affect the community's fire protection and transportation systems and nearby airports and communications systems. Communities should work with wind project developers to ensure that any financial burden placed on them will be compensated through appropriate/reasonable property tax or other revenues.

   a) Identify any community services, costs, and infrastructure that may be affected by a project and work to involve all stakeholders in solving any conflicts and designing mitigation plans. Work with all the concerned stakeholders to develop appropriate mitigation for unavoidable impacts and monitor compliance to ensure the measures are implemented. Attempt to avoid or minimize potential impacts on community services, costs, and infrastructure.

   b) House Bill 1235, passed during Legislative Session 2003, is an act to provide for the taxation of wind energy property in South Dakota, encouraging developers to build in South Dakota yet help local communities. As any changes to the property tax rate are considered, local taxing jurisdictions should seek to recover only those costs directly associated with services to the wind development to avoid discouraging new wind projects. Involve local communities in economic plan and work to be good neighbors.

   c) Recognize that some districts, counties, and/or cities do not have an established zoning and/or permitting process applicable to wind power development. Do not exploit this fact rather work with appropriate local officials to establish reasonable parameters and make the process as clear to the public as possible.

   d) Use local contractors and providers for supplies, services, and equipment, when possible, during the construction and operation phases of the project.

   e) Acknowledge that there may not be specific needs by local communities for electricity generated by the proposed wind power project, therefore substantive public benefits should be provided beyond hosting the renewable energy facility.

   f) Provide information to all stakeholders in regards to future project expansions to ensure all stakeholders have precise information. Recognize that developers may not be fully informed about future expansions and stakeholders may have issues and concerns that are dependent on the project scale.

g) Expanded projects may involve impacts not specifically addressed during the initial project. Anticipate and make provisions for future site decommissioning and restoration.

10) Solid and Hazardous Wastes - Solid wastes need to be collected from dispersed sites and properly disposed of in a manner consistent with other power plants or facilities. Non-hazardous fluids should be used where possible, and a Hazardous Materials Waste Plan should be developed if their use cannot be avoided. By performing major maintenance and repair work off-site, certain problems can be avoided.

a) Ensure that construction wastes are collected from all wind power sites and disposed of at a licensed facility. Waste disposal practices should not be different in wind power from those required at other power plants or repair facilities.

b) Anticipate fluid leaks and avoid hazardous leaks by using non-hazardous fluids. Design a Hazardous Materials Waste Plan to address avoidance, handling, disposal, and cleanup, when necessary.

c) Conduct turbine maintenance facilities and major turbine repairs off-site.

11) Air Quality and Climate - Wind projects produce energy without generating many of the pollutants associated with fuel combustion. Temporary, local emissions associated with project construction and maintenance can be minimized, and any micro-climatic impacts should be insignificant.

a) Address air quality issues potentially associated with construction and operation of the wind generation project. Mitigate any impacts during sensitive operations so the overall impact is relatively small and temporary.

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Name	Specialty	Agency	Address	Telephone	Email
Silka Kempema	Birds and Bats	SDGFP	523 E Capitol Ave Pierre, SD 57501	605-773-2742	silka.kempema@state.sd.us
Natalie Gates	Federal Wildlife Regulations	USFWS	420 South Garfield Avenue, Suite 400 Pierre, SD 57501	605-224-8693	natalie_gates@fws.gov
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Dennis Skadsen	Butterflies	SDACD/Day Co.	600 Hwy 12, Suite 1 Webster, SD 57274	605-345-4661	dennis.skadsen@sd.nacdnet.net

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Holly Downing	Dean of Dept	BHSU	Dept of Biology Jonas Rm 108 Spearfish, SD 57799	605-642-6056	hollydowning@bhsu.edu

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Rick Warhurst/Paul Bultsma	Ducks Unlimited (Great Plains)	22525 River Rd Bismarck, ND 57503	701-355-3500	rwarhusrt@ducks.org pbultsma@ducks.org
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Manager	USFWS Huron WMD	Rm 309 Federal Bldg 200 4th St SW Huron, SD 57350	605-352-5894	HuronWetlands@fws.gov

Appendix B. Acronyms used in tables and appendices.

Acronyms	**Description**
BHSU	Black Hills State University
BIA	Bureau of Indian Affairs
DSU	Dakota State University
NPWRC	Northern Prairie Wildlife Research Center
NRCS	Natural Resources Conservation Service
NSU	Northern State University
NWR	National Wildlife Refuge
SDGFP	South Dakota Game, Fish and Parks
SDACD	South Dakota Association of Conservation Districts
SDSU	South Dakota State University
SHPO	State Historic Preservation Office
USD	University of South Dakota
USFWS	U. S. Fish and Wildlife Service
USGS	U. S. Geological Survey
WMD	Wetlands Management District

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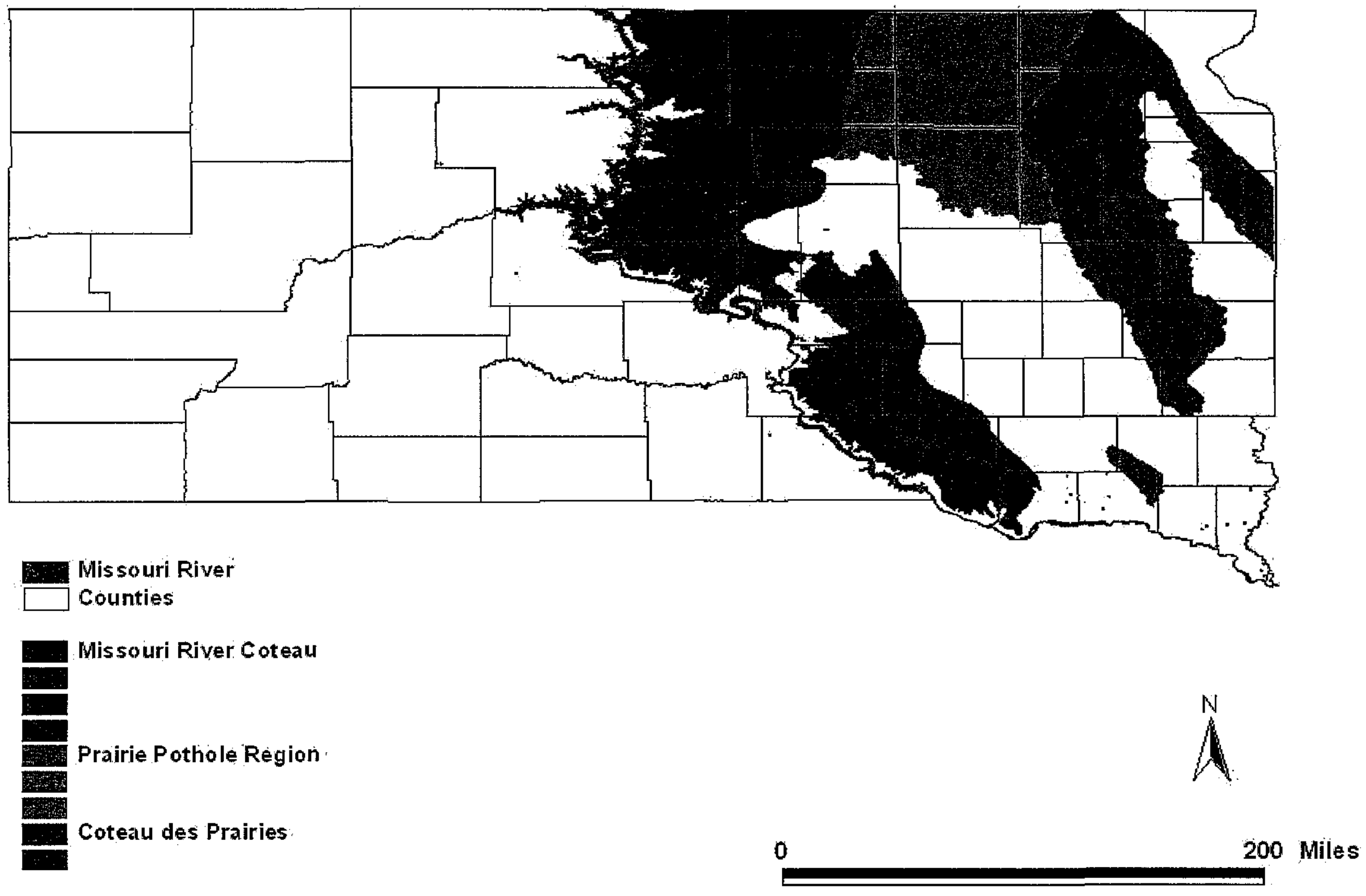
Figure 1. Regions in South Dakota: Wind Power Siting Guidelines



PRAIRIE GROUSE MANAGEMENT PLAN FOR SOUTH DAKOTA 2017–2021

Sharp-tailed Grouse

Greater Prairie-Chicken

SOUTH DAKOTA DEPARTMENT OF GAME, FISH AND PARKS

PIERRE, SOUTH DAKOTA

WILDLIFE DIVISION REPORT 2017–03

JULY 2017

ACKNOWLEDGMENTS

This plan is a product from hours of discussion, debate, effort and input of many wildlife professionals. In addition, those comments and suggestions received from private landowners, hunters, and those who recognize the value of prairie grouse and their associated habitats were also considered.

This document is for general, strategic guidance for the Division of Wildlife (DOW) and serves to identify the role that the DOW plays, how we function, and what we strive to accomplish related to prairie grouse management. By itself this document is of little value; the value is in its implementation. This process will emphasize working cooperatively with interested publics in both the planning process and the regular program activities related to prairie grouse management. This plan will be utilized by Department staff and Commission on a regular basis and will be formally evaluated at least every five years. Plan updates and changes, however, may occur more frequently as needed.

All text and data contained within this document are subject to revisions for corrections, updates, and data analyses.

Management Plan Coordinator—Travis Runia, South Dakota Department of Game, Fish and Parks (SDGFP).

SDGFP Management Plan Team— Nathan Baker, Paul Coughlin, Josh Delger, Jacquie Ermer, Casey Heimerl, John Kanta, David Mallett, Mark Norton, Tim Olson, Brian Pauly, Alex Solem, and Chad Switzer.

Recommended citation:

South Dakota Department of Game, Fish and Parks. 2017. Prairie Grouse Management Plan for South Dakota, 2017–2021. Completion Report 2017–03. South Dakota Department of Game, Fish and Parks, Pierre, South Dakota, USA.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS

CRP	Conservation Reserve Program
CREP	Conservation Reserve Enhancement Program
DOW	Division of Wildlife
FPNG	Fort Pierre National Grassland
NRCS	Natural Resources Conservation Service
SDGFP	South Dakota Department of Game, Fish and Parks
SDSU	South Dakota State University
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service

EXECUTIVE SUMMARY

Sharp-tailed grouse (*Tympanuchus phasianellus*) and greater prairie chickens (*T. cupido*), collectively hereafter referred to as prairie grouse, are the most abundant grouse species in South Dakota (SD). The vast expanses of open grassland found throughout much of SD provide ideal habitat for these two game birds. Although slight differences in micro and macro habitat requirements exist between these two species, management strategies are similar enough to warrant a single management plan for prairie grouse in SD.

As prairie obligates, prairie grouse are dependant upon grasslands for nearly all annual life cycle needs. Although weather can influence prairie grouse demographics from year to year, habitat quantity and quality have the primary influence over prairie grouse distribution and abundance. The "Prairie Grouse Management Plan for South Dakota 2017–2021" focuses on issues related to the abundance and quality of grassland habitat. This management plan also provides overview information including the history of prairie grouse in SD, general ecology, monitoring and current status, hunting season structure and authority, hunter and harvest trends, habitat trends, research and issues, and challenges and opportunities facing prairie grouse, private landowners, and wildlife managers.

The South Dakota Department of Game, Fish and Parks' (SDGFP) goal for prairie grouse management in SD is to maintain or expand sustainable prairie grouse populations by fostering partnerships, promoting grassland habitat stewardship, and applying biological and social sciences. Objectives and strategies have been developed to guide implementation of this plan.

INTRODUCTION

South Dakota is home to two species of true prairie grouse, the sharp-tailed grouse and greater prairie-chicken, hereafter prairie-chicken. Prairie grouse are medium sized (16–18 inches long, 1.3–2.2 pounds) round-bodied and short-legged game birds native to grasslands, steppe, and mixed-shrub habitats of North America. Their cryptic coloration functions as camouflage and allows the birds to blend into the grassland habitat, reducing detection from predators. The unique feathering of the legs and nostrils make them especially adapted to cold and snowy climates found in SD. The feathering of the legs and feet is more pronounced in sharp-tailed grouse, whereas the feet of prairie-chickens appear nearly featherless. Although most prominent in sharp-tailed grouse, an additional adaptation to winter weather in both species is the lateral pectinate scales on their feet which perform like snowshoes.

The primary differentiating feature between the two species of prairie grouse is the shape of the tail. Sharp-tailed grouse, like the name suggests, have tail feathers which come to a sharp point while tail feathers of prairie-chickens are gently rounded. The distinct dark barring over much of the body of a prairie-chicken also differs from the generally non-barred dark colored dorsal and light colored ventral coloration of sharp-tailed grouse. The long pinnae, or ear feathers which are erected during male courtship displays, are absent on sharp-tailed grouse. Both species of male prairie grouse have colored external air sacs located on each side of the neck which are inflated during courtship. These air sacs are purple for sharp-tailed grouse and orange for prairie-chickens.

As their name suggests, prairie grouse are found primarily within landscapes dominated by grassland habitat. The unique behavior and habitat use of prairie grouse make them an exciting game bird and valued watchable wildlife species. Most hunting occurs on open grasslands with the aid of dogs, often pointing breeds. The explosive flush of prairie grouse attracts thousands of hunters to SD each year. In 2015, nearly 13,000 hunters harvested about 50,000 prairie grouse. South Dakota is one of the few states where both species of prairie grouse can be harvested under liberal hunting regulations. Hunting is authorized from the third Saturday of September through the first Sunday in January with a combined daily bag limit of three prairie grouse.

The unique lekking behavior of prairie grouse (described below) attracts numerous wildlife viewers each year. Several viewing blinds are annually available for public use on the Fort Pierre and Buffalo Gap National Grasslands as well as Custer State Park. The amazing sight and sound of the prairie grouse courtship display is an annual sign that spring is soon to arrive on the prairies. Prairie grouse are an indicator of a functioning prairie ecosystem which suggests landscape-level habitat exists for other prairie obligate species. Prairie grouse are considered "flagship" species for conservation of prairie habitat throughout their range and in SD.

This management plan identifies and provides detailed objectives and strategies which will be used to meet the goal for prairie grouse management in SD. The future of prairie grouse in SD is primarily dependent upon prairie habitat, thus the bulk of this plan focuses on prairie habitat management. Because important prairie grouse habitat intersects many ownership boundaries, this plan addresses issues related to both public and private land. Without a doubt, many prairie-dependent species, both game and nongame, will benefit from the implementation of this plan.

HISTORICAL INFORMATION AND CURRENT DISTRIBUTION

Prior to European settlement, SD's landscape was a rolling sea of mixed and tallgrass prairie which likely supported sharp-tailed grouse nearly statewide. Sharp-tailed grouse are considered a landscape species which requires substantial grassland habitat at a landscape level to persist (Hanowski 2000). Mass conversion of grassland to cropland has reduced the distribution of sharp-tailed grouse particularly in southeastern SD. The current distribution of sharp-tailed grouse includes nearly all of western SD and about half of the eastern portion of the state (Figure 1). Although sharp-tailed grouse still occur in every county west of the Missouri River, conversion of prairie to cropland has undoubtedly reduced their abundance west river and statewide.

Prairie-chickens may have been native to portions of eastern and central SD in limited numbers prior to European settlement (summarized in Flake et al. 2010). While conversion of prairie to cropland strictly reduced the distribution and abundance of sharp-tailed grouse, prairie-chickens actually expanded in distribution and increased in abundance when portions of the landscape were converted to cropland. Prairie-chickens benefit greatly when waste grain from agricultural fields is available in northern states such as SD. As European settlement and associated agriculture marched north and west across the prairies, prairie-chicken populations exploded and "followed the plow" all the way to prairie Canada (Johnsgard and Wood 1968, Houston 2002). During the early 1900s prairie-chickens could be found nearly statewide in SD. It is likely that they benefited from the extirpation of bison which resulted in the associated temporary increase in vegetation height across the state. The distribution and abundance of prairie-chickens probably peaked at the turn of the 20th century (Johnsgard and Wood 1968). It became quite apparent that a landscape dominated by grasslands with interspersed cropland provided ideal habitat for prairie-chickens.

The range of prairie-chickens quickly declined as agriculture became too intense and cattle grazing reduced grass height over much of their newly acquired range. As prairie-chickens are also landscape species, their current distribution occurs where large tracts of native prairie remain, mostly in central SD (Figure 2). Prairie-chickens are thought to be limited within SD by lack of grassland habitat in the east and grass height in the west.

Although prairie grouse are primarily birds of the open prairies in SD, one exception is the Black Hills National Forest. Sharp-tailed grouse do occur in the Black Hills, primarily within herbaceous openings such as those created by wildfires or timber harvest. The Black Hills were historically less wooded and probably had greater amount of suitable habitat for sharp-tailed grouse.

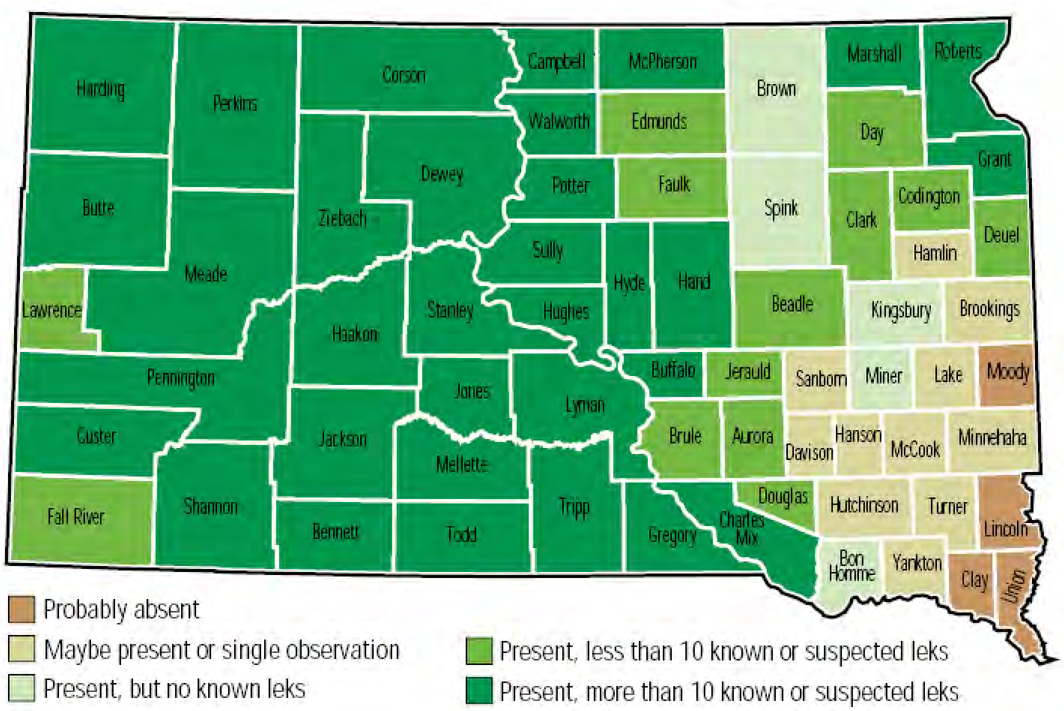


Figure 1. Distribution and general abundance of sharp-tailed grouse in South Dakota (Flake et al. 2010).

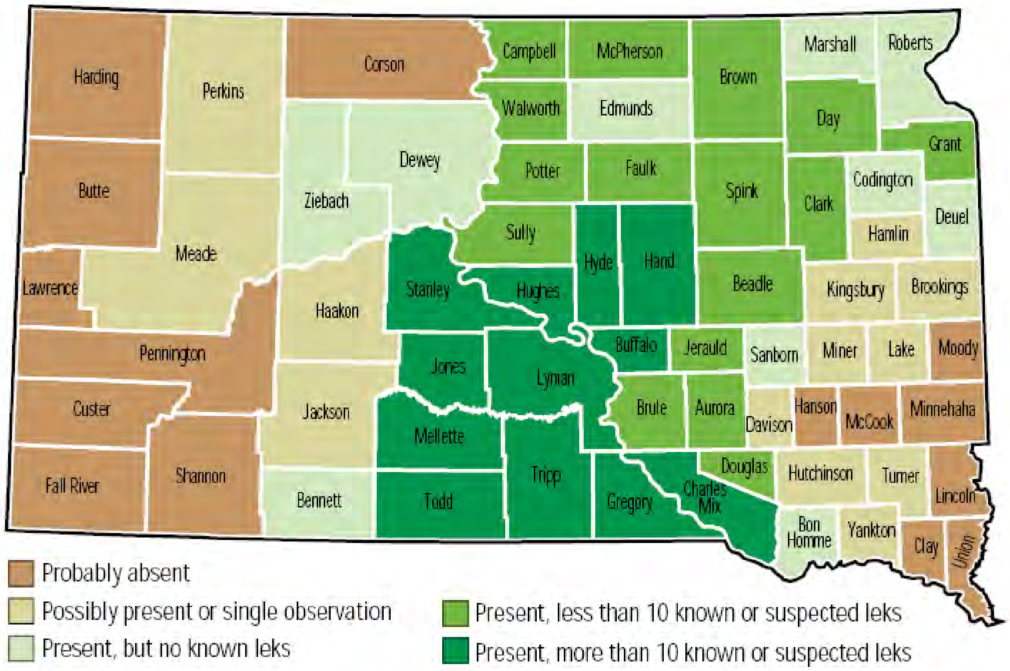


Figure 2. Distribution and general abundance of greater prairie-chickens in South Dakota (Flake et al. 2010).

PRAIRIE GROUSE ECOLOGY

Leks, also known as "dancing grounds" for sharp-tailed grouse and "booming grounds" for prairie-chickens, are located in areas of high breeding potential and typically exist within centers of large tracts of suitable prairie habitat (Merrill et al. 1999, Niemuth 2000, Hanowski et al. 2000). Leks are the focal point for reproductive ecology and behavior in prairie grouse. Prairie grouse leks are typically located on knolls or on a gentle rise, although prairie-chicken leks are sometimes located on flat bottomlands such as a dry wetland. Males gather on leks primarily during spring to defend territories and attract females during the breeding season. While it is not unusual for hens to visit several leks during a single season, males typically attend one lek each year and likely return to the same lek year after year.

In SD, male prairie grouse begin defending territories on leks as early as late February with peak activity coinciding with peak hen attendance in early April. Sharp-tailed grouse display behavior involves rapid foot stomping, rapid tail vibrations (tail rattling), inflation of purple air sacs, and aggressive face-off behavior with other males. Prairie-chickens raise their pinnae and tail feathers while producing loud booming noises by inflating their orange external air sacs. Aggressive behavior between males is common, with some males even leaping several feet in the air during face-offs. The booming noise made by male prairie-chickens can be heard from several miles away during calm conditions.

Lekking activity can start well before daylight and last for several hours. Leks are attended during evening, although duration and display behavior is usually less intense. Male sharp-tailed grouse may also defend territories on leks during fall, although duration and intensity of display behavior is minimal. Lek attendance during fall is thought to be important in recruiting young males that did not establish a territory during the previous spring.

Hen prairie grouse may attend several leks before selecting a male for copulation. After breeding, hen prairie grouse will not visit a lek again unless her nest is destroyed. Most hen prairie grouse will initiate a nest within a few miles of the lek they visited for breeding, although some may nest 10 mi away or farther. Nest initiation typically occurs within several days to a week after copulation.

Mean nest initiation date was April 22 during a 3-year study on the Fort Pierre National Grassland (FPNG) (Norton 2005). First nests of the year are usually located in residual grass or herbaceous vegetation, and sometimes under a small shrub such as western snowberry (*Symphoricarpos occidentalis*), as green up has yet to occur (Eng et al. 1988). First nest clutches typically contain 14 dull brown eggs (Norton 2005). Incubation begins before the last 1–2 eggs are laid and continues for 23 days. Nest success has been found to be higher when residual cover conceals the nest and the landscape consists of primarily intact grasslands (Frederickson 1995, McCarthy et al. 1998, Ryan et al. 1998,). Mammalian predators are the primary cause of nest loss, although nest success of 80% has been documented on the ideal and intact habitat of the FPNG (Norton 2005). Hens may re-nest up to three times if previous nests are destroyed, but clutch size and egg size decreases with subsequent nesting attempts.

Although incubation begins before the last egg is laid, all eggs hatch concurrently after 23 days of incubation. Newly hatched chicks will remain in the nest bowl for about a day before the hen leads the brood to habitats containing plentiful insects, primarily areas with abundant forbs such as non-native sweet clover (*Melilotus spp.)* and other native wildflowers. By 10 days of age, young grouse are capable of short flights and by 8–10 weeks they resemble adults in size. Chick survival was found to be about 36% during a 3-year study on the FPNG (Norton 2005). Young-of-the-year grouse will remain in loose family groups well into the fall. Only female prairie grouse provide parental care for nests and young.

During spring and summer, adult prairie grouse spend a majority of their time in grasslands including grass and alfalfa hay fields. Their diet consists of plant material such as seeds, berries, and buds but can also include insects. During fall, prairie grouse form flocks which may contain both species and remain together through winter. Prairie grouse also utilize waste grain from agricultural fields, mostly during fall and winter. Waste grains from agricultural crops are used by sharp-tailed grouse, but are not necessary for winter survival; however, waste grains likely contribute to prairie-chicken survival and persistence in some landscapes. In SD, prairie-chickens likely rely on waste grains during winter and remain within 1–2 mi of this food source during the entire winter. The interaction between agriculture and prairie-chicken distribution and abundance is described in detail in the historical information section.

Prairie grouse are well-adapted to survive severe winter weather in open grassland habitat. During winter, prairie grouse use woody cover for shelter or simply roost in the snow. This unique behavior of snow roosting protects prairie grouse from harsh winds and blowing snow in open habitats. Sharp-tailed grouse will occasionally roost in trees during winter. As winter transitions to spring, large flocks of prairie grouse disperse across the landscape in preparation for the breeding season.

SURVEYS AND MONITORING

Traditional Lek Surveys

The most widely used method to survey prairie grouse throughout their range is the spring lek survey. Male attendance on leks is relatively stable throughout the breeding season while female attendance is highly variable and exhibits distinct peaks. In SD, observers search established survey areas which are approximately 40 mi^2 for prairie grouse leks and count all males attending each lek. The number of males/mi^2 is tracked from year to year and is considered an index to the spring population. Currently, 10 traditional surveys (Figure 3) are conducted annually throughout the state. These surveys have been conducted since the 1940s, although consistent protocol and routes were not established until the early 1950s. From that time forward, direct comparisons can be made (Figure 4).

Occupancy Modeling

Data collection began in 2014 to develop a spatially explicit habitat-based occupancy model. Results of the model will be used to develop an expected distribution map for prairie grouse which could be used to focus conservation efforts and prioritize certain geographic areas. The model will be developed by determining presence or absence of prairie grouse leks on 1 mi^2 sample units across the state. Samples were spatially balanced across the state and occurred along a gradient of landscape-level grassland availability. Each 1 mi^2 area is searched 2–3 times per year and the final presence/absence data set will be used in conjunction with landscape level covariates to develop an occupancy model. A total of 423 sections were searched from 2014–2016 field seasons. Results from this modeling effort could also be used to develop an improved monitoring framework. A final report for data collected from 2014–2016 is expected in 2018.

Age Ratio Surveys

Wings from hunter harvested prairie grouse are also collected during the first two weeks of the season at wing collection boxes located west of the Missouri River. (http://www.gfp.sd.gov/hunting/small-game/prairie-grouse-wing-boxes.aspx). Hunters are encouraged to place one wing from each harvested grouse in 1 of 18 collection boxes. Each wing is identified to species (sharp-tailed grouse or greater prairie-chicken) and aged (adult or hatch year) to determine species harvest distribution and age ratios. The ratio of hatch year to adult grouse can be used to gauge production during that specific year (Figure 5). Biologists use these data to relate grouse production to weather variables to predict grouse production in future years.

Figure 3. Prairie grouse traditional lek survey areas.

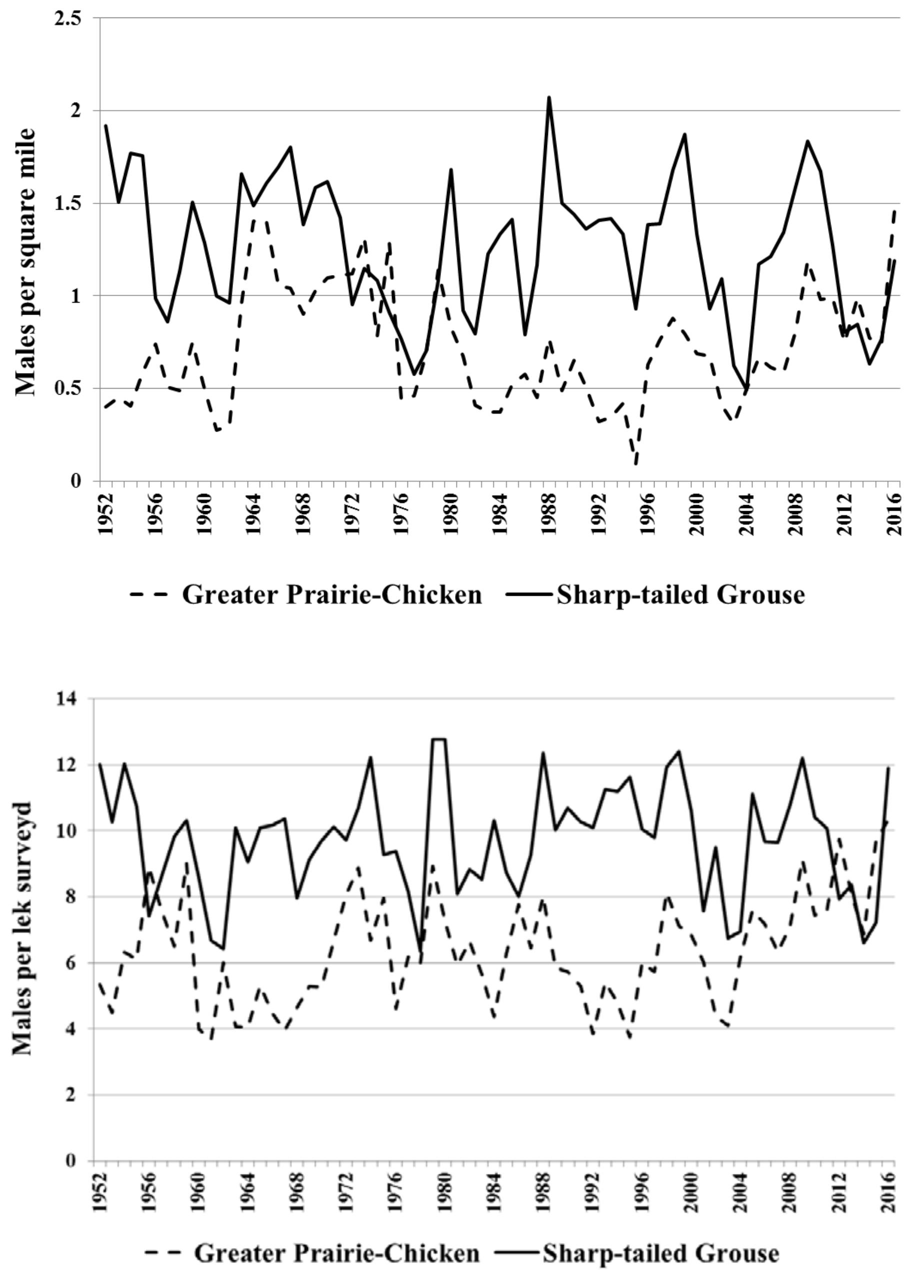


Figure 4. Results of prairie grouse traditional lek surveys 1952–2016.

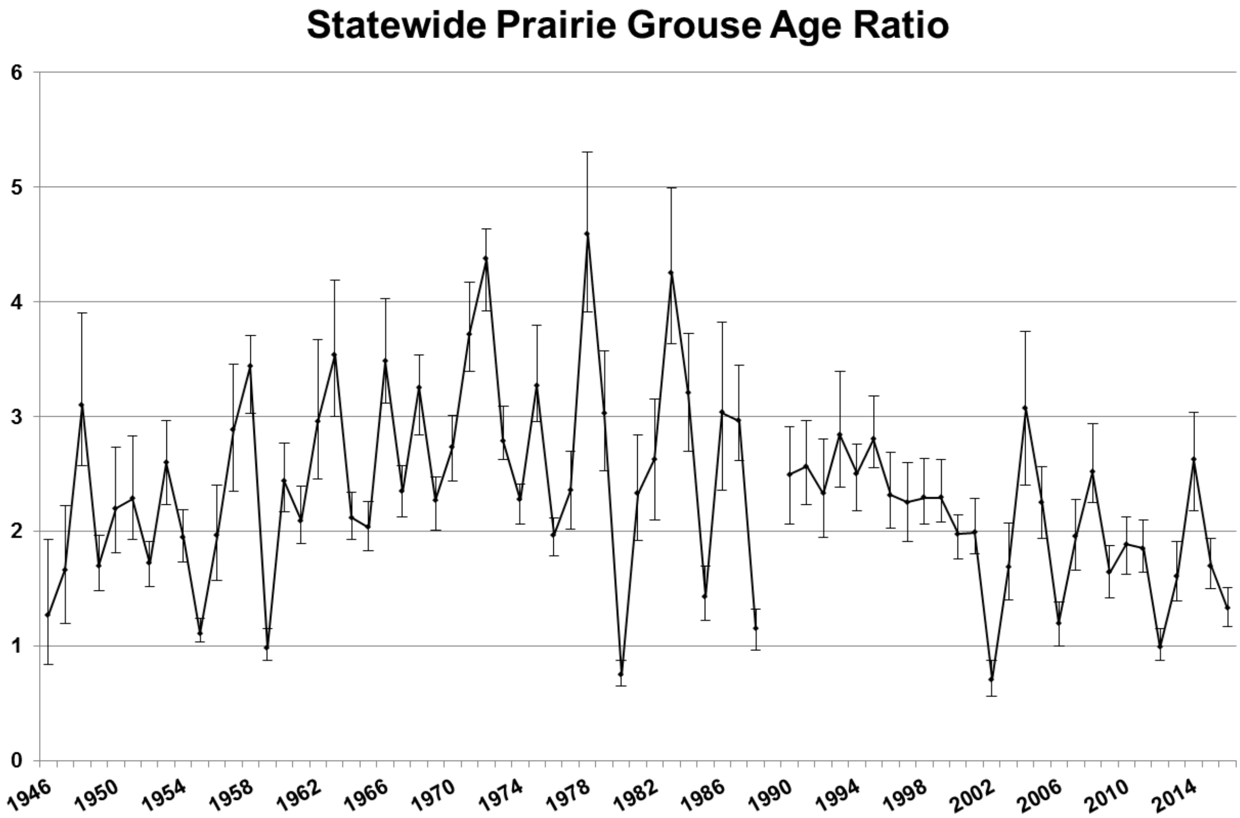


Figure 5. Statewide prairie grouse age ratio (± 95% confidence interval) from fall hunter-harvested sharp-tailed grouse and greater prairie-chickens 1946–2016.

PRAIRIE GROUSE RESEARCH

Rice and Carter (1982) investigated the relationship between grassland management practices and their subsequent influence on prairie grouse populations on the FPNG from 1974–1978. Specifically, they evaluated grazing regimes and resulting residual grass available to nesting grouse. Comparisons were made among rest-rotation, deferred-rotation, winter pasture, bull pasture, and wildlife areas. Prairie grouse production was compared among systems and related to available grass cover. Rest-rotation systems included a series of pastures in which one pasture was rested for an entire year. The pasture grazed last was the rested the following year. The deferred-rotation systems consisted of a series of pastures, which were all rotationally grazed once during the growing season. The wildlife area was not grazed during the study. Bull pastures were stocked at very low density. The winter pasture was not grazed during the growing season.

The rest-rotation ungrazed pastures, winter pastures, and bull pastures yielded the most nests-broods/acre and also possessed the highest amount of residual cover for nesting. Even when grazed rest-rotation pastures were included in analyses, rest-rotation pastures had more nest-broods/acre than deferred rotation pastures. The wildlife area study plots had among the highest amounts of residual grass, but much of the grass was produced on lowland sites which prairie grouse avoided for nesting.

The key finding of this study was that grazing systems which produced at least 900 lbs/acre of forage provided adequate residual cover for prairie grouse nesting and brood rearing. The authors recommended rest-rotation and winter grazing systems be used on the FPNG as a way to boost local prairie grouse populations.

Fredrickson (1995) evaluated the success of a prairie-chicken reintroduction effort during 1985–1989. Prairie-chickens were captured on the FPNG and Lower Brule Indian Reservation and released in south-central McPherson County during 1986–1988. Birds were fitted with radio collars and tracked to determine survival, home range, and habitat use. The reintroduction effort was deemed unsuccessful as no prairie-chickens were observed in the release area for 5 years (1989–1993) following the last year of releases. Cause for the lack of success in the release area was attributed to habitat deficiencies, particularly during winter. Most of the released prairie-chickens traveled up to 20 mi during winter to find adequate croplands for winter food that were adjacent to high quality grassland for roosting. Within the release area, adequate grass cover was lacking near available crop fields. Most of the migrating prairie-chickens were killed by predators before they could return to the release area after each winter.

Norton (2005) estimated prairie-chicken and sharp-tailed grouse brood habitat use, nest success, and hen and brood survival on the FPNG during 2003–2005. Overall combined nest success was approximately 75%, which is one of the highest estimates ever recorded. Breeding season hen survival was approximately 82% during the three-year study. Brood survival was also an astonishing 85% and chick survival was estimated at 36%. Prairie grouse broods avoided the use of smooth brome and selected for forb cover such as sweet clover. This study demonstrated how prairie grouse can exhibit very high reproductive potential in landscapes dominated by well managed grasslands.

Kirschenmann (2008) studied the spatial ecology and harvest of prairie grouse on the FPNG during 2003–2005. Mean home range size for hens with broods was 184 ha for sharp-tailed grouse and 174 ha for prairie-chickens. Mean distance from lek of capture to nest sites was 1.98 km for prairie-chickens and 2.03 km for sharp-tailed grouse. Hens of both species selected pastures that were not grazed the previous year. Only 17 of 209 (8.1%) marked adult prairie grouse were reported as harvested by hunters during the 3-year study. Dog training had minimal impacts on prairie grouse behavior. Flushing distance was similar between areas open and closed to dog training. Results of this study indicate repeated flushes from dog training did not cause prairie grouse to exhibit more "wild" behavior during the hunting season.

Runia (2009) investigated how large-scale land use affects the distribution and abundance of prairie grouse in northeastern SD with an emphasis on the influence of CRP. Land use surrounding prairie grouse leks was compared to land use surrounding non-lek locations at several spatial scales. Landscapes surrounding prairie grouse leks contained higher proportions of pasture and CRP at several spatial scales. Spatially explicit habitat suitability models also were developed in a geographic information system to predict which landscapes are most likely to support prairie grouse leks. Strongest models occurred at the 1 mile scale which is similar to other similar studies (Merrill et al. 1999, Niemuth 2000). A similar study documented landscape level habitat characteristics associated with prairie-chicken leks on the extreme eastern fringe of their range (Orth 2012). Orth (2012) documented the need for a higher proportion of grassland on the landscape needed for lek locations, as well as, the avoidance of trees and wetlands within ½ mile of the lek location.

A recently completed research project collected base line data on a pre-construction wind energy site in central SD (Runia and Solem 2015). A control site (wind energy development not anticipated) with similar landscape characteristics was used as a comparison. Annual survival was 44% and nest success was 31%. Survival and nest success were similar between sharp-tailed grouse and prairie-chickens. Prairie grouse hens selected for nest sites within grassland dominated landscapes and avoided trees when considering only macro-scale habitat variables. This study demonstrated that prairie-chickens and sharp-tailed grouse select for and are most successful in tracts of unfragmented grasslands for reproduction. The study will be repeated if wind energy development occurs.

From 2009–2015, Geaumont and Graham (2015) studied the relationship between grassland habitat attributes and sharp-tailed grouse reproductive success on the Grand River National Grassland. Similar to past studies, they found sharp-tailed grouse selected for and were more successful using areas with taller grass for nesting and brood-rearing. Estimated overall nesting success with average habitat covariate values was 52%. Brood survival to 60 days was 55% based on average habitat covariate values. Maximum grass height was 8.2 inches for nest sites and 7.3 inches at random locations. For broods less than 14 days old, maximum grass height was 8.6 inches and 8.2 inches at random locations. For broods older than 14 days old, maximum grass height was 10.0 inches and 8.9 inches at random locations.

HUNTING SEASON STRUCTURE AND AUTHORITY

Hunting is currently authorized from the third Saturday of September through the first Sunday in January (Administrative Rule 41:06:09:01) with a combined daily bag of three prairie grouse (Administrative Rule 41:06:09:03). The season and bag limit is set by the SDGFP commission on a 3-year cycle with the next two cycles occurring in 2017 and 2020.

The current hunting season structure has very little impact on the long-term population. Hunting mortality is thought to be mostly compensatory because prairie grouse are short-lived, have high reproductive potential, and are subject to a relatively low harvest rate. Only 2 out of 195 marked female prairie grouse were harvested by hunters during a 3-year study in Hyde and Hand counties (unpublished data from Runia and Solem 2015). Only 17 out of 209 marked adult prairie grouse were harvested during a 3-year study on the FPNG (Kirschenmann 2008). Hunter harvest would have very little, if any, impact on the population at these observed harvest rates (Powell et al. 2011). Prairie grouse have a large distribution in SD and local populations likely respond to environmental and local habitat conditions.

Prairie grouse hunting is most popular during the first few weeks of the season based on license sales and field staff observation. During the first few weeks of the season, prairie grouse are loosely scattered across the landscape in small coveys and family groups which is favorable for hunting. As the season progresses, flock sizes increase and hunting success generally declines sharply. Prairie grouse hunting pressure declines after the first few weeks in response to lower success and as hunters shift effort to other upland game such as pheasants. Some broods may not be fully grown if the season started earlier in the season, and a later start date could sacrifice some of the most productive days of the season. An earlier start date could also make it more difficult to differentiate between prairie grouse and young pheasants. The current bag limit is thought to be socially and biologically acceptable. For these reasons, the SDGFP does not foresee any major recommended changes to the current hunting season structure. The SDGFP will continue to monitor the population, examine hunting statistics, and review public and SDGFP staff input when developing hunting season recommendations.

HUNTER & HARVEST TRENDS

Prairie grouse hunters and harvest have been estimated annually by analyzing response from hunter survey cards since 1945. Hunter and harvest numbers have been steadily declining since 1975 (Figure 6). In 2016, an estimated 7,879 resident and 5,386 non-resident prairie grouse hunters harvested approximately 56,888 prairie grouse. Although harvest is a summation of both species of prairie grouse, prior to 2006, 60% of the bag was thought to be sharp-tailed grouse. Much of the prairie grouse harvest occurs in the central and western portion of the state (Figure 7). In 2006, hunters were asked specifically how many of each species of prairie grouse they harvested. Results from this survey revealed the 2006 harvest was approximately 76% sharp-tailed grouse, 20% prairie-chickens, and 4% unknown.

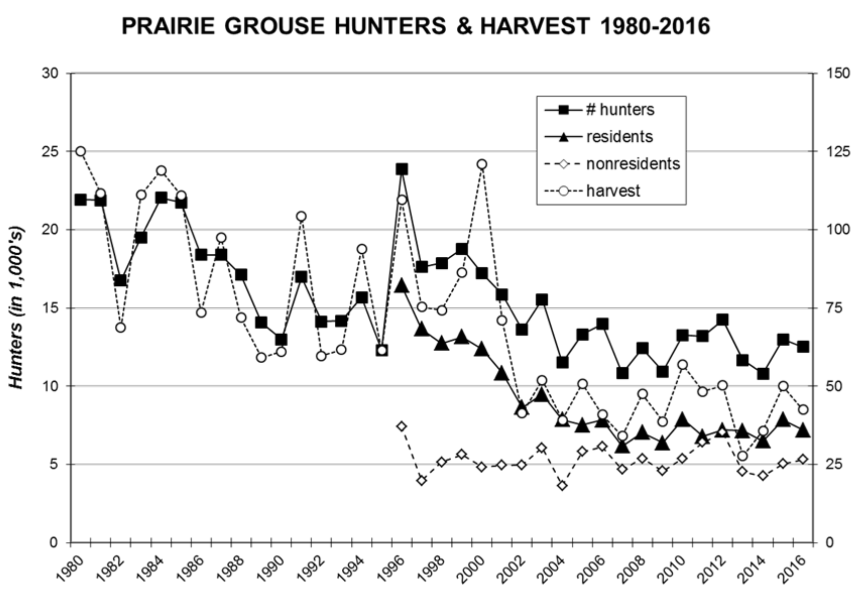


Figure 6. Prairie grouse hunters and harvest, 1980–2016.

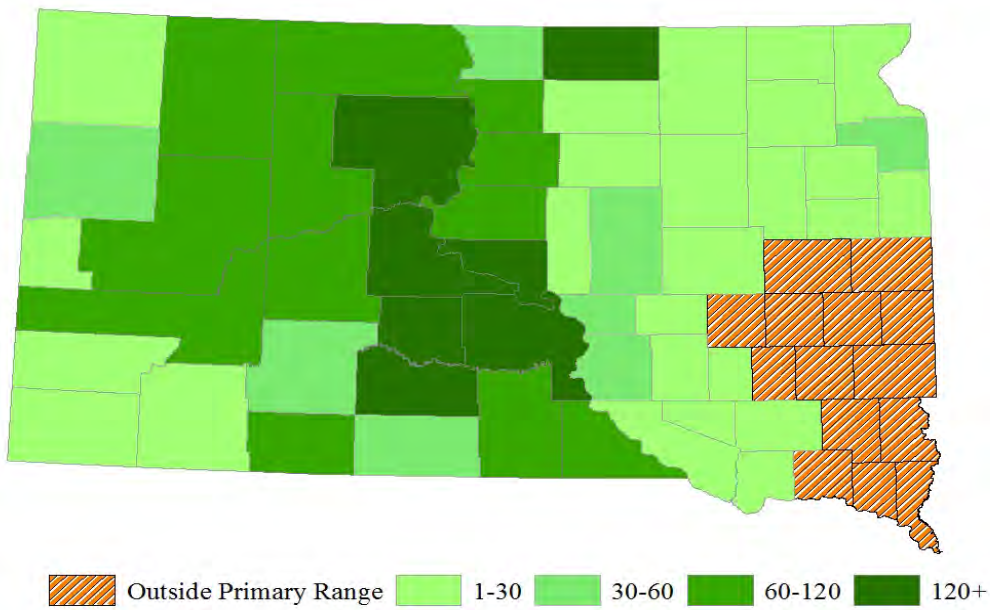


Figure 7. Average prairie grouse harvest/100 mi^2, 2006–2015.

HABITAT TRENDS

Prairie grouse require landscapes that contain a high percentage of grassland to persist (Merrill et al. 1999, Hanowski et al. 2000, Niemuth 2000). Since European settlement, grasslands have become one of the most imperiled ecosystems in the Great Plains primarily due to conversion to cropland (summarized in Samson et al. 2004). Range wide, severe loss of native grasslands has resulted in a decrease in abundance and distribution of prairie grouse (Johnsgard and Wood 1968) and these declines continue (Silvy and Hagen 2004). Sharp-tailed grouse were once found in 21 states, but habitat loss has reduced their range to portions of 11 states. Prairie grouse are prime examples of how large-scale land use changes can influence the distribution and abundance of landscape prairie obligates. Further conversion of grassland to cropland has been identified as a primary threat to prairie grouse throughout the northern Great Plains (Vodehnal and Haufler 2008).

South Dakota's landscape has changed substantially since European settlement in the late 1800s. Early settlers found the rich soils of eastern SD to be very productive for agricultural crops and quickly converted much of the grassland landscape to cropland. Conversion of grassland to cropland was more intense in the far eastern portion of the state because of higher annual precipitation. More recently, high commodity prices fueled by the ethanol industry and improvements in agricultural technology (e.g. improved crop genetics) have resulted in mass conversion of grassland to cropland in SD (U.S. GAO 2007). Total cropland in SD increased by nearly 2.8 million acres in the last 40 years (USDA NASS 2017, Figure 8) as more land, primarily grasslands, have been converted to cropland.

During the 15-year period of 1982–1997, 1.82 million acres of grassland were converted to cropland (U.S. GAO 2007). A more recent study found 1.84 million acres of grassland were lost, primarily to conversion to cropland, from 2006–2012 (Reitsma et al 2014). Wright and Wimberly (2013) estimated 450,000 acres of grassland were converted to corn or soybeans between 2006 and 2011. Grassland to cropland conversion continues at a rate of approximately 50,000 acres per year (Stubbs 2007) and the rate of conversion appears to be accelerating (Rashford et al. 2011). Using these statistics, it is reasonable to say that SD has lost an estimated 4.5 million acres of grassland to cropland conversion since the early 1980s. Much of the recent conversions are occurring within the Missouri Coteau (Stubbs 2007, Stephens et al. 2008) which also represents the eastern fringe of the prairie grouse range in SD. This region contains vast grasslands that are vulnerable to future conversion (Stephens et al. 2008, Rashford et al. 2011).

Bauman et al. (2016) recently completed a fine-scale inventory of all undisturbed grasslands in eastern South Dakota delineating remaining tracts of native sod grasslands, which are potentially important prairie grouse habitat on the fringe of their range. Overall, 5,488,025 acres (24.2%) of the approximately 22.6 million acres in eastern SD were designated as potentially undisturbed. Nearly 1 million acres of the approximately 5.5 million acres of undisturbed land (17.5%) had some level of permanent conservation protection status. In total, they identified 962,734 acres of undisturbed habitat that is protected from future conversion, representing only 4.3% of eastern SD's total land base. While all grassland represent prairie grouse habitat, undisturbed grasslands are particularly important, especially when the diverse native plant community still persists.

While grasslands are being converted to cropland at alarming rates, there is interest by landowners to keep land in grassland in perpetuity. In fact, as of October 2015, 650 landowners representing 203,000 acres were on the waiting list to enroll their land in a perpetual grassland easement through the U.S. Fish and Wildlife Service (USFWS; Bill Mulvaney, personal communication). Recent funding allows for approximately 21,813 acres of enrollment annually and 903,589 acres are currently protected by grassland easements in SD.

Conversion of grassland to cropland has been substantial, but the Conservation Reserve Program (CRP) authorized under the 1985 Farm Bill has returned some cropland to grassland (Figure 9). Through this program, landowners receive an annual rental payment to convert eligible cropland to perennial cover (mostly grass) for 10–15 year contracts. As of October 1, 2016, SD had 972,000 acres of CRP. As much as 1.77 million acres of CRP has been enrolled at one time in SD which occurred in 1995. Although CRP can benefit prairie grouse (Rodgers and Hoffman 2005, Nielson et al. 2006, Runia 2009), it represents a short-term solution to a long term habitat loss problem.

In addition to declines in grassland habitat quantity, invasive plant species have also reduced grassland habitat quality across SD. Non-native grasses such smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), and crested wheatgrass (*Agropyron cristatum)* compete with native grasses and provide lower quality habitat than native plant communities. Moreover, invasive weeds such as Canada thistle (*Cirsium arvense*) and leafy spurge (*Euphorbia esula*) are difficult to control and can become dominant if not managed. Fire suppression also has allowed encroachment of woody species such as eastern red cedar (*Juniperus virginiana*) into otherwise open grasslands, thereby reducing or even eliminating prairie grouse habitat. Loss of grasslands to invasive eastern red cedar along the Missouri River breaks and in similar landscapes along its larger western tributary rivers (e.g. White River and Cheyenne River) has gotten the attention of both the ranching community and wildlife managers.

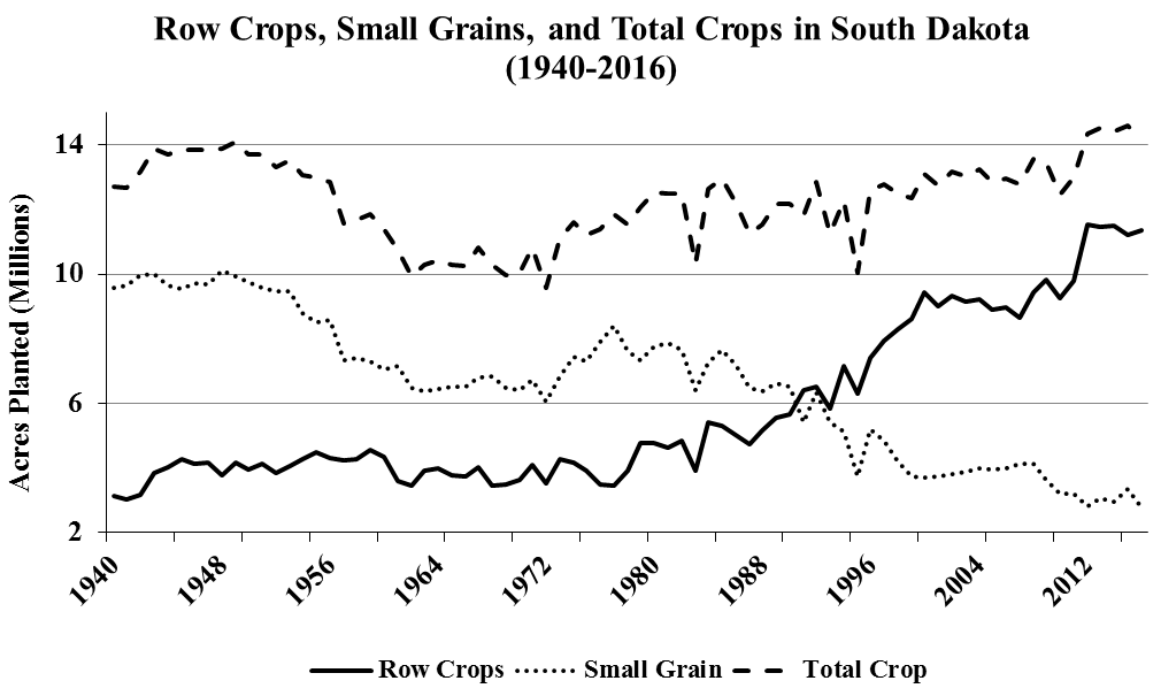


Figure 8. Total cropland in South Dakota 1940–2016 (USDA NASS 2017).

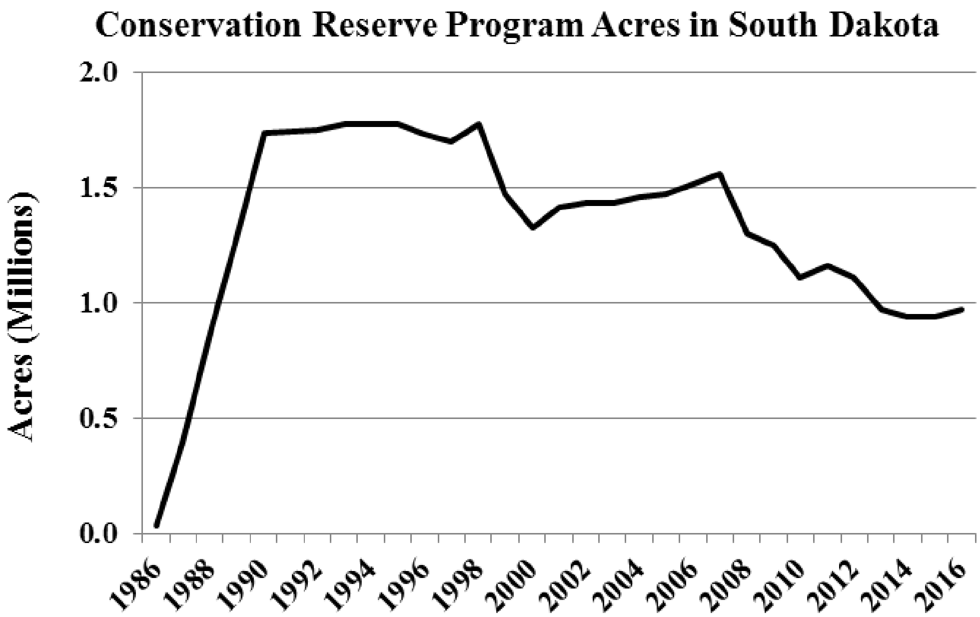


Figure 9. Total Conservation Reserve Program acres in South Dakota 1985–2016.

HABITAT BEST MANAGEMENT PRACTICES

Prairie grouse require large blocks of unfragmented grassland to persist. Prairie grouse use grasslands during all seasons, but they are particularly critical during the breeding, nesting, and brood-rearing season. The following Best Management Practices apply primarily to occupied prairie grouse habitat, but some could also be applied to areas where there is a desire to restore suitable habitat in currently unoccupied areas. Occupied habitat can be difficult to define, but areas within 5 mi of active leks, especially grasslands, could generally be expected to be occupied by prairie grouse. Best Management Practices for prairie grouse habitat may not be Best Management Practices for all wildlife species. The following list was developed using best available science and expert opinion.

- Maintain existing grasslands as grasslands (e.g., do not convert to cropland), especially unfragmented tracts within occupied prairie grouse range.

- Restore grasslands within occupied range and in areas where current grassland availability does not support prairie grouse.

- Use high diversity mixes of native grasses, forbs and shrubs for restorations and establishments. Some introduced forbs may be appropriate for some ecological sites but should be selected judiciously.

- Manage existing grasslands with disturbance regimes (grazing, fire) that encourage growth of diverse communities of native grasses, forbs and shrubs. Livestock grazing, particularly when part of a well-designed rotation or system that results in multiple levels of vegetation height and structure, is compatible with prairie grouse habitat needs. Management regimes that result in 8−12 inches of maximum residual grass height during normal conditions are adequate for providing concealment for nesting and slightly taller growing vegetation for brood rearing. Rotational grazing could be designed to provide adequate residual cover on at least some pastures or paddocks within a larger operation. Local climate, weather, and ecological conditions may limit site-specific forage production, which could make residual cover goals less practical or even unattainable during some years or in some locations.

- Use spot spraying herbicide application in lieu of field-level herbicide applications to control noxious weeds.

- Delay grassland haying until after the primary nesting season (after July 30). Haying is generally less effective at maintaining plant diversity and desirable nesting and brood rearing habitat structure than managed grazing or prescribed fire.

- Cropland retirement programs such as CRP are beneficial to prairie grouse. Short-term cropland retirement programs such as CRP should be prioritized to the current breeding range, or areas where the addition of grassland is expected to expand the range. Periodic management such as prescribed fire once every 3 years and/or grazing once every other year should occur to maintain plant diversity and desirable nesting and brood rearing habitat structure.

- Avoid establishing trees within large blocks of existing grasslands, especially native prairie within the occupied range. Remove encroaching trees from grasslands, especially ecological sites within native prairie where trees did not historically occur.

- Remove abandoned buildings which could harbor mammalian nest predators.

- Avoid activities near (~ 2 mi) lek sites that could interrupt lekking and nesting activity from March 1–July 30. If disruptive activities cannot be avoided, limit disruptive activities to three hours after sunrise to one hour before sunset. Disruptive activities could include but are not limited to well drilling and operation (water or energy development), burying pipeline or other utilities, building roads, vehicle traffic, direct disruption by human presence, wind tower construction and operation, or low flights by air craft or drones.

- Avoid development (e.g., roads, power lines, structures, energy development) in grasslands within occupied range, especially within 1 mi of lek sites. Where development occurs within occupied range, leks within 5 mi of development should be monitored indefinitely.

ISSUES, CHALLENGES, AND OPPORTUNITIES

Loss of grassland habitat, primarily through conversion to cropland, is currently and will be the primary threat to prairie grouse in SD. History has demonstrated how prairie grouse population declines are linked to landscape level land use changes. Because SD's landscape changes are driven by many factors, it will be challenging to slow these habitat trends. With challenges also come opportunities, and many opportunities do exist to maintain, manage, and restore prairie grouse habitat on private and public land in SD.

Partnership-based programs and initiatives which promote sound stewardship of grasslands on private lands are essential to management of prairie grouse habitat. The partnerships among SDGFP, USFWS, Ducks Unlimited, Pheasants Forever, Bird Conservatory of the Rockies, and the Natural Resources Conservation Service (NRCS) to station biologists in NRCS and USFWS service centers has been a successful way to expedite delivery of grassland conservation programs. It will be imperative to continue to support the efforts of the SD Grassland Coalition in their mission to improve stewardship of grasslands through sustainable and profitable management. It is important for the SDGFP to continue to promote grazing stewardship practices through cost-share for department programs. For further information about SDGFP programs and other habitat resources, visit the Habitat Pays web site (http://habitat.sd.gov/).

There are opportunities to promote and advocate for local, state, and national policies which would be favorable to prairie grouse habitat. Federal policies, particularly Farm Bill provisions, can have huge influences on landuse decisions. Participation in a variety of technical committees, working groups, joint ventures, advisory boards, and associations will assure prairie grouse habitat needs are included in decision making processes. It is critical to sustain working relationships with other public land management agencies, such as U.S. Department of Agriculture Forest Service, US Bureau of Land Management and SD School and Public Lands, to foster similar land use goals which benefit prairie grouse and other prairie obligate species.

South Dakota has been identified as one of the top geographic locations for wind energy development within the United States. According to the U.S. Department of Energy, SD's resource potential for wind energy includes vast areas with wind power classifications of good to superb (Figure 10). As of February 21, 2017, SD had 13 operational wind energy projects capable of generating 884 MW of power (SD PUC 2017). Many of SD's large intact grasslands occur in areas of high wind potential such as the Missouri Coteau and vast areas of western SD. Wind energy development has occurred in occupied prairie grouse habitat and future development is likely. It will be imperative to work with wind energy developers to minimize potential impacts on prairie grouse habitat from wind energy development.

The impacts of wind energy on greater prairie-chickens are generally equivocal and the impacts on sharp-tailed grouse have not been studied. Greater prairie-chicken lek persistence was ~0.5 for leks <0.62 mi from a turbine, ~0.9 for leks 1.86 mi from a turbine, and >0.95 for leks ≥3.73 mi from a turbine during the 3-year post-construction period for a study in Kansas (Winder et al. 2015a). The rate of lek abandonment was 3× higher for leks <4.97 mi from a turbine compared to leks ≥4.97 mi from a turbine (22% vs 8%) supporting the USFWS's 4.97-mi buffer zone for wind energy development (Manville 2004). The increased rate of lek abandonment within 4.97

mi of wind turbines is concerning because female prairie-chicken activity centers are nearly always centered within 3.1 mi of active leks (Winder et al. 2015b). Although previous research found female greater prairie-chickens avoid turbines in their space use and movements, turbines did not negatively affect nest-site selection, nest survival, or adult survival (McNew et al. 2014, Winder et al. 2014a, Winder et al. 2014b). An unpublished study from a 36 turbine wind farm in an unfragmented Nebraska landscape found no influence of wind energy development on nesting, brood-rearing, or special ecology of greater prairie-chickens (Harrison 2015).

There is also evidence that other forms of development within occupied habitat could have a negative impact on prairie grouse. Greater prairie-chickens were found to avoid power lines by 330 ft in Oklahoma (Pruett et al. 2009). A habitat-based greater prairie-chicken lek site model revealed a weak avoidance effect of roads at a 3.1-mi scale in Kansas (Gregory et al. 2011). A similar modeling effort in Minnesota suggests road density at a 2-mile scale was a negative predictor of lek presence (USFWS HAPET 2010). Significantly more roads occurred within 1,640 and 3,280 ft of inactive sharp-tailed grouse leks when compared to active leks in Minnesota (Hanowski et al. 2000).

The SDGFP occasionally receives comments of concern about the effect of dog training on prairie grouse hunting opportunity. Dog training on wild game birds is allowed from August 1 through the Friday preceding the third Saturday in September. See the SDGFP Hunting Handbook for all restrictions. Research has shown dog training has very little influence on prairie grouse behavior and is not expected to detrimentally impact hunting opportunity. The SDGFP will continue to consider public comments, staff input and emerging research when considering changes to dog training rules.

There are also opportunities to further inform the public about prairie grouse behavior, habitat needs and trends, and hunting/viewing opportunities. The SDGFP has many media available to further inform the public about prairie grouse and encourage them to participate in hunting or viewing opportunities. The SDGFP's recently published "Grouse of Plains and Mountains" book is an excellent resource for information related to all grouse species in SD and is available at https://gfp.sd.gov/shopping/Catalog.aspx?cat=6 . With increased public awareness of the challenges facing prairie grouse, more interest in the preservation of these great birds and their habitats may occur.

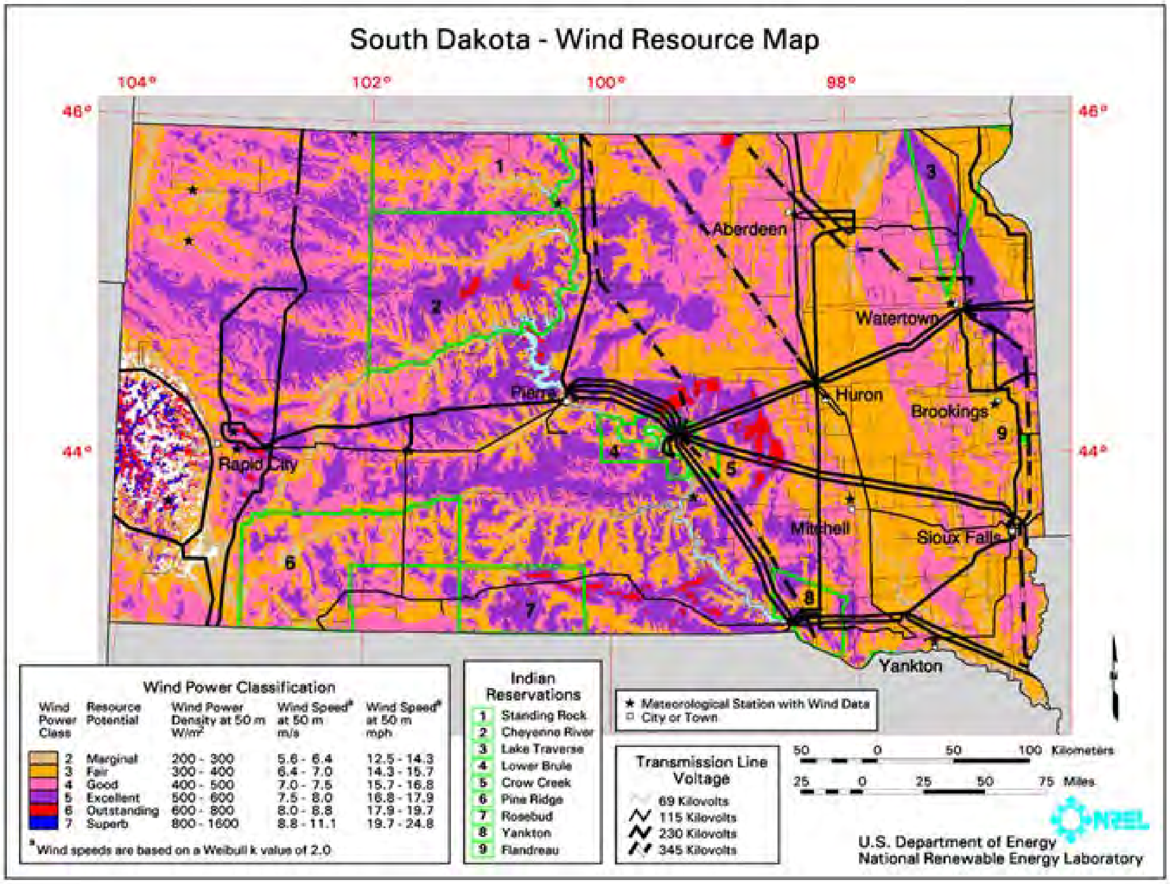


Figure 10. Wind energy classification classes for South Dakota (U.S. Department of Energy 2010).

GUIDING PHILOSOPHY

Vision – Who Do We Strive To Be?

The South Dakota Game, Fish and Parks will conserve our state's outdoor heritage to enhance the quality of life for current and future generations.

Mission – What Do We Do?

The South Dakota Game, Fish and Parks provides sustainable outdoor recreational opportunities through responsible management of our state's parks, fisheries and wildlife by fostering partnerships, cultivating stewardship and safely connecting people with the outdoors.

GOALS

Provide outdoor recreational opportunities – Optimize the quantity and quality of sustainable hunting, fishing, camping, trapping and other outdoor recreational opportunities.

Serve as stewards of our state's outdoor resources – Maintain and improve our outdoor resources to ensure sustainability.

Inspire confidence – Instill trust from the people we serve through transparency and accountability.

Foster professional excellence – Develop and empower highly engaged and well-trained staff.

VALUES

Excellence – We believe in a culture of professionalism and accountability to meet the expectations of our customers and empower staff to succeed.

Stewardship – We believe in applying biological and social sciences to conserve and respectfully manage our state's outdoor resources for current and future generations.

Integrity – We believe in being transparent and honest by promoting high ethical standards.

Compassion – We believe in the dignity of each person and genuinely care for the people we serve.

PRAIRIE GROUSE MANAGEMENT GOAL

Maintain or expand sustainable prairie grouse populations by fostering partnerships, promoting grassland habitat stewardship, and applying biological and social sciences.

OBJECTIVE 1: Promote and implement responsible stewardship of prairie grouse habitat on public and private lands.

STRATEGIES

1.1 Advocate for current and future United States Department of Agriculture (USDA) Farm Bill programs and policies in the Commodities, Conservation, Energy, and Crop Insurance titles that incentivize native grassland preservation, protection, and enhancement.

1.2 Maintain support for Conservation Reserve Program (CRP) in federal farm legislation through continued cooperation with the Governor's Office, USDA, other state and federal agencies, non-governmental conservation organizations, coalition groups (e.g. Northern Great Plains Working Group, Association of Fish & Wildlife Agencies), landowners and agricultural groups.

1.3 Advocate for land use policies and procedures, including local zoning and property tax assessment which preserve and protect native grassland functions and values in a fair and equitable manner. Note: the South Dakota legislature created the Agricultural Land Assessment Implementation and Oversight Advisory Task Force to provide guidance to the Department of Revenue on the implementation of the productivity system of assessing agricultural land. The Task Force holds meetings during the legislature's interim calendar to review assessment information and make recommendations to the legislature for potential revisions to the productivity system.

1.4 Continue to advocate for strategic use of existing and new continuous CRP practices that provide quality prairie grouse habitat (West River SAFE, Grasslands CRP). Use designated prairie grouse priority areas (Vodehnal and Haufler 2008) and results of the occupancy modeling project to guide specific CRP advocacy.

1.5 Annually seek and provide assistance to landowners with expiring CRP contracts, by providing re-enrollment options into general and continuous CRP, or other programs that are available for maintaining all or a portion of this grassland habitat. At the appropriate times, use direct mailings to producers with expiring CRP contracts.

1.6 Maintain existing partnerships with Pheasants Forever, Natural Resources Conservation Service, Bird Conservatory of the Rockies, and Ducks Unlimited to fund partnership biologists to assist private landowners with technical assistance and the promotion of grassland-related conservation programs. Continually assess the need for technical services provided by partnership biologists and staff the appropriate positions as budgets allow.

1.7 Continue to provide financial commitment to the 81,000 acres enrolled in the Conservation Reserve Enhancement Program (CREP) and utilize funding sources as they become available to enroll the project goal of 100,000 acres in the CREP.

1.8 Continue to support perpetual conservation easements and fee title acquisitions of grassland habitat by other public and private entities.

1.9 Remain engaged with the Governor's Habitat Conservation Initiative and the Habitat Conservation Board.

1.10 Continue to promote grassland habitat stewardship and sustainability through the Habitat Pays initiative, and through support of landowner-based conservation stewardship interests such as the South Dakota Grassland Coalition and South Dakota Soil Health Coalition. (http://habitat.sd.gov/workshops/default.aspx).

1.11 Continue to be involved in providing technical assistance for and participation in state-level policy making processes related to Farm Bill delivery through the State Technical Committee, Sub-Committees, and Working Groups.

1.12 Maintain support for the vision and mission of the Prairie Pothole Joint Venture and Northern Great Plains Joint Venture to implement grassland stewardship by serving on appropriate management boards and technical committees.

1.13 Continue to promote grazing stewardship practices through department private lands cost-share programs, partner programs, and other initiatives when and where appropriate.

1.14 Continue to financially support and advocate for completion of South Dakota State University (SDSU) Extension's inventory of undisturbed (native) lands in western South Dakota.

1.15 Utilize SDSU Extension's inventory of undisturbed (native) lands across the state to better target SDGFP's private lands technical and financial assistance programs on native sod areas in high priority landscapes.

1.16 Continue to participate in public scoping opportunities with federal agencies that manage native grasslands and convey recommendations which support public land uses that best maintain or enhance prairie grouse habitats.

1.17 Where prairie grouse are the primary habitat management species, best management practices for prairie grouse habitat management (page 16 of this plan) will be used with discretion to guide development and updates of Game Production Area management plans within fiscal, biological, and land use constraints.

1.18 Continue to use all available prairie grouse research findings to guide the environmental review process of proposed development projects (e.g. communication towers, wind energy, oil and gas, livestock grazing and allotment revisions, livestock infrastructure, recreational sites, trails, roads, prescribed fire, post-fire land management, etc.) where the

SDGFP has the opportunity to provide environmental review. Use Habitat Best Management Practices to guide environmental review process.

1.19 Participate in the greater prairie-chicken and sharp-tailed grouse interstate working group and assist in the development of a national prairie grouse conservation plan.

1.20 Explore the feasibility of using grass banking as a way to cooperatively and concurrently manage grassland habitat on Game Production Areas and nearby private lands.

OBJECTIVE 2: Monitor prairie grouse abundance, harvest, hunter numbers and hunter satisfaction.

STRATEGIES

2.1 Annually conduct traditional lek surveys and summarize data to determine changes in population status.

2.2 Periodically review prairie grouse lek survey protocol and discuss changes that could improve data collection efficiency and accuracy.

2.3 Annually conduct and summarize results of hunter harvest surveys to project prairie grouse harvest, number of prairie grouse hunters, and hunter satisfaction.

2.4 Continue to collect wings from hunter harvested prairie grouse in western South Dakota to evaluate age ratio and species composition of harvested grouse. Continue to collaborate with Forest Service biologists to relate weather variables to prairie grouse production on federal lands and other areas using wing data. Ensure that information gathered is shared among SDGFP and other participating agencies.

2.5 Continue to annually coordinate with federal land management agencies to collect prairie grouse habitat information, population/trend data and hunter-harvest statistics. Ensure that information gathered is shared among SDGFP and other participating agencies.

OBJECTIVE 3: Evaluate research needs and prioritize on an annual basis.

STRATEGIES

3.1 Annually collaborate with stakeholders and summarize research needs and ideas.

3.2 By December 2018, prepare completion report for prairie grouse occupancy modeling project.

3.3 At least one staff member will attend the semi-annual meeting of the Prairie Grouse Technical Committee meeting. This meeting facilitates the exchange of information between states on survey techniques, harvest regulations, research and habitat management.

3.4 Continue to attend scientific meetings that will exchange information related to prairie grouse management.

OBJECTIVE 4. Provide prairie grouse hunting opportunities on private and public land

STRATEGIES

4.1 Use all available biological and social data to develop 3-year hunting season recommendations for SDGFP Commission consideration.

4.2 Continue to enroll large blocks of well managed grasslands into the walk-in area program, especially in central and western South Dakota where high density prairie grouse populations exist.

4.3 Collaborate with SD School and Public Lands and the Bureau of Land Management to provide public access to land-locked public lands through access agreements and easements.

4.4 Continue to provide the South Dakota Hunting Atlas in print, as a pdf document, interactive map within the department's website, as a smartphone application, and as a map file for certain GPS units.

4.5 Annually prepare a prairie grouse hunting forecast based on spring lek counts and the production model based on weather variables.

OBJECTIVE 5. Promote public, landowner, agency and industry awareness of prairie grouse and habitat management issues of highest conservation concern.

STRATEGIES

5.1 Provide an electronic copy of "Prairie Grouse Management Plan for South Dakota 2017-2021" on the SDGFP web site. Printed copies will be available upon request.

5.2 Periodically include articles about prairie grouse and prairie grouse habitat in the SD Conservation Digest and Landowners Matter Newsletter.

5.3 Develop a prairie grouse habitat best management practices fact sheet for SD landowners.

5.4 By 2019, add a web page about prairie grouse under the outdoor learning section of the department website which includes descriptions, videos and pictures of prairie grouse display behavior.

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(The following is an excerpt from the June 7th, 2021, Commissioner Proceedings, Hughes County, South Dakota)

COMMISSIONER: Okay. Wind project update. Thanks, Ben.

COMMISSIONER: Thank you.

COMMISSIONER: Come on in.

MR. WILLIS: Good afternoon. My name is Casey Willis. I'm with ENGIE North America, so I'm the project developer for a project that we have partially in Hughes County, partially in Hyde County called the North Bend Wind Project. So, first off, I apologize for not being here before. Obviously, there's been some limitations for a lot of folks in the past 16 months or so. This is actually my first authorized travel out here, so thank you for allowing me to come in front of you.

Just to give you kind of an overview. We have been working out here with the landowners since about 2015 signing easements. It's usually the start of how a wind project begins and develops is we partner with some of the landowners to determine if there's interest.

The project itself is located on about 40,000 acres of easements that have been signed over time. This represents about 75 landowner groups. In that period of time, once we have a significant period of easements signed, we've been doing what I'd call baseline biological and environmental studies over the past couple of years. It was partially in conjunction with the adjacent Triple H wind project, which is now operating, and in addition to that, finalizing interconnect studies.

The interconnect studies are kind of the significant milestone for any wind project. Here in this area, it's the Southwest Power Pool where you enter into the interconnection queue and they evaluate the capacity on the system and what happens when you inject wind power at a particular location, what upgrades are needed, how does that factor in with existing resources' demand, other energies that have queue positions, so that process is fairly technical and it goes through several iterations and takes years to complete.

So we're now at a point where we know that basically the queue position that we have, that it's viable. In some instances, you can have a queue position where you think it will work great, and, unfortunately, it triggers eighty, a hundred million dollars of upgrades that can't be absorbed by a project. Project doesn't work in that location.

In this instance, we think it does. Our queue position is on a WAPA line. It's kind of on the southeast side of the project that exists right there. It's the Fort Thompson to Oahe 230-kilovolt line.

As of the moment right now, we have not formally signed a turbine supply agreement. Part of the reason for that is we also have not signed a power purchase agreement to sell power from the project, nor have signed the balance of plan, which is who the -- the construction contractor. Those are what I would deem as, like, the key major contracts. Generally, you try to sign them all at the same time.

We're fairly confident this project will be very competitive, similar to how Triple H was. And we've been very competitive in submitting bids into various proposals to sell power to different entities, and we think we'll be successful at some point in the not too distant future.

Right now, if everything aligns perfectly, we would look to start construction in 2022. This would obviously -- we obviously would need permits in hand before, in order to do that.

So if everything worked out perfectly, we'd look at starting construction in early 2022 and attempt to complete construction and have it be operating by the end of 2022. That may not happen. It could slip slightly, just depending on how things progress out in terms of negotiations and selling power.

So the second -- the map in here just shows the general project boundary of how it sits across the Hughes and Hyde County line. Right at the moment, we kind of envision it split 50/50 between turbine locations, and it shows the location that we're interconnecting into.

In terms of the project size, what we're targeting is a 200-megawatt project. This would be considered kind of a moderate-sized project. In comparison, the Triple H project is slightly bigger at 250-megawatts.

The turbine model that we believe is the most competitive here is the GE model. It's just slightly different than the one that was used at Triple H. It's just it happens that the turbine manufacturers continually innovate the models they offer and so this is basically like a slight upgrade. It's the new model for the next -- you know, the next year that they would deliver part -- or turbines for it.

So what we're looking at using is a G -- it's a General Electric 2.82 127 machine. What that means is that each turbine can generate up to 2.82 megawatts each, and the rotor on the turbine is 127 meters.

So based on that, what we're going to look to do is prepare permit applications that would request a total of 78 locations of which we would only build 71. That difference represents alternatives that are within there. It gives us a little bit of flexibility in the event that, as we do geotech studies, that there's something from a soils standpoint that would not work with one location, we can supplement it out for another, but no more than 71 would be built.

So I mentioned that the size of the rotor is 127 meters. What that means is that at the 12 o'clock position, the turbine would be just under 500 feet.

So for reference, the Triple H turbines out there are 486 feet at tip height, so it's slightly taller. From a broad perspective, these are actually on the smaller size for wind turbines these days. What we're finding is that the nameplate capacity of the turbine has been increasing and the size of the turbines have been larger with time.

The reason -- the reason we're able to use a smaller turbine here is the higher consistent wind speeds in that area that we found.

I'd mention again, the point of interconnect is on the Fort Thompson to Oahe. We're currently working with state lands on a location that WAPA would own and build a switch arc right at that location.

This project would not have an overhead transmission line. What happens is that we'll build this project's substation immediately adjacent to it. All of the -- all of the turbines have been collected at a 34.5 kilovolt level. What that means is they're basically -- it's a lower voltage after it's stepped up in the turbine. They're strung together. And all of those lines are trenched and in the ground so that they're not overhead.

And then this last video that I include in here is -- it shows the usable turbine area. And the reason I include this is that at the start of when I started speaking, I mentioned 40,000 acres under an easement. Oftentimes, there's an assumption that we can place turbines anywhere, and that doesn't -- that's not the case, really.

It's -- once you factor in those setbacks that we would use as a company, or in this case, county setbacks that have been adopted, it significantly reduces the area where you can consider placing a turbine.

So in this figure, it reduces it down by over -- almost 80 percent. 21 percent of the leased area we can actually use and consider. After that, there's even spacing aspects. We can't put turbines too close to each other, perpendicular to the wind or parallel to the wind, otherwise they wag each other in terms of the performance, so there's a fairly limited area where you can place the turbines.

So overall, this project would represent a capital investment of about 250 to $270 million. The project is likely to create about six to eight new full-time positions during operation.

This is lightly lower than a stand-alone project and it's because the Triple H project employs -- I don't know the exact figure. We'll call it 15 to 18 because it's the same turbine model. Because they're in close proximity, we anticipate that there would be some efficiencies there where we'd hire anywhere from six to eight, but that's just kind of -- that's a best guess at this point.

During construction, we typically see about up to 400 people on-site at any one time -- excuse me. Up to 400 people that are employed, 130 on-site at any one time.

The property taxes in South Dakota are dictated by state statute. It's based on the production from the site itself. And also the nameplate capacity of the project as a whole. And the reason -- I would guess the reason for that is in certain years there's a higher production and lower production, so by including a calculation based on the size of the project, it balances that out.

Our estimate, based on the annual production over the life of the project, is that it will produce just under a million dollars a year or about 29 million in taxes over the life of the project. That's split out between the state, the counties, and the school districts -- the school district calculation.

The state would receive about 300,000 or 8.8 over the 30-year life. The counties, roughly 337,000 annually, or about 10.1 million, and the school district calculation tracks alongside of that.

What we find -- and obviously this is going to generate, you know, income for the local -- for the residents that are participating. And we find that there's a fair amount of indirect benefit that comes with other local services that are used in conjunction with the project operation as well as in -- during construction itself.

So that's kind of a high-level overview of what we're contemplating. And I am here for any questions that you may have.

COMMISSIONER: Casey, I have a quick question for you.

MR. WILLIS: Sure.

COMMISSIONER: I mean, we're hearing all the positives and the dollars and everything. There was a lot of questions back when we were setting the setbacks about health and effects on wildlife. Have you guys done any updated studies? I am assuming that concerns you guys. Have you done any updated studies on anything?

MR. WILLIS: So I'll touch on the health one. That doesn't. The reason I say that is there's fairly significant studies that I can provide you that have documented that there is not health effects caused by wind turbines. These are done and replicated in different countries, different county agencies, different states. I can provide you a list of those studies, but that's fairly conclusive.

From the biological aspect, I mentioned that we've done three years of studies. In large part -- you know, this particular area I don't find is particularly sensitive, and a large part is because there's a lot of tilled areas used in agricultural production.

We don't find this from our studies in our baseline work. And even what we found at Triple H, which has a very similar kind of habitat dynamic, that the impacts are fairly minimal.

COMMISSIONER: Okay. Do you have any other questions?

COMMISSIONER: ENGIE, is it a U.S. company or is it a foreign company?

MR. WILLIS: It's a French company.

COMMISSIONER: It's a French company.

MR. WILLIS: So it's a -- I should go beyond that. It's a conglomerate that is Belgium and French, and it has ties to building the Suez Canal, but yet -- so my aspect, I work for ENGIE North America and our headquarters are based in Houston.

COMMISSIONER: Is there any U.S. companies that puts up wind turbines?

MR. WILLIS: I'm sure the answer is yes, but you get various players in the market. So I -- this project itself -- this project itself, I worked for the prior company called Infinity Renewables. We were entirely a U.S.-based company. The difference is is that our role at that time was develop and de-risk a project, because the capital costs associated with building it were -- far exceeded what a small company can do.

There are a lot of companies that operate like that. And then they partner with a larger partner with a balance sheet they can build on and operate it.

What ENGIE did is they bought out Infinity. I came on as an employee along with 20 or 30 other folks, so they're an owner-operator long-term and always have been, but they brought in a group that can develop as well. So that's a long way of me saying, in some instances there are, like NextEra is a Florida-based company that builds projects. They have a project in Hyde County. There are probably other ones, but there definitely are a lot of European-owned utilities that have groups in the

U.S. that owner-operate projects.

COMMISSIONER: I just know from past, you know, experience, when you're dealing with an overseas company, when it comes to money or problems, you're toast. If you have to go to court on something, they're gone.

I used to ship grain to China. I got paid before it got to Seattle, you know, stuff like that. So if there was ever an issue, you know, there was already prior inspection. But, you know, I've seen foreign companies come in, do projects. When it doesn't work out, they either try to flip them or they dissolve and you're left with damage. How can we be sure that ENGIE won't be one of them?

MR. WILLIS: Right. So grain, you can pick up and move, right? I can't pick up and move a project once this is done. I'll give you the example of the Triple H project, that is a $300 million project that is in the ground.

Let's assume ENGIE went bankrupt. There's power purchase agreements with Wal-Mart and Boston University that have significant value. They would take -- someone would buy that project out of bankruptcy -- Brett could probably speak to this a bit better than I can -- it would own and operate the project because there's still significant value. In terms of protecting the community, there's a decommissioning bond and plan associated with that project that is required by the Public Utilities Commission to ensure that the infrastructure would be removed in the event that an entity was not there.

I don't see that as an issue. That really hasn't occurred. There's value in these projects. You can't move them.

COMMISSIONER: So -- if it's okay, Chairman. With that being said, you can't move them and the life is 30 years, then what? Because what happens that we're seeing right now, and it's been reported, especially down south, is when these things have been basically decommissioned, some of them are being cut up and put in landfills where they take them. A lot of them aren't being taken because the landfills won't take them anymore because they don't -- they'll never go away, what they're built from.

Number two is that when they sit there long enough and it's time to get rid of them, the company that originally started it is long gone and sold again and sold to the third company that took the last bit of money. Even though they had a bond during the revenue days, the bond is now gone and they've bankrupted. And now there is nobody to take it down, and the farmers or the landowners or the counties or the state, which is what they're fighting over right now, on how to handle this.

So, I mean, it's new territory for a lot of us, and some of them are still being rebuilt and going. But our concern is for the guy that says, Okay, now what happens with ENGIE, because ENGIE does not keep them, I'm understanding. They sell them as well.

MR. WILLIS: No.

COMMISSIONER: They've kept all their windmills they've built? Every one so far?

MR. WILLIS: Correct. We're operators.

COMMISSIONER: When you say "operators" --

MR. WILLIS: We own and operate the projects. We don't -- we don't --

COMMISSIONER: For how long?

MR. WILLIS: 30 -- the life of the project. I mean, there could be circumstances where, as a company farther down the line, that you're right, it could be sold to a different entity.

COMMISSIONER: Are any of these entities owned by a U.S. company?

MR. WILLIS: From my company -- from --

COMMISSIONER: Any of these windmill companies that you know out here right now.

MR. WILLIS: NextEra is a significant player in the U.S. market. What are the projects in the south that you're referencing?

COMMISSIONER: In Oklahoma right now.

MR. WILLIS: What's that?

COMMISSIONER: In Oklahoma. I can't give you a name --

MR. WILLIS: Okay.

COMMISSIONER: -- right off the top of my head.

MR. WILLIS: The recycling aspect, no, that's a significant issue that the industry is aware of. It's something that we'd like to resolve, but, yeah, there are some issues. It's not every part can be recycled. That is absolutely the case. The blades, in particular, are composite.

COMMISSIONER: Right. And they're dealing with that in Sioux Falls right now. They're hauling them as long as they're taking them, but even that, we're told, is going to come to an end. So then what happens to them?

MR. WILLIS: The aspect that I mentioned, again, is --

COMMISSIONER: Because they'll never go away. I mean, these things, what we're told, the carbon fibers will never disintegrate, ever.

MR. WILLIS: Right. The actual removal is covered in the decommissioning plan as required by the PUC during the life of the project. We're required to fund it, so that ensures the removal of it.

COMMISSIONER: As long as you still have financial --

MR. WILLIS: Or anybody that owns it has to -- is required to take on that commitment.

COMMISSIONER: As long as they have the financial wherewithal to do it; correct?

MR. WILLIS: No. I mean, you want to explain the bond better than I can?

MR. KOENECKE: Sure. The -- all the wind farms that have been built since -- well, this current bulge, since 2017 have been required to escrow funds through a South Dakota bank to pay for the decommissioning, so that builds up a cash balance over time --

COMMISSIONER: So that will never go away?

MR. KOENECKE: -- so that goes along with the project and can't be spent without authority of the Public Utilities Commission.

COMMISSIONER: Why was there some states or even in different counties, why are they putting moratoriums on building wind turbines here in the last six months to a year? What's going on in them areas?

MR. WILLIS: I don't know.

MR. KOENECKE: I'm not familiar with --

MR. WILLIS: Perception sometimes.

MR. KOENECKE: I would say one thing I know is that there are some counties that haven't done the hard work of putting their zoning and construction ordinances in place. That -- I'm familiar with that, I guess. But as far as other reasons, I couldn't speak to what those are.

If a county hasn't prepared and hasn't done the work and are not ready for it, and then they feel, Oh, my gosh, there's an announcement, we've got to react to that. I guess, I've seen that. But, otherwise, I don't know about a moratorium that's just been put in place. I couldn't speak to that.

COMMISSIONER: Do you have another one?

COMMISSIONER: Yes. On the WAPA line you said you're going to be using, so am I understanding correctly that the power that is generated from these dams right now doesn't utilize the line fully today, so there's room on that line for more power?

MR. WILLIS: It depends on how the power flows from that area. That's taken into account because the power generated from dams, gas-fired power plants, coal-powered --

COMMISSIONER: Let's just talk about WAPA here with our dams.

MR. WILLIS: Right.

COMMISSIONER: Is this line empty then? It's not used?

MR. WILLIS: It's not that it's empty. It's -- there's capacity to allow just additional generation, so those dams would have been factored into the analysis as the baseline.

COMMISSIONER: So when you say there's capacity available, that's assuming that the dams are not running or if they're running at full?

MR. WILLIS: I would imagine it's the latter.

COMMISSIONER: So if they're all running at full capacity --

MR. WILLIS: Yes.

COMMISSIONER: -- there's still capacity on that line for these?

MR. WILLIS: It doesn't necessarily mean it all goes through that line. It can go to a variety of locations. It depends on where the substations are.

So the one that it interconnects to is the fairly large one north of Fort Thompson.

COMMISSIONER: So let me ask you this, then: By the wind turbines that are operating, if they're operating, because they go on and off based upon the wind.

MR. WILLIS: Right.

COMMISSIONER: Will they interfere with this dam, mainly Oahe or Fort Thompson, would their power source having to shut or go, they'll -- it never effects when there are things awry, then?

MR. WILLIS: To my knowledge, no.

COMMISSIONER: Will all the power be dumped right on just that WAPA line or it's going to go into other lines as well.

MR. WILLIS: It kind of flows -- you don't direct electrons. They go from a high to a low source, right?

COMMISSIONER: Okay.

MR. WILLIS: They go to the load center. So they would generally stay locally.

That said, there are -- you know, I mentioned -- I keep mentioning Triple H because it's an obvious example. We had a power purchase contract with Wal-Mart. We're not delivering electrons directly

to Wal-Mart stores. It's -- you know, it's a paper
transaction --
COMMISSIONER: Right.
MR. WILLIS: -- that's tied to their corporate
incentives.
COMMISSIONER: Right.
MR. WILLIS: They fund, invest in renewables.
That's kind of how it works.
COMMISSIONER: Because who kind of controls most
of -- where do we buy our power from now? Who is
that big company?
COMMISSIONER: East River?
COMMISSIONER: No. Where do they get it from?
COMMISSIONER: Basin Electric.
COMMISSIONER: Basin Electric.
COMMISSIONER: Yep.
COMMISSIONER: So you'll be dumping a lot of this
into Basin Electric; right?
MR. WILLIS: No, it's the WAPA system. Triple H
is in the Basin system.
COMMISSIONER: Okay.
MR. WILLIS: It's all part of the Southwest Power
Pool as a whole, which is the regional transmission
authority that they all operate within.
COMMISSIONER: I mean, I've got to be honest with

you, after watching Texas this year, it's kind of a head-scratcher. You know, I don't know if we all have enough pickups to power our houses if we get pretty dependent on renewable energy.

MR. WILLIS: Yeah. So we recommend that -- that was not caused -- what occurred in Texas, in terms of the winter, was not completely caused by renewables. And that's been --

COMMISSIONER: I agree.

MR. WILLIS: Right?

COMMISSIONER: They just got a little too dependent and --

MR. WILLIS: No. Actually, it has to do with winterization of energy resources as a whole. So this was something that was flagged ten to fifteen years ago in a prior freeze as a problem, and that was what happened, to a lot of oil and gas facilities as well. Certainly renewables went down.

We had projects in Texas as well. What happens is that -- you know, in South Dakota we use winter packages in the turbines because it's consistently cold.

In Texas we don't typically do that. It's kind of like taking a parka to Miami in the summer. You're probably not going to need it.

The same goes with a lot of the energy productions facilities in Texas. There's other aspects, too, ERCOT is really unique. It's an isolated island. Texas is independent and always has been. They can't pull any power from additional areas to offset when generation goes down. That's another component that was problematic as well.

COMMISSIONER: Thank you. Connie?

COMMISSIONER: Thank you, Mr. Chairman. I have just a couple of questions, Casey. When we were talking about our setbacks, were you the one that was on the phone that time with us?

MR. WILLIS: I was, yes.

COMMISSIONER: Okay. Well, thank you for being here. It's nice to put a face with a name.

MR. WILLIS: Yes.

COMMISSIONER: And I -- at that time I had a question and asked about the residents, so I'd like to kind of look at that map.

MR. WILLIS: Sure.

COMMISSIONER: Where we have all of these little dots and -- so these are the -- these are people where they're actually living on these little dots. Is that --

MR. WILLIS: Yes.

COMMISSIONER: -- what I'm seeing?

MR. WILLIS: They're occupied residents per the county's description, yes.

COMMISSIONER: So when we were talking about that, about -- my question back then was: How many people are within this project area? And you didn't have that answer.

MR. WILLIS: I still don't know that I have that necessarily.

COMMISSIONER: Okay.

MR. WILLIS: I don't know the exact number. I am going to guess, and I am only going to guess this because I've seen our noise analysis --

COMMISSIONER: Okay.

MR. WILLIS: -- that will be coming with an application. It's probably 50 homes, give or take. If in 40 acres plus a half-mile boundary around that 40 -- excuse me 40,000 acres, so it's a fairly large area. I want to say 50 to 60 homes.

COMMISSIONER: So what does it mean by -- so I'm just looking at the map. Just, please, bear with me. So what -- what does it mean by the proposed net locations? What's those triangles?

MR. WILLIS: Those are -- so what we use are net towers, which are essentially -- and this is what we've used to test the wind speeds at various levels. It helps us to assess whether something is viable or not. I've had projects that we put them up and wind speed is not what we thought. Those are temporary.

COMMISSIONER: Okay.

MR. WILLIS: So they're placed out there. There's probably five or six of them over significant periods of time that are up right now. And that's what we use to assess the wind speeds.

COMMISSIONER: Okay. So I just have a couple of requests, if that's --

COMMISSIONER: Go ahead.

COMMISSIONER: Okay. So my questions are -- or my request to you would be -- I'm a numbers person, so my question would be: I'd like to know, could I get a copy of your calculations of how you generated 971,000 a year for taxes?

MR. WILLIS: Yes.

COMMISSIONER: And how that was broke down amongst the state, counties, and school districts?

MR. WILLIS: Yeah. I can do that to a certain degree. What it does depend on is the net capacity factor.

COMMISSIONER: Sure.

MR. WILLIS: That's a proprietary thing.

COMMISSIONER: Okay.

MR. WILLIS: It's not something -- we use the accurate one, but it's kind of -- it's not something that's shared publicly, but that's what we base the tax calculations on.

COMMISSIONER: I guess I don't understand.

MR. WILLIS: So it's -- it's kind of like asking someone: How much is in your bank account? That's the rough equivalent, so it's proprietary. It's what we collect. It's based on the --

COMMISSIONER: You might be looking for more capacity factor.

MR. WILLIS: Capacity factor is -- the net capacity factor is the average wind production once you factor in electrical losses.

COMMISSIONER: Yeah.

MR. WILLIS: So it's the 50 percent value. The median, I should say. So in certain areas you hear net capacity factor at 40 percent. So 40 percent of the time it's produced -- it produces 40 percent of the power over 365 days a year.

COMMISSIONER: Sure. Okay. So can you tell me -- let's say it's 40 percent, whatever that number is.

MR. WILLIS: Yeah.

COMMISSIONER: Whatever that is, can you tell me what the ones that are currently right there, like they're right in here already; right? Are you estimating those same numbers? You guys have -- you own something real close to this; right?

MR. WILLIS: Right.

COMMISSIONER: Can you tell me what those actual numbers are? And where I am trying to go with this is: Are those numbers close to what this is -- what those estimates are?

MR. WILLIS: But remember, they're variable. So -- right? You're going to have some instances where wind production is lower than expected.

COMMISSIONER: Yep.

MR. WILLIS: Net capacity is the 50 percent of the median and sometimes it's higher, so it depends on what the wind production was for a particular year.

In terms of Triple H, we just started operating within the first six months so we haven't paid the taxes at least for the first year yet. I can tell you what the estimates were. It's the same idea. It's based on the net capacity factor, but it's no different than, you know, the calculation -- I can provide the calculations. It will have the average estimate, but it won't include the capacity factor.

COMMISSIONER: Okay. Great. Thanks. I'm trying to debate whether to ask this next question.

COMMISSIONER: Go ahead.

COMMISSIONER: I guess I will. So here is my last question: Is there federal funding tied to this? How does that work? I'm just curious because I'm a number person, so --

MR. WILLIS: No, that's fine.

COMMISSIONER: -- is it so much per tower? How does that work?

MR. WILLIS: So it's called a production tax credit. There's a tax credit.

COMMISSIONER: Okay.

MR. WILLIS: I think it's 2.1 -- I don't even remember off the top of my head, but either -- it's 2.1 -- let me get back to you on the exact number --

COMMISSIONER: Okay.

MR. WILLIS: -- because it's variable. There's an -- so essentially what happens is we have a tax equity partner that will come in. Usually it's a bank that has a tax liability. That's how it's monetized essentially, the federal tax credit.

COMMISSIONER: Right. Okay. So dumb it down for me.

COMMISSIONER: We do that with housing all the time. If you're going to build with housing authority, whatever, you get a tax credit back when you buy it, the banks do. So how I -- I think what your question is is how do you do that with this? How is that calculated out? I can get you to the penny on -- South Dakota Housing is doing a tax credit for a senior housing center. So I would imagine the tax credit is handled the same way for this; correct?

COMMISSIONER: It figures into the financing is, I think -- my limited understanding of it is when these guys put the project out for financing and go through that process, that gets figured in at that point is how I understand it.

MR. WILLIS: That is correct.

COMMISSIONER: I haven't done that kind of work on that side of a transaction, but the financing is where they take that out and turn that into -- it's essentially financial reward or whatever you want to say to the wind farm company. It figures into their costs of doing business and their costs of production, and all of those things, but that's where it comes in at is in the financing part with the bonds that are sold or however they choose to do it.

COMMISSIONER: Does that make sense?

COMMISSIONER: Kind of. So -- okay. So you go to a bank or you bond it. The turbine, the project itself gets -- you borrow the money to borrow this 250 to 270 million to build the towers?

MR. WILLIS: It's not bonded, necessarily. This gets a little outside of my background, so I apologize for that. I'll try to give you a better explanation when I come in.

COMMISSIONER: Okay.

MR. WILLIS: Essentially you have an entity. It's not bonded, but you have an entity that has a tax liability that wants to look to offset that, so they're putting up -- they're contributing a portion into the project, it's kind of a silent partner, to utilize that tax credit for themselves.

COMMISSIONER: Okay.

COMMISSIONER: So instead of really going out and borrowing funds at 7 percent, it may be down to 1.5, and that bank basically eats the rest for the credit for that, and they get a credit or tax deal for it. I can show you on a --

COMMISSIONER: Yeah, I -- okay.

COMMISSIONER: And I think that can all --

COMMISSIONER: And we can take this offside.

I'm just curious how it works.
MR. WILLIS: I can get you a better explanation from our finance folks better than I can explain it.
COMMISSIONER: Great. Thank you.
COMMISSIONER: Any more questions for Casey? Tom? Melanie? Any more questions?
COMMISSIONER: One more thing. The health deal, there's no health issues to any of the public here. But do you have your people that sign up for it, do they have to sign any paperwork saying that you're held harmless of any health issues?
MR. WILLIS: I mean, I think there's hold harmless language in most development easements that I'm aware of. Yeah, we have those, for sure.
COMMISSIONER: So if there's no health issue, there shouldn't really need to be a health --
MR. WILLIS: It's a common --
COMMISSIONER: -- held harmless.
MR. WILLIS: You're the lawyer here.
MR. KOENECKE: They're complex agreements and they cover a number of things. And there's certainly nothing in there that would hold us harmless from negligence or criminal standpoint, but there are things in there as far as you do agree to live with some of the known effects as well and so --

COMMISSIONER: What are they?

MR. WILLIS: Generally, noise.

MR. KOENECKE: Generally.

MR. WILLIS: And flicker.

MR. KOENECKE: Shadow flicker would be the two that I can think of. If you're going to take the money from hosting a turbine and be a part of the project, you don't get to then be an opponent of the project.

COMMISSIONER: You can't sue yourself basically.

MR. KOENECKE: That's kind of the general line of thinking there, but certainly there's no exemption from negligence or criminal matters or anything like that.

COMMISSIONER: Any more questions? Okay. Thanks, gentlemen, for your time.

MR. WILLIS: Thank you.

COMMISSIONER: Nice meeting you, too, by the way.

MR. WILLIS: Yeah.

COMMISSIONER: Appreciate you coming in.

MR. WILLIS: Yes. It's much nicer in person than over the phone. Thank you.

(End of transcription)

STATE OF SOUTH DAKOTA)
:SS
COUNTY OF LINCOLN)

CERTIFICATE OF TRANSCRIBER

I, Paige K. Frantzen, Court Reporter and Notary Public within and for the State of South Dakota:

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I FURTHER CERTIFY that I am not related by consanguinity or affinity within the fourth degree to any party, his attorney, or an employee of any of them; that I am not financially interested in this action; and that I am not the attorney or employee of any party.

To all of which I have affixed my signature this 12th day of September, 2021.

/s/ Paige K. Frantzen
Paige K. Frantzen, Notary Public
Expiration Date: December 22, 2023

PRAIRIE GROUSE LEK SURVEYS

The Project area occurs within the occupied range of the greater prairie-chicken (*Tympanuchus cupido*) and sharp-tailed grouse (*T. phasianellus*; combined as "prairie grouse"). Greater prairie-chickens are listed as a species of greatest conservation need in South Dakota, but both species are considered upland game birds and are hunted in South Dakota (SDGFP 2014). WEST conducted surveys to document prairie grouse leks during the breeding season within the Project area. The objective of the prairie grouse lek surveys was to identify potential leks and determine status of each to help inform Project siting decisions. These surveys were conducted in 2016, 2018, 2019, and 2020 and followed Project changes as described above in "Avian Use Surveys" for their respective years (Figure 3).

Surveys were conducted three times from late March to the end of the first week of May each year and included their respective Project areas and 1.6-km (1.0-mi) buffer. Surveys began approximately 30 min prior to sunrise until 90–120 min after sunrise. To the extent possible, all surveys were conducted on relatively calm mornings (winds less than 24–32 km [15–20 mi] per hr) and on days with no precipitation. Surveys were conducted to document the presence and the number of male and female birds attending leks. Because both sharp-tailed grouse and greater prairie-chickens are found within the area, identification of species during the survey was recorded, when possible. Information collected during all surveys included date, time, temperature, cloud cover, precipitation, and observer(s).

The SDGFP defines a lek as "a traditional display area where two or more male sage-grouse have attended in two or more of the previous five years" (Connelly et al. 2003). "Active leks" are locations where two or more birds have been observed or heard in courtship behavior during more than one survey period. "Potential leks" are locations where birds have been observed or heard engaging in courtship behavior during only one survey period, where birds were observed in more than one survey period but not in courtship behavior, or where number of birds could not be confirmed (e.g., heard at least one bird). If no birds were seen or heard in any of the three surveys, the lek was classified as inactive for the season. Results include a cumulative summary of all survey efforts across years as it relates to the current Project area and 1-mi buffer (Figure 8).

Aerial Surveys

Aerial surveys were conducted in 2016 and 2018 with a Cessna 172. Surveys included north/south transects across the Project area and 1-mi buffer spaced approximately 0.40 km (0.25 mi) apart at an altitude of approximately 30–45 m (100–150 ft) above ground level. An onboard GPS unit was used to keep the plane on transect, document lek locations, and record daily flight paths. Biologists recorded the number of birds on the lek and whether occupied by greater prairie-chicken or sharp-tailed grouse. The following characteristics were used to distinguish between these species from the air: a square-tail shape and dark, blocky body for greater prairie-chickens versus a pointed-tail shape with white under tail coverts and lighter body color for sharp-tailed grouse.

Ground Surveys

Ground visits were conducted in 2019 and 2020 by traveling publically accessible roads (or roads where permission was previously obtained) throughout the Project area and 1-mi buffer. During ground visits, the following information was recorded and included lek ID, location, species, type of detection (auditory or visual), number of males (if possible), and number of females (if possible). If a new lek was identified during this effort it was documented with the same information and identified using a new unique lek ID.

Twenty prairie grouse leks were identified during a combination of aerial surveys and ground lek visits during the 2016, 2018, 2019, and 2020 breeding season within the Project area and 1-mi buffer (Figure 8). Four lek locations were active in 2016, seven in 2018, three in 2019, and eight in 2020 (Table 6). Of these active and potential leks, one was a sharp-tailed grouse lek and nineteen were greater prairie-chicken leks (Table 6).

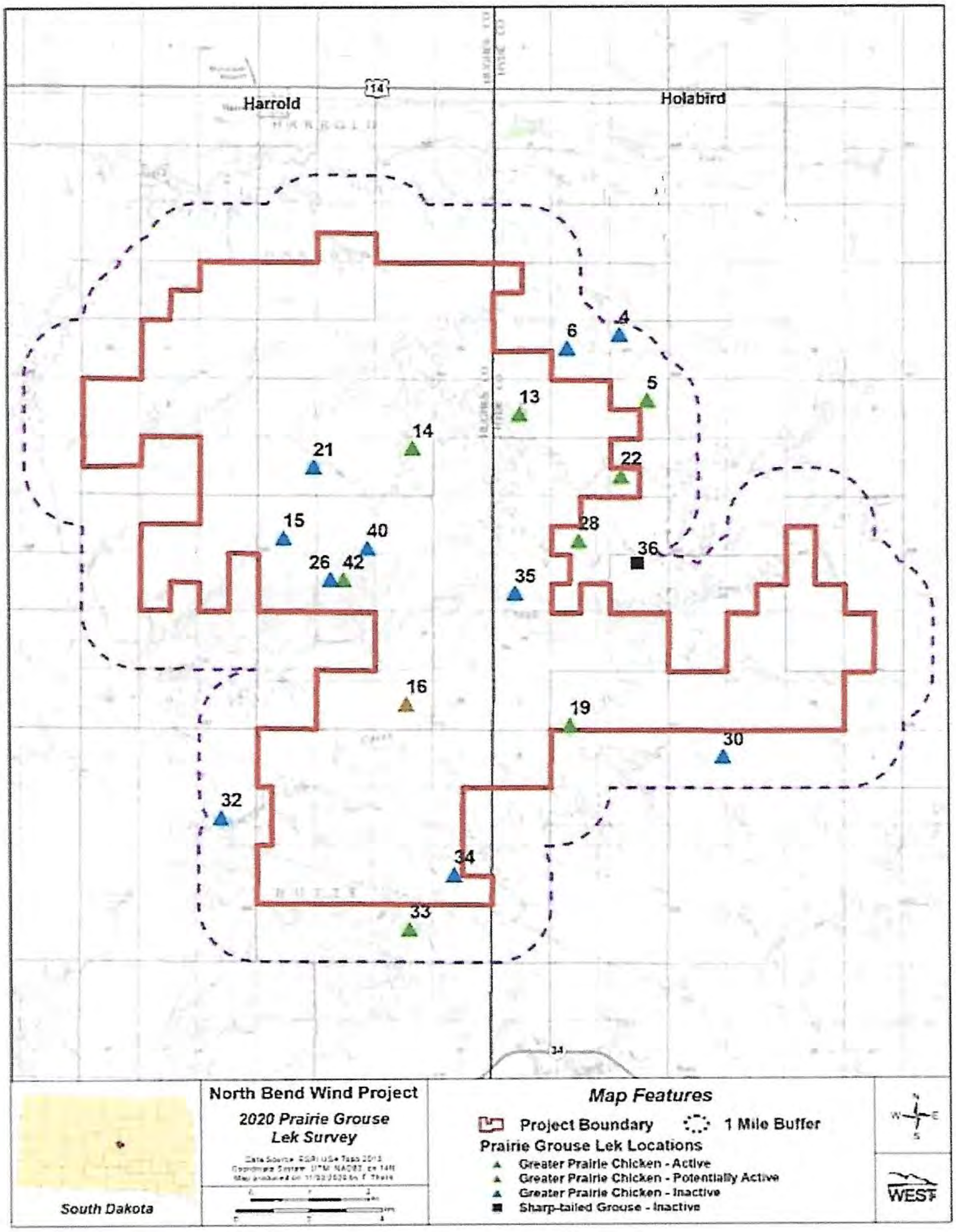

Figure 8. Location and 2020 status of potential prairie grouse leks identified during surveys within the North Bend Wind Project and 1.6-kilometer (1.0-mile) buffer from the 2016, 2018, 2019, and 2020 breeding seasons, Hughes and Hyde counties, South Dakota.

Table 6. Location and maximum number of prairie grouse observed at potential leks during surveys for the current North Bend Wind Project and 1.6-kilometer (1.0-mile) buffer, Hughes and Hyde counties, South Dakota.

Lek ID	Northing	Easting	Species	2016 Status	2018 Status	2019 Status	2020 Status	Grouse # (2020)
4	450633	4923799	GRPC	active	active	active	Inactive	0
5	451387	4921969	GRPC	active	inactive	active	Active-Auditory Only	at least 2
6	449195	4923428	GRPC	active	inactive	inactive	Inactive	0
13	447884	4921599	GRPC	NA	active	active	Active	5
14	444949	4920674	GRPC	NA	active	active	Active-Auditory Only	at least 3
15	441411	4918223	GRPC	NA	active	inactive	Inactive	0
16	444744	4913615	GRPC	NA	active	active-auditory only	Potentially Active	at least 1
19	449214	4913008	GRPC	NA	active	active	Active	4
21	442248	4920168	GRPC	NA	active	inactive	Inactive	0
22	450661	4919869	GRPC	NA	active	inactive	Active-Auditory Only	at least 2
26	442688	4917054	GRPC	NA	active	inactive	Inactive	0
28	449496	4918102	GRPC	NA	active	inactive	Active	5
30	453409	4912128	GRPC	NA	active	inactive	Inactive	0
32	439651	4910488	GRPC	NA	active	inactive	Inactive	0
33	444800	4907382	GRPC	NA	active	active	Active-Auditory Only	unknown
34	446025	4908887	GRPC	NA	active	inactive	Inactive	0
35	447735	4916644	GRPC	NA	active	inactive	Inactive	0
36	451106	4917464	STGR	NA	active	active	Inactive	0
40	443708	4917928	GRPC	NA	active	inactive	Inactive	0
42	443038	4917050	GRPC	NA	NA	active	Active-Auditory Only	at least 3

ID = identification; GRPC = greater prairie-chicken; STGR = sharp-tailed grouse.

Briefing Paper

Prairie Grouse Leks and Wind Turbines: U.S. Fish and Wildlife Service Justification for a 5-Mile Buffer from Leks; Additional Grassland Songbird Recommendations

Date: July 30, 2004 [Prairie Grouse Lek 5 Mile Public.doc]

Issue: The U.S. Fish and Wildlife Service (FWS, Service, or we) recommended "... avoiding placing wind turbines within 5 miles [8 km] of known leks (communal pair formation grounds[a]) in known prairie grouse habitat" (see p. 4, item 7, Site Development Recommendations) in our *Interim Guidelines to Avoid and Minimize Wildlife Impacts from Wind Turbines*, a notice of its availability published July 10, 2003 in the *Federal Register*. Some have questioned the validity of this recommendation, specifically the distance metric. While many grouse biologists consider 3 distinct groups of grouse in North America, including forest grouse (*e.g.*, Ruffed, Blue, and Spruce), prairie grouse (*e.g.*, Greater and Lesser Prairie-chickens and Sharp-tailed Grouse), and Sage-grouse (F. Hall 2004 personal communication [hereafter pers. comm.]), the Service's guidance included prairie and sage grouse within the same general "prairie grouse" category. This briefing paper provides justification for the Service's recommendation for a 5-mile buffer from occupied prairie grouse leks.

The Service reiterates that our wind siting guidelines are voluntary; we are not restricting installation of wind turbines or wind facilities within a 5-mile radius of active leks. Prior to any site selection, we recommend that the wind consultant/company/contractor assess the complete habitat requirements and habitat use and needs of whatever species of prairie and sage grouse is involved (*e.g.,* Greater and Lesser Prairie-chickens, and Gunnison and Greater Sage-grouse, and Columbia Sharp-tailed Grouse) at the site. All habitat requirements of prairie grouse should be considered, *i.e.*, habitats for courting and breeding (leks), nesting, brooding, resting, feeding, migrating, and wintering. Given continuing uncertainties about structural impacts on prairie grouse, especially the lack of data regarding impacts from wind facilities, and the clearly declining trends in prairie grouse populations (see below), we urge a precautionary approach by industry and recommend a 5-mile buffer where feasible. The public comment period on our voluntary guidance will continue to be open through July 10, 2005. We strongly encourage all interested parties to provide suggestions and recommendations on our voluntary guidance that will help improve its reliability and update its usability. Comments on the distance metric, especially those derived from ongoing scientific studies, will be important.

It also was recommended that we include a brief discussion on the declining populations of grassland and sage-steppe obligate songbirds and the need to protect their habitats. This briefing statement will review their habitat needs and will briefly discuss disturbance and habitat fragmentation.

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[a] Leks are technically not "communal pair formation grounds." Sage-grouse, for example, are not "pair forming" on leks and only a few males complete most of the breeding (F. Hall 2004 pers. comm.). Leks may best be described as traditional display areas normally located on very open sites in or immediately adjacent to breeding (nesting and early brood-rearing) habitats (J. Connelly 2004 pers. comm.).

<u>Prairie Grouse Status</u>:

All species of prairie grouse are declining, some severely. The range and population of the Lesser Prairie-chicken (LPCH) have declined > 90% since European settlement of the great plains 100 years ago (Giesen 1998). The Attwater's Greater Prairie-chicken has been Federally listed as endangered in its entire range -- now Texas -- since 1967. The LPCH is currently listed as a candidate species under ESA in CO, KS, NM, OK, and TX. A "candidate species" is a plant or animal for which FWS has sufficient information on their biological status and threats to propose listing under ESA, but for which development of a listing regulation is precluded by other higher priority listing activities. It is a formal ESA designation, although candidate species do not receive legal protections under the Act.

The Gunnison Sage-grouse, found in the Gunnison Basin (CO and UT) was candidate-designated under ESA in 2000. Their listing priority has recently been elevated. Populations of the Greater Sage-grouse have declined 66-92% during the past 30 years in western Canada where they are listed as endangered (Aldridge and Brigham 2002). Throughout North America, Sage-grouse distribution has been reduced by at least 50% since the early 1900s, with extirpation in 5 of 16 States and 1 of 3 Canadian Provinces. Breeding populations of Sage-grouse have declined 45-80% from numbers estimated in the 1950s (Connelly and Braun 1997, Braun 1998, Connelly *et al.* 2004). The Greater Sage-grouse in the Columbia Basin (WA and OR) was also designated as a candidate species. In April 2004, FWS published a 90-day finding in the *Federal Register* (69 FR 21484) with regard to range-wide listing petitions for the Greater Sage-grouse. The FWS found that the petitions and additional information available in our files present substantial information indicating that listing may be warranted. This positive 90-day finding triggered a FWS status review of the species which will result in a 12-month finding that is to be available in December 2004 (K. Kritz 2004 pers. comm.). In June 2004, the Western Association of Fish and Wildlife Agencies published a comprehensive, science-based assessment of the Greater Sage-grouse and its habitat, reviewing landscape information for the past 100 years, population data for the past 60 years, and the available literature (Connelly *et al.* 2004; see beyond).

While wind turbines and wind facilities are new additions to prairie grouse habitats in the Midwest and West, their impacts to grouse populations could add to the cumulative effects of human development and exploitation from other sources in grouse and songbird habitats. With these continuing uncertainties, we recommend that the industry take a cautious approach. Prairie grouse did not evolve with tall vertical structures present so the addition of wind turbines and their supporting infrastructure represents a significant change in the species' environment (J. Connelly 2004 pers. comm.). Given the declining or precarious status of grouse populations, the impacts of wind development on prairie grouse must be evaluated with great care and considerable detail. Prairie grouse are "indicator organisms," showing us the health of their environments, and sage grouse are "sensitive keystone species," representing critical components of their habitats (Lyon and

Anderson 2003, S. Harmon 2004 pers. comm.). Grassland and sage-steppe-obligate songbirds (*e.g.*, Sage Sparrow, Brewer's Sparrow, Sage Thrasher, and Black-chinned Sparrow) are also showing serious population declines. Grassland songbirds are the fastest declining suite of birds in North America (Johnson *et al.* 2004).

Justification for Our Distance Recommendation:

While we acknowledge that much research continues on prairie grouse and the impacts of tall structures, including wind turbines – and thus much of the data have yet to be peer reviewed and published – several studies and their recommendations have been published and are used as the basis for our 5-mile recommendation. Most compelling was the recommendation by Connelly *et al.* (2000:978) calling for protection of breeding habitats within 11.2 mi (18 km) of the leks of migratory populations of Sage-grouse (see discussion beyond). See also Giesen and Connelly (1993) beyond for a discussion of management guidelines for Columbian Sharp-tailed grouse.

Extensive personal communications with many grouse specialists were also important in helping us make our determination. The published reviews (some of which were in press at the time of our recommendation) are included below.

We believe it is important to clarify that avoidance of vertical structures by grassland and sage-steppe-obligate wildlife is not a new issue, and the Service's recommendations are not merely reactive to current recommendations promoting wind power development nationwide. Concerns were brought to the Division of Migratory Bird Management as early as 2000 regarding the possible impacts of wind turbines on prairie grouse, including noise, habitat disruption, disturbance, fragmentation, and increased predator access (R. Reynolds and N. Niemuth, FWS Habitat and Population Evaluation Team, Bismark, ND 2000 pers. comm.). Much research has also been conducted on the impacts of high tension power transmission and electric distribution lines on prairie grouse, providing a detailed body of literature on a related structural issue (*e.g.*, Connelly *et al.* 2000, Braun *et al.* 2002, Hagen 2003, Wolfe *et al.* 2003a and 2003b, Pitman 2003, Hagen *et al.* 2004, Patten *et al.* 2004, and Connelly *et al.* 2004).

***Lesser Prairie-chicken*s**

Mote *et al.* (1998:18) reported the findings of the Lesser Prairie-Chicken Interstate Working Group (represented by CO Division of Wildlife, KS Department of Wildlife and Parks, NM Department of Game & Fish, OK Department of Wildlife Conservation, and TX Department of Parks & Wildlife). This State-led team of species experts, with input and review by researchers and academics, identified the need for a contiguous block of 20 mi^2 (52 km^2) of high quality rangeland habitat to successfully maintain a local population of LPCH. If this area represented a hypothetical square home range (Figure 1), its boundaries would be approximately 4.5 x 4.5 mi (7.2 km) and a lek located in its center would be 2.25 mi (3.6 km) from the nearest side. If the hypothetical contiguous block were a circle (Figure 2), its radius would be 2.5 mi (4.1 km) in length from a lek located in its center. In Figure 2, we incorporated an additional 1.25-mi (2 km) minimum protection buffer zone beyond this hypothetical home range as recommended by Hagen *et al.* (2004:79), discussed below. Because range wide, the majority of remaining LPCH populations are fragmented and isolated into "islands" of unfragmented, open prairie, thus we assert that a 5-mile buffer from a lek is recommended to protect the wind power industry from later determinations that construction activities could significantly impact important LPCH populations and habitat corridors needed for future recovery.

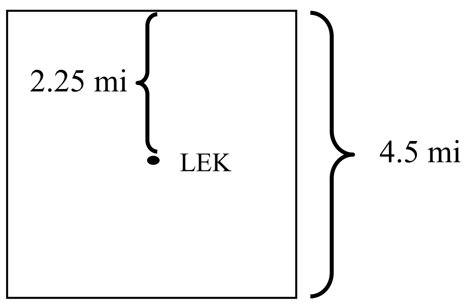

Fig 1. 20 mi^2 protected habitat.

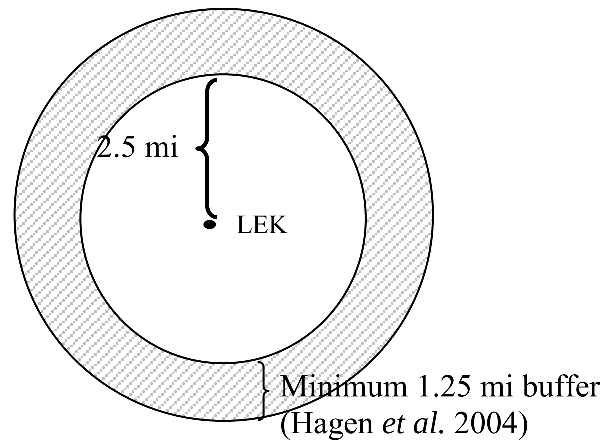

Fig 2. 20 mi^2 protected habitat using 2.5 mi radius from lek; with additional buffer zone recommended by Hagen *et al.* (2004), protected area = 44.2 mi^2.

Figures 1 and 2 illustrate the minimum scale of unfragmented habitat necessary to maintain a LPCH local population (S. Harmon 2004 pers. comm., B. Obermeyer 2004 pers. comm., after Mote *et al.* 1998:18).

Other individual studies however, discussed in the next several paragraphs, have suggested recommendations for protected distances less than those presented by Mote *et al.* (1998). These variations may reflect differences between individual populations, the variability in the complexity of different habitats, habitat fragmentation and disturbance, and other unknowns. For example, Pitman (2003:45, 49) and J. Pitman (2004 pers. comm.) noted that > 80% of LPCH hens nested closer to a lek other than their lek of capture and they moved on average > 1.9 mi (3 km) from their capture location to initiate a nest. He indicated that the presence of buildings, improved roads, power lines, agricultural edge, and oil and gas wellheads all eliminated potential nesting habitat for a radius of up to 0.62 mi (1 km; p. 46). Roads, power lines and sometimes agricultural edge are all anthropogenic features associated with wind energy facilities. He suggested that in order to maintain movement between sub-populations of LPCH, habitat fragments should not be further than 6.2 mi (10 km; p. 142) apart. The recommendation was based on the dispersal distance of juvenile females although the sample size was very small.

As a further example, Hagen (2003:156, 177) and C. Hagen (2004 pers. comm.) studied LPCH in southwestern KS. He concluded that landscape features, the proportion of an area occupied by power lines, and the proximity of human structures clearly reduced otherwise suitable habitat. The mean distance chickens avoided structures was 0.9 mi (1.4 km; p. 162). However, Hagen (2004 pers. comm.) cautioned that data are presently lacking that indicate what happens to LPCH as habitat patches become smaller or as patch quality becomes less diverse and as anthropogenic features become more abundant. The distances in his study may reflect the "tolerance" level of LPCH to structures in fragments of < 12,350 ac (5,000 ha) in size of moderate quality. He recommended that as patch size becomes smaller and/or of lower quality, the LPCH will be less tolerant to disturbance and fragmentation. Until data can support an alternate hypothesis, Hagen (2003:159) and C. Hagen (2004 pers. comm.) suggested protecting as large a buffer around remaining habitat as possible.

Hagen *et al.* (2004:79), in "guidelines for managing lesser prairie-chicken populations and their habitats," recommended that wind turbines and other tall vertical structures be constructed >1.25 mi (2 km) from known or potentially occupied LPCH habitat, at a minimum. This recommended area represents a buffer beyond already existing LPCH home ranges (Figure 2). If wind facilities must be placed in known LPCH habitats, Hagen *et al.* (2004) suggested they be positioned along prairie edge or clustered in sites with other disturbances.

Wolfe *et al.* (2003a:18) assessed LPCH habitat use and avian impacts in OK and NM. They indicated that while a common suggestion is to manage for nesting habitat within 1 mile (1.6 km) of a gobbling ground (lek), much larger areas are more likely to sustain broods. On average, hens nested 2.3 miles (3.7 km) from the lek on which they were captured (the record distance was 13.7 mi [21.9 km], p. 9), while successful nests averaged 2.6 miles (4.2 km) from the lek upon which the hen was captured. Their research also suggested that fragmentation from roads, fences, and power lines are a greater mortality factor than what had previously been thought. Collisions with human-built structures may be additive to other mortality. Wolfe *et al.* (2003b) reported that fragmentation likely elevated LPCH mortality due to collisions with fences and power lines. Wolfe *et al.* (2003a:16 and 2003b) noted that scavenging, especially by mammals, can occur at > 50% of the carcasses within days, resulting in collision rates that are likely higher than they had reported. Wolfe *et al.* (2003b) and Patten *et al.* (2004a:1) reported that females in both NM and OK suffered greater mortality from collisions with human-built structures than did males. Females were reported less susceptible to predation in both NM and OK, but more susceptible to collisions with fences, power lines, and vehicles (Patten *et al.* 2004a:9; 0.29 for female mortality due to predation vs. 0.48 for female mortality due to collisions, N=79 females, based on the Kendall's τ correlation matrix).

Patten *et al.* (2004a:12-13) noted that female LPCHs tend to breed only during a single year in OK, making the OK population more susceptible to annual environmental stochasticity (randomness) and a higher probability of going extinct within the near future. In NM, breeding was more likely to also occur in the 2nd and 3rd years. Habitat fragmentation, based on evidence from their study, can markedly affect the likelihood of population persistence and survival (p. 14). Patten *et al.* (2004a:28) modeled the probability of extirpation of LPCH in OK over the next 30 years. A few "bad years," they concluded (*i.e.,* climatic changes resulting in unfavorable weather conditions, low food yields, and heavy predation) could put the species over the brink, giving conservation professionals little time to react. This "too little, too late" scenario occurred with the Attwater's Prairie-chicken, largely due to the unavailability of necessary habitat that prairie grouse require (S. Harmon 2004 pers. comm.).

For LPHCs, increased habitat fragmentation and isolation of existing populations are of major concern. The placement of wind plants in a critical corridor area between 2 or more populations might permanently prevent connectivity. Potential connectivity corridors, however, have not been fully identified (D. Wolfe 2004 pers. comm.).

Greater Prairie-chickens

Although many studies have identified prairie grouse avoidance of vertical structures, to date, the only documented case of interaction specifically between prairie grouse and a commercial wind facility comes from northwestern MN. This information, however, is anecdotal in nature, collected peripheral to other research. As a result, no peer review or statistical testing of the findings are possible at this time. Society and Toepfer (2003:47) reported in their study area, composed of a habitat patch approximately 3 x 4 mi (4.8 x 6.4 km), that some individual Greater Prairie-chickens (GPCH) appeared to tolerate to some degree a small complex of 3 wind turbines. Specifically, researchers documented 6 active leks within 2 mi (3.2 km) of the 3 wind turbines, 1 lek within 0.6 mi (1 km) of the nearest turbine, and 1 hen with a brood immediately adjacent to a turbine. However, Society and Toepfer (2003:47) cautioned that further development and expansion of wind power on this site could negatively impact the use of the grassland by Chickens.

When considering this case, the Service contacted the primary investigator and discussed the observations at length. For the following 3 reasons, we find that Society and Toepfer's (2003) observations may not necessarily be in conflict with other researchers' findings and our voluntary siting guidelines. First, it is important to emphasize that this study site is relatively small and isolated within a landscape of primarily cultivated fields. As a result, individual GPCHs in the local population have little alternative than to continue using the habitat, regardless of its level of fragmentation.

Second, the documentation of active leks within 5 miles of the turbines may reinforce what is widely known about the behavior and life history of male Prairie Grouse. Within these species, females are the primary dispersers, whereas males "imprint" on a particular lek and nearby leks, and remain in the vicinity until their death. For this reason, males are very unlikely to leave historic leks, regardless of habitat quality or disturbance. Unless a particular human activity results in direct adult mortality, local lek counts may not decline for many years following a particular fragmentation event. An often-cited example of this behavior involves Greater Sage-grouse cocks observed strutting on the busy airport runway in Jackson Hole, WY. The runway was constructed over an historic lek, yet cocks continued to display on the site for many years because there is little alternative habitat in the small, isolated valley (P. Deibert 2004, pers. comm.).

Third, the population of GPCHs inhabiting this particular study site is considered very robust compared to other studies of Prairie Grouse. Lek counts in the small study area are known to be as high as 40 birds/lek. Given the small habitat scale and high density of both leks and birds per unit area, it is clear that amount of habitat, and not necessarily survivability, is a primary limiting factor constraining this population. Consequently, birds within this population are likely to be observed in all portions of useable space, and anecdotal sitings near the wind turbines neither confirm nor deny prairie grouse tolerance of commercial wind facilities in more typical habitats. However, these sitings offer the possibility that prairie grouse may be more tolerant of wind turbines than current research data suggest (S. Harmon 2004 pers. comm., B. Obermeyer 2004 pers. comm.). The preliminary findings also imply that, if other factors are not limiting to GPCHs, turbines might not be avoided elsewhere. However, while birds may persist near turbines, survival of those individuals may be compromised, resulting in a population decline. Until more studies are conducted, we can only speculate about cause-and-effect and survivorship (B. Millsap 2004 pers. comm.).

Because Prairie Grouse are relatively long-lived birds (often 3-6 years), and because they exhibit high site fidelity and clumped distribution on the landscape, the Service cautions that anecdotal sitings of individuals near wind turbines are neither unexpected nor informative about the cumulative effects of structural avoidance and habitat fragmentation on populations as a whole. Comprehensive, long-term studies in unconstrained habitats are essential to determining what level of habitat avoidance can be expected in response to wind turbine construction in occupied Prairie Grouse range (S. Harmon 2004 pers. comm.).

Patten *et al.* (2004b:1-2, 32) examined habitat fragmentation and its impacts on GPCH. Because of virtually no habitat fragmentation and a high continuity of tallgrass prairie in their study area, their estimate of home range size was determined to be the smallest of any study for this species. The minimum habitat size needed to avoid impacts to GPCHs in their study area was estimated at about 38.5 mi^2 (99.7 km^2). If the hypothetical contiguous block were a circle (Figure 4), its radius would be 3.5 mi (5.6 km) in length from a lek located in its center. When we incorporated an additional minimum 1.25-mi (2 km) protection zone recommended by Hagen *et al* (2004:79), the area of the larger circular home range is 70.9 mi^2 (184.3 km^2). If this area represented a hypothetical square home range (Figure 3), its boundaries would be approximately 6.2 x 6.2 mi (10 km) and a lek located in its center would be 3.1 mi (5 km) from the nearest side.

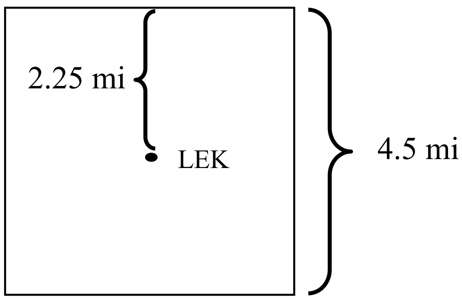

Fig 3. 20 mi^2 home range.

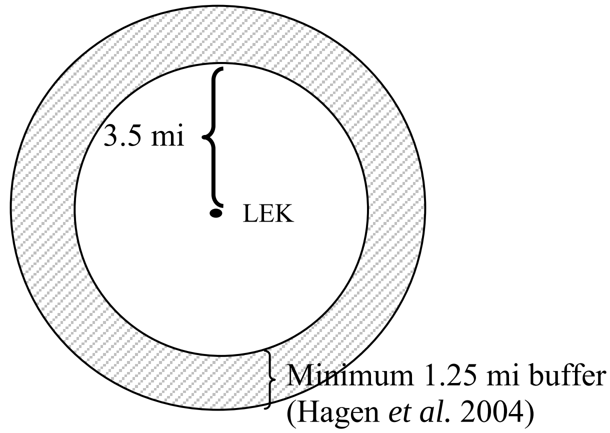

Fig 4. 38.5 mi^2 protected habitat using 3.5 mi radius from lek; with additional buffer zone recommended by Hagen *et al.* (2004), protected area = 70.9 mi^2.

Figures 3 and 4 show the minimum area of un-fragmented habitat necessary to maintain a local population of GPCH (S. Harmon 2004 pers. comm., B. Obermeyer 2004 pers. comm., after Patten *et al.* 2004b:1-2,32).

Results of the Patten *et al.* (2004b:2, 32) study predict that increased habitat fragmentation will force individual GPCHs to expand their home range, resulting in a decrease in survivorship from more predation, collisions, and energy expenditures.

Sage-grouse

Connelly *et al.* (2000) recently revised and expanded the guidelines for the management of Sage-grouse, originally published by Braun *et al.* (1977). Based on seasonal movements among populations, Connelly *et al.* (2000:969) summarized the 3 types of Sage-grouse populations: 1) those which are non-migratory and do not make long-distance movements (*i.e.* > 6 mi [10 km] one-way), 2) those which exhibit one-stage migration between 2 distinct seasonal ranges, and 3) those which exhibit 2-stage migration among 3 distinct seasonal ranges. Connelly *et al.* (2000:969) further reported that migratory Sage-grouse can occupy areas in excess of 1,042 mi^2 (2,700 km^2). Connelly *et al.* (2000:977-978) developed recommendations for habitat protection upon which, in part, the Service's guidance is based. Specifically, for non-migratory populations occupying habitats that are uniformly distributed, they recommended protecting sagebrush and herbaceous understory within 2 mi (3.2 km) of all occupied leks. For non-migratory populations, leks should be considered the center of year-round activity and treated as the focal points for management activities. For non-migratory populations where sagebrush is not uniformly distributed, suitable habitats should all be protected out to 3.1 mi (5 km) from all occupied leks. For migratory populations of Sage Grouse, breeding habitats within 11.2 mi (18 km) of active leks should be protected, recognizing that nesting birds may move > 11.2 mi (18 km) from leks to nest sites. This recommendation (Figures 5 and 6) obviously represents a protected area much larger than the 5-mile suggestion by the Service. While Connelly *et al.* (2000) made a distinction between resident and migratory (2 types) populations, in radio telemetry research conducted by Hall in Lassen County, CA, from 1998-2001 (F. Hall 2004 pers. comm.), his team discovered that some Sage-grouse populations include both resident and migratory birds down to the individual lek level. Specifically, they found resident, 1-stage and 2-stage females present on each of 9 leks (unpublished data). Populations are not always either resident or migratory.

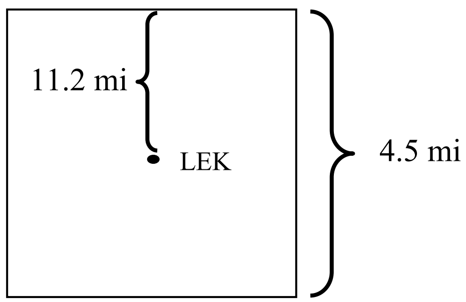

Fig 5. 502 mi^2 home range.

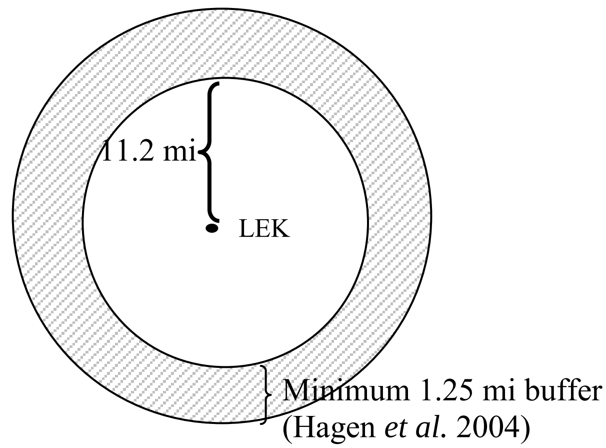

Fig 6. 394 mi^2 protected habitat using 11.2 mi radius from lek; with additional buffer zone recommended by Hagen *et al.* (2004), protected area = 486.95 mi^2.

Figures 5 and 6 illustrate the recommended protected breeding habitat for migratory populations of Sage-grouse based on a hypothetical square and circular home range, after Connelly *et al.* (2000:978) with buffer suggested by Hagen *et al.* (2004:79).

C. Braun (2004 pers. comm.) provided further comment on the recommendations discussed by Connelly *et al.* (2000:978) above (he was a coauthor of this article). For non-migratory populations of Sage-grouse, he felt a distance of 2 mi (3.2 km) was sufficient to protect breeding habitat from leks where no habitat disturbance was present. Where habitat disturbances were noted, he recommended a 3-mile (5 km) no-disturbance zone. For migratory populations, he reiterated Connelly *et al*'s 11-mile (18 km) no-disturbance zone from active leks. These recommendations he felt were based on "best professional judgment" and should change only when "no impacts could be demonstrated" by industry for zones of disturbance of lesser distance from leks. Wind generators, he indicated, were quite tall and could be seen and avoided by Sage-grouse for long distances. Noise (especially humming), motion, and height all may negatively affect Sage-grouse, although he indicated we still don't know the specific effects. Braun therefore felt that FWS could defend our 5-mile recommendation even though definitive data showing impacts are still being collected. C. Aldridge (2004 pers. comm.) also felt the Service's 5-mile distance recommendation "was reasonable" and represented an adaptive management approach by the FWS. He indicated that it was in "everybody's best interest to err on the safe side" especially due to issues regarding avoidance (including known and unknown impacts), landscape effects of wind and other structures, and the simple occurrence of birds versus their overall survival.

For the biologists who have worked on Sage-grouse for some time, it was noted that birds seem to be especially susceptible to disturbance and will often abandon nests even in later stages of incubation. Certainly wind turbine construction and maintenance activities fall under the category of "disturbance" (J. Connelly 2004 pers. comm.).

Connelly *et al.* (2004) published the most comprehensive, science-based synthesis of the Greater Sage-grouse and its habitat needs yet conducted. While the Conservation Assessment did not provide minimum distance recommendations from wind turbines, it did discuss wind energy development as one of several factors that could impact sagebrush ecosystems and thereby Sage-grouse. Noise from wind turbine rotor blades and bird mortality were cited as issues of concern regarding wind energy (Chap. 7:42-43). Connelly *et al.* (2004) were not optimistic about the future of Sage-grouse because of long-term population declines coupled with loss and degradation of habitat and other factors such as disease (ES:5). They also raised concerns about the distribution, configuration, and characteristics of Grouse migration corridors which unfortunately are largely unknown in most portions of the Sage-grouse range (Chap. 4:19). Disturbance issues were also discussed regarding lek distribution and highways (Chap. 13:12-13. Lyon and Anderson (2003) further documented effects of disturbance on breeding Sage-grouse.

Braun *et al.* (2002:345, 346) reported that the sagebrush-obligate species, Gunnison and Greater Sage-grouse, were particularly susceptible to noise near leks and to the placement of overhead power lines at least 0.5 mi (0.8 km) from any Greater Sage-grouse breeding and nesting grounds. Development was viewed as a negative impact in this study, characterized by a loss of habitat and disturbances associated with structures, roads, and noise – especially during the breeding season.

F. Hall (2004 pers. comm.) in a Lassen County, CA study on Greater Sage-grouse has recently documented significant impacts from overhead power transmission and communication distribution lines to this species out to 3.7 mi (6 km). When these lines are placed near turbines, they could provide perches for Golden Eagles and nest sites for Common Ravens. This concern coincides with the Service's recommendation (see Turbine Design and Operation, no. 4, p. 4) to place electric power lines underground or on the surface as insulated, shielded wire to minimize strike and electrocution problems.

In a related study, Popham and Gutierrez (2003:331, 332) radio-tagged 65 female Greater Sage-grouse in northern CA of which 45 radio-tagged hens were tracked to their nests. Successful grouse nests were located farther from the nearest lek (2.2 mi [3.6 km], SE= 811 m) than were nests that were unsuccessful (1.2 mi [1.96 km], SE=384 m; p. 331). Others, however, have not noticed this difference (J. Connelly 2004 pers. comm.). Popham and Gutierrez noted that native shrub-steppe habitat had been degraded due to excessive grazing, juniper encroachment, agriculture, and anthropogenic development.

Results from the Popham and Gutierrez study represent a portion of the entire ongoing project being conducted by Hall and his team in Lassen County, CA (F. Hall 2004 pers. comm.).

Johnsgard (2002:116) indicated that there was no obvious relationship between lek location and nest site. In 5 different studies involving more than 300 nests the average distance between lek and Sage-grouse nest where the females was first seen or captured was 3.5 mi (5.6 km). This distance is greater than the mean interlek distance from several studies, which ranged from 0.8- 3 mi (1.3- 4.8 km; Wakkinen *et al.* 1992, Johnsgard 2002:116, J. Connelly 2004 pers. comm., R. Hazlewood 2004 pers. comm.).

Columbia Sharp-tailed Grouse

Disturbance to Sharp-tailed Grouse was reported by Baydack and Hein (1987:538) in southwestern Manitoba. While males were reported present during disturbances (*e.g.*, parked vehicles, propane exploders, scarecrows, taped voices, radio sounds, and a leashed dog), female Sharptails were not observed on leks during test disturbances. Disturbance appeared to limit reproductive opportunities for both sexes. They concluded that continued disturbance over several seasons could bring about population declines.

Giesen and Connelly (1993) reported on movements and management needs of Columbia Sharp-tailed Grouse in the West. While wind turbines were unavailable to assess during this time frame, reported Grouse movements between breeding areas and winter range – varying from 1.6 mi (2.6 km) to 12.4 mi (20 km) depending on study and location (p. 327) – could be impacted by current and proposed wind development. They specifically indicated the lack of experimental data on the effects of habitat alterations on this species. Among their recommendations, Giesen and Connelly (1993:331) suggested avoiding vegetation manipulation within a 1.25-mi (2 km) radius of the active lek in order to protect the nesting and brood-rearing habitats of this Sharp-tailed Grouse.

Suitable But Abandoned Habitat

During periods of population decline, prairie grouse may abandon lekking sites in smaller, fragmented habitats and congregate into larger, more intact areas (core habitat). Given that many grouse species are currently at population lows, human development of suitable but abandoned prairie grouse habitat could severely impede efforts to restore their numbers. In other words, protection of core prairie grouse habitat through the use of the Service’s 5-mile buffer is a conservative approach (B. Obermeyer 2004 pers. comm.).

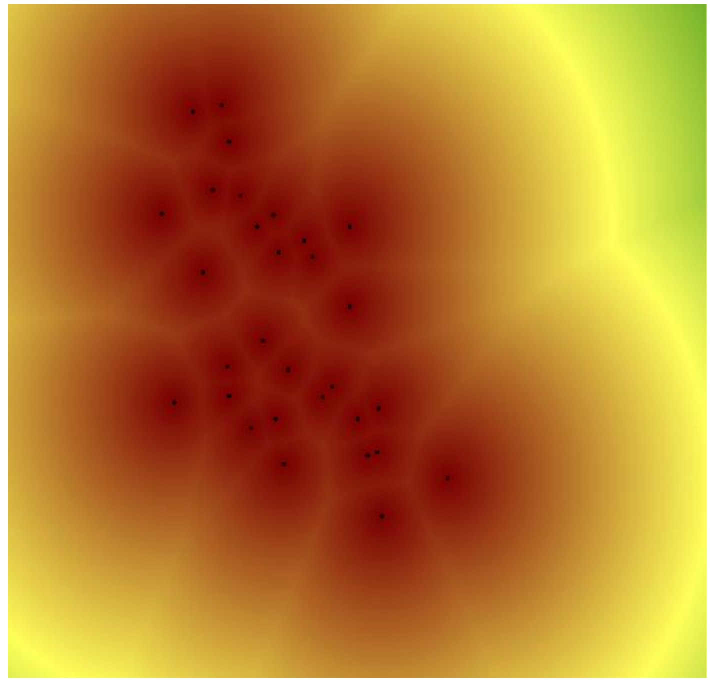

Figure 7. Dots represent 1997 locations of GPCH leks within a 115,000-acre block of tallgrass prairie in KS. Yellow area = ~237 mi^2 (608 km^2; unpubl. data).

Obermeyer and Applegate (unpublished data) located 31 active GPCH leks in a 181-mi^2 area (465 km^2, 115,000 acres) of native rangeland in eastern Greenwood County, KS, during spring of 1997. Lek influence within the study area, as defined by a 1.9-mi (3-km) radius, was 152.6 mi^2 (391.4 km^2; Figure 7). Generally, the stronger leks were located in the more unfragmented areas of native rangeland. A much larger zone of lek influence at this study area was noted just a few years previous. Lek distribution along the western boundary shrank by approximately 6 miles between 1987 and 1997 (B. Obermeyer 2004 pers. comm.). Development of suitable but abandoned prairie grouse habitat (*e.g.*, unoccupied, historical leks) could seriously impede prairie grouse restoration efforts.

Concerns for Other Grassland and Shrub-Steppe Avifauna in Relation to Wind Energy Development

Manes *et al.* (2004 manuscript in preparation, R. Manes, S. Harmon, B. Obermeyer, and R. Applegate 2004 pers. comm.) summarized the documented effects of wind facilities on birds, indicating that Golden Plovers and Lapwings had been displaced by as much as 0.5 mi (0.8 km) from wind facilities in Denmark (citing Pederson and Poulsen 1991) while in Netherlands, Lapwings and Curlews avoided areas within 0.15-0.3 mi (0.25 – 0.5 km) of wind turbines (citing Winkelman 1990).

Although focused on grassland passerines rather than prairie grouse, Leddy *et al.* (1999:101) recommended placing wind plants within cropland habitats in MN rather than in native grasslands. Research at the Buffalo Ridge Project in southwestern MN revealed that the Bobolink, Red-winged Blackbird, Savanna Sparrow, and Sedge Wren nested in densities 4 times higher in grasslands that were ~ 600 ft. (180 m) from wind turbines than those within ~ 260 ft (80 m) of turbines. Densities beyond 600 ft. were not evaluated (Leddy *et al.* 1999). Because of the trend for larger turbines, avoidance zones adjacent to the new generation turbines may differ from those of previous studies (R. Manes, S. Harmon, B. Obermeyer, and R. Applegate 2004 pers. comm.). Sage-steppe-obligate songbirds (*e.g.*, Sage Sparrow, Brewer’s Sparrow, Sage Thrasher, and Black-chinned

Sparrow) are also showing population declines and management concerns should also focus on these species.

The Service asserts that by avoiding or minimizing construction of wind facilities in native prairie grasslands and native sage-steppe habitats, grassland- and sage-dependent native songbird species would be protected and habitat fragmentation would be avoided.

Service's Recommendation for 5-Mile Buffer from Leks

The intent of the Service's recommendation for a 5-mile zone of protection is to buffer against increased mortality (both human-caused and natural), against habitat degradation and fragmentation, and against disturbance. In considering our recommendation, FWS recognizes major declines in populations and habitats of prairie grouse. All species of prairie grouse are in varying stages of decline – some populations declining precipitously -- requiring a major focus on direct human impacts, disturbance from structures, and fragmentation of habitats. While wind plants are new additions to prairie grouse habitats in the Midwest and West, cumulative impacts from human development and exploitation must be assessed with great care and considerable detail. To reverse these declines will take significant commitment from industry, the Service, and other stakeholders. We view the voluntary nature of our guidance and specifically our 5-mile recommendation as a reasonable effort needed to conserve these important resources.

While migratory populations of Sage-grouse may require in excess of 11 miles in radius of protected habitat from active leks (Connelly *et al.* 2000:978), it can be argued that LPCH may require protection less than being suggested by FWS (Mote *et al.* 1998:18; 2.5 mi [4.1 km] distance from a lek located in the center of a circular home range). However, rangewide the majority of remaining LPCH populations are fragmented and isolated into "islands" of open prairie. Our 5-mile setback is intended to protect both Prairie Chickens and the wind industry. Later wind turbine construction, for example, could if in close proximity to leks significantly impact Prairie Chicken populations. Habitat corridors between leks and population centers could also be impacted by close development, likely impacting future recovery. Our distance recommendation will also help address decreasing habitat patch sizes and diminishing habitat complexity that will be affected as structures become more abundant and roads, power lines, vehicles, and human disturbance further fragment and impact habitats. Current distance recommendations for LPCHs may simply reflect the "tolerance" level of LPCHs to "structures" in fragments of < 12,350 ac (5,000 ha) in size of moderate complexity (C. Hagen 2004 pers. comm.). As patch size becomes smaller and less complex, the LPCH may likely be less tolerant of disturbance. Until data can support an alternate hypothesis, Hagen (2003:159) and C. Hagen (2004 pers. comm.) suggested protecting as large a buffer as possible for LPCH. Again, the Service's 5-mile recommendation seems reasonable (Figures 7 and 8) and applicable to all species of prairie grouse. As the necessary research is conducted to more clearly define the effects on grassland and sage-steppe species and as new data become publicly available, we will use it to refine our recommendation.

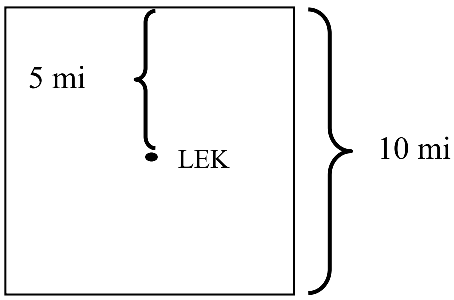

Fig 7. 100 mi^2

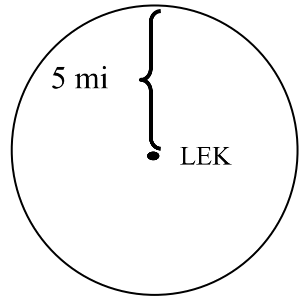

Fig 8. 78.5 mi^2

Figures 7 and 8. FWS summary of recommended 5-mile protection zone from active leks for populations of prairie grouse based on hypothetical square and circular home ranges with centrally-located leks, after S. Harmon (2004 pers. comm.), Connelly *et al.* (2000:978), Pitman (2003), Hagen (2003), C. Hagen (2004 pers. comm.), Wolfe *et al.* (2003a and 2003b), Patten *et al.* (2004a and 2004b), C. Braun (2004 pers. comm.), C. Aldridge (2004 pers. comm.), F. Hall (2004 pers. comm.), and B. Obermeyer (2004 pers. comm.).

The results from and concerns raised by a March 2003 Kansas City, MO, workshop on "Great Plains Wind Power and Wildlife" were used as further evidence by the Service to take a precautionary approach in recommending our 5-mile distance (R. Manes 2003 pers. comm.).

Acknowledgements:

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Suggested citation:

Manville, A.M., II. 2004. Prairie grouse leks and wind turbines: U.S. Fish and Wildlife Service justification for a 5-mile buffer from leks; additional grassland songbird recommendations. Division of Migratory Bird Management, USFWS, Arlington, VA, peer-reviewed briefing paper. 17 pp.

BEFORE THE SOUTH DAKOTA PUBLIC UTILITIES COMMISSION

DOCKET NO. EL19-003

IN THE MATTER OF THE APPLICATION BY CROWNED RIDGE WIND, LLC FOR A PERMIT OF A WIND ENERGY FACILITY IN GRANT AND CODINGTON COUNTIES, SOUTH DAKOTA, FOR CROWNED RIDGE WIND FARM

Direct Testimony of Tom Kirschenmann
On Behalf of the Staff of the South Dakota Public Utilities Commission
May 10, 2019

EXHIBIT
Staff
S3

Q: **State your name.**
A: Tom Kirschenmann

Q: **State your employer.**
A: State of South Dakota, Department of Game, Fish, and Parks

Q: **State the program for which you work.**
A: Division of Wildlife, Terrestrial Resource Section

Q: **State the program roles and your specific job with the department.**
A: The role of the Terrestrial Resources section is to study, evaluate, and assist in the management of all wildlife and associated habitats. Management includes game and non-game wildlife populations, habitat management on public lands and technical assistance and habitat development on private lands, population and habitat inventory, and environmental review of local and landscape projects. As the Deputy Director of the Wildlife Division and Chief of the Terrestrial Resources Section, I oversee and am involved with wildlife management and research, as well as habitat management consisting of the department's public lands and private lands programs.

Q: **Explain the range of duties you perform.**

A: Duties include leading the Terrestrial Resources section that includes three program administrators (Wildlife, Habitat, Wildlife Damage) and 23 wildlife biologists; coordinate and assist with the Division of Wildlife's Operations at four administrative regions; oversee wildlife research, management, and the establishment of hunting seasons for game species; oversee private lands and public lands habitat programs; coordinate environmental review evaluations and responses related to terrestrial issues with department staff; serve as the Department's liaison for several state and federal agencies; and represent the Department on state and national committees.

Q: On whose behalf was this testimony prepared?

A: This testimony was prepared on behalf of the Staff of the South Dakota Public Utilities Commission.

Q: What role does the Department of Game, Fish and Parks have in the permitting process of a wind energy development project?

A: Game, Fish and Parks has no regulatory authority when it comes to permitting wind energy development projects. The agencies role is to consult with developers and provide recommendations and suggestions on how to minimize or remove potential impacts to wildlife and associated habitats or provide available information to make informed decisions as related to natural resources.

Q: Have you reviewed the Application and attachments? How else did you learn details around the proposed project?

A: Yes, relevant sections of the application and attachments and also discussed project details with GFP biologists who had more direct communications with the developer.

Q: Did the GF&P provide comments and recommendations to Crowned about the project area? Please identify who provided those comments and provide a brief summary of them.

A: Game, Fish and Parks was initially contacted in October 2007 by TetraTech to request a search of GFP listed threatened or endangered species, and any additional environmental concerns for the project area. A response was sent in December of 2007 by Silka Kempema, wildlife biologist. During this initial contact, information about species of concern and important or sensitive wildlife habitats in the project area were shared with the applicant. Additionally, in November 2007, Doug Backland, wildlife biologist provided a shapefile of threatened, rare, or endangered species present within the project area (natural heritage database review). In December 2009, TetraTech contacted GFP to request an additional natural heritage database review. Game, Fish and Parks provided a list of species occurrences for the project area. In November of 2010, Western Area Power Administration (WAPA) contacted GFP with a scoping notice for the Crowned Ridge Wind Energy Center in Codington County, South

Dakota. GFP replied to the WAPA scoping notice in January 2011 with a letter describing important wildlife habitats (grasslands, wetlands, etc.), information about rare, endangered or threatened species that could occur in the project area as well as general wildlife survey guidelines. In March 2014, GFP provided historic grouse lek locations in and around the project boundary. Game, Fish and Parks was contacted by TetraTech in February 2015 requesting information regarding ecologically significant areas and listed endangered, threatened or special concern species at a potential wind energy development site in Codington and Grant Counties, South Dakota. Game, Fish and Parks staff replied to their request in March 2015 with a letter describing ecologically sensitive areas in the project area and advising an up-to-date Natural Heritage database request, based on the amount of time that passed since the previous request. Information was also included about important wildlife habitats, avoidance of turbine placement in and around public lands, recommendations on transmission line construction and general wildlife survey guidelines for pre and post construction surveys. In March 2017, GFP was first contacted by Nextera, and Ms. Kempema recommended an in-person meeting for the opportunity to review proposed turbine layout and wildlife surveys that had been conducted to-date. In April 2017, a conference call with GFP, USFWS and Nextera was conducted to share a project overview, as well as results from wildlife surveys. During this conference call, Ms. Kempema recommended Nextera avoid placing turbines in untilled grasslands and wetlands, and recommended a 1 mile no-construction buffer around grouse leks. Ms. Kempema also requested a copy of any wildlife survey reports, and recommended a site-visit with GFP and USFWS. In July 2017, GFP received a request from SWCA Environmental Consultants to request information regarding ecologically sensitive areas and federally and state listed endangered, threatened or special concern species in the Crowned Ridge project area. Results from a natural heritage database search was provided to SWCA in August 2017. On April 3rd, 2019, SWCA Environmental Consultants requested information regarding ecologically sensitive areas and federally and state listed endangered, threatened or special concern species in the Crowned Ridge project area. Results from a natural heritage database search were provided to SWCA on April 26th 2019.

Q: Do you agree with the comments and recommendations provided to Crowned Ridge by Ms. Kempema? If not, please explain.

A: Yes. These are typical discussion topics and recommendations our Department would share with wind power companies to identify, minimize, or reduce impacts to wildlife and wildlife habitats, especially those projects that are proposed in grassland and wetland habitats.

Q: Based on the information provided in the Application, in your opinion did Crowned Ridge utilize the proper studies and wildlife surveys

necessary to identify potential impacts to the terrestrial environment?

A: Pre-construction wildlife survey data usually incorporates a small snap-shot in time (ex. monthly large bird counts) but is used to assess risks for the life of a project (~30 years) therefore, it is important to perform surveys with a high degree of scientific rigor. The US Fish and Wildlife Service (USFWS) Land-Based Wind Energy Guidelines (hereafter referred to as USFWS guidelines) are intended to encourage scientifically rigorous survey, monitoring, assessment and research designs, produce potentially comparable data across the nation, and improve the ability to predict and resolve effects of wind energy development locally, regionally and nationally. These guidelines, along with GF&P siting guidelines (https://gfp.sd.gov/userdocs/docs/SDSitingGuides_2018-10-17.pdf) are voluntary suggestions (USFWS 2012).

Survey methods used by Crowned Ridge followed the USFWS guidelines, and were reasonable and appropriate. Crowned Ridge conducted aerial raptor nest surveys, avian use surveys, large bird use surveys, grouse lek surveys, bat acoustic surveys, bat habitat assessments and an endangered butterfly habitat assessment.

Q: **What are the potential impacts to wildlife as a result of the construction of a wind project?**

A: Direct; birds and bats can be killed by turbines due to direct strikes. Indirect; some species may be displaced from otherwise suitable habitat around turbines and roads. A research project on the effects of wind energy on breeding grassland bird densities in North and South Dakota showed seven of nine species of grassland birds had reduced densities around wind turbines over time (Shaffer and Buhl 2016).

Q: What potential impacts to wildlife habitat can result from a wind project?

A: Permanent loss; habitat is permanently converted to turbine pads, roads or buildings. This is often a small percent of the total project acreage (area define by wind easements or otherwise defined project boundary). Temporary loss; habitat is disturbed for a time during construction (e.g. widened roads, crane paths) but is restored. Fragmentation; habitat fragmentation is the division of a block of habitat into smaller, and at times into isolated patches. Habitat fragmentation can decrease the overall value of the remaining habitat.

Q: Can you suggest methods to address temporary and permanent changes to habitat?

A: Temporary impacts to habitat resulting from construction activities likely can be reclaimed by restoring impacted areas by grading and reseeding. Disturbed areas should be restored using native seed sources to reduce the introduction of new or discourage encroachment of already present exotic and/or invasive species.

For those areas that are permanently changed, lost grassland or wetland acres could be addressed through consideration of mitigation options. Disturbed areas again should be restored using native seed sources to reduce the introduction of new or discourage encroachment of already present exotic and/or invasive species. It would also be recommended that if lost acres are replaced to carry out these replacement activities in the closest possible proximity of the project.

Q: Are there any other impacts besides temporary and permanent habitat impacts that are likely to occur as a result of the project?

A: Indirect habitat impacts are also a consideration. Potential indirect impacts created by wind turbines and associated infrastructure raise concerns with habitat fragmentation and potential displacement, especially with regards to breeding grassland and wetland species. Research into the effects of wind energy on habitat avoidance has shown that some species will not use grassland or wetland habitat within a certain distance of a wind turbine (Loesch et al. 2013, Shaffer and Buhl 2016).

Q: Did GFP have any wildlife or habitat concerns regarding the proposed Crowned Ridge project? If yes, what are they?

A: Yes. The area of primary interest is the potential impacts to the various grassland habitats and associated wildlife.

Q: **Did GFP provide any recommendations to avoid wildlife and habitat impacts from Crowned Ridge? If yes, what were they?**

A: Yes. The primary recommendations were to site turbines and associated infrastructure in cropland, minimize fragmentation, utilize existing infrastructure and avoid siting turbines in grasslands, and completion of post-construction surveys for bat and bird mortality which could be used in assisting with operational adjustments in the future.

Q: Are there different types of grasslands?

A: Yes.

Q: Please describe the following: native prairie, hayland, pasture, CRP, and cropland.

A: Grasslands are areas that contain plants species such as graminoids and commonly used for grazing or set aside for conservation purposes. They can also be areas which are planted to a mixture of grasses and legumes for livestock grazing or feed. Native prairie is grassland upon which the soil has not undergone a mechanical disturbance associated with agriculture or any other type of development. Hayland is grassland that is managed by frequent mowing and often contains non-native plant species either intentionally or by encroachment. Pasture is grassland that may contain non-native plant species either intentionally or by encroachment and is managed by through grazing. In some instances hayland and pasture could be native prairie; in other situations hayland and pasture in particular could be land once cultivated and restored to grassland habitat. Conservation Reserve Program acres (CRP) is grassland that occurs on land that was once tilled and used for crop production and has now been seeded to herbaceous cover to address soil loss, water quality, and provide wildlife habitat. Cropland could be described as agricultural lands cultivated and used to grow crops such as corn, soybeans, small grains, and others.

Q: **Are there any areas of native prairie in the proposed project?**

A: Yes. Spatial analysis conducted by Bauman et al. (2016) has identified potentially undisturbed lands within the proposed project boundary. This is one of the best available spatial data sets representing the location of untilled native grasslands. The applicant also identified within the application an estimated 17,889 acres of untilled grassland within the project area (pg. 49).

Q: Do grasslands other than native prairie have conservation value?

A: Yes. Given the loss of native prairie, working grasslands like pasture, hayland, and conservation grassland plantings serve as surrogates for native grasslands.

Q: To your knowledge, are there grazed grasslands in the project area?

A: Yes.

Q: Do grazed grasslands have any conservation value and what is the impact to grassland wildlife?

A: All grasslands have a conservation value, including those managed through grazing. Grassland birds require a diversity of grassland types and structure to complete life-cycle requirements. Studies have shown that grassland birds respond primarily not to variation in plant species composition but to the structure that these plants provide. Grassland birds have evolved with a gradation of grazing intensities. Grassland wildlife diversity can be maximized by creating a heterogeneous landscape comprised of short, medium and tall vegetation structures. Grazing (haying and burning) management can provide this variation in vegetative structure. Changes in land management and annual precipitation levels can alter plant species composition and vegetation structure of grassland within a short timeframe.

Q: One of the GF&P's recommendations was that efforts should be made to avoid placement of turbines and new roads in grasslands, especially untilled native prairie. Based on the information in the Application and the proposed turbine layout, did Crowned Ridge demonstrate efforts to address this recommendation? Please explain.

A: Data from the application indicates that 17,889 acres of the 53,186 acre project area is native prairie habitat. From reviewing the available maps, resources, and other information available there were efforts to avoid placement of turbines on untilled native prairie as approximately 19 of the planned 130 turbines appear to be positioned in native prairie. A continued recommendation for wind development is to avoid untilled native prairie habitat to the greatest extent possible. It appears that multiple turbines are being planned in cultivated land (disturbed) which from a wildlife perspective is a positive siting approach. Some turbines will likely be placed on other types of grassland habitats (hay and pasture) within the project area. Avoidance of all grassland habitat will be challenging in this part of the state and in the project area as a high proportion of the total area is some type of grassland/herbaceous habitat as demonstrated by the application indicating that project construction easement is 26% grass/pasture (page 47).

Q: One of GF&P's concerns around wind farm development is the fragmentation of contiguous blocks of grasslands. Why is fragmentation a concern?

A: Fragmentation results in the direct loss of habitat and diminishes the value of remaining habitat. Habitat fragmentation is the division of large contiguous blocks of habitat into smaller, and in some instances isolated patches. Identification of contiguous blocks of habitat, especially in predominantly non-habitat landscapes is an important component of grassland and wetland bird conservation.

Q: Are there any areas of contiguous grassland habitat in the proposed project?

A: Yes. The northeastern portion, central portion and northwestern portion of the proposed project area have the highest level of contiguous blocks of grassland habitat.

Q: Based on the information available does the GF&P have concerns over the placement of turbines and roads in contiguous blocks of grassland?

A: Based on reviewing available information, fragmentation of grassland habitats were avoided/minimized in some of the project area through the proposed layout of the infrastructure of the wind farm. This is a result of primarily utilizing tilled agricultural fields for turbine locations. There are other locations of the project area which the placement of turbines will likely create some level of fragmentation of smaller grassland blocks (comprised of different grassland cover types: hay, pasture, etc.). Based on the location of the project area and the existing land-use, it will be challenging not to create some additional fragmentation of grassland habitat, and in some situations larger contiguous blocks comprised of different grassland cover types.

Q. Does the state or GF&P have specific mitigation recommendations that will minimize or compensate potential impacts from wind energy development if they cannot be avoided?

A. At the current time South Dakota does not have a state mitigation policy that can be provided to wind energy developers. However, there are resources available which can provide guidance and suggestions that can be considered as well as self-imposed actions or activities that can minimize natural resource impacts.

Q: What are potential mitigation considerations?

A: Mitigation can take multiple forms and accomplished in a multitude of ways. It could be an approach which implements an applied management activity/strategy on impacted lands which elevates these lands to a more productive state or higher ecological state (example – grazing management) to an approach which is more sophisticated and detailed using tools developed to calculate acres of habitat to be restored or created based on impacted acres and other relevant research data (example – decision support tool). Two examples that are available specifically for wind energy projects is a decision support tool based off the research conducted by Loesch et al. (2013) that considers breeding waterfowl and another which focuses on breeding grassland songbirds resulting from research findings of Shaffer and Buhl (2016). As stated earlier South Dakota does not have a state mitigation policy nor does the state endorse either study and resulting products, however it is worthy of mentioning these tools demonstrating resources available to developers and managers.

Q: The GF&P recommended that turbines should not be placed in or near wetland basins and special care should be made to avoid areas with high concentrations of wetlands. Do you believe that Crowned Ridge's proposed turbine layout incorporates this recommendation?

A: The application mentions under mitigation measures for wildlife that wetlands will be avoided or minimize disturbance of individual wetlands during project construction. These are appropriate measures. No turbines are planned in wetland basins. Reviewing the turbine layout and using NWI wetland information for the project area, some turbines appear to be placed in areas of higher concentrations of wetland basins (specifically in the central and eastern portions of the project). It will be challenging to avoid areas of wetland concentrations because of the number of wetland acres and basins found in this part of the state and project area. Recommendations to avoid areas of higher concentrations of wetlands is supported by findings from Loesch et al. (2013).

Q: Are you aware of any other wind farms near this proposed project?

A: Yes. I am aware of projects in the area by reviewing the map of wind projects found on the PUC website indicating projects either in the status of existence, proposed, pending, or under construction.

Q: Does the GF&P have any thoughts regarding the potential for cumulative impacts the Project may have?

A: As projects are completed and based on location and proximity to other projects, the question of cumulative impacts will become more apparent. Knowing the importance of native prairie tracts and other forms of grassland habitat to several grassland dependent species, continued development on these types of lands could result in reduced or limited habitat value. Placement of turbines in lands currently under cultivation and avoiding where possible the different varieties of grassland and wetland habitats will help minimize potential cumulative impacts.

Our agency will continue to work with wind developers and provide recommendations that we believe will help minimize cumulative impacts.

No different than offered to this project, the focus could include, but not limited to, recommendations on avoiding grassland habitats, in particular native prairie remnants, avoidance of high wetland complex areas, maximize the use of existing corridors for infrastructure, and pre and post construction surveys to assess the proposed project area that may assist in operational decisions.

Q: Do any State threatened or endangered species have the potential to be impacted by the wind farm?

A: There are two records of the state threatened Northern River Otter adjacent to the project boundary. Filing a storm water pollution prevention plan and putting in place practices to reduce or eliminate sedimentation will help negate potential negative impacts to Northern River Otters that may be in or near the project area.

Q: Are there any GF&P lands or other public lands that may be impacted by the wind farm?

A: It does not appear any Game Production Areas within the project area will be impacted by the project. There are six walk-in-area parcels within the project area; three turbines are planned on these properties. These properties are privately owned and an agreement with GFP opens them to free public access for hunting. Should a Walk-In Area be temporarily disrupted for construction, GFP would ask we are involved with those discussions to determine whether any action required from our agency to notify the public.

For clarification, Game Production Areas and Waterfowl Production Areas are not private land leased by GFP. Game Production Areas are owned by the State of South Dakota and managed by GFP. Waterfowl Production Areas are publicly owned and managed by the US Fish and Wildlife Service.

Q: Does the GF&P have any recommendations to protect those GF&P lands or other public lands?

A: The state does not have an established set-back policy or recommendation for wind turbine placement in proximity to state properties such as Game Production Areas. Set-back policies have been established at local levels by local government entities and in some instances have been suggested as the potential set-back distance from state properties. At this time it is the state's belief that these types of policies be established at the local level and at the discretion of the PUC Commission to impose such set-backs when considering wind energy permits.

Q: If the final turbine locations changed from those provided in the proposed turbine layout, could the potential terrestrial environment impacts change?

A: Yes.

Q: You mentioned the applicant requesting data from the Natural Heritage Database. What is the South Dakota Natural Heritage database? What type of information does it contain?

A: The South Dakota Natural Heritage database tracks species at risk. Species at risk are those that are listed as threatened or endangered at the state or federal level or those that are rare. Rare species are those found at the periphery of their range, those that have isolated populations or those for which we simply do not have extensive information on.

This database houses and maintains data from a variety of sources including site-specific surveys, research projects and incidental reports of species that cover a time period from 1979 to the present. It is important to note that the absence of data from this database does not preclude a species presence in the proposed project area.

Q: In summary, does GF&P offer any specific permit recommendations should the permit be granted?

A: Game, Fish & Parks would suggest performing post-construction avian and bat mortality monitoring for at least two years; one year of post-construction surveys is currently proposed by the developer in the PUC application to confirm operational trends are consistent with previously observed trends for other projects in the region. That consistency would have more assurance with two years of data.

Additionally, GFP recommends post-construction grouse lek monitoring of confirmed leks less than 1 mile from proposed turbines. This data could be useful information for future discussions around cumulative effects of wind energy development on prairie grouse. We also recommend consultation between the developers, GFP and the US Fish and Wildlife Service on proposed survey methodology for post-construction lek monitoring. GFP would request a copy of any future report to be shared with the US Fish and Wildlife Service and GFP.

Q: Does this conclude your testimony?

A: Yes.

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Eureka High School, Eureka, SD, 1989
BS: Wildlife and Fisheries Sciences, South Dakota State University, May 1993
MS: Wildlife Management, South Dakota State University, May 1996

Certifications:
Certified Wildlife Biologist, The Wildlife Society, July 2000
Level III Career Development Training, SD GF&P, 2007

Experience:

SOUTH DAKOTA GAME, FISH, AND PARKS, Pierre, SD
Wildlife Division Deputy Director (2016 - present) & Chief of Terrestrial Resources (11/08 - present)
Supervisor: Tony Leif, Director, Division of Wildlife, 605-773-4518

- Serve as the Wildlife Division's Deputy Director to assist with the overall management of the Division.
- Coordinate the management and research of game and non-game species statewide.
- Coordinate the management of the Departments habitat programs, including the private lands programs, public lands management, access programs, terrestrial environmental assessments, and programs related to the federal Farm Bill.
- Oversee a staff that includes a Program Administrator for Wildlife, Habitat and Wildlife Damage programs and 23 biologists.
- Serve as the Department's liaison or representative for several state and federal agencies and associated committees.
- Coordinate with non-government organizations, constituency groups, and agricultural groups on resource management programs, projects, and issues.
- Manage an annual budget of approximately $16M which includes research, direct payments to landowners for habitat, hunting access, and wildlife damage, and contracts to complete surveys, programs, and projects.
- Lead rules promulgation process for respective duties by presenting to the GFP Commission and assisting in writing administrative rules.

SOUTH DAKOTA GAME, FISH, AND PARKS, Pierre, SD
Wildlife Program Administrator, Game Management (12/07 – 11/08)
Supervisor: George Vandel, Assistant Director, Division of Wildlife, retired

- Coordinated the management and research of all game species statewide.
- Coordinated the accumulation and organization of data and regional suggestions in the development of hunting season recommendations.
- Drafted action sheets and present season recommendations to GF&P Commission.
- Assisted with the development and a team member that reviews hunting season applications and the Hunting Handbook.
- Supervised 9 biologists and 1 secretary stationed in five locations across the state.

- Served as department representative on committees (wildlife disease boards and poultry advisory board) and liaison to the SDSU Diagnostic Lab and APHIS Wildlife Services for Avian Influenza monitoring.
- "Press Release" review team member.
- Oversaw the Game Budget, including the contractual research projects with SDSU Wildlife and Fisheries Department and other academic institutions.
- Worked with the media addressing game and related issues, including live interviews, newspaper articles, and the writing of short articles.
- Team member in the development and implementation of the Mentored Hunting Program.
- Presented research and management information at regional meetings, Commission meetings, and to conservation organizations.

SOUTH DAKOTA GAME, FISH, AND PARKS, Huron, SD
Sr. Wildlife Biologist (1/05 – 12/07)
Supervisor: Tony Leif, Director, Division of Wildlife, 605-773-4518

- Oversaw management and research of upland game species statewide.
- Directed internal upland game research, analyses, and reports.
- Part of game staff committee that provided recommendations on all game seasons and license allocations.
- Served as Office Manager at the Huron GF&P District Office: directing day to day activities of Resource Biologist and Secretary within the Upland Game Section.
- Served as field co-leader with waterfowl biologist in the coordination of statewide Avian Influenza (AI) sampling.
- Worked with regional game staff on management, survey, research, and mortality projects.
- Administered the departments Wildlife Partnership Program for two years and provided guidance and direction upon request.
- Assisted with the coordination of meetings and trainings, including serving as chair person of the Prairie Grouse Technical Council (PGTC) meeting in October 2007.
- Served as department representative on several committees such as Midwest Pheasant Study Group, PGTC, Sage Grouse Council, Poultry Advisory Board (AI matters), and the National Wild Turkey Federation Technical Representative.
- Wrote management and scientific reports, as well as magazine and newspaper articles.
- Conducted presentations internally, as well as landowner and sportsmen club meetings.

PHEASANTS FOREVER, INC., St. Paul, MN
Regional Wildlife Biologist
South Dakota & Wyoming (4/00 – 1/05)
Illinois & Indiana (7/95 – 4/00)
Supervisor: Richard Young, VP Field Operations, 877-773-2070

- Established and maintained chapters comprised of grassroots volunteers and guided them in the development of habitat programs, fundraising efforts, and youth programs.
- Worked with chapters to develop wildlife habitat programs designed to fit the needs for both local and regional areas.
- Directed and assisted chapters with annual fund-raising events. Wrote grants to support local and state habitat efforts.
- Built partnerships between Pheasants Forever (both chapters and national) with local, state, and federal conservation agencies. Primary PF representative in developing SD Wildlife Habitat Extension Biologist (WHEB) program with SD GF&P and SD NRCS.
- Developed reporting system, submitted reports to GF&P, NRCS, and PF national, wrote grants, and some supervisory duties related to the WHEB program.
- Served on several state and federal habitat committees (State Technical Committee for both SD and WY, SD CRP sub-committee, WHIP sub-committee for SD and WY, SD School and

Public Lands, Northern Great Plains Joint Venture, Great Lakes and Upper Mississippi Joint Venture, IL Pheasant Fund Committee, IN DNR Gamebird Partnership Committee, IL DNR Conservation Congress).

- Organized and conducted wildlife habitat workshops for chapters, landowners, and other agency personnel.
- Established agenda, budget, and organized annual meeting for subgroup of co-Regional Wildlife Biologists, while serving as Mentor Group Leader.
- Wrote newspaper articles, interviewed for radio and TV shows, conducted presentations, and distributed newsletters.
- Educated volunteers about wildlife biology, habitat, wildlife interactions, and counsel on current, upcoming, and changes to state and federal conservation programs.

SOUTH DAKOTA STATE UNIVERSITY; Brookings, SD
Graduate Research Assistant (4/93 - 7/95; graduated 1996)
Supervisor: Dr. Daniel Hubbard, Professor, retired
Graduate Research Project.

- Research involved the comparison of avian and aquatic invertebrate abundances on conventional, organic, and no-till farming systems.
- Efforts included breeding waterfowl pair counts, waterfowl brood counts, wetland bird surveys, upland bird surveys, and aquatic invertebrate sampling.
- Other duties included surveying aquatic plants and collecting soil seed bank samples.
- Prepared bi-annual reports for USDA and EPA.

SOUTH DAKOTA STATE UNIVERSITY; Brookings, SD
Research Technician (3/92 - 8/92)
Supervisor: Diane Granfors, Graduate Research Assistant
Seasonal position.

- Assisted with wood duck study determining brood habitat and survival.
- Built, repaired, and placed wood duck nesting structures.
- Candled eggs, web tagged ducklings, banded hens, placed radio telemetry collars and acquired locations.

SOUTH DAKOTA STATE UNIVERSITY; Brookings, SD
Research Technician (10/90 - 3/91; 10/91 - 3/92)
Supervisor: Todd Bogenschutz, Graduate Research Assistant
Seasonal position.

- Aided on the research study that evaluated corn and sorghum as a winter food source for the ring-neck pheasant.
- Shared duties to feed pen birds on restricted diets.
- Sampled winter food plots.
- Assisted in extracting intestinal organs and taking anatomical measurements and weights.

SOUTH DAKOTA STATE UNIVERSITY; Brookings, SD
Research Technician (5/91 - 8/91)
Supervisor: John Lott, Graduate Research Assistant
Seasonal position.

- Worked on yellow perch food habit study.

- Used various equipment to sample fish and zooplankton. Aged fish and processed stomach contents. Sorted and tabulated zooplankton samples.

THE NATURE CONSERVANCY, Ordway Prairie, Leola, SD
Intern/Preserve Worker (5/90 - 8/90)
Supervisor: Andy Schollett, Preserve Manager
Seasonal position.

- Monitored grazing leases and rotations, conducted brome and prairie plant surveys, spraying of noxious weeds, fencing and general maintenance.

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Management and Conservation

Effect of Wind Energy Development on Breeding Duck Densities in the Prairie Pothole Region

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ABSTRACT Industrial wind energy production is a relatively new phenomenon in the Prairie Pothole Region and given the predicted future development, it has the potential to affect large land areas. The effects of wind energy development on breeding duck pair use of wetlands in proximity to wind turbines were unknown. During springs 2008–2010, we conducted surveys of breeding duck pairs for 5 species of dabbling ducks in 2 wind energy production sites (wind) and 2 paired reference sites (reference) without wind energy development located in the Missouri Coteau of North Dakota and South Dakota, USA. We conducted 10,338 wetland visits and observed 15,760 breeding duck pairs. Estimated densities of duck pairs on wetlands in wind sites were lower for 26 of 30 site, species, and year combinations and of these 16 had 95% credible intervals that did not overlap zero and resulted in a 4–56% reduction in breeding pairs. The negative median displacement observed in this study (21%) may influence the prioritization of grassland and wetland resources for conservation when existing decision support tools based on breeding-pair density are used. However, for the 2 wind study sites, priority was not reduced. We were unable to directly assess the potential for cumulative impacts and recommend long-term, large-scale waterfowl studies to reduce the uncertainty related to effects of broad-scale wind energy development on both abundance and demographic rates of breeding duck populations. In addition, continued dialogue between waterfowl conservation groups and wind energy developers is necessary to develop conservation strategies to mitigate potential negative effects of wind energy development on duck populations.

KEY WORDS *Anas discors*, *A. platyrhynchos*, blue-winged teal, breeding population, mallard, Prairie Pothole Region, wind energy development, wind turbines.

Millions of glaciated wetlands and expansive grasslands make the Prairie Pothole Region (PPR) the primary breeding area for North America's upland nesting ducks (Batt et al. 1989). Wetland and grassland loss in the PPR due to settlement and agriculture has been extensive (Dahl 1990, Mac et al. 1998), and conversion to agriculture continues to reduce available habitat for breeding waterfowl and other wetland- and grassland-dependent birds (Oslund et al. 2010, Claassen et al. 2011). During recent years, anthropogenic impacts in the PPR have expanded to include energy development (e.g., wind, oil, natural gas; see Copeland et al. 2011: table 2.1). From 2002 to 2011, industrial wind energy production has increased 1,158% (i.e., 769–9,670 MW), 205% during the past 5 years (United States Department of Energy [USDOE] 2011). Impacts from wind energy development including direct mortality from strikes and avoidance of wind towers and associated infrastructure have been widely documented for many avian species, including raptors, passerines, upland gamebirds, shorebirds, and waterfowl, as well as bats (Drewitt and Langston 2006; Arnett et al. 2007, 2008; Kuvlesky et al. 2007).

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Wetland habitats in the PPR annually attract and support >50% of the breeding waterfowl population in North America (Bellrose 1980). The productivity and subsequent use of prairie wetlands by breeding ducks in the PPR are critical for the maintenance of continental duck populations (Batt et al. 1989, van der Valk 1989). Because of the potential for extensive wind energy development (USDOE 2008, 2011, Kiesecker et al. 2011), understanding the potential effect of wind power development on the use of wetland habitat by breeding duck pairs in the region is critical.

The potential impacts of wind energy development on breeding ducks are similar to other wildlife reviewed in Kuvlesky et al. (2007). Breeding pairs may abandon otherwise suitable wetland habitat, display behavioral avoidance thereby reducing densities of pairs using wetlands near wind turbines, and experience mortality from collision with turbines and associated infrastructure. Additionally, indirect effects on breeding ducks potentially include avoidance of associated grassland by nesting females, increased predation, or reduced reproduction. Wind towers and supporting infrastructure generally do not directly affect the wetlands that provide habitat for breeding ducks. However, ducks are sensitive to many forms of disturbance (Dahlgren and Korschgen 1992, Madsen 1995, Larsen and Madsen 2000). Avoidance related to the presence of towers, movement of blades (e.g., shadow flicker), blade noise (Habib et al. 2007), infrastructure development including roads and transmission lines (Forman and Alexander 1998, Ingelfinger and Anderson 2004, Reijnen and Foppen 2006), and maintenance activities have been documented for other avian species and may similarly affect breeding pairs and reduce the use of wetlands within and adjacent to wind farms.

The presence of wind energy development in high density wetland and breeding pair habitat in the PPR is relatively recent, and previous studies of the effects of land-based wind development on waterfowl (*Anatidae*) have focused primarily on collision mortality (Winkelman 1990, Johnson et al. 2000, Gue 2012) and the effect of wind farms on foraging behavior of wintering and migrating waterfowl (Winkelman 1990, Larsen and Madsen 2000, Drewitt and Langston 2006, Kuvlesky et al. 2007, Stewart et al. 2007). Wind development appears to cause displacement of wintering or migrating Anseriformes, and bird abundance may decrease over time (Stewart et al. 2007). However, habituation has been reported for foraging pink-footed geese (*Anser brachyrhynchos*) during winter (Madsen and Boertmann 2008). Displacement of duck pairs due to wind development could affect population dynamics similar to habitat loss (Drewitt and Langston 2006, Kuvlesky et al. 2007). However, little information exists on how land-based wind development affects the settling patterns, distribution, and density of duck pairs during the breeding season.

The number and distribution of breeding duck pairs in the PPR is related to annual wetland and upland conditions (Johnson et al. 1992; Austin 2002; Reynolds et al. 2006, 2007; U.S. Fish and Wildlife Service [USFWS] 2012). Wetland conditions in the PPR vary both spatially and temporally (Niemuth et al. 2010) and during dry years in the PPR, waterfowl are displaced to lesser quality habitats farther north (USFWS 2012) where productivity is generally reduced (Bellrose 1980). The long-term sustainability of breeding duck populations is dependent on availability and use of productive wetlands in the PPR that provide local breeding pair habitat when they are wet (Johnson and Grier 1988). Avoidance of wetlands near wind energy development by breeding ducks on otherwise suitable wetland habitat may result in displacement to lesser quality habitats similar to the effect of displacement during dry years. Given the relatively large development footprint (i.e., unit area/GW) for energy produced from wind relative to other energy sources such as coal (e.g., 7.4 times; wind = 72.1 km^2/TW-hr/yr, coal = 9.7 km^2/TW-hr/yr; McDonald et al. 2009) and the projected growth of the industry (USDOE 2008), a relatively large land area and subsequently a large number of wetlands and associated duck pairs in the PPR can potentially be affected.

We assessed the potential effects of wind energy development and operation on the density of 5 common species of breeding ducks in the PPR of North Dakota and South Dakota: blue-winged teal (*Anas discors*), gadwall (*A. strepera*), mallard (*A. platyrhynchos*), northern pintail (*A. acuta*), and northern shoveler (*A. clypeata*). Our objective was to determine whether the expected density of breeding duck pairs differed between wetlands located within land-based wind energy production sites (hereafter wind sites) and wetlands located within paired sites of similar wetland and upland composition without wind development (hereafter reference sites). We predicted that if disturbance due to wind energy development caused avoidance of wetlands by breeding duck pairs, then expected density of breeding pairs would be lower on wind energy development sites. We interpreted differences in estimated breeding pair densities between paired wind energy development sites and reference sites in the context of the current Prairie Pothole Joint Venture (PPJV) waterfowl conservation strategy for the United States PPR (Ringelman 2005).

STUDY AREA

We selected operational wind energy and paired reference sites as a function of the geographic location, the local wetland community and its potential to attract breeding pairs (i.e., ≥40 pairs/km^2; Reynolds et al. 2006), and wetland conditions. In 2008, 11 wind farms were operational in the PPR of North and South Dakota, USA. Of those, only 3 were located in areas with the potential to attract relatively large numbers of breeding duck pairs for the 5 species in this study (Loesch et al. 2012, OpenEnergyInfo 2012). We identified 2 existing wind energy production sites in the Missouri Coteau physiographic region (Bluemle 1991) of south-central North Dakota, USA, and north-central South Dakota, USA (Fig. 1). Both wind sites contained wetland communities with the potential to attract an estimated 46 breeding duck pairs/km^2 (mean density = 8.5 pairs/km^2 for the PPR; Reynolds et al. 2006, Loesch et al. 2012). The Kulm-Edgeley (KE) wind energy development consisted of 41 towers in a cropland-dominated landscape (e.g., 83% of

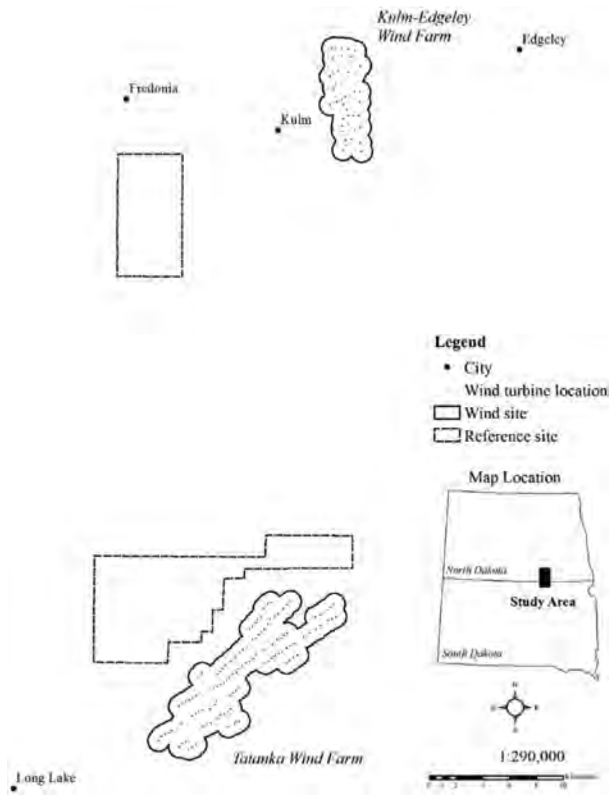

Figure 1. Paired study sites with and without wind energy development surveyed for breeding waterfowl pairs in North Dakota and South Dakota, USA, 2008–2010.

uplands were cropland; Table 1) and was located 3.2 km east of Kulm, North Dakota, USA. The Tatanka (TAT) wind energy development, consisted of 120 towers in a perennial cover-dominated landscape (e.g., 92% of uplands were perennial cover; native grassland, idle planted tame grass, alfalfa hay; Table 1) and was located 9.7 km northeast of Long Lake, South Dakota, USA. The KE site began operation in 2003; approximately 50% of the TAT towers were operational by 28 April 2008 and all were operational by 21 May 2008. Turbine locations were on-screen digitized using ESRI ArcGIS 9.2 software (ArcGIS Version 9.2, Environmental Systems Research Institute, Redlands, CA) and United States Department of Agriculture National Aerial Imagery Program (NAIP) imagery (ca. 2007).

The potential zone of influence for breeding waterfowl from a wind turbine to a wetland during the breeding season is unknown. The limited research that has been conducted to measure displacement of birds in grassland landscapes has primarily targeted migratory grassland passerines, and has identified relatively short (e.g., 80–400 m) distances (Leddy et al. 1999, Johnson et al. 2000, Shaffer and Johnson 2008, Pearce-Higgins et al. 2009). Compared to grassland passerines, waterfowl have relatively large breeding territories and mallards use multiple wetlands within their home range (e.g., 10.36 km^2 generalized to a circle based on a 1,608 m radius; Cowardin et al. 1988). Because the objective of this study was to test the potential effects of wind energy development on breeding duck pair density and not to identify a potential zone of influence, we chose a buffer size with the objective to spatially position sample wetlands in proximity to 1 or many turbines where a potential effect of wind energy development would likely be measurable. Consequently, we used the generalized home range of a mallard hen and buffered each wind turbine by 804 m (i.e., half the radius of a circular mallard home range; Cowardin et al. 1988), to ensure overlap of breeding territories with nearby wind turbines. The wind sites contained different numbers of turbines and as a result the sites were not equally sized (KE wind site = 2,893 ha; TAT wind site = 6,875 ha; Fig. 1).

We derived wetland boundaries from digital USFWS National Wetlands Inventory (NWI) data. We post-processed NWI wetlands to a basin classification (Cowardin et al. 1995, Johnson and Higgins 1997) where we combined complex wetlands (i.e., multiple polygons describing a basin) into a single basin and then classified them to the most permanent water regime (Cowardin et al. 1979). Wetlands partially or completely within the buffer areas were considered treatment wetlands.

For each of the 2 wind sites, we employed a rule-based process to select paired sites to control for differences in wetland and landscape characteristics among sites. We first

Table 1. Characteristics of wetland (i.e., number, area [ha], % of total wetland area) and upland (i.e., area [ha], % of total upland area) areas in development (wind) and paired reference sites in North Dakota and South Dakota, USA, where we surveyed wetlands for breeding duck pairs during spring 2008, 2009, and 2010. Sites included Kulm-Edgely (KE) and Tatanka (TAT) Wind Farms.

	KE wind			KE reference			TAT wind			TAT reference		
Class	Number	Area	%	Number	Area	%	Number	Area	%	Number	Area	%
Wetland												
Temporary	272	41.4	9	283	41.7	7	362	29.9	3	462	97.3	8
Seasonal	372	167.2	37	240	347.3	55	917	253.5	29	815	419.9	36
Semi-permanent	37	239.5	53	37	242.9	38	322	581.7	67	231	636.5	55
Total	681	448.1		560	631.9		1,601	865.0		1,508	1,153.7	
Upland												
Perennial cover[a]		416.3	16		1,324.4	37		5,428.4	92		6,039.7	85
Cropland		2,120.5	83		2,232.8	63		455.3	8		1,064.1	15
Other		6.6	<1		13.4	<1		18.3	<1		11.4	<1
Total		2,543			3,570.6			5,902.1			7,115.2	

[a] Includes native grassland, undisturbed grassland, and alfalfa hay landcover classes.

considered physiographic region and proximity to wind sites when identifying potential reference sites. To reduce the potential for environmental variation, especially wetness (Niemuth et al. 2010), between wind and reference sites, we only considered sites <25 km from the nearest turbine and within the Missouri Coteau physiographic region. Additionally, we assumed that wetlands >2.5 km from the nearest turbine were beyond a potential zone of influence. Using the distance and physiographic region criteria, we identified 3 potential reference sites of similar size for each wind site based on upland land use (i.e., proportion of cropland and perennial cover) and wetland density. For the 6 potential sites, we compared the wetland number and area (ha) for each class (i.e., temporary, seasonal, semi-permanent) between each potential reference site and the respective wind site to select the most similar reference site (Table 1). The KE reference site was located 11.3 km west of the KE wind site and the TAT reference site was located 3.2 km northwest of the TAT wind site (Fig. 1).

We identified 5,146 wetland basins encompassing 3,410 ha from NWI data within the wind and reference sites and considered each wetland a potential sample basin. Only temporary, seasonal, and semi-permanent basins were present at the wind sites so we did not survey lake wetlands at reference sites. We did not survey basins that extended >402 m from the boundary of a site to eliminate linear wetlands that potentially extended long distances from the wind and reference sites.

METHODS

Surveys

We surveyed sample wetlands during spring 2008, 2009, and 2010 to count local breeding duck pairs. We used 2 survey periods (i.e., 28 April–18 May, early; and 21 May–7 June, late) to account for differences in settling patterns for the 5 species (Stewart and Kantrud 1973, Cowardin et al. 1995) and to reduce potential bias associated with differences in breeding chronology among species (Dzubin 1969, Higgins et al. 1992, Naugle et al. 2000). We divided the wind and reference sites into 3 crew areas to spatially distribute survey effort across the sites, and crews of 2 observers conducted surveys on each of the 3 crew areas daily. The detection probability of duck pairs was likely not equal among observers (Pagano and Arnold 2009) and we minimized potential confounding of detection, observer, and survey area by rotating observers among crew areas and partners daily. Additionally, our analytical approach was not to compare population estimates for wind and reference sites, which may require development of correction factors (Brasher et al. 2002, Pagano and Arnold 2009), but rather to compare expected rates of pair abundance. Consequently, we assumed non-detection of ducks to be equal among all sites.

We surveyed wetlands within each crew area in a 2.59-km grid pattern based on public land survey sections (PLSS). We used maps with NAIP imagery and wetland basin perimeters from NWI to assist orientation and navigation to survey wetlands. Permission, accessibility, wetness, numbers of wetlands, size of wetlands, and numbers of birds affected the rate at which we surveyed PLSS. Surveys began at 0800 hours and continued until 1700 hours and were discontinued during steady rainfall or winds exceeding 48 km/hr. We surveyed most wetlands twice each year, once during each survey period. We visited all sample wetlands during the early survey period. We did not revisit wetlands that were dry during the early survey. Annual changes in access permission and wetland conditions due to precipitation resulted in some basins being surveyed during only 1 of the survey periods.

During the breeding season, waterfowl assemble into various social groupings that are influenced by sex ratios, breeding phenology, and daily activities (Dzubin 1969). We counted social groups of the 5 target species using established survey protocols (Hammond 1969, Higgins et al. 1992, Cowardin et al. 1995, Reynolds et al. 2006) and recorded observations for all sample wetlands that contained surface water regardless of whether birds were present or absent. We summarized field observations into 7 social groupings that we subsequently interpreted to determine the number of indicated breeding pairs for each species, basin, and survey period (Dzubin 1969, Cowardin et al. 1995). On average, the first count period (late April–early May) is regarded as an acceptable approximation of the breeding population for mallard and northern pintail (Cowardin et al. 1995, Reynolds et al. 2006). Consequently, we used observations during the early survey period to determine the number of indicated breeding pairs for mallard and northern pintail. Similarly, the second count period (late May–early June) is generally used to approximate the breeding population of blue-winged teal, gadwall, and northern shoveler (Cowardin et al. 1995, Reynolds et al. 2006) and we used observations during the late survey period to determine the number of indicated breeding pairs for these 3 species. We used indicated breeding pairs as the response variable in our models of estimated duck pairs.

We reduced disturbance during surveys by observing wetlands from 1 or more distant, strategic positions. We approached and surveyed portions of basins that were obscured by terrain or vegetation on foot. We noted birds leaving the wetland because of observer disturbance to minimize recounting on wetlands that we had not yet surveyed. We estimated the proportion of the wetland that was wet by visually comparing the surface water present in the basin relative to the wetland extent displayed on the field map. We recorded basins with no surface water as dry and not surveyed.

We used NAIP (ca. 2009) and on-screen photo-interpretation to develop a categorical variable describing the landcover of uplands (i.e., cropland, native grassland, idle planted tame grass, alfalfa hayland) adjacent to or surrounding all wetlands on the wind and reference sites. For wetlands touching multiple upland landcover classes, we assigned the class based on the largest wetland perimeter length. The exception was for idle planted tame grass, where we assigned the class if it touched any length of a wetland perimeter because of the limited presence of this class in the landscape and its positive influence on pair settling densities (Reynolds et al. 2007).

Data Analysis

The objective of our analysis was to compare estimates of expected wetland-level abundance of breeding pairs on the wind and reference sites among years. We used past analyses of breeding duck pairs in the United States PPR and their relationship to wetland and upland parameters to inform the selection of candidate covariates (Cowardin et al. 1988, 1995; Reynolds et al. 1996). Wetland-level covariates included wetland class (i.e., seasonal, semi-permanent, or temporary; Johnson and Higgins 1997), surface area of water in NWI basin (wet area), and square root (sqrt) of wet area to reflect the non-linear response to wetland area demonstrated by breeding ducks in the PPR (Cowardin et al. 1988, 1995; Reynolds et al. 2006). We used a categorical variable for upland landcover (i.e., perennial cover, cropland) adjacent to the wetland for the only upland covariate (Reynolds et al. 2007).

Generalized linear models with Poisson errors provided an appropriate statistical framework for the analysis (McCullagh and Nelder 1989, McDonald et al. 2000). Preliminary summaries of the breeding pair data showed, however, that all 5 species displayed indications of over-dispersion relative to standard Poisson assumptions (i.e., both excess zeros and infrequent large counts; Appendix A, available online at www.onlinelibrary.wiley.com; Zuur et al. 2007). We addressed these challenges, while maintain an approach consistent with past studies by conducting a 2-stage analysis. We began by selecting appropriate models and subsets of the covariates using a likelihood-based approach. Then we used a simulation-based Bayesian approach to estimate parameters of species-specific statistical models, site- and year-level contrasts between wind and reference sites, and lack-of-fit statistics. Our combined approach allowed us to take advantage of the strengths of both approaches (Royle and Dorazio 2008:74–75) to provide a thorough analysis of the data.

We analyzed indicated breeding pairs from counts for each of the 5 study species using separate models. Full Poisson regression models described expected breeding pairs as a log-linear function of site, year, wetland class, landcover, wet area, and sqrt (wet area). We used Akaike's Information Criterion (AIC) differences (Burnham and Anderson 2002) to compare full Poisson models with Zero-Inflated Poisson (ZIP) models. The ZIP models partially accounted for potential excess zeros due to 2 sources: 1) non-detections and 2) unoccupied, but suitable, wetlands. The ZIP models described the data as a mixture of the counts described by the log-linear model and a mass of excess zeros described by a logit-linear model (Zuur et al. 2007). We conducted a comparison of Poisson and ZIP models between the full Poisson model and ZIP model that included a single additional parameter describing the expected probability of a false zero. When AIC differences indicated the ZIP model was more appropriate (i.e., $AIC_{Poisson} - AIC_{ZIP} \geq 4$), we used ZIP models for all subsequent analysis. When ZIP models were selected, the full logit-linear model for excess zeros included covariates describing the upland vegetation cover class associated with each wetland (cover class; Stewart and Kantrud 1973), the area of the NWI basin covered by water (wet area), and the square root of wet area.

We expected that the full models would likely be most appropriate for the study species, as they were parameterized with covariates that have been identified as useful predictors of pair abundance in the Four-Square-Mile Breeding Waterfowl Survey (FSMS) dataset, which has been collected by the USFWS National Wildlife Refuge System since 1987 (Cowardin et al. 1995; Reynolds et al. 2006, 2007). Nonetheless, we sought to efficiently use the information in our less-extensive dataset by ensuring that we had selected a parsimonious subset of the covariates for each species-specific model. We removed a single covariate, or group of covariates in the case of factor variables, from the full model, ran the resulting reduced model, and recorded its AIC value (Chambers 1992, Crawley 2007:327–329). We repeated this procedure for every covariate. This resulted in a vector of AIC values that described, for each covariate, or covariate group, the effect of its removal on the AIC value of the full model. Reduced models for each species contained the set of covariates in the full model or the subset of covariates that resulted in increases in AIC values greater than 2 units per estimated parameter when they were removed from the full model (Arnold 2010).

After selecting a model structure for each species, we estimated the posterior distributions of model parameters with Markov Chain Monte Carlo (MCMC) simulation (Link and Barker 2009) in the Bayesian analysis software WinBUGS 1.4.1 (Spiegelhalter et al., 2003). The structure of the Bayesian ZIP models differed from the maximum likelihood models in 2 ways. The 12 site and year combinations were hierarchically centered and parameterized as normally distributed displacements from a common intercept (Gelman et al. 2004, Congdon 2005), and extra-Poisson variation due to large wetland-level counts was accommodated by a normally distributed error term (Appendix B, available online at www.onlinelibrary.wiley.com).

We conducted all statistical analyses in the R environment (R Development Core Team 2011). We used the generalized linear models capability of base R and the contributed package pscl (Jackman 2008) to estimate likelihoods and AIC values for Poisson and ZIP models. When selecting models and subsets of the covariates, we considered AIC differences greater than 4 to provide good evidence in favor of the model with the smaller value (Burnham and Anderson 2002). To generate Bayesian estimates of model parameters, we used the contributed R2WinBugs (Sturtz et al. 2005) package to run MCMC simulations in WinBUGS via R. For each model, we ran 2 Markov chains for 500,000 iterations and discarded the first 100,000 iterations from each chain to minimize the influence of starting values and prior distributions. We used minimally informative prior distributions and random starting values for model parameters and random effects. We evaluated convergence to the posterior distribution by examining plots of sequential draws for each parameter and also by the Gelman–Rubin statistic (Gelman et al. 2004). We estimated the number of uncorrelated samples generated by each Markov Chain by the Effective Sample Size (ESS; Kass et al. 1998, Streftaris and Worton 2008). We required at least 200 uncorrelated samples per chain for inference. We considered a model to have converged when its Gelman–Rubin statistic was <1.1 and the plots of sequential draws indicated that the chains had stabilized and were sampling from a similar space (Gelman et al. 2004). We tested for lack-of-fit of the model using a posterior predictive test (Gelman et al. 2004). Specifically, we compared the variance-mean ratio for the observed data to the variance-mean ratio of simulated data generated from the posterior draws of model parameters. We concluded that the model fit the data if the posterior proportion of simulated variance-mean ratios that exceeded the observed variance-mean ratio was greater than 0.01 and less than 0.99 (Congdon 2005). We then used the CODA (Plummer et al. 2009) package to summarize the posterior distributions of model parameters, convergence diagnostics, and derived quantities like lack-of-fit statistics and back-transformed estimates of abundance. Using the 800,000 posterior simulations from each model, modal values of categorical covariates, and median values of continuous covariates, we calculated species-, site-, and year-specific medians and 95% credible intervals of 1) the estimated posterior distribution of the log-scale model parameters, 2) the estimated posterior distribution of expected pair abundance on wetlands of median area, and 3) the estimated posterior distribution of the back-transformed contrast in expected pair abundance between wind and reference sites in each year. These quantities provided the basis for comparison of pair abundance between wind and reference sites.

We used point estimates of pair density for the median seasonal wetlands size (i.e., 0.2 ha) in grassland to assess the potential effect of wind energy development on breeding duck pair densities. We selected seasonal wetlands because they were the most numerous wetlands in our sample (58%) and because breeding duck pairs use seasonal wetlands at greater rates than other wetland classes (see Reynolds et al. 2006, 2007; Loesch et al. 2012); most pairs (54%) were observed on seasonal wetlands.

We evaluated the potential impact of wind energy development from both a statistical and biological perspective. We compared point estimates of density among sites and within years to either support or reject an effect. We assessed the potential biological impact of breeding pair avoidance of wind sites by calculating the proportional change in the estimated density of pairs between wetlands in wind and reference sites for each species and year. The percent change reflects the potential impact to breeding duck populations in the presence of wind energy development.

RESULTS

As a result of variable wetland conditions both within and among years, and annual changes in access to private land, we surveyed different numbers and area of wetland basins each year. Water levels in wetlands were low during 2008 and 35% of wetland basins visited during the early count contained water and generally were only partially full (e.g., seasonal regime, mean = 54% full, n = 684). Water levels increased in 2009 and 2010 and only 15% of 2,464 and 12% of 3,309 wetland basins, respectively, were dry during the early count. Basins containing water were also more full during 2009 (e.g., seasonal basin mean = 103% full, n = 1,089) and 2010 (e.g., seasonal basin mean = 93% full, n = 1,407). We conducted 5,339 wetland visits during the early count and 4,999 wetland visits during the late count. During the early count, we observed 5,287 indicated breeding pairs of mallard (3,456 [range = 146–552]) and northern pintail (1,831 [range = 51–310]), and 10,473 indicated breeding pairs of blue-winged teal (5,886 [range = 180–984]), gadwall (2,839 [range = 75–506]), and northern shoveler (1,748 [range = 55–318]) during the late count.

Model Selection and Estimation

Our ZIP models provided a substantially better fit than Poisson models for every species. Differences in AIC ($AIC_{poisson} - AIC_{zip}$) were 426 for blue-winged teal, 137 for gadwall, 218 for mallard, 384 for northern pintail, and 78 for northern shoveler. All of the covariates in the full model were retained for mallard, northern pintail, blue-winged teal, and northern shoveler. Wetland class was dropped for gadwall. Differences in AIC between the full model and the nearest reduced model were 11 for blue-winged teal, 3 for gadwall, 26 for mallard, 6 for northern pintail, and 29 for northern shoveler. The MCMC simulations converged for every species-specific model, indicating that the parameter estimates and credible intervals from these models provided a sound basis for inference. The maximum upper 95% credible interval of all R-hat values for any structural parameter was 1.01 for blue-winged teal, 1.01 for gadwall, 1.01 for mallard, 1.02 for northern pintail, and 1.04 for northern shoveler. The posterior predictive test indicated that the models fit the data for every species. The proportion of simulated variance-mean ratios that exceeded the observed variance-mean ratio was 0.52 for blue-winged teal, 0.75 for gadwall, 0.61 for mallard, 0.59 for northern pintail, and 0.72 for northern shoveler. Minimum effective sample sizes were 709 for blue-winged teal, 553 for gadwall, 307 for mallard, 346 for northern pintail, and 612 for northern shoveler.

Estimates

Differences in estimated breeding duck pair densities in a wind site and a reference site varied among site pairs (2), years (3), and species (5), and posterior median values of these 30 contrasts ranged from −0.281 to 0.130 (Table 2). Estimated patterns of contrasts for expected breeding duck pair density between wind and reference sites were similar for all species. Given median wet area and the mode of the categorical covariates, expected, basin-level densities of duck pairs for the 5 species was either statistically indistinguishable (14 of 30) between wind and reference sites or was lower (16 of 30) on wind sites than reference sites depending on site, year, and species (Fig. 2). Regardless of whether 95% credible intervals overlapped zero, density estimates were

Table 2. Log-scale estimated posterior medians and 95% of the estimated posterior distribution from the count portion of a zero-inflated, overdispersed Poisson model of indicated blue-winged teal (*Anas discors* [BWTE]), gadwall (*A. strepera* [GADW]), mallard (*A. platyrhynchos* [MALL]), northern pintail (*A. acuta* [NOPI]), and northern shoveler (*A. clypeata* [NSHO]) pairs on seasonal wetland basins for development (wind) and paired reference sites in North Dakota and South Dakota, USA. Sites are Kulm-Edgely (KE) and Tatanka (TAT) for years 2008 (08), 2009 (09), and 2010 (10).

			Reference			Wind		
Species	Site	Year	Median	2.5%	97.5%	Median	2.5%	97.5%
MALL	KE	08	0.47	0.21	0.73	0.15	−0.13	0.43
	KE	09	−0.49	−0.78	−0.22	−0.90	−1.17	−0.64
	KE	10	−0.42	−0.66	−0.20	−0.77	−1.04	−0.51
	TAT	08	0.29	0.02	0.56	0.41	0.17	0.65
	TAT	09	−0.38	−0.61	−0.14	−0.63	−0.89	−0.38
	TAT	10	−0.33	−0.55	−0.10	−0.47	−0.71	−0.22
BWTE	KE	08	−0.13	−0.25	−0.00	0.22	0.01	0.45
	KE	09	−0.46	−0.66	−0.27	−0.52	−0.74	−0.32
	KE	10	−0.13	−0.30	0.04	−0.58	−0.78	−0.39
	TAT	08	0.25	0.06	0.45	0.18	0.01	0.36
	TAT	09	−0.15	−0.32	0.02	−0.39	−0.58	−0.21
	TAT	10	0.03	−0.12	0.19	−0.19	−0.36	−0.02
NOPI	KE	08	−0.25	−0.61	0.12	−0.80	−1.24	−0.39
	KE	09	−0.80	−1.16	−0.45	−1.54	−1.93	−1.17
	KE	10	−0.72	−1.01	−0.42	−1.20	−1.56	−0.87
	TAT	08	−0.10	−0.46	0.27	0.16	−0.15	0.48
	TAT	09	−0.35	−0.63	−0.06	−0.76	−1.07	−0.44
	TAT	10	−0.15	−0.41	0.13	−0.38	−0.67	−0.07
GADW	KE	08	0.09	−0.17	0.37	−0.13	−0.43	0.18
	KE	09	−0.52	−0.77	−0.28	−0.91	−1.19	−0.64
	KE	10	−0.61	−0.83	−0.38	−1.42	−1.72	−1.14
	TAT	08	0.07	−0.18	0.34	0.17	−0.05	0.41
	TAT	09	−0.46	−0.69	−0.22	−0.55	−0.81	−0.29
	TAT	10	−0.69	−0.92	−0.46	−0.62	−0.86	−0.38
NSHO	KE	08	−0.35	−0.61	−0.08	−0.49	−0.79	−0.18
	KE	09	−0.91	−1.17	−0.67	−1.00	−1.29	−0.73
	KE	10	−0.78	−1.00	−0.57	−1.11	−1.39	−0.85
	TAT	08	−0.23	−0.49	0.00	−0.30	−0.52	−0.08
	TAT	09	−0.59	−0.80	−0.37	−0.99	−1.25	−0.74
	TAT	10	−0.36	−0.55	−0.16	−0.69	−0.90	−0.47

lower on sites with wind development for 26 of the 30 combinations (i.e., mallard and blue-winged teal: 12 combinations, 11 negative [range −6% to −36%]), 7 did not overlap zero; gadwall, northern pintail, northern shoveler: 18 combinations, 15 negative [range −5% to −56%], 9 did not overlap zero). The general pattern of results were similar for all species, consequently, we chose a representative early and late arriving species with the largest number of indicated breeding pairs, mallard and blue-winged teal, respectively, for detailed presentation of results.

Mallard and Blue-Winged Teal

Mallard and blue-winged teal comprised 59% of the indicated breeding pair observations (i.e., 3,473 mallard; 5,928 blue-winged teal). Full models were retained for both mallard and blue-winged teal, and the point estimate of density was greatest in 2008 for both KE and TAT sites, but varied among years and sites (mallard: wind median = 0.42 [range = 0.30–1.03], reference median = 0.41 [range = 0.21–0.97]; blue-winged teal: wind median = 0.51 [range = 0.42–0.94], reference median = 0.66 [range = 0.47–0.96]). For mallard, estimated breeding pair densities on seasonal wetlands at wind sites were lower for 5 of the 6 site-year combinations (median = 0.11, range = −0.28 to 0.11) and error bars representing 95% of the posterior distribution of the estimate did not overlap zero for 4 of the 6 site-year comparisons (Fig. 2A). Similarly, for blue-winged teal in 5 of the 6 site-year combinations, estimated pair densities were lower for seasonal wetlands on wind sites (median = −0.14, range = −0.24 to <0.01) and error bars representing 95% of the posterior distribution of the estimate did not overlap zero for 3 of the 6 site-year comparisons (Fig. 2B). Only 1 site-year combination for each of mallard and blue-winged teal suggested greater pair densities on wind sites, but in both cases 95% confidence intervals overlapped zero.

The estimated proportional change of mallard pair densities for wetlands in wind sites was negative in 5 of 6 site-year combinations (median = −10%, range = 13% [TAT 2008] to −34% [KE 2009]; Fig. 3A). The proportional change for blue-winged teal was also negative in 5 of 6 site-year combinations (Fig. 3B). The median estimate of proportional change for blue-winged teal densities between wind and reference sites was −18% (range 0% [KE 2009] to −36% [KE 2010]).

DISCUSSION

All 5 of our dabbling duck study species demonstrated a negative response to wind energy development and the reduced abundance we observed was consistent with behavioral avoidance. Avoidance of land-based wind energy development has been observed for numerous avian species during

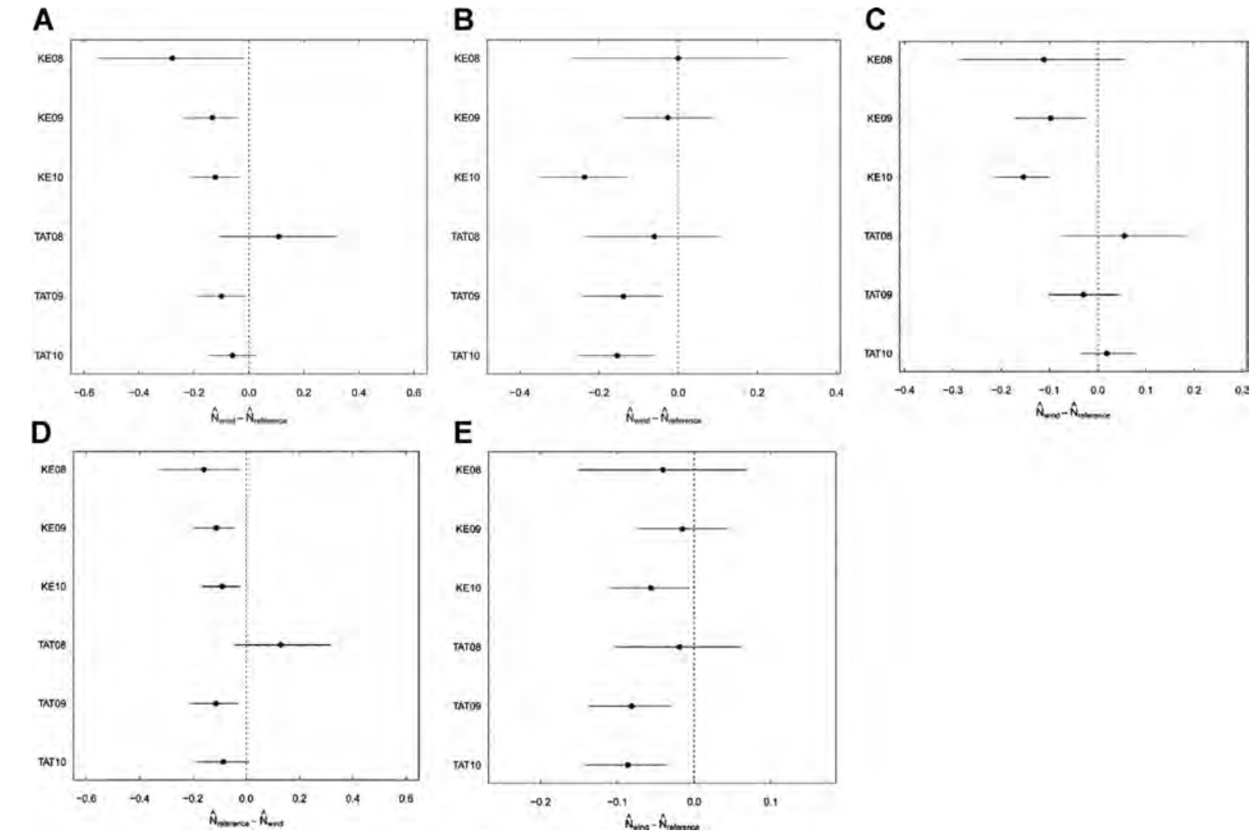

Figure 2. Year-specific estimated differences between estimated posterior median abundance of mallard (*Anas platyrhynchos*; A), blue-winged teal (*A. discors*; B), gadwall (*A. strepera*; C), northern pintail (*A. acuta*; D), and northern shoveler (*A. clypeata*; E) on a seasonal wetland of median area (0.2 ha) embedded in perennial cover on a wind site and its corresponding reference site in North Dakota and South Dakota. Error bars represent 95% of the posterior distribution of the estimate. Site-year combinations are Kulm-Edgely (KE) and Tatanka (TAT) for 2008 (08), 2009 (09), and 2010 (10).

breeding (Leddy et al. 1999, Johnson et al. 2000, Walker et al. 2005, Shaffer and Johnson 2008, see Madders and Whitfield 2006), and does not imply complete abandonment of an area but rather the reduced use of a site (Schneider et al. 2003). This is consistent with our results, where breeding pairs continued to use wetland habitat at the wind sites but at reduced densities.

Our selection of paired wind and reference sites and analytical approach were designed to control for differences in site characteristics and annual variation in habitat conditions, and to use well-understood relationships between breeding duck pairs and wetlands (Cowardin et al. 1995; Reynolds et al. 2006, 2007). Despite the large amount of breeding pair data we collected, discerning if the presence of wind energy development was the ultimate cause of the lower estimated pair abundance on the wind versus reference sites is difficult. However, we did detect a directional effect of wind energy development sites over a 3-year period at the 2 sites that are representative of areas with greater estimated duck densities, and adds to the body of evidence suggesting a negative effect of wind energy development. Reduced wetland use in high density wetland areas with the potential to attract and support relatively greater densities of breeding duck pairs is of concern to waterfowl biologists and managers because when wet, these areas are vital to the sustainability of North American duck populations. The somewhat limited temporal and geographic scope of our study and confounding between land use and duration of development prevents us from drawing strong conclusions about cumulative effects of wind energy development on breeding ducks (see Krausman 2011). Nonetheless, a 10–18% reduction in addition to other stressors is potentially substantial.

We observed larger negative displacement for most species and years in the KE wind site when compared to the TAT wind site. We found 2 notable differences in the wind sites that may have contributed to these results, the land use and age of development. The KE site was predominantly cropland and older than the grassland-dominated TAT site. The combination of multiple stressors, in this case agriculture and wind energy development, may have resulted in a greater impact to breeding ducks using wetlands in agricultural settings. Differences in estimated pair abundance between the cropland and grassland site suggest that greater habitat quality measured by the percent of grassland area and lack of cropping history in associated wetlands within a site may reduce avoidance of wind development when compared to agricultural landscapes. Breeding waterfowl may occupy wetlands at greater rates in grassland than cropland (Reynolds et al. 2007), nest success is generally greater in grasslands (Greenwood et al. 1995, Reynolds et al. 2001, Stephens et al.

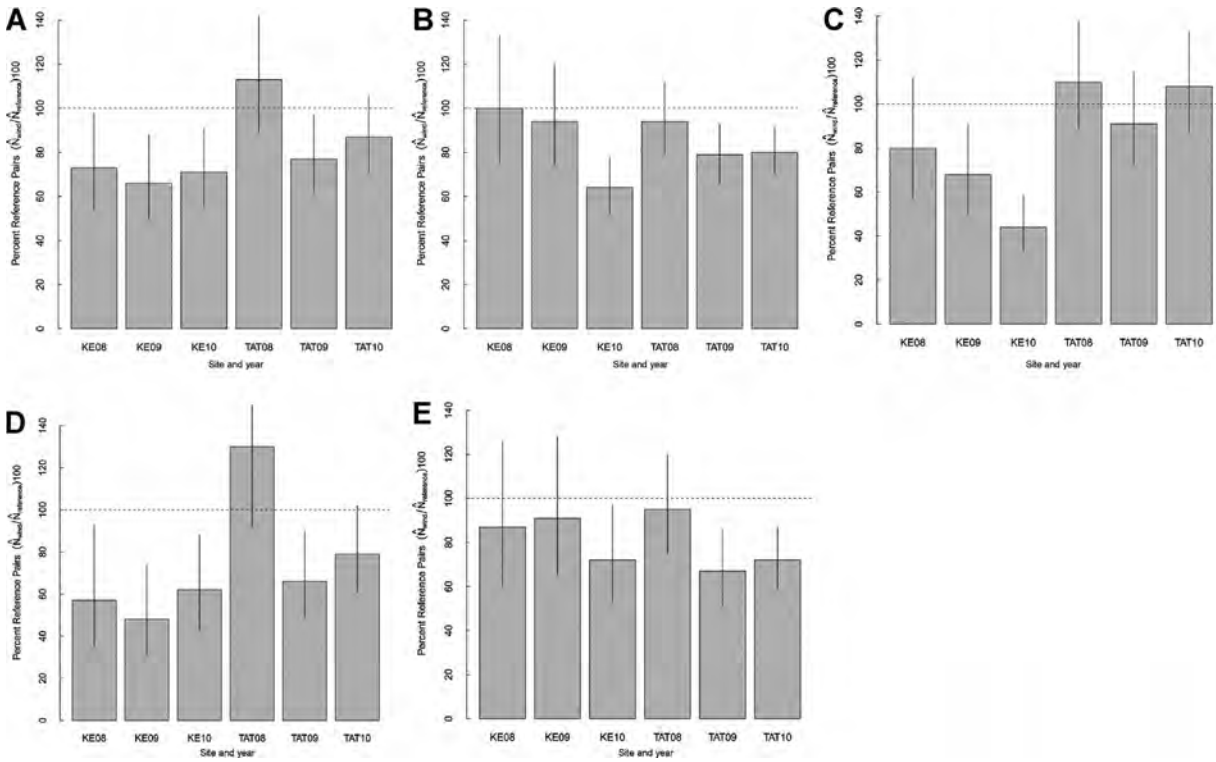

Figure 3. Year-specific estimated number of mallard (*Anas platyrhynchos*; A), blue-winged teal (*A. discors*; B), gadwall (*A. strepera*; C), northern pintail (*A. acuta*; D), and northern shoveler (*A. clypeata*; E) on a seasonal wetland of median area (0.2 ha) embedded in perennial cover on a wind site expressed as a percentage of pairs expected on the same wetland in the corresponding reference site in North Dakota and South Dakota. Error bars represent 95% of the posterior distribution of the estimate. Site-year combinations are Kulm-Edgely (KE) and Tatanka (TAT) for 2008 (08), 2009 (09), and 2010 (10).

2005), and wetlands in grass landscapes have greater occupancy rates by duck broods (Walker 2011), suggesting an overall greater productivity potential for breeding ducks in grassland versus cropland landscapes. The ability of intact habitat to reduce impacts of energy development is supported in current literature. In Wyoming, sage-grouse (*Centrocercus urophasianus*) residing in a fragmented landscape showed a 3 times greater decline in active leks at conventional coal bed methane well densities (1 well per 32 ha) than those in the most contiguous expanses of Wyoming big sagebrush (*Artemisia tridentata*) in North America (Doherty et al. 2010). A similar relationship has been document for large mammals. In the Boreal forest, woodland caribou (*Rangifer tarandus caribou*) populations could sustain greater levels of industrial development and maintain an increasing population when they resided in large forest tracts that were not fragmented by wildfires (Sorensen et al. 2008).

Our ability to support the hypothesis that habitat quality mitigates impacts could be confounded by time-lags in detecting impacts, as well as the potential for ducks to habituate to wind energy development over time but at a cost to individual fitness (Bejder et al. 2009). The KE wind site was cropland-dominated and began operation in 2003, whereas the TAT wind site was grassland-dominated and began operation in 2008, and was 3 years old during the final field season. Many recent studies for a variety of species and ecosystems have shown time lags between dates of first construction and full biological impacts. In Wyoming impacts to sage-grouse in some instances doubled 4 years post-development versus the initial year of development (Doherty et al. 2010) and lags varied from 2 to 10 years (Harju et al. 2010). In some instances, full biological impacts may not be apparent for decades. For example, 2 decades passed before impacts of forest logging resulted in woodland caribou population extirpation within 13 km of logging (Vors et al. 2007). In a review paper on the effects of wind farms to birds on 19 globally distributed wind farms using meta-analyses, time lags were important in detecting impacts for their meta-analyses with longer operating times of wind farms resulting in greater declines in abundance of Anseriformes (Stewart et al. 2007). Pink-footed geese foraging during spring appear to have habituated to the presence of wind turbines in Europe (Madsen and Boertmann 2008). We therefore cannot distinguish between these 2 competing hypotheses without additional study.

Wind resources are both abundant and wide-spread in the PPR in the United States (Heimiller and Haymes 2001, Kiesecker et al. 2011), and the development of an additional 37 GW of wind energy capacity in the PPR states is necessary to meet 20% of domestic energy needs by 2030 (USDOE 2008). The projected wind farm footprint in PPR states to support this target is approximately 39,601 km^2. Even if recommendations for siting energy development outside of intact landscapes suggested by

Kiesecker et al. (2011) are implemented by the wind industry, millions of wetlands occur in agricultural landscapes and our results indicate that wind energy development will likely reduce their use by breeding duck pairs.

Waterfowl conservation partners in the PPR use strategic habitat conservation (Reynolds et al. 1996, 2006; Ringelman 2005; USFWS 2006; Loesch et al. 2012) in an adaptive management framework to target protection, management, and restoration based on biological and landscape information, primarily in response to habitat loss from agricultural activities. From a habitat quality and conservation perspective, wind energy development should be considered as another stressor relative to the cumulative effects of anthropogenic impacts on limiting factors to breeding waterfowl populations.

The protection of remaining, high priority grassland and wetland resources in the United States PPR is the primary focus of waterfowl habitat conservation (Ringelman 2005, Niemuth et al. 2008, Loesch et al. 2012). Population goals and habitat objectives were established to maintain habitat for breeding pairs and the current productivity of the landscape (Ringelman 2005, Government Accounting Office 2007). Spatially explicit decision support tools (Reynolds et al. 1996, Niemuth et al. 2005, Stephens et al. 2008, Loesch et al. 2012) have been used effectively to target and prioritize resources for protection. New stressors such as energy development in the PPR that negatively affect the use of wetland resources have ramifications to breeding waterfowl populations (i.e., potential displacement to lower quality wetland habitat) and their conservation and management. Thus, population and habitat goals, and targeting criteria may need to be revisited if large-scale wind development occurs within continentally important waterfowl conservation areas like the PPR.

MANAGEMENT IMPLICATIONS

Balancing the development of wind energy and current conservation efforts to protect habitat for migratory birds is complex because most conservation and wind energy development in the region occur on private land (USFWS 2011). Given that breeding duck pairs do not completely avoid wetlands in and adjacent to wind energy developments and resource benefits remain, albeit at reduced levels, the grassland and wetland protection prioritization criteria used by conservation partners in the PPR (Ringelman 2005) could be adjusted to account for avoidance using various scenarios of acceptable impact. For example, the wind sites used in our study are in high priority conservation locations (Ringelman 2005, Loesch et al. 2012). After accounting for effects of duck displacement by wind development, their priority was not reduced for either site. Consequently, wind-development does not necessarily preclude these sites from consideration for protection. Additionally, using the measured negative impact of wind energy development and production on breeding duck pairs, opportunities to work with wind energy industry to mitigate the reduced value of wetlands in proximity to wind towers should be investigated. Continued partnership by the wind energy industry and wildlife conservation groups will be critical for continued research. Further, we suggest expanding our research both spatially and temporally to better address cumulative impacts, zone of influence, impacts on vital rates, potential habituation or tolerance, and/or lag effects of long-term exposure to wind energy development.

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Conservation Biology

Contributed Paper

Effects of wind-energy facilities on breeding grassland bird distributions

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Abstract: *The contribution of renewable energy to meet worldwide demand continues to grow. Wind energy is one of the fastest growing renewable sectors, but new wind facilities are often placed in prime wildlife habitat. Long-term studies that incorporate a rigorous statistical design to evaluate the effects of wind facilities on wildlife are rare. We conducted a before-after-control-impact (BACI) assessment to determine if wind facilities placed in native mixed-grass prairies displaced breeding grassland birds. During 2003–2012, we monitored changes in bird density in 3 study areas in North Dakota and South Dakota (U.S.A.). We examined whether displacement or attraction occurred 1 year after construction (immediate effect) and the average displacement or attraction 2–5 years after construction (delayed effect). We tested for these effects overall and within distance bands of 100, 200, 300, and >300 m from turbines. We observed displacement for 7 of 9 species. One species was unaffected by wind facilities and one species exhibited attraction. Displacement and attraction generally occurred within 100 m and often extended up to 300 m. In a few instances, displacement extended beyond 300 m. Displacement and attraction occurred 1 year after construction and persisted at least 5 years. Our research provides a framework for applying a BACI design to displacement studies and highlights the erroneous conclusions that can be made without the benefit of adopting such a design. More broadly, species-specific behaviors can be used to inform management decisions about turbine placement and the potential impact to individual species. Additionally, the avoidance distance metrics we estimated can facilitate future development of models evaluating impacts of wind facilities under differing land-use scenarios.*

Keywords: avoidance, before-after-control-impact design, climate change, displacement, renewable energy, upland birds, wind turbine

Efectos de las Instalaciones de Energía Eólica sobre la Distribución de las Aves de Pastizales en Época Reproductiva

Resumen: *La contribución de la energía renovable para cumplir con las demandas mundiales sigue creciendo. La energía eólica es uno de los sectores renovables con mayor crecimiento, pero continuamente se colocan nuevas instalaciones eólicas en los principales hábitats de fauna silvestre. Los estudios a largo plazo que incorporan un diseño estadístico riguroso para evaluar los efectos de estas instalaciones sobre la fauna son escasos. Realizamos una evaluación de control de impacto de antes y después (CIAD) para determinar si las instalaciones eólicas colocadas en praderas de pastos mixtos nativos desplazaron a las aves de pastizales en época reproductiva. Durante el periodo 2003-2012, monitoreamos los cambios en la densidad de aves en tres áreas de estudio en Dakota del Norte y del Sur (E.U.A). Examinamos si había ocurrido desplazamiento o atracción un año después de la construcción (efecto inmediato) y también el promedio de desplazamiento o atracción 2-5 años después de la construcción (efecto retardado). Analizamos estos efectos en general y dentro de franjas de distancia de 100, 200, 300 y >300 m de las turbinas. Observamos desplazamiento en siete de las nueve especies. Una especie no fue afectada por las instalaciones eólicas y una especie mostró atracción. El desplazamiento y la atracción ocurrieron generalmente dentro de los 100 m y frecuentemente se extendieron hasta los 300 m. En algunos casos, el desplazamiento se extendió más allá de los 300 m. El desplazamiento y la atracción ocurrieron un año después de la construcción y continuaron durante por lo*

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menos cinco años. Nuestra investigación proporciona un marco de trabajo para aplicar el diseño CIAD a los estudios de desplazamiento y resalta las conclusiones erróneas que pueden hacerse sin el beneficio de adoptar dicho diseño. En términos más generales, los comportamientos específicos de especie pueden usarse para informar a las decisiones de manejo sobre la colocación de turbinas y el impacto potencial para las especies individuales. Además, las medidas de distancia de evitación que estimamos pueden facilitar el desarrollo futuro de los modelos de evaluación de impacto de las instalaciones eólicas bajo escenarios diferentes de uso de suelo.

Palabras Clave: aves de tierras altas, cambio climático, desplazamiento, diseño de control de impacto de antes y después, energía renovable, evitación, turbina de viento

Introduction

Renewable energies will help meet energy demands while reducing carbon emissions and providing energy security (IPCC 2012). Globally, the contribution of wind power to energy demand is anticipated to be 20% by 2050 (IPCC 2011). The United States became the global leader in new wind capacity in 2012, representing 29% of global installed capacity due to sustained growth throughout the interior of the country (i.e., within the Great Plains) (USDOE 2013).

The Great Plains also supports the last remaining expanses of native temperate grasslands in North America (Stephens et al. 2008; Rashford et al. 2011; Doherty et al. 2013); thus, the increase in habitat loss and fragmentation associated with wind development has adverse impacts on wildlife (McDonald et al. 2009; Kiesecker et al. 2011). Wildlife are directly affected by wind facilities via collision mortality (Johnston et al. 2013; Péron et al. 2013) and indirectly affected through avoidance of turbines and related infrastructure (i.e., displacement [Drewitt & Langston 2006]). Per unit energy, wind energy has a larger terrestrial footprint than other forms of energy production (Kiesecker et al. 2011). Although the ground disturbance per turbine is relatively small (about 1.2 ha), other disturbances such as construction and operation of the facility, vehicular traffic, maintenance visits, turbine noise and movement, and changes to predator activity contribute to the impact of wind facilities (Arnett et al. 2007; Helldin et al. 2012; Gue et al. 2013).

Although displacement research on an international level has been ongoing for about 2 decades, Drewitt and Langston (2006) note that few displacement studies are conclusive, often because of the minimal magnitude of the effect, poor precision of estimates, and lack of study design allowing for strong inference assessments. For observational studies, the before-after-control (reference)-impact (BACI) design is considered the "optimal impact study design" (Green 1979) as exemplified by Irons et al. (2000) and Smucker et al. (2005) and is the preferred method to determine displacement of wildlife from wind facilities (Strickland et al. 2011). However, of the numerous displacement studies, most are short-term, are not BACI designs, and occur on only one wind facility (Supporting Information). Effective conservation strategies that reduce negative effects of wind facilities to sensitive wildlife require information from well-designed studies (Strickland et al. 2011). Preferred characteristics include a multi-species approach to understand prevalence of displacement behavior, a long-term perspective, and a design that allows for strong inference (e.g., BACI) (Stewart et al. 2007; Strickland et al. 2011). Pearce-Higgins et al. (2012) provide an example of a well-implemented wind-specific BACI design.

Our overall goal was to determine if wind facilities influenced distribution of sensitive and declining grassland-nesting birds (Supporting Information). Specifically, our objectives were to assess immediate and delayed effects of the placement of wind facilities. We assessed potential changes in bird distribution overall and at varying distances from wind turbines. We implemented a BACI design that incorporated multiple years, replicated impact and reference sites within 3 facilities, and 9 species, making our study one of a few that used a rigorous optimal impact assessment design (Supporting Information). Thus, our research provides a strong foundation for building a more refined understanding of how wind facilities influence grassland bird distribution temporally and spatially.

Methods

Collaboration with wind companies provided locations of impending construction within North Dakota and South Dakota (U.S.A.). We selected wind facilities situated within expanses of native grassland and in landscapes characterized by morainic rolling plains interspersed with wetlands, mixed-grass prairie pastures, and few planted grasslands, hayfields, or cropland (Bluemle 1991). Three wind facilities (hereafter, study areas) met our criteria: NextEra Energy's (NEE) South Dakota Wind Energy Center (SD), Highmore, South Dakota; Acciona's Tatanka Wind Farm (TAT), Forbes, North Dakota; and NEE's Oliver Wind Energy Center (OL), Oliver County, North Dakota (Table 1, Fig. 1). The study areas differed in several anthropogenic features (Table 1). The SD site was within the most heterogeneous landscape and had

Table 1. Summary characteristics of 3 wind facilities in North Dakota and South Dakota (U.S.A.) for which field survey data were collected for the study on effects of wind facilities on grassland birds.

Facility	*Pre-treatment year*	*Post-treatment years*	*No. treatment plots (size range, ha)*	*No. reference plots (size range, ha)*	*Row crop area (%)*	*Total area (km^2)*	*Roads* (km/km^2)*	*No. of turbines/km^2*
NextEra Energy SD Wind Energy Center	2003	2004-6, 8, 10, 12	5 (55-158)	3 (34-46)	20	34.5	0.6	0.8
Acciona Tatanka Wind Farm	2007	2009-10, 12	2 (43-441)	4 (11-109)	0	31.6	0.4	0.6
NextEra Energy Oliver Wind Energy Center	2006	2007, 9, 11	2 (122-260)	2 (37-274)	13	24.3	0.7	0.7

* *Includes paved, gravel, and turbine roads.*

the highest percentage of lands under row-crop cultivation and the second most kilometers of roads, whereas TAT was within the least heterogeneous landscape of primarily grasslands. During the years we were on each study area (Table 1), TAT and OL had above-average precipitation and SD received below-average precipitation (NOAA 2015).

Because of the short time frame between facility site selection and construction, we conducted only 1 year of pre-treatment surveys. Within a study area, we selected turbine strings (i.e., turbines connected by a road) that would be placed in grazed mixed-grass prairie. We defined a turbine site as the area encompassing the turbines and extending 0.8 km on all sides of the turbine string, as long as the land and land cover remained grazed mixed-grass prairie. Reference sites were selected based on proximity to paired wind facilities (within 3.2 km) and similarity of land use and cover, topography, and elevation to turbine sites. Measures of vegetation structure were similar between turbine and reference sites and therefore were excluded as a possible confounding effect (Supporting Information).

We conducted total-area avian surveys (Stewart & Kantrud 1972) within a grid system (Shaffer & Thiele 2013) 2 times annually from late May to early July, from 0.5 hours after sunrise to 1100, on days of good visibility and good aural detectability (i.e., days with little or no precipitation and low to moderate winds [<40 km/hour]). We established avian survey plots with grids of fiberglass posts arranged in parallel lines spaced 200 m apart. Transect lines were established 100 m apart perpendicular to the grid lines. Observers recorded all birds seen and heard within 50 m of transects established within the grids. Genders of non-dimorphic species were determined by the presence or absence of song. For 9 grassland bird species (Table 2; Supporting Information), we computed the number of breeding pairs for each site (turbine and reference), survey, and year combination. A male and female observed together was considered a breeding pair; a male or female observed alone was also considered a breeding pair. The number of pairs was divided by the suitable breeding area in each turbine and reference site, as determined by breeding habitat for each species (Supporting Information), and multiplied by 100 to determine density per 100 ha (Supporting Information). We used the maximum of the biannual survey densities for each species-site-year combination to reflect peak breeding density.

We employed a BACI design (McDonald et al. 2000) to examine turbine effects on bird density. We used data from surveys conducted prior to and after turbine construction at turbine and reference sites. Using 2 different treatment specifications, we conducted analyses separately for each species and study area. The first analysis consisted of 2 treatment levels, turbine sites and reference sites, to assess overall effects of turbines on

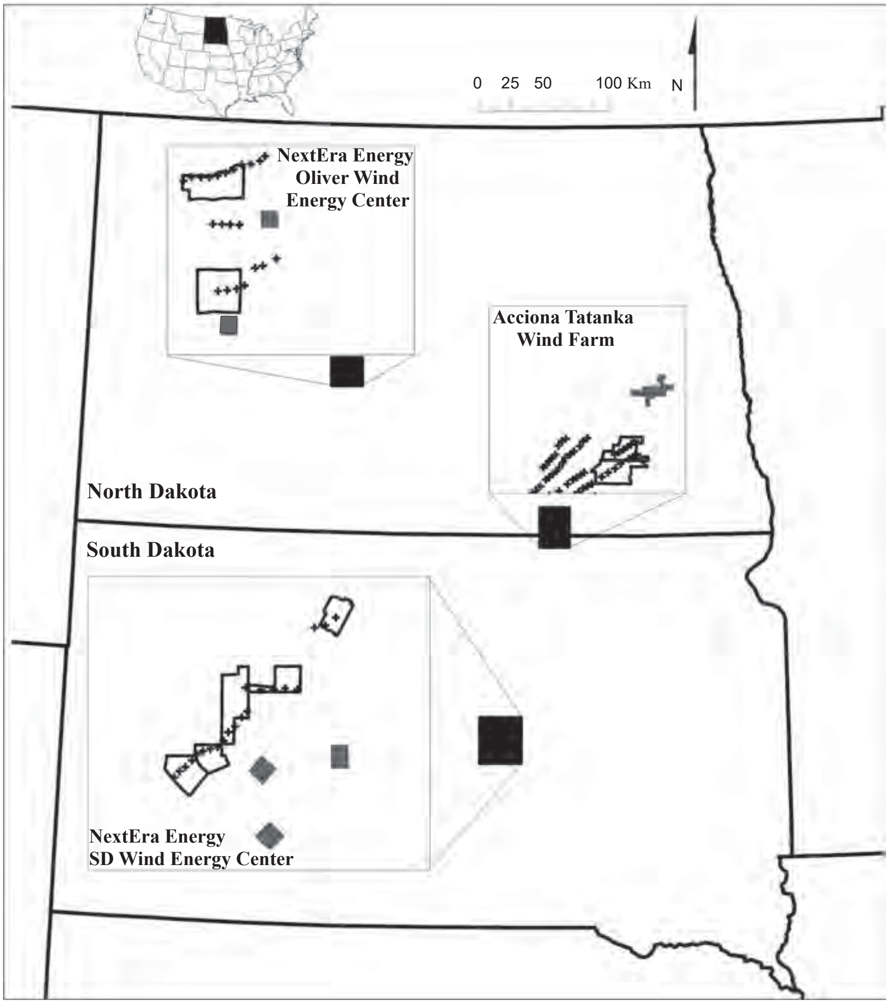

Figure 1. Map of studied wind-energy facilities in North Dakota and South Dakota (U.S.A.) (white polygons, turbine treatment sites; gray polygons, reference sites; plus symbol, turbine locations).

densities of breeding birds. For the second analysis, we divided turbine sites into 4 100-m distance bands from turbines (0-100 m, 100–200 m, 200–300 m, and >300 m), for a total of 5 treatment levels including the reference sites. We used repeated measures analysis of variance (RMANOVA) in SAS PROC MIXED (SAS Institute 2012) to assess effects of treatment and year on bird density (Verbeke & Molenberghs 2000). In the first treatment specification, year was the repeated measure and site within treatment was the experimental unit sampled each year. For the second treatment specification, site was included as a random block, year was the repeated measure, and site-by-treatment combinations were the experimental units sampled yearly. We accounted for autocorrelation among years by running a correlated error model (auto-regressive) (Littell et al. 2006).

Using the BACI design, we conducted planned contrasts among treatment means (Milliken & Johnson 2009) to estimate turbine effects. The contrasts tested whether average density for first post-treatment year minus average density for pre-treatment year was equal between turbine and reference treatments (H_0: $[\text{density}_{\text{turbine,1yr-post}} - \text{density}_{\text{turbine,pre}}] - [\text{density}_{\text{reference,1yr-post}} - \text{density}_{\text{reference,pre}}] = 0$) and if average 2- to 5-year post-treatment mean density (i.e., mean density for the 2 to 5 calendar years following turbine construction) minus average density for pre-treatment year was equal between turbine and reference treatments (H_0: $[\text{density}_{\text{turbine,2-5yr-post}} - \text{density}_{\text{turbine,pre}}] - [\text{density}_{\text{reference,2-5yr-post}} - \text{density}_{\text{reference,pre}}] = 0$). The former contrast tested for an immediate turbine effect, whereas the latter contrast tested for a delayed effect. Immediate effects were not testable at TAT because 1-year post-treatment data were not collected. For the delayed effects, the span of years in which surveys were conducted varied among study areas, and surveys were not done every year within that time span. To achieve a consistent time frame that could be assessed at all 3 study areas, we used the average of 2–5 years post-treatment to assess the delayed effect, rather than assessing effects for each post-treatment year separately.

Table 2. Test statistics from the contrasts comparing changes in bird density per 100 ha between reference and turbine sites from pre-treatment year to 1 year post-treatment in South Dakota (NextEra Energy [NEE] SD Wind Energy Center [SD]) and North Dakota (NEE Oliver Wind Energy Center [OL]), (U.S.A.) 2003–2012.*

Location and distance from turbines (m)	*Grasshopper Sparrow*	*Western Meadowlark*	*Bobolink*	*Upland Sandpiper*	*Killdeer*	*Savannah Sparrow*	*Clay-colored Sparrow*	*Chestnut-collared Longspur*	*Vesper Sparrow*
SD									
0-100	t_{76} = -1.84, p = 0.07	t_{77} = -3.90, p<0.01	t_{57} = -1.25, p = 0.22	t_{83} = -1.33, p = 0.19	t_{92} = 3.21, p<0.01			t_{69} = 0.62, p = 0.54	
100–200	t_{76} = -0.31, p = 0.76	t_{77} = -0.73, p = 0.47	t_{57} = -0.26, p = 0.80	t_{83} = 0.38, p = 0.70	t_{92} = 0.70, p = 0.49			t_{69} = -1.09, p = 0.28	
200–300	t_{76} = -0.25, p = 0.81	t_{77} = -0.67, p = 0.50	t_{57} = -1.28, p = 0.20	t_{83} = -1.63, p = 0.11	t_{92} = 1.60, p = 0.11			t_{69} = -0.81, p = 0.42	
>300	t_{76} = 0.21, p = 0.83	t_{77} = -1.23, p = 0.22	t_{57} = -1.65, p = 0.10	t_{83} = -1.07, p = 0.29	t_{92} = 0.88, p = 0.38			t_{69} = 1.10, p = 0.27	
Overall	t_{29} = -0.11, p = 0.91	t_{20} = -2.27, p = 0.03	t_{36} = -1.71, p = 0.10	t_{32} = -1.23, p = 0.23	t_{25} = 2.01, p = 0.06			t_{39} = 0.50, p = 0.62	
OL									
0–100	t_{20} = -1.80, p = 0.09	t_{14} = 0.46, p = 0.65	t_{18} = -1.21, p = 0.24	t_{18} = -2.39, p = 0.03	t_{27} = 2.85, p = 0.01	t_{21} = -1.43, p = 0.17	t_{22} = -1.79, p = 0.09		t_{20} = 0.58, p = 0.57
100–200	t_{20} = -0.71, p = 0.49	t_{14} = 1.14, p = 0.27	t_{18} = -0.47, p = 0.64	t_{18} = 1.00, p = 0.33	t_{27} = 0.71, p = 0.48	t_{21} = -2.45, p = 0.02	t_{22} = -1.77, p = 0.09		t_{20} = 0.21, p = 0.83
200–300	t_{20} = 0.09, p = 0.93	t_{14} = 1.94, p = 0.07	t_{18} = 2.14, p = 0.05	t_{18} = -0.23, p = 0.82	t_{27} = -0.33, p = 0.74	t_{21} = -3.41, p<0.01	t_{22} = -0.76, p = 0.46		t_{20} = -1.64, p = 0.12
>300	t_{20} = 1.14, p = 0.27	t_{14} = 1.45, p = 0.17	t_{18} = 1.93, p = 0.07	t_{18} = -0.17, p = 0.87	t_{27} = -0.15, p = 0.88	t_{21} = -0.50, p = 0.62	t_{22} = -1.62, p = 0.12		t_{20} = 0.29, p = 0.77
Overall	t_{9} = 0.78, p = 0.46	t_{8} = 1.17, p = 0.28	t_{9} = 1.40, p = 0.20	t_{9} = -0.02, p = 0.99	t_{8} = -0.03, p = 0.98	t_{12} = -1.03, p = 0.32	t_{10} = -2.07, p = 0.06		t_{12} = 0.22, p = 0.83

* *Cells with no values indicate an analysis for that species was not conducted because of low number of observations.*

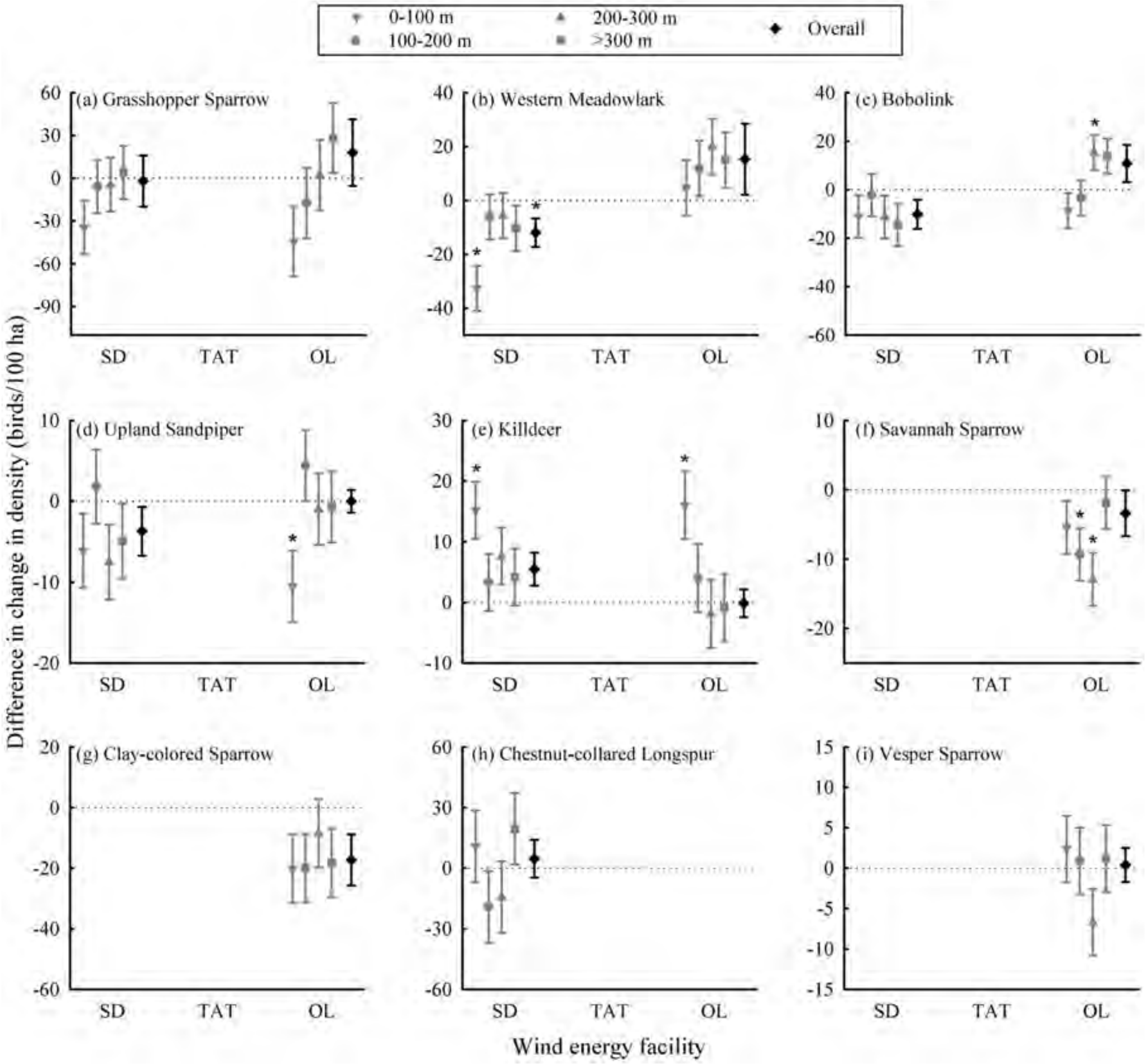

Figure 2. Difference in change in bird density/100 ha between reference and wind turbine sites from pre-treatment year to 1 year post-treatment (immediate effect) in South Dakota (NextEra Energy [NEE] SD Wind Energy Center [SD]) and North Dakota (Acciona Tatanka Wind Farm [TAT] and NEE Oliver Wind Energy Center [OL]), 2003–2012 for (a) Grasshopper Sparrow, (b) Western Meadowlark, (c) Bobolink, (d) Upland Sandpiper, (e) Killdeer, (f) Savannah Sparrow, (g) Clay-colored Sparrow, (h) Chestnut-collared Longspur, and (i) Vesper Sparrow (difference = [$density_{turbine,1yr\text{-}post}$ – $density_{turbine,pre}$] – [$density_{reference,1yr\text{-}post}$ – $density_{reference,pre}$]; error bars, SE; value >0, positive effect; value <0, negative effect; asterisk, significant [α = 0.05] difference).

One strength of a BACI design is that it allows researchers to assume that any naturally occurring changes occur at both the impact and control sites; thus, any changes observed at the impact sites can be attributed to the impact (Manly 2001). Therefore, we assumed annual variation in bird populations and weather effects were the same for turbine and reference sites within a study area. Vegetation structure also was similar between sites (Supporting Information). In addition, turbine and reference sites were spatially replicated within wind facilities; this allowed us to account for variability among sites and to test if, on average, changes in density differed between turbine and reference sites. Therefore, any immediate or delayed effects were due to the construction of the wind facility.

Results

Immediate Effects

We detected statistically significant immediate (1-year) displacement behavior for 3 of 9 species (Western

Table 3. Test statistics from the contrasts comparing changes in bird density/100 ha between reference and turbine sites from pre-treatment year to 2-5-years post-treatment in South Dakota (NextEra Energy [NEE] SD Wind Energy Center [SD]) and North Dakota (Acciona Tatanka Wind Farm [TAT] and NEE Oliver Wind Energy Center [OL]), (U.S.A.), 2003–2012.*

Location and distance from turbines (m)	*Grasshopper Sparrow*	*Western Meadowlark*	*Bobolink*	*Upland Sandpiper*	*Killdeer*	*Savannah Sparrow*	*Clay-colored Sparrow*	*Chestnut-collared Longspur*	*Vesper Sparrow*
SD									
0-100	$t_{142} = -3.94$, $p<0.01$	$t_{145} = -3.86$, $p<0.01$	$t_{110} = -1.10$, $p = 0.27$	$t_{145} = -1.31$, $p = 0.19$	$t_{149} = 0.97$, $p = 0.33$			$t_{140} = -2.27$, $p = 0.02$	
100–200	$t_{142} = -1.94$, $p = 0.05$	$t_{145} = -1.34$, $p = 0.18$	$t_{110} = 0.41$, $p = 0.69$	$t_{145} = -1.32$, $p = 0.19$	$t_{149} = -0.56$, $p = 0.58$			$t_{140} = -2.52$, $p = 0.01$	
200–300	$t_{142} = -1.54$, $p = 0.13$	$t_{145} = -1.97$, $p = 0.05$	$t_{110} = -0.96$, $p = 0.34$	$t_{145} = -1.92$, $p = 0.06$	$t_{149} = -0.76$, $p = 0.45$			$t_{140} = -2.54$, $p = 0.01$	
>300	$t_{142} = -1.66$, $p = 0.10$	$t_{145} = -2.32$, $p = 0.02$	$t_{110} = -0.91$, $p = 0.37$	$t_{145} = -2.82$, $p = 0.01$	$t_{149} = 0.28$, $p = 0.78$			$t_{140} = -1.10$, $p = 0.27$	
Overall	$t_{54} = -1.99$, $p = 0.05$	$t_{52} = -4.12$, $p<0.01$	$t_{54} = -0.36$, $p = 0.72$	$t_{54} = -2.79$, $p = 0.01$	$t_{54} = 0.07$, $p = 0.94$			$t_{55} = -2.19$, $p = 0.03$	
TAT									
0-100	$t_{38} = -3.49$, $p<0.01$	$t_{41} = 0.16$, $p = 0.87$	$t_{33} = -5.34$, $p<0.01$	$t_{39} = 0.11$, $p = 0.91$	$t_{43} = 1.74$, $p = 0.09$	$t_{31} = -0.94$, $p = 0.35$	$t_{39} = -3.57$, $p<0.01$		$t_{47} = 1.18$, $p = 0.24$
100–200	$t_{38} = -2.54$, $p = 0.02$	$t_{41} = -0.01$, $p = 0.99$	$t_{33} = -5.69$, $p<0.01$	$t_{39} = -0.28$, $p = 0.78$	$t_{43} = 0.80$, $p = 0.43$	$t_{31} = -2.78$, $p = 0.01$	$t_{39} = -3.52$, $p<0.01$		$t_{47} = -0.61$, $p = 0.54$
200–300	$t_{38} = -2.43$, $p = 0.02$	$t_{41} = -0.21$, $p = 0.84$	$t_{33} = -6.85$, $p<0.01$	$t_{39} = -0.48$, $p = 0.63$	$t_{43} = 1.73$, $p = 0.09$	$t_{31} = -2.53$, $p = 0.02$	$t_{39} = -1.83$, $p = 0.08$		$t_{47} = -0.15$, $p = 0.88$
>300	$t_{38} = -1.75$, $p = 0.09$	$t_{41} = 0.13$, $p = 0.90$	$t_{33} = -4.78$, $p<0.01$	$t_{39} = -0.32$, $p = 0.75$	$t_{43} = 0.52$, $p = 0.60$	$t_{31} = -0.52$, $p = 0.61$	$t_{39} = -1.55$, $p = 0.13$		$t_{47} = 0.84$, $p = 0.41$
Overall	$t_{23} = -1.67$, $p = 0.11$	$t_{23} = 0.19$, $p = 0.85$	$t_{23} = -4.55$, $p<0.01$	$t_{23} = -0.15$, $p = 0.88$	$t_{11} = 1.51$, $p = 0.16$	$t_{22} = -0.93$, $p = 0.36$	$t_{20} = -1.37$, $p = 0.18$		$t_{22} = 0.37$, $p = 0.71$
OL									
0-100	$t_{36} = -3.62$, $p<0.01$	$t_{33} = -0.79$, $p = 0.43$	$t_{39} = -2.75$, $p = 0.01$	$t_{35} = -2.90$, $p = 0.01$	$t_{37} = 0.70$, $p = 0.49$	$t_{34} = -0.41$, $p = 0.68$	$t_{36} = -1.62$, $p = 0.11$		$t_{33} = 1.97$, $p = 0.06$
100–200	$t_{36} = -3.41$, $p<0.01$	$t_{33} = -1.41$, $p = 0.17$	$t_{39} = -2.31$, $p = 0.03$	$t_{35} = 0.15$, $p = 0.88$	$t_{37} = 0.42$, $p = 0.68$	$t_{34} = -1.32$, $p = 0.20$	$t_{36} = -1.61$, $p = 0.12$		$t_{33} = -0.52$, $p = 0.61$
200–300	$t_{36} = -3.35$, $p<0.01$	$t_{33} = -0.05$, $p = 0.96$	$t_{39} = 0.33$, $p = 0.74$	$t_{35} = -0.99$, $p = 0.33$	$t_{37} = -0.14$, $p = 0.89$	$t_{34} = -2.88$, $p = 0.01$	$t_{36} = -1.68$, $p = 0.10$		$t_{33} = -1.40$, $p = 0.17$
>300	$t_{36} = -0.98$, $p = 0.33$	$t_{33} = -0.56$, $p = 0.58$	$t_{39} = 0.01$, $p = 0.99$	$t_{35} = -0.58$, $p = 0.57$	$t_{37} = -0.72$, $p = 0.47$	$t_{34} = -0.28$, $p = 0.78$	$t_{36} = -2.09$, $p = 0.04$		$t_{33} = 0.25$, $p = 0.80$
Overall	$t_{12} = -1.82$, $p = 0.09$	$t_{16} = -0.53$, $p = 0.60$	$t_{16} = -0.34$, $p = 0.74$	$t_{16} = -1.01$, $p = 0.33$	$t_{7} = -1.34$, $p = 0.22$	$t_{16} = -0.65$, $p = 0.53$	$t_{16} = -1.79$, $p = 0.09$		$t_{16} = -0.09$, $p = 0.93$

Cells with no values indicate an analysis for that species was not conducted because of low number of observations.

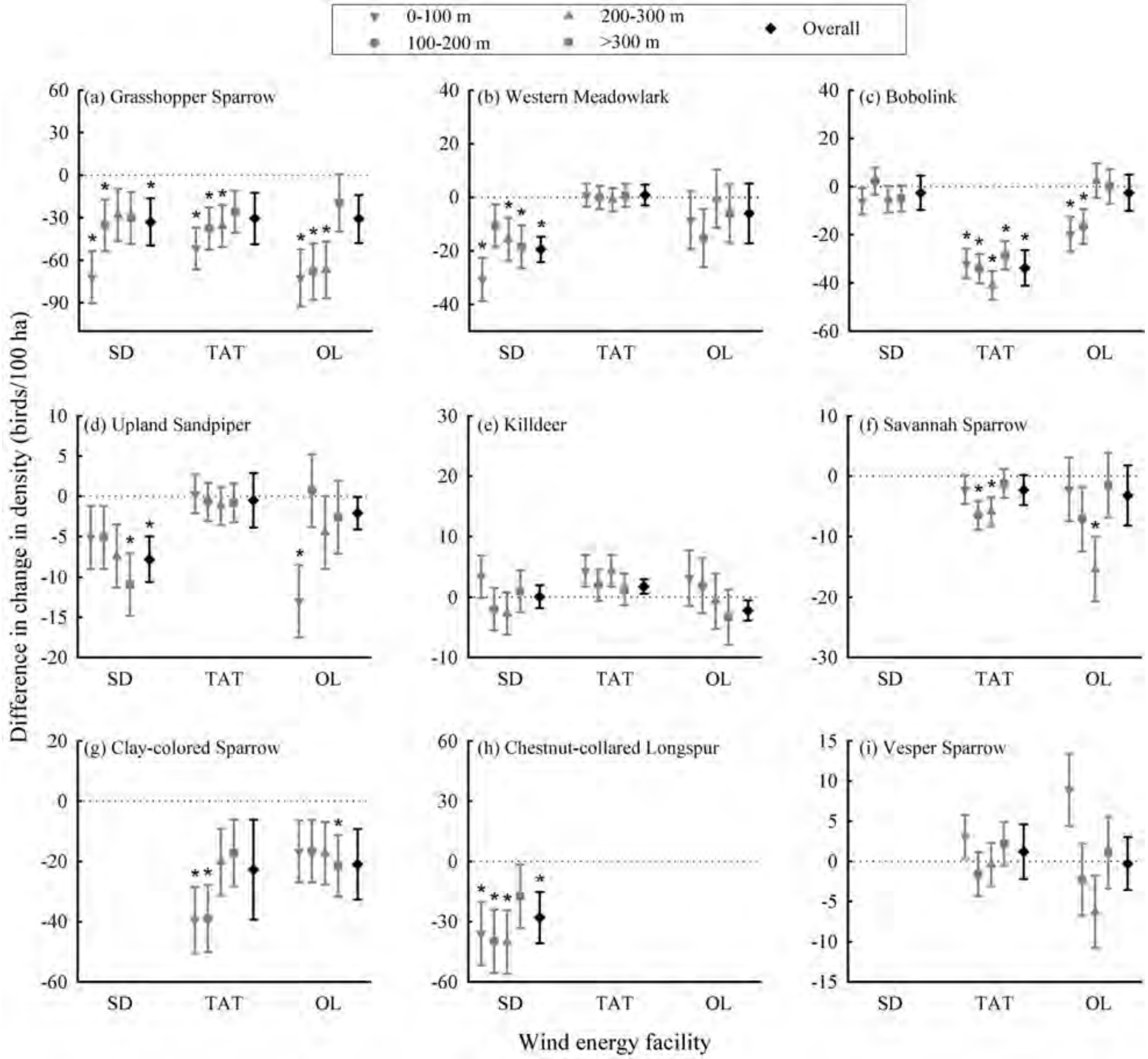

Figure 3. Difference in change in bird density/100 ha between reference and wind turbine site from pre-treatment year to 2–5 years post-treatment (delayed effect) in South Dakota (NextEra Energy [NEE] SD Wind Energy Center [SD]) and North Dakota (Acciona Tatanka Wind Farm [TAT] and NEE Oliver Wind Energy Center [OL]), 2003–2012 for (a) Grasshopper Sparrow, (b) Western Meadowlark, (c) Bobolink, (d) Upland Sandpiper, (e) Killdeer, (f) Savannah Sparrow, (g) Clay-colored Sparrow, (h) Chestnut-collared Longspur, and (i) Vesper Sparrow (difference = [$density_{turbine,2\text{-}5yr\text{-}post}$ – $density_{turbine,pre}$] – [$density_{reference,2\text{-}5yr\text{-}post}$ – $density_{reference,pre}$]; error bars, SE; value >0, positive effect; value <0, negative effect; asterisk, significant [α = 0.05] difference).

Meadowlark [*Sturnella neglecta*], Upland Sandpiper [*Bartramia longicauda*], and Savannah Sparrow [*Passerculus sandwichensis*]) and attraction for 2 species (Killdeer [*Charadrius vociferous*] and Bobolink [*Dolichonyx oryzivorus*]) (Table 2). For Western Meadowlark, displacement was detected at SD; effects were apparent overall and within 100 m (Fig. 2b). For Upland Sandpiper, displacement was detected at OL, but only within 100 m (Fig. 2d). Change in density of Savannah Sparrow was lower 100–300 m from turbines than at reference sites at OL, the one study area in which immediate effects could be determined for this species (Fig. 2f). Killdeer expressed attraction within 100 m of turbines at both study areas 1 year post-construction (Fig. 2e, Table 2). Bobolink exhibited a positive difference 200–300 m at OL (Fig. 2c, Table 2).

Wind facilities had no significant immediate effect on Grasshopper Sparrow (*Ammodramus savannarum*), Clay-colored Sparrow (*Spizella pallida*), or Chestnut-collared Longspur (*Calcarius ornatus*) (Table 2). However, the magnitude of differences (≥20 birds/100 ha) between turbine sites and reference sites suggested these species may have exhibited immediate displacement (Fig. 2a, 2g, 2h). Vesper Sparrow (*Pooecetes gramineus*) appeared unaffected by wind facilities (Fig. 2i).

Delayed Effects

We detected significant displacement behavior beyond 1 year for 7 species (Table 3). For Grasshopper Sparrow, we detected displacement overall at SD, within 200 m at all 3 study areas, and within 200–300 m at TAT and OL (Fig. 3a). Bobolink, Upland Sandpiper, Savannah Sparrow, and Clay-colored Sparrow exhibited displacement at 2 study areas each (Fig. 3c, 3d, 3f, 3g). Displacement occurred overall and at all distances for Bobolink at TAT, but only within 200 m at OL. Upland Sandpiper exhibited displacement overall and beyond 300 m at SD, but only within 100 m at OL. Displacement was observed within 200–300 m for Savannah Sparrow at both TAT and OL and within 100–200 m at TAT. For Clay-colored Sparrow, significant displacement occurred within 200 m at TAT and >300 m at OL. For Western Meadowlark and Chestnut-collared Longspur, displacement was detected at SD only. Effects were apparent overall, within 100 m, and beyond 200 m for Western Meadowlark (Fig. 3b) and overall and within 300 m for Chestnut-collared Longspur (Fig. 3h). Killdeer and Vesper Sparrow showed no delayed effects (Fig. 3e, 3i).

Discussion

The preferred design for testing impacts of energy infrastructure on wildlife is the BACI design (Evans 2008; Strickland et al. 2011), but examples are rare (Supporting Information). Our work provides a framework for applying a BACI design to behavioral studies and highlights the erroneous conclusions that can be made when the BACI approach is not used. If we had data from only impact sites (i.e., no reference sites) or had only post-treatment data (i.e., no pre-treatment monitoring) and thus not been able to use a BACI design, our conclusions would have been different. Obtaining data from impact and reference sites allowed us to discern changes in avian densities due to wind facilities as opposed to naturally occurring changes. For example, Grasshopper Sparrow at SD showed a large change in density on the turbine sites (i.e., a decrease of more than 60 birds/100 ha) from the pre-treatment year to the first year post-treatment (Supporting Information). Without reference sites, we may have interpreted this decrease in density to be due to turbine operation. However, we observed a similar change in density at reference sites, indicating the change on the turbine sites was probably due not to turbine operation but rather to normal annual variation in avian density. Pre-treatment data were used to account for differences among the turbine and reference sites prior to turbine construction, which allowed us to attribute post-treatment differences to turbine operation. For example, Grasshopper Sparrows at SD had higher average density for reference sites (60.1 birds/100 ha) than for turbine sites (38.3 birds/100 ha) in the first post-construction year (Supporting Information). Without pre-treatment data, this difference might have been interpreted as a turbine effect. However, pre-treatment data provided evidence of existing site differences of the same magnitude (Supporting Information) and therefore indicates there was no turbine effect.

By collecting data the year following construction and beyond 1 year post-construction, we were able to assess whether species exhibited immediate effects, delayed effects, or sustained effects. Because our turbine and reference sites were near one another and were similar with respect to landscape composition, vegetation, topography, and weather, the BACI design allowed us to assume that any naturally occurring changes happen at both the turbine and reference sites and therefore can be ruled out as alternative explanations. In addition, spatial replication of turbine and reference sites within study areas accounts for inherent variability among sites (Underwood 1992). Thus, any effects we observed were attributed to the operation of the wind facility.

Immediate effects were manifested by displacement or attraction the year following turbine construction. Birds returning in the spring following construction would encounter an altered landscape and would need to decide whether to settle near a wind facility or move elsewhere. In our study areas, Vesper Sparrows and Killdeer showed a high degree of tolerance to newly constructed wind facilities. Vesper Sparrows are often the first species to occupy disturbed areas (Jones & Cornely 2002); therefore, lack of displacement is not surprising given this life-history characteristic. Moreover, Johnson et al. (2000) reported attraction of Vesper Sparrows to turbines 1 year post-construction at grassland sites in Minnesota (U.S.A.). Killdeer prefer gravel substrates for nesting, and roadsides are preferred habitat (Jackson & Jackson 2000). Our finding that Killdeer density increased nearest to newly constructed turbines likely reflects similar habitat selection. Similarly, Johnson et al. (2000) reported higher than expected use of turbine plots in Minnesota by Horned Larks (*Eremophila alpestris*), another species that prefers disturbed areas. However, Erickson et al. (2004) found no evidence of attraction (or displacement) for this species in Oregon (U.S.A.).

Some species in our study areas did not exhibit immediate effects, yet we observed displacement in years beyond the first year post-construction (i.e., delayed effects). Species exhibiting breeding site fidelity might be more inclined to show delayed effects than immediate effects. Individuals will return to a turbine site 1 year post-construction due to site fidelity, but they may not return in subsequent years because of intolerance of the wind facility. In addition, new individuals may be unwilling to settle near turbines. We detected delayed displacement for Grasshopper Sparrow, Western Meadowlark, Bobolink, Upland Sandpiper, Clay-colored Sparrow, and Chestnut-collared Longspur, all of which exhibit breeding site fidelity (Hill & Gould 1997; Jones et al. 2007). Likewise, Johnson et al. (2000) reported delayed effects for Grasshopper Sparrow, Bobolink, and Savannah Sparrow, which also shows breeding site fidelity (Fajardo et al. 2009). On a Scottish wind facility 3 years post-construction, Douglas et al. (2011) detected delayed effects for 2 upland species, Red Grouse (*Lagopus lagopus scotica*) and European Golden Plover (*Pluvialis apricaria*); these 2 species are also site faithful (Jenkins et al. 1963; Parr 1980).

We considered a species to be exhibiting a sustained effect if displacement continued from 1 year post-construction into 2–5 years post-construction. In our study, sustained displacement usually occurred within 100 m (e.g., Western Meadowlark at SD and Upland Sandpiper at OL). Few other researchers have examined sustained effects. Pearce-Higgins et al. (2012) detected positive long-term effects in the United Kingdom for 2 upland species and negative effects for 2 waterbird species.

Consistency of behavioral responses to wind facilities varied across the 9 species of grassland nesting birds we monitored. Grasshopper Sparrows and Clay-colored Sparrows exhibited the most consistent results across study areas. The Grasshopper Sparrow is an area- and edge-sensitive species (Grant et al. 2004; Ribic et al. 2009) for which amount of grassland in the surrounding landscape is important (Berman 2007; Greer 2009). Wind facilities appear to be an additional landscape change not tolerated by Grasshopper Sparrows, and the construction of additional wind facilities throughout native grasslands could be detrimental to the species. Clay-colored Sparrows prefer grasslands intermixed with shrubs and woody edges (Grant & Knapton 2012). We speculate that removal of woody vegetation during construction of roads and turbines reduced breeding habitat for this species.

Bobolinks, Western Meadowlarks, Upland Sandpipers, and Savannah Sparrows exhibited inconsistent displacement behavior across study areas. Because we were not always present on study areas in the same years, we suspect inconsistencies resulted from habitat differences specific to study area that may have been influenced by variable precipitation patterns. The interaction of habitat conditions and species-specific life-history strategies may have influenced behavior. For example, Bobolinks exhibited strong displacement at TAT, which was the largest wind facility with the most intact grasslands and the highest precipitation. Densities of Bobolinks also were greatest at TAT (Supporting Information); hence, density dependent effects may arise at these higher densities and may result from habitat loss (both grassland and wetland) with construction of turbines. As a result of high precipitation, grasslands at this site were interspersed with many small wetlands containing nesting pairs of Red-winged Blackbirds (*Agelaius phoeniceus*). Red-winged Blackbirds and Bobolinks are antagonistic. Red-winged Blackbirds may displace Bobolinks from perches, and Bobolinks appear to avoid nesting near active blackbird nests (Martin & Gavin 1995). Thus, displacement of Bobolinks at TAT could have been more evident because of intra- or interspecific competition.

For other species, cumulative effects of wind facilities and other landscape changes might be the cause of inconsistent results. Western Meadowlarks are a gregarious species not reported to be sensitive to habitat area or habitat edges (Johnson & Igl 2001), and some degree of anthropogenic activity appears acceptable to them. However, we speculate that the degree of anthropogenic disturbance at SD surpassed the species' threshold of tolerance to human activity. The sustained displacement observed at SD could be the species' response to the additive stressors of wind-facility operation and recent land conversion from grassland to agricultural fields (Wright & Wimberly 2013). Increasing urbanization had a strong negative effect on the density of a congeneric species, Eastern Meadowlark (*Sturnella magna*), in grasslands (McLaughlin et al. 2014). Conversely, TAT, where no displacement effects were observed for Western Meadowlarks, has undergone little land conversion, was composed of 92% perennial grasslands (Loesch et al. 2013), and was located in a remote area rarely traversed by humans other than personnel associated with the wind facility. Upland Sandpiper displayed the most inconsistent results and a similar pattern as Western Meadowlark. The species is highly sensitive to habitat fragmentation (Ribic et al. 2009), and the strongest displacement effects occurred on the most fragmented study areas, SD and OL. No displacement was detected on the least fragmented study area. As with Western Meadowlarks, Upland Sandpipers may have reached a threshold beyond which additional landscape disturbance could not be tolerated and displacement behavior became apparent.

Our results for displacement distances for Grasshopper Sparrow (300 m), Bobolink (>300 m), Western Meadowlark (>300 m), Upland Sandpiper (100 m), Clay-colored Sparrow (200 m), Savannah Sparrow (300 m), and Chestnut-collared Longspur (300 m) were consistent with those reported by other researchers. In a literature review of North American grassland birds, Johnson and Stephens (2011) reported displacement extending 50–180 m from turbines. Stevens et al. (2013) found that mean plot occupancy for Le Conte's Sparrows

(*Ammodramus leconteii*) wintering in Texas was 4 times lower in plots <200 m from nearest wind turbine relative to >400 m from the nearest turbine. In the United Kingdom, 7 of 12 upland species exhibited displacement within 500 m (Pearce-Higgins et al. 2009). Winkelman (1992) found that shorebirds in a Netherlands wind facility occurred in significantly smaller numbers within 500 m from turbines. Thus, although displacement can occur as far as 500 m from turbines, most studies show displacement within 200 m.

Evaluating turbine effects overall and by distance from turbine allowed us to differentiate between localized displacement and site abandonment. For several species, immediate or delayed effects occurred by distance at a site, but there was no significant reduction in density at that site overall. This may have occurred because breeding pairs near turbines relocated short distances from turbines but not off the site completely. For example, Grasshopper Sparrow at OL showed an immediate reduction in density of birds near turbines and an increased density at distance categories >300 m and overall. Thus, Grasshopper Sparrows may not abandon sites completely; rather, they may relocate away from the turbines and establish territories farther from turbines. Without examining displacement by distance band, we would have missed this localized displacement and instead concluded there was no displacement. Niemuth et al. (2013) also found near-turbine displacement. They modeled mean occupancy for 4 waterbird species at 2 wind facilities in North Dakota, one of which was TAT, and found that species occurrences were not substantially reduced overall at either facility post-construction. However, occupancy was slightly and consistently lower for 3 of the 4 species at one wind facility. Thus, effects of wind facilities should be examined overall and by distance from turbines.

Our identification of species-specific behaviors to wind facilities can be used to inform management decisions about turbine placement in grasslands and the potential impact at an individual species level. Metrics of displacement distances can be used to parameterize models that quantify the potential loss of habitat under scenarios of differing land uses and corresponding avian community composition. Output from these models may help drive conservation planning, such as prioritizing landscapes of highest value for preservation or restoration.

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Supporting Information

A comparison of avian and mammal displacement studies in which impact assessment designs were used (Appendix S1), a description of avian habitat preferences and population status of focal species (Appendix S2), a description of vegetation surveys and a related table of least squares means for vegetation variables (Appendix S3), and 3 tables with least squares means for density of birds on reference and turbine sites (Appendix S4) are available online. The authors are solely responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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Supporting Information - Appendix S1.

Table S1.1. Studies of avian and mammal displacement from onshore wind facilities that used impact assessment designs of Before-After Control-Impact (BACI), Control-Impact (CI), Before-After (BA), and Impact-Gradient (IG) (Manly 2001).

Source	Country	Taxonomic group	Variable of interest	Season	No. wind Facilities	Impact assessment design	No. Yrs. Pre-Treatment	No. Yrs. Post-Treatment[a]
Winkelman 1992	Netherlands	multiple avian	abundance	year-round	1	IG, BACI	1-3	1
Osborn et al. 1998	USA	multiple avian	abundance flight height	breeding migration	1	CI	0	2
Leddy et al. 1999	USA	passerine	density	breeding	1	CI	0	1
Johnson et al. 2000a	USA	multiple avian	avian use	breeding migration	1	BACI	2	2
Johnson et al. 2000b	USA	multiple avian and mammal	abundance distribution use	year-round	1	BACI	2	1
Larsen and Madsen 2000	Denmark	waterbird	field utilization	winter	2	IG	0	1
Barrios and Rodriguez 2004	Spain	raptor	flight behavior	year-round	2	IG	0	1
de Lucas et al. 2004	Spain	passerine raptor	abundance productivity flight behavior	year-round	1	CI	0	2
Erickson et al. 2004	USA	passerine	avian use	breeding	1	BA, IG	1	1
de Lucas et al. 2005	Spain	multiple avian and mammal	abundance flight behavior	breeding	1	BACI, IG	1	1
Rabin et al. 2006	USA	ground squirrel	antipredator behavior	breeding	1	CI	0	1

Walter et al. 2006	USA	elk	distance home range	year-round	1	BA	1	2
Devereaux et al. 2008	UK	multiple avian	occurrence	winter	2	IG	0	1
Madsen and Boertmann 2008	Denmark	waterbird	field utilization	migration	3	IG	0	2
Pearce-Higgins et al. 2009	UK	multiple avian	occurrence flight height	breeding	12	CI	0	1
Douglas et al. 2011	UK	game bird waterbird	abundance occurrence	breeding	1	CI	0	2
Garvin et al. 2011	USA	raptor	abundance flight height	breeding	1	BA, CI	1	2
Jain et al. 2011	USA	bats	activity	migration breeding	1	CI	0	2
Pearce-Higgins et al. 2012	UK	game bird passerine waterbird	density	breeding	18	BACI	1	1-5
Rubenstahl et al. 2012	USA	passerine	productivity	breeding	1	IG	0	1
Hatchett et al. 2013	USA	passerine	productivity	breeding	1	IG	0	2
Loesch et al. 2013	USA	waterbird	density	breeding	2	CI	0	3
Niemuth et al. 2013	USA	waterbird	occurrence	breeding	2	CI	0	3
Stevens et al. 2013	USA	passerine	occupancy	winter	1	IG	0	2
Bennett et al. 2014	USA	passerine	productivity	breeding	1	IG	0	1
LeBeau et al. 2014	USA	game bird	fitness productivity	breeding	1	IG	0	2
McNew et al. 2014	USA	game bird	site selection productivity	breeding	1	BA, IG	2	3
Winder et al. 2014a	USA	game bird	fitness	year-round	1	BA, IG	2	3

Winder et al. 2014b	USA	game bird	home range distribution	year-round	1	BA, IG	2	3
Shaffer and Buhl, this paper	USA	passerine waterbird	density	breeding	3	BACI	1	3-4[b]

[a]Construction years were not included.
[b]We had 3-4 post-treatment years of data over the 5-year post-treatment time frame (i.e., 5 calendar years) used for analyses.

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Supporting Information - Appendix S2.

Table S2.1. Habitat classification, population trend, and conservation status of avian species that were sufficiently abundant to include in analyses examining the effects of wind energy development on avian density in South Dakota (NextEra Energy [NEE] SD Wind Energy Center [SD], U.S.A.) and North Dakota (Acciona Tatanka Wind Farm [TAT] and NEE Oliver Wind Energy Center [OL], U.S.A.), 2003-2012.

Species	Habitat classification[a]	Population trend (%)[b]	Species of concern[b]
Grasshopper sparrow *Ammodramus savannarum*	grassland obligate	-2.5	no
Bobolink *Dolichonyx oryzivorus*	grassland obligate	-2.1	yes
Western meadowlark *Sturnella neglecta*	grassland obligate	-1.3	no
Killdeer *Charadrius vociferous*	generalist	-1.2	no
Upland sandpiper *Bartramia longicauda*	grassland obligate	0.5	yes
Clay-colored sparrow *Spizella pallida*	grassland/shrubland	-1.4	no
Vesper sparrow *Pooecetes gramineus*	grassland obligate	-0.9	no
Savannah sparrow *Passerculus sandwichensis*	grassland obligate	-1.2	no
Chestnut-collared longspur *Calcarius ornatus*	grassland obligate	-4.3	yes

[a]Habitat classification and concern rankings from NABCI (2014).

[b]Breeding Bird Survey population trends from Sauer et al. (2013).

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Supporting Information

Appendix S3. Description of vegetation surveys and analysis for the study on effects of wind energy facilities on grassland birds in South Dakota (NextEra Energy [NEE] SD Wind Energy Center [SD], U.S.A.) and North Dakota (Acciona Tatanka Wind Farm [TAT] and NEE Oliver Wind Energy Center (OL), U.S.A.), 2003-2012.

The mixed-grass prairie biome in North Dakota and South Dakota (U.S.A.) is a heterogeneous landscape of wetland complexes embedded within grasslands of highly scattered patches of low-growing trees and shrubs, such as S*ymphoricarpos occidentalis* (Hook) and *Prunus virginiana* (L.). Non-grassland habitats within sites were mapped using GPS units and digital photography because our focal species did not breed within all available habitat types within any particular site. For example, grasshopper sparrows were never detected within wetlands or colonies of black-tailed prairie dogs *Cynomys ludovicianus* (Ord). We accounted for the fact that some of our focal species have particular breeding habitat preferences by mapping area of wetlands (open water), woodlands, colonies of black-tailed prairie dogs, and exceptionally lush grass and deleting these areas from total area of each site, as applicable, so as to calculate suitable breeding area at a species level. Wetland area was removed for all nine of our focal species, woodland area was removed for all species except clay-colored sparrow, area of prairie-dog colony was removed for grasshopper sparrow (JAS, personal observation), and area of lush grass was removed for chestnut-collared longspur (Hill & Gould 1997).

Vegetation measurements were taken within the 50 m by 200 m cells formed by the avian survey grids. Cells were systematically chosen and sampling was conducted along 1-2 sampling lines. Percent composition of six basic life forms, bare ground (e.g., bare ground, cow pie, rock), grass, forb, shrub, standing residual, and lying litter, was estimated using a step-point sampler (Owensby 1973). Height-density (i.e., visual obstruction) was measured with a Robel pole (Robel et al. 1970). Vegetation height and litter depth were measured with a meter stick. Measurements were averaged to characterize each site.

To examine the similarity in vegetation metrics (e.g., vegetation height, proportion bare ground) between turbine and reference sites, a repeated measures analysis of variance was conducted to estimate and compare mean habitat features between turbine and reference sites and among years.

Vegetation characteristics did not significantly vary between reference and turbine sites except for VOR at TAT, where the difference was still quite small (see Appendix Table S2.1). As expected, yearly differences did occur for most vegetation characteristics. Therefore, the habitat was similar between reference and turbine sites and can be excluded as a possible confounding factor.

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Table S3.1. Least squares means of each vegetation variable for reference and turbine sites, at SD Wind Energy Center (SD) in Highmore, South Dakota (2003-2012); Acciona's Tatanka Wind Farm (TAT) in Forbes, North Dakota (2007-2012); and Oliver Wind Energy Center (OL) in Oliver Co., North Dakota (2006-2011), U.S.A. Sig. column indicates significance at a significance level of 0.05, t indicates significant difference between reference and turbine sites, y indicates significant difference among years, and t*y indicates a significant turbine*year interaction.

	SD			TAT			OL		
	Reference	Turbine	Sig. [a]	Reference	Turbine	Sig.	Reference	Turbine	Sig. [a]
VOR	0.97 (0.16)	0.74 (0.12)	y	0.93 (0.05)	1.33 (0.07)	t	1.09 (0.07)	0.77 (0.07)	t*y
Litter Depth	2.58 (0.41)	2.11 (0.32)	t*y	3.05 (0.28)	3.71 (0.38)	y	2.92 (0.34)	2.48 (0.34)	y
Veg Height	26.47 (2.32)	23.48 (1.81)	y	29.30 (1.90)	33.67 (2.65)	y	29.76 (2.05)	23.41 (2.05)	t*y
Bare Ground	0.03 (0.01)	0.03 (0.01)	y	0.02 (0.00)	0.01 (0.01)		0.01 (0.01)	0.04 (0.01)	
Forbs	0.11 (0.02)	0.10 (0.02)	t*y	0.17 (0.01)	0.21 (0.02)	y	0.12 (0.02)	0.15 (0.02)	y
Grass	0.64 (0.02)	0.65 (0.01)	y	0.62 (0.03)	0.58 (0.04)	y	0.68 (0.03)	0.59 (0.03)	
Lying Litter	0.16 (0.02)	0.17 (0.02)	t*y	0.08 (0.01)	0.05 (0.01)	y	0.09 (0.02)	0.09 (0.02)	
Res. Litter	0.05 (0.01)	0.05 (0.01)	y	0.04 (0.01)	0.05 (0.01)	y	0.08 (0.01)	0.07 (0.01)	y
Shrubs	---	---		0.07 (0.02)	0.09 (0.03)		0.02 (0.02)	0.05 (0.02)	y

[a]Most interaction effects were significant due to year differences rather than to differences between reference and turbine sites.

Supporting Information

Appendix S4. Least squares means (SE) of density / 100 ha for reference and turbine sites for 3 study sites in North Dakota and South Dakota (U.S.A.), 2003-2012.

Table S4.1. Least squares means (SE) of density/100 ha for reference and turbine sites each year at SD Wind Energy Center (SD) in Highmore, South Dakota.

	Year	Grasshopper Sparrow	Chestnut-collared Longspur	Western Meadowlark	Bobolink	Upland Sandpiper	Killdeer
Reference Sites	2003	124.3 (11.2)	56.7 (10.4)	22.0 (3.2)	8.5 (5.2)	2.3 (1.9)	3.2 (1.3)
	2004	60.1 (11.2)	42.3 (10.4)	22.0 (3.2)	12.9 (5.2)	1.5 (1.9)	0.0 (1.3)
	2005	62.1 (11.2)	36.2 (10.4)	15.5 (3.2)	6.6 (5.2)	2.9 (1.9)	0.7 (1.3)
	2006	100.6 (11.2)	65.8 (10.4)	30.3 (3.2)	5.2 (5.2)	3.7 (1.9)	2.2 (1.3)
	2008	130.7 (11.2)	120.6 (10.4)	37.6 (3.2)	14.8 (5.2)	1.8 (1.9)	0.8 (1.3)
	2010	87.4 (11.2)	39.8 (10.4)	23.2 (3.2)	18.2 (5.2)	5.1 (1.9)	0.0 (1.3)
	2012	79.4 (11.2)	60.3 (10.4)	15.5 (3.2)	42.4 (5.2)	2.6 (1.9)	1.7 (1.3)
Turbine Sites	2003	104.6 (8.6)	47.3 (8.1)	36.6 (2.5)	7.2 (4.0)	9.8 (1.5)	4.7 (1.0)
	2004	38.3 (8.6)	37.5 (8.1)	24.6 (2.5)	1.3 (4.0)	5.3 (1.5)	7.1 (1.0)
	2005	31.6 (8.6)	23.7 (8.1)	16.5 (2.5)	3.1 (4.0)	2.2 (1.5)	1.8 (1.0)
	2006	52.0 (8.6)	38.4 (8.1)	28.3 (2.5)	5.6 (4.0)	3.2 (1.5)	4.2 (1.0)
	2008	51.4 (8.6)	48.2 (8.1)	23.9 (2.5)	6.1 (4.0)	2.1 (1.5)	2.8 (1.0)
	2010	34.5 (8.6)	35.3 (8.1)	20.3 (2.5)	2.3 (4.0)	3.7 (1.5)	4.3 (1.0)
	2012	53.9 (9.7)	43.7 (8.8)	27.7 (2.8)	9.7 (4.5)	5.3 (1.6)	4.3 (1.2)
Reference Average		92.1 (4.6)	60.2 (7.1)	23.7 (1.2)	15.5 (2.9)	2.9 (0.8)	1.2 (0.5)
Turbine Average		52.3 (3.6)	39.1 (5.5)	25.4 (1.0)	5.0 (2.3)	4.5 (0.6)	4.2 (0.4)
Overall Average		72.2 (2.9)	49.7 (4.5)	24.6 (0.8)	10.3 (1.8)	3.7 (0.5)	2.7 (0.3)

Table S4.2. Least squares means (SE) of density/100 ha for reference and turbine sites each year at Acciona's Tatanka Wind Farm (TAT) in Forbes, North Dakota.

	Year	Grasshopper Sparrow	Clay-colored Sparrow	Western Meadowlark	Bobolink	Upland Sandpiper	Killdeer	Savannah Sparrow	Vesper Sparrow
Reference Sites	2007	67.6 (8.8)	27.1 (11.6)	13.8 (2.0)	39.0 (3.6)	8.8 (1.9)	0.2 (0.6)	5.2 (1.4)	6.4 (1.7)
	2009	55.1 (8.8)	31.9 (11.6)	13.1 (2.0)	22.1 (3.6)	10.3 (1.9)	1.4 (0.6)	3.0 (1.4)	4.6 (1.7)
	2010	84.4 (8.8)	30.6 (11.6)	17.2 (2.0)	31.0 (3.6)	11.5 (1.9)	1.2 (0.6)	4.3 (1.4)	1.9 (1.7)
	2012	93.7 (10.2)	92.4 (12.6)	10.8 (2.3)	31.4 (4.2)	4.1 (2.1)	2.9 (0.7)	10.5 (1.5)	5.7 (1.9)
Turbine Sites	2007	87.8 (12.5)	47.1 (16.4)	10.6 (2.9)	70.9 (5.1)	3.9 (2.7)	1.2 (0.9)	6.6 (1.9)	2.7 (2.4)
	2009	47.3 (12.5)	35.3 (16.4)	12.1 (2.9)	24.8 (5.1)	3.2 (2.7)	3.1 (0.9)	4.8 (1.9)	2.4 (2.4)
	2010	89.6 (12.5)	30.3 (16.4)	9.8 (2.9)	25.0 (5.1)	4.3 (2.7)	5.3 (0.9)	3.7 (1.9)	1.2 (2.4)
	2012	65.6 (12.5)	80.8 (16.4)	11.8 (2.9)	28.9 (5.1)	2.0 (2.7)	5.6 (0.9)	6.7 (1.9)	1.5 (2.4)
Reference Average		75.2 (4.6)	45.5 (10.0)	13.7 (1.0)	30.9 (2.0)	8.7 (1.4)	1.4 (0.3)	5.8 (1.0)	4.7 (0.8)
Turbine Average		72.6 (6.3)	48.4 (14.1)	11.1 (1.4)	37.4 (2.7)	3.3 (1.9)	3.8 (0.4)	5.4 (1.4)	2.0 (1.1)
Overall Average		73.9 (3.9)	46.9 (8.6)	12.4 (0.8)	34.1 (1.7)	6.0 (1.2)	2.6 (0.3)	5.6 (0.9)	3.3 (0.7)

Table S4.3. Least squares means (SE) of density/100 ha for reference and turbine sites each year at Oliver Wind Energy Center (OL) in Oliver County, North Dakota.

	Year	Grasshopper Sparrow	Clay-colored Sparrow	Western Meadowlark	Bobolink	Upland Sandpiper	Killdeer	Savannah Sparrow	Vesper Sparrow
Reference Sites	2006	105.2 (10.2)	25.6 (6.8)	28.0 (6.6)	42.0 (4.3)	7.7 (1.2)	1.3 (1.0)	2.5 (3.1)	1.3 (2.2)
	2007	65.6 (10.2)	21.2 (6.8)	10.0 (6.6)	19.0 (4.3)	4.9 (1.2)	1.3 (1.0)	7.9 (3.1)	2.4 (2.2)
	2009	133.6 (10.2)	33.4 (6.8)	49.3 (6.6)	16.1 (4.3)	8.0 (1.2)	2.7 (1.0)	8.0 (3.1)	0.0 (2.2)
	2011	56.3 (10.2)	13.7 (6.8)	31.5 (6.6)	49.5 (4.3)	6.9 (1.2)	1.4 (1.0)	1.4 (3.1)	0.0 (2.2)
Turbine Sites	2006	84.4 (10.2)	55.3 (6.8)	17.3 (6.6)	21.2 (4.3)	6.5 (1.2)	4.0 (1.0)	3.5 (3.1)	6.3 (2.2)
	2007	62.9 (10.2)	33.5 (6.8)	14.7 (6.6)	9.0 (4.3)	3.6 (1.2)	4.0 (1.0)	5.5 (3.1)	7.8 (2.2)
	2009	47.1 (10.2)	44.1 (6.8)	25.1 (6.6)	5.2 (4.3)	4.8 (1.2)	2.4 (1.0)	3.4 (3.1)	5.3 (2.2)
	2011	39.5 (10.2)	20.4 (6.8)	22.4 (6.6)	13.7 (4.3)	3.6 (1.2)	2.7 (1.0)	1.5 (3.1)	3.9 (2.2)
Reference Average		90.2 (4.7)	23.5 (4.6)	29.7 (3.1)	31.6 (2.2)	6.9 (0.8)	1.7 (0.5)	4.9 (2.3)	0.9 (1.8)
Turbine Average		58.5 (4.7)	38.3 (4.6)	19.9 (3.1)	12.3 (2.2)	4.6 (0.8)	3.3 (0.5)	3.5 (2.3)	5.8 (1.8)
Overall Average		74.3 (3.4)	30.9 (3.3)	24.8 (2.2)	22.0 (1.5)	5.7 (0.5)	2.5 (0.3)	4.2 (1.6)	3.4 (1.2)

July 30, 2020

South Dakota Public Utilities Commission
Capitol Building, 1st Floor
500 E. Capitol Ave
Pierre, SD 57501-5070
Phone (605) 773-3201

Dear Chairman Hanson, Vice Chairman Nelson, Commissioner Fiegen, and Utility Analyst Thurber:

The National Agricultural Aviation Association (NAAA) would like to bring to your attention our concern with towers erected without considering the safety of aerial applications made to South Dakota's cropland. These could be utility towers, wind-energy towers, or other, similar structures.

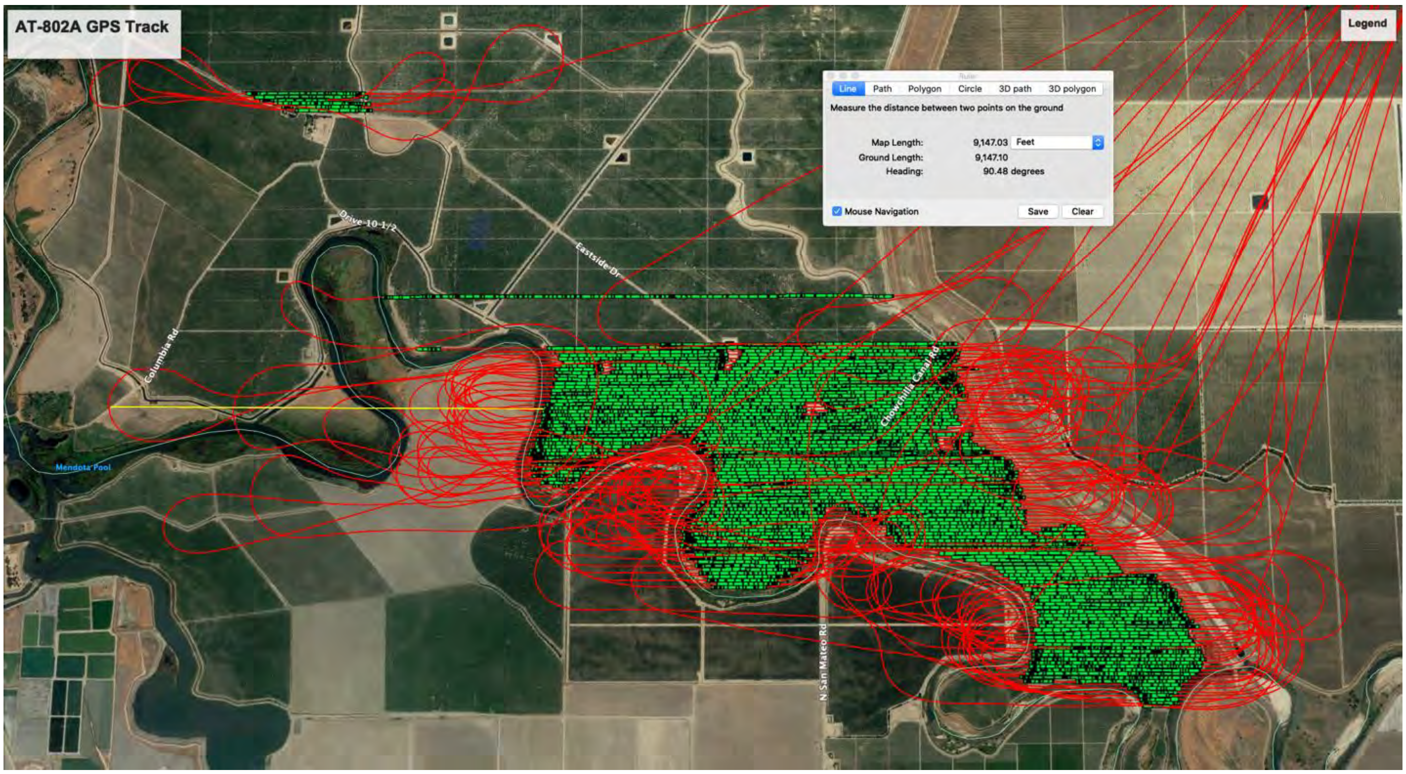
In terms of background about the aerial application industry, it is responsible for treating over 127 million acres of U.S. cropland either by seeding, fertilizing, or applying plant protecting pesticides. The NAAA represents over 1,600 members in in the field of aerial application, which consists mostly of small business owners and pilots licensed as commercial applicators that use aircraft to enhance the production of food, fiber and bio-fuel; protect forestry; protect waterways and ranchland from invasive species; and provide services to agencies and homeowner groups for the control of mosquitoes and other health-threatening pests. Within agriculture and other pest control situations, aerial application is a vitally important method for applying pesticides, for it permits large areas to be covered rapidly—by far the fastest application method of crop inputs—when it matters most. It takes advantage, more than any other form of application, of the often too-brief periods of acceptable weather for spraying and allows timely treatment of pests while they are in critical developmental stages, often over terrain that is too wet or otherwise inaccessible for ground applications. It also treats above the crop canopy, thereby not disrupting the crop and damaging it, nor compacting the soil.

Although the average aerial application company is comprised of but six employees and two aircraft, as an industry these businesses, as earlier stated, treat nearly 127 million acres of U.S. cropland each season, which is about 28% of all cropland used for crop production in the U.S.—this doesn't include the substantial amount of aerial applications that are made to pasture and rangeland. Aerial pest control for managers of forests, rangeland, waterways and public health also add to these many millions of acres treated annually. While there are alternatives to making aerial applications of pesticides, these options have several disadvantages compared to aerial application. In addition to the speed and timeliness advantage aerial application has over ground application, there is also a yield difference. Driving a ground sprayer through a standing crop results in a significant yield loss. Research from Purdue University found that yield loss from ground sprayer wheel tracks varied from 1.3% to 4.9% depending on boom width. While this study was conducted in soybeans, similar results could be expected in other crops as well. Research summarized by the University of Minnesota describes how soil compaction from ground rigs can negatively affect crop yields due to nitrogen loss, reduced potassium availability, inhibition of root respiration due to reduced soil aeration, decreased water infiltration and storage, and decreased root growth. Aerial application offers the only means of applying a crop protection product when the ground is wet and when time is crucial during a pest outbreak. A study on the application efficacy of fungicides on corn applied by ground, aerial, and chemigation applications (attached with these comments) further demonstrates that aerial application exceeds ground and chemigation application methods in terms of yield response. The success of aerial application using manned aircraft has resulted in an industry that will celebrate 100 years in 2021. Throughout its 100-year history, the industry has constantly improved itself through the use of research and technology. Aerial applicators constantly strive to incorporate the latest technology that can improve accuracy, including GPS guidance, flow control for variable and constant rate applications, and on-board weather monitoring equipment. Electronic valves that will allow flow to be controlled on individual nozzles is currently being evaluated for use on agricultural aircraft.

Regarding towers, they can be extremely difficult for aerial applicators to see, as their work is conducted while flying at over 100 mph just 10 feet off the ground. From 2008 – 2018, there were 22 agricultural aviation accidents from collisions with METs, communication towers, towers supporting powerlines and wind turbines resulting in nine fatalities. For all general aviation, there have been 40 tower related accidents and incidents resulting in 36 fatalities over the same 11-year period. As such, NAAA has developed the following information on safe distances towers should be located from cropland. It has come to NAAA's attention that a wind farm sponsor in South Dakota has proposed a setback of a mere 500 feet, which is far too short a distance for making safe aerial applications in a field adjacent to a wind turbine or tower location site with a fixed-wing aircraft.

NAAA has calculated a safe distance using aircraft speed and average turn time to estimate the total distance required to make a safe turn via a fixed-wing ag aircraft. An AT-802A with a working speed of 145 mph was used as the example aircraft. The working speed was taken from the midpoint between 130 and 160 mph as denoted on Air Tractor's specifications page for the AT-802A: https://airtractor.com/aircraft/at-802a/. An agricultural turn time of 45 seconds was used; this information was gleamed from operators' experience and used in comments made to EPA on several pesticide re-registrations. A speed of 145 mph is equal to 213 feet per second; 45 seconds to turn multiplied by 213 feet per second is equal to 9,585 feet or 1.82 miles needed to make the turn.

The second method NAAA used to provide evidence on the distance required to make a turn while conducting an aerial application was via GPS as-applied aerial application maps and Google Earth. Google Earth was used to measure the distance into the field that two turns required. The first was one of the shorter turns from the application from when the aircraft was lighter. This turn pushed 2,273 feet or 0.43 miles into the adjacent field. The second was from a longer turn made when the aircraft was fully loaded. This turn penetrated 9,147 feet or 1.73 miles into the adjacent field.



A Google Earth map showing an application made by an AT-802A. Green represents the flight path spray on, while red represent the flight path with spray off. The yellow line is the ruler tool used to measure the total length into the field a longer turn required: 9,147 feet (1.73 miles).

NAAA hopes that you the South Dakota Public Utilities Commissions finds the above information helpful and takes into account the dangers wind turbines and other obstacles represent to the safety of agricultural aviators in South Dakota where agriculture is such an integral part of the economy.

Thank you for the opportunity to share this information.

Most sincerely,

Andrew D. Moore
Chief Executive Officer

11/03/2021

James Malters
727 Oxford St.
Worthington, MN 56187

Mr. Malters,

In regards to the follow up question asked by the SD Public Utilities commission:

> *"In order to accommodate a safe turn radius at the end of a field for an agricultural application aircraft, what is Mr. Christensen recommending as an appropriate setback for a wind turbine from the property line to safely spray that field. Please explain and provide supporting calculations."*

I recommend a setback for a wind turbine no less than 0.8 miles from the end of field.

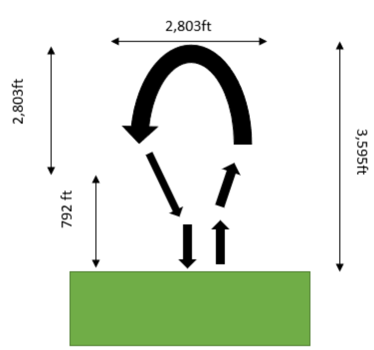
The calculations used to support the 0.8-mile setback include:

A straight out or teardrop/lightbulb pattern leaving the field including a climb, a 180° turn back on target = 3,595ft lateral distance from end of field.

Four seconds to climb and space for lateral distance = 792ft

Then 180° turn = 2,803ft radius

Lateral distance (792ft) +turn (2,803ft) = 3,595ft lateral distance from end of field = 0.68 miles *15% margin of error = 0.782 mile, rounded up to 0.8-mile minimum setback from obstacles, such as wind turbines.



Calculation:

-Assuming no obstacles, at the end of field, approximately four seconds to climb (135MPH= 198fps*4 sec) = 792ft

-A radius turn is equal to the velocity squared (V^2) divided by 11.26 times the tangent of the bank angle as described in the *Pilot Handbook of Aeronautical Knowledge* (2016):

$$R = \frac{V^2}{11.26 \times \text{tangent of bank angle}}$$

V= 135mph — Air Tractor 502 working speed *Air Tractor AT-502 FAA Approved Flight Manual*. (1987).

Tangent bank angle = 30°

$$\frac{18,225}{11.26 \times 0.57735} = 2,803\text{ft radius}$$

Based on the standard Air Tractor 502 (smaller size compared to Air Tractor 802), a setback of 0.8 miles is required with minimal margin of error. This would not take into consideration a faster working speed, non-standard atmospheric days, tailwinds, or pilot error outside of a marginal 15% addition to the calculation. Additionally, this calculation does not add any safety distance margin for the turbulence (which can be considerable) coming off the blades of the turbines.

Based on the provided calculation, I recommend a setback for a wind turbine no less than 0.8 miles from the end of field.

Respectfully,

Cody Christensen, Ed.D.
Airline Transport Pilot
FAA Gold seal flight instructor

Works Cited

Pilots Handbook of Aeronautical Knowledge. (2016). (FAA-H-8083-25B) https://www.faa.gov/regulations_policies/handbooks_manuals/aviation/

Air Tractor AT-502 FAA Approved Flight Manual. (1987). Air Tractor, INC. Olney, Texas.

BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA

IN THE MATTER OF THE APPLICATION BY NORTH BEND WIND PROJECT, LLC FOR A PERMIT TO CONSTRUCT AND OPERATE THE NORTH BEND WIND PROJECT IN HYDE COUNTY AND HUGHES COUNTY, SOUTH DAKOTA	* * * * * * * *	**MR. MICHAEL BOLLWEG'S RESPONSES TO STAFF'S THIRD SET OF DATA REQUESTS** **EL21-018**

Below, please find Mr. Michael Bollweg's Responses to Staff's Third Set of Data Requests to Mr. Bollweg, individually, and on behalf of Bollweg Family, LLLP.

3-1) For each parcel of farmland owned by Mr. Bollweg or Ms. Bollweg near the proposed North Bend Wind Project, please provide the crop rotation history over the last five years.

Response: See attached.

3-2) Has Mr. Bollweg contacted any other local aerial applicators besides Mr. Barber to see if they would aerial spray his property with the proposed placement of wind turbines? Please provide the individuals contacted and Mr. Bollweg's understanding of their response.

Response: Michael Bollweg is very satisfied with his current ag sprayer/applicator. To date the fields in question are not a threat.

Being in the business for thirty some years he knows the following applicators and has asked them their opinions of the potential towers. He has worked with several of them. He has shown them maps of the proposed sites. Their responses are as follows.

Heath Kretschmar, Dakota Pro Air, LLC, 24028 405th Avenue, Letcher, South Dakota; (605) 248-2314. He is an ag pilot. Mr. Kretschmar hates turbines but has to work around them. He typically will fly under them to spray. The turbulence coming off the blades varies and as the wind increases the turbulence increases. He said that there are lots of other variables but you really don't know how bad it is until you go fly by them. Ground contours, and the presence of other turbines, also contribute to the mix. He says that many of the newer turbines have the blades swinging closer to the ground, leaving less room to fly under them. He says that there is still more room under a blade than under a power line.

He said he has three concerns: 1) Safety due to the turbulence. 2) Risk due to the presence of related hardware, like mets towers, that are not marked and difficult to see. The pilots do not have time to drive to the sights and see what is there and flying at the speeds they do makes any of the other hazards risky. 3) Liability if you hit one of the towers, etc.

Less than 5% of the fields he sprays have towers.

If a field has towers, he waits until the weather is perfect to spray that field which can mean that there is a delay and that he has to travel out of his ordinary pattern to go back and pick up a field. This happens often.

Jake Kraft, Air Kraft Spraying, Inc., 13684 250th Avenue, Timber Lake, South Dakota; (605) 865-3500. Mr. Kraft says turbines are a bad deal. Turbines make some fields impossible to spray, especially if the fields are hemmed in by turbines. Eliminates any margin for error. They will kill some pilots. The companies say they will turn off the turbines to permit spraying but when you request that they be turned off they refuse; too much power demand. The turbines in the field being sprayed, if off, are less of a problem than if they are in the adjacent turn around area. Mr. Kraft sprays around turbines but hates to.

Rob Scherer, Sherer Spray Service, LLC, 25522 US Hwy 14-34, Hayes, South Dakota; (605) 222-0559. Mr. Scherer will not spray fields with turbines in them or around them. He never has, he never will. He says that his son is starting and he will discourage him from doing so as long as he has any influence on him. He looked at the map of the proposed towers and some of the layout would make it impossible to spray those fields. He indicated that there is not enough money in the job to make it worth the risk. He is sure some guys will take the risk but he says as far as he is concerned it is an unacceptable risk.

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Dated this 23nd day of November 2021.

s/ JAMES E. MALTERS
For: MALTERS, SHEPHERD & VON HOLTUM
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Bollweg Property Crop History
Properties listed include only those directly affected by the current proposed North Bend Wind Project

Field-Legal	2017	2018	2019	2020	2021	2022 Proposed
SW ¼ Section 11: 111-74	SOY	HRS	HRW	SOY	HRS	SUN
NE ¼ Section 10: 111-74	HRS	HRW	SOY	HRS	HRW	SUN
S ½, SE ¼ Section 16: 111-74 & NE ¼ Section 21: 111-74	CORN	HRS	HRW	SOY	SUN	MILO
SW ¼ Section 9: 111-74	HRW	SOY/MILO	MILO	CORN	SOY	HRS
W ½ Section 4 & NW ¼ Section 9: 111-74	SOY	HRS	HRW	SOY	HRS	HRW
NW ¼, NW ¼ Section 4: 111-74	SOY	MILO	CORN	SOY	CORN	SOY
E ½ Section 4: 111-74	HRS	HRW	SOY/CORN	HRS/MILO	SOY/CORN	HRS/MILO
SW ¼ Section 33: 112-74	HRS	HRW	SUN	HRS	HRW	SUN
SE ¼ Section 33: 112-74 & S ½ Section 34: 112-74 & Section 3: 111- 74	- Annual mix of multiple fields of corn, sorghum, wheat, soybeans, grasses, legumes					
S ½ Section 23: 112-74 & SW ¼ Section 24: 112-74	HRW	SOY	HRS	HRW/SOY	SOY	HRS/SUN
N ½ & N ½, SE ¼ Section 27: 111-74	MILO	MILO	MILO	CORN	MILO	CORN

HRS = Hard red spring wheat
HRW = Hard red winter wheat
SUN = Sunflowers
SOY = Soybeans
MILO = Grain Sorghum
CORN = Corn

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Dated this 23nd day of November 2021.

s/ JAMES E. MALTERS
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**BEFORE THE PUBLIC UTILITIES COMMISSION
OF THE STATE OF SOUTH DAKOTA**

IN THE MATTER OF THE APPLICATION BY NORTH BEND WIND PROJECT, LLC FOR A PERMIT TO CONSTRUCT AND OPERATE THE NORTH BEND WIND PROJECT IN HYDE COUNTY AND HUGHES COUNTY, SOUTH DAKOTA	* * * * * * * *	**MR. MICHAEL BOLLWEG'S RESPONSES TO STAFF'S FOURTH SET OF DATA REQUESTS TO MR. MICHAEL BOLLWEG** **EL21-018**

Below, please find Mr. Michael Bollweg's Responses to Staff's Fourth Set of Data Requests to Mr. Bollweg, individually, and on behalf of Bollweg Family, LLLP.

4-1) For 2018 through 2021, please provide the annual harvest from the Tumbleweed Lodge hunting operation for:

a) Wild pheasants;
b) Released pheasants;
c) Sharp-tail grouse;
d) Prairie chicken; and
e) Hungarian partridge.

Response: The annual harvest numbers are confidential and are being provided under separate cover.

4-2) In Docket EL19-027, the Commission ordered the following permit condition for the Crowned Ridge Wind II Project to facilitate aerial spraying in the vicinity of wind turbines:

> Project owner must cooperate with agricultural spray applicators in shutting down turbines as needed to facilitate safe and effective spray operation and application.

In Dr. Christensen's report filed in response to staff's first set of discovery, he stated:

> The other option would be instead of pulling up to climb over an obstacle to fly around it, below it, or through the blade arc or guy-wire, all of which are not prudent options, especially considering any abnormal operations. Additionally, the turbulence created by the wind turbines would have a direct and immediate impact on the pilot operating downwind of the turbine.

(a) Does Dr. Christenson maintain that a pilot cannot safely fly around a turbine that is shut down and not moving as ordered for the Crowned Ridge Wind II Project?

(b) Please explain how flying around a wind turbine that is shut down is different than flying around other stationary obstacles, such as a power line, grain bin, house, trees, or cell tower.

Response: The Crown Ridge II project failed to property vet the safety concerns that Dr. Christensen, the SDAA, and the NAAA have pointed out.

Michael Bollweg is skeptical that Applicant would turn the turbines off when requested. Weather conditions change at the drop of a hat. Insect infestations happen overnight. Soil conditions change with a thunderstorm. Would the Applicant turn off a 2.7 MW generator at a moments' notice so farm work can be done same day? It is likely not practical, and there is no accountability if they do not.

See attached letter from Dr. Christensen.

4-3) Refer to the response to staff data request 2-4. Mr. Christensen recommend a setback for a wind turbine no less than 0.8 miles from the end of the field. Is Mr. Christensen aware of any governmental entity that has ordered a similar setback for wind turbines from a property line to facilitate aerial spraying? If so, please provide supporting documentation.

Response: See attached letter from Dr. Christensen.

Dated this 6th day of January, 2022.

JAMES E. MALTERS
For: MALTERS, SHEPHERD & VON HOLTUM
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January 4, 2022

James Malters
727 Oxford St.
Worthington, MN 56187

Mr. Malters,

In regards to the STAFF'S FOURTH SET OF DATA REQUESTS TO MR. MICHAEL BOLLWEG EL21-018:

(a) Does Dr. Christenson maintain that a pilot cannot safely fly around a turbine that is shut down and not moving as ordered for the Crowned Ridge Wind II Project?

No.

If the wind towers were not in operation, it would substantial decrease the turbulence created by the wind turbines. As long as the distance from the field to the obstacle can be maintained, pilots could safety operate around a wind turbine.

(b) Please explain how flying around a wind turbine that is shut down is different than flying around other stationary obstacles, such as a power line, grain bin, house, trees, or cell tower.

As a professional pilot and flight instructor, I do not see a major difference between obstacles when height and circumference are adequately considered. I would not try to outmaneuver an obstacle without proper setback clearances for any stationary obstacles such as a wind turbine, powerline, grain bin, house, trees, or cell tower. The height and size of the obstacle must be taken into consideration when operating an aircraft in the vicinity of known obstacles.

I would recommend if a 100 ft grain bin was located within the area of operation, it would be considered much like a 100-foot shut down wind turbine would be except that a wind turbine can rotate so the orientation of the blades in relation to the aircraft turn would have to be taken into consideration. An operator could fly closer to a 100 ft grain bin because the climb required to clear a 100ft bin is less than a taller obstacle.

A 600-foot-tall grain bin with the same circumference as a 600-foot- tall wind turbine would be treated with equal caution. I have yet to encounter a 600-foot-tall grain bin so the best description would be trying to operate in downtown Manhattan with 60 story buildings on multiple sides. It would be possible to operate around them, but the distance between the building (wind turbine/grain bin/obstacle) would need to be sufficiently away to allow for a proper turn. The margin of error decreases and safety margins virtually disappear.

If the PUC request was to evaluate a new tower that was 600ft tall with known guy wires, I would treat it the same as a 600-foot wind turbine using the height and circumference of the obstacle. The tower along with the guywires constitute an obstacle that is not able to be flow through. Yes, it is possible to fly under, over, or through guy wires but the margin of safety decreases with each pass. Flying under or through stopped wind turbine blades is much like guy wires.

As a professional pilot I would not fly under shut down wind turbine blades, nor would I teach that maneuver to any student.

4-3) Refer to the response to staff data request 2-4. Mr. Christensen recommend a setback for a wind turbine no less than 0.8 miles from the end of the field. Is Mr. Christensen aware of any governmental entity that has ordered a similar setback for wind turbines from a property line to facilitate aerial spraying? If so, please provide supporting documentation.

I am not aware of any governmental entity that has ordered a similar setback for wind turbines from property line to facilitate aerial spraying. My job was to evaluate the threats to safety to agricultural spray aircraft posed by the turbines. That analysis had to do with the hard science of physics as it applied to aircraft and pilot performance. No political considerations were evaluated. Governmental agencies sometimes take other factors into consideration.

Respectfully,

Cody Christensen, Ed.D.
Airline Transport Pilot
FAA Gold seal flight instructor