ECOLOGICAL AND SOCIOLOGICAL CONSIDERATIONS OF WIND ENERGY:

A MULTIDISCIPLINARY STUDY

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Title

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

Wind energy is quickly becoming a critical technology for providing Americans with renewable energy, and rapid construction of wind facilities may have impacts on both wildlife and human communities. Understanding both the social and ecological issues related to wind energy development could provide a framework for effectively meeting human energy needs while conserving species biodiversity.

In this research I looked at two aspects of wind energy development: public attitudes toward wind energy development and wind facility impacts on local bat populations. These papers present aspects of wind energy development that have been the subject of increasing study. This preliminary research is intended to demonstrate the responsibility we have to making well-informed decisions as we continue to expand wind energy development. Additionally, I hope to generate interest in interdisciplinary study as a means to broaden the scope of research by making use of the diverse tools available within different disciplines.

ACKNOWLEDGMENTS

I am extremely appreciative for all the support given to me in order to complete this project. I want to first thank my advisors Dr. Chris Biga and Dr. Erin Gillam for their guidance, encouragement and assistance in the development and writing of my research, as well as their patience and friendship. I also want to thank my committee members Dr. Wendy Reed, for sharing her extensive knowledge and support and being a great source of motivation throughout my undergraduate and graduate years at NDSU; and Dr. Linda Helstern for her unique perspective and for putting a halt to my excessive use of semi-colons.

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I am also grateful to the many supportive faculty and staff within the Department of Biological Sciences and the Environmental and Conservation Sciences Program, particularly Phyllis Murray for all of her assistance in just about everything.

DEDICATION

This work is dedicated to my partner, Jennifer. This would have been impossible without her endless support and encouragement, her belief in me and her constant strength over the past several years. Thank you for never giving up on me and for never allowing me to give up on myself. I am forever grateful to my mother and my sister for their support, encouragement, and unconditional love. I also dedicate this to my three beautiful, smart and strong children. Haley, Dakota and Timmy, I hope that one day you know that all I do, I do for you.

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GENERAL INTRODUCTION

This research is a multidisciplinary Master's Thesis conducted in the Environmental and Conservation Sciences (ECS) program. As ECS is an interdisciplinary program, it is a logical step to conduct a project that crosses over disciplines and utilizes the varied tools each discipline has available to reveal an in-depth picture of an environmental issue currently facing society. This research was conducted over two years and is part of a larger project to illustrate the interaction between the social and biological sciences. The intent is to demonstrate the value of this type of study and to create a baseline for future research.

A significant increase in wind energy development is occurring across the country and with this rapid growth come diverse issues that need to be taken into consideration. As wind energy involves many stakeholders and is a complex and multifaceted undertaking, it is important to understand the varied perspectives involved in its development.

While there are many scientific disciplines involved in wind energy development, this research was conducted to address concerns within the biological and social sciences. Specifically, I looked at wind facility impacts on bat populations and perceptions of wind facility impacts on local communities and environments. The common denominator in both of these areas of wind energy development is to understand the human role in ensuring responsible growth and implementation of this technology.

Little research has been conducted on public attitudes toward onshore wind energy, and few studies have been conducted to understand specific reasons for held attitudes or measure attitude strength. To this end, my first study consists of a public opinion survey to examine attitudes of community members living near an existing wind farm. The aim of this study was threefold: to determine public attitudes toward wind energy in general and toward a specific wind farm; measure the strength of those attitudes; and to assess the perceptions that may influence support for wind energy.

My second study was an assessment of the distribution, composition and level of activity of bat populations in the area of a proposed wind farm in North Dakota. Additionally, I examined fatality rates of bats at an existing wind farm in the same county. It has been shown that bats are being killed at turbines across the country and researchers are concerned that certain species may not be able to withstand significant impacts on their populations.

There are three overall goals for this research: 1) to demonstrate that the public have formed opinions regarding wind energy development, and that understanding these attitudes may create an open channel for discourse so that wind energy can continue to grow; 2) to bring to light the potential problem facing North Dakota bats and establish the importance of ecological responsibility in terms of planning and mitigating potential impacts to these populations; and finally; 3) to create the groundwork for future studies to examine the potential of collaboration across disciplines to more effectively address the complex topics that face society today.

As scientists, we have a responsibility to gather accurate empirical data to answer questions in order to increase our understanding of important aspects of humanity. We have a responsibility to find the answers to the many questions that arise with rapidly advancing technology. It is advantageous that we use whatever resources we have at hand to find those answers and communicate them in such a way that they are not only accessible by all stakeholders, but also to ensure that in our quest for answers we do not overlook crucial information that may be obtained by thinking creatively.

EXPLANATION OF THESIS ORGANIZATION

This thesis is organized into four chapters. The first, entitled General Introduction, introduced the thesis and summarized the manner in which this research was conducted. This thesis work is comprised of research in both the biological and social sciences.

Chapter Two is written in manuscript form. This paper addresses my first study, which was a public opinion survey conducted to determine public attitudes toward wind energy development in North Dakota. I first present an introduction to, and literature review of, the role of public attitudes in wind energy development, as well as demonstrating the need for this research. This is followed by a section outlining the methods taken to assess these attitudes as well as to determine the strength of attitudes and their correlation with support for a local, operational wind farm. I then present the findings of this research, followed by an in depth discussion of the results and recommendations for future studies. Finally, I summarize the study and identify the value that can be found in pursuing a greater understanding of this issue.

Chapter Three is also written in manuscript form. This second paper outlines my research to assess the potential impacts that wind farms may have on bat populations in North Dakota. The first section is comprised of an introduction to this issue in the form of a review of existing literature as well as outlining the importance of this research. I follow this with an explanation of the methods and materials that were used to determine the composition and distribution of bat species in the study area, as well as to assess the impacts an operating wind farm may have on those species. In the next section, I present my findings. This is followed with an explanation of the results and suggestions for future studies. In concluding, the study is summarized and the necessity for future research in this area is presented.

The fourth and final chapter, General Conclusions, is a summary of my thoughts on the value of taking an interdisciplinary approach to research, as well as recommendations for future projects of this nature.

PAPER 1. PUBLIC ATTITUDES TOWARD NORTH DAKOTA WIND ENERGY DEVELOPMENT

INTRODUCTION

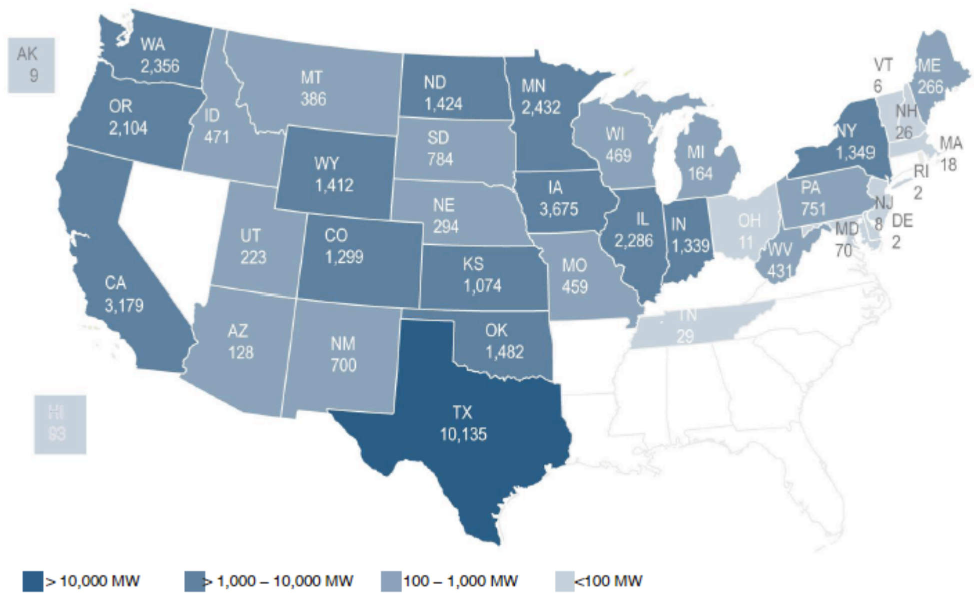
Wind energy in the United States

Wind energy has rapidly become a critical technology for providing renewable energy and reducing greenhouse gas emissions (Pasqualetti et al. 2004, Szarka 2006). Twenty-nine states have renewable portfolio standards, which mandate that a certain percentage of the state's energy be produced by renewable sources by a certain year. North Dakota has a voluntary, non-binding agreement to produce 10% of energy from renewable sources by 2015 and state law supports the national initiative of producing 25% of its energy from renewable sources by 2025 (EmpowerND Comprehensive State Energy Policy 2010). In May of 2008, the U.S. Department of Energy published a report entitled *20% Wind Energy by 2030*, which states that the United States has enough resources to effectively and economically produce 20 percent of our energy from wind by 2030. This demonstrates the significant role wind energy could have in national energy production in the near future (20% Wind Energy by 2030 2008).

As of December 31, 2010, the global installed wind energy capacity was 197,039 MW. From 1999 to 2010, the installed wind energy capacity in the United States has increased from 2,472 MW to 40,180 MW (Figure 1.1), which ranks second in the world behind China (Global Wind Energy Council Annual Report 2010).

As wind energy facilities increase in number across the country, the number of communities impacted by these facilities increases as well. It is important that the perceptions and concerns of the communities impacted by these wind energy facilities are understood and taken into consideration when these facilities are built and maintained. The following research was conducted to measure public attitudes of the communities surrounding the Ashtabula Wind Farm, the largest wind energy facility in the state of North Dakota.

Figure 1.1 U.S. wind power capacity installations by state as of the end of the first quarter of 2011 (American Wind Energy Association April 2011).



Large-scale wind facilities consist of turbines that range from 212 feet to 410 feet in height. A common turbine used in the United States is the GE 1.5MW model, which has a 212-foot tower. These turbines have three 116-foot blades that have a rotor swept area that covers nearly an acre. The Denmark-produced 1.8 MW capacity Vestas V90 is another commonly used turbine. Its 262-foot tower supports three 148-foot blades (Wind-Watch, n.d). A wind facility may consist of tens to hundreds of turbines. The Roscoe Wind Farm in Texas is comprised of 627 turbines with a generating capacity of 782 MW and was the largest onshore wind facility in the world at the end of 2010 (American Wind Energy Association May 2011).

The development of a wind energy facility involves many different stakeholders, each with their own concerns. Locations with plentiful wind resources must be established and turbines must be sited in such a way that does not disrupt downwind resources. Land must be acquired in order to place turbines, transmission lines and generating stations, which involves landowner cooperation and, in the case of transmission lines, interstate cooperation among government agencies. A significant obstacle in turbine siting decisions is communication among these stakeholders (Wolsink 2007a,b). To effectively implement the use of wind energy, all parties involved must be able to communicate effectively and to cooperate when points of view differ. To enhance communication, the opinions of all stakeholders should be considered, to include public opinion.

Social acceptance can be an integral part of the success of wind energy projects (Wüstenhagen et al. 2007) and research has shown that the public is generally supportive of wind energy (Gipe 1995 cited by Krohn & Damborg 1999, Simon 1996, Wolsink 2000, Ek 2005, Ansolabehere and Konisky 2009). Despite these findings, public opposition to wind development has been noted. While wind energy has been considered by some to be inefficient or inadequate, public opposition appears to lie with wind farms, rather than the idea of wind energy itself (Warren et al. 2005, Wolsink 2007b). The arguments of wind energy opponents tend to be based on economic, social and environmental costs (Simon 1996, Szarka 2006), though personal concerns, such as negative visual impacts, are often found to be a significant issue (Haggett 2008, Toke et al. 2008, Phadke 2010, Sibille et al. 2009).

Aitken et al. (2008) suggested that most groups opposed to wind development are able to delay, but not halt, development. Opponents are more likely to be successful in blocking construction if they able to work within the political arena effectively, particularly when local power does not view the development as favorable, and small opposition groups tend to be more successful when the argument is context-dependent (Bell et al. 2005, Toke 2005). Such might be the case in the instance of a local group, which halted the construction of a wind farm in North

Carolina based on objections to the farm's proposed ridge top location (Grady 2002).

Although a number of reasons, such as geographical location or legal issues, may account for the disparity between submitted planning applications and the acceptance of those applications, successful opposition of proposed projects is likely due to the combined efforts of the local community and planners, rather than to public resistance alone (Toke 2008). However, Toke (2005, 2008) suggests that while negative public attitudes may not be a major obstacle in the development of wind energy projects, how those attitudes are viewed at the decision-making level and what efforts are taken to influence the public can be significant factors in project implementation.

The importance of understanding and acknowledgement of public attitudes as a factor in wind energy production is clear, particularly with the rapid increase in development. While there is some literature on attitudes toward offshore wind projects in the United States, little research has been conducted to examine attitudes toward onshore development. General attitudes toward energy and energy sources (Bureau of Governmental Affairs 2006, Ansolabehere 2007) have been measured in North Dakota, however as communities across the state experience tremendous changes to their landscapes, economies and traditional ways of life, specific attitudes held by these communities toward wind energy development cannot be ignored.

The objective of this paper is to quantitatively assess the variables contributing to the perceptions of North Dakota residents on the social, environmental, economic, aesthetic, and cultural aspects of wind farming in their communities.

Social acceptance of wind energy

<u>NIMBY and the Social Gap</u>. There is a disparity between the high levels of public support for wind energy, as expressed by respondents in opinion surveys, and the low success rate of the

development of wind energy facilities. Bell et al. (2005) have suggested several reasons for this disparity, which they termed 'the social gap.'

First they suggested that public meetings and hearings are more likely to encourage opponents, rather than proponents, of wind energy development to come forward with their concerns (Wolsink 2000). They also proposed that people who support wind energy in general may have qualifications tied to that support, but are often not asked to identify specific reservations in surveys. For example, a respondent may be asked if they support or oppose a particular wind project, but may actually fall somewhere in between those two answers. Or, they may support or oppose the project under specific circumstances only. The third reason, termed the individual gap, is the discrepancy between an individual's support for wind energy and their opposition to a specific wind farm. Opposition to a specific project based on perceptions that potential impacts may negatively affect an individual or their community is referred to as NIMBY (Not In My Backyard) (Devine-Wright 2004, Bell et al. 2005, Kempton et al. 2005, Warren et al. 2005, Wolsink 2007a,b).

Recent research has suggested that NIMBY may not factor as significantly in the determination of public attitudes toward wind energy as previously thought (Devine-Wright 2004, 2009, Kempton et al. 2005, Van der Horst 2007, Wolsink 2000) and that opposition to particular wind farms in close proximity may be the result of other reasons (Wolsink 2000, Warren et al. 2005, Graham et al. 2009). This demonstrates the need for both quantitative and qualitative research. A more holistic representation of public attitudes can be gathered if an individual is asked to rate their opinion on a measurable scale, as well as to qualify that opinion. In this way, concerns about specific impacts can be understood.

<u>Perceptions of impacts on community and environment</u>. Individuals faced with the

construction of a wind farm near their home or community may express concern about possible impacts to their community or surrounding environment. Although construction of a wind farm may create jobs and improve the economy or the environment, there may be negative impacts associated with the facility that incur opposition to its placement. Opponents of the wind farm may feel that loss of agricultural fields, disruption of wildlife habitat or placement of turbines in a migratory pathway, landscape alteration and decreased property values (Thayer 1987, Wolsink 2000, Grady 2002, Warren et al. 2005, Aitken et al. 2008, Graham et al. 2009) are unacceptable risks to objects or ideas in which they place value.

Place attachment is a positive emotional attachment to a particular place, which can be a factor not only in real changes to the environment, but also perceived changes (Vorkinn and Riese 2001). In a survey to measure respondent acceptance of a proposed hydropower plant in Norway, findings suggested that place attachment may be very important in predicting the attitudes of respondents on a local level toward a specific environmental change (Vorkinn and Riese 2001). Respondents who feel significantly attached to their community or surrounding environment may oppose the construction of a wind farm if they perceive that it may negatively impact that place.

Environmental concerns. An additional concern in regard to wind facility development is potential impacts to wildlife (Kuvlesky et al. 2007). Public attitudes have shifted from the perspective that wildlife should be managed for human benefit to a more conservationist approach (Manfredo et al. 2003) and the importance of balancing the needs of humans while conserving nature has risen to the surface as a topic of major concern (Paterson 2006). Multiple studies have found that avian and bat species are at risk of being killed by wind turbines (Kerns and Kerlinger 2004, Derby et al. 2007, Fiedler et al. 2007, Arnett et al. 2008, Baerwald and

Barclay 2009).

At wind energy facilities outside of California, songbirds protected by the Migratory Bird Treaty Act comprised 78% of the avian fatalities, with half of those being nocturnal, migrating passerines (Erickson et al. 2005). In the United States, bat fatalities have been reported to range anywhere from .8 – 8.6 bats/MW/year up to 53.3 bats/MW/year at facilities located on forested ridge tops (Kunz et al. 2007). In the U.S., migratory tree bats comprise approximately 75% of all wind facility related mortalities (Arnett et al. 2008) and unexpected levels of mortality of those species from wind facilities could have long-term effects on those populations (Kunz et al. 2007).

Despite arguments that few species are necessarily beneficial to humans, the loss of many species over time will disrupt ecosystem characteristics and health (Paterson 2006) and must be taken into consideration. All species play a role in maintaining ecosystem biodiversity and some potential impacts resulting from the loss of biodiversity could be disruption in the food chain, decreased pollination of plant species and decreased reproductive success.

Immediate and long-term wind facility environmental impacts must be examined together with conservation issues so that wind energy development can be a viable solution for meeting human energy needs while conserving biodiversity. Accurate scientific information will reduce misconceptions about the potential environmental impacts wind facilities may pose and allow the public to make better-informed opinions.

Fundamental to the success of wind energy projects is an understanding of the attitudes and perceptions held by the public, as well as ensuring public involvement in the planning and development stages of the project (Bell et al. 2005, Klick and Smith 2010, Jones and Eisner 2009). It is likely that public opposition will be greater if community members are not permitted to be an active part of the decision-making process (Krohn & Damborg 1999).

Measurement of public attitudes worldwide

In order to measure public attitudes toward wind energy development, research has typically been conducted through the use of interviews and questionnaires. Studies measuring public attitudes toward both onshore and offshore wind energy have primarily been conducted in countries such as the United Kingdom (Simon 1996, Warren et al. 2005, Eltham et al. 2008, Devine-Wright et al. 2007, Jones and Eisner 2009), Denmark (Krohn and Damborg 1999), Greece (Dimitripoulos et al. 2009, Koundouri et al. 2009), Sweden (Ek 2005), Australia (Gross 2007), New Zealand (Graham et al. 2009) and Japan (Maruyama 2007).

Findings from these studies, as well as others, suggest a high level of support for wind energy development. In 2005, Warren et al. conducted personal interviews of local residents in two areas; one near an existing wind farm and one near an approved, proposed wind farm. Respondents near the existing site expressed support or strong support for wind energy in Scotland (90%) and 88% supported the local wind farm. Seventy-seven percent of respondents near the existing site were supportive of wind energy in general in Scotland and 63% supported the proposed wind farm. Ek (2005) reported findings that 64% of Swedish residents surveyed had a positive attitude toward wind energy, 23% had no opinion and 10% had a negative opinion of wind power. In 2008, Eltham et al. found that 84% of residents surveyed supported wind energy usage in the United Kingdom with 16% being either undecided or opposed. In Greece, 84% of respondents supported wind energy production across the country (Koundouri et al. 2009).

Opponents of wind energy projects have listed visual and noise impacts, landscape alteration and environmental impacts as primary concerns (Thayer 1987, Wolsink 2000, Grady

2002, Warren et al. 2005, Aitken et al. 2008, Haggett 2008, Toke et al. 2008, Graham et al. 2009, Phadke 2009, Sibille et al. 2009). Research has also shown that acceptance of wind energy projects tends to increase after construction is completed (Wolsink 1989, Walker, 1995; Krohn & Damborg, 1999). A study conducted in the Netherlands found a slight “U-shaped” pattern where acceptance was initially high, dropped during planning and construction, then returned to nearly the initial level of acceptance after the facilities open (Gipe 1995).

Although studies across the world have found a great deal of support for the construction of wind energy facilities, few studies have been conducted in the United States. As the world’s second leading producer of energy from wind, the research that has been conducted is relatively sparse.

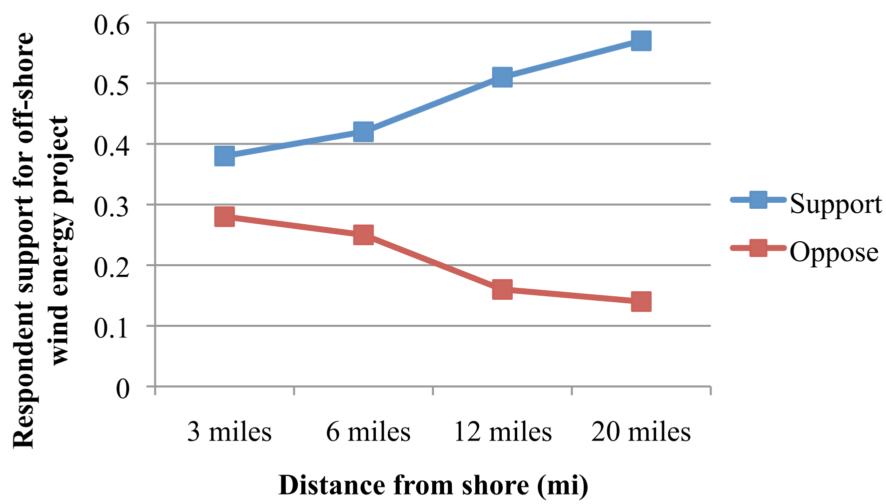
Measurement of public attitudes in the United States

Offshore development. Some research has been conducted to examine public attitudes toward offshore (wind facilities constructed in water) wind energy development in the United States. A study comprised of personal interviews with 4,026 New Jersey residents and tourists reported fairly equal responses of support for offshore wind development (46% and 48% respectively), while 23% of residents and 19% of tourists were opposed. There was a positive relationship between the distances that the turbines were located offshore and respondent’s support for the project (Mills and Rosen 2006).

A study conducted of Delaware residents (Rickinson 2007) found that 87% of respondents were in favor of wind power based on their existing knowledge of wind energy. After being read a brief description of wind power, which stated that there would be an increased cost to the consumer and a long-term commitment to the project, the number of respondents in support dropped to 79%, which was statistically significant, but still represented a majority of respondents.

A study to measure the opinions of shore community residents and tourists in four New Jersey counties found that 47% supported the on the use of offshore turbines for energy production and 21% were opposed (Mills and Rosen 2006). Respondent support for the project increased the further away from shore the turbines were to be placed (Figure 1.2).

Figure 1.2 Respondent support for New Jersey offshore wind energy project related to turbine distance from shore (Modified from Mills and Rosen 2006).



A private company proposed the Cape Wind Project, comprised of 130 wind turbines in 24 square miles of Nantucket Sound, in 2001. The Opinion Dynamics Corporation (2008) measured various aspects of public attitudes toward the project in 2006, 2007 and 2008. In 2006, 81% supported the project (47% strongly supported), which increased in 2007 to 84% (53% strongly supported). In 2008, 86% of respondents reported that they supported the project (57% strongly supported). The Cape Wind Project funded this survey.

However, a study conducted by the University of Delaware to examine resident's opinions of the Cape Wind Project, found that 24.6% of the respondents supported the project, 42.4% opposed the project and 32.3% were undecided. When those respondents who were undecided were asked which way they were leaning, it was calculated that 43.8% supported the project and 55.5% opposed the project (Firestone and Kempton 2007).

In personal interviews conducted of 24 Massachusetts residents, reasons given for support of the Cape Wind project included clean renewable energy (43%), economic or cost reasons (10.4%), environmental reasons (7.6%) and dependence on foreign oil or the use of fossil fuels (7.1%). A major source of opposition was based on concern over negative impacts to the landscape and a feeling of attachment to the ocean (Kempton et al. 2005), which is consistent with suggestions from other authors (Vorkinn and Riese 2001, Firestone, Kempton, and Krueger 2009, Wolsink 2007, Devine-Wright 2009).

Onshore development. In 2002, an attempt by the Tennessee Valley Authority to develop a wind farm not far from the North Carolina border was shut down due to strong local opposition. As a result, a public opinion survey was conducted in 24 North Carolina counties to measure resident's attitudes toward turbine placement on ridge tops.

Findings suggested that only 19.3% of respondent's felt that turbines should be prohibited from being sited on ridge tops, whereas 63.5% did not feel that it should be prohibited. Additional results indicated that 36% felt turbines should be prohibited from being placed in National Forests. The primary causes for concern in turbine placement were visual pollution (44%), unreliability in energy production (12%), noise (94%) and environmental damage during construction (3.5%) (Grady 2002).

This study demonstrated the capability of local community to impact the development of wind energy projects. Further, it provided empirical evidence which indicated overall public support for wind energy development, despite a vocal group of organized opponents. This reflects the necessity of an accurate understanding of public attitudes to facilitate successful resolution of the complicated issues involved in wind energy development (Manfredo, Decker, & Duda 1998). Also demonstrated was the value of attaining quantifiable data, rather than making judgments based solely on qualitative information.

Need for Study

Though public attitudes toward wind energy have been widely studied in literature, much of the data has been qualitative in nature and specific reasons for attitudes held toward wind energy development have not been studied in depth. My research was conducted in order to measure public support for the Ashtabula Wind Energy Center in Barnes, Griggs and Steele Counties of North Dakota, as well as to determine variables responsible for shaping public attitudes toward wind energy.

North Dakota has tremendous wind resources and is ranked 9th in the US in existing capacity and 6th in potential capacity for wind energy. The state currently has a capacity of 1,424 MW in existing wind facility projects and has 11,493 MW in queue (American Wind Energy Association May 2011).

Through the use of accepted and validated attitude measurement scales, I evaluated 1) general attitudes toward wind energy; 2) public perceptions of the advantages and disadvantages of wind energy; 3) perceived personal impacts; 4) perceived impacts to the community and environment; 5) acceptance of the construction of wind farms at varying distances from personal property; 6) the value placed on wind farms as renewable energy sources as compared to other sources of energy; and 7) public concerns for possible wind farm related impacts on wildlife.

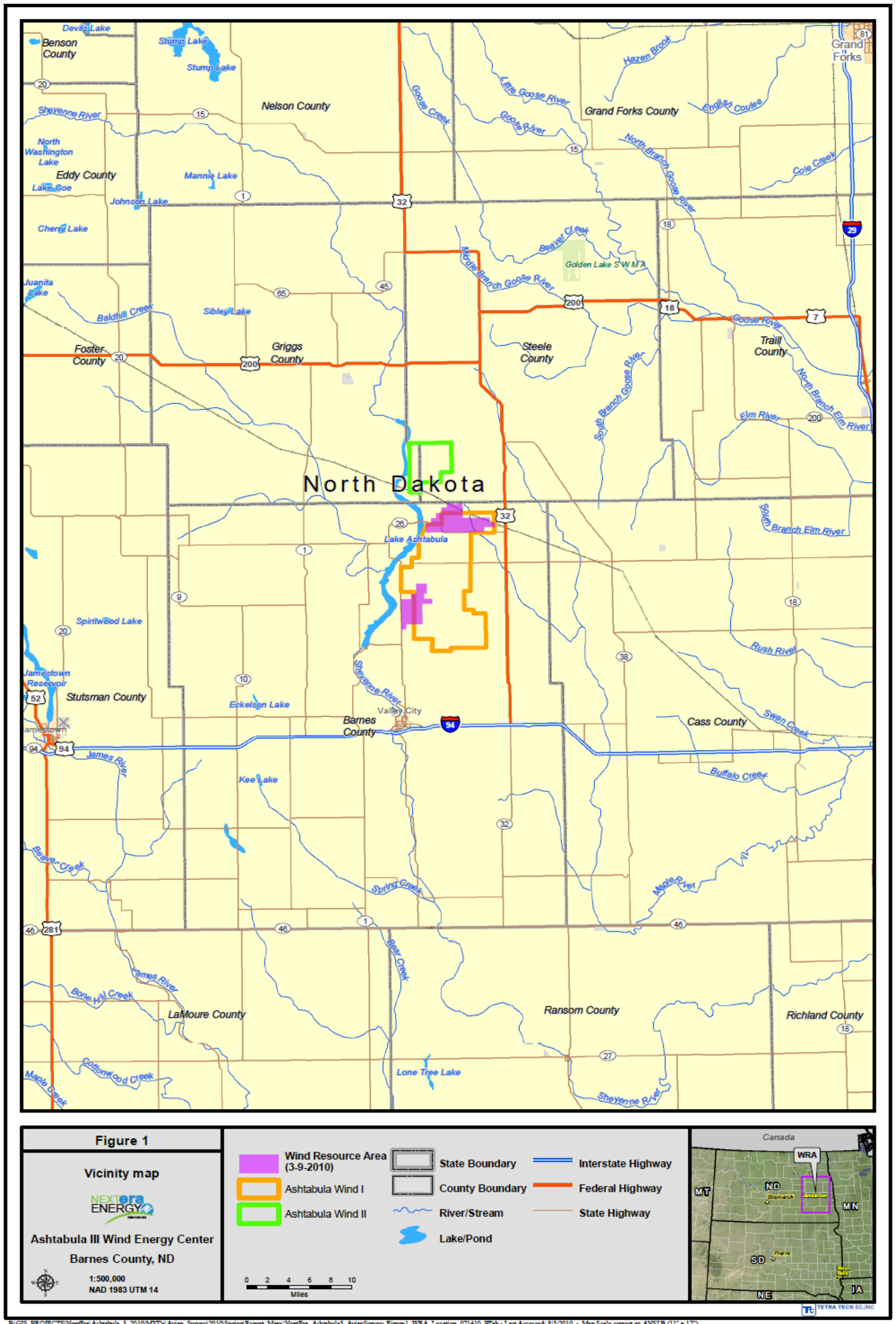
METHODS

Study Area

This survey was conducted to examine public opinions toward wind energy in North Dakota. Respondents were selected from three counties; Barnes, Griggs and Steele Counties. These counties are home to the largest existing wind farm in North Dakota, the Ashtabula Wind Energy Center (hereto after referred to as Ashtabula). The Ashtabula Wind I, II and III Energy Centers are comprised of 218 turbines producing at capacity 330.9MW of electricity. Ashtabula I became operational in 2008 in Barnes County with 99 1.5MW turbines. Located in Griggs and Steele Counties, Ashtabula II has 80 1.5 MW turbines and became operational in 2009. Ashtabula III, also located in Barnes County has 39 1.6MW turbines that went online in 2010. The turbines are 80 meters tall with 37 meter-long blades having a rotor diameter of 82 meters. Energy is transmitted through a 62 mile, 230kv line owned by Minnkota Power Cooperative from the Pillsbury 230kv Substation to the Maple River 230kv Substation (NextEra n.d.). The Ashtabula Wind Energy Center covers over 75 square miles of North Dakota (Figure 1.3).

The three counties comprising the Ashtabula study area have a combined total population of 16,787 divided evenly between male and female residents, with a mean age of 42.6. The racial composition of the study area is 99% Caucasian, 0.23% Black or African American, 0.86% American Indian and Alaska Native, 0.13% Asian and 0.37% Hispanic. High school graduates comprise 81.6% of the population and 19.4% hold a Bachelor's degree or higher. The total employment rate is 65%, with 57% of the labor force employed in: agriculture, forestry and fisheries (22%); retail trade (16%); educational services (11%); and health services (8%). Households in the study area have a mean income of $44,416 (U.S. Census Bureau n.d.).

Figure 1.3 Ashtabula Wind Energy Center (Tetra Tech EC, Inc, Boston, MA. August 2010. Avian and Bat Protection Plan for the Ashtabula III Wind Energy Center, Barnes County, ND. Prepared for NextEra Energy).



Sampling

A sampling frame of 2,800 phone numbers and corresponding addresses from Barnes, Griggs and Steele Counties were purchased from Infogroup/InfoUSA. 2009 US Census population data for the sample area was used to calculate sample size. The sample consisted of 150 adults (18+), which were selected using proportional random sampling: 108 respondents from Barnes County, 26 from Griggs County, and 16 from Steele County (Table 1.1).

Table 1.1 Proportional selection method for sample selection**.**

County	Population (18+) in 2009	Proportion to Sample Area	Sample Size
Barnes	8,688	0.72	108
Griggs	1,942	0.16	26
Steele	1,412	0.12	16
Total	12,042	1.00	150

Call hours were from 9 am to 5pm and 6pm to 8pm weekdays (Monday through Friday). Six attempts were made to reach each respondent and no phone messages were left. Phone numbers were moved to the end of the call list after each unsuccessful attempt at contact. If after six attempts no contact was made, the number was removed from the active call list and replaced by a new randomly chosen number. Call logs were used to record the phone number, time and date of call, number of contact attempts and disposition of the call (Appendix A).

Selected phone numbers were called and I requested to speak with the member of the household who was over 18 and had the most recent birthday. That person was then invited to participate in the survey. Informed consent was obtained and no compensation was provided (Appendix B).

Phone surveys were conducted between June 20, 2010 and March 31, 2011. Data was collected under North Dakota State University Internal Review Board (IRB) human subjects protocol number HS10298. There was no risk associated with this survey as all information was confidential and participants were not identified by name, address, occupation or economic standing.

Hypotheses

I posed and tested the following hypotheses:

H_1) Support for wind energy in general will predict support for Ashtabula

H_2) Respondents who perceive wind energy as positively impacting the environment will express greater support for Ashtabula.

H_3) Respondents who feel negatively impacted by wind energy personally, will express less support for Ashtabula.

H_4) Respondents who perceive their community or environment as being negatively impacted by wind energy will express less support for Ashtabula.

H_5) As wind farm construction is proposed closer to a respondent's home, their support will decrease, as will their support for Ashtabula.

H_6) Support for other sources of energy will be negatively correlated with support for Ashtabula.

H_7) Concern for impacts to wildlife will be negatively correlated with support for Ashtabula.

H_8) There will not be a significant relationship between socio-demographics and support for Ashtabula.

Measurement

To test my hypotheses, I constructed a survey that included various existing and validated attitude measurement scales to measure general attitudes toward wind energy, advantages and disadvantages of wind energy, perceptions of wind energy impacts, acceptance of wind farm construction, support for other sources of energy and concern for impacts to wildlife (Appendix C). The survey consisted of 43 closed-ended questions, most of which were rated using a five-point Likert-type scale. Respondent's socio-demographic information was also gathered (Appendix C: Q28 – Q36). To ensure clarity of the survey questions and consistent understanding by respondents, the survey was test sampled for content validation. This was accomplished by administering the survey to several individuals and, where necessary, adapting survey questions based upon comments made by those individuals.

Dependent Measure. To measure support/opposition for the Ashtabula Wind Energy Center, respondents were first read the following information about the wind farm: "The Ashtabula Wind Energy Center began electricity production in 2008 with 131 wind turbines in Barnes County. The wind farm now consists of 218 turbines in Barnes, Griggs and Steele counties, with plans to expand to over 250 turbines. These turbines are 260 feet tall" (Firestone et al. 2009). Respondents were then asked to rate their level of support for Ashtabula using the following 5-point scale: strongly support (5); support (4); feel neutral (3); oppose (2); or strongly oppose (1) (Appendix C: Q4).

Independent Measures. Survey questions were designed to measure respondent's attitudes in different areas of wind energy that may or may not influence their support of or opposition to Ashtabula. Survey questions were grouped into eight models, each of which tested a specific hypothesis.

Model 1: General support for wind energy (H_1). Questions modified from Firestone and Kempton (2007), Firestone et al. (2009) were used to test Hypothesis 1, which stated that support for Ashtabula would be predicted by a respondent's support of wind energy in general. Respondents were asked to rate their general attitude toward wind energy, level of support for wind energy production in North Dakota and level of support for Ashtabula. Respondents were also asked if they had ever seen a large-scale wind farm in operation (Appendix C: Q1-Q3).

Model 2: Perceptions of advantages and disadvantages of wind energy (H_2). Four statements modified from Smith and Klick (2010) were used to evaluate Hypothesis 2, which stated that respondent's perceptions of the advantages and disadvantages of wind energy would be correlated with support for Ashtabula. Respondents rated whether they agreed or disagreed that producing energy from wind 1) reduces dependence on foreign energy; 2) reduces human contribution to global warming and air pollution; and 3) is a symbol of local, state and federal commitment to renewable energy (Appendix C: Q6-Q9).

Model 3: Perceptions of personal impacts (H_3). Hypothesis 3 stated that how respondents perceived themselves as being personally impacted by the wind farm would be correlated with their level of support for Ashtabula. To test this hypothesis, questions modified from Firestone and Krueger (2007) and Firestone et al. (2009) measured respondent perceptions of noise, visual appeal, turbine flicker, and impacts on property values (Appendix C: Q13-Q16).

Model 4: Perceptions of impacts to community and environment (H_4). This model tested the hypothesis (H_4) that respondent's perceptions of impacts to the local community and environment would predict support for Ashtabula. Questions modified from Firestone and Kempton (2007) on potential wind farm impacts on the local community and environment were used to measure respondent's perceptions of impacts on hunting, tourism, job creation, economy, air quality, residential electricity rates, aesthetics of countryside, property values, and impacts on crops and pastures (Appendix C: Q5a-Q5i).

Model 5: Acceptance of wind farms in close proximity to personal property (H_5). Six questions modified from the Bogardus Social Distance Scale (Bogardus 1947) were used to rate respondent acceptance of wind farm construction in the United States, Midwest, North Dakota, in their county, within five miles, and within one mile of their home (Appendix C: Q17-

Q22). This model tested the hypothesis that the distance a wind farm was located from a respondent would be correlated with their level of support for Ashtabula (H_5).

Model 6: Support for different energy sources (H_6). Questions modified from Smith and Klick (2010) and the MIT Energy Survey (Ansolabehere 2007) were used to test the hypothesis that support for other sources of energy would not predict support for Ashtabula (H_6). Respondents were asked to rate their support for wind, solar, hydroelectric, nuclear, biomass, oil, and coal as energy sources (Appendix C: Q23a-Q23g).

Model 7: Concern for wildlife (H_7). Questions adapted from Stern et al. (1995) and Fulton et al. (1996) tested Hypothesis 7, which stated that respondents concerned about impacts to wildlife would express less support for Ashtabula. Concern for wildlife was measured by asking respondents to rate their concern for wildlife impacts, the importance of conservation of biodiversity, whether they believed that turbines could kill bats or birds, and whether they enjoyed learning about wildlife (Appendix C: Q10-Q12, Q24-Q25).

Model 8: Socio-demographics (H_8). Respondent's marital status, sex, education level, political ideology, age and annual household income were collected in order to test hypothesis that socio-demographics would not be correlated with support for Ashtabula (Appendix C: Q28-Q31, Q35-Q36).

Model 9: All variables held constant. A ninth model, consisting of all variables held constant against the dependent variable, was also evaluated.

Coding and Analysis

A five-point, Likert-type scale was used to measures the degree to which a respondent agreed or disagreed with a statement. Responses were coded from one through five representing 'strongly disagree' through 'strongly agree,' 'strongly oppose' through 'strongly support' and ‘very negative impact’ through ‘very positive impact’. Responses of “don’t know” or “unsure” were initially coded as nine, but coded as three (“neutral” or “no impact”) for analysis. Data collected from the survey were entered into an Excel spreadsheet and imported into SPSS (PAWS) version 19 for analysis. Statistical methods consisted of Pearson's correlation coefficient, multiple regression and factor analysis.

RESULTS

The following sections describe the results of data analysis to test the posed hypotheses. In Table 1.2 is the regression analysis of all models.

Table 1.2 Standardized estimates of significance for all models (N=150).

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**
Variables	**β**	**β**	**β**	**β**	**β**	**β**	**β**	**β**	**β**
Seen a wind farm in operation	0								0
General attitude	0.47								0
Placement in North Dakota	0.32								0.27
Reduce foreign dependence		0							0
Reduce global warming		0							0
Commitment to renewable energy		.30							0.16^
Reduce air pollution		0							0
Turbines are noisy			-0.17^						0
Turbine flicker is bothersome			-0.14^						-0.13^
Turbines are ugly			-0.25						0
Will lower property values			0						0.15^
Local hunting				0.27					0
Local tourism				0					0
Job creation				0.13^					0
Local economy				0.24					0.19
Local air quality				0					0
Local electricity rates				0.219					0.21
Aesthetics of countryside				0					-0.15^
Local property values				0.19					0
Local crops and pastures				0					0

Table 1.2 continued.

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Variables	**β**	**β**	**β**	**β**	**β**	**β**	**β**	**β**	**β**
United States					0				0
Midwest					0.95				1.29
North Dakota					-0.90				-1.03
County					0.30				0
Within 5 miles of home					0				0
Within 1 mile of home					0.26				0
Wind						0.53			0
Solar						0			-0.26
Hydroelectric						-0.18^			0
Nuclear						0			0
Biomass						0			0
Oil						0			0
Coal						0			0
Concern for wildlife impacts							-0.34		-0.22
Turbines can kill migratory birds							0		0
Turbines can kill bats							0		0
Enjoy learning about wildlife							0		0
Protect wildlife diversity							0		0
Marital status								0	0
Sex								0	0
Education level								0	0
Political ideology								0	0
Age								0	0
Total household income								0	0

^=p<0.10; non-zero coefficients= p<0.05; zero coefficients = n.s.

Model 1: General attitude toward wind farming (H_1)

Table 1.3 shows the means and standard deviations for Model 1, which was used to test the hypothesis that support for wind energy in general will predict support for Ashtabula (H_1).

Table 1.3 Means and standard deviations of variables in Model 1 (N=150).

Variables	Mean	σ	N
Support for Ashtabula	3.93	1.014	150
Has seen a large-scale wind farm in operation	1.04	.197	150
General attitude toward wind farms	4.01	.879	150
Placement of wind farms in North Dakota for electricity generation	3.38	.748	150

Table 1.4 shows the frequency of responses to the variables in this model. Out of a sample size of 150, 79% of respondents were found to support or strongly support wind energy in general. Fifty-two percent of respondents felt that the placement of wind farms in North Dakota should be encouraged and promoted and 35% felt it should be allowed in appropriate circumstances. Ninety-six percent of respondents reported having seen a large-scale wind farm in operation (Table 1.4).

Table 1.4 Frequency of responses to variables in Model 1 (N=150).

Has seen a large-scale wind farm in operation		
	Frequency	Percent
Yes	144	96.0
No	6	4.0
Total	150	100.0
General attitude toward wind farms		
	Frequency	Percent
Very Negative	4	2.7
Negative	3	2
Neutral	24	16
Positive	76	50.7
Very Positive	43	28.7
Total	150	100
The placement of wind farms in North Dakota for electricity generation should be:		
	Frequency	Percent
Prohibited in all instances	3	2
Tolerated	15	10
Allowed in appropriate circumstances	54	36
Encouraged and promoted	78	52
Total	150	100

Table 1.5 presents the correlations among variables in this model. Respondent attitudes toward wind energy in general (p=0.62, p<0.01) and the placement of wind farms in North Dakota (p=0.54, p<.01) were strongly correlated with support for Ashtabula. These variables were also strongly correlated with each other (p=0.49, p<0.01). A negative correlation was found between having seen a large-scale wind farm and support for Ashtabula (p=-0.15, p<0.05).

Table 1.5 Correlations of variables in Model 1 (N=150).

Variables	1	2	3	4
1. Will support the Ashtabula wind farm	1			
2. Has seen a large-scale wind farm in operation	-0.02	1		
3. General attitude toward wind farms	.618**	-0.118	1	
4. The placement of wind farms in North Dakota for electricity generation	.538**	-.150*	.486**	1

* Correlation is significant at the 0.05 level (1-tailed)
**Correlation is significant at the 0.01 level (1 tailed).

Table 1.2 shows the regression analysis of the variables in this model. A significant positive relationship (β=0.47, p<0.05) between general attitude toward wind farms and support for Ashtabula was found. Respondents who supported the construction of wind farms in North Dakota for electricity generation were more likely to express support for Ashtabula (β=0.32, p<0.05). Despite a negative correlation with support, having seen a large-scale wind farm in operation was not significantly related to support for Ashtabula.

Model 2: Advantages and disadvantages of wind farming to the environment (H_2)

Model 2 tested the hypothesis that respondent's perceptions of the advantages and disadvantages of wind farming would predict support for Ashtabula (H_2). Overall sample size was 148, as two respondents chose not to answer the question pertaining to global warming. Table 1.6 shows the means and standard deviations for each of the variables in this model.

Table 1.6 Means and standard deviations of variables in Model 2 (N=148).

Variables	Mean	σ	N
Producing energy from wind reduces the amount of energy we need to import from foreign sources	4.07	.886	148
Human contribution to global warming is reduced because wind turbines do not release greenhouse gases, such as carbon dioxide	3.96	.840	148
Wind power projects are a symbol of local, state and federal commitment to renewable energy	4.11	.612	148
Human contribution to air pollution is reduced because wind turbines do not release chemicals or particulates, such as mercury and soot into the atmosphere	4.06	.672	148

Table 1.7 shows the frequency of responses to variables. The majority of respondents agreed with statements about the perceived advantages of wind energy. Eighty-eight percent of respondents agreed that wind energy production would decrease dependence on foreign energy sources. Respondents also believed that human contribution to global warming (77%) and air pollution (88%) would be reduced by wind energy production, and 89% perceived wind energy production as a symbol of local, state and federal commitment to renewable energy.

Table 1.8 presents the correlations among these variables. Agreement with the statements: producing energy from wind turbines reduces the amount of energy we need to import from foreign sources ($p=0.29$, $p<0.01$); human contribution to global warming is reduced by wind energy production ($p=0.28$, $p<0.01$); wind power projects are a symbol of commitment to renewable energy ($p=0.35$, $p<0.01$); and human contribution to air pollution is reduced through wind energy production ($p=0.33$, $p<0.01$), was moderately correlated with support for Ashtabula. The beliefs that wind energy would reduce human contribution to air pollution ($p=0.47$, $p<0.01$) and global warming ($p=0.48$, $p<0.01$) were strongly correlated with the belief that wind energy is a symbol of commitment to renewable energy (p=0.54, p<0.01).

Table 1.7 Frequency of responses to variables in Model 2 (N=148).

Producing energy from wind reduces the amount of energy we need to import from foreign sources		
	Frequency	Percent
Strongly disagree	2	1.3
Disagree	12	8.0
Neutral	11	7.3
Agree	77	51.3
Strongly Agree	48	32.0
Total	150	100.0
Human contribution to global warming is reduced because wind turbines do not release greenhouse gases, such as carbon dioxide		
	Frequency	Percent
Strongly Disagree	1	.7
Disagree	9	6.0
Neutral	22	14.7
Agree	79	52.7
Strongly Agree	37	24.7
Total	148	98.7
Missing	2	1.3
	150	100.0
Wind power projects are a symbol of local, state and federal commitment to renewable energy		
	Frequency	Percent
Strongly Disagree	1	.7
Disagree	2	1.3
Neutral	14	9.3
Agree	98	65.3
Strongly Agree	35	23.3
Total	150	100.0
Human contribution to air pollution is reduced because wind turbines do not release chemicals or particulates, such as mercury and soot into the atmosphere		
	Frequency	Percent
Disagree	6	4.0
Neutral	12	8.0
Agree	99	66.0
Strongly Agree	33	22.0
Total	150	100.0

Table 1.8 Correlations of variables in Model 2 (N=148).

Variables	**1**	**2**	**3**	**4**	**5**
1. Support or oppose the Ashtabula wind farm	1				
2. Producing energy from wind reduces the amount of energy we need to import from foreign sources	.285**	1			
3. Human contribution to global warming is reduced because wind turbines do not release greenhouse gases, such as carbon dioxide	.284**	.479**	1		
4. Wind power projects are a symbol of local, state and federal commitment to renewable energy	.351**	.538**	.512**	1	
5. Human contribution to air pollution is reduced because wind turbines do not release chemicals or particulates, such as mercury and soot into the atmosphere	.328**	.472**	.522**	.498**	1

** Correlation is significant at the 0.01 level (1-tailed).

Though there was a positive correlation between support for Ashtabula and many of the variables, the only significant relationship that was found when controlling for all other variables was between perceptions of wind energy production as a symbol of commitment to renewable energy and support for Ashtabula (β=0.30, p=0.05). The belief that wind energy production would reduce dependence on foreign energy sources, human contribution to air pollution and global warming were not significant factors in determining support for the wind farm (Table 1.2).

Model 3: Perceived personal impacts (H_3)

Model 3 tested the hypothesis that respondents who felt that they had been negatively impacted on a personal level would demonstrate less support for the wind farm (H_3). Support for this hypothesis was mixed.

Table 1.9 shows the means and standard deviations and Table 1.10 shows the frequency of responses to variables in this model. Most respondents did not perceive turbines as having a negative impact on them personally. The greatest perceived negative impact was that of turbines being noisy and bothersome to those living near them, with 47% agreeing either somewhat or strongly. Turbine flicker was perceived as a negative impact by 34% of respondents. The minority of respondents perceived turbines as being ugly and spoiling the scenery (19%) and as lowering property values (17%).

Table 1.11 shows the correlations among variables. The perceptions of turbines being noisy (p=-0.35, p<0.01), lowering property values (p=-0.28, p<0.01) and producing a bothersome flicker (p=-0.34, p<0.01) were all moderately and negatively correlated with support for Ashtabula. The perception that turbines were ugly and spoiled the scenery of the local landscape (p=-0.40, p<0.01) exhibited a strong negative correlation with support. The four independent variables were all positively correlated with each other.

Table 1.9 Means and standard deviations of variables in Model 3 (N=150).

Variables	**Mean**	**σ**	**N**
Turbines are noisy and can bother people who live near wind farms	3.12	1.080	150
Wind turbine flicker can bother people who live near wind farms	2.97	.986	150
Wind turbines will lower local property values	2.55	.959	150
Wind turbines are ugly and spoil the scenery of the local landscape	2.52	.946	150

Table 1.10 Frequency of responses to variables in Model 3 (N=150).

Wind turbines are noisy, which can bother people who live near wind farms		
	Frequency	Percent
Strongly Disagree	9	6.0
Disagree	43	28.7
Neutral	28	18.7
Agree	61	40.7
Strongly Agree	9	6.0
Total	150	100.0
Wind turbine flicker can bother people who live near wind farms		
	Frequency	Percent
Strongly Disagree	5	3.3
Disagree	53	35.3
Neutral	41	27.3
Agree	44	29.3
Strongly Agree	7	4.7
Total	150	100.0
Wind turbines are ugly and spoil the scenery of the local landscape		
	Frequency	Percent
Strongly Disagree	9	6.0
Disagree	84	56.0
Neutral	28	18.7
Agree	23	15.3
Strongly Agree	6	4.0
Total	150	100.0
Wind turbines will lower local property values, harming local homeowners		
	Frequency	Percent
Strongly Disagree	11	7.3
Disagree	81	54.0
Neutral	33	22.0
Agree	19	12.7
Strongly Agree	6	4.0
Total	150	100.0

Table 1.11 Correlations of variables in Model 3 (N=150).

Variables	**1**	**2**	**3**	**4**	**5**
1. Will support Ashtabula	1				
2. Wind turbines are noisy, which can bother people who live near wind farms	-.354**	1			
3. Wind turbine flicker can bother people who live near wind farms	-.344**	.470**	1		
4. Wind turbines are ugly and spoil the scenery of the landscape	-.403**	.350**	.424**	1	
5. Wind turbines will lower local property values, harming local homeowners	-.278**	.392**	.227**	.413**	1

** Correlation is significant at the 0.01 level (1-tailed).

Regression analysis found mixed support for the hypothesis (H_3). Respondents who perceived that turbines were ugly and spoiled the scenery of the local landscape (ß=-0.25, p<0.05) as well as those who perceived turbines as being noisy, were less supportive of the wind farm (ß=-0.17, p=0.054). The relationship between perceptions of turbine flicker as a negative impact and support approached significance at p<0.10 (ß=-0.14, p=0.11). When controlled for all other variables, there was no relationship between perceptions of lower property values and support for Ashtabula (Table 1.2).

Model 4: Impacts to community and environment (H_4)

Mixed support was found for Hypothesis 4, which stated that negative impacts to the community and environment would predict decreased support for Ashtabula. Table 1.12 shows the means and standard deviations and Table 1.13 presents the frequency of the responses to the variables. Six of the nine variables were rated by the majority of respondents as having no impact on the local community or environment. Respondents expressed that the wind farm had had no impact on hunting (75%), air quality (79%), electricity rates (64%), aesthetics of countryside (45%), property values (49%) or local crops and pastures (67%). Areas that were perceived as having been positively or very positively impacted by the wind farm were tourism (55%), job creation (85%) and the local economy (80%).

Table 1.12 Means and standard deviations of variables in Model 4 (N=150).

Variables	**Mean**	**σ**	**N**
Impact on local hunting	3.93	1.014	150
Impact on local tourism	2.92	.512	150
Impact on job creation	3.59	.646	150
Impact on local economy	4.05	.588	150
Impact on local air quality	3.97	.675	150
Impact on residential electricity rates	3.20	.463	150
Impact on aesthetics of countryside	2.88	.713	150
Impact on property values	2.91	.922	150
Impact on local crops and pastures	3.35	.705	150

Table 1.13 Frequency of responses to variables in Model 4 (N=150).

Ashtabula impact on local hunting		
	Frequency	Percent
Very Negative	1	.7
Negative	23	15.3
No Impact	113	75.3
Positive	13	8.7
Total	150	100.0
Ashtabula impact on local tourism		
	Frequency	Percent
Negative	3	2.0
No Impact	65	43.3
Positive	72	48.0
Very Positive	10	6.7
Total	150	100.0
Ashtabula impact on job creation		
	Frequency	Percent
No Impact	22	14.7
Positive	98	65.3
Very Positive	30	20.0
Total	150	100.0
Ashtabula impact on local economy		
	Frequency	Percent
Negative	3	2.0
No Impact	27	18.0
Positive	91	60.7
Very Positive	29	19.3
Total	150	100.0
Ashtabula impact on local air quality		
	Frequency	Percent
Negative	2	1.3
No Impact	118	78.7
Positive	28	18.7
Very Positive	2	1.3
Total	150	100.0
Ashtabula impact on residential electricity rates		
	Frequency	Percent
Very Negative	8	5.3
Negative	24	16.0
No Impact	96	64.0
Positive	22	14.7
Total	150	100.0
Ashtabula impact on aesthetics of countryside		
	Frequency	Percent
Very Negative	8	5.3
Negative	40	26.7
No Impact	67	44.7
Positive	28	18.7
Very Positive	7	4.7
Total	150	100.0
Ashtabula impact on property values		
	Frequency	Percent
Very Negative	1	.7
Negative	13	8.7
No Impact	73	48.7
Positive	59	39.3
Very Positive	4	2.7
Total	150	100.0
Ashtabula impact on local crops and pastures		
	Frequency	Percent
Very Negative	3	2.0
Negative	28	18.7
No Impact	100	66.7
Positive	19	12.7
Total	150	100.0

Table 1.14 shows correlations among variables of Model 4. All variables were correlated to some degree with support for Ashtabula. Perceived positive impacts on the economy were most strongly correlated with support for Ashtabula (p=0.41, p<0.01) and a fairly strong positive correlation was found between positive impacts on hunting and support for the wind farm (p=0.39, p<0.01). Perceptions of impacts on job creation (p=0.30, p<0.01), residential electricity rates (p=0.27, p<0.01), the aesthetics of countryside (p=0.29, p<0.01) and local crops and pastures (p=0.25, p<0.01) were all moderately correlated with support for the wind farm. The correlations between impacts to tourism (p=0.19, p<0.01) and air quality (p=0.16, p<0.05) with support for Ashtabula were positive, though weak. Impacts to the local economy and job creation were the variables most strongly correlated with each other (p=0.61, p<0.01).

Table 1.14 Correlations of variables in Model 4 (N=150).

Variables	1	2	3	4	5	6	7	8	9	10
1. Will support Ashtabula	1									
2. Hunting	.390**	1								
3. Tourism	.194**	.165*	1							
4. Job creation	.298**	-0.03	0.11	1						
5. Local economy	.409**	0.13	.144*	.612**	1					
6. Air quality	.157*	.209**	.318**	0.059	.146*	1				
7. Residential electricity rates	.276**	.194**	0.097	0.015	0.133	.195**	1			
8. Aesthetics of countryside	.287**	.368**	.341**	0.046	.190**	.154*	.238**	1		
9. Property values	.295**	.226**	.223**	0.101	0.09	0.012	-0.023	.360**	1	
10. Local crops/ pastures	.245**	.376**	.216**	0.015	0.09	.187*	.260**	.159*	.294**	1

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Respondents who perceived positive impacts on local hunting (ß=0.27, $p<0.05$), local economy (ß=0.24, $p<0.05$), and residential electricity rates (ß=0.19, $p<0.05$) were more likely to express support for Ashtabula. Although no relationship was found between impacts to property values and support for Ashtabula in Model 3, a positive relationship was found in this model (ß=0.19, $p<0.05$). People who perceived wind farm having a positive impact on property values were more likely to support the Ashtabula wind facility (Table 1.2).

A negative relationship between visual impacts and respondent support for Ashtabula was found in Model 3, however perceived impacts to the aesthetics of countryside and support for the wind farm were not significantly correlated in this model. No significant relationships were found between perceived impacts on tourism, job creation, air quality or crops and pastures and level of support (Table 1.2).

Model 5: Distance from respondent's home (H_5)

Model 5 tested the hypothesis that opposition for Ashtabula would be predicted by level of acceptance of wind farm construction near a respondent's home (H_5). Table 1.15 shows means and standard deviations of the variables. Table 1.16 shows the frequency of responses to the variables in this model.

Table 1.15 Means and standard deviations of variables in Model 5 (N=150).

Variables	Mean	σ	N
I support the construction of wind farms in the United States	4.17	.784	150
I support the construction of wind farms in the Midwest	4.17	.755	150
I support the construction of wind farms in North Dakota	4.18	.742	150
I support the construction of wind farms in the county I live in	4.07	.891	150
I support the construction of wind farms within 5 miles of my home	3.82	1.056	150
I support the construction of wind farms within 1 mile of my home	3.49	1.246	150

Table 1.16 Frequency of responses to variables in Model 5 (N=150).

I support the construction of wind farms in the United States		
	Frequency	Percent
Strongly Disagree	3	2.0
Disagree	3	2.0
Neutral	8	5.3
Agree	87	58.0
Strongly Agree	49	32.7
Total	150	100.0
I support the construction of wind farms in the Midwest		
	Frequency	Percent
Strongly Disagree	2	1.3
Disagree	5	3.3
Neutral	5	3.3
Agree	92	61.3
Strongly Agree	46	30.7
Total	150	100.0
I support the construction of wind farms in North Dakota		
	Frequency	Percent
Strongly Disagree	2	1.3
Disagree	5	3.3
Neutral	3	2.0
Agree	94	62.7
Strongly Agree	46	30.7
Total	150	100.0
I support the construction of wind farms in the county I live in		
	Frequency	Percent
Strongly Disagree	5	3.3
Disagree	6	4.0
Neutral	6	4.0
Agree	89	59.3
Strongly Agree	44	29.3
Total	150	100.0
I support the construction of wind farms within 5 miles of my home		
	Frequency	Percent
Strongly Disagree	8	5.3
Disagree	14	9.3
Neutral	9	6.0
Agree	85	56.7
Strongly Agree	34	22.7
Total	150	100.0
I support the construction of wind farms within 1 mile of my home		
	Frequency	Percent
Strongly Disagree	14	9.3
Disagree	26	17.3
Neutral	11	7.3
Agree	70	46.7
Strongly Agree	29	19.3
Total	150	100.0

The combined responses for 'support' (58%) and 'strongly support' (33%) wind farm construction fell from 91% supporting construction in the United States to 66% supporting construction within one mile of their home (Table 1.6). Conversely, the combined responses for 'oppose' (2%) and 'strongly oppose' (2%) rose from 4% opposed to construction in the United States to 26% opposed to construction when the wind farm would be located within one mile of their home (Table 1.6, Figure 1.4). The majority of respondents expressed support of construction at any distance.

Figure 1.4 Percentage of support for wind farm construction as a function of the distance of the wind farm from respondent (Lucas Bicknell 2011).

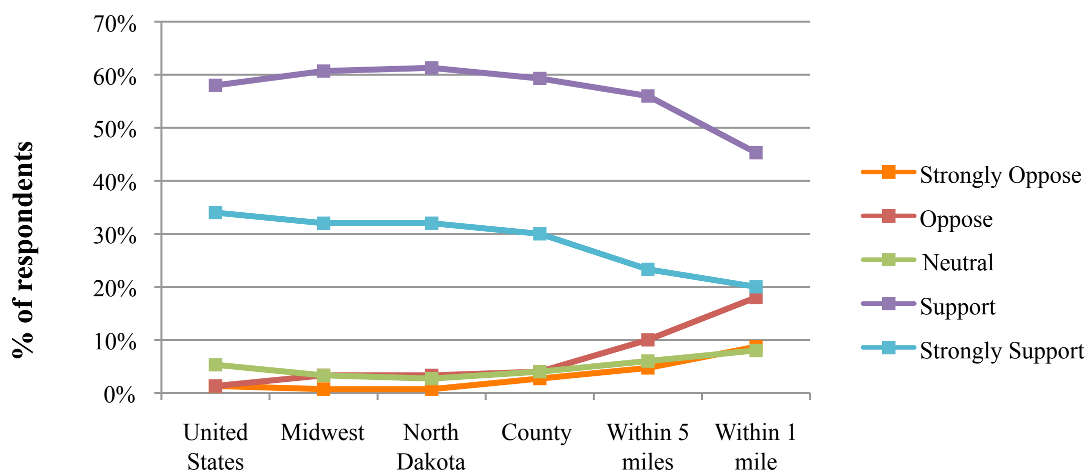


Table 1.17 shows correlations among variables. Support for construction in the United States (p=0.34, p<0.01) was somewhat strongly correlated with support. Support for construction in the Midwest (p=0.51, p<0.01), North Dakota (p=0.5, p<0.01), in the respondent's county (p=0.57, p<0.01) and within 5 miles (p=0.59, p<0.01) and 1 mile (0.58, p<0.01) of a respondent's home exhibited strong, positive correlations with support for Ashtabula.

The strongest correlation among variables occurred between support in the Midwest and North Dakota (p=0.99, p<0.01). Support for wind farms located between 1 and 5 miles of a respondent's home were also strongly correlated with each other ($p=0.83$, $p<0.01$). Each time the location of a wind farm was proposed closer to the respondent and their support of that location went up, it was much more likely that they would also support construction within one mile of their home (Table 1.17).

Table 1.17 Correlations of variables in Model 5 (N=150).

Variables	1	2	3	4	5	6	7
1. Will support Ashtabula	1						
2. United States	.335**	1					
3. Midwest	.514**	.779**	1				
4. North Dakota	.497**	.777**	.988**	1			
5. County	.570**	.645**	.851**	.853**	1		
6. Within 5 miles of home	.590**	.492**	.653**	.666**	.721**	1	
7. Within 1 mile of home	.584**	.441**	.611**	.614**	.620**	.828**	1

** Correlation is significant at the 0.01 level (1-tailed).

Correlation between support for wind farm construction in the United States and support for Ashtabula was weak and no significant relationships were found. Those respondents who supported the construction of a wind farm in the Midwest ($\beta=0.95$, $p<0.05$), in their county ($\beta=0.30$, $p<0.05$), and within one mile of their home ($\beta=0.26$, $p<0.05$) were more likely to support Ashtabula. No relationship was found between support for construction within five miles of home and support for Ashtabula. The relationship between support for construction in North Dakota and support for Ashtabula was negatively correlated ($\beta=-0.90$, $p<0.05$) (Table 1.2).

Model 6: Support for other sources of energy (H_6)

Model 6 measured seven items to test the hypothesis that respondents expressing support for other sources of energy would demonstrate less support for Ashtabula (H_6). Table 1.18 shows the means and standard deviations.

Wind energy was supported or strongly supported by 95% of respondents, which was the variable that received the most support overall. Ninety-one percent of respondents either somewhat or strongly supported solar energy, and hydroelectric and coal-produced energy were each supported by 84% of respondents. Biomass and oil were supported by 73% and 69% respectively. Nuclear power as an energy source was the least supported (47%), and the most opposed by those surveyed (25%) (Table 1.19).

Support of wind energy in general was strongly correlated with support for Ashtabula ($p=0.46$, $p<0.01$). Very weak positive correlations were found between support for solar (0.14, $p<0.05$) and biomass ($p=0.14$, $p<0.05$) as energy sources and support for Ashtabula. Increased support for wind energy was indicative of increased support for solar ($p=0.5$, $p<0.01$), hydroelectric ($p=0.28$, $p<0.01$) and biomass ($p=0.31$, $p<0.01$) produced energy. Support for oil ($p=-0.2$, $p<0.01$) and coal ($p=-0.19$, $p<0.05$) was weakly correlated with decreased support for Ashtabula. Biomass production was positively correlated with all other variables and coal and oil production were the variables most strongly related to each other ($p=0.64$, $p<0.01$) (Table 1.20).

Table 1.18 Means and standard deviations of variables in Model 6 (N=150).

Variables	**Mean**	**σ**	**N**
Support of wind as energy source	4.20	.742	150
Support of solar as energy source	4.22	.644	150
Support of hydroelectric as energy source	4.01	.768	150
Support of nuclear as energy source	3.23	1.138	150
Support of biomass as energy source	3.79	.924	150
Support of oil as energy source	3.57	.862	150
Support of coal as energy source	3.83	.763	150

Table 1.19 Frequency of responses to variables in Model 6 (N=150).

Support of wind as energy source		
	Frequency	Percent
Strongly Oppose	3	2.0
Oppose	3	2.0
Neutral	2	1.3
Support	95	63.3
Strongly Support	47	31.3
Total	150	100.0
Support of solar as energy source		
	Frequency	Percent
Oppose	2	1.3
Neutral	12	8.0
Support	87	58.0
Strongly Support	49	32.7
Total	150	100.0
Support of hydroelectric as energy source		
	Frequency	Percent
Strongly Oppose	3	2.0
Oppose	2	1.3
Neutral	19	12.7
Support	92	61.3
Strongly Support	34	22.7
Total	150	100.0
Support of nuclear as energy source		
	Frequency	Percent
Strongly Oppose	14	9.3
Oppose	24	16.0
Neutral	42	28.0
Support	53	35.3
Strongly Support	17	11.3
Total	150	100.0
Support of biomass as energy source		
	Frequency	Percent
Strongly Oppose	1	.7
Oppose	19	12.7
Neutral	20	13.3
Support	81	54.0
Strongly Support	29	19.3
Total	150	100.0
Support of oil as energy source		
	Frequency	Percent
Strongly Oppose	3	2.0
Oppose	20	13.3
Neutral	24	16.0
Support	95	63.3
Strongly Support	8	5.3
Total	150	100.0
Support of coal as energy source		
	Frequency	Percent
Strongly Oppose	2	1.3
Oppose	12	8.0
Neutral	10	6.7
Support	111	74.0
Strongly Support	15	10.0
Total	150	100.0

Table 1.20 Correlations of variables in Model 6 (N=150).

Variables	1	2	3	4	5	6	7	8
1. Will support Ashtabula	1							
2. Wind	.455**	1						
3. Solar	.136*	.498**	1					
4. Hydroelectric	-0.007	.278**	.442**	1				
5. Nuclear	-0.016	-0.08	0.085	.265**	1			
6. Biomass	.142*	.307**	.373**	.429**	.239**	1		
7. Oil	-0.102	-.199**	-0.057	.221**	.288**	0.094	1	
8. Coal	-0.066	-.190*	-0.116	.290**	.354**	.159*	.644**	1

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Not surprisingly, regression analysis found a positive relationship between support for wind energy in general and support for Ashtabula ($ß=0.53$, $p<0.05$). Respondents that expressed support for hydroelectric energy were less likely to support Ashtabula ($ß=-0.18$, $p=0.06$). Support for solar, nuclear, biomass, oil or coal was not significantly correlated with support for the wind farm and no significant relationships were found when all other variables were controlled, therefore the hypothesis was not supported (Table 1.2).

Model 7: Concern for impacts to wildlife (H_7)

Model 7 examined the relationship between concern for impacts to wildlife and support for Ashtabula (H_7). Table 1.21 shows the means and standard deviations. Table 1.22 presents the frequency of responses to the variables in this model.

Table 1.21 Means and standard deviations of variables in Model 7 (N=150).

Variables	Mean	σ	N
Concern for impacts to wildlife	2.77	1.082	150
Wind turbine blades can kill migratory birds	3.11	.928	150
Wind turbine blades can kill bats	2.98	.815	150
I enjoy learning about the wildlife in my community	4.13	.672	150
It is important to protect wildlife diversity in my community	4.07	.748	150

Table 1.22 Frequency of responses to variables in Model 7 (N=150).

	Frequency	Percent
I am concerned about the impacts of wind development on wildlife in my community		
	Frequency	Percent
Strongly Disagree	10	6.7
Disagree	71	47.3
Neutral	19	12.7
Agree	43	28.7
Strongly Agree	7	4.7
Total	150	100.0
Wind turbine blades can kill migratory birds		
	Frequency	Percent
Strongly Disagree	6	4.0
Disagree	37	24.7
Neutral	44	29.3
Agree	61	40.7
Strongly Agree	2	1.3
Total	150	100.0
Wind turbine blades can kill bats		
	Frequency	Percent
Strongly Disagree	1	.7
Disagree	44	29.3
Neutral	66	44.0
Agree	35	23.3
Strongly Agree	4	2.7
Total	150	100.0
I enjoy learning about the wildlife in my community		
	Frequency	Percent
Strongly Disagree	1	.7
Disagree	3	2.0
Neutral	10	6.7
Agree	97	64.7
Strongly Agree	39	26.0
Total	150	100.0
It is important to protect wildlife diversity in my community		
	Frequency	Percent
Strongly Disagree	2	1.3
Disagree	3	2.0
Neutral	16	10.7
Agree	91	60.7
Strongly Agree	38	25.3
Total	150	100.0

Respondents who expressed concern about wind farm impacts to wildlife comprised 33% of the sample, while 54% expressed no concerned. Forty-two percent of respondents believed that turbines could kill migratory birds, and opposition (either somewhat or strong) and feeling neutral each made up 29% of the remaining respondents. Just 26% of respondents agreed that turbines could kill bats. The greatest level of agreement came from respondents who state that they enjoyed learning about the wildlife in their community (91%) and those who felt it was important to protect wildlife diversity (86%).

Table 1.23 shows the correlations among variables. Respondents who were concerned about impacts to wildlife (p=-0.34, p<0.01) were less likely to support Ashtabula. The perception that turbines could kill migratory birds exhibited a weak correlation with support for Ashtabula (p=-0.19, P<0.01) and a strong positive correlation with concern for wildlife impacts (p=0.47, p<0.01). Enjoyment of learning about wildlife and the importance of protecting wildlife diversity were the variables most strongly correlated with each other (p=0.64, p<0.01), and while both indicated concern for impacts to wildlife, they were not correlated with support for Ashtabula.

Table 1.23 Correlations of variables in Model 7 (N=150).

Variables	1	2	3	4	5	6
1. Will support Ashtabula	1					
2. Concern about the impacts on wildlife	-.344**	1				
3. Wind turbine blades can kill migratory birds	-.192**	.466**	1			
4. Wind turbine blades can kill bats	-0.115	.269**	.464**	1		
5. Enjoy learning about the wildlife	-0.007	.171*	-0.055	-0.02	1	
6. It is important to protect wildlife diversity	-0.047	.259**	0.019	.178*	.636**	1

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Respondents who expressed concern about impacts on wildlife were significantly less supportive of Ashtabula (β=-0.34, p<0.05), which suggests support for the hypothesis as that variable specifically addressed a respondent's concern for wildlife impacts. The correlation between belief that turbines could kill migratory birds and support was weak, and did not predict support for the wind farm once all other variables were controlled. Protection of wildlife diversity, enjoyment in learning about wildlife, and the belief that turbines could kill bats were not significantly related to support for Ashtabula (Table 1.2).

Model 8: Socio-demographics (H_8)

Model 8 was used to determine if any relationship existed between socio-demographics and support for Ashtabula (H_8). Table 1.24 shows the means and standard deviations for the variables in this model, Table 1.25 presents a descriptive breakdown of the variables.

Table 1.24 Means and standard deviations of variables in Model 8 (N=134).

Variables	Mean	σ	N
Marital Status	1.5	1.109	134
Sex	0.51	0.502	134
Highest degree or level of school completed	4.35	1.437	134
Political Ideology	3.53	1.212	134
Age	58.16	15.882	134
Total Household Income	5.16	1.951	134

Table 1.25 Means and descriptions of variables in Model 8 (N=134).

Variable	Mean	Description
Marital status		Married 75%, 13% Widowed, 9% Never married, 3% Divorced
Sex		Male – 48% Female – 52%
Level of education	4.35	Some college credit
Political ideology	3.53	Mod. Conservative/Down the middle
Age	59.3	
Household income	5.16	$35,001 - 50,000

Slightly more women answered the survey than men. The average age of the respondent was 59 years old, which was slightly higher than the average age of 43 for the study area. Most respondents had some college credit and the average income was between $35,001 and $50,000. The breakdown was consistent with the demographic profile of the study area.

Table 1.26 shows the correlations of variables. No correlations were found between any of the variables and support for Ashtabula. Total household income was weakly correlated with age ($p=-0.19$, $p<0.05$) and sex ($p=-0.2$, $p<0.01$) and was somewhat more strongly correlated with marital status ($p=-0.32$, $p<0.01$) and level of education ($p=-0.31$, $p<0.01$).

Table 1.26 Correlations of variables in Model 8 (N=134).

Variables	1	2	3	4	5	6	7
1. Will support Ashtabula	1						
2. Marital Status	-0.032	1					
3. Sex	0.042	0.079	1				
4. Highest degree or level of school completed	-0.114	-0.062	-0.036	1			
5. Political Ideology	0.036	0.037	-0.018	0.131	1		
6. Age	-0.026	-0.071	-0.005	-.235**	-0.044	1	
7. Total Household Income	-0.022	-.318**	-.198**	.314**	-0.072	-.185*	1

** Correlation is significant at the 0.01 level (1-tailed).
* Correlation is significant at the 0.05 level (1-tailed).

Regression analysis found no significant relationships between marital status, sex, education level, political ideology, age or household income and a respondent's support for Ashtabula, thus supporting Hypothesis 3 (Table 1.2).

Model 9: All variables held constant

Model 9 was comprised of all previously measured variables held constant against the dependent variable. As shown in Table 1.27, six variables had significant relationships with the dependent variable in this model and some changes in other models were noted.

Support for wind farm construction in the Midwest was positively correlated (β=1.29, $p<0.05$), while support for construction in North Dakota was negatively correlated (β=-1.03, $p<0.05$). The latter was inconsistent with the findings that respondents who felt that wind energy should be encouraged or allowed in appropriate circumstances in North Dakota expressed greater support for Ashtabula (β=0.27, $p<0.05$). Support for solar energy was negatively correlated with support for Ashtabula (β=-0.26, $p<0.05$). Those respondents that perceived positive impacts to the local economy were more likely to support Ashtabula in this model (β=0.19, $p<0.05$). Respondents concerned about impacts to wildlife were less likely to support the wind farm (β=-

0.22, p<0.05). Respondents who perceived turbine flicker as a nuisance (ß=-0.13, p=0.13) and those who perceived the impact on the aesthetics of countryside as negative (ß=-0.15, p=0.15) expressed less support for Ashtabula at a level that approached significance at p<0.10. Conversely, respondents who viewed wind power projects as a symbol of commitment to renewable energy (ß=0.15, p=0.11) as well as those who agreed with the statement that wind turbines will lower local property values were more likely to express support (ß=0.15, p=0.11) (Table 1.27).

Seven variables no longer predicted support for Ashtabula: general attitudes toward wind farming; impacts on hunting; impacts on electricity rates; impacts on property values; construction of a wind farm in the respondent's county or within one mile of their home; and support of wind as an energy source (Table 1.27).

Table 1.27 Standardized estimates of significance of variables in Model 9 (N=134).

Variables	β	t.	Sig.
(Constant)		-0.109	0.913
Has seen a large-scale wind farm in operation	0.097	1.366	0.176
General attitude toward wind farms	0.072	0.603	0.548
Placement of wind farms in North Dakota for electricity generation	0.271	3.241	0.002*
Ashtabula impact on local hunting	0.102	1.191	0.237
Ashtabula impact on local tourism	-0.045	-0.584	0.561
Ashtabula impact on job creation	0.022	0.252	0.802
Ashtabula impact on local economy	0.19	2.08	0.04*
Ashtabula impact on local air quality	0.029	0.398	0.692
Ashtabula impact on residential electricity rates	0.074	0.932	0.354
Ashtabula impact on aesthetics of countryside	-0.145	-1.446	0.152
Ashtabula impact on property values	0.102	1.101	0.274
Ashtabula impact on local crops and pastures	-0.024	-0.3	0.765
Reduces the amount of energy we need to import from foreign sources	0.054	0.565	0.574
Human contribution to global warming is reduced	0.062	0.603	0.548
Symbol of local, state and federal commitment to renewable energy	0.157	1.611	0.111
Human contribution to air pollution is reduced	-0.114	-1.201	0.233
Concern for impacts of wind development on wildlife in community	-0.215	-2.112	0.038*

Table 1.27 continued.

Variables	β	t.	Sig.
Wind turbine blades can kill migratory birds	0.006	0.064	0.949
Wind turbine blades can kill bats	0.078	0.968	0.336
Wind turbines are noisy and can bother people living near wind farms	-0.084	-0.957	0.341
Wind turbine flicker can bother people who live near wind farms	-0.132	-1.523	0.131
Wind turbines are ugly and spoil the scenery of the local landscape	-0.035	-0.318	0.751
Wind turbines lower property values, harming local homeowners	0.152	1.599	0.113
I support the construction of wind farms in the United States	-0.163	-1.407	0.163
I support the construction of wind farms in the Midwest	1.287	2.745	0.007*
I support the construction of wind farms in North Dakota	-1.029	-2.277	0.025*
I support the construction of wind farms in the county I live in	0.04	0.276	0.783
I support the construction of wind farms within 5 miles of my home	0.034	0.228	0.82
I support the construction of wind farms within 1 mile of my home	0.117	0.877	0.383
Support of wind as energy source	0.027	0.187	0.852
Support of solar as energy source	-0.255	-2.562	0.012*
Support of hydroelectric as energy source	0.065	0.64	0.524
Support of nuclear as energy source	0.036	0.421	0.675
Support of biomass as energy source	0.053	0.592	0.555
Support of oil as energy source	-0.008	-0.089	0.929
Support of coal as energy source	-0.036	-0.375	0.708
I enjoy learning about the wildlife in my community	-0.006	-0.064	0.949
It is important to protect wildlife diversity in my community	-0.017	-0.171	0.865
Marital Status	0.011	0.148	0.883
Sex	0.026	0.338	0.736
Highest degree or level of school completed	0.038	0.489	0.626
Political Ideology	-0.072	-0.931	0.354
Age	0.002	0.029	0.977
Total Household Income	-0.04	-0.507	0.613

* $P<0.05$

Qualitative findings

Unsolicited comments made by respondents were noted to obtain additional information regarding respondent’s opinions toward wind energy development in North Dakota.

Often mentioned as a reason for decreased support for the wind farm was that local residents had to bear a visual or economic burden, without reaping the benefits of the energy produced. One respondent stated, “we have to look at the turbines and lines, but all the energy is shipped out of state.” Similarly, one respondent felt that “I would support it more if we actually got the energy here instead of sending it to other states. My electric rates have gone up and my property values have gone down and I get nothing for it.” Some respondents expressed concern that wind energy production would become ‘passé’ in a few years and the turbines would be left in place unmaintained. Several respondents mentioned turbines in California that are no longer operational, one comment being, “I’ve driven by them and they sit there unused and run-down looking. That will definitely be an eyesore.”

A number of respondents stated that they had negative opinions of the wind farm initially, but they had gotten used to it. One respondent commented that he had moved to the area “to be surrounded only by nature.” When Ashtabula was proposed he attended community meetings to express his ‘strong opposition’ to the project. After learning more about the project he became “very supportive” and ultimately allowed the sub-station to be built on his land. He stated that he lives in the center of the wind farm and is “surrounded by more turbines than any other resident near the farm.”

DISCUSSION

Model 1: General attitude toward wind energy

The majority of respondents in the study area were supportive of wind energy in general, which is consistent with literature that suggests an overall positive attitude toward wind energy (Simon 1996, Wolsink 2000, Ek 2005, Rickinson Group 2007, Ansolabehere and Konisky 2009). A strong positive correlation was found between levels of support for wind energy in general and support for the Ashtabula Wind Energy Center with 79% supporting wind energy in general and 78% of respondents expressing support for Ashtabula (See Table 1.4).

Respondents indicated an overwhelming level of support for wind energy development with 90% expressing the belief that wind energy production in North Dakota should be either encouraged and supported or allowed in appropriate circumstances. A consideration with this finding is that 37% of respondents stated it should be allowed in appropriate circumstances, but interpretation of what is appropriate will vary in meaning for different individuals. One individual may believe that construction near their property would be inappropriate and therefore be opposed to the project; another may feel that as long as wildlife habitats are not being disrupted, construction is appropriate (See Table 1.4).

Model 2: Advantages and disadvantages of wind energy

Perceptions of the advantages and disadvantages of wind farming had no significant bearing on public acceptance of the wind farm. Respondents in agreement with statements about the advantages of wind farming, but opposed to Ashtabula, may have formed their opinion on some other factor such as personal impacts or wind farm distance from their home.

In Smith and Klick's survey (2010) respondents were told that wind energy decreased dependence on foreign energy. When asked to rate the importance of that advantage of wind energy, approximately 78% considered it to be very important. In my survey, respondents were asked whether they agreed with the statement that wind energy production would decrease our dependence on foreign energy sources, and 83% either somewhat or strongly agreed (See Table 1.7). The North Dakota Energy Survey (Bureau of Governmental Affairs 2006) found that 93% of respondents agreed, either somewhat or strongly, that the best way to decrease dependence on foreign oil was to increase renewable energy production and conserve energy. As oil comprises the majority of our foreign energy dependence, conservation of petroleum-based energy, such as automotive fuels, may decrease this dependence. However, as oil does not power the same energy sectors as does wind, increased wind energy production will not affect foreign dependence. These findings are indicative of a need for clarification of energy production and usage.

I found that the majority of respondents agreed that wind energy production would decrease human contributions to pollution (88%) and global warming (77%) (See Table 1.7), which Smith and Klick (2010) found to be the most important characteristics of wind energy (approximately 81% of respondents each). Also, 91% of respondents agreed with the statement that wind energy is a symbol of local, state and federal commitment to renewable energy (See Table 1.7), which was rated as a very important characteristic of wind energy by approximately 64% of the respondents in the national survey (Smith and Klick 2010). This perception may indicate an overall willingness of the public to support government-led or -backed wind energy initiatives, which is consistent with findings that 93% of North Dakotans surveyed believed that renewable energy should be a priority for the State Legislature (Bureau of Governmental Affairs 2006).

Model 3: **Perceptions of personal impacts**

Consistent with previous studies, which have shown that visual impacts are often cited as a reason for opposition to wind farm construction (Haggett 2008, Toke et al. 2008, Phadke 2009, Sibille et al. 2009), negative impacts on the view were most strongly related to level of support for Ashtabula. Despite this relationship, 62% of respondents disagreed with the statement that turbines are ugly and spoil the scenery of the local landscape (See Table 1.10). Also related to visual impacts was the perception that turbine flicker was bothersome, though this negative relationship only approached significance at $p<0.10$. A larger sample size may have increased the significance of this relationship (See Table 1.2).

Although the relationship between perceived noise impacts and support for Ashtabula approached significance at $p<0.05$ ($ß=-0.17$, $p=0.054$) (See Table 1.2), only 47% of respondents agreed that turbine noise could bother those individuals living near a wind farm (See Table 1.10). Results of studies addressing perceived noise impacts have been mixed.

A study was conducted of 100 residents in Cornwall, UK who had lived in the study area prior to a wind farm being built. Respondents were interviewed in 2001, after having lived near the wind farm for 14 years. Approximately 12% of respondents perceived turbine noise as more intrusive than they had expected prior to construction and 14% felt that noise was less intrusive than had been anticipated (Eltham et al. 2008). In this same study, one individual stated that it was no longer pleasant to sit outside due to turbine noise, while the respondent's neighbor was unsure if the noise was even detectible. In Scotland, only one of 115 respondents located from 0 – 10 km from a wind farm, found noise to be a negative impact. 15% of respondents had adopted a more favorable attitude after the wind farm had been built expressing that there was no noise impact (Warren et al. 2005).

There was no relationship between perceptions of lower property values and support for Ashtabula, however this corresponds with the findings that only 16% of respondents felt that the wind farm had negatively impacted property values (See Table 1.10). Hoen et al. (2009) studied the sales prices of 7,459 homes near ten different wind facilities around the country. They found no statistical difference in home prices within 10 km of the wind farm, and though some individual homes or a small number of homes may have had decreased sales prices, those results were not significant enough to be measurable.

Model 4: Impacts on community and environment

There was mixed support for the hypothesis that perceptions of negative impacts to the community and environment would predict decreased support for Ashtabula, as only four of the nine measured variables were significant at $p<0.05$ (See Table 1.2). Respondents that perceived positive impacts on local hunting indicated a greater level of support for Ashtabula. While hunting is a common pastime in North Dakota and it is likely that support would be high for something that is perceived to improve hunting conditions, it is unknown as to why respondents felt that hunting had been positively impacted.

Those who felt that Ashtabula had had positive impacts on the local economy and residential electricity rates expressed greater support for the wind farm. A frequently made comment was that the improved economy was a very localized effect, which benefitted only those people who received subsidies for turbines sited on their land. Despite this perception, 83% (See Table 1.13) felt that the economy had been positively impacted, which may suggest that improved economic conditions for even a few individuals may have a considerable economic impact, particularly in smaller, rural towns. Impacts to local crops and pastures and property values were not correlated with impacts on the local economy. This reinforces the findings that most residents perceived these items as having had no impact, as income from crops as well as property values are likely closely tied to the local economy.

Despite the negative relationships between visual impacts and respondent support for Ashtabula found in Model 3, no relationship between perceived impacts to the aesthetics of countryside and support for the wind farm was found in this model (See Table 1.2). This variable was phrased differently between models. In Model 3, 47% (See Table 1.10) of respondents either agreed or strongly agreed with the statement "Wind turbines are ugly and spoil the scenery of the local landscape" (Appendix C: Q15). When asked to rate the "Impact on the aesthetics of countryside" (Appendix C: Q5g), 32% of respondents stated that there had been a negative or very negative impact and 45% stated that there had been no impact (See Table 1.13). A possible explanation for the difference in these findings is that respondents may not have understood what was meant by aesthetics. It is also possible that the word "ugly" was found to be more severe than people were comfortable using.

Although Model 3 found no relationship between impacts on property values and support for Ashtabula, a positive relationship was found in this model ($ß=0.19$, $p<0.05$) (See Table 1.2). Respondent's opinions toward wind farm impacts on property values were assessed in two ways. In Model 3, 17% of respondents agreed or strongly agreed with the statement "Wind turbines will lower local property values, harming local homeowners" (Appendix C: Q16) (See Table 1.10), however, when asked to rate Ashtabula's "impact on property values," (Appendix C: 5h) only 9% of respondents rated the impacts as either negative or very negative (See Table 1.13). It is possible the language "harming local homeowners" made the negative impact feel more personal, resulting in a more negative perception of what an impact to property values might mean to them. Future studies may ask respondents to rate the impact on property values, followed by a question asking them to rate how harmful that impact would be to homeowners.

Job creation and tourism were not found to be predictors of respondent support for the wind farm. Respondents who gave reasons for this belief often stated that any positive impacts were fleeting, as the jobs created were lost once construction was completed. Similarly, tourists may go once to the area to observe the wind farm, but may not return to the area for that purpose. Smith and Klick (2010) found that 31% of respondents that were told that wind facilities increases tourism considered that to be an important characteristic of wind energy and 21% considered it very important.

Impacts on air quality did not predict support for the wind farm, however 79% of respondents stated that Ashtabula had not had an impact on air quality, which explains the lack of correlation (See Tables 1.2 and 1.13). Unless a wind farm is replacing a refinery or other power generating station, it is unlikely that there would be any immediate and localized change in air quality.

Model 5: Acceptance of wind farm construction

This scale was used to determine if the distance a wind farm is placed from a respondent's home is correlated with their level of support or opposition for Ashtabula. Support of wind energy in the United States, but opposition to a wind farm more closely located to personal property, would be consistent with literature that suggests that most people object to particular wind farms more often than to the idea of wind energy production in general (Warren et al. 2005, Wolsink 2007b).

Not surprisingly, respondents supporting construction of a wind farm within one mile of their home ($\beta=0.26$, $p<0.05$) expressed higher support for Ashtabula, as well as respondents who support construction in the county, in North Dakota and the Midwest. Oddly, the relationship between opposition to wind farm construction within five miles of a respondent's home and support for Ashtabula only approached significance at $p<0.10$ ($\beta=0.20$, $p=0.13$) (See Table 1.2). A possible hypothesis for this might be that turbines are not sited on a respondent's land and there is no financial benefit, however they may be sited closely enough to negatively impact the view.

Despite studies that indicate that NIMBY may not be a significant factor in wind energy support (Devine-Wright 2004, 2009, Kempton et al. 2005, Van der Horst 2007, Wolsink 2000), this model did show a relationship between the proximity of wind farm construction and respondent support for that wind farm. As the location for proposed construction moved from the United States to within one mile of a respondent's home, the averaged responses expressing support and strongly support (46%) decreased by 13.5%, while opposition rose 17.5% (See Table 1.16).

These findings are similar to those of Mills and Rosen (2006) that determined that as the turbines were proposed further from the shore, support grew and opposition lessened. Turbines proposed for construction located three miles from shore were supported by 38% of respondents with 28% in opposition; at 20 miles out, 57% favored the project and 14% were opposed. The main reason for opposition was that the wind project would be ugly (regarding a wind farm located 3 miles from shore, 20% expressed this opinion), however as the distance from shore increased, fewer respondents rated this as a negative factor (12% at 20 miles from shore). These findings suggest that proximity does have an effect on attitudes toward wind farms and the role that distance plays in public acceptance should continue to be studied. A more in-depth understanding could be had if respondents were asked to qualify their reasoning for increased opposition to construction near their home, rather than to make an assumption that they are simply opposed to it as a whole.

Model 6: Support of other sources of energy

The data did not support the hypothesis that support for other sources of energy would be negatively correlated with support for Ashtabula (H_6). As expected, support for wind energy in general was a strong predictor of support for Ashtabula, however support for solar, nuclear, oil or coal energy production did not predict decreased support for the wind farm.

It is unclear as to why respondents who supported hydroelectric energy were somewhat less likely to support Ashtabula (ß=-0.18, p=0.058) (See Table 1.2). North Dakota does not generate much energy from hydroelectric sources, which may suggest that respondents perceive hydroelectric impacts to be less negative than wind energy impacts. However, this hypothesis is inconsistent with in the MIT energy survey (Ansolabehere 2007), which found that 40% of respondents rated hydroelectric energy as not at all harmful and 71% rated wind energy production as not at all harmful. As that study was conducted across the United States, sampling may have occurred in areas with more hydroelectric and less wind energy production, which would lead to attitudes being based on direct experience, rather than presumptions of impacts.

North Dakota is a significant producer of coal and oil and the revenue from these sources is an important factor in the state's economy (EmpowerND 2010). It might be expected that support of oil and/or coal would be a strong predictor of decreased support for wind energy due to economic benefits or long-term ties to oil and coal industries. While support for oil and coal was negatively correlated with support for wind energy, it was not related to support for Ashtabula specifically. Ninety-five percent of respondents expressed support for wind energy, however only 69% expressed support for oil and 84% expressed support for energy supplied by coal (See Table 1.19). Much of the oil and coal production occurs further west than the study area and research on public attitudes toward wind energy development in that part of the state may lead to different findings.

The North Dakota Energy Survey (2006) found that 93% of North Dakota residents felt that renewable energy should be a priority, and 81% of respondents would support a law that mandated utilities to obtain 10% of their energy from renewable sources. This is consistent with my findings that respondents expressed the greatest level of support for wind, solar, hydroelectric and biomass as energy sources.

North Dakota produces 350 million gallons of ethanol from biomass each year, as well as being a significant producer of soybeans and prairie grasses which are used in the production of biodiesel (EmpowerND 2010). While the majority (73%) of respondents expressed support for biomass as an energy source (See Table 1.19), this is less than the BGA findings of 95% of respondents that stated that they agreed with growing crops for biomass production to replace petroleum diesel usage (Bureau of Governmental Affairs 2006).

It is possible that respondents who supported growing crops for ethanol production were more supportive of the potential revenue from biomass production than they were of the idea of ethanol in and of itself. Another explanation might be that the BGA survey asked respondents to state whether they felt it was or was not a good idea. Given an opportunity to answer with “don’t know” or “neutral”, the level of support may have fallen in that BGA study. Conversely, the 13% of respondents in my survey that expressed neutrality toward biomass production may not have been familiar with ethanol or how it is produced. If an explanation of biomass production had been given, it is possible that more respondents would have stated definitive support or opposition, rather than neutrality.

Model 7: Concern for wildlife

Though only 44% of respondents expressed concern about wind farm impacts to wildlife (See Table 1.22), agreement with this statement was strongly correlated with decreased support for Ashtabula (β=-0.34, $p<0.05$) (See Table 1.2). This is suggestive of an area that wind developers could concentrate efforts in educating the public to wind farm impacts on wildlife and potential mitigative measures. Of the 45% of respondents that believed that turbines could kill migratory birds, 46% believed the loss of those birds would be harmful to the environment (See Table 1.22).

Turbines kill passerines, waterfowl and raptors, though mortality rates vary between facilities. Wind farm placement may also disrupt established migratory routes and stopover sites. While studies have suggested that impacts are not significant for most avian populations, raptors are long-lived and have lower reproductive potential which makes it more difficult for them to recover from population losses (Osborn et al. 1996, Kuvelesky 2007).

Like raptors, bats are long-lived and generally produce only one pup per year. This study found that 26% of respondents felt that turbines could kill bats and of those, only 11% felt that this loss would be harmful to the environment (See Table 1.22). However, mortality rates at turbines, particularly along migration routes and ridge tops, range from 1 to 40 bats per turbine per year and scientists are concerned that bat populations may be unable to recover from those impacts (Kunz et al. 2007).

Bats are important predators of crop and disease-carrying pests and are excellent bioindicators of environmental quality (Jones et al. 2009), and although 45% of respondents agreed with the statement that bats play significant roles in the environment, this was not a factor in determining support for Ashtabula (β=0.10, n.s.) (See Tables 1.22 and 1.2).

While 75% of respondents believed that the protection of wildlife diversity was important, holding this belief did not predict support for Ashtabula (See Tables 1.22 and 1.2). This is likely explained by the findings that most people were not concerned about turbine-related wildlife impacts and did not feel that turbines posed a risk to birds or bats.

Model 8: Socio-demographics

No significant relationships were found between support for Ashtabula and age, marital status, level of education, political ideology, income or sex. This may suggest that the public is basing their opinions on their personal experiences with the wind farm, and that proximity or personal experience is a better indication of support. Age, however, was found to be a predictor of decreased support for Ashtabula at $p<0.10$ ($\beta=-0.16$, $p=0.70$) (See Table 1.2).

Several studies have found increasing age to be negatively correlated with support for wind energy projects. Ek (2005) found that older respondents were less likely to support wind energy production, and Firestone and Kempton (2007) found that the odds an individual would support the Cape Wind Project decreased by 3% for every year the individual's age increased. It was hypothesized that length of residence in the Cape may have been a factor in older residents' increased opposition. Conversely, in 2008 data suggested that older residents were more likely to support an offshore wind project in Delaware (Firestone et al. 2008).

Level of education did not appear to have a role in determining support for Ashtabula ($\beta=-0.14$, n.s.) (See Table 1.2). Ek (2005) found that respondents with a higher level of education were less likely to support wind energy, but that the relationship was not statistically significant. In the study of western North Carolina residents, education was not significantly related to a respondent's support for placement of turbines on ridge tops (Grady 2002). This would indicate that education does not lead to a greater understanding or acceptance of wind energy.

Model 9: All variables held constant

Wind farm location, rather than personal impacts, appeared to be the strongest predictor of support in this model, as three of the six significant variables addressed wind farm placement or location. Respondents who supported the placement of wind farms in the Midwest and in North Dakota were more likely to support Ashtabula. This may be important to study; as Model 5 suggested that the distance a wind farm was located from a respondent was a predictor of support.

Adverse visual and noise impacts were not correlated with opposition for Ashtabula, and the relationship between wind turbine flicker being perceived as a nuisance and support for Ashtabula only approached significance at $p<0.10$ ($ß=-0.13$, $p=0.13$) (See Table 1.27). Additionally, the only impact to the community or environment that was statistically significant was the impact on the local economy ($ß=0.19$, $p<0.05$). At the time of this research, a depressed economy had negatively impacted many communities across the country. This may have been a factor in influencing a respondent's concern about economic impacts.

The perceived advantages and disadvantages of wind energy production were not found to be predictive of support for Ashtabula. The energy survey conducted of North Dakota residents (Bureau of Governmental Affairs 2006) reported that 67% of respondents expressed concern about global warming, thus it could be hypothesized that the perception of Ashtabula as being beneficial in the reduction of anthropogenic influences on global warming would be correlated with level of support. However, this model did not find a correlation, despite the finding that 77% of respondents agreed that wind energy would reduce human contribution to global warming (See Table 1.7). The phrase "global climate change" may have elicited different responses, as it may hold a different connotation for some individuals.

Concern about impacts to wildlife was also no longer correlated with respondent support (See Table 1.27). The frequency of responses indicating concern for wildlife was quite low in model 7 (See Table 1.22) and the relationship was relatively weak (See Table 1.2), thus the increased number of variables held constant in this model may be an explanation of the lack of significance.

To increase understanding of the lack of significance between environmental concern and support for wind energy, it may be beneficial to assess what measures the public is willing to take to reduce human contribution to environmental impacts such as global warming, air pollution or impacts on wildlife. While these issues may be important to people, they may choose to externalize them, rather than risk experiencing negative, personal impacts.

Several items failed to exhibit significant relationships as they had in other models. Impacts to local hunting and support of hydroelectric energy were no longer correlated with support for Ashtabula. The reason for the significance of these items in previous variables was unknown. It is possible that a larger sample size or qualification from respondents on responses to impacts could help to explain these findings.

While relationships within individual models were strong, variables between models were not significantly correlated with each other, which may have attributed to some of the changes in relationships seen in this model. These changes may also suggest that when all factors are considered, location is the most important public concern in regard to wind energy. A larger sample size may draw out more significant relationships and allow for clarification of discrepancies between models.

General findings

The findings from this study indicate a high level of support for wind energy in general, as well as support for the Ashtabula Wind Farm. As North Dakota stands to significantly increase wind facility construction over the next five years, and likely beyond that, it is encouraging that the majority of respondents expressed support for wind production.

The strongest predictors of support or opposition were those areas in which respondents felt personally impacted. It is important to note that, although only 19% of respondents perceived turbines as spoiling the scenery and 47% felt turbines were noisy, these were strong predictors of opposition to the project (See Table 1.10). It would be very valuable to ask specific questions to in order to determine whether a respondent assumes that turbines are noisy or if they themselves are actually bothered by turbine noise. The findings that noise and visual impacts were significant predictors of support for Ashtabula, whereas global warming or reduction in pollution were not, may suggest that egoistic concerns play a more significant role in determining an individual's support for wind energy than do concern for impacts to wildlife or the environment (Schultz 2001).

This study provided valuable insight in formulating survey questions. It is difficult to compare results if the option to remain neutral is given in one study and not in another, as respondents may feel forced to answer a question for which they do not have a definitive opinion. Questions that evaluate a respondent's familiarity with the subject provide a more accurate understanding of findings. Additionally, the disparity in responses to items that were framed differently, but in essence were asking the same question, demonstrates how respondents may be guided depending on individual interpretation.

Suggestions for future studies

It would be valuable to conduct a survey with respondents who live near a proposed wind farm in North Dakota, so that findings might be compared with the results of this study. This would serve to identify perceptions that may be held prior to construction, but change after construction is completed. A pre-construction survey would also be an excellent baseline for a follow-up study with the same respondents to see how attitudes may or may not have changed after the wind farm had been located in that community for some time.

To create a more complete picture of why certain attitudes are held and how they are formed, it is recommended that a quantifiable study, such as this one, include questions with which respondents could explain their responses. Important data could be gathered by ascertaining if informational meetings about the wind project had been attended, where respondents get most of their information about wind energy (such as internet, television, newspaper or word of mouth) and what information respondents feel would be beneficial in terms of forming opinions about a wind farm.

It would also be beneficial to include questions that specifically address a respondent's understanding of wildlife impacts. It is difficult to definitively measure the relationship between a respondent's concern for impacts to wildlife and their support for Ashtabula, as responses may be based upon misconceptions or hearsay, rather than accurate information. This may assist wind energy developers in addressing public concerns early on in the development process.

Also, determining how far the respondent is located from the nearest turbine and how many turbines are in close proximity to their home would be valuable. This could serve to assess the role that NIMBY may play in forming support for a project, as well as to determine the distance at which negative impacts cease to be significantly related to support for the wind farm. This could be accomplished through survey questions and the use of Geographic Information Systems (GIS) analysis to create a detailed map depicting the correlation between perceived effects of, as well as support for, a specific wind farm as a function of distance.

It is clear that the public supports wind energy in general, however perceptions exist that could potentially influence the development of wind energy production. Data can be found in existing literature that address the issue of opposition to wind energy development as well as general levels of support for wind energy, however specific attitudes that influence support have not been measured.

The central component of this study was to identify specific attitudes that were important in determining support for an existing wind farm, as well as to measure the strength of those attitudes. The findings from this research present a valuable tool for understanding where opposition lies and how strongly the public supports or opposes a particular project. Additionally, the ability to assess and identify misconceptions will allow for the dissemination of accurate scientific information that might allay unfounded concerns and encourage public support of wind energy production.

CONCLUSION

While a great deal of public support for wind energy has been found both in this study and others, it has also been shown that some specific wind farms may face opposition. The public has a very unique perspective on wind energy production, as it is their community that is being impacted. Developers may view wind energy production solely from a business position and policy makers may not be located near the facility or have a connection to the community, thereby experiencing none of its potential impacts.

This study found that the public is concerned about being impacted personally and that the argument that wind energy is beneficial for the environment may not be strong enough to sway opponents to a position of support. Public support is required for accessing the land required to put up turbines, transmission lines and generation stations. Thus, a real need has been demonstrated for accurate studies that focus on public attitudes toward wind energy and provide direction for addressing publically held concerns. If a wind farm is to have the support of the public, it is clear that it will be important to demonstrate that their community and personal livelihood will not be negatively impacted and, if negative impacts are unavoidable, that those impacts will be mitigated so as to be as minimally intrusive as possible.

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PAPER 2. WIND ENERGY FACILITY IMPACTS ON NORTH DAKOTA BAT SPECIES

INTRODUCTION

The use of wind energy as a renewable source of energy has increased dramatically in recent years (Pasqualetti et al. 2004). However, there are biological implications that can delay or even halt the progress of this much needed and highly viable source of energy. It has been shown that wind farms can have substantial impacts on wildlife and wildlife habitats, and that bats are especially susceptible to injury and mortality near wind turbines (Baerwald et al. 2008, Horn 2008a).

Bat populations are currently facing threats such as White Nose Syndrome (WNS), a fungal disease significantly impacting cave-dwelling species, as well as possible population declines due to other ecological and anthropomorphic changes (Windhold et al. 2008). Bats have low reproductive rates, making rapid recovery from population disturbances difficult (Barclay and Harder 2003). In light of the rapid increase in wind energy production, it is imperative to understand the impacts these facilities can have on bat populations.

Negative Impacts of Wind Energy on Bats

The first wind energy–related bat fatalities in the United States were recorded during avian fatality searches at California facilities (e.g., Orloff and Flannery 1992, Thelander and Rugge 2000). Between 1996 and 1999, 184 bats were found at the Buffalo Ridge Wind Resource Area (WRA) in Minnesota. Of the 163 that could be identified to species, 66% of the carcasses were hoary bats (*Lasiurus cinereus*), 23% were eastern red bats (*Lasiurus borealis*) and the remainder consisted of silver-haired bats (*Lasionycteris noctivagans*), eastern pipistrelles (*Pipistrellus subflavus*), little brown bats (*Myotis lucifugus*) and big brown bats (*Eptesicus fuscus*) (Johnson et al. 2003a). Further data collected by Johnson et al. (2004) at 281 turbines in the Buffalo Ridge WRA found an estimated mean of 3.02 fatalities per turbine in 2001 and 1.30

fatalities per turbine in 2002.

The significance of wind energy impacts on bat populations became apparent when 475 bat carcasses were found during avian searches at the Mountaineer Wind Energy Center in West Virginia in 2003. An estimated 2,092 bats were killed at the study site (adjusted for searcher bias and scavenger removal rates), with 92.5% of the carcasses found during the fall migration period (Kerns and Kerlinger 2004). At the Buffalo Mountain Wind Farm in Tennessee, which was comprised of three turbines on an isolated mountaintop, an estimated 20.82 bats were killed per turbine per year from 2000-2003 (Fiedler 2004). Fatalities have continued to be documented at Buffalo Mountain (Fiedler et al. 2007) and Mountaineer (398 in 2004).

Major impacts have been consistently shown at wind facilities across the country. A study conducted at the Judith Gap Wind Energy Center in Montana estimated 1,206 bats were killed during the study period (August 2006 – October 2006 and February 2007 – May 2007), with 97% percent of fatalities occurring during fall migration (TRC Environmental Corporation 2008). At the Meyersdale Energy Center, near Meyersdale, PA, there were 262 fatalities documented during a six-week study period in 2004 (Kerns et al. 2005). At the Blue Sky Green Field Wind Energy Center, in Fond du Lac County, Wisconsin, a study conducted between the fall 2008 (July 21 – October 31) and spring 2009 (March 15 – June 6) found a total of 247 fatalities (242 in 2008 and 5 in 2009), which was calculated to be an estimated 40.54 fatalities per turbine (Gruver et al. 2009).

Research that synthesized fatality data from 21 post-construction fatality studies showed that the species experiencing the highest number of fatalities at turbines are hoary bats (*L. cinereus*), silver-haired bats (*L. noctivagans*) and eastern red bats (*L. borealis*) (Johnson 2005, Cryan and Brown 2007, Kunz et al. 2007a). These tree-dwelling species exhibit fall migratory behavior, moving from Canada and the northern United States to the southern United States (Findley and Jones 1964, LaVal and LaVal 1979, Izor 1979, Koehler and Barclay 2000, Cryan 2003), although little is known about specific migratory patterns or corridors. Research has shown that fatalities are consistently highest during the fall migration period of late summer and fall (Johnson 2005, Cryan and Brown 2007, Arnett et al. 2008).

Advancements in Understanding and Mitigation

Causes of fatalities. In recent years, a clearer picture has developed as to why bats are so readily killed at wind energy facilities. Through the use of thermal infrared cameras at the Mountaineer Wind Energy Center, researchers observed that bats approached both rotating and non-rotating blades and would investigate and follow the blade-tips. Bats were shown caught in blade-tip vortices, as well as being directly struck by turning blades (Horn et al. 2008a).

In 2008, Baerwald et al. (2008) reported that barotrauma is a significant factor in wind facility related bat fatalities. Barotrauma occurs as a result of sudden or extreme changes in pressure. This sudden change in pressure causes an expansion of the air in the lungs, resulting in internal hemorrhaging. It is believed that bats experience such barotraumas when they enter undetectable areas of low pressure found at blade vortices. At a wind energy facility in southwestern Alberta, Canada, evidence of pulmonary barotrauma was found in 90% of fatalities, while only half of the fatalities demonstrated signs of having been directly struck by turbine blades (Baerwald et al. 2008).

Reasons for fatalities. Despite progress toward understanding how bats are killed at wind energy facilities, little is known about why these bats even approach turbines. Several hypotheses have been posed to explain the apparent attraction of bats to wind turbines (Cryan and Barclay 2009).

One hypothesis explaining bat fatalities is that during migration, the odds of fatalities may be increased due to greater numbers of individuals passing through one area. Prior to fall migration, bats may exhibit increased flying activity while mating or feeding, which may result in higher mortality rates. The fact that migratory tree-roosting bats are the most susceptible to turbine-related mortality also suggests the possibility that individuals are attracted to turbines as they seek out the tallest tree in the landscape (Kunz 2004, Cryan and Barclay 2009).

It has also been hypothesized that the migratory or spatial patterns of the insects upon which bats prey may be a factor in fatality rates (Ahlén et al. 2009, Rydell et al. 2010). Rydell et al. (2010) suggest that migrating insects may fly at turbine height, thus drawing bats closer to the turbines during foraging. Further, if turbines are placed in regions where insects preferred by bats are abundant, the risk of turbine related fatalities might be increased (Kunz et. al 2007b).

Additional hypotheses propose the following as possible causes for fatalities: location of wind turbines in landscapes preferred by bats or the prey upon which they forage; the failure of bats to acoustically detect moving turbine blades; attraction to movement, sounds or heat produced by turbines; or disorientation due to turbine-produced electromagnetic fields (Kunz et al. 2007b, Cryan and Barclay 2009).

<u>Mitigation.</u> Bat activity is higher during low-wind nights and a positive relationship between fatalities and low wind speeds has been consistently demonstrated (Arnett et al. 2006, 2008, Redell et al. 2006). While the reason for this is not yet fully understood, it is suggested that high winds cause migratory movement to be less efficient (Baerwald et al. 2009a). Turbines typically begin operating when the wind reaches a speed of 4 m/second (cut-in speed). Increasing cut-in speeds mean that the rotors will not begin to turn and will not start generating electricity until the wind reaches the selected speed.

Researchers at the Casselman Wind Project in Pennsylvania (Arnett et al. 2009) found that by increasing the cut-in speed to 5 m/second, average nightly fatalities were reduced by 53 - 87%, with minimal loss to power production. In Alberta, Canada, Baerwald et al. (2009b) found similar results, with reductions from 50 - 70%. As power production is already reduced on low-wind nights, increasing the cut-in speeds at that time could significantly reduce bat fatalities without causing great economic loss to power companies. Because this experiment has been conducted only three times worldwide (Arnett et al. 2009), it will be necessary to conduct further research to determine consistent results in regard to impacts on bat populations, as well as economic impacts on power companies.

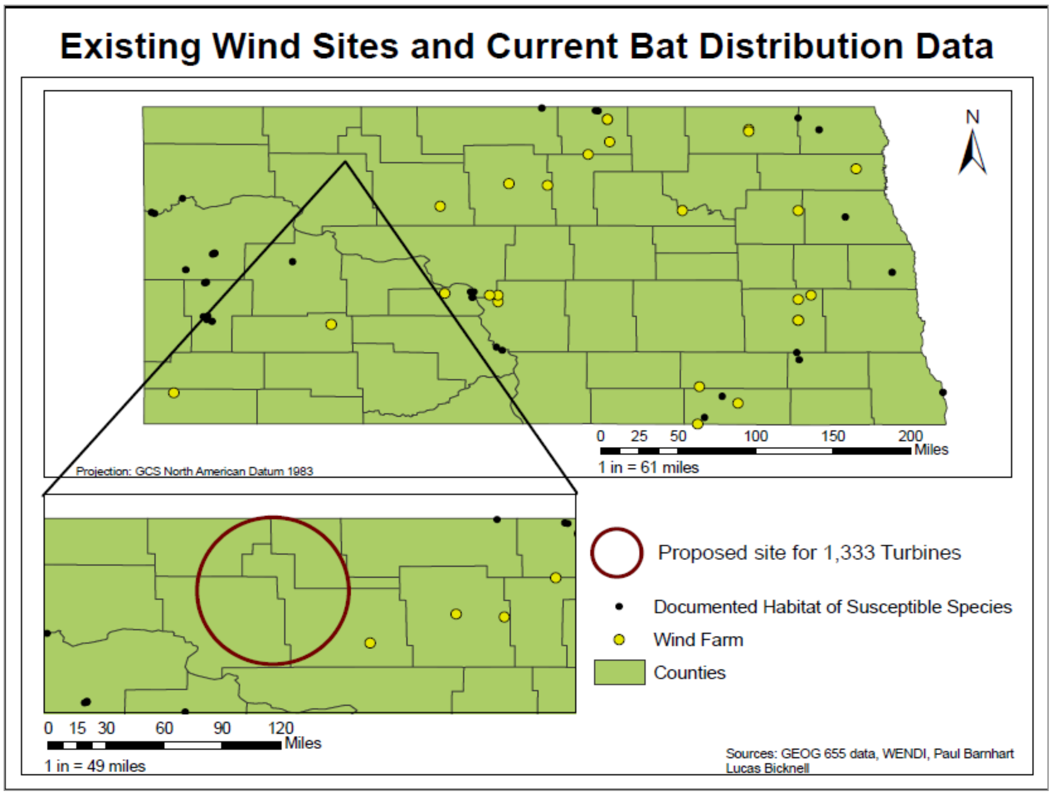
An additional method of mitigation that is being tested is the use of electromagnetic radiation pulses to disorient bats near turbines. One study found that bat activity was reduced in the presence of such pulses, though some bats did continue to forage in the study area. Signal attenuation may have been a factor and it is possible that bats may habituate to ultrasonic effects. Additional research is needed to determine if this would be a viable deterrent at turbines (Horn et al. 2008b, Nicholls and Racey 2009).

Need for Study

Due to the rapid development of wind energy facilities across the country, continued research is necessary to understand causes of turbine-related fatalities. A significant factor in being able to further understand wind facility risks to bat populations is the need for baseline data on the distribution of bat populations and an increased understanding of the migratory patterns and behavior of bats (Larkin 2006, Arnett et al. 2006). Also of concern is the possibility of cumulative impacts as additional habitats and migratory corridors are altered (Kunz et al. 2007a).

The need for research in North Dakota is essential, as there is little data on species composition and distribution of bats in the state (Figure 2.1).

Figure 2.1 Existing wind facilities and current (March 2011) bat distribution data for North Dakota (Lucas Bicknell 2011).



Research is also lacking on migratory patterns and how local bat populations may be affected by major landscape modifications. Furthermore, no research has focused on assessing the impacts of wind energy on resident or migratory bat populations in North Dakota.

North Dakota currently has 1,424 MW in existing wind facility projects, with over 800 turbines erected in the past eight years and over 11,000MW in proposed construction (American Wind Energy Association 2011, Energynd 2011). The Hartland Wind Farm alone, proposed in Northwestern North Dakota, will consist of over 1,300 turbines when completed (Hartland Wind Farm 2008).

This rapid increase in wind energy facilities across the state indicates a critical need for research. Red bats, hoary bats and silver-haired bats, as well as other species impacted by wind facilities, are known to be present in North Dakota. All bats resident in North Dakota during the summer migrate in the late summer and early fall, which has been found to be a consistent factor in increased fatalities at turbines. High mortality rates at wind turbines could have potentially significant impacts on bat populations due to slow reproductive rates and long lifespan (Wilkinson and South 2002, Kunz et al. 2007a, Winhold (2008) has suggested that a current decline in red bat populations, coupled with the propensity of this species toward wind facility mortality, is cause for concern.

It is essential to gather baseline data on the activity levels, distribution and composition of local bat populations, as well as to assess any potential wind facility impacts, so that changes to populations may be monitored and where necessary, mitigation measures may be taken to decrease any impacts found.

Research objectives

The objectives of my research were to determine the composition of the local bat community and activity levels at pre- and post-construction wind facility sites in North Dakota, as well as to determine mortality rates at the post-construction site. Specifically, I conducted acoustic monitoring and mist netting to determine bat populations and activity levels at the proposed Merricourt Wind Power Project in south-central North Dakota. I also conducted acoustic monitoring and carcass surveys at the Tatanka Wind Facility, which has been operational since 2008. The information acquired from this research will be beneficial in determining placement of wind farms, in addition to identifying needs for the implementation of mitigation measures to reduce habitat loss and bat mortality. Additionally, all data gathered with reference to species distributions and activity levels will be added to a database of bat populations in North Dakota for future reference and study.

METHODS

Pre-Construction

Study Area. The study area for the pre-construction survey was at the proposed Merricourt Wind Power Project (hereto after referred to as Merricourt) in southeastern North Dakota. The facility is proposed to cover 9,600 acres in the Drift Prairie region of North Dakota. Vegetative cover consisted mainly of agricultural crops such as soybeans, corn and grains. Prairie grasses dominated the majority of non-agricultural land and the topography was primarily flat prairie land with some low grade, rolling hills. Tree cover was limited to shelterbelts around farmsteads and few low-density tree stands at some water edges. There are many sloughs and lakes (Bluemle 1979) in the area, consequently many low-lying areas were poorly drained and portions of the study area were under water and inaccessible at times.

Merricourt is proposed to be comprised of 100 1.5-megawatt (MW) General Electric wind turbines standing 80 meters high and was scheduled to be operational by the end of 2011 (Xcel Energy 2011). However, on April 1, 2011, Xcel Energy (Minneapolis, MN, USA) terminated its contract with enXco Energy (San Diego, CA, USA) due to potential impacts on whooping crane and piping plover populations in the area (Securities Exchange Commission 2011). The Dakota Public Service Commission has given enXco the final approval to build the Merricourt Wind Power Project once the dispute between enXco and Xcel is resolved (enXco 2011).

The Merricourt study area is located approximately ten miles southwest of two existing wind facilities. North Dakota Wind I, the first wind farm in North Dakota, became operational in 2003 with fourteen turbines and North Dakota Wind II, added an additional twenty-nine turbines. It is important to note these turbines when considering the potential for cumulative impacts on bat populations in the area.

While research is currently lacking on the distribution of bat species in North Dakota, five species are known to occur in this area of the state (Seabloom 2011): 1) *E. fuscus*, 2) *M. lucifugus*, 3) *L. borealis*, 4) *L. noctivagans*, and 5) *L. cinereus*. Among these are the three species shown to have the highest turbine-related mortality rates amongst bat species of the United States (Kunz et al. 2007a, Cryan and Brown 2007, Johnson 2005).

The pre-construction survey at Merricourt was conducted during the fall migration period from July 27, 2009 to September 15, 2009, as previous research has shown that turbine-related kills are highest in this time period (Johnson 2005, Fiedler 2004, Johnson 2005, Kern and Kerlinger 2004, Cryan and Brown 2007, Fiedler et al. 2007, Kunz et al. 2007a, Arnett et al. 2008). All pre- and post-construction study methods were approved by the North Dakota Game and Fish Department, the NDSU IACUC office (A0941), and met the standards of the US Fish and Wildlife Service and the Endangered Species Act.

Mistnetting. Surveys consisted of erecting mistnets along edges, across open water, atop earthen mounds or along shelterbelts. Mistnets were 36mm long, 10-meter high mesh nets of variable widths (9m, 12m or 18m), depending on the topography of the location. Nets were raised after sundown and checked for bats every ten minutes for approximately four hours.

Acoustic Recording. Passive acoustic monitoring was conducted at seven sites within the study area. Echolocation calls were recorded with two AnabatSD1 detectors and Zero Crossing Analysis Interface Modules (ZCAIMs; Titley Electronics, Ballina, NSW, Australia) using compact flash (CF) cards for file storage. Anabats use zero-crossing analysis to count the number of times a zero voltage level is crossed by an incoming waveform and converts the resultant signal into a sine or square wave (Parsons et al. 2000). Frequency division uses a predetermined ratio to divide the frequency of that incoming signal, thus lowering its frequency and converting the calls into audible signals. My detectors were set to a division ratio of 16, which measured every 16^{th} crossing, retaining much of the original signal without excessive dilution of that signal (Corben 2004). Unlike time expansion detectors, frequency division allows for continuous, real-time recording.

Anabat detectors were housed in weatherproof Rubbermaid tubs fitted with a 4" in diameter polyvinyl chloride (PVC) 45° elbow. Holes were drilled into the bottom of the elbow to allow for water drainage and the broadband microphone was positioned toward the PVC elbow (O'Farrell 1998, Britzke et al. 2010). This method effectively protected the units from the elements, while allowing for efficient recording. The Anabat detector was powered by a 12v battery and programmed to turn on at 1930 and off at 0730 each day. Sensitivity of the Anabats was adjusted to '6' in order to record the highest quality bat calls, while minimizing the recording of extraneous noise (Johnson et al. 2004).

The Anabats were placed at a variety of locations throughout the study area. At each site, I recorded information about the location of the detector, including GPS coordinates, height of the detector from ground level and local weather conditions. After a detector had been at a location for approximately one week, data was downloaded and the unit was moved to another location.

Data Analysis and Species Identification. A bat call was defined as a single, recorded vocalization. A sequence was defined as calls produced consecutively in series. It was assumed that a single individual produced a series of calls on a single pass (O'Farrell et al. 1999). Data gathered from AnabatSD1 detectors were uploaded to a Dell Latitude laptop (Dell Inc., Round Rock, TX, USA) using CFCRead v. 4.2 and analyzed with ANALOOK 4.9g (Titley Electronics).

Screening filters developed and provided by E. Britzke were used to clean files of noise unrelated to echolocation calls. The first filter marked all files that did not contain bat calls (Britzke and Murray 2000). When irrelevant noise files had been deleted, an additional filter was used to remove noise from files containing echolocation calls. Of the remaining files, only files containing greater than three calls were analyzed. Values of ten parameters were measured for each call within a sequence (Table 2.1).

Table 2.1 Acoustic parameters measured by ANALOOK.

Call Parameter	Description
Dur	Duration of the call
S1	Initial slope of the call
Sc	Slope of the call body (flattest section of the call)
Fmax	Maximum frequency
Fmin	Minimum frequency
Fmean	Weighted mean frequency
Tk	Time from initiation to call knee (point where S1 changes to Sc)
Fk	Frequency of the call knee
Tc	Time from initiation to Fc is reached
Fc	Characteristic frequency of the call body

The number of bat calls recorded each night was used to define a general level of bat activity and trends in activity throughout the night were noted. Information about minimum temperature, maximum temperature, precipitation and wind speed at time of recording was obtained from the archives at Weather Underground (Wunderground 2009) and used to examine possible relationships between general activity and local weather.

A custom source code and call library developed by E. Britzke that was based in program R (v. 2.7.2., packages class and mda; http:/www.r-project.org) (Britzke et al. 2011) was used to identify calls to species. The call library consisted of 6,262 calls produced by the five species known to inhabit in the study area. Calls were recorded from bats that had been captured, positively identified and then released comprised the call library.

To identify sequences to species, each call within a sequence was individually identified to species. The species identified most often within a sequence was assigned to that sequence. When no one species was identified as occurring more frequently than any other, the sequence was considered unidentifiable and not used analysis.

Post-Construction

Study Area. Post-construction assessment took place in the North Dakota portion of Tatanka Wind Farm (hereto after referred as Tatanka), which is located in a region covering approximately 14,000 acres along the North Dakota/South Dakota border. Tatanka is located in the Missouri Coteau region, in which elevations range from 546 m to 610 m above sea level (Bluemle 1979). Vegetation types consist primarily of pasture and Conservation Reserve Program (CRP) grasslands. Other vegetation consists of deciduous shelterbelts, as well as tree stands around farmlands, wetlands and springs. Although these stands are very rare, there are several heavily treed areas surrounding underground springs. Transmission lines, farmsteads, gravel county roads and gravel turbine maintenance roads are also present within the wind energy facility. The North Dakota portion of Tatanka Wind Farm consists of sixty-one 1.5MW turbines. The turbines are 80 meters tall and have a rotor diameter of 77 meters (Acciona-NA 2011).

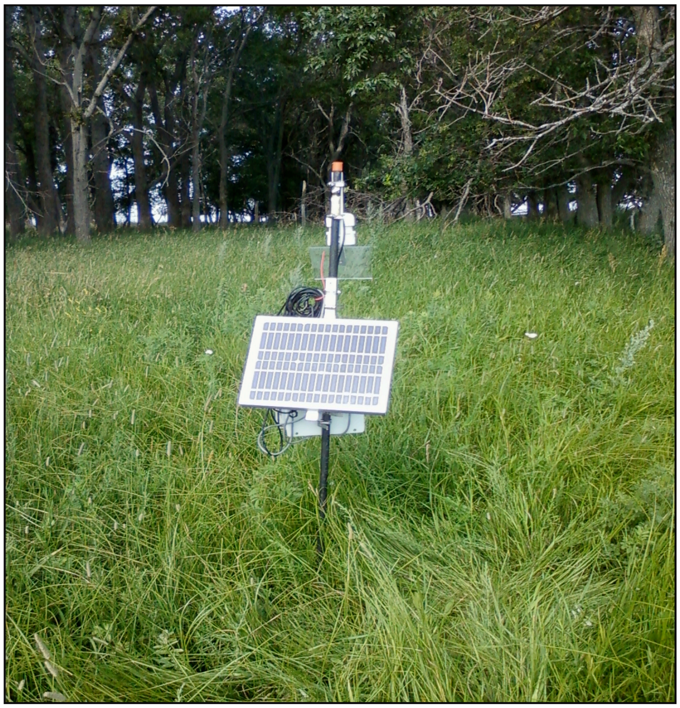
Acoustic Monitoring. Active monitoring was conducted with a Pettersson D240x ultrasonic recorder (Pettersson Elektronik AB, Uppsala, Sweden) and Iriver (Iriver House, Seocho-Gu, Seoul, Korea) (July 18 through July 31), or an H2 Handy Recorder (Zoom Corporation, Kanda-surugadai, Chiyoda-ku, Tokyo 101-0062, Japan) (August 7 and 8, and August 21 through September 12). These time expansion detectors store recorded calls in digital memory and then broadcast the signal back at rate ten times slower than the rate at which they were recorded (Keunzi and Morrison 1998). Sounds were captured for 1.7 seconds and then broadcast at an expansion rate of 17 seconds. During the time expansion broadcast, new incoming calls could not be recorded (Britzke 2003).

Bat activity was recorded at potential bat foraging and roosting sites in the study area. Sites selected included preferred habitats such as tree stands, shelterbelts or buildings. As these habitats were few in number and permission was not attained from some landowners, very few such areas were available for monitoring. Thus, active monitoring occurred at five sites over the study period. Monitoring began at sunset and continued for three to four hours.

Passive acoustical monitoring was conducted with two AnabatSD1 detectors and Zero Crossing Analysis Interface Modules (ZCAIMs; Titley Electronics, Ballina, NSW, Australia) using compact flash (CF) cards. Anabat detectors were placed in weatherproofed Rubbermaid tubs (see pre-construction methods) or used with the Bat-Hat system (BatHat; EME Systems Inc., www.emesystems.com; Arnett et al. 2006). The Bat-hat system encased the Anabat in a metal, weatherproof housing and was powered by a 5w solar panel (Figure 2.2).

Bat activity was passively recorded at six locations during the post-construction study. Detectors were placed at or near potential bat foraging and roosting sites in the study area and left for one week. At the end of the week, data was removed from the CF card and the detector moved to a new location. Detector distance from turbines was recorded using GPS and topography maps. Types of vegetation, potential roosting sites and approximate distance to water sources was also documented. Detectors were set to record from sunset to sunrise. Data analysis and species identification methods are the same as described above for calls captured on the Anabat system.

Figure 2.2 Bat-hat system for Anabat detector (Lucas Bicknell 2011).



Data analysis and species identification. Calls recorded by the Pettersson detectors were uploaded to a Toshiba Satellite laptop (Toshiba America Information Systems, Inc., Irvine, CA), converted to .wav files with GoldWave Digital Editor 5.85 (GoldWave, Inc., St. Johns, NL, CAN) and analyzed for species identification with Sonobat 3 software (J. Szewczak, DNDesign, Arcata, CA). Sonobat 3 uses Fast Fourier Transformation (FFT) to display each call as a full-spectrum sonogram. The program then measures 72 parameters, such as the lowest and highest frequency, as well as the duration of the call, to characterize the call structure. A series of algorithms is then used to compare call parameters to a built-in reference library to identify the call to species. Sonobat 3 combines each identified call with the probability that it occurs in a sequence of calls, resulting in an overall probability of that call sequence identification as being correct (Sonobat 2011).

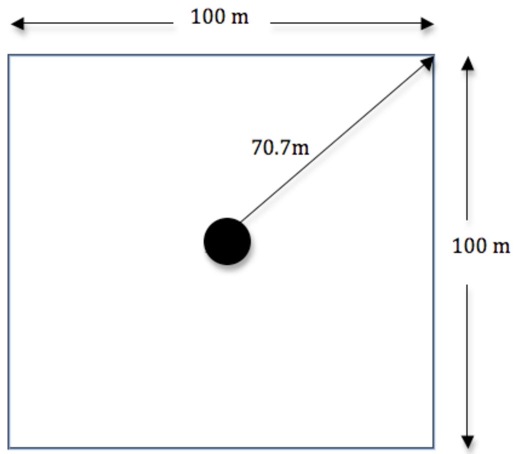
All calls not identified by Sonobat 3 were then analyzed with Avisoft SASLab Pro software, version 4.2 (Raimund Specht, Berlin) for identification to species. Weak calls, where identifying start and end points was difficult to assess, were excluded from analysis. To create spectrograms, I used a Hamming window with a 1024 FFT, a frame of 100% and an overlap of 93.75% (Jung et al. 2006). Extraneous noise was filtered out from each file. The parameters measured for each call were minimum, maximum and peak frequencies as well as call duration. I measured each call with the 'bound cursor' feature by marking the beginning and ending of each call where energy was the greatest (Jung et al. 2006). All calls within a sequence were measured and the parameter averages were used to identify species using known echolocation call characteristics.

Fatality Searches. Personnel involved in fatality searches received safety training from Acciona personnel prior to starting the study. Fatality searches were conducted at 12 of the 61 turbines at the ND Tatanka Wind Farm. Each turbine was searched every seven days from July 23 to September 19, 2010 however, no turbines were searched between August 11 and 20. Two turbines in the study area, T14 and T61, were excluded from searches on September 10 due to sudden heavy rain and lightning.

Turbine sites selected for carcass searches included various habitat and vegetation types and were representative of the whole wind farm. Densely vegetated plots, plots covered by extensive water or fencing, or lack of landowner permission made some plots not feasible for sampling.

A measuring wheel, handheld Magellan 2000 GPS unit (MiTAC Digital Corporation, Santa Clara, CA, USA) and magnetic compass were used to create 100m x 100m square plots. Plots were centered on the turbine to ensure that a minimum of 50 meters around the turbine was searched in all directions (Figure 2.3).

Figure 2.3 Drawing of search area around turbine (Lucas Bicknell 2011).



Studies conducted at other wind farms suggest that the majority of carcasses are found within 40 meters of the turbine (Johnson et al. 2003a, b, Johnson et al. 2004, Anderson et al. 1999). Parallel transects 100 meters in length were marked by flags every 6 meters, with a maximum searching distance of 3 meters on each side of the transect.

Searches were conducted each day beginning at sunrise. Total search time ranged from 45 to 70 minutes per turbine, depending on the habitat type and topography. All carcasses were photographed as they were found and a waypoint was recorded on the GPS unit. The condition of each carcass found was recorded using the following categories (Johnson et al. 2004):

1 = Intact – a completely intact carcass, not badly decomposed, no evidence of being scavenged.

2 = Scavenged – an entire carcass, which shows signs of being scavenged, or some amount of remains.

3 = Decomposition – some degree of decomposition had occurred. Insect presence was also noted

Recorded data included: date and time collected; turbine; species; sex when possible; condition (e.g., intact or scavenged); visible injuries, such as a broken wing or limb; distance and direction from the turbine; and distance from transect. All carcasses found were labeled, triplebagged and frozen for further examination in the lab. Unique numbers were created for each specimen using turbine number, date, and number order in which the bat was found in relation to all other specimens: for example, T217242010-1 would indicate that at turbine 21 on July 24, 2010 the first bat was found. In addition to active carcass searches, non-study personnel such as Acciona employees or landowners, informed me about the presence of bat casualties discovered at turbines.

Minimum and maximum temperature, precipitation amounts, visibility and wind speed from the previous nights were obtained from Weather Underground archives (Wunderground 2010).

Carcass Removal Trials. Carcass removal trials were conducted to estimate the length of time bat fatalities remained in the search area before being scavenged. The trials were conducted at a randomly selected turbine location, which was consistent with the vegetation type and density found throughout the study area. As no bat or bird carcasses were available for this study, removal trials were conducted with four previously frozen mice carcasses and two previously frozen rat carcasses. On average, mice carcasses weighed 8 grams and rat carcasses weighed 10 grams. These are similar to the average mass of the bat species found in the study area.

Carcasses were placed randomly within the plot. To simulate how carcasses might fall, one mouse and one rat were placed in full view, an additional mouse and rat were placed under vegetation and two mice were placed partially under vegetation. Each trial carcass was recorded as a GPS waypoint and was checked for a period of 28 days to determine removal rates. Carcasses were checked at sunrise on days 1 and 2, and then on days 7, 14, 21, and 28. At the end of the 28-day period any remaining carcasses were removed (Johnson et al. 2003a).

Searcher Efficiency Trials. To correct for potential detection bias in the determination of overall number of fatalities, a searcher efficiency trial was conducted to estimate the number of carcasses that were not located during searches (Johnson et al. 2003a, b, Johnson et al. 2004, Gruver 2009). The searcher efficiency trial was conducted in a field near North Dakota State University with a vegetation community similar in species composition, height and heterogeneity as the turbine sites at Tatanka Wind Farm. I replicated a study area 100m x 100m square plot with flags marking transects every 6 meters on the north and south sides of the plot. An independent researcher placed 10 previously frozen bat carcasses at random locations within the plot and marked them with GPS waypoints using a Garmin eTrex handheld GPS unit (Garmin International, Inc., Olathe, KS, USA). Carcasses used were big brown, little brown and silver-haired bats ranging from 8-12 grams in mass, which were slightly smaller than the carcasses found at the study site. Carcasses were placed so that they were completely exposed, hidden by vegetation or partially hidden by vegetation in order to replicate the possible placements of carcasses recovered at turbines (Johnson et al. 2003a). The number and location of the trial carcasses found during the carcass search were recorded. Upon completion of the trial, I was informed as to the number of carcasses placed in the plot.

Statistical Methods. Estimates of the number of fatalities per turbine per year at a given site, known as annual facility fatality rates, are based on the following (Derby et al. 2007, Gruver et al. 2009):

1) Observed number of carcasses found during standardized searches during the study period;

2) Scavenger trial results, which estimated the average probability a carcass is expected to remain in the study area and available to be found; and

3) Searcher efficiency results, which determined the proportion of planted carcasses found by searchers

The following variables were used in the equations below (Derby et al. 2007, Gruver et al. 2009):

c_i the number of carcasses detected at plot *i* for the study period of interest (e.g., one monitoring year), for which the cause of death is either unknown or is attributed to the facility

n the number of search plots

k the number of turbines searched (including the turbines centered within each search plot)

c the average number of carcasses observed per turbine per monitoring year

s the number of carcasses used in removal trials

s_c the number of carcasses in removal trials that remain in the study area after 30 days

s_e standard error (square of the sample variance of the mean)

t_i the time (in days) a carcass remains in the study area before it is removed, as determined by the removal trials

$\bar{t}$ the average time (in days) a carcass remains in the study area before it is removed, as determined by the removal trials

d the total number of carcasses placed in searcher efficiency trials

p the estimated proportion of detectable carcasses found by searchers, as determined by the searcher efficiency trials

I the average interval between standardized carcass searches, in days

A proportion of the search area of a turbine actually searched

π^ the estimated probability that a carcass is both available to be found during a search and is found, as determined by the removal trials and the searcher efficiency trials

m the estimated annual average number of fatalities per turbine per year, adjusted for removal and searcher efficiency bias

Fatality Rates per Turbine. I calculated the number of fatalities per turbine per year (c) with the following formula:

$$\bar{c} = \frac{\sum_{i=1}^{n} c_i}{k \cdot A}$$

Carcass Removal Rates. The mean length of time a carcass remained before being removed by scavengers (t) was calculated with the following formula:

$$\bar{t} = \frac{\sum_{i=1}^{s} t_i}{s - s_c}$$

Annual Facility Fatality Rates. The annual fatality rate for the entire wind facility (m) was calculated using the following formula:

$$m = \frac{\bar{c}}{\hat{\pi}} \qquad \hat{\pi} = \frac{\bar{t} \cdot p}{I} \cdot \left[\frac{\exp\left(\frac{I}{\bar{t}}\right) - 1}{\exp\left(\frac{I}{\bar{t}}\right) - 1 + p} \right]$$

RESULTS

Pre-Construction

Mistnetting. Mistnetting was conducted for six nights throughout the 51-day study period. Due to rain, nets were closed early on one sampling night; therefore adequate sampling occurred at only five sites. No bats were captured during mistnetting attempts.

Acoustic Monitoring. I recorded 6,779 files on the two Anabat SD-1 units during the sampling period. One Anabat detector was damaged during the first week of the study, thereby limiting our data collection to one unit. From the two units, we obtained 621 sampling hours. After filtering and cleaning the 6,779 files of extraneous noise, 547 files were found to contain echolocation calls. High wind speeds can prompt the detector to record, leading to a high numbers of files containing non-bat related noise. Echolocation calls were recorded from July 27 to August 25, 2009, with no calls recorded after August 25. This suggests that most bats had migrated out of the area by the end of the study period. Bat activity was highest during late July and early August. The highest number of calls was recorded the night of August 3rd, with a total of 987 calls (Figure 2.4).

Significant variation in bat activity throughout the night was also noted throughout the study. Activity rose progressively from early evening, peaking near 1:00 am and then steadily decreasing throughout the morning (Figure 2.5).

Figure 2.4 Overall bat activity per night.

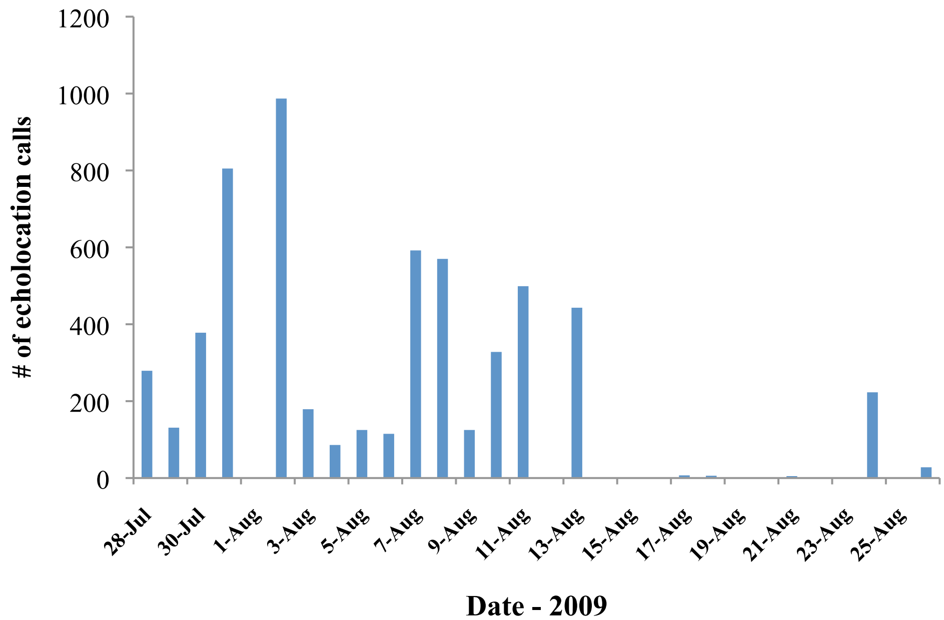
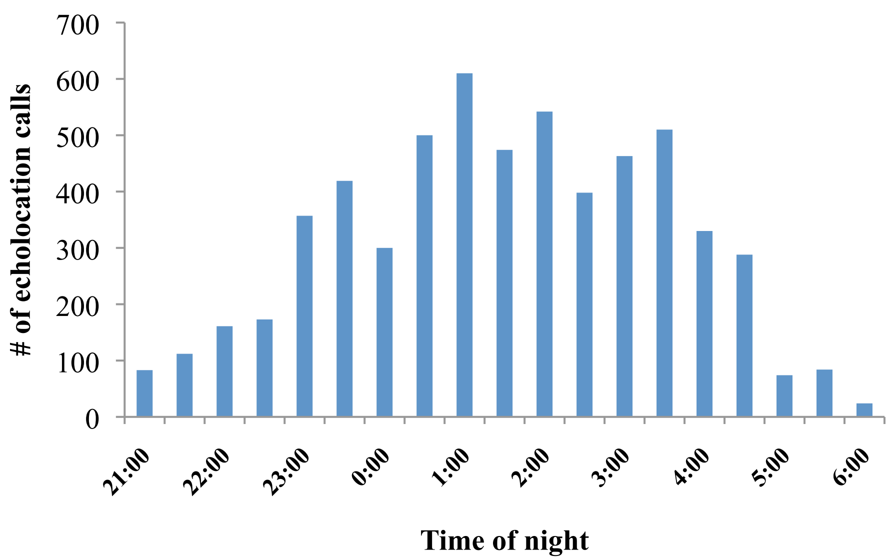


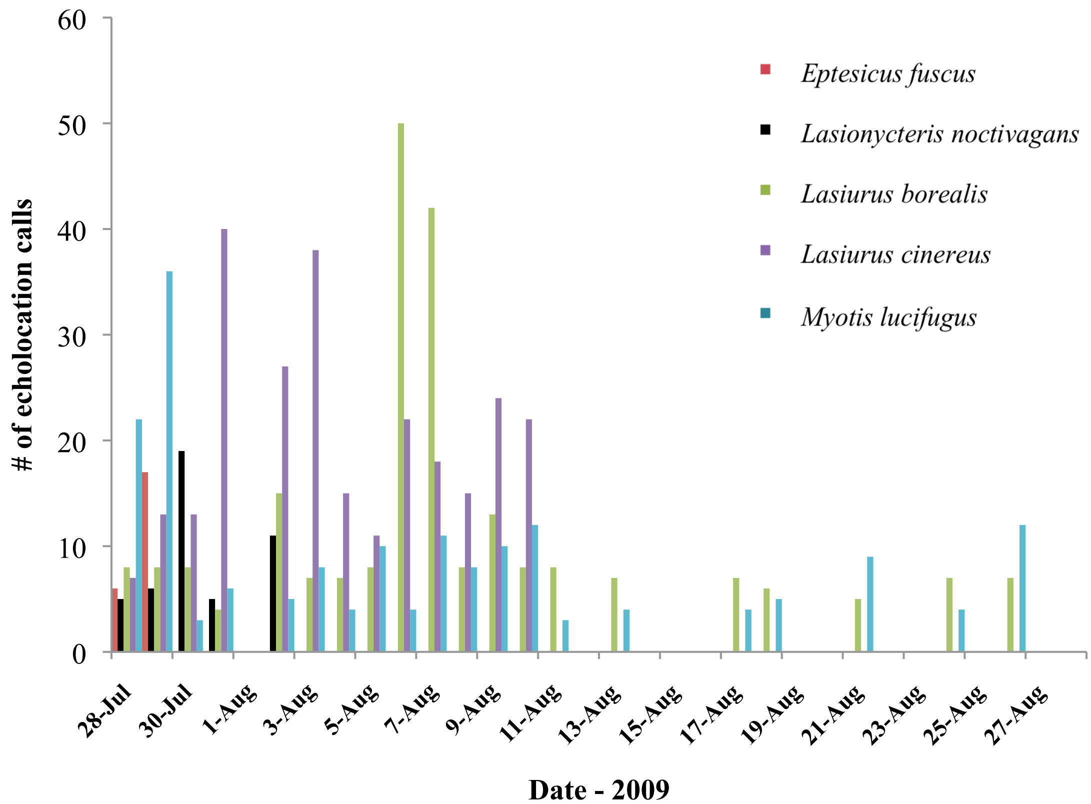
Figure 2.5 Bat activity throughout the night.



*Bat activity is defined as the number of recorded echolocation calls. All dates are pooled together and values reflect number of sequences recorded in a 30-minute period (ex. bar at 21:00 represents number of sequences from 21:00 to 21:29).

Five species were identified from the recordings: red bats, little brown bats, hoary bats, silver-haired bats and big brown bats. Diversity started off high at the start of the sampling period, with all five species represented in recordings until August 3. After August 8, only red bat and little brown bat calls were recorded (Figure 2.6).

Figure 2.6 Bat activity by species per night.



Activity was recorded over a wide range of climatic conditions such as temperature and wind speed, regression analysis of climatic variables and nightly call count showed no significant relationship.

I identified 547 call sequences to the species level. The majority of calls (86%) were attributed to red bats. The remaining calls were identified as little brown bats (10%), hoary bats

(2%), silver-haired bats (1%) and big brown bats (<1%) (Table 2.2). Cross-classification analysis indicated that the calls were accurately identified to species >90% of the time. High classification rates were demonstrated for red bats (99.9%) and little brown bats (100%); therefore confidence is high that these species are rarely misidentified (Table 2.3).

Table 2.2 Number of call sequences attributed to each of the five species known to occur in south-central North Dakota.

Bat Species	Call Sequences	% of Calls
Eastern red bat (Lasiurus borealis)	471	86%
Little brown bat (Myotis lucifugus)	57	10%
Hoary bat (Lasiurus cinereus)	12	2%
Silver-haired bat (Lasionycteris noctivagans)	5	1%
Big brown bat (Eptesicus fuscus)	2	<1%
TOTAL	547	

Table 2.3 Cross-classification rates for species identification analysis.

Actual	**Predicted**	**Count of actual**	**% of total**
Big brown	Big brown	2684	94.64
Big brown	Silver-haired	147	5.18
Big brown	Hoary	5	0.18
Silver-haired	Silver-haired	461	96.24
Silver-haired	Big brown	18	3.76
Red	Red	1340	99.33
Red	Little brown	9	0.67
Hoary	Hoary	115	88.46
Hoary	Big brown	15	11.54
Little brown	Little brown	1451	100.00

***** "Actual" column refers to the correct species identity, and "Predicted" refers to the species assigned to a call in the discriminant function analysis. "Count of actual" refers to the number of calls classified into each of these categories. From these values, the accuracy rate of the call library can be calculated ("% of total").

Post-Construction

Acoustic Monitoring. I attempted to gather passive acoustic data throughout the study period of July 18 to September 12, 2010. Due to damage to both Anabat SD-1 units, no calls were recorded on those instruments.

Active acoustic data was collected via a Pettersson D240x from July 18 through September 22, 2010, with no calls being recorded after July 30. After July 30, all files recorded with the Pettersson D240x contained only noise. Several files between July 18 and July 30 were recorded as inverted waveforms. It was determined that internal damage was preventing the equipment from recording properly. No calls were recorded on the H2 Zoom between August 7 and September 12, 2010.

One hundred and seventy-five files were recorded on the Pettersson system between July 18 and September 12, 2010, with 18 days being sampled in that period. Once all files were cleaned of extraneous noise, only 41 were attributed to echolocation calls.

Of files containing usable echolocation calls, 31 calls were identified to the species level (Table 2.4).

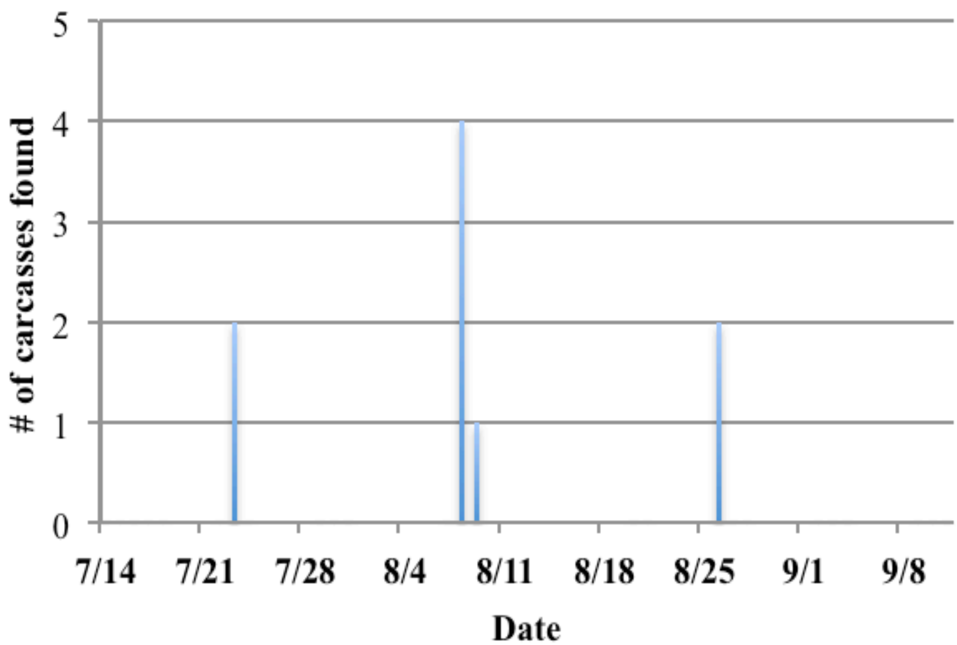
Table 2.4 Number of echolocation calls identified to species (post-construction).

Date	# of calls identified	Species
July 18, 2010	9	Red
July 19, 2010	11	Red
July 23, 2010	4	Red
July 24, 2010	5	Hoary
July 30, 2010	2	1-Hoary 1-Little Brown

Red bats accounted for 24 (77%) of the calls; six calls (19%) were attributed to hoary bats; and one (0.03%) to a little brown bat. Four files contained calls that could not be definitively identified and were discarded. The remaining six files that contained echolocation calls were visually and acoustically identifiable as bat calls, however due to significant waveform display errors that resulted from the Pettersson damage they could not be conclusively identified by Avisoft, Sonobat or manual identification.

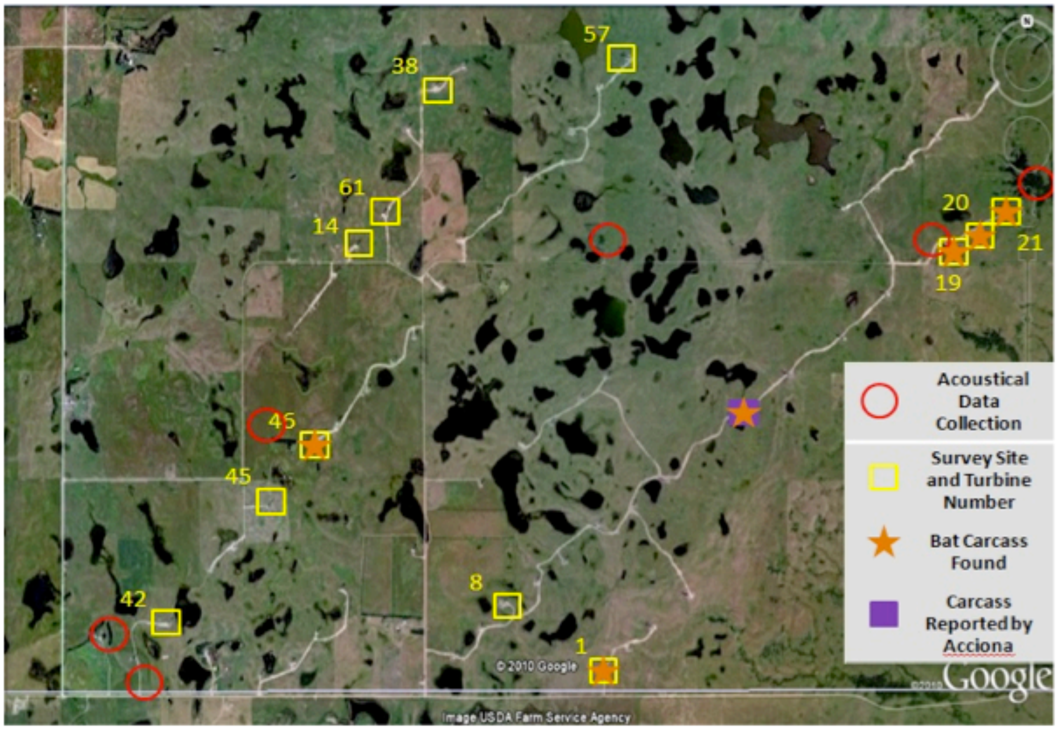
Carcass Surveys. Nine bat carcasses were found during the study period of July 23 through September 12, 2010 (Appendix A). The majority of carcasses (78%) were found between July 24 and August 10. No carcasses were found after August 27, 2010 (Figure 2.7).

Figure 2.7 Number of carcasses found during turbine searches.



Carcasses were identified to species as eight hoary bats and one silver-haired bat. A tenth bat was located by Acciona personnel and reported to me. Scavengers had removed the carcass before I arrived to collect it, so a photograph taken by Acciona personnel was used to conclusively identify the carcass as a hoary bat. This fatality was not used in analysis or in calculating overall fatality rates for the facility. Two female hoary bats and two male hoary bats were identified; the remaining carcasses could not be sexed due to scavenging or degree of decomposition. Carcasses were found at 5 of the 12 turbines (Figure 2.8).

Figure 2.8 Turbine, acoustic data collection and carcass locations (Lucas Bicknell 2011)**.**



The incidental find was found at a sixth location, turbine 15. The largest numbers of bats located at one turbine in one search period was two bats, which occurred at turbines 2, 20 and 21. The turbine at which the greatest number of carcasses was located was turbine 21, with three carcasses found over the entire study period. Carcass distance from the turbine base ranged from 1 to 38 meters, with an average distance of 9.7 meters from the turbine base. The incidental find was located directly on the concrete turbine pad. Carcasses were found an average of 1.3 meters from the transect, with a range of 3 meters (Table 2.5).

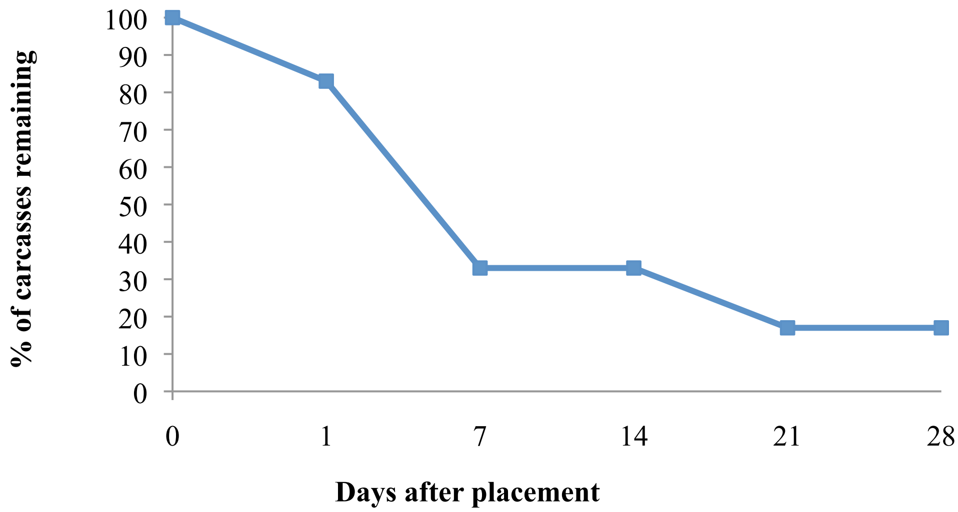
Table 2.5 Species of carcass found, location, distance from transect line and distance carcass located from turbine.

Turbine #	Species	Distance from turbine (m)	Distance from transect line (m)
21	Hoary	18	0.5
21	Hoary	1	2
21	Hoary	12	3
20	Hoary	2	1.5
20	Hoary	10	2
19	Hoary	38	2
46	Hoary	3	0.2
2	Hoary	3	0.5
2	Silver-haired	4	0

Of the nine carcasses found, three (33%) were fully intact, four (44%) had been scavenged by insects, one was found in water and had deteriorated extensively as a result and one was completely desiccated. Maggots were found in all but two of the intact carcasses and carrion beetles were scavenging one carcass when it was discovered. Due to their small size (<8mm) carrion beetles were presumed to be *Necrophila americana,* not the endangered burying beetle, *Nicrophorus americanus.*

Scavenger removal rates. Carcasses of four mice and two rats were used for scavenger removal trials during the study. The mean length of time that any carcass remained in the study area and was available to be found was 14.2 days. After one day in the field, one carcass had been completely removed. After seven days in the field, three carcasses remained and by day 28 (end of trial), only one carcass remained (Figure 2.9).

Figure 2.9 Percentage of scavenger trial carcasses remaining for detection between the 7-day intervals between carcass searches.



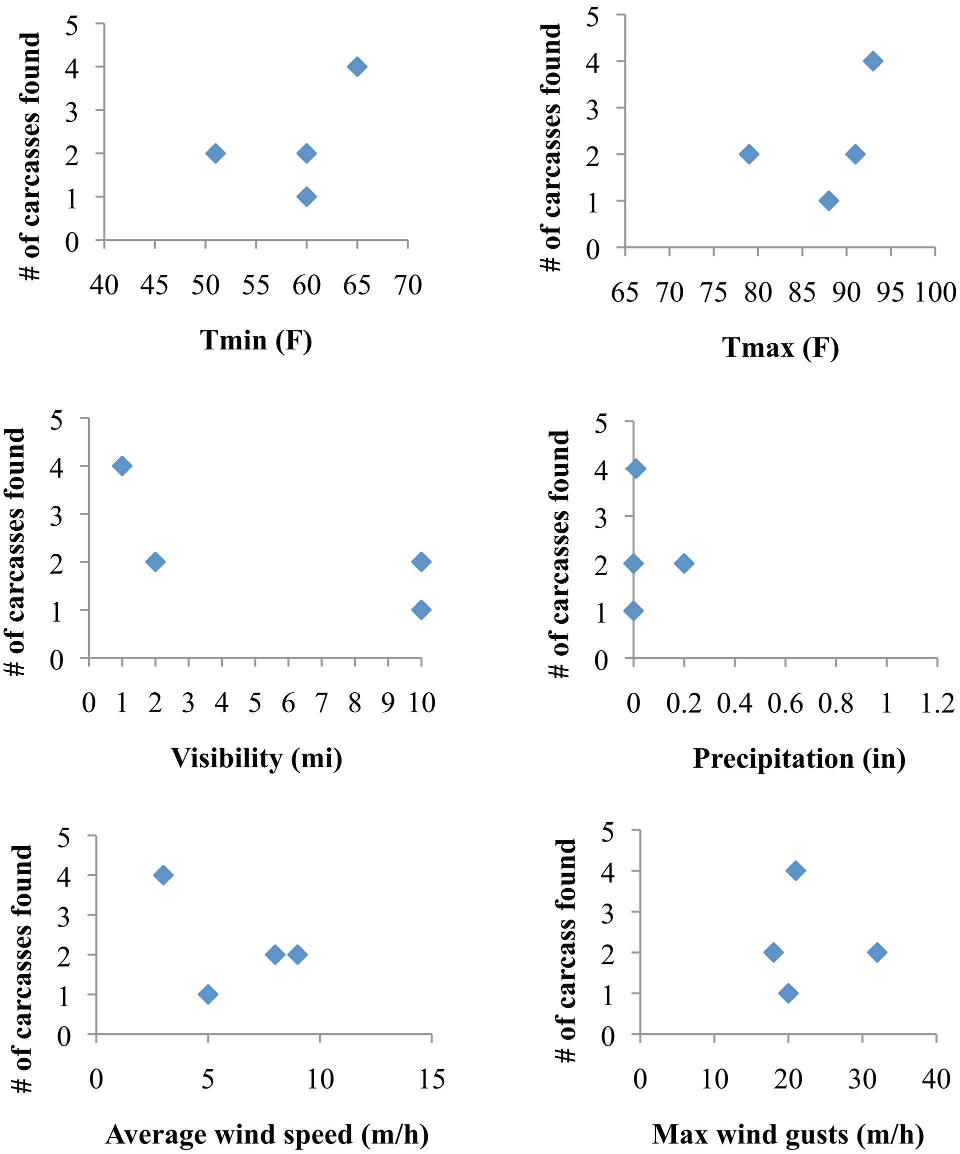
Potential scavengers observed in the study area included raptors, gulls and badgers. Coyotes were heard on several occasions during the study period, but never observed.

Searcher efficiency rates. One searcher efficiency trial was conducted throughout the study period. The probability that a carcass was found by a searcher was 30%.

Estimated mortality rates. Estimated mortality rates, once adjusted for searcher efficiency and carcass removal rates, were determined to be 1.9 bats/turbine/year, or 1.3 bats/MW/year.

Climatic correlations. No significant linear relationships were found between the number of carcasses found and any measured climatic variable. However, six (67%) of fatalities were found following nights when visibility was two miles or less. All carcasses were found following nights of an average wind speed of 10 m/h or less, and five (56%) following nights that had an average wind speed of 5 m/h or less (Figure 2.10).

Figure 2.10 Relationships between carcass finds and climatic conditions.



DISCUSSION

Pre-Construction

<u>Species composition and activity patterns</u>. All five species known to occur in south central North Dakota were detected at the Merricourt study area. While a high abundance of fall migratory bats was expected, the especially high numbers of red bat calls was unexpected. Given that hoary bats, silver-haired bats and red bats are all known to migrate from north to south in August and September (Barbour and Davis 1969, Izor 1979, Cryan 2003), it was expected that a higher number of calls would be attributed to hoary bats and silver-haired bats than was noted. It is possible that hoary and silver-haired bats use different migratory routes through this area of south central North Dakota, although this is contrary to our findings in the post-construction survey.

Acoustic data indicated that big brown bats and little brown bats were abundant in the Merricourt study area. Though fatalities of these species have been reported in other studies (Fiedler 2004, Arnett et al. 2005, Kunz et al. 2007a), they are not as frequently killed at turbines (Kunz et al. 2007, Arnett et al. 2008). Little brown bats tend to forage at edges and over water, rather than in open spaces (Patriquin and Barclay 2003) and at heights of 1.5 to 6 meters high (Young et al. 2003), which may minimize their encounters with turbines.

<u>Migratory and seasonal patterns</u>. Most bats exhibit a bimodal pattern of activity in the summer, with highest levels of activity occurring from 9-11pm and 3-5 am (Hayes 1997). The unimodal distribution of activity observed in my data (See Figure 2.5) may suggest that the bats were exhibiting migratory activity, leaving roosts later in the night and not returning. Bat activity patterns indicated that the sampling occurred during the fall migration period. Low activity of red bats and hoary bats during late July, higher activity levels in early August and then decreased

activity levels in late August suggests that minimal migratory activity was occurring at the beginning and end of the study. It was expected that silver-haired bats would be migrating through the study area at the same time as hoary bats and red bats. As this species was only detected in late July, it is possible that silver-haired bats do not share a migratory corridor with hoary and red bats or that they begin their migration earlier than other species. It will be necessary to conduct further research into the patterns of fall migrations to determine if the migratory corridors of silver-haired bats differ from those of hoary and red bats.

Big brown bats are summer residents of North Dakota that migrate east in August. This species was only detected in the first few days of the pre-construction study, which suggests that my sampling period captured the last part of the summer season, before the composition of the bat community changed due to fall migration. Little brown bats also exhibit an eastward migratory pattern, yet their presence into late August after big brown bats were no longer detected was unexpected. Due to limited knowledge about the migratory ecology of little brown bats in North Dakota, further research on the migratory, foraging and habitat patterns of these species should be conducted in the state.

Climatic conditions. No correlations were found between bat activity and temperature, wind speeds or precipitation. While temperatures ranged from 43 – 83 °F, it is possible that bats continue to exhibit migratory behavior until temperatures remain at consistently lower temperatures. As wind speeds vary throughout the night, it is difficult to determine whether there were times during which wind speeds remained low for a length of time that would encourage bats to leave their roosts to forage or to continue migratory flight. Similar conditions may hold true for precipitation levels, as rain may have abated for a period of time that would have allowed bats to leave the roost to forage or migrate.

Habitat. The type of habitat in which detectors were placed is likely to have affected recorded levels of bat activity and species composition. From July 27 to August 12, when both bat activity and diversity were highest, the detectors were placed near hardwood shelterbelts. During the recording period of August 13 – 25, detectors placed in an open field and along a wetland edge recorded a decreased level of activity and species diversity. This may be in part due to the majority of bats having migrated through the area by the time of the later recording; however, the sharp decrease indicates that habitat may also play a role in the number of calls recorded. Activity was significantly higher near shelterbelts, which is consistent with the preferred habitat of these tree-roosting species. Additionally, edge habitats are rich in insect populations, which would attract bats for foraging (Everette et al. 2001, Mager and Nelson 2001).

While pre-construction work focused on determining activity levels and species composition at ground level, it is important to note that the environment and flight activity of bats was not assessed at turbine rotor heights. Activity levels and echolocation behavior are known to vary with altitude in bats (McCracken et al. 2008, Gillam et al. 2010), therefore the incorporation of such information into future studies is important (Menzel et al. 1999, Collins and Jones 2009).

Post-Construction

Species composition and activity. Three of the five species known to inhabit this area of North Dakota were detected acoustically at the Tatanka study area. Red bats comprised the majority of the dataset, with 67% of files assigned to this species (See Table 2.4). While the majority of acoustic calls at Tatanka were attributed to red bats, only hoary and silver-haired carcasses were found at turbines. Acoustic data was very limited in this study, however the proximity of the study sites (approximately 30 miles) and similar landscapes may allow for some confidence in assuming species activity at the proposed Merricourt site is somewhat representative of the general population at the Tatanka site.

A disproportionate relationship between the number of recorded hoary bat calls or physical captures and fatality rate among hoary bats has been previously recorded (Gruver 2002, Fiedler 2004). Thus, despite the low number of hoary and silver-haired calls recorded at the Merricourt study site, the discovery of carcasses of these species at Tatanka could suggest that these bats may be at risk for turbine-related mortality at the Merricourt location or the nearby North Dakota I and II. Due to limited acoustic data, activity levels and species composition patterns over time is difficult to ascertain.

Seasonal and migratory patterns. Although no red bat carcasses were found during searches, the eight hoary bat carcasses and one silver-haired bat carcass were consistent with previous findings that demonstrated that those species experience high number of fatalities at turbines (Johnson 2005, Kunz et al. 2007a). These species exhibit fall migratory movements and bat fatalities have been consistently shown to be highest during the fall migration period of late summer and fall (Johnson 2005, Cryan and Brown 2007, Arnett et al. 2008). That no carcasses were found after August 27 corresponds with the expected southward migration patterns of hoary, red and silver-haired bats (Cryan 2003), suggesting that the vast majority of bats had already moved through North Dakota by late August.

As mortality rates vary significantly across the country, it is prudent to compare results from the Tatanka Wind Farm to other wind facilities with comparable topography, land use and habitat. My estimated mortality rate of 1.9 bats/turbine/year was comparable to those of studies conducted at Buffalo Ridge, MN (2 bats/turbine/yr) (Johnson et al. 2003a), Klondike, OR (1.2

bats/turbine/yr) (Johnson et al. 2003b), Foote Creek Rim, WY (1.3 bats/turbine/yr) (Gruver 2002, Young et al. 2003) and NPPD Ainsworth, NE (1.9 bats/turbine/yr) (Derby et al. 2007), all of which are fairly similar in vegetative cover and terrain. The highest fatalities have been noted at facilities near heavily forested areas and on ridge tops (Arnett et al. 2005, Fiedler 2004, 2007).

My finding that 78% of the carcasses were found within 10 meters of the turbine base also aligns with previous studies and suggests that the search plot area was sufficient to detect most turbine-related fatalities (Gauthreaux 1996, Johnson et. al 2003a, b, Johnson et al. 2004). Factors that likely impacted my estimate were that searcher efficiency trials were not conducted on a plot containing a turbine, nor were they repeated. An area approximately 20m in diameter surrounding the turbine consists primarily of gravel and has very little vegetation, resulting in a large area where carcasses may be more easily spotted. The exclusion of this area in the trial likely biased the results of the searcher efficiency estimation. This bias could lead to a lower estimated fatality rate for the facility.

Climatic conditions. Two fatalities were found after a heavy rain the previous night; however there is not enough data to suggest a relationship between rainfall and mortality rate. There was no correlation between high winds and fatality rates, which is consistent with previous studies (Kerns and Kerlinger 2004, Johnson et al. 2004).

Distance to woodland habitat. All carcasses were found at turbines located within a distance of 700 meters to wooded areas, which would provide the most suitable habitat for roosting. This data is consistent with research that found a negative relationship between distance to nearest woodlot and bat activity (Johnson et al. 2004). One hoary bat carcass was found 125 meters away from a multi-building abandoned farmstead surrounded by dense stands of deciduous trees. While there were two small ponds to the west of the farmstead, the turbine where the carcass was located (46) stood between the farmstead and an expansive area of very large kettle lakes to the east. This is the same location at which all hoary echolocation calls were recorded on July 24 and 30.

Though small cattle ponds and larger kettle lakes were present over most of the study area, the area between the woodland closest to turbine 2, where two fatalities were recorded, had little water resources. No data was collected at that woodland, thus I can hypothesize that if bats were using that woodland as a roosting site, it is possible that those fatalities might be due to the fact that turbine 2 was sited between that woodland and the nearest water source.

Mitigation of potential impacts

To minimize impacts to bat populations, destruction of bat roosting and foraging habitats should be kept to a minimum. Data suggests that areas such as tree stands and shelterbelts are high quality habitats. Since these habitat types are infrequently found in the prairie landscape, removal could be detrimental to bat populations, as well as other taxa.

Measures to reduce mortality rates, such as slowing or stopping turbines on low wind nights when mortality rates are highest or bringing turbines online at slightly higher wind speeds, have been shown to significantly reduce turbine-related bat mortality (Arnett et al. 2009, Baerwald and Barclay 2009b). Due to the number of species that inhabit and migrate through this area of North Dakota, the curtailment of turbines on low wind nights during fall migration may significantly reduce impacts on those populations. Losses to energy companies on low-wind nights are minimal, as these conditions already contribute to decreased energy production. Further studies on the use of electromagnetic pulses to deter bats from flying or foraging near turbines (Horn et al. 2008b, Nicholls and Racey 2009) are also encouraged, as that type of mitigation, if it proves both effective and harmless to the bats, could be instrumental in minimizing losses to bat populations and energy companies alike.

Suggestions for future studies

The findings from this research are consistent with other studies across the country and have shown that bat populations in North Dakota may be at risk of being negatively impacted by wind energy development in the state. If the Merricourt Wind Power Project is reinstated, post-construction research will be necessary to determine mortality rates in this area. Despite the current inactive status of the Merricourt project, the high level of bat activity recorded suggests that additional acoustic studies in this area would be beneficial for determining migratory corridors as well as monitoring changes in population size and habitat use.

Further monitoring at the Tatanka Wind Farm is necessary to ensure that all species in the area have an equal chance of being detected throughout the fall migration period and to examine possible relationships between levels of activity and turbine mortality. Further studies should also include acoustical data gathered directly at turbines. As all acoustic data was gathered at ground level, it may also be advantageous to place monitors at varying heights to get an accurate representation of bat activity and flight patterns at rotor height (Menzel et al. 1999, Baerwald and Barclay 2009a, Collins and Jones 2009).

Repetition of the post-construction component of this study would be valuable for confirming my results and expanding our knowledge of turbine effects on bats. Full transect plots conducted daily around 1/3rd of the turbines at a facility would provide a dataset with greater statistical power and a more accurate estimate of fatality rates.

CONCLUSION

This was the first study in North Dakota to examine turbine-related bat mortality. I found high levels of bat activity of the species most susceptible to turbine impacts as well as empirical evidence that wind turbines are impacting local bat populations. That hoary bat and a silver-haired bat carcass were located at turbines is consistent with other studies that have found these to be species most impacted. The data strongly suggested that these species are migrating through the area of both the operating and proposed wind facilities and as more turbines are constructed, the risk to these species of increased fatality may be a concern. Further, as the preferred habitats of bats are not plentiful on the plains of North Dakota, further disruptions to these existing habitats may significantly impact these populations. These impacts are a critical consideration when siting turbines as well as allowing for mitigation measures when and where necessary.

While the importance of mitigation at existing facilities cannot be understated, research must be also conducted prior to wind facility construction so that the threat to these populations is minimized from the onset. Accurate scientific data shared between stakeholders, such as development companies, wildlife management organizations and policy-making agencies, will be crucial if we are to protect bat species while providing much needed renewable energy.

To this end, it is essential that we quickly take measures to increase our understanding of habitat usage, species distribution, behavior and migratory patterns of bats in North Dakota. The loss of critical ecosystem services provided by bats, including crop-pest reduction, indication of environmental quality and ecological biodiversity, is a threat too great to ignore.

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GENERAL CONCLUSION

This Master's Thesis was the first in the Environmental and Conservation Sciences program to examine an environmental issue in both the sociological and biological sciences. This preliminary research was conducted with the intent to demonstrate the value of this type of study and to create a baseline for future research.

While the two components of this study were conducted individually, this research is an initial step in the examination of different aspects of one issue. The intent of continuing this research is to demonstrate that elements of a problem can span disciplines. This is not to say that the elements are necessarily inclusive, rather that there are components of a problem that might be effectively examined using methods or means typically outside of a researchers usual field.

In conducting this research I found that a significant factor in public acceptance of wind farms is a stated concern for impacts to wildlife; respondents who expressed concern about wind facility impacts on wildlife were less likely to support the wind farm. While my study found that bats were negatively impacted by wind facilities, they were not shown to be of significant concern to the respondents in my opinion study. However, other wildlife species are impacted by wind facilities and studies that provide accurate information about wildlife impacts and possible mitigation measures might help to increase support of wind energy development in those who are opposed to it. If this is to be effective, it is critical to ensure that the information is made accessible to the public and can be readily understood.

A consideration for future studies of this nature would be length of time in which the project is completed. As several topics are being covered, this approach might be most effective in a PhD. program or a three-year Master's program in order to ensure that sufficient data are gathered and a thorough review of existing literature is conducted. Additionally, more time could then be allotted to explore areas of commonality between the studies.

In my research I identified specific factors that influence support for a particular wind farm, as well as demonstrated areas of public concern about wind energy development and potential impacts. Also, I gathered baseline data on local bat populations, and found that North Dakota bats may indeed be at risk from turbine-related impacts, suggesting that mitigation may be necessary. This work has been a good starting point for future research in both areas of study, as well as for continued examination of the intersection of the social and biological sciences.

APPENDICES

Appendix A

Table 1.28 Data recorded during phone surveys

Phone #	9am-12pm			12pm-5pm			5pm-8pm		
Montrail	1st	2nd	3rd	4th	5th	6th	7th	8th	9th
xxx-xxx-xxxx	9:00, 6/25/10, VM								

PHONE CODES

NA NO ANSWER/NO VOICEMAIL

VM VOICEMAIL

NWN NON-WORKING NUMBER

B BUSY

CB CALL BACK - ENTER TIME/DATE REQUESTED

CBC CALL BACK TO COMPLETE - ENTER TIME/DATE REQUESTED

R REFUSED

RHU REFUSED HUNG UP

INEL INELIGIBLE TO COMPLETE

COMP COMPLETED SURVEY

Appendix B. Statement of informed consent.

Public Opinions of Wind Energy in North Dakota
(BARNES, GRIGGS and STEELE COUNTIES)

Hello, my name is Lucas Bicknell. I am conducting research with Dr. Chris Biga at North Dakota State University and am asking for your cooperation in gathering information from North Dakota residents on their opinions concerning wind energy in North Dakota. By completing this questionnaire you will help us ascertain community perceptions and understanding of wind energy developments in your area.

In order to have a sample that is valued, I need to speak with the person in your household who is 18 years of age or older and who had the most recent birthday. Would that person be you?

(*No*) Could I speak with the adult in the household who most recently celebrated their birthday?

(*When speaking with the correct individual –**Repeat introduction***)

(*Yes*) This questionnaire will take approximately 10 minutes of your time. Your telephone number was randomly generated by a computer, your participation is anonymous and all of your answers will be kept completely confidential. Participation is voluntary and you may quit participating at any time without penalty. There are no correct answers to these questions and all opinions will be helpful to our study. Would you be willing to complete a 10-minute questionnaire on wind energy in North Dakota?

If there are any questions that you don't feel you can answer, please let me know and we'll move to the next one.

If you do not have any questions, let us begin!

Appendix C. Survey Instrument.

A "wind farm" is a group of wind turbines that capture energy from the wind to generate electricity. There are several large-scale wind farms in North Dakota. A large-scale wind farm consists of 10 or more turbines.

1) Have you ever seen a large-scale wind farm in operation?

□ Yes ……………..(1)
□ No ……………...(2)

2) What is your general attitude toward wind farms? Is it….

□ Very positive ….…………..(5)
□ Positive ……………………(4)
□ Neutral ……………..……....(3)
□ Negative……………………(2)
□ Very negative ……..………..(1)
□ Not sure ………….………..(9)

3) In general, do you think the placement of wind farms in North Dakota for electricity generation should be:

□ Encouraged and promoted ………………….(4)
□ Allowed in appropriate circumstances……....(3)
□ Tolerated ……………………………………(2)
□ Prohibited in all instances…………………..…..(1)
□ Not sure ……………………………………..(9)

The Ashtabula Wind Energy Center began electricity production in 2008 with 131 wind turbines in Barnes County. The wind farm now consists of 218 turbines in Barnes, Griggs and Steele counties, with plans to expand to over 250 turbines. These turbines are 260 feet tall.

4) Do you Support or Oppose this wind farm in Barnes Griggs and Steele counties? Do you…

□ Strongly Support………...(5)
□ Support….………………(4)
□ Neutral….………………..(3)
□ Oppose….………………..(2)
□ Strongly Oppose……...….(1)
□ Not Sure….……………....(9)

The following questions ask about your opinion concerning possible impacts the Ashtabula wind farm may have had on the community and environment of Barnes, Griggs and Steele counties. I will list several possible areas of impact. In general, do you believe that the Ashtabula wind farm has had a Very Positive, Positive, No Impact, Negative or Very Negative impact on the following items?

Items	Very Positive	Positive	No Impact	Negative	Very Negative	Not sure/ Don't Know
5a) Local hunting	(5)	(4)	(3)	(2)	(1)	(9)
5b) Local tourism	(5)	(4)	(3)	(2)	(1)	(9)
5c) Job creation	(5)	(4)	(3)	(2)	(1)	(9)
5d) Local economy	(5)	(4)	(3)	(2)	(1)	(9)
5e) Local air quality	(5)	(4)	(3)	(2)	(1)	(9)
5f) Residential Electricity rates	(5)	(4)	(3)	(2)	(1)	(9)
5g) Aesthetics of countryside	(5)	(4)	(3)	(2)	(1)	(9)
5h) Property values	(5)	(4)	(3)	(2)	(1)	(9)
5i) Local Crops and Pastures	(5)	(4)	(3)	(2)	(1)	(9)

There are several advantages and disadvantages to wind farming. I am going to ask your opinion about wind farming, please let me know if you Strongly Agree, Agree, feel Neutral, Disagree or Strongly Disagree with the following statements.

6) Producing energy from wind reduces the amount of energy we need to import from foreign sources.

□ Strongly Agree ……….(5)
□ Agree ………………....(4)
□ Neutral ………………..(3)
□ Disagree ……………....(2)
□ Strongly Disagree……..(1)
□ Don't know..…….…….(9)

7) Human contribution to global warming is reduced because wind turbines do not release greenhouse gases, such as carbon dioxide.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ………………...(3)
□ Disagree ……………….(2)
□ Strongly Disagree……...(1)
□ Don't know..…………...(9)

8) Wind power projects are a symbol of local, state and federal commitment to renewable energy.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ………………...(3)
□ Disagree ……………….(2)
□ Strongly Disagree……...(1)
□ Don't know..………......(9)

9) Human contribution to air pollution is reduced because wind turbines do not release chemicals or particulates, such as mercury and soot, into the atmosphere.

- □ Strongly Agree ……..….(5)
- □ Agree ………………….(4)
- □ Neutral ……………..….(3)
- □ Disagree …………….....(2)
- □ Strongly Disagree……...(1)
- □ Don't know..……….......(9)

10) I am concerned about the impacts of wind development on wildlife in my community.

- □ Strongly Agree…….(5)
- □ Agree……….……..(4)
- □ Neutral……………..(3)
- □ Disagree…………....(2)
- □ Strongly Disagree….(1)
- □ Don't know..…….....(9)

11) Wind turbine blades can kill migratory birds.

- □ Strongly Agree …….(5)
- □ Agree …………….....(4)
- □ Neutral ……………..(3)
- □ Disagree ……………(2)
- □ Strongly Disagree…..(1)
- □ Don't know..………..(9)

IF AGREE OR STRONGLY AGREE:

11a) The loss of migratory birds due to wind turbines would be harmful to the environment.

- □ Strongly Agree ………..(5)
- □ Agree ………………….(4)
- □ Neutral ……………..….(3)
- □ Disagree …………….....(2)
- □ Strongly Disagree…...…(1)
- □ Don't know..…………...(9)

12) Wind turbine blades can kill bats.

- □ Strongly Agree ……..….(5)
- □ Agree ………………….(4)
- □ Neutral ……………..….(3)
- □ Disagree …………...….(2)
- □ Strongly Disagree……...(1)
- □ Don't know..………......(9)

IF AGREE OR STRONGLY AGREE:

12a) The loss of bats due to wind turbines would be harmful to the environment.

□ Strongly Agree …….(5)
□ Agree ………………(4)
□ Neutral ……………..(3)
□ Disagree ……………(2)
□ Strongly Disagree…..(1)
□ Don't know..………..(9)

13) Wind turbines are noisy, which can bother people who live near wind farms.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ………………...(3)
□ Disagree ……………….(2)
□ Strongly Disagree…...…(1)
□ Don't know..…………...(9)

14) Wind turbine flicker (the rapid moving shadow of the blades) can bother people who live near wind farms.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ……………..…(3)
□ Disagree …………….....(2)
□ Strongly Disagree……...(1)
□ Don't know..…..……....(9)

15) Wind turbines are ugly and spoil the scenery of the local landscape.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ………………...(3)
□ Disagree ……………….(2)
□ Strongly Disagree……...(1)
□ Don't know..……….....(9)

16) Wind turbines will lower local property values, harming local homeowners.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ………………..(3)
□ Disagree ………………(2)
□ Strongly Disagree……..(1)
□ Don't know..……….....(9)

I am going to read you some statements about wind energy. Please tell me whether you Strongly Agree, Agree, feel Neutral, Disagree, or Strongly Disagree with each of the following statements.

17) I support the construction of wind farms in the United States.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ……………..….(3)
□ Disagree …………..…...(2)
□ Strongly Disagree……...(1)
□ Don't know..…………...(9)

18) I support the construction of wind farms in the Midwest.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ……………..….(3)
□ Disagree …………...…..(2)
□ Strongly Disagree…...…(1)
□ Don't know..…………...(9)

19) I support the construction of wind farms in North Dakota.

□ Strongly Agree ……..….(5)
□ Agree ………………….(4)
□ Neutral ……………..….(3)
□ Disagree …………….....(2)
□ Strongly Disagree……...(1)
□ Don't know..……….......(9)

20) I support the construction of a wind farm in the county I live in.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ……………..….(3)
□ Disagree ……...………..(2)
□ Strongly Disagree……...(1)
□ Don't know..…………...(9)

21) I support the construction of a wind farm in my community (within 5 miles of my home).

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ………..……….(3)
□ Disagree …………...…..(2)
□ Strongly Disagree……...(1)
□ Don't know..…………...(9)

22) I support the construction of a wind farm within my neighborhood (within 1 mile of my home).

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ………..……….(3)

□ Disagree …………...…..(2)
□ Strongly Disagree……...(1)
□ Don't know..…………...(9)

Wind energy is just one type of energy source that meets our energy needs. I would like to ask about your general feelings toward other sources of energy. In general, do you Strongly Support, Support, feel Neutral, Oppose or Strongly Oppose the following energy sources?

	Strongly Support	**Support**	**Neutral**	**Oppose**	**Strongly Oppose**	**Don't know/ Not Sure**
23a) Wind Energy	**(**5)	(4)	(3)	(2)	(1)	(9)
23b) Solar Energy	(5)	(4)	(3)	(2)	(1)	(9)
23c) Hydroelectric Energy *(river dams)*	(5)	(4)	(3)	(2)	(1)	(9)
23d) Nuclear Energy	(5)	(4)	(3)	(2)	(1)	(9)
23e) Biomass *(Ethanol, etc)*	(5)	(4)	(3)	(2)	(1)	(9)
23f) Oil	(5)	(4)	(3)	(2)	(1)	(9)
23g) Coal	(5)	(4)	(3)	(2)	(1)	(9)

People have different opinions and beliefs about wildlife. I would like to ask about your general feelings towards these different opinions. In general, how do you feel about the following statements about wildlife? Do you Strongly Agree, Agree, feel Neutral, Disagree, or Strongly Disagree?

24) I enjoy learning about the wildlife in my community.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ……………..…(3)
□ Disagree …………...…..(2)
□ Strongly Disagree……...(1)
□ Don't know..…………...(9)

25) It is important to protect wildlife diversity in my community.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ……………….(3)
□ Disagree …………..…..(2)
□ Strongly Disagree……..(1)
□ Don't know..……….....(9)

26) Bats play an important role in the environment in my community.

□ Strongly Agree ………..(5)
□ Agree ………………….(4)
□ Neutral ……………….(3)
□ Disagree ……………...(2)
□ Strongly Disagree……..(1)

□ Don't know..…………....(9)

27) I DO NOT want bats near my home or family.

□ Strongly Agree ……..….(5)
□ Agree ………………….(4)
□ Neutral ……………..….(3)
□ Disagree ……………....(2)
□ Strongly Disagree……...(1)
□ Don't know..……….......(9)

The following questions concern information about you. Please select one response that best represents you.

28) What is your marital status?

Now Married …...(1)
Widowed ....…..(2)
Divorced………...(3)
Separated………..(4)
Never married..…(5)

29) What is your sex?

Male ……………….(0)
Female…………...…(1)

30) What is the highest degree or level of school that you have completed?

Grade school………………………………..(1)
Some high school…………………...…….(2)
High school……………………...……….(3)
Some college credit……………………....…(4)
Associate degree……………………...…..(5)
Bachelor's degree…………………………...(6)
Graduate Degree or Professional Degree…...(7)

31) Which of the following best matches your political ideology?

Extremely Conservative…..(1)
Conservative………………(2)
Moderate Conservative…....(3)
Down the Middle………….(4)
Moderately Liberal………..(5)
Liberal……………………..(6)
Extremely Liberal……….....(7)
Don't know………………..(9)

32) What is your political preference?

Republican……………..(1)
Democrat………….....…..(2)
Independent……………(3)
Libertarian……………..(4)
Green…………………..(5)

Other ________________________(6)
None…………………....(8)
Don't know……………....(9)

33) What is your religion?

Protestant…………....(1)
Catholic……………..(2)
Jewish……………….(3)
Muslim……………...(4)
Other ________________________(6)
None………………...(8)
Don't know………....(9)

34) What is your race?

Black………..................(1)
Asian………..................(2)
Hispanic……………….....(3)
White…………………......(4)
American Indian……….(5)
Other ________________________(6)
If "Other" please identify

35) What is your age? _______________

36) What was your total family income last year?
Under $10,000…………………....(1)
Between $10,001-15,000………....(2)
Between $15,001-25,000………....(3)
Between $25,001-35,000………....(4)
Between $35,001-50,000………....(5)
Between $50,001-75,000………....(6)
Between $75,001-100,000………..(7)
Between $100,001-150,000……....(8)
Between $150,001-200,000……....(9)
200,001 and above……….............(10)

Findings from this study will be prepared in Spring 2011 and a copy of this report will be available upon request. You should feel free to ask questions now or at the any time during the questionnaire. In the future, if you have any questions about this study, you can contact Dr. Chris Biga, at 701-231-5887 or at chris.biga@ndsu.edu. If you have any questions about rights of human research participants, or wish to report a research-related problem, please contact the NDSU IRB office at 701-231-8908 or ndsu.irb@ndsu.edu.

Appendix D

Table 2.6 Data gathered on carcasses located during plot searches.

Date	ID	Turbine	Species	Sex	Distance from transect (m)	Distance from turbine (m)	Condition
7/24/10	T217242010-1	21	Hoary	-	.5 m	18	2,3
7/24/10	T217242010-2	21	Hoary	F	2m	1	1, broken wing
*8/5/10	T15852010-*	15	Hoary	-		Turbine pad	1
8/9/10	T21892010-3	21	Hoary	M	3m	12	1
8/9/10	T20892010-4	20	Hoary	-	1.5m	2	2
8/9/10	T20892010-5	20	Hoary	-	2m	10	2
8/9/10	T19892010-6	19	Hoary	F	2m	38	1
8/10/10	T468102010-7	46	Hoary	-	.2m	3	2, Submerged in water
8/27/10	T258272010-8	2	Hoary	M	.5m	3	2
8/27/10	T28272010-9	2	Silver-haired	?	0m	4	2

1 Intact – a completely intact carcass, not badly decomposed, no evidence of being scavenged.
2 Scavenged – an entire carcass, which shows signs of being scavenged, or some amount of remains.
3 Decomposition – some degree of decomposition. Insect presence was noted
* Incidental find by Acciona personnel. Data not used in analysis.

Appendix E

Table 2.7 Data recorded during scavenger removal trial.

Specimen/ID/mass	Date/Day*		Cover	Condition
Rat/1/12g	8/1/10	(1)	Long grass, covered	30% scavenged
	8/8/10	(7)		Bone and tail remain, no soft parts
	8/15/10	(14)		UNABLE TO CHECK
	8/22/10	(21)		Bone and tail remain, no soft parts
	8/29/10	(28)		Bone and tail remain, no soft parts
Rat/2/12g	8/1/10	(1)	Mixed tall, short grasses, partially covered	Fully intact, insects present on carcass
	8/8/10	(7)		Gone
	8/15/10	(14)		
	8/22/10	(21)		
	8/29/10	(28)		
Mouse/1/8g	8/1/10	(1)	Bare ground, uncovered	Intact
	8/8/10	(7)		Head, fur and bones remain, no soft parts
	8/15/10	(14)		UNABLE TO CHECK
	8/22/10	(21)		Gone
	8/29/10	(28)		
Mouse/2/8g	8/1/10	(1)	Heterogeneous short vegetation, covered	Gone
	8/8/10	(7)		
	8/15/10	(14)		
	8/22/10	(21)		
	8/29/10	(28)		
Mouse/3/8g	8/1/10	(1)	Short grasses, partially covered	10% scavenged at gut
	8/8/10	(7)		Gone
	8/15/10	(14)		
	8/22/10	(21)		
	8/29/10	(28)		
Mouse/4/8g	8/1/10	(1)	Mix tall/short grasses partially covered	Fully intact, no insects present
	8/8/10	(7)		Gone
	8/15/10	(14)		
	8/22/10	(21)		
	8/29/10	(28)		

*Carcasses placed at 0700 on July 31, 2010.