

Where the Wind Goes:
Motivating Low Ecological Risk Wind Development

Prepared by
HANNA BUECHI, ALEX IRVIN, DELANEY RONEY,
MARGAUX SLECKMAN, CRISTINA SPARKS

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THE NATURE CONSERVANCY

Committee in charge:
PROF. SARAH E. ANDERSON, PROF. KYLE C. MENG

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Bren School
of Environmental Science & Management
UNIVERSITY OF CALIFORNIA, SANTA BARBARA

Motivating Low-Risk Wind Development Using Cancellation Risk

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HANNA BUECHI

ALEX IRVIN

DELANEY RONEY

MARGAUX SLECKMAN

CRISTINA SPARKS

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PROF. SARAH E. ANDERSON

PROF. KYLE C. MENG

DATE

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Abstract

Climate change is a pressing global issue, with consequences that can be mitigated in part by transitioning our energy sector to renewable energy sources. The market share of renewable energy is increasing in the United States, and in particular, the use of wind energy is growing due to its relatively cheap and plentiful nature. The highest potential for future onshore wind expansion is in the central U.S. region known as the "Wind Belt." However, wind energy has a large spatial footprint and can negatively affect the local environment through ecosystem fragmentation and wildlife impacts. Therefore, there is a need to encourage developers to prioritize wind farm siting in the least ecologically-sensitive areas. This study explores how wind developers can be encouraged to site wind projects in regions that pose a low-risk to wildlife habitat, via an assessment of project cancellation risk. It also provides recommendations for how other stakeholders, such as environmental and conservation planning groups, can guide wind siting. A logistic regression model shows that projects with a low-risk to wildlife and more positive publicity have a significantly lower risk of cancellation. These findings provide an opportunity for stakeholder groups to increase public awareness of the environmental impact of wind development in the Wind Belt, knowing that the likelihood of wind project cancellation decreases in low-risk areas.

Key Words

Wind, onshore wind energy, renewable energy, sentiment analysis, publicity, land use, ecological impacts, cancellation, wildlife

Open Source Access to Data Analysis

All programming scripts associated with the analysis of this report are made publicly available in a GitHub repository: msleckman/WindBelt-BrenMastersGroupProject

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Executive Summary

Focusing on the Great Plains region of the United States, the following report assesses how wind energy developers can be encouraged to site wind energy projects in areas that have a low risk of impacting sensitive wildlife and habitat. More specifically, this analysis reveals that siting a wind project in an ecologically sensitive area increases its odds of cancellation. This work helps highlight the shared interests of renewable energy developers and conservationists to accelerate the adoption of well-sited wind, protect biodiversity, and mitigate the impacts of climate change.

Climate change is shifting the ecological balance of the globe, threatening to harm human well-being and key natural resources by increasing sea level, the size and frequency of natural disasters, and average global temperatures. Over the last century, greenhouse gas emissions such as carbon dioxide (CO_2) have risen due to rapid industrial production and economic growth. The concentration of atmospheric CO_2 observed in 2008 was 30% higher than the highest concentration recorded over the course of the last 800,000 years (Karl *et al.*, 2009). Mitigation and adaptation actions are necessary to minimize the consequences of climate change.

In 2016, the energy and transportation sectors were tied as the largest sources of greenhouse gas emissions in the U.S., contributing 28% of total GHG emissions each (U.S. EPA, 2018). Therefore, a key solution to the climate change crisis is the transition away from greenhouse-gas emitting energy sources and towards clean and renewable energy sources that produce energy with fewer emissions.

Renewable energy is developing quickly. In the U.S., over 15% of the share of electricity comes from renewables, a two-fold increase over the last decade (Enerdata, 2019). The growth in renewable energy is not only due to its mitigating effect on climate change, but also to its competitive cost compared to many non-renewable sources with current technology (Appendix 1; Jacobson and Delucchi, 2011).

The Department of Energy has predicted that the U.S. can produce 35% of its total energy demand using wind by 2050 (DOE, 2015). This expansion is expected to occur within 17 states of the central U.S. collectively known as the “Wind Belt” (Figure 1). Currently, this region is home to 80% of domestically installed wind energy, with 49 Gigawatts (GW) of capacity. In the next 10 years an additional 100 GW of capacity is expected to be added to the region (Department of Energy, 2008).

Not only is the wind industry poised for expansion, the costs associated with wind have also decreased. The levelized cost of energy (LCOE) is second lowest only to solar at $0.03 – 0.06/kWh and is less expensive than energy from natural gas, coal, and nuclear (Lazard, 2018).

While wind energy can contribute to mitigating climate change, it affects the environment by directly harming wildlife and fragmenting sensitive habitats and intact landscapes. The Wind Belt region is home to many species of value, such as eagles, raptors, and prairie chickens (World Wildlife Fund, 2018). This valuable and expansive grassland region supports hundreds of important wetlands, shrubland biomes, and forests. Electricity from wind has a spatial footprint two to eight times that of conventional fossil fuel-based electricity, and if poorly sited can cause direct ecological impacts such as bat and bird collisions, mortality during construction, and habitat fragmentation (Trainor *et al.*, 2016).

The Nature Conservancy (TNC) has identified areas within the Wind Belt that are suitable for wind energy development (e.g. with feasible wind speeds) and avoid wildlife areas. TNC terms these areas “low-risk regions,” and displays them through an online map called Site Wind Right (SWR). This map is publicly available and is intended to help wind developers make siting decisions that consider existing ecosystems.

Despite the existence of SWR and other outreach efforts related to the environmental impacts of wind energy, developers (as profit-maximizing firms) are likely to site wind farms in areas that are most profitable and that ensure production over the long term. To do so, they seek to minimize costs during the development process and prioritize areas with high wind speeds. A worst-case scenario for developers is project cancellation after extensive time and money has been invested into development.

In order to promote the siting of wind turbines in low-risk areas, this report explores how developers can be encouraged to focus development of wind energy within areas that cause less adverse impacts to the region’s sensitive ecosystems, such as important wetlands and brood-rearing habitat for sage-grouse. To do this, the report assesses the relationship between the siting of a wind farms on “low-risk” land, as defined by the Site Wind Right map, and the likelihood of the project being canceled (referred to as the “project outcome” in this report). Furthermore, this research considers the effects of negative news publicity on cancellation and explores the topics of community concern that are most discussed in the media, in order to better gauge sources of negative and positive publicity.

By exploring these issues, this report aims to answer the following questions:

1. Do wind projects sited in low-risk areas have a lower likelihood of being canceled?
2. How does the relative negativity or positivity of publicity surrounding a project affect the likelihood of it being canceled?

To tackle these questions, 868 wind projects distributed across the Wind Belt are evaluated to understand predictors of cancellation or operation. Some of the variables included are whether a project is located in a low-risk area (as defined by the Site Wind Right map), the duration of project development time, the degree of publicity associated with the project, and turbine visibility. These factors are then used in a logistic regression model to evaluate how they each influence the odds of project cancellation. In order to evaluate the publicity of each project, a sentiment analysis of Google news articles is conducted. Additionally, turbine visibility is assessed through digital elevation models and road distance to determine a visibility score for each project. In addition to the logistic model, this report reviews the variation of publicity scores that can be attributed to project outcomes, and what specific topics (i.e. wildlife, health, etc.) drive public sentiment.

The logistic regression model results reveal that siting a wind project in a low-risk area reduces its probability of cancellation by approximately 50%, relative to a similar project in a higher risk area. Moreover, even a slight reduction in the positivity of a project's publicity can also be tied to an increase in the project's likelihood of cancellation by over 25%, regardless of the project's location. There is also some indication that publicity has a greater effect on the probability of cancellation in more sensitive ecological areas. Finally, wildlife impacts are the most commonly mentioned issues in news articles about projects, with more mentions than aesthetic impacts, noise impacts, or health concerns. These findings suggest that firms can reduce their risk of cancellation by locating in low-risk areas and by avoiding triggering publicity about wildlife consequences. However, it should be noted that transmission line location and available power capacity are an important aspect of siting decisions, but their inclusion was beyond the scope of this study.

Main Findings:

- The cancellation probability of a wind project is significantly lower in low-risk areas.
- The cancellation probability of a wind project increases as its associated publicity becomes more negative.
- Publicity has a greater effect on probability of cancellation in regions not defined as low-risk.
- Wildlife impacts are discussed more frequently in news articles about wind projects as compared with health or aesthetic impacts.

Recommendations:

1. The Nature Conservancy should use and promote the Sight Wind Right map by letting wind developers know that locating in low-risk areas will significantly reduce a project's risk of cancellation.
2. Negative publicity significantly impacts the probability of project outcome. This presents an opportunity for conservation organizations to push the conversation about the environmental impacts of poorly sited wind energy through media.

A. The Problem

Climate change is expected to radically impact our environment in the future and emission of greenhouse gases is a major factor in the increasing warming of the planet. In the United States, the energy sector is tied with transportation for the largest source of GHG emissions, contributing 28% of total US 2016 GHG emissions (Environmental Protection Agency, 2018). Through the pursuit of climate change solutions, changes in our energy sector are surely needed if progress is to be made.

In particular, wind power generation is expected to continue its rapid expansion. Wind energy is the second most dominant renewable energy source in the world after hydropower and is second to solar in levelized cost of energy. Along with solar, wind power has the highest growth rate among all renewable energy sources (EIA, 2017). Large-scale investment in wind power is expected within the next half decade to capitalize on the decreased cost and large potential of wind energy. In the U.S., the Wind Belt region is currently home to 80% of domestic wind energy, generating almost 90 GW of low-carbon wind energy through installed and planned projects (Denholm *et al.*, 2009; American Wind Energy Association, 2017; Fig. 1). This region, encompassing 17 states in the center of the nation, has a large potential for wind development. The Department of Energy (DOE) predicts that nationwide wind generation capacity is expected to grow to 202 GW by 2030 and 318 GW by 2050. This capacity represents 20% and 35% of the nation's end-use energy demand respectively (Department of Energy, 2015).

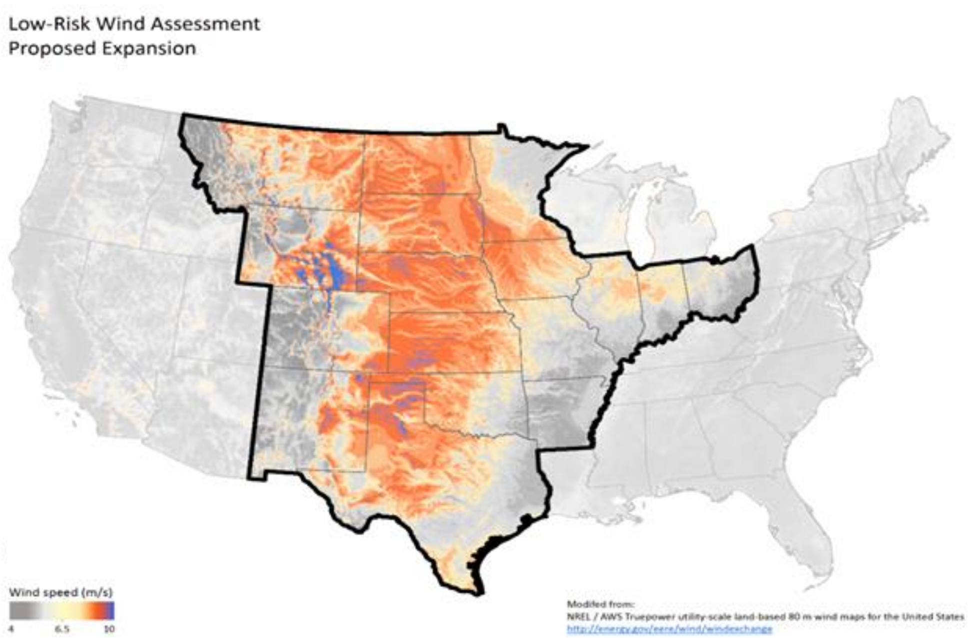

Figure 1. Wind speeds in the 17-state region known as the "Wind Belt." *Source: NREL/AWS Truepower utility-scale land-based 80 m wind maps for the United States.*

However, electricity from wind has a spatial footprint two to eight times that of conventional fossil fuel-based electricity. Current and planned wind power capacity have an approximate spatial footprint of 11.5 thousand square miles – roughly the size of the state of Maryland – and the DOE expects the potential growth to cover over 20 thousand square miles by 2030 (Department of Energy, 2008; Denholm *et al.*, 2009).

If poorly sited, wind power projects can be detrimental to the natural environment they are sited in, both through direct impacts, like bird and bat mortality via collisions with turbines, and indirect impacts, such as habitat loss and fragmentation (Fargione *et al.*, 2012). These indirect impacts do not cause mortality but may inhibit migrations, fragment critical breeding habitat and feeding habitat, and cause wind farm avoidance by certain prairie-obligate species such as sage grouse, disrupting normal behavior. Bat collisions with wind turbines are a notable problem that kills around 500,000 bats in the U.S. and Canada (Frick *et al.*, 2017); in 2003, between 1,300 and 4,000 bats were killed at a single site in West Virginia (Arnett *et al.*, 2008). The central U.S. also supports many vulnerable grassland species; 55% of them are listed in the Endangered Species Act as threatened or endangered (Samson and Knopf, 1994).

Mitigation measures to reduce collisions and mortality rates in existing facilities are possible, such as limiting the operation of wind turbines during low-wind periods (The Wildlife Society, 2014). Yet, while adopting low-collision wind turbine configurations is a useful installation measure, the avoidance of habitat is the most effective means of mitigation (Kuvlesky *et al.*, 2007; The Wildlife Society, 2014).

Despite approximately 1,056 GW of potential wind energy available throughout the Wind Belt in low-risk regions, 70% of proposed wind turbines were not located in low-risk areas (Fargione *et al*., 2012; Fig. 2).

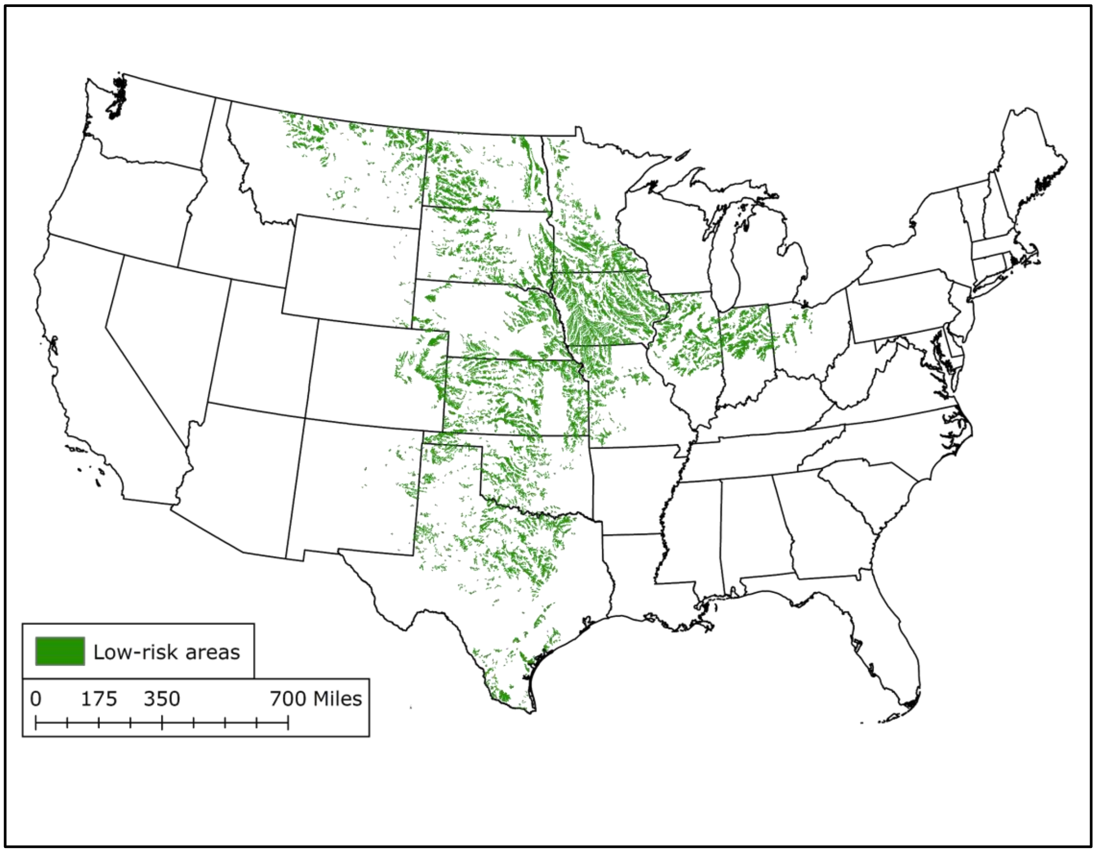

Figure 2. Low-risk ecological areas identified within the "Wind Belt" region. *Source: The Nature Conservancy*

In addition to benefits to wildlife, it is possible that wind developers themselves can gain economic benefits by siting projects in areas that pose a low risk of fragmenting intact habitat and disturbing sensitive species. These benefits could come in the form of reduced costs such as accelerated production timelines, due to less permitting controversy and decreased likelihood of project cancellation. This report investigates the relationship between siting wind farms on low-risk land and the likelihood of project cancellation (often referred to as the "project outcome" in this report).

This report also explores the effects of negative news publicity generated due to community conflicts. These community conflicts can be problematic to developers because of the effects they can have on the timeline and success of projects. Specifically, our analysis measures how publicity affects the odds of project cancellation, what conflicts are most prevalent in negatively-charged news stories, and ultimately the potential interaction between ecological impact and publicity.

In summary, the following questions are answered in this study:

1. Do wind projects sited in low-risk areas have a lower likelihood of being canceled?
2. How does the relative negativity or positivity of publicity about a project affect the likelihood of a project being canceled?

B. Connecting Lower Ecological Risk to Economic Risk

Predicting Cancellation

To address the relationships between likelihood of cancellation, site location, and publicity, it is important to understand the issues affecting developers, and in turn, the underlying decisions they make when siting a wind project. When siting wind projects, developers consider factors such as availability of transmission capability, rebates available on a state level, and availability of suitable wind and land resources (Tegen *et al.*, 2016). A key concern is avoiding wasted cost resulting from project cancellation; the cancellation of a project is not uncommon, and the success rate of a wind power project has been estimated between 25% and 50% – an improvement from around 10% in the early 2000s (Tegen *et al.*, 2016).

By summarizing the standard development process of a wind project and the costs associated with each stage (Fig. 3; Table 1), the potential for lost resources due to project cancellation becomes clear. Developers begin with prospecting to determine areas where development may be feasible, given wind resources and land features. This stage has been estimated to cost between $250 and $500 per megawatt (MW) of the project. After an area has been identified, detailed studies are conducted to gather further information about the area. This is done to determine if any environmental concerns exist and if wildlife permits or mitigation may be required; these studies cost between $5,000 and $7,000 per MW. After these studies, permits are applied for as required by local regulations. Land use permits are generally obtained at a city and county level following the regulations of these entities; however, development must also follow state and federal regulations. This stage generally costs about $20,000 per MW. After permits, financing will be obtained to begin the bulk of the physical construction of the project, and developers must also ensure buyers of the energy developers through power purchasing agreements or other contracts. Finally, additional financing, design and procurement of the wind power project takes place. These last stages cost between $20,000 and $30,000 per MW (Tegen *et al.*, 2016). Generally, the entire process takes five to ten years to complete. If a project is canceled at any point, the funds invested in that project will likely have little to no returns for that developer. It is therefore key for developers to avoid cancellation of a project, especially when reaching the later stages that carry more cost per MW.

Table 1. Development process of a wind project, with the estimated costs for each stage. Adapted from Tegen *et al*. (2016).

Stage	Prospecting	Detailed studies	Permitting	Financing	Design/Procurement
Cost Range ($ per MW)	250 – 500	5,000 – 7,000	~20,000	Varies	20,000 – 30,000
Cost Range ($) of a 117 MW Project (sample average)	29,250 – 58,500	585,000 – 819,000	~2,340,000	Varies	2,340,000 – 3,510,000

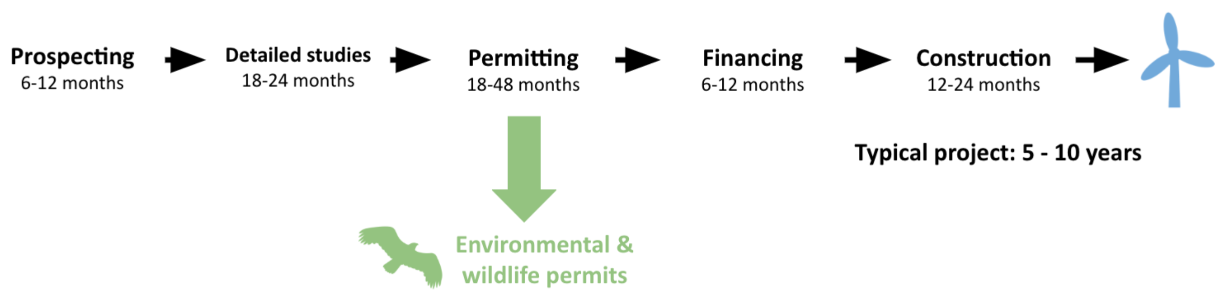

Figure 3. Development process and typical timeline of a wind project. Adapted from Futuren Group.

This report explores wind project characteristics that could be expected to influence the likelihood of project cancellation using a logistic regression model. With this model, it is possible to identify which variables best predict the project outcome and to what degree. By investigating a variety of potential predictors, the effect of low-risk siting and publicity on the risk of cancellation can be isolated. The key hypothesis of this research is that developers may be able to reduce their risk of project cancellation if they site projects on land that is of low-risk to sensitive habitat.

Eight different factors were identified through research as potential indicators of project outcomes. These variables include publicity, ecological impact, environmental memberships, project capacity, project duration, visibility, demographics (both income and population density), and finally, the state in which the project is located. These variables are discussed in more detail in the remainder of this section within the context of predicting project outcomes.

Publicity Score and Sentiment Analysis

The publicity surrounding each wind project is hypothesized to predict project cancellation. Support for wind energy is generally high in the United States, with 70-90% of North Americans approving of wind energy in general (Rand and Hoen, 2017). Public acceptance of a specific wind project, however, may be reduced for a variety of reasons. These include: a community's proximity to a wind farm; a lack of perceived participation in the planning process; distributions of socioeconomic impacts; or concerns around sound or visual annoyances caused by the wind turbines (Tanaka *et al.*, 2012; Hoen *et al.*, 2018). A lack of public acceptance increases costs and the likelihood of cancellation when developing wind projects, particularly within the planning stages (Nadaï and van der Horst, 2010; Enevoldsen and Sovacool, 2016). Public acceptance can also influence the support of other associated bodies, such as investors, consumers, and policymakers, meaning projects may be completely derailed due to a lack of public acceptance at the planning stage (Rand and Hoen, 2017).

The level of public acceptance surrounding wind projects has been extensively studied in the literature by employing targeted surveys of sentiment towards individual projects and wind more generally (Devine-Wright, 2005; Klick and Smith, 2010; Rand and Hoen, 2017). However, surveys are difficult to employ on a large-scale when sentiment needs to be attached to a specific project, rather than assessing sentiment towards wind more generally, and require years of study to capture multiple projects over time. The media is a useful representation of public sentiment and has previously been utilized to assess general public discourse on wind energy (Stephens, Rand, and Melnick, 2009). Additionally, the media has the added benefit of being preserved online, meaning research on previous wind projects is possible. For this reason, the media (i.e. publicity) is assessed as a predictor of project outcome, where publicity is defined as attention that is given to someone or something through newspapers, magazines, and television news programs (Publicity, n.d.).

To calculate this variable, a sentiment analysis algorithm was used to estimate the degree of positive or negative publicity surrounding each wind project in published newspaper articles. Through sentiment analysis, a news story receives a numeric score representing its overall positivity or negativity, based on the collection of words or phrases found in the article text. This automated method allows for a non-subjective reading of the article and for a high volume of text to be analyzed with fewer time costs. It is intended to mimic the connotations (positive or negative, and to what extent) understood by a human reading an article as accurately as possible.

This type of analysis has been used for many different research purposes, such as analyzing tweets for negative or positive sentiment (Hansen *et al.*, 2011), analyzing social media related to large hydro power projects (Hanchen *et al.*, 2016), and interpreting stakeholder sentiments and confidence from documents (Purao, Desouza, and Becker, 2012). Sentiment analysis has been found to be a reliable way of interpreting sentiment and has been used previously to study large volumes of text, including one study that analyzed almost 500,000 articles and 250,000 survey responses (Hopkins, Kim and Kim, 2017). Additionally, a sentiment analysis conducted in 2013 that closely resembles the methods used here, found that sentiment analysis could be used to capture opinions in a relatively accurate manner (Mostafa, 2013).

Therefore, given previous usage, this study utilizes sentiment analysis to generate a quantitative metric of publicity that represents the level of community and public acceptance about wind energy projects. The resultant "Publicity Score" is hypothesized to influence the likelihood of a wind project's cancellation.

Ecological Impact

The ecological impact of the project is a key variable of interest in the model as a potential predictor of cancellation. For instance, regions with greater ecological impact may have more complex legal requirements, such as longer permitting times and greater uncertainty because of the proximity of an endangered species. When projects are located near species of concern, developers must work with multiple stakeholders, such as the U.S. Fish and Wildlife Service, to develop risk assessments for said species, and potentially habitat conservation plans or permits under the Endangered Species Act; each of these processes can add time and cost to the project, and are becoming more costly over time as a result of greater stakeholder involvement (Tegen, 2016). This increased time and cost could potentially derail projects, particularly if initial risk assessments highlight conflicts between the proposed project and any species of concern that would either prevent the project outright or discourage developers due to additional costs. In turn, this could lead to increased cancellations in ecologically-sensitive areas.

The ecological impact of a project may also influence the publicity of the project, due to community concerns over negative environmental impacts caused by wind farms. Between 18% and 24% of local residents surrounding a given wind project perceive wind turbines as dangerous to wildlife, although it remains uncertain if these perceptions are significant enough to influence overall opinion (Larson and Krannich, 2016; Rand and Hoen, 2017). Often, these concerns contrast with support for wind farms due to their positive impacts on air pollution or climate change, in a so-called "green versus green" debate (Rand and Hoen, 2017). Thus, in addition to the hypothesized connection between ecological impact and cancellation, there is a potential relationship between ecological impact and publicity. An interaction term is included in the model to account for this relationship.

Therefore, ecological impact is included in the model to test the hypothesis that it influences the likelihood of cancellation. For the purposes of this report, ecological impact is defined as a binary variable, designating each project as ecologically low-risk or not. This was measured using The Nature Conservancy's Site Wind Right map, which classified low-risk regions as land that is not only suitable for wind development— through avoidance of engineering restrictions and unsuitable wind speeds— but is also less likely to impact sensitive wildlife habitat.

Environmental Membership

Environmental membership is also included in the model as it is potentially important when evaluating the likelihood of cancellation. An individual's group membership has been found to impact the behaviors, beliefs and choices of members when compared to non-members. Individuals look to group membership when making decisions and forming opinions, even if it has no impact on the payoffs (Charness, Rigotti and Rustichini, 2007). Members of environmental groups have been found to have higher levels of environmental concern (Dennis and Zube, 1988). Thus, members of environmental groups are more predisposed to pro-environmental beliefs and actions, and these beliefs are likely to correlate with perceptions toward renewable energy development (Larson and Krannich, 2016). As a result, environmental membership is expected to influence community resistance towards a wind project, and in turn potentially affect the likelihood of cancellation. The relationship between environmental group membership and project outcome is therefore also explored in the model, and is measured as the number of people who are members of the National Resources Defense Council, the National Wildlife Federation, or The Nature Conservancy in the county that the project falls in.

Project Capacity

Additionally, the capacity or size of a project is hypothesized to predict project outcome. For instance, larger projects may increase community resistance or encounter more legal barriers, therefore causing them to be more vulnerable to cancellation. Conversely, larger projects may have more resources backing them and they therefore may be less susceptible to cancellation. To consider the effects of project size on project outcome, this variable is included in the model, and is measured in terms of MW.

Project Duration

The duration of the project, defined as the time between a project proposal and its first operating or canceled date, is hypothesized to predict whether the project is eventually canceled. For instance, a longer project that experiences more delays, for whatever reason, may eventually be canceled rather than undergo further delays. Controlling for project duration better captures the effects of ecological impact and publicity on the project outcome; in other words, the model controls for instances where project duration influenced the cancellation of a project.

Visibility

The visibility of a project is also included in the model as a predictor of cancellation. The visibility of wind turbines is one of the most common reasons cited for negative publicity surrounding a wind project (Rand and Hoen, 2017); as Pasqualetti (2010; page 381) quotes: "it is an energy source that reminds us that our electricity comes from somewhere." Expectations surrounding visibility and increased employment have been suggested as the biggest influencers of specific project opinion, and they may account for differences between general opinions of wind energy as a whole and opinions of specific projects (Larson and Krannich, 2016). Based on this research, visibility is hypothesized to influence the project outcome directly, in addition to having a correlation with publicity, and so is included in the model to reduce omitted variable bias. Visibility is measured in this report as the number of miles of primary and secondary roads that can see each wind project. By measuring the visibility of turbines from roads, the total visibility of each project is dependent on the distribution of people (the observers) more so than if other data are used, such as city locations (where an entire town would either see or not see a turbine) or population densities (which are generalized to a broader area).

Demographics

Both the average income and population of the area surrounding a wind project may also influence how a wind project is perceived and are included in the model. Rural areas often feel like they must unfairly bear the weight of energy siting (Rand and Hoen, 2017). Conversely, more rural, lower-income areas are often less resistant to wind energy projects due to perceived economic and job opportunities (Larson and Krannich, 2016; Rand and Hoen, 2017). In addition, recent surveys have shown that the closer people live to wind development, the more negatively they feel about the effects that its presence has on them (Hoen *et al.*, 2018). Population density data can serve as an estimate of how many people live close to each wind project. Median household income and population density for the county of each project is included as part of the model. These elements are theorized to also influence the likelihood of project cancellation directly; as with the inclusion of visibility, including these variables reduces omitted variable bias.

State

Finally, since different states have different regulations and permitting processes surrounding wind farm development, the state itself may influence the likelihood of project cancellation (Heibel & Durkay, 2016). State-fixed effects control for all the characteristics of a state that are not expected to change over time.

Objectives

Following from the above, the specific objectives of this report are to:

1. Model the relationship between ecological impact, publicity, and outcome (operational or cancellation) of wind power projects, identifying the most likely predictors of project outcome.
2. Form recommendations that would encourage developers to build on low-risk areas

C. Methods

The wind project data used for this analysis comes from ABB New Entrants Report, a subscription-based software that is used extensively by stakeholders in the energy industry, government entities, academic researchers, and NGOs, accessed in November 2018. The information comes from ABB's proprietary research; the Federal Energy Regulatory Commission's (FERC) quarterly and annual financials; EIA's monthly and annual industry statistics; independent system operator's (ISOs) current assignments, capacity, and interconnection queues; and Enerfax and NYMEX's daily trade logs (ABB Velocity Suite 2019).

This database includes specific information about wind projects across the United States, including each project's location, development timeline, and project attributes such as capacity. The development timeline of each project is a list of each of the project's phases and is used to determine whether a project is ultimately operational or canceled. There is a total of 2,233 wind projects initially in the U.S-wide database. Since this study is primarily concerned with the Wind Belt, only projects within this region are included, resulting in a remaining sample of 1,110 projects. However, 228 of these projects are unfinished, as they do not have an operating or canceled date in their timeline. Removing these projects, along with 13 projects with impossible timelines (i.e. operating date before proposal), results in a final sample of 868 canceled and operating wind farms. The 228 unfinished projects are used later to calculate predicted probabilities, in order to test the model.

To examine all 868 projects, a logistic regression model is used to investigate the drivers of project cancellation, and ultimately isolate the effect of low-risk siting. This model considers how the log odds of cancellation are influenced by the key variables outlined in the Theory section of this report, and is functionally defined as:

$$
\begin{aligned}
LogOdds(Cancellation) \\
&= \beta_0 + \beta_1(Sentiment) + \beta_2(LowRisk) + \beta_3(TimelineLength) \\
&+ \beta_4(PopDensity) + \beta_5(MedianIncome) + \beta_6(Capacity) \\
&+ \beta_7(ViewScore) + \beta_8(EnvMemberships) \\
&+ \beta_9(Sentiment * LowRisk) + \beta_{10}(State) + \varepsilon
\end{aligned}
$$

The calculation of each of these variables is described in the sub-sections below.

Ecological Impact

The ecological impact of a project is represented by the "LowRisk" variable in the model, which indicates whether or not a project is located in an area that is of low-risk to sensitive habitats. This is defined by TNC's "Site Wind Right" (SWR) map. Areas described as low-risk are regions that are not only suitable for wind development, but also avoid sensitive wildlife habitat. Suitability for wind development is determined through a series of general exclusions, such as excessive slope, land use restrictions (e.g., airfields), and low wind resource. Whether the region is considered low-risk or not is based on a spatial filter of 12 different types of sensitive species habitats. This includes habitats for specific species such as the whooping crane, bald eagle, and greater prairie-chicken, as well as generally important habitats such as intact wetlands, grasslands, and forests. The full map of low-risk areas and the locations of all 1,110 Wind Belt projects can be seen in Figure 4. The different habitats avoided by the tool can be found in Figure 5, using Kansas and Oklahoma as an example.

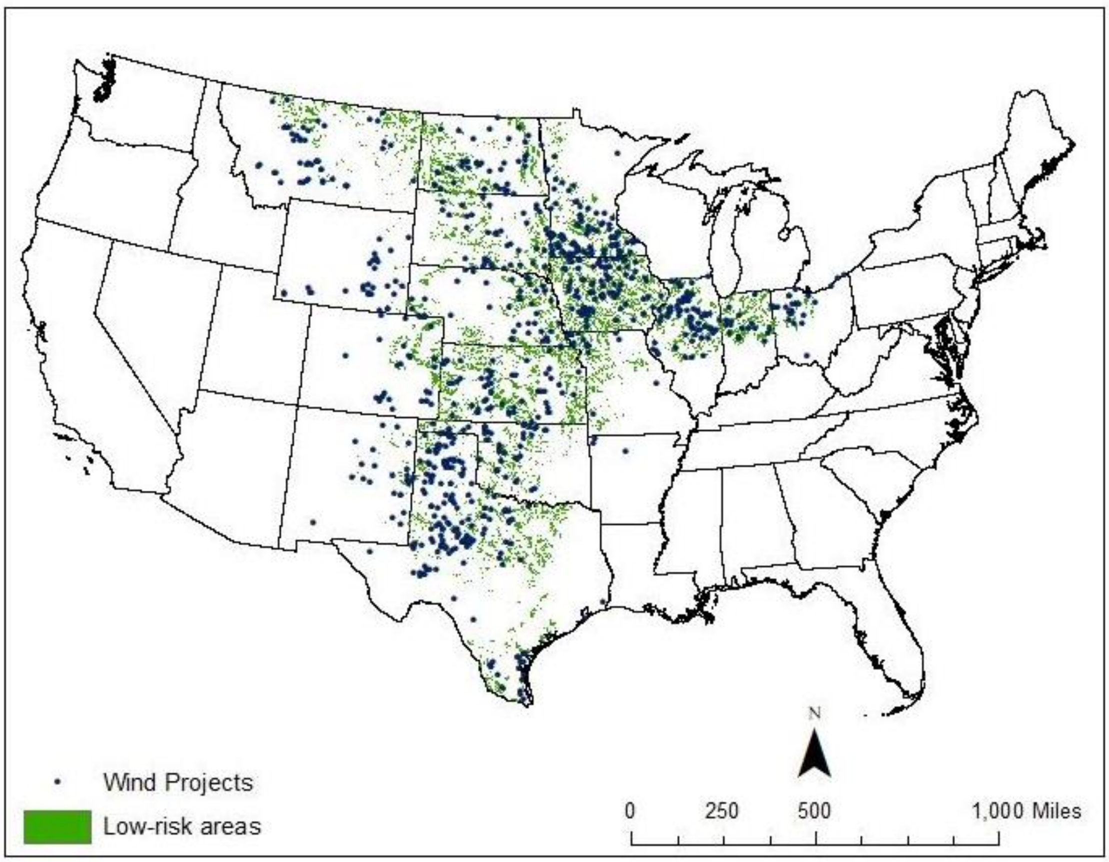

Figure 4. "Low Risk" Land Designations. The full extent of low-risk land throughout the Wind Belt, with the locations of all 1,110 projects displayed.

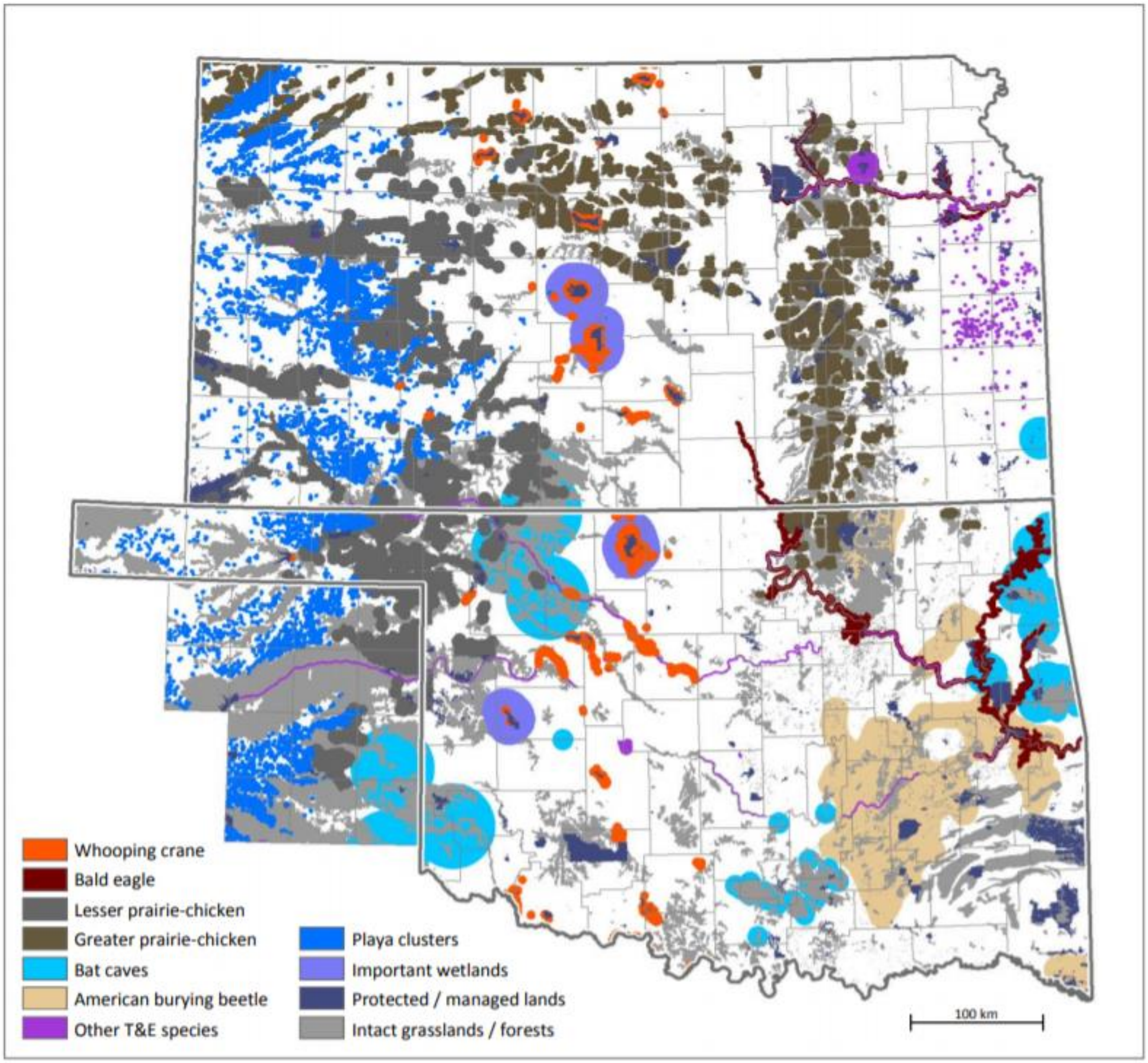

Figure 5. "Site Wind Right" Habitat Exclusions - Kansas and Oklahoma. Low-risk areas are not only suitable for wind development, but also avoid these sensitive regions. There are approximately 16.3 million acres of low-risk land available for siting in Kansas and Oklahoma (TNC, 2017).

View Score

The view score of a project is represented by the miles of road that can see the project, given variations in the topography of the landscape (Figure 6). Miles of road was chosen as a metric since it incorporates the distribution of people, or observers, to a greater extent than other data such as city or town locations. Data on elevation and roads are required to calculate this score. Thus, Digital Elevation Models (DEMs) at a 1 arc-second resolution, accessed from the United States Geological Survey (n.d.), are resampled to a mile cell size resolution. Moreover, primary and secondary roads, gathered from the United States Census Bureau (2018), are converted from line segments into points that represent every mile. With these two datasets, the view score of each project is calculated by counting how many road points, or miles, can see each cell in the landscape. In other words, a cell that was observed by 50 points could be assumed to be visible to approximately 50 miles of road. This is calculated with Model Builder, using ArcMap 10.6.

Using the "Visibility" tool, a surface offset is set at 80 meters, representing the common height of a wind turbine (WINDExchange, n.d.), ensuring that the visibility is calculated for an object at 80 meters in height rather than simply ground level. The observer offset is set to two meters, representing a high estimate for the height of a large vehicle and a conceivable height of an observer along the road. The outer radius of the calculation, or the distance after which no visibility is assumed, is set to 15km (Gibbons, n.d.).

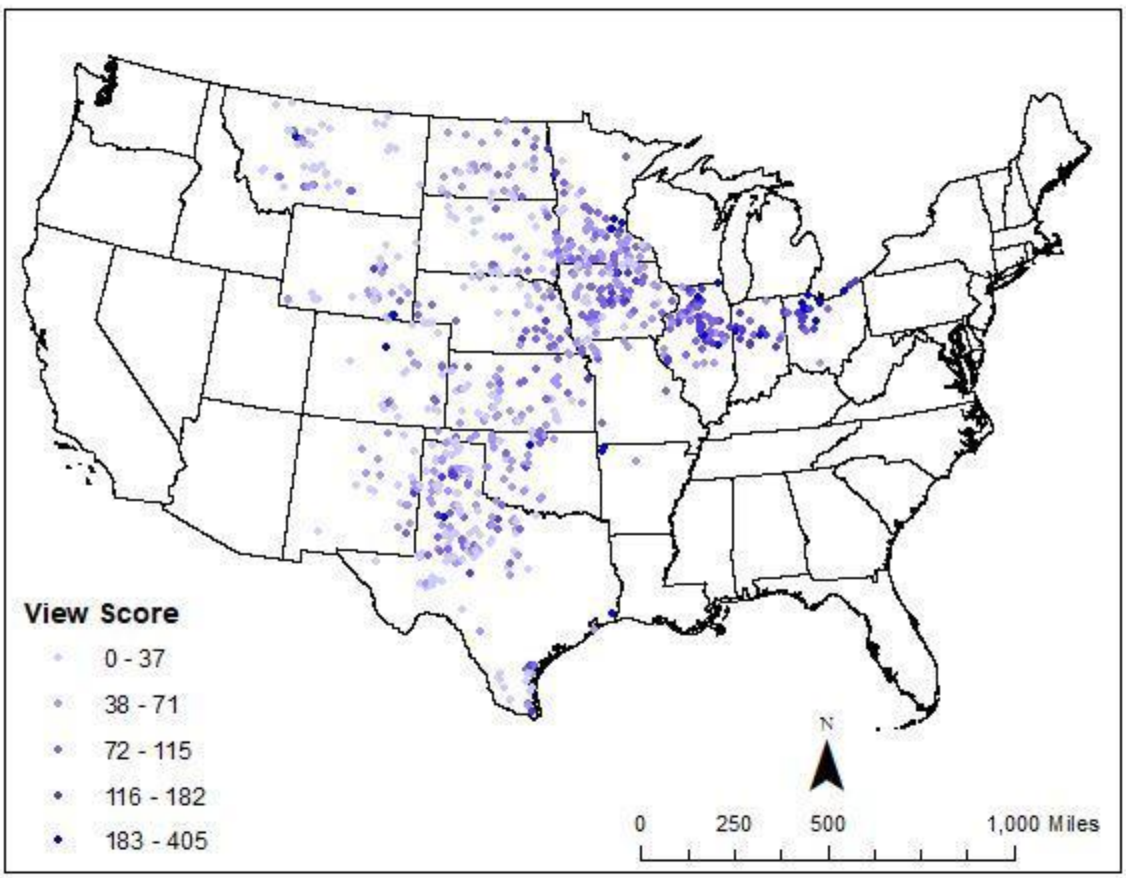

Figure 6. View Score of ABB New Entrants Report Projects. View score, measured by how many miles of road the project can be seen from, is displayed for every project in the database. Darker purple points are projects that have a high degree of visibility.

Sentiment

Publicity is used as a predictor variable for cancellation and is represented by a sentiment score. This score is calculated through a sentiment analysis algorithm, based on all the news articles found for each project. Google News was chosen as the search engine since it only includes news stories, unlike search engines such as Nexus Uni— considered initially for this research— which contain legal documents (see Appendix 2 for Nexus Uni methodology). In addition, Google News is relatively straightforward to access through automatic means. This is critical, because given a large sample size of 1,110 projects, a manual search of each project is not feasible. As a result, a web-scraping algorithm is used to automatically search each project, retrieve the relevant articles, and save all the article texts to a .csv file.

This automation is done with a Python script, using the “BeautifulSoup”, “Newspaper”, and “Requests” modules. The script first reads in the .csv file of ABB New Entrants Report projects and constructs how each project will be searched in Google News. This search query includes the project name, developer, state, and the key words “wind” and “project”. For example, a search query for the “Adams County Wind” project in Colorado would be: Adams County Wind NextEra Energy Resources Colorado wind project. This search is done without quotes to obtain more relevant results, as the name of the project in the ABB New Entrants Report database may not necessarily be the same name used in media publications. After a project has been searched, the full text of each article is downloaded, excluding extraneous details such as comments and advertisements. For each of these articles, the project name and the word “wind” are searched through a string comparison, and if neither are found, the article is removed. This is done because Google News can sometimes display erroneous results, so irrelevant articles need to be filtered out.

After all relevant articles have been found, each news story is assigned an overall sentiment score, using a lexicon of words associated with positive and negative sentiment. In this way, the general feeling the public has about the wind project can be captured. There are a variety of sentiment analysis lexicons that exist; the lexicon used in this analysis includes a score ranging from -5 (most negative) to +5 (most positive) for 2,477 words and phrases (Finn Årup Nielsen, 2011). For example, the word ‘anger’ has a -5 score, while the word ‘beautiful’ has a +5 score. This lexicon (“AFINN”) is found in the “tidytext” R package and is used in a number of text-analysis publications, such as the Twitter sentiment analysis by Hansen *et al*. (2011). To score each news story, every word is matched with its associated score in the AFINN lexicon and is weighted based on how many times it is found in the article. Words that are not found in the lexicon are excluded. The result of this calculation is a weighted score for each article, which can then be used to calculate the average score for a given project.

Given that not all projects have news stories associated with them, not all projects will have a sentiment score. For the purposes of this analysis, these projects are assumed to have a perfectly neutral score of zero, as they lack any presence in the media. This is a sizeable assumption, and therefore a robustness check is performed by testing how model results change when these projects are removed.

Project Duration

The duration of a project is represented by the "TimelineLength" variable and is the number of days between a project's proposal and its operation or cancellation. This number is not directly provided in the ABB New Entrants Report dataset and therefore must be calculated. Not all projects in the dataset have operation or cancellation dates; many are still in construction or another intermediate phase. These projects are not included in the logistic regression, as they do not have an appropriate "end date." In other words, they are a part of the 1,110 Wind Belt projects that are evaluated, but not in the sample of 868 projects used to train the model. However, they are still needed as a test sample for the model later on, as it is useful to know how the model predicts their probabilities of cancellation. Timelines for operating projects are calculated by subtracting the first proposal date by the first operating date, while canceled project timelines are the period between the first proposal date and the first canceled date. This is done because some projects have multiple proposal, operating, or canceled dates associated with different phases of the project, and this study is most concerned with the time until a project is first operating or first canceled. A canceled date is only looked for if there is no operating date in the timeline.

Environmental Memberships

The overall environmental inclinations of the region surrounding a wind project is hypothesized to have some effect on the pushback it will receive, and ultimately its probability of cancellation. Thus, the "EnvMemberships" variable is calculated as the sum of all TNC, National Resource Defense Council (NRDC), and National Wildlife Foundation (NWF) members who reside in the county that a given project is located in. This data is gathered through direct contact with the organizations in a prior study (Anderson, 2011).

Other Control Variables

The other control variables included in the model are state, household median income, and population density. State-fixed effects are included given that each state has a different permitting and regulatory procedures for renewable energy projects, which may impact odds of cancellation. The state of each project is found in the ABB New Entrants Report dataset. The household median income and population density by county variables test how income and population influences cancellation odds and are derived from U.S. Census Bureau data. Specifically, the data used are the 2012-2016 American Community Survey 5-year estimates and the 2010 Census, respectively.

Further Text Analysis

In addition to the logistic regression model, the content within the Google News articles found for each project is further explored to determine what topics are discussed most frequently and to determine what drives publicity. The sentiment score of any given wind project may be driven by a variety of negative or positive impacts. Factors beyond wildlife and habitat impacts may influence the directionality of the publicity score. In addition to wildlife and habitat impacts— such as bird fatalities or landscape fragmentation—wind farms engender aesthetic disadvantages for many, such as noise pollution and visual encumbrance (Wang and Wang, 2015; Wagner and Mathur, 2018). Additionally, some have claimed that wind turbines can affect the health of those living adjacent to the farm through low-frequency noise hindrance or shadow flickers, although this has been widely debated (Knopper and Ollson, 2011; Coz and Sherman, 2017). As such, to evaluate the main topics that drive publicity of wind project, the main external impacts of wind energy are categorized into the following categories: wildlife impacts, visual or noise pollution impacts (aesthetics), human health impacts, and habitat impacts (e.g. fragmentation).

Four word queries are built to broadly represent these groupings. The words were selected based on commonly used words in the above literature about each different wind energy impact category.

Table 2. Search queries used to extract content of interest from Google News articles. The selected words were determined based on frequent occurrence in the literature about wind energy impacts.

Word queries used to extract topics of interest in Google News articles			
Wildlife	**Habitat/Ecosystem**	**Aesthetics**	**Health**
wildlife bats birds wildlife impact collisions species animals	habitat fragmentation ecosystem environmental impact landscape habitat loss wetlands	aesthetics noise noise pollution visual impacts turbine visibility property values	health health concerns health impacts human health

Using R, the stringr package is used to extract the words listed in the queries from each article retrieved from the Google News Python script. The queries were modified using regular expressions to ensure all versions of a given word listed above are encapsulated in the match. If a given article mentions one or more of the words in a particular category, it is classified as an article that mentions the associated topic. For example, if the words "wildlife" and "collision" are found in an article, this article is classified under the wildlife topic. Topics are not mutually exclusive; in other words, an article can be classified in both the wildlife and health topic categories. This text analysis enables a comparison of the topics of interest found in news articles about wind projects. In addition, this analysis is used to highlight projects as case studies and qualitatively assess what topics drive a project's sentiment score and ultimately its cancellation risk.

D. Results

Descriptive Statistics

All 868 operating or canceled projects are used to train the logistic regression model. Of these, 473 are operating and 395 are canceled, with 64% of operating projects and 40% of canceled projects located in low-risk areas. Across these two types of timelines, the mean of each control variable used in the model is shown in Table 3, while the range of each variable is displayed in Table 4. With regard to sentiment score, 276 of the 868 projects (32%) have Google News articles associated with them, with an average of 6.2 articles per project. The complete range of non-zero sentiment scores for both operating and canceled projects can be found in Figure 7. In addition, the mean and range of timelines is higher among canceled projects than operating projects, with the full distribution of these timelines visualized in Figure 8.

Table 3. Mean variable values of operating and canceled projects.

End Date	Timeline (Days)	Viewshed Score	Sentiment Score	Capacity (MW)	Population Density (per mi2)	Median Household Income	Environmental Memberships
Operating	863	63.28	0.46	101	56.04	$50,477	1223
Canceled	1494	67.31	0.09	137	60.13	$50,565	1497

Table 4. Variable ranges for operating and canceled projects.

End Date	Timeline (Days)	Viewshed Score	Sentiment Score	Capacity (MW)	Population Density (per mi2)	Median Household Income	Environmental Memberships
Operating	1 - 3,656	0 - 405	-0.89 - 2.67	0.002 - 470	0.3 - 3,342	$24,000 - $90,198	0 - 21,493
Canceled	29 - 4,230	0 - 277	-1.2 - 2.6	1.5 - 3,000	0.3 - 1,586	$24,000 - $80,822	0 - 21,493

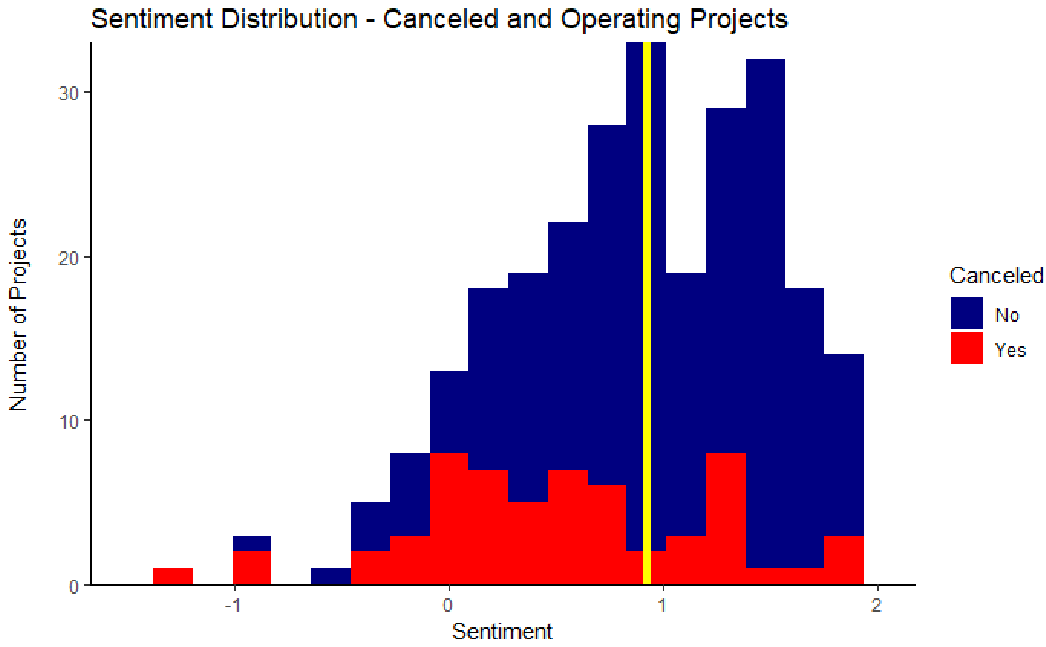

Figure 7. Sentiment distribution of canceled and operating projects. Note that 68% of the projects did not have articles associated with them, so have a sentiment score of zero. These are not included in this graph for visualization purposes. The yellow line indicates the mean of non-zero sentiment scores. Of the 275 projects with sentiment scores, 59 of them were canceled and 216 were not canceled.

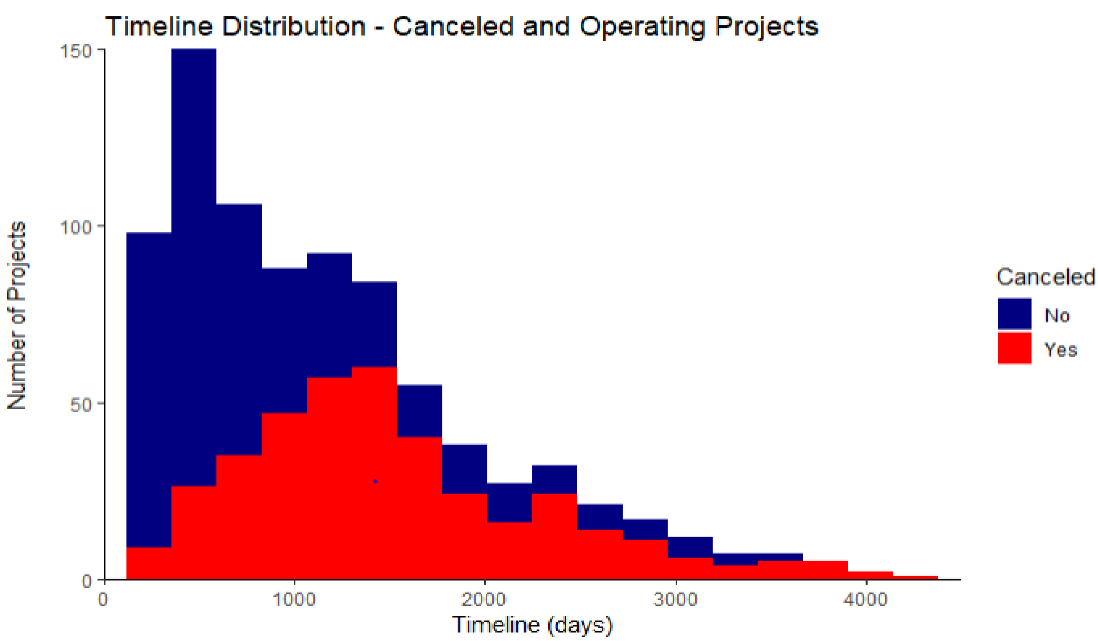

Figure 8. Timeline distribution of canceled and operating projects. The timelines of all 868 projects in the dataset. In general, canceled projects have longer timelines than operating projects.

Regression

Our primary logistic model revealed that whether or not a project is located in a low-risk area significantly predicts that project's odds of cancellation ($p = 0.001$). The log odds of cancellation are reduced by -0.67 when a project is located in a low-risk area, which translates to a 50% reduction in the odds of cancellation. In addition to this key variable, there is a significant connection between publicity and cancellation ($p < 0.0001$). A single point of negative publicity increases the log odds of cancellation by -2.1. When this coefficient is exponentiated, a project with sentiment score of -1 has 790% higher odds of cancellation relative to a project with a score of 0, assuming all else is equal. While -1 is on the more extreme end of sentiment scores, even a slightly negative score of -0.1 still has 25% higher odds of cancellation relative to a project with a score of 0.

Of the other variables controlled for in the model, only capacity ($p = 0.01$) and project timeline ($p < 0.0001$) have a significant effect on a project's odds of cancellation. The directionality of these variables is as expected, with higher capacity projects having 0.2% higher odds of cancellation for every additional MW, and a 0.1% increase in cancellation odds for every day in the project's timeline. While the interaction term between sentiment and project location is not significant, it is useful to highlight its directionality, which is that publicity has a greater effect on odds of cancellation when a project is not located in a low-risk area.

Performing a variance inflation factor (VIF) test for multicollinearity between variables reveals low multicollinearity, with all VIF values being less than 2.

Once the model was trained on all 868 operating and canceled projects, it was tested on the 228 unfinished projects that were initially removed from the dataset. This was done in order to investigate predicted probabilities of cancellation for projects that have yet to be completed. Of these projects, the mean probability of cancellation was 50%, with probabilities ranging from 0.5% to 99%. The distribution of projects with a probability of cancellation greater than 50%, across project location, is shown in Figure 9.

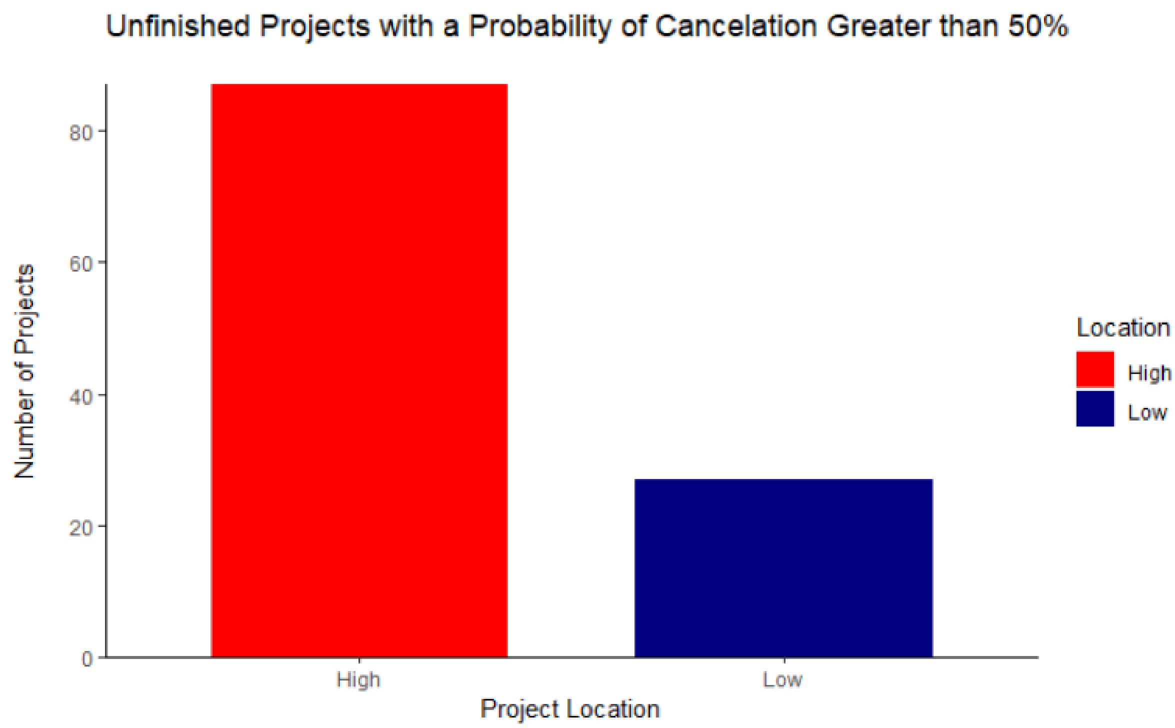

Figure 9. Unfinished projects with a probability of cancellation greater than 50%. Of the 60 unfinished projects located in low-risk areas, 27 of them (45%) have a probability of cancellation over 50%. There were 168 unfinished projects located in high-impact areas, with 87 of them (52%) having a probability of cancellation higher than 50%.

In addition to predicting probabilities on these truncated projects, predicted probabilities are calculated for a random portion of projects (n = 70) from the main operating/canceled dataset, in order to evaluate how well these probabilities line up with actual cancellations. Given this sample, a misclassification test reveals that approximately 82% of projects are accurately predicted from the model, using an optimized cutoff of 45%. Similarly, evaluating the concordance correlation coefficient, which indicates how well high probabilities of cancellation align with actual cancellation, reveals a concordance of 85%.

To further investigate the quality of the model, a robustness check is performed by excluding projects that did not have Google News articles associated with them. In doing this, the number of operating and canceled projects in the dataset is reduced from 868 to 275. Re-running the model revealed reductions in power and coefficients, although no changes in coefficient directionality. Both key variables of sentiment ($p < 0.0001$) and whether or not the project is located in a low-risk area ($p = 0.03$) are still significant, albeit having smaller correlations with the odds of cancellation.

The full regression results for all 868 projects are found in Table 5.

Table 5. Logistic Regression Results. The main logistic regression, which coded sentiment scores for projects without news articles as 0, is shown here. Timeline length (p < 0.001), low-risk project location (p < 0.001), sentiment (p < 0.001), and capacity (p < 0.001) all significantly predict log odds of cancellation.

Logistic Regression Results
Predicting Log Odds of Cancellation

Variable	Coefficient	SD	P-value
Intercept	-1.99389	0.58648	0.00067
TimelineLength	0.00115	0.00013	0.00000
ViewScore	0.00473	0.00234	0.04330
Sentiment	-2.13896	0.29001	0.00000
PopDensity	-0.00036	0.00051	0.47869
MedianIncome	0.00000	0.00001	0.83763
Capacity	0.00234	0.00092	0.01054
LowRisk	-0.65793	0.21532	0.00225
EnvMemberships	0.00003	0.00003	0.42287
Sentiment*LowRisk	0.44522	0.44629	0.31848

Concerns Discussed in Articles

Out of 228 projects with Google News articles, 128 projects are found to have articles that contain one or more of the words queried in the four topics of interest. The word “landscape” was removed from the habitat ecosystem impact queries because the usage of these words in the articles was found to be largely out of context, given the words broader applicability in the English language. The topic of “wildlife” showed up in the most Google News articles — a total of 117 times — relating to 84 unique wind power projects. This is followed by the “health impacts” topic which shows up in 100 articles relating to 69 different projects. Meanwhile, the “aesthetic impacts” mentions are observed in 67 different articles about 41 different projects (Figure 10), and habitat impacts shows up in only 50 different articles, relating to 38 unique projects. Still, the following topics are not mutually exclusive; one given article may discuss both wildlife and habitat or lawsuit and noise. Amongst the various wind farm impacts investigated, the topic of wildlife appears most frequently in the media about wind energy projects, based on this analysis (see Appendix 5 for in depth analysis).

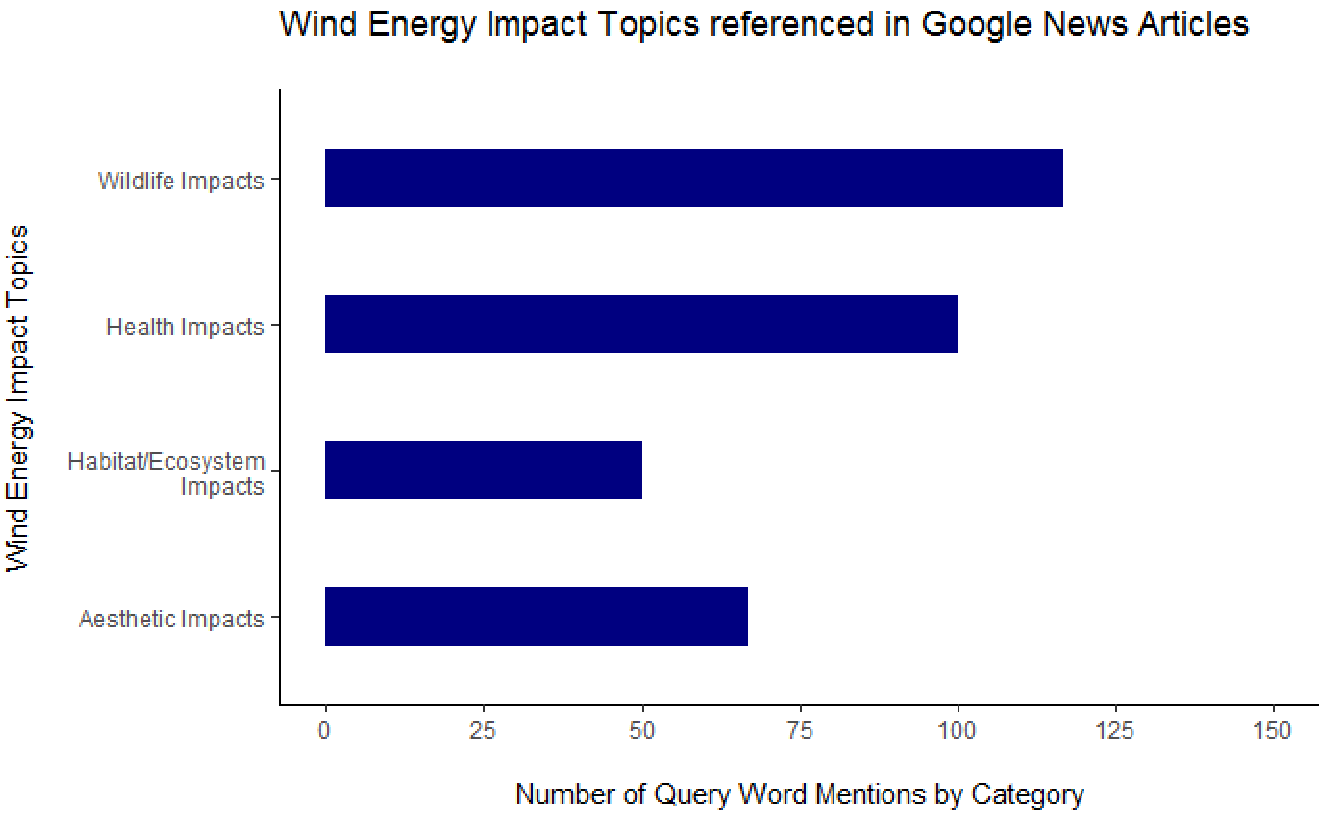

Figure 10. Top topics of interest mentioned in Google News Articles about wind projects in the Wind Belt. The mentions per topic were built based on query word extraction from the Google News articles.

E. Discussion

Implications

This project aimed to 1) model the relationship between various project characteristics, such as publicity and ecological impact, on project outcome; 2) identify the most likely predictors of project outcome; 3) and develop recommendations to encourage developers to build in low-risk areas. This was accomplished by developing a model to predict the probability of cancellation based on project characteristics.

We found that wind projects that are located on low-risk land are much less likely to be canceled than projects that are located in other places. We also found that negative publicity, as measured by sentiment analysis of online news sources that discuss each wind project in our dataset, increases the probability of cancellation. Finally, further exploration of the article texts showed that wildlife, as opposed to aesthetic or health concerns, is mentioned in the greatest number of articles, highlighting these concerns as potential drivers of cancellation.

These results have important implications for wind developers. Wind development is already a risky and complicated endeavor; only a quarter to half of all projects succeed. A similar pattern in visible in the dataset, where 45% of projects were canceled and not redeveloped. The process of development is complicated. It requires input and approval from multiple stakeholders, including federal agencies like the Federal Aviation Administration (FAA), the U.S. Fish & Wildlife Service (USFWS), and the U.S. Environmental Protection Agency (EPA), as well as county commissioners, local planning and zoning boards, and private citizens. Furthermore, each stage of development, from prospecting to permitting to financing to construction, can take years. While wind energy has been growing and will continue to grow in the United States, this leads to a more crowded development landscape. This future growth of the industry could make the consideration of siting challenges and additional regulation even more critical to success. Any tools that help wind developers mitigate risk will contribute to the successful deployment of wind energy in the United States.

Our model showed that if all else is equal, the odds of being canceled are *cut in half* for a project located on land that poses a low risk to wildlife as opposed to high-risk land. This is important for developers, because it indicates that considering wildlife impacts during the siting process can have huge implications for project success. However, it is worth noting again that the low-risk versus high-risk designation, based on TNC's Site Wind Right map, classifies "high-risk" as land that either critical for wildlife or unsuitable for development, therefore it is not all land that is critical for wildlife. "Low-risk" land, on the other hand, is suitable for development when considering engineering restrictions and wind power class.

While not all projects that impact wildlife habitat will end up in media publications, those that do face greater odds of cancellation. Our model found that as publicity moves from being neutral to negative, the odds of a project being canceled increase immensely; even a small reduction in publicity score (-0.1) increases the probability of cancellation by 25%.

The effect of these types of small changes can be seen in Figure 11, a matrix comparing the likelihood of cancellation of a wind power project that would be perfectly average for our sample given both low and high-risk siting as well as slight changes in publicity score.

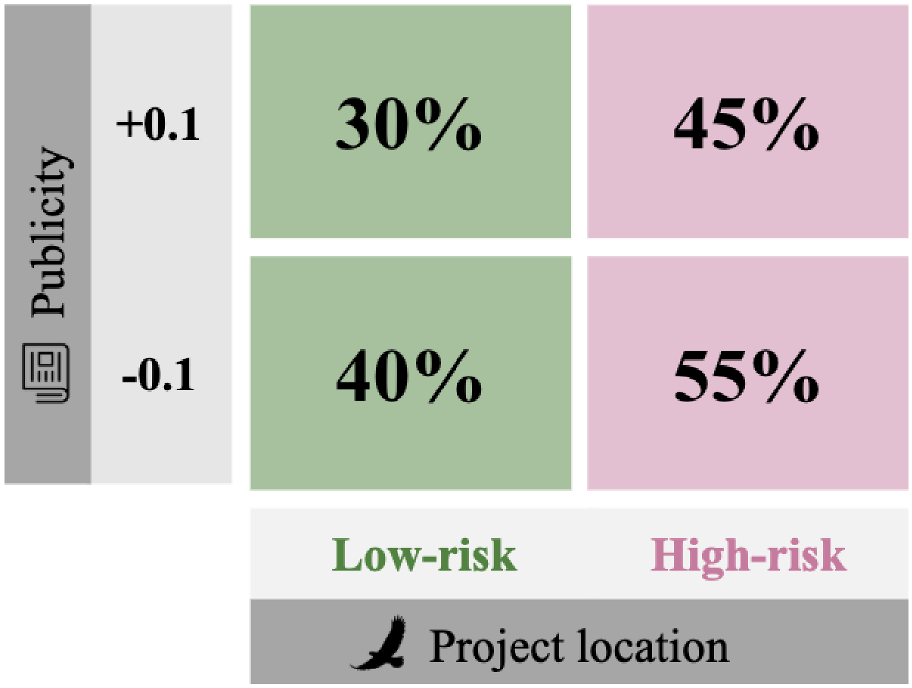

Figure 11. A comparison of the cancellation likelihood given different publicity scores and project locations. This comparison was made assuming a project that was perfectly average for our sample. The characteristics of this project were as follows; State: Texas, Population density: 60,000 people, Median income: $50,525, View score: 65 road points, Capacity: 117 MW, Timeline: 1150 days, and Environmental membership: 1348 members.

For example, the Crazy Mountain Wind Farm and the Spion Kop Wind Farm, both in Montana, are similar projects. They do not vary much based on the characteristics that are significant for predicting cancellation. Both have a capacity between 30 and 40 MW, took between two and three years to reach a development outcome, and are located on high-risk land. However, Crazy Mountain Wind Farm has a sentiment score of 0.12, while Spion Kop is more positive (0.5). Crazy Mountain Wind Farm was canceled in 2014. Spion Kop began operating in 2012.

The articles about Crazy Mountain Wind Farm accessed through Google News told a story of multiple lawsuits filed by landowners living near the project, alleging that local roads were being illegally commandeered by the developer and that threats to wildlife were not being taken seriously. They also characterized a divide between wealthy, out-of-state landowners who opposed the project based on its aesthetic impacts and local ranchers who were relying on the potential income provided by the development to keep their land and livelihood.

The story of Spion Kop Wind Farm is not as contentious. Concerns are still raised about impacts on wildlife, particularly bats, and the articles detail post-construction plans to monitor these impacts. There is no mention of aesthetic, health, or legal concerns. Further case studies are included in Appendix 3.

After a cursory analysis of topics of concern in the articles from Google News, the most common concerns surrounding projects had to do with wildlife impacts. Other environmental considerations, like habitat fragmentation, were less than half as common, behind health and aesthetics; illustrative quotes are included in Appendix 4. Whether these are truly the cause of opposition or the cause of cancellation is unknown, as these questions were beyond the scope of this study.

Understanding the factors that correlate with cancellation risk has real, financial benefits to developers. There are hidden costs associated with failed projects. Firms lose their initial investment once a project is canceled, which can be on the order of millions of dollars, depending on the stage in which it is canceled. They also have to maintain facilities, staff, and a development pipeline; pay to redo prospecting studies to find new sites; and absorb penalties for not meeting the terms of Power Purchase Agreements (Tegen *et al.*, 2016).

Furthermore, firms typically sign a Power Purchase Agreement (PPA) to guarantee an off-taker and financing *after* choosing a site and applying for environmental permits. As the wind industry has become more crowded, there is more competition between developers for off-takers and PPAs. While off-takers may make decisions based primarily on costs, they may also prioritize signing contracts with trustworthy developers that have demonstrated the ability to deliver projects successfully. A developer may be more competitive in winning bids if it can show that its current proposal has much higher odds of being successful based on the location they have chosen to develop. Additionally, as wildlife impacts become more publicized, off-takers may not want to be involved with "harmful" projects. That could cause costly public relations problems for their own operations or may simply not align with the organization's values.

Limitations

This project has a few key limitations that are important to consider when interpreting the results. First, the ABB New Entrants Report, the source of the wind project data, does not explicitly indicate when a project is first included in the dataset and tracked through the development process; projects that were started and canceled early on in the process may have been missed. We are unable to determine how likely this occurrence may have been. Moreover, the criteria for entering a project into the database is largely unknown for this research. There may be projects known to developers who have committed resources to pursue wind development that are not captured in our dataset. This is an important consideration for our logistic regression model because those could be projects that were scrapped early on due to concerns about negative public acceptance about the proposal. As such, we have no way of modeling the effect that these early decisions have on odds of cancellation. However, this likely makes our results more conservative. If a project was scrapped early due to concerns about a characteristic like publicity, that would *increase* the coefficient for publicity in our regression, making it a more impactful driver of cancellation risk.

Second, our study aimed to estimate the level of public acceptance for each wind project in our dataset by calculating a "publicity score" through sentiment analysis of online news articles. This publicity score is a proxy for public acceptance because we were not able to directly survey local residents about each project. Our publicity score is not a perfect proxy for local public acceptance because traditional news reporting tries to be balanced, and multiple sources and opinions are offered in order to report the full breadth of a story. However, enough variation was observed in publicity score, even though calculated scores were mostly positive, to be used in the regression model and still detect the variability between projects when assessing the relationships between independent and dependent variables. Furthermore, sentiment analysis of traditional news reports is an accepted, if not common, practice in public acceptance and public opinion research, including about energy generation technologies (Burscher *et al.*, 2016; Nuortimo and Härkönen, 2018; Nuortimo *et al.,* 2018) and in other fields like real estate and finance.

Third, the process we designed to scrape new results from Google News introduces some statistical "noise." Despite filtering by project name, developer, and other specific search terms, a handful of results are not specifically about the queried project itself. The project may be mentioned along with the developer as an example of previous work or may be referenced when talking about wind energy capacity expansion in a specific county. However, after reading through a majority of our search results, few examples of this were found.

Finally, as a statistical test, logistic regression modeling describes correlations between variables. It does not measure direct causation. We are not able to say that building a wind project on high-risk land causes the higher probability of cancellation. All we can say is that those two variables are related. There may be other, unmeasured factors that relate to land impact that drive cancellation. This is especially true given the structure of the low- vs. high-risk classification. The "high-risk" category also includes areas that already have wind farms, have engineering restrictions that make development impossible, or do not have adequate wind resources. There could be other subfactors, like these, that are driving the risk of cancellation. Still, these results sufficiently demonstrate compelling enough to show developers that building on low-risk land that has adequate wind resources, no engineering restrictions, and poses a low risk to wildlife dramatically decreases the probability of cancellation.

Further Research

To our knowledge, no other studies have tried to model the cancellation risk of wind projects based on ecological impact, quantification of publicity, and other project characteristics. This report represents the beginning of important work that gives wind developers and other stakeholders such as environmental organizations, conservation planners, government agencies, and local communities the tools to understand the impact that siting decisions have on the future of wind development.

While we show that there are significant correlations between ecological impact, publicity, capacity, and project duration on cancellation risk, there is much more to learn. This project assembled a corpus of 916 news articles about 276 separate wind projects in the Wind Belt of the United States. We searched the text for mentions of wildlife, habitat, health, noise, and legal concerns in order to get a sense of the drivers of negative publicity.

Future analyses could go much deeper. There is the possibility of answering questions about the spatial distribution of concerns. In what states are wildlife concerns mentioned the most? What are the concerns of rural communities? What about urban ones? How often is the reason for cancellation reported? Exploration of these questions, in addition to others, could greatly expand our understanding of the interplay between publicity, ecological impact, cancellation risk, and other project descriptors. Many of these subjects have only been touched on briefly in this report.

In addition, it would be valuable to further justify the sample of wind projects used in this study. A logistic regression power analysis in particular could evaluate how effective the sample is in generalizing the wind industry as a whole. Other types of sample justification are difficult, given the lack of public information about specific wind projects. The ABB New Entrants Report stands as one of the more comprehensive sources of wind project data.

Finally, availability of transmission connection was not included as a predictor variable for cancellation, as the team did not have data with which to address this. Anecdotal evidence from discussions with developers indicates that the ability to connect to existing transmission lines and the time it takes to be approved while waiting in the transmission queue could influence siting decisions and the success of projects. It is difficult to emphasize enough how important transmission capacity is for successful wind development, and transmission line development goes through similar planning and development phases to energy generation projects. A similar modeling framework, including sentiment analysis, could be used to predict the risk of cancellation of transmission projects, as well. The development of these projects also has the potential to affect wildlife and intact landscapes, so more knowledge of their processes could help developers, environmental groups, and regulators advance the adoption of well-sited renewable energy.

F. Conclusions & Recommendations

Our results show that wind project location on high-risk ecological land and negative publicity significantly impacts project success. This has implications for developers, who could use our results to make siting choices that mitigate their risk of project failure. It also creates opportunities for our client, The Nature Conservancy (TNC), to influence siting decisions and make the case for wind development that poses a low risk to wildlife.

Building the business case for conservation considerations in energy development can be difficult, as stakeholders have different and often competing values. This goes beyond the common development-vs.-nature trope. Within the conservation community, there are divides on how much to push for conservation-compatible renewable energy development because renewables are such a critical piece of the fight to address climate change. To date, it has also been difficult to find metrics that measure the effect that siting decisions has on the success of wind development in order to speak directly to the business values of wind developers.

Our results provide a critical piece of this puzzle. TNC's Site Wind Right map, which shows land for wind development that is low-risk for wildlife, can now be represented as a useful tool for lowering the risk of cancellation. If all else about a project is held equal, developers can reduce the odds of cancellation by half if they site on the low-risk land.

We recommend that TNC market Site Wind Right in this way when communicating with developers. The map could also be updated to clearly display the reduced risk of switching sites and be made interactive. TNC could also use our model to predict the cancellation risk of projects that are in development phases right now in order to target developers for educational opportunities and partnerships.

TNC and other stakeholders also have the opportunity to affect project success by influencing publicity. This could be through granting interviews to reporters about specific projects or increasing outreach to communities in high-risk areas to raise awareness. And while we focus on how negative publicity significantly increases the odds of project cancellation in this report, it is important to note that *the other direction is impactful, too*. More positive publicity decreases the risk of cancellation. TNC can use this to highlight and support projects that are sited well as examples. There are already examples of projects like this that have positive publicity for considering wildlife impacts; see Appendix 3 on the Meridian Way Wind Farm case study.

However, we recommend using this power cautiously so as not to come across as "anti-wind" when leveraging negative publicity against a project. Wind energy is an important piece of the transition to cleaner energy sources. DOE's Wind Vision estimates that increasing wind penetration to 50% of U.S. energy demand by 2050 could save the country $85-1,230 billion in avoided damages associated with greenhouse gas emissions and another $52-272 billion in avoided damages from other air pollutants— all of which affect wildlife as well as humans.

In conclusion, our results reveal that it is beneficial for developers to focus wind farm siting on low-risk land. In turn, this benefits the ecologically sensitive land and wildlife that may otherwise be negatively impacted by wind turbines. Moving into the future, developers can continue to expand the use of wind energy as part of the solution to tackle climate change and limit their risk of project cancellation and avoid ecological impacts at the same time. Based on this research, developers, communities and conservation groups can work together to create projects that both have a relatively low chance of cancellation and are on land that poses a low risk for native ecosystems and wildlife. This would be a win-win for the future development of wind energy in the Wind Belt region.

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H. Appendices

Appendix 1 - Further details about renewable energy

Table 6. Levelized Cost of electricity across different energy sources, both renewable and conventional energy. Values were pulled from Lazard, 2018.

	Energy Technology	Levelized cost of electricity USD/kWh (2018)
Renewable resources	Solar Photovoltaic	0.03 - 0.04
	Onshore Wind	0.03 - 0.06
Non-renewable resources and conventional fossil fuels	Natural Gas	0.04 - 0.07
	Coal	0.06 - 0.14
	Nuclear	0.11 - 0.19

Appendix 2 - Process for retrieving articles from Nexis Uni

Nexis Uni (formerly Lexis Nexis academic) is the academic version of LexisNexis, a large online database of news, legal, government information sources. The platform, accessible through our UCSB library portal, provides access to thousands of news sources and articles, domestic and international, dating back to the 1970s (UCSB library, 2019). The database includes helpful features such as narrowing search results by location of publication (USA in our case), removing duplicates results, and downloading the body text of all search results into one combine pdf. We manually extracted Nexis Uni texts from each wind power project in the Nexis Uni article database. To do so, the following steps were taken:

1. To obtain the most accurate search results from Nexis Uni, we used the following query:

   "Project name" AND "Project Developer Name" AND "wind" AND "energy" AND "State-full word" OR "State abbreviated."

   a. Each group member conducted the manual search of approximately 180 projects.
2. For each of the search results per project:
   a. Duplicates results were removed
   b. The location by publication setting was narrowed to "United States" to keep only domestic news articles
   c. Geography by document was set to North America
   d. Number of article results range from 1 to 386 unique articles per wind power project.
3. Download full text of search results:
   a. For each project, the full set of search results are downloaded.
   b. Wind projects with no search results from Nexis Uni do not get a sentiment score, given that there is not text to analyze (publicity value = NA). However, some projects may have 0 results under Nexis Uni but get results under Google News.
   c. Ultimately, each project has a single pdf document containing the full body text of all articles associated with the project's search query.

Outlined below are the steps that were taken to process the extracted Google news text and calculate publicity scores:

1. Create a data frame of Nexis Uni and Google News full article text:
   a. Since the Nexis Uni articles are in .pdf format and the Google News ones are in a compiled .csv format, they were first loaded into a data frame in R. The data frame has two columns: the first contains the name of the project, which will repeat depending on how many articles were found, and the second contains the full article text in string format. Google News and Nexis Uni

articles may ultimately be separated if publicity score results vary widely. Extraction of the body text from pdf to a data frame was done using the pdftools package.

2. Unnest/Parse all words within article texts:
    a. Once the text is in a data frame format, the text associated with each wind project is unnested, meaning it is parsed by word. The resulting larger dataset was structured such that every word is a separate row. The article associated with the given word was listed in a separate column.
3. Match each word with score from the AFINN dictionary:
    a. Using the AFINN dictionary stored in the tidytext R package, we joined the AFINN words that matched words from the combine text. This way, we captured each word's associated sentiment/publicity score from the body text about each wind farm. Words that did not match the AFINN dictionary did not received a publicity score and were recorded as NA.
4. Mean sentiment score per wind project
    a. Once every word has an associated publicity score, we calculated the weighted mean of each article. We chose to calculate a weighted mean rather than a regular mean value to account for the higher relative weight of some words repeated multiple time in the text. This weighted mean is the primary value used to represent overall sentiment of the articles associated with a given wind power project. After a weighted mean was determined for each article, an average sentiment score for each wind project was calculated. The standard deviation was also calculated to assess the distribution of the word-based sentiment.

Appendix 3 - Case studies

Seven Mile Wind Farm (Carbon County, Wyoming):

Seven Mile Wind Farm (118 MW) has been operating for Wyoming Rocky Mountain Power since 2008. Developed by Oregon-based wind energy company, PacificCorp, this farm is not located in the low-risk area. Three articles were extracted from Google News about this project, generating an overall positive publicity score of 0.12. Still, a lot of variance is observed in the articles. One of the negative articles (score of -1.6) highlights how the farm was successfully sued by the federal government due to migratory bird mortality, a violation of the Migratory Birds Treaty Act (MBTA). The fine totaled $25 million and the company was required to adopt a migratory compliance plan (Richard, 2018). By contrast, the positive articles highlighted the benefits of the wind energy expansion in the state of Wyoming, a state that has traditionally had reservations about wind energy expansion despite high wind power potential.

Osage County Wind Farm (Osage County, Oklahoma):

The Osage County Wind Project has fallen into an intense legal battle with the Osage Nation Reservation, where the farm is sited. It is classified as high-risk. Despite intense pressure to close, this wind farm remains in operation since 2015. One of the project's negative articles (-0.66 publicity score) describes the numerous state and federal lawsuits filed by the Osage Nation regarding the construction of the Wind Farm, which they deem violates their rights to mineral access on their own land, as well as damaging the local ecosystem. The suit claims the construction of the farm destroyed rocks that belong to Osage Nation. The legal fight is ongoing. (Thompson, 2017). This series of events illustrates the greater costs and possible delays associated with siting wind farms in more contentious locations that have ecological value. Adjacent to Osage Wind was Mustang Run Wind Farm of Osage County, another project in our sample. Mustang Run Wind Farm was forced to cancel due to a similar legal fight with the Osage Nation.

Meridian Way Wind Farm (Concordia, Kansas):

Environmental impacts by wind farms are not always negative. The Meridian Way Wind Farm received a positive publicity score (1.4) despite being located in a higher risk area near lek sites[1] for sage grouse. This new wind development prompted conservation researchers to evaluate the impact of the Meridian Wind Farm on the sage grouse population. While many studies on wind power and energy development sites have observed a significant impact of

[1] Lek sites: communal areas for sage grouse where males come together and make calls to attract females.

the energy site on sage grouse mating and survival success, Meridian was found to have no substantial impact and results even found that female survival rates increased with the wind farm (Kansas State University, 2015).

Boone County Wind Farm (Boone County, Illinois):

Not all projects face environmental pushback. In fact, many of canceled projects from the sample were associated with local discontent with regard to the wind farms' human health impacts. Boone County Wind Farm is located in a high-risk area and received a slightly positive publicity score (0.005) despite large variability in scores amongst articles. One negative article (-0.95) cites the local communities' efforts to shut down Boone County Wind Farm based on sleep deprivation, low frequency noise, and hazards from turbine blade failure and flying debris (Kraft, 2015). Boone County Wind Farm faced a legal battle with local community that included a 9-month testimony period. Ultimately, the developers lost in court and the project was canceled in June 2016.

Appendix 4 - Article quotes

Table 7. Quotes pulled from wind power project Google News articles related to the categorized topics about wind energy impacts. All quotes were extracted while exploring the Google News articles scraped using Python.

Topic category	Project name	Article Score	Outcome	Low High Impact	Statements
Wildlife impacts	Seven Mile Wind Farm	-1.6	Operating	High	"The federal government had successfully sued developers under the Migratory Bird Treaty Act (MBTA) resulting in multi-million dollar fines." (Richard, 2018)
	Wolf Ridge Wind Farm	-0.5	Operating	High	"The American Bird Conservancy and other groups have concerns about the number of birds killed by wind turbines" at "Wolf Ridge wind farm." (Salisbury, 2013)
Aesthetics impacts	Osborn Wind Energy Center,	-0.04	Operating	Low	"Residents of Clinton and DeKalb counties who don't want a modern wind farm in their backyards say they have no plans to abandon their positions [...], those contrary to the plan have a list of concerns that include damage to roads by heavy trucks and the switch from the basic pastoral aesthetics the towering turbines would bring to their corner of Northwest Missouri" (St.Joseph News-Press, 2016)

Human health impacts	Bent Tree Wind Farm	0.05	Canceled	Low	"Wisconsin Power and Light constructed the Bent Tree Wind Farm […]" there are 19 turbines within one mile and 5 within ½ mile. Both my wife and I have had difficulty sleeping in our home since the turbines started operating. If we leave the area we don't have this problem. The turbines have also caused severe headaches for my wife." (Noon, 2016)

Appendix 5 - Article topics – supplemental write-up

Submitted to TNC clients on 05/22/19

Summary:

- Objective: Use word extraction in google news articles to determine wind energy impact topics.
- Preliminary qualitative results:
    - Overall, 13% of all articles referenced words related to wildlife, while 11% referenced words related to health. Aesthetic and habitat impacts were also mentioned, but to a lesser extent (Appendix Table 1). We see a similar order of results across all projects subgroups (i.e. whether project is located in high or low risk area, negative or positive, cancelled or operating).
    - For articles about projects in high-risk areas, 12% (76 articles) mentioned wildlife, while 9% mentioned health (Appendix Table 2).
    - For articles about projects that were ultimately cancelled (60), 17% mentioned wildlife impacts while 16% mentioned health (Appendix Table 4).
    - For articles about cancelled projects in high-risk areas (41), 18% of the articles mentioned wildlife, 18% mentioned health (Appendix Table 8).
    - Out of all negative articles, 22% of the articles included words associated with the health impact from wind energy, 19% included words associated with the wildlife impact of wind energy (Appendix Table 12).
    - See Appendix for all proportions observed in the topics overview analysis

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Introduction:

The sentiment score of any wind project in our dataset may be driven by a variety of negative or positive impacts. While we were broadly able to retrieve the overall directionality of sentiment (positivity and negativity) in the Google News articles through sentiment analysis, this analysis did not extract the content of the article that drives sentiment. To further our text analysis and logistic regression results, the content within the Google News Articles was explored to see what wind energy impacts were discussed.

The logistic regression should a link between the potential environmental impact of a given wind energy project and its degree of positivity and negativity in the news. While wind energy has important external environmental impacts, particularly with wildlife, there also other affects from wind energy that may fuel more negative public opinion. In addition to wind energy's impact on wildlife and habitat— such as bird fatalities or landscape fragmentation— wind farms also engender aesthetic disadvantages for many, such as noise pollution and visual encumbrance (Wang and Wang, 2015; Wagner and Mathur, 2018). Moreover, some have claimed that wind turbines can affect the health of those living adjacent to the farm through low-frequency noise hindrance or shadow flickers, although this has been widely debated (Knopper and Ollson, 2011; Coz and Sherman, 2017).

Based on the topics discussed in the literature, four external impacts of wind energy were categorized into the following groups: wildlife impacts, visual or noise pollution impacts (aesthetics), human health impacts, and habitat and ecosystem impacts (e.g. fragmentation). We sought to determine which of these impacts are discussed in the articles.

Methodology:

For this topic overview, between 5 and 7 words were chosen to represent our topics of interest. These words were selected based on their frequency in the literature regarding these topics (Table 1). To find these topics in the google news articles, the words – making up unique groupings – were extracted from the articles.

Using R, the stringr package was used to extract the words listed in the queries from each article. The queries were modified using regular expressions to ensure all versions of a given word listed above are encapsulated in the match. If a given article mentions one or more of the words in a particular category, it is classified as an article that mentions the associated topic. For example, if the words "wildlife" and "collision" are found in an article, this article is classified under the wildlife topic. Topics are not mutually exclusive; in other words, an article can be classified in both the wildlife and health topic categories.

Once the word extraction and article classification is completed, a dataset (extract_text.csv) was outputted. The final dataset therefore includes all the projects, its individual articles, and all the characteristics associated with the project (as found in ventyx_operating_canceled_03-11-2019). Moreover, the dataset contains an additional column (*extract*) populated with all the extracted words from the query groups.

Moreover, four additional columns were created for each of the different topics. If a project mentioned a wildlife topic, then the wildlife column was populated with the word "wildlife". If a project mentioned one of more words from the health topic, the word "health" will populate the Health column rather than NA. The same was done for the other query groupings. Moreover, additional words related to the topic of litigation were extracted for additional information on the content of interest in the articles.

Finally, with this final dataset, we calculated the proportion of articles classified in our topics of interest.

Table 1 - Word queries to extract wind-energy impact topic of interest from articles

Word queries used to extract topics of interest in Google News articles			
Wildlife	**Habitat/Ecosystem**	**Aesthetics**	**Health**
wildlife bats birds wildlife impact collisions species animals	habitat fragmentation ecosystem environmental impact landscape habitat loss wetlands	aesthetics noise noise pollution visual impacts turbine visibility property values	health health concerns health impacts human health

Findings:

Across all articles in our dataset

Across all articles 915 articles, covering 276 projects, 228 articles mentioned either wildlife impacts, habitat/ecosystem impact, aesthetic impacts, or health impacts. These 228 articles refer to 128 projects.

Overall, 13% of all Google News articles discussed wildlife impacts, 11% discussed health impacts, 7 % reference aesthetic impacts, and ~5% refer to habitat and ecosystem impacts (Appendix Table 1).

Next, we evaluated the proportion of topics mentioned for the subgroup of articles for which the selected topics were mentioned. The findings elaborated below are in reference to the 128-projects subgroup that mention the 4 selected wildlife impact topics.

With the subgroup with mentioned in one of the 4 categories:

Amongst all project articles for which there is a mention of one or more of the topics of interest, the words associated with the wildlife topic were mentioned the most.

Out of 228 articles relating to 128 projects, over half mentioned wildlife impacts (117 articles), while 100 mentioned health impacts. Aesthetic impacts was referenced in 67 articles, habitat impacts in 50 articles.

High-Risk Projects:

For projects in high-risk area, 602 articles were retrieved from Google News about 170 projects. Among this subgroup, 141 articles relating to 80 different projects mentioned at least one of the four-wind energy topics discussed.

53% of those 141 articles mentioned wildlife impacts, 41% mentioned health impacts. Meanwhile, respectively only 30 articles mentioned aesthetic or habitat impacts (Appendix Table 2).

Low-Risk Projects:

For projects in low-risk area, 313 articles were retrieved from Google news relating to 106 projects. Among this subgroup, 87 articles relating to 48 different projects mentioned at least one of the four wind-energy topics discussed. In low-risk areas, the health topic was mentioned in the most articles (42 times) while wildlife impacts were referenced 41 times. Aesthetic impacts were mentioned in 36 of those articles, while the habitat and ecosystem impact topic was mentioned in only 18 articles (Table 3).

Cancelled Projects:

Out of the 276 projects that had Google news articles, 60 of them were cancelled projects. There are 164 articles relating to these 60 cancelled projects. Only 64 of these articles mentioned at least one of the four wildlife impact topics.

Based on the data, approximately 44% of these 64 articles (28 articles) mentioned the wildlife topic, and 42% of them mentioned the health impact topic. Meanwhile only 17 and 15 articles about cancelled projects mentioned habitat impacts or aesthetic impacts, respectively (Appendix: Table 4).

Operating Projects:

Out of the 276 projects on our dataset that have news articles, 216 of them are currently operating. There were 751 articles about these projects, however only 164 of these articles, related to 90 projects, mentioned at least one of the four wind energy impacts topics grouped in our methodology.

We find that over 50% of these 164 articles mentioned wildlife impacts, and 44% mentioned health impacts. As observed in the other project categories above, the aesthetic and habitat impacts were mentioned proportionally less (Appendix Table 5).

Projects with Negative Publicity:

Only 25 of total projects with Google News articles received a negative overall sentiment score. Moreover, only 51 articles were associated with these negatively scored projects. 18 out of these 51 articles discussed at least one of the four topics of interest. Moreover, similar to the rest of the subcategories, wildlife impacts and health impact topics were mentioned in the most (Appendix Table 6).

Projects with Positive Publicity:

By contrast, 864 articles are associated with projects that received a positive sentiment score. 251 projects received a positive sentiment score from the total number of associated articles extracted from Google News. We found that wind energy impacts topics appeared in 210 articles, relating to 117 projects. Wildlife impacts topics appeared the most among this subgroup (50%) ahead of the health impact topic (42%) (Appendix Table 7).

Cancelled Projects in high-risk areas:

Furthermore, we assessed the relevant of our four topic to canceled projects that also happened to be located in a high-risk area.

41 projects in our data were located in a high-risk area and ultimately failed. We found 118 articles associated with this group of projects. About 49 of these articles (41%) discussed one or more of the wind-energy impact topics. Wildlife and health impacts were mentioned in an equal number of articles (21 respectively). The aesthetic impacts topic came up in 13 articles, and habitat impacts came up in 11 articles (Appendix Table 8).

Operating Projects in high-risk areas:

Out of the 216 operating projects with articles, 129 of these projects are located in high-risk areas. There are 484 articles about these projects, making up 64% of all the articles about operating wind energy projects. We found, 92 of these articles, relating to 53 projects, referenced one or more of the wind-energy impact topics. Of these 92 articles, 60% discussed wildlife impact topic, while 40% discussed health impacts. Meanwhile, 21 articles mentioned habitat impacts, and 18 articles mentioned aesthetic impacts (Appendix Table 9).

Operating projects in low-risk areas:

87 projects located in the low-risk area with articles from google news are operating today. There are 267 articles about these projects. Among these 87 projects, 37 of them have articles that discussed at least one of the wind-energy impact topics. Out of the articles that mention these topics, 50% of them (36) mentioned health impacts, while 47% (34) mentioned wildlife impacts and aesthetic impacts, respectively (Appendix Table 10).

Cancelled projects in low-risk areas:

19 projects located in the low-risk area with articles from googles news were ultimately cancelled. There are 46 articles about these projects. Among these projects, 11 of them have articles that discussed at least one of the wind-energy impact topics. There are 15 articles that these topics for this subgroup, seven of which mentioned wildlife impacts, six mentioned health impacts, six mentioned habitat impacts, and two mention aesthetic impacts.

Lawsuit Topic:

In addition, we conducted a quick overview of the number of articles that discuss lawsuit and legal issues with regard to wind energy impacts (see *Rmarkdown_TextExtraction_supp.Rmd* markdown for word selection).

We found that 31% of all articles extracted from Google News mentioned words related to litigation.

Interestingly, 33% of articles associated with low-risk projects discuss lawsuits, while 30% of articles associated high-risk projects discuss this topic. Moreover, 43% of articles associated with cancelled projects discussed lawsuits, while only 29% of articles for operating projects. Finally, 60% of articles about projects with a negative overall sentiment score discussed the litigation topic while approximately 30% of articles about projects with a positive overall sentiment score discussed this.

Tables:

- Table 1: Among all projects and articles:

Topics	Number of article with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	117	12.79%	915	276
Habitat/Ecosystem Impacts	50	5.46%		
Aesthetic Impacts	67	7.32%		
Health Impacts	100	10.92%		

- Table 2: Projects in high risk areas:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	76	12.62%	602	170
Habitat/Ecosystem Impacts	32	5.31%		
Aesthetic Impacts	31	5.15%		
Health Impacts	58	9.63%		

- Table 3: Projects in low-risk areas:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	41	13.1 %	313	106
Habitat/Ecosystem Impacts	18	5.75 %		
Aesthetic Impacts	36	11. 5 %		
Health Impacts	42	13.41 %		

- Table 4: Projects in cancelled Projects:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	28	17.07 %	164	60
Habitat/Ecosystem Impacts	17	10.36 %		
Aesthetic Impacts	15	9.14 %		
Health Impacts	27	16.46 %		

- Table 5: Projects in operating projects:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	89	11.85 %	751	216
Habitat/Ecosystem Impacts	33	4.39 %		
Aesthetic Impacts	52	6.92 %		
Health Impacts	73	9.72 %		

- Table 6: Projects with negative overall sentiment scores:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	10	19.6 %	51	25
Habitat/Ecosystem Impacts	3	5.88 %		
Aesthetic Impacts	5	9.8 %		
Health Impacts	11	21.56 %		

- Table 7: Projects with positive overall sentiment scores:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	107	12.38 %	864	251
Habitat/Ecosystem Impacts	47	5.44 %		
Aesthetic Impacts	62	7.17 %		
Health Impacts	89	10.3 %		

- Table 8: Cancelled Projects in high-risk areas:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	21	17.8 %	118	41
Habitat/Ecosystem Impacts	11	9.32 %		
Aesthetic Impacts	13	11.01 %		
Health Impacts	21	17.8 %		

- Table 9: Operating Projects in high-risk areas:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	55	11.36 %	484	129
Habitat/Ecosystem Impacts	21	4.34 %		
Aesthetic Impacts	18	3.72 %		
Health Impacts	37	7.64%		

- Table 10: Operating projects in low-risk areas:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	34	12.73 %	267	87
Habitat/Ecosystem Impacts	12	4.49 %		
Aesthetic Impacts	34	12.73 %		
Health Impacts	36	13.48 %		

- Table 11: Cancelled projects in low-risk areas:

Topics	Number of articles with one or more mentions	Proportion of total articles	Number of articles	Number of projects
Wildlife Impacts	7	15.22 %	46	19
Habitat/Ecosystem Impacts	6	13.04 %		
Aesthetic Impacts	2	4.35 %		
Health Impacts	6	13.04 %		

- Table 12: Positivity and negativity of articles by topic

	Positive Score Articles		Negative Score Articles	
Topics	Proportion with respect to all positive articles	Number of Projects	Proportion with respect to all negative articles	Number of Projects
Wildlife Impacts	12%	73	19%	19
Habitat/Ecosystem Impacts	5%	28	10%	10
Aesthetic Impacts	7%	37	11%	9
Health Impacts	10%	56	22%	20

** Note: we determined that it was not useful to look at the proportion of negative and positive articles per topic (e.g. what the proportion of wildlife articles that were negative and positive) because we have far fewer negative articles (51) compared to positive articles (864). Each topic would automatically have a very low proportion of negative articles compared to positive articles. As such, we observed the proportions of negative articles about each topic with respect to all negative or positive articles.