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Potential Hazards of Wind Energy For Rare, Tereatened, and Endangered Birds and Batsin Texas

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ABSTRACT: The purpose of this study was to estimate relative potential hazards to birds and bats from wind developments in Texas. We compiled lists of rare, threatened, or endangered species, along with their respective ranges in Texas. Using a geographic information system (GIS), we calculated a potential hazard index (PHI) for 31 bird and ten bat species based upon the percentage of known or observed species range area (by county) within each wind speed classification. Results demonstrate considerable range in relative hazard, with the lesser prairie chicken and ferruginous hawk among the most potentially impacted birds; and the pale Townsend's bat, western small-footed bat, and big free-tailed bat among the most potentially impacted bats. While additional data are necessary to establish actual impacts of wind developments, relative potential hazard indices may help prioritize future studies.

Key words: Birds, Bats,Wind energy, Texas

INTRODUCTION

Wind has received tremendous interest as an alternative energy source over the past few decades. Currently, the United States leads all nations with the highest installed wind energy capacity (UDE, 2008). At present, wind energy amounts to only about 2% of total energy consumption in the United States; however, the country aspires to 20% wind energy by 2030 (UDE, 2008). Though its benefits as a non-polluting, renewable source of energy are well established, wind turbines and associated infrastructure (roads, substations, and transmission lines) do impact birds and bats through habitat displacement, avoidance, and collision-related fatalities (GAO, 2005).

Observed impacts vary geographically due to varying topography, habitat, flyways, species diversity, and species abundance (GAO, 2005). Some recent studies suggest insignificant threats to wildlife from commercial wind-generated electricity relative to other anthropogenic structures (such as buildings and automobiles) and energy sources (NRC, 2007; Sovacool, 2009). However, potential cumulative impacts of current and future wind developments remain unknown.

Several investigators have reported bird or bat collisions with wind turbines at various locations in the United States (Thelander and Rugge, 2000; Erickson *et al.*, 2001; Johnson *et al.*, 2002; Johnson and Perlik, 2004; GAO, 2005; Nicholson *et al.*, 2005; Kunz *et al.*, 2007; Kuvlesky *et al.*, 2007; Stewart *et al.*, 2007). Erickson et al. (2001) calculated an average annual fatality rate of approximately 2.2 birds per turbine based on available monitoring data, turbine density, and nameplate capacity in the United States. Smallwood and Thelander (2004) estimated an average national fatality rate of 2.1 birds per megawatt per year, basing their estimates on rated energy output to account for differences in turbine sizes.

Bats appear to have a higher frequency of collision-related fatalities, including air pressure trauma, than birds (GAO, 2005; Kunz *et al.*, 2007; Arnett *et al.*, 2008; Baerwald *et al.*, 2008). Moreover, bats have generally lower reproduction rates than birds, potentially compounding adverse impacts from wind developments (Arnett *et al.*, 2008).

Commercial wind-generated electricity is currently only economically feasible in areas of class 3+ mean wind speed (NREL, 2010). The main focus of this research is Texas, where roughly a quarter of the state is considered fair to excellent for commercial wind energy production (Fig. 1). Texas has had a rapid expansion of wind infrastructure within the last few

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years and continued growth is anticipated. Currently, Texas produces more wind electricity than any other state in the United States (AWEA, 2010), but lacks publicly-available wildlife impact reports.

Wind farms in Texas are located mainly in the western, northwestern, and southern portions of the state (Fig. 1). Most of these wind farms are within class 3+ annual mean wind speeds, but some are in areas less than class 3. With advancements in wind turbine technology, areas currently lacking wind turbines may be prime locations for future wind energy, based on land availability and temporal fluctuations in wind speed.

While Texas has favorable conditions for wind development (NREL, 2010), it also has great bird and bat diversity. The objective of this study was to document potential interaction with wind developments by rare, threatened, and endangered birds and bats in Texas, considering species range relative to wind class distributions.

MATERIALS & METHODS

We compiled lists of rare, threatened, and endangered bird and bat species and their range areas in Texas. Using a geographic information system (GIS), we calculated a potential hazard index (PHI) for 31 birds and ten bats based upon the percentage of known or observed range area within each wind speed classification. That is, PHI is a weighted average as follows:

$$PHI = \Sigma A_i W_i \qquad (1)$$

where: A_i is the percentage of the total Texas range area in wind class W_i, and wind classes range from 1-6

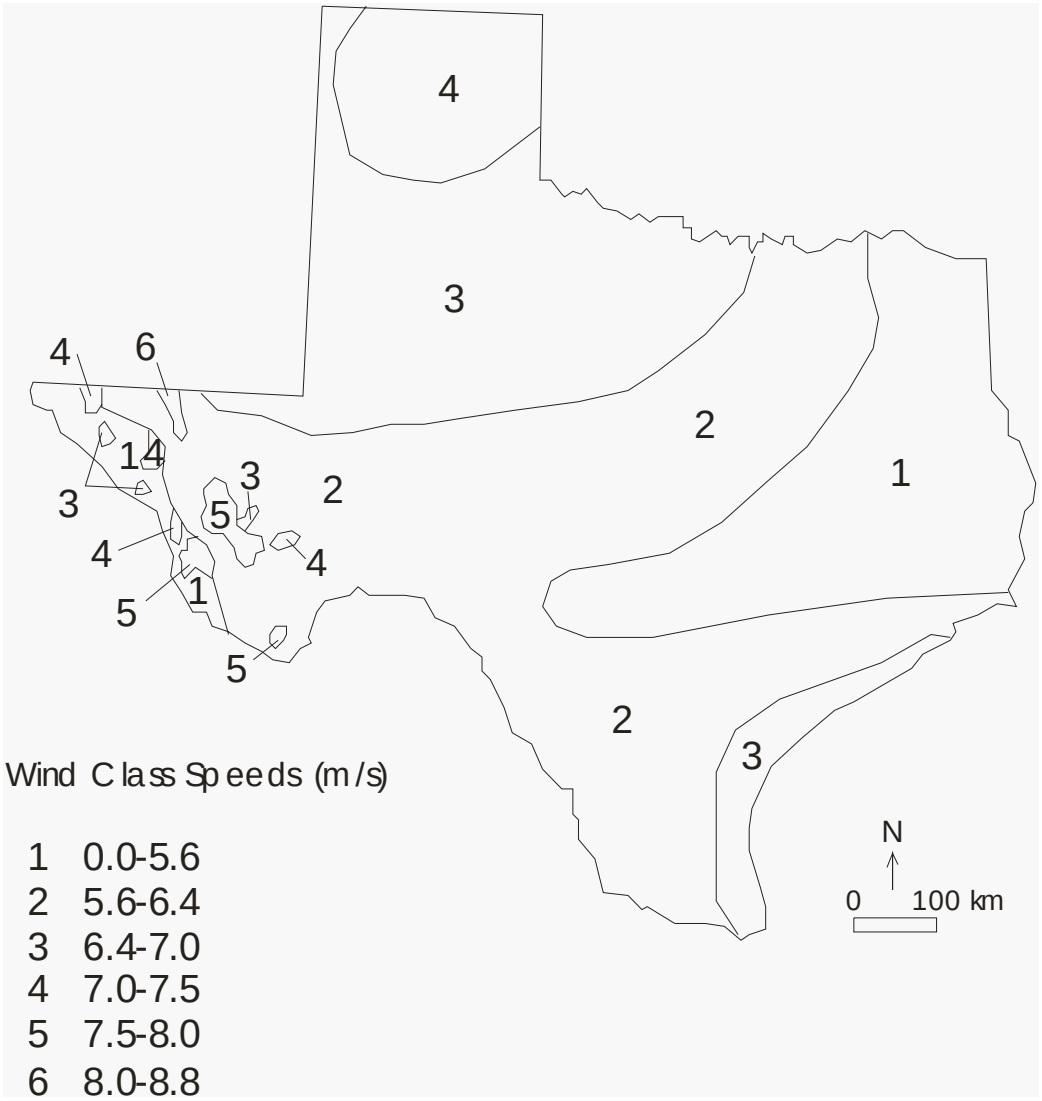

Fig. 1. Average wind class speeds, 50-m height (NREL 2010)

within the state (Fig. 1). For example, a species whose range area encompasses three wind classes in Texas, with 20% of the area in Class 1, 45% in Class 2, and 35% in Class 3, would have a PHI value of: (0.20) (1) + (0.45) (2) + (0.35) (3) = 2.15.

ArcMap GIS (Environmental Systems Research Institute, Redlands, California) was used to display maps and calculate variables for Equation 1. Species range data were obtained from the Texas Parks and Wildlife Department's rare, threatened, and endangered species database. Generalized Texas wind maps were obtained from the National Renewable Energy Laboratory. PHI calculations outlined above do not reflect actual risk, but relative hazard based upon potential for interaction with wind farm developments. We assume that higher wind classes will support more wind developments, bringing associated hazards.
Based on existing literature (GAO, 2005), features not likely to contain commercial wind turbines—major cities, rivers, lakes, state parks, and wildlife refuges—and surrounding buffers were excluded from PHI calculations. Buffers were 460 m for cities and 1.6 km for the other features.

RESULTS & DISCUSSION

There are 31 species of birds and ten species of bats considered to be rare, threatened, endangered, or species of concern, that reside in or migrate through Texas annually (TPWD, 2010). These species are subject to impacts from wind developments in their respective ranges. The 31 species of birds include: five water birds, 11 raptors, two upland birds, four shore birds, one woodpecker, and eight songbirds.

Water birds in the above compilation are the: brown pelican (*Pelecanus occidentalis*), reddish egret (*Egretta rufescens*), white-faced ibis (*Plegadis chihi*), whooping crane (*Grus americana*), and wood stork (*Mycteria americana*), which reside largely along the Gulf Coast, but also elsewhere in Texas during migration (TPWD, 2010).

Raptors include the: bald eagle (*Haliaeetus leucocephalus*) in northwest, central, east, and coastal regions of Texas; ferruginous hawk (*Buteo regalis*) and Mexican spotted owl (*Strix occidentalis lucida*) in west Texas; common black hawk (*Buteogallus anthracinus*), gray hawk (*Asturina nitida*), zone-tailed hawk (*Buteo albonotatus*), and northern Aplomado falcon (*Falco femoralis septentrionalis*) in south and west Texas; cactus ferruginous pygmy-owl (*Glaucidium brasilianum cactorum*) in south Texas; white-tailed hawk (*Buteo albicaudatus*) in south and east Texas; swallow-tailed kite (*Elanoides forficatus*) in east Texas; and American peregrine falcon (*Falco peregrinus anatum*) in all Texas counties.

Upland birds in the above list are the greater prairie chicken (*Tympanuchus cupido attwateri*) and lesser prairie chicken (*Tympanuchus pallidicinctus*). The greater prairie chicken can be found inland along the Gulf Coast, while the lesser prairie chicken resides in arid grasslands interspersed with native shrubbery in northwest Texas. Prairie chickens are not affected by wind turbine collision, but rather impacted by habitat fragmentation, avoiding anthropogenic alterations of natural landscapes (Fuhlendorf *et al*., 2002).

Threatened or endangered shorebirds include the: (possibly extinct) Eskimo curlew (*Numenius borealis*) along the Gulf Coast; interior least tern (*Sterna antillarum athalassos*) distributed widely throughout Texas, inland from the Gulf Coast; and piping plover (*Charadrius melodus*) and sooty tern (*Sterna fuscata*) in east and southeast Texas. The endangered red-cockaded woodpecker (*Picoides borealis*) occupies portions of east Texas.

Finally, the eight species of songbirds are the: northern beardless tyrannulet (*Camptostoma imberbe*), rose-throated becard (*Pachyramphus aglaiae*), tropical parula (*Parula Parula pitiayumi*), and Texas Botteri's sparrow (*Aimophila botterii texana*) in south Texas; southwestern willow flycatcher (*Empidonax traillii extimus*) in west Texas; Bachman's sparrow (*Aimophila aestivalis*) in east Texas; and black-capped vireo (*Vireo atricapilla*) and golden-cheeked warbler (*Dendroica chrysoparia*) in central Texas. Most songbirds are considered migratory birds, which are protected under law and potentially impacted through interaction and collision with anthropogenic sources.

The ten species of bats are the: big free-tailed bat (*Nyctinomops macrotis*), western small-footed bat (*Myotis ciliolabrum*), and pale Townsend's big-eared bat (*Corynorhinus townsendii pallescens*) in west and northwest Texas; cave myotis bat (*Myotis velifer*) distributed widely throughout central, south, west, and northwest Texas; ghost-faced bat (*Mormoops megalophylla*) in west and southwest Texas; Mexican long-nosed bat (*Leptonycteris nivalis*) and spotted bat (*Euderma maculatum*) in southwest Texas; Mexican long-tongued bat (*Choeronycteris mexicana*) and southern yellow bat (*Lasiurus ega*) in south Texas; and Rafinesque's big-eared bat (*Corynorhinus rafinesquii*) in east Texas.

Of the 31 computed PHIs for birds, only one (lesser prairie chicken) exceeded 3.00 (Table 1). This species is non-migratory and a small population can be found within the northern panhandle of Texas (an area with relatively high wind potential) year round (Alsop, 2002). The ferruginous hawk had the second highest PHI for

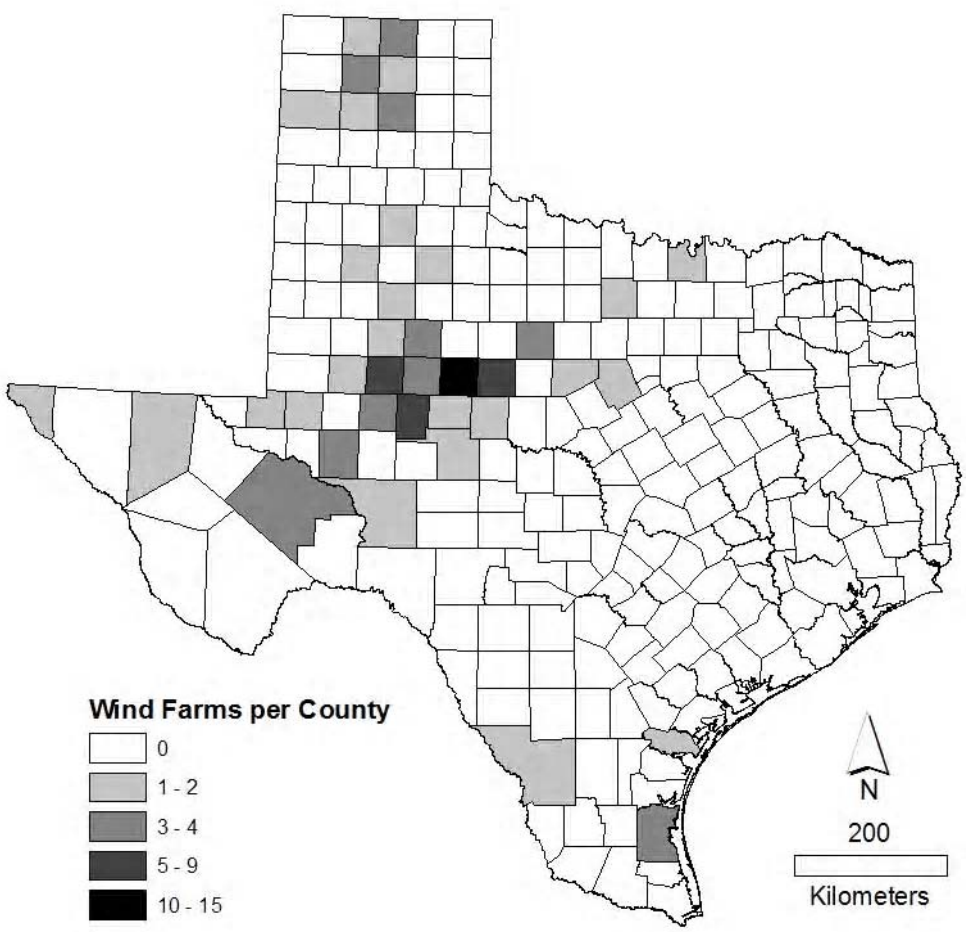

Fig. 2. Wind developments in Texas (AEI 2009)

birds, 2.77, reflecting portions of its range in areas of relatively high wind potential. In contrast, the red-cockaded woodpecker, swallow-tailed kite, and Bachman's sparrow had the lowest PHIs, 1.00-1.08. These species occupy areas of relatively low wind potential in east Texas. The mean PHI calculated for all birds was 2.10.

PHI compilations for bats varied from 1.00-2.74, the latter computed for the pale Townsend's bat (Table 2). The western small-footed bat and big free-tailed bats also had relatively high PHIs, 2.70. Similar to the lesser prairie chicken and ferruginous hawk, high PHIs for these three bat species reflect ranges in relatively high wind potential. The lowest PHI value, 1.00, was computed for the Rafinesque's big-eared bat, inhabiting areas of low wind potential in east Texas.
While increasing PHIs for birds and bats suggest greater hazard, no single threshold dictates presence or absence of hazard. For example, commercial developments tend to be in wind class 3 or higher; however, PHIs are weighted averages, and values below 3 may reflect a portion of species' total range in class 3 or higher. Moreover, future technology may enable wind developments in classes below 3. Actual mortality rates at current and future wind-generation sites throughout Texas have yet to be documented; however, as noted in the introductory section above, previous studies in other regions suggest an average of 2-3 birds per turbine annually. Longer-term, regionally-specific data are needed to better document mortality rates attributable to wind generation.

While the PHI tabulations provide a general view of potential hazard from wind development, site-specific, pre- and post-construction monitoring is essential for understanding actual impacts of wind development (USFWS, 2003; GAO, 2005). However, Texas lacks a formal regulatory protocol for conducting such monitoring. Surveys of species diversity and abundance, landscape features influencing roosting and foraging, and proximity of flyways are among important pre-construction considerations (Smallwood *et al.*, 2004). For example, cropland tends to be less useful habitat for wildlife than undisturbed areas; placing wind farms on altered landscapes may lower

Table 1. PHIs for Birds

Species Name	PHI
Lesser prairie chicken	3.50
Ferruginous hawk	2.77
Sooty tern	2.51
Whooping crane	2.47
Eskimo curlew	2.36
Bald eagle	2.33
Tropical parula	2.29
Rose-throated becard	2.29
Peregrine falcon	2.25
Brown pelican	2.25
Northern beardless-tyrannulet	2.24
Common black hawk	2.24
Texas Botteri's sparrow	2.23
Northern aplomado falcon	2.23
Southwestern willow flycatcher	2.22
Mexican spotted owl	2.20
Cactus ferruginous pigmy owl	2.20
Reddish egret	2.19
Gray hawk	2.17
White-tailed hawk	2.09
Interior least tern	2.07
Zone-tailed hawk	2.06
Black-capped vireo	2.05
Golden-cheeked warbler	1.94
White-faced ibis	1.88
Greater prairie chicken	1.85
Wood stork	1.60
Piping plover	1.53
Bachman's sparrow	1.08
Swallow-tailed kite	1.03
Red-cockaded woodpecker	1.00
MEAN	2.10

Table 2. PHIs for Bats

Species Name	PHI
Pale Townsend's big-eared bat	2.74
Western small-footed bat	2.74
Big free-tailed bat	2.70
Mexican long-nosed bat	2.44
Southern yellow bat	2.36
Cave myotis	2.35
Spotted bat	2.29
Mexican long-tongued bat	2.15
Ghost-faced bat	2.08
Rafinesque's big-eared bat	1.00
MEAN	2.29

risks for some species. Post-construction surveys must take into account surveyor bias and scavengers, among other considerations (Morrison, 2002).

Despite the economic and environmental benefits of wind energy, local opposition to such concerns as aesthetics, noise, and impacts to wildlife will strongly influence future wind development in Texas. For example, the cities of Llano and Fredericksburg, and Gillespie County, have passed resolutions opposing the installation of commercial wind energy developments due to aesthetic impairment and perceived threats to species of birds and bats known to reside within the Texas Hill Country (TCPA, 2008). Moreover, potentially adverse effects on ecotourism and migratory species have fueled opposition to wind development in south Texas. Requiring and publicly disclosing post-construction surveys of actual impacts would add valuable context to ongoing battles between conservationists, wind developers, and local interest groups.

In addition to local investigations of wildlife impacts, future regional studies could address temporal hazards, by comparing seasonal ranges of birds and bats with seasonal wind class distributions. While seasonal wind class maps are readily available, seasonal ranges of individual species are more difficult to accurately portray. Generally, wind speeds are higher in Texas in the spring; PHI estimates for spring would likely be higher than those compiled in this study. Finally, this study addressed onshore wind energy production and associated threats to birds and bats in Texas. However, future offshore developments also pose potential hazard to large populations of birds residing along, or migrating through, the Gulf Coast.

CONCLUSION

The objective of this study was to generalize potential hazards to birds and bats in Texas from current and future wind developments. Results demonstrate considerable range in relative hazard, with the lesser prairie chicken and ferruginous hawk among the most potentially impacted birds; and the pale Townsend's bat, western small-footed bat, and big free-tailed bat among the most potentially impacted bats. While additional data are needed to establish actual impacts of wind developments, potential hazard indices may help prioritize future studies. Such information should be of interest to conservationists, regulators, and developers interested in developing the wind resource, while minimizing impacts to the environment.

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