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10/01/2012 03:27 PM

To: "midwestwindhcp@fws.gov" <midwestwindhcp@fws.gov>
cc:
Subject: Comments regarding proposed Midwest Multi-Species HCP/FWS-R3-ES-2012-N179

Dear Mr. Amidon,

Attached are Appendices 3 and 4 of the comments of Union Neighbors United, Julia F. Johnson, and Robert and Diane McConnell as referenced in my earlier email.

Respectfully,

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Appx. 3, Kunz Paper.pdf Appx. 4, Knapp Ltr. to Golembeski.pdf

Ecological impacts of wind energy development on bats: questions, research needs, and hypotheses

Thomas H Kunz[1*], Edward B Arnett[2], Wallace P Erickson[3], Alexander R Hoar[4], Gregory D Johnson[3], Ronald P Larkin[5], M Dale Strickland[3], Robert W Thresher[6], and Merlin D Tuttle[2]

At a time of growing concern over the rising costs and long-term environmental impacts of the use of fossil fuels and nuclear energy, wind energy has become an increasingly important sector of the electrical power industry, largely because it has been promoted as being emission-free and is supported by government subsidies and tax credits. However, large numbers of bats are killed at utility-scale wind energy facilities, especially along forested ridgetops in the eastern United States. These fatalities raise important concerns about cumulative impacts of proposed wind energy development on bat populations. This paper summarizes evidence of bat fatalities at wind energy facilities in the US, makes projections of cumulative fatalities of bats in the Mid-Atlantic Highlands, identifies research needs, and proposes hypotheses to better inform researchers, developers, decision makers, and other stakeholders, and to help minimize adverse effects of wind energy development.

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Wind energy has become an increasingly important sector of the renewable energy industry, and may help to satisfy a growing worldwide demand for electricity (Pasqualetti *et al.* 2004; GAO 2005; Manville 2005). Environmental benefits of wind energy accrue from the replacement of energy generated by other means (eg fossil fuels, nuclear fuels), reducing some adverse environmental effects from those industries (Keith *et al.* 2003). However, development of the wind energy industry has led to some unexpected environmental costs (Morrison and Sinclair 2004). For example, soaring and feeding raptors have been killed in relatively large numbers in areas of high raptor abundance in the United States and Europe (Barrios and Rodriquez 2004; Hoover and Morrison 2005). More recently, large numbers of bat fatalities have been observed at utility-scale wind energy facilities, especially along forested ridgetops in the eastern US (Arnett 2005; GOA 2005; Johnson 2005; Fiedler *et al.* 2007), and in agricultural regions of southwestern Alberta, Canada (RMR Barclay and E Baerwald pers comm). Similar fatalities have been reported at wind energy facilities in Europe (UNEP/Eurobats 2005; Brinkmann *et al.* 2006). As such facilities continue to develop in other parts of the world, especially in Australia, China, and India (National Wind Watch Inc 2006), increased numbers of bat and bird fatalities can be expected.

In this paper, we highlight ongoing development of wind energy facilities in the US, summarize evidence of bat fatalities at these sites, make projections of cumulative fatalities of bats for the Mid-Atlantic Highlands (MD, PA, VA, and WV), identify research needs to help reduce or mitigate adverse environmental impacts at these facilities, and propose hypotheses to evaluate where, when, how, and why bats are being killed.

In a nutshell:

- Bat species that migrate long distances are those most commonly killed at utility-scale wind energy facilities in the US
- Future research and monitoring should emphasize regions and sites with the highest potential for adverse environmental impacts on bats
- Multi-year monitoring and hypothesis-based research are needed to address these concerns
- A policy framework that requires owners and developers to provide full access to publicly-supported wind energy facilities should be implemented, and should include funds for research and monitoring at these sites

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■ Utility-scale wind energy development in the US

In 2005, utility-scale wind energy facilities in the US accounted for approximately 9616 MW of installed capacity (also called name plate capacity or the potential generating capacity of turbines; EIA 2006). The number and size of wind energy facilities have continued to increase, with taller and larger turbines being constructed. Available estimates of installed capacity in the US by 2020 range up to 72 000 MW, or the equivalent 48 000 1.5 MW wind turbines. This is enough, according

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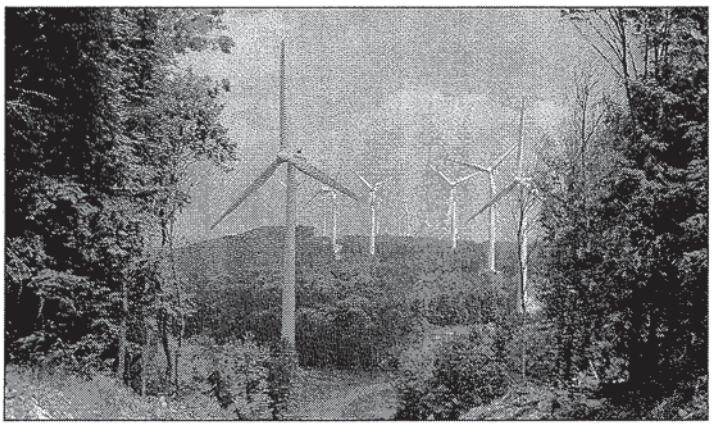

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Figure 1. *Partial view of the Mountaineer Wind Energy Center, Tucker County, WV, located along a forested ridgetop, where large numbers of bats have been killed.*

to some projections, to account for 5% of the country's electrical generating capacity. Most existing wind energy facilities in the US include turbines with installed capacity ranging from 600 kW to 2 MW per turbine. Wind turbines up to about 3 MW of installed capacity for onshore applications are currently being tested. However, owing to seasonally variable wind speeds, the generating capacity of most existing wind turbines is less than 30% of installed capacity.

Utility-scale wind turbines (> 1 MW) installed in, or planned for, the US since the 1990s are designed with a single monopole (tubular tower), ranging in height from 45 to 100 m, with rotor blades up to 50 m in length. At their greatest height, blade tips of typical 1.5 MW turbines may extend to 137 m (as tall as a 40-story building with a rotor diameter the size of a 747 jumbo jet). The nacelle, located at the top of the monopole, houses a gearbox that is connected to an electric generator and associated electronic converters and controls. Three rotor blades are attached to a drive shaft that extends outward from the nacelle. The pitch or angular orientation of the three blades can be adjusted to control turbine output and rotation speed of the rotor. Typically, wind turbines are arranged in one or more arrays, linked by underground cables that provide energy to a local power grid (WebFigure 1). Some modern turbines (eg GAMESA G87 2.0 MW turbine) rotate up to 19 rpm, driving blade tips at 86 m s^{-1} (193 mph) or more. Since utility-scale wind turbines were first deployed in the US in the 1980s, the height and rotor-swept area has steadily increased with each new generation of turbines.

To date, most utility-scale wind turbines in the US have been installed in grassland, agricultural, and desert landscapes in western and mid-western regions. More recently, however, wind turbines have been installed along forested ridgetops in eastern states (Figure 1). More are proposed in this and other regions, including the Gulf Coast and along coastal areas of the Great Lakes. Large wind energy facilities off the coastline of the northeastern US have also been proposed.

■ Bat fatalities

Relatively small numbers of bat fatalities were reported at wind energy facilities in the US before 2001 (Johnson 2005), largely because most monitoring studies were designed to assess bird fatalities (Anderson *et al.* 1999). Thus, it is quite likely that bat fatalities were underestimated in previous research. Recent monitoring studies indicate that some utility-scale wind energy facilities have killed large numbers of bats (Kerns and Kerlinger 2004; Arnett 2005; Johnson 2005). Of the 45 species of bats found in North America, 11 have been identified in ground searches at wind energy facilities (Table 1). Of these, nearly 75% were foliage-roosting, eastern red bats (*Lasiurus borealis*), hoary bats (*Lasiurus cinereus*), and tree cavity-dwelling silver-haired bats (*Lasionycteris noctivagans*), each of which migrate long distances (Figure 2). Other bat species killed by wind turbines in the US include the western red bat (*Lasiurus blossivilli*), Seminole bat (*Lasiurus seminolus*), eastern pipistrelle (*Perimyotis [=Pipistrellus] subflavus*), little brown myotis (*Myotis lucifugus*), northern long-eared myotis (*Myotis septentrionalis*), long-eared myotis (*Myotis evotis*), big brown bat (*Eptesicus fuscus*), and Brazilian free-tailed bat (*Tadarida brasiliensis*). A consistent theme in most of the monitoring studies conducted to date has been the predominance of migratory, tree-roosting species among the fatalities.

For several reasons (eg cryptic coloration, small body size, steep topography, overgrown vegetation), bats may have been overlooked during previous carcass searches. Based on recent evaluations of searcher efficiency, on average, only about half of test subjects (fresh and frozen bats or birds) are recovered by human observers (Arnett *et al.* in press; WebTable 1). In these studies, bats were nearly twice as likely to be found in grassland areas as in agricultural landscapes and along forested ridgetops. Moreover, scavengers often remove carcasses before researchers are able to recover them (Arnett *et al.* in press).

To date, no fatalities of state or federally listed bat species have been reported; however, the large number of fatalities of other North American species has raised concerns among scientists and the general public about the environmental friendliness of utility-scale wind energy facilities. For example, the number of bats killed in the eastern US at wind energy facilities installed along forested ridgetops has ranged from 15.3 to 41.1 bats per MW of installed capacity per year (WebTable 1). Bat fatalities reported from other regions of the western and mid-western US have been lower, ranging from 0.8 to 8.6 bats $MW^{-1}yr^{-1}$, although many of these studies were designed only to assess bird fatalities (Anderson *et al.* 1999). Nonetheless, in a recent study designed to assess bat fatalities in southwestern Alberta, Canada, observed fatalities were comparable to those found at wind energy facilities located in forested regions of the eastern US (RMR Barclay and E Baerwald pers comm).

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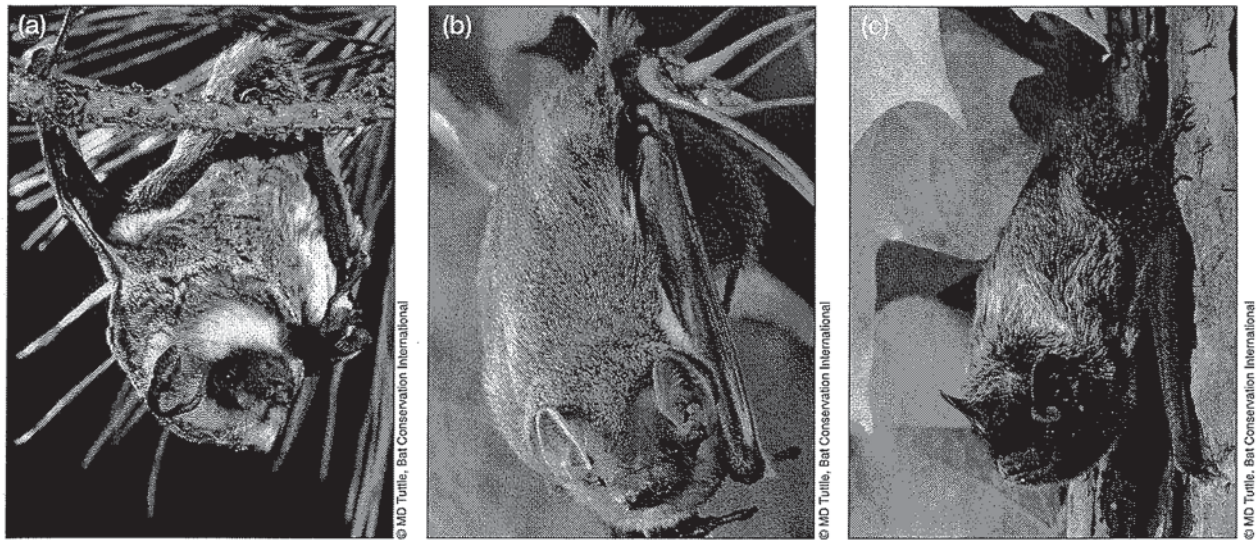

Figure 2. *The three species of migratory tree bats most frequently killed at wind turbine facilities in North America. (a) Hoary bat* (Lasiurus cinereus)*, (b) eastern red bat* (L borealis)*, and (c) silver-haired bat* (Lasionycteris noctivagans)

While the seasonal duration of reported studies, corrections for searcher efficiency, and scavenging rates vary geographically, fatality rates have been among the highest reported in the eastern US (Table 1). As research protocols for bats shift toward improved monitoring studies, more bat species are likely to be affected and greater measured fatality rates at wind energy facilities are expected.

Locations of bat fatalities

Bat fatalities at wind energy facilities appear to be highest along forested ridgetops in the eastern US and lowest in relatively open landscapes in the mid-western and western states (Johnson 2005; Arnett *et al.* in press), although relatively large numbers of fatalities have been reported in agricultural regions from northern Iowa (Jain 2005) and southwestern Alberta, Canada (RMR Barclay and E Baerwald pers comm). Additionally, in a recent study conducted in mixed-grass prairie in Woodward County, north-central Oklahoma, Piorkowski (2006) found 111 dead bats beneath wind turbines, 86% of which were pregnant or lactating Brazilian free-tailed bats. Western red bats, hoary bats, silver-haired bats, and Brazilian free-tailed bats have also been reported at wind energy facilities in northern California (Kerlinger *et al.* 2006). To date, no assessments of bat fatalities have been reported at wind energy facilities in the southwestern US, a region where large numbers of migratory Brazilian free-tailed bats are resident during the warm months (McCracken 2003), and where this species provides important ecosystems services to agriculture (Cleveland *et al.* 2006). High fatality rates can also be expected for other species in the southwestern US and at wind energy facilities in western states, where rigorous monitoring for bat fatalities has been limited.

Seasonal timing of bat fatalities

Most bat fatalities in North America have been reported in late summer and early autumn (Johnson 2005; Arnett *et al.* in press; RMR Barclay and E Baerwald pers comm), and similar seasonal trends have been reported for bats in northern Europe (Bach and Rahmel 2004; Dürr and Bach 2004). Migration of tree bats in North America is known to occur from March through May and again from August through November (Cryan 2003). The few bat fatalities reported during spring migration and early summer may reflect the fact that less intensive fatality searches were conducted during this period, but it may also be due to bats migrating at higher altitudes during spring. Many, if not most, of the bat species that have been killed by wind turbines in the US (Table 1 and WebTable 1) are resident during summer months (Barbour and Davis 1969). A study by Piorkowski (2006) provided evidence that bats are at risk of being killed by wind turbines during summer, and, thus, more rigorous fatality assessment is warranted during this season. In addition to being at risk during migration, the large colonies of Brazilian free-tailed bats that disperse nightly across vast landscapes in the southwestern US (McCracken 2003; Kunz 2004) may be at risk during the period of summer residency. Uncertainty with respect to the seasonality of bat fatalities in North America may, in part, reflect the lack of full-season, multi-year monitoring studies that include spring and autumn migratory periods as well as summer months, when bats are in residence (Arnett *et al.* in press).

■ How and why are bats being killed?

It is clear that bats are being struck and killed by the turning rotor blades of wind turbines (Horn *et al.* in press). It is unclear, however, why wind turbines are killing bats, although existing studies offer some clues. Are bats in

some way attracted to wind turbines? Some migratory species are known to seek the nearest available trees as daylight approaches (Cryan and Brown in press), and thus could mistake large monopoles for roost trees (Ahlén 2003; Hensen 2004). Tree-roosting bats, in particular, often seek refuge in tall trees (Pierson 1998; Kunz and Lumsden 2003; Barclay and Kurta 2007). As wind turbines continue to increase in height, bats that migrate or forage at higher altitudes may be at increased risk (Barclay *et al.* 2007).

Are bats attracted to sites that provide rich foraging habitats? Modifications of landscapes during installation of wind energy facilities, including the construction of roads and power-line corridors, and removal of trees to create clearings (usually 0.5–2.0 ha) around each turbine site may create favorable conditions for the aerial insects upon which most insectivorous bats feed (Grindal and Brigham 1998; Hensen 2004). Thus, bats that migrate, commute, or forage along linear landscapes (Limpens and Kapteyn 1991; Verboom and Spoelstra 1999; Hensen 2004; Menzel *et al.* 2005) may be at increased risk of encountering and being killed by wind turbines.

Are bats attracted to the sounds produced by wind turbines? Some bat species are known to orient toward distant audible sounds (Buchler and Childs 1981), so it is possible that they are attracted to the swishing sounds produced by the rotating blades. Alternatively, bats may become acoustically disoriented upon encountering these structures during migration or feeding. Bats may also be attracted to the ultrasonic noise produced by turbines (Schmidt and Jermann 1986). Observations using thermal infrared imaging of flight activity of bats at wind energy facilities suggest that they do fly (and feed) in close proximity to wind turbines (Ahlén 2003; Horn *et al.* 2007; Figure 3).

What other factors might contribute to bat fatalities? Wind turbines are also known to produce complex electromagnetic fields in the vicinity of nacelles. Given that some bats have receptors that are sensitive to magnetic fields (Buchler and Wasilewski 1985; Holland *et al.* 2006), interference with perception in these receptors may increase the risk of being killed by rotating turbine blades. Bats flying in the vicinity of turbines may also become trapped in blade-tip vortices (Figure 4) and experience rapid decompression due to changes in atmospheric pressure as the turbine blades rotate downward. Some bats killed at wind turbines have shown no sign of external injury, but evidence of internal tissue damage is consistent with decompression (Dürr and Bach 2004; Hensen 2004). Additionally, some flying insects are reportedly attracted to the heat produced by nacelles (Ahlén 2003; Hensen 2004). Preliminary evidence suggests that bats are not attracted to the lighting attached to wind turbines (Arnett 2005; Kerlinger *et al.* 2006; Horn *et al.* in press).

Do some weather conditions place bats at increased risk of being killed by wind turbines? Preliminary observations suggest an association between bat fatalities and thermal inversions following storm fronts or during low cloud cover that force the animals to fly at low altitudes (Durr and Bach 2004; Arnett 2005). Thermal inversions create cool, foggy conditions in valleys, with warmer air masses rising to ridgetops. If both insects and bats respond to these conditions by concentrating their activities along ridgetops instead of at lower altitudes, their risk of being struck by the moving turbine blades would increase (Dürr and Bach 2004). Interestingly, the highest bat fatalities occur on nights when wind speed is low ($< 6\ m\ s^{-1}$), which is when aerial insects are most active (Ahlén 2003; Fiedler 2004; Hensen 2004; Arnett 2005).

Table 1. Species composition[1] of annual bat fatalities reported for wind energy facilities in the United States, modified from Johnson (2005)

Species[2]	*Pacific Northwest*	*Rocky Mountains*	*South–Central*	*Upper Midwest*	*East*	*Total*
Hoary bat	153 (49.8%)	155 (89.1%)	10 (9.0%)	309 (59.1%)	396 (28.9%)	1023 (41.1%)
Eastern red bat	–	–	3 (2.7%)	106 (20.3%)	471 (34.4%)	580 (23.3%)
Western red bat	4 (1.3%)	–	–	–	–	4 (0.2%)
Seminole bat	–	–	–	–	1 (0.1%)	1 (0.1%)
Silver-haired bat	94 (30.6%)	7 (4.1%)	1 (0.9%)	35 (6.7%)	72 (5.2%)	209 (8.4%)
Eastern pipistrelle	–	–	1 (0.9%)	7 (1.3%)	253 (18.5%)	261 (10.5%)
Little brown myotis	2 (0.7%)	6 (3.5%)	–	17 (3.3%)	120 (8.7%)	145 (5.8%)
Northern long-eared myotis	–	–	–	–	8 (0.6%)	8 (0.4%)
Big brown bat	2 (0.7%)	2 (1.1%)	1 (0.9%)	19 (3.6%)	35 (2.5%)	59 (2.4%)
Brazilian free-tailed bat	48 (15.6%)	–	95 (85.5%)	–	–	143 (5.7%)
Unknown	4 (1.3%)	4 (2.2%)	–	30 (5.7)	15 (1.1%)	53 (2.1%)
Total	307	174	111	523	1371	2486

[1]Pacific Northwest data are from one wind energy facility in CA, three in eastern OR, and one in WA; Rocky Mountain data are from one facility in WY and one in CO; Upper Midwest data are from one facility in MN, one in WI, and one in IA; South–Central data are from one facility in OK; East data are from one facility in PA, one in WV, and one in TN.
[2]One confirmed anecdotal observation of a western long-eared myotis (*Myotis evotis*) has been reported in CA, but is not included in this table.

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Are bats at risk because they are unable to acoustically detect the moving rotor blades? Current evidence is inconclusive as to whether bats echolocate during migration, independent of time spent searching for and capturing insects. Bats less likely to make long-distant migrations in North America (eg members of the genera *Myotis*, *Eptesicus*, *Perimyotis*) and others that engage in long-distance migrations (eg *Lasiurus*, *Lasionycteris*, *Tadarida*) typically rely on echolocation to capture aerial insects and to avoid objects in their flight paths. However, for most bat species, echolocation is ineffective at distances greater than 10 m (Fenton 2004), so bats foraging in the vicinity of wind turbines may miscalculate rotor velocity or fail to detect the large, rapidly moving turbine blades (Ahlén 2003; Bach and Rachmel 2004; Dürr and Bach 2004). Given the speed at which the tips of turbine blades rotate, even in relatively low-wind conditions, some bats may not be able to detect blades soon enough to avoid being struck as they navigate.

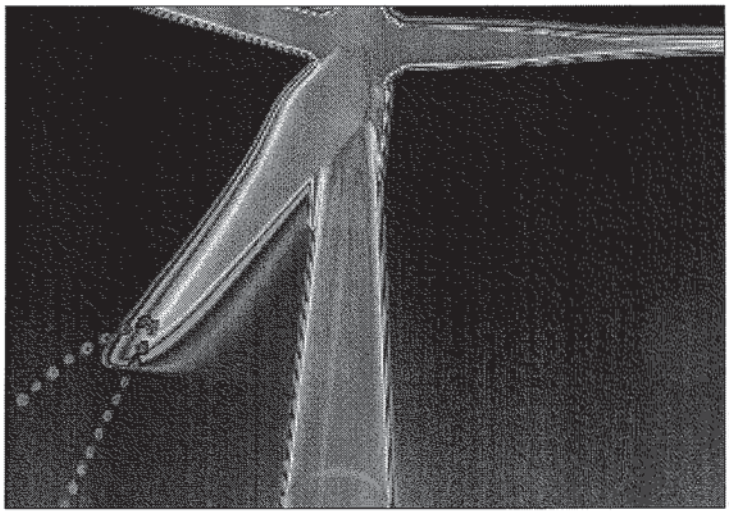


Figure 3. *Thermal infrared image of a modern wind turbine rotor, showing the trajectory of a bat that was struck by a moving blade (lower left).*

■ Projected cumulative fatalities

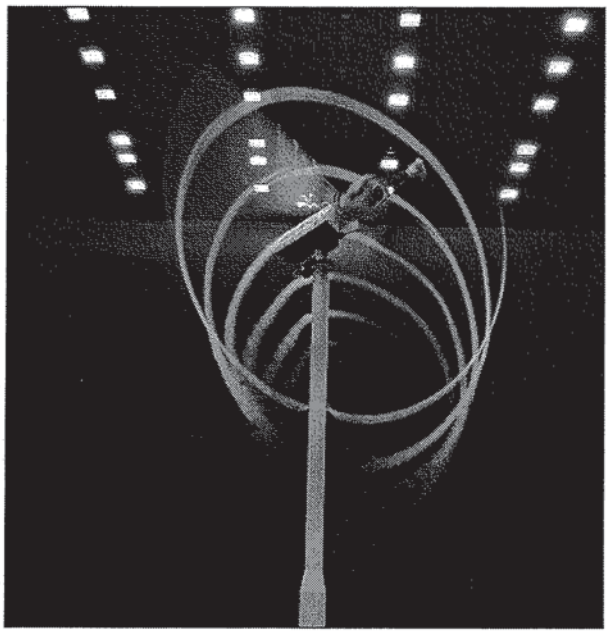
We have projected cumulative fatalities of bats at wind energy facilities for the Mid-Atlantic Highlands using data on current fatality rates (Table 1) and projections of installed capacity for wind energy facilities in the Highlands for the year 2020 (see WebTable 2 for supporting data, assumptions, and calculations). Projections of installed capacity range from 2158 MW (based on the National Renewable Energy Laboratory [NREL] WinDS model [nd]) to 3856 MW (based on the PJM electricity grid operator interconnection queue; see PJM [2006]). Although the estimated number of bat fatalities reported for each study (WebTable 1) were not consistently corrected for search efficiency or for potential bias associated with carcass removal by scavengers, we have nonetheless used these estimates to project cumulative impacts on bats because they are the only fatality rates available for bats in this region.

In making our projections of cumulative fatalities, we have assumed that: (1) current variation in fatality rates is representative of the Mid-Atlantic Highlands, (2) future changes in design or placement of turbines (eg more and larger installed turbines) will not cause deviations from current fatality estimates, (3) abundance of affected bat species will not decrease due to turbine-related fatalities or other factors (eg habitat loss), and (4) projections of cumulative fatalities for other geographic regions differ from those in the Mid-Atlantic Highlands.

The projected number of annual fatalities in the year 2020 (rounded to the nearest 500) range from 33 000 to 62 000 individuals, based on the NREL's WinDS Model, and 59 000 to 111 000 bats based on the PJM grid operator interconnection queue. For the three migratory, tree-roosting species from the Mid-Atlantic Highlands, the projected cumulative fatalities in the year 2020 based on the WinDS model and PJM grid operator queue, respectively, would include 9500 to 32 000 hoary bats, 11 500 to 38 000 eastern red bats, and 1500 to 6 000 silver-haired bats. Given the uncertainty in estimated installed wind turbine capacity for the Mid-Atlantic Highlands and existing data on bat fatalities reported for this region, the above projections of cumulative fatalities should be considered provisional and thus viewed as hypotheses to be tested as improved estimates (or enumerations) of installed capacity and additional data on bat life histories and fatalities become available for this region. Nonetheless, these provisional projections suggest substantial fatality rates in the future. At this time, we have avoided making projections of cumulative fatalities for the entire period from 2006–2020, because of uncertainty with respect to population sizes and the demographics of bat species being killed in this region.

If these and other species-specific projections are realized for the Mid-Atlantic Highlands, there may be a substantial impact on both migratory and local bat populations. Migratory tree-roosting species are of particular concern because these bats have experienced the highest fatality rates at wind energy facilities in North America. Risk assessments of ecological impacts typically require knowledge of baseline population estimates and demographics (Munns 2006). However, virtually no such data exist for any foliage-roosting species (Carter *et al.* 2003; O'Shea *et al.* 2003), on either regional or continental scales, that would make it possible to conduct a meaningful risk assessment. However, given the limitations noted above, the projected numbers of bat fatalities in the Mid-Atlantic Highlands are very troubling.

Our current knowledge and the projected future devel-



Courtesy of RW Thresher

Figure 4. *Blade-tip vortices created by moving rotor blades in a wind tunnel illustrate the swirling wake that trails downwind from an operating wind turbine.*

opment of wind energy facilities in the US suggest the potential for a substantial population impact to bats. For example, it is unlikely that the eastern red bat (*Lasiurus borealis*) could sustain cumulative fatality rates associated with wind energy development as projected, given that this species already appears to be in decline throughout much of its range (Whitaker et al. 2002; Carter *et al.* 2003; Winhold and Kurta 2006). There are major gaps in knowledge regarding the timing, magnitude, and patterns of bat migration, and the underlying evolutionary forces that have shaped this seasonal behavior (Fleming and Eby 2003). When lack of knowledge is combined with the fact that bats generally have low reproductive rates (Barclay and Harder 2003), significant cumulative impacts of wind energy development on bat populations are likely.

Much of the existing data on bat fatalities at wind energy facilities are based on monitoring studies designed primarily for the detection and estimation of bird fatalities. Results from these studies vary considerably with respect to geographic location, landscape conditions, search frequency, season of monitoring, and potential biases based on searcher efficiency and carcass removal by scavengers. In addition, search intervals have ranged from 1 to 28 days (WebTable 1). Because some studies have shown that bats can be scavenged within hours of being killed, there is considerable uncertainty in reported fatality estimates when search intervals longer than 24 hrs are used (Fiedler *et al.* 2007; Arnett *et al.* in press). Moreover, because only six monitoring studies have routinely used bat carcasses to correct for observer bias, the number of reported fatalities provides, at best, a minimum estimate (WebTable 1).

■ Research needs

The unexpectedly large number of migratory tree bats being killed by wind turbines and the projected cumulative fatalities in the Mid-Atlantic Highlands should be a wake-up call for those who promote wind energy as being "green" or environmentally friendly. Uncertainties with respect to the projected fatalities, as noted above, invite comprehensive, multi-year surveys and hypothesis-based research to advance our understanding of where, when, how, and why bats are killed at wind energy facilities (Panel 1). Research is needed to develop solutions at existing facilities and to aid in assessing risk at proposed facility sites, particularly in landscapes where high bat fatalities have been reported and in regions where little is known about the migratory and foraging habits of bats. To advance our knowledge about the causes of bat fatalities at wind energy facilities and to help guide the establishment of mitigating solutions, we propose the following research directions:

- Employ scientifically valid, pre- and post-construction monitoring protocols to ensure comparable results across different sites.
- Conduct full-season (April–November in the continental US, for example), multi-year pre- and post-construction monitoring studies to assess species composition, species abundance, local population variability, and temporal and spatial patterns of bat activity at facilities that encompass diverse landscapes.
- Conduct pre- and post-construction studies that simultaneously employ different methods and tools (eg mist-netting, horizontal and vertical radar, NEXRAD [WSR-88D] Doppler radar, thermal infrared imaging, radiotelemetry, and acoustic monitoring) to improve understanding of bat activity, migration, nightly dispersal patterns, and interactions with moving turbine blades at different wind speeds.
- Conduct local-, regional-, and continental-scale population estimates of North American bat species. In particular, use of molecular methods to estimate effective population size of species most at risk should be a high priority.
- Quantify geographic patterns of bat activity and migration with respect to topography and land cover.
- Quantify relationships between bat abundance and fatality risks and the relationship between fatalities and bat demography at local, regional, and continental scales.
- Conduct quantitative studies of bat activity at existing wind energy facilities to evaluate how variations in weather and operating conditions of turbines affect bat activity and fatalities. Variables to be evaluated should include air temperature, wind speed and direction, cloud cover, moon phase, barometric pressure, precipitation, and turbine operating status such as rotation rate and cut-in speeds.
- Quantify effects of wind turbine design on bat fatalities with respect to height and rotor diameter, base and tip height of rotor-swept areas, distance between adjacent

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turbine rotor swept areas, and the scale (size) of wind power facilities.

- Quantify effects of feathered (ie turbine blades pitched parallel to the wind, making them essentially stationary) versus not feathered (ie turbine blades pitched angularly to the wind, causing rotation) turbines at different wind speeds and at multiple sites, especially during high-risk, migratory periods.
- Evaluate and quantify sources of potential attraction of bats to turbines (eg sound emissions, lighting, blade movement, prey availability, potential roosting sites).
- Develop predictive and risk assessment models, with appropriate confidence intervals, on local, regional, and continental scales to evaluate impacts of wind energy development on bat populations.
- Evaluate possible deterrents under controlled conditions and under different operating conditions and turbine characteristics at multiple sites.

A call for full cooperation and research support from the wind industry

As part of the permitting process, owners and developers should be required to provide full access to proposed and existing wind energy facilities and to fund research and monitoring studies by qualified researchers. Research and monitoring protocols should be designed and conducted to ensure unbiased data collection and should be held to the highest peer-review and legal standards.

Conclusions

To date, bat fatalities reported in the US have been highest at wind energy facilities along forested ridgetops in the East. While the lowest fatality rates have been observed in western states, few of these studies were designed to monitor bat fatalities, and thus may represent substantial underestimates. The highest fatality rate for bats (41.6 bat fatalities $MW^{-1}yr^{-1}$) was reported at the Buffalo Mountain Wind Energy Center, TN, where estimates were consistently corrected for both search efficiency and scavenging. A recent study conducted at wind energy facilities in an agricultural region in southwestern Alberta, Canada, unexpectedly found fatality rates comparable to those observed in some forested ridgetops in the eastern US. Given that previous monitoring studies in western agricultural and grassland regions reported relatively low fatality rates of bats, high fatality rates in regions with similar landscapes should receive increased attention. High fatality rates can also be expected at wind energy facilities located in the southwestern US, where, to date, no monitoring studies have been conducted.

Future research should focus on regions and at sites with the greatest potential for adverse effects. Improved documentation, with emphasis on evaluation of causes and cumulative impacts, should be a high priority. There is an urgent need to estimate population sizes of bat species most at risk, especially migrating, tree-roosting species. Moreover, additional data are needed for assessing fatalities caused by other human activities (eg agricultural pesticides, heavy metals released from the burning of fossil

Panel 1. Hypotheses for bat fatalities at wind energy facilities

We propose 11 hypotheses to explain where, when, how, and why insectivorous bats are killed at wind energy facilities. These hypotheses are not mutually exclusive, given that several causes may act synergistically to cause fatalities. Nevertheless, testing these and other hypotheses promises to provide science-based answers to inform researchers, developers, decision makers, and other stakeholders of the observed and projected impacts of wind energy development on bat populations.

Linear corridor hypothesis. Wind energy facilities constructed along forested ridgetops create clearings with linear landscapes that are attractive to bats.

Roost attraction hypothesis. Wind turbines attract bats because they are perceived as potential roosts.

Landscape attraction hypothesis. Bats feed on insects that are attracted to the altered landscapes that commonly surround wind turbines.

Low wind velocity hypothesis. Fatalities of feeding and migrating bats are highest during periods of low wind velocity.

Heat attraction hypothesis. Flying insects upon which bats feed are attracted to the heat produced by nacelles of wind turbines.

Acoustic attraction hypothesis. Bats are attracted to audible and/or ultrasonic sound produced by wind turbines.

Visual attraction hypothesis. Nocturnal insects are visually attracted to wind turbines.

Echolocation failure hypothesis. Bats cannot acoustically detect moving turbine blades or miscalculate rotor velocity.

Electromagnetic field disorientation hypothesis. Wind turbines produce complex electromagnetic fields, causing bats to become disoriented.

Decompression hypothesis. Rapid pressure changes cause internal injuries and/or disorient bats while foraging or migrating in proximity to wind turbines.

Thermal inversion hypothesis. Thermal inversions create dense fog in cool valleys, concentrating both bats and insects on ridgetops.

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fuels and other industrial processes, collisions with communication towers) to place impacts of wind energy development on bats into a broader context. However, these latter studies should not take priority over research to find solutions for fatalities caused by wind turbines. An important challenge for policy makers is to ensure that owners and developers of wind energy and other energy-generating facilities are required, as part of the permitting process, to fund qualified research designed to assess impacts of these facilities on bats and other wildlife.

Results of scientifically sound research and monitoring studies are needed to inform policy makers during the siting, permitting, and operation of renewable energy sources. Although bat fatalities at wind turbines have been reported at nearly every wind energy facility where post-construction surveys have been conducted, few of these studies were designed to estimate bat fatalities and only a few included a full season or more of monitoring. Rigorous protocols should include reliable estimates of searcher efficiency and scavenger removal to correct fatality estimates for potential biases.

Future development of wind energy facilities, and expected impacts on bats, depend upon complex interactions among economic factors, technological development, regulatory changes, political forces, and other factors that cannot be easily or accurately predicted at this time. Our preliminary projections of cumulative fatalities of bats for the Mid-Atlantic Highlands are likely to be unrealistically low, especially as larger and increasing numbers of wind turbines are installed. Reliable data on bat fatalities and estimates of demographic and effective population sizes for species at risk are needed from all regions of North America, to fully understand the continental-scale impacts of wind energy development. Until then, current and projected cumulative fatalities should provide an important wake-up call to developers and decision makers. Additional monitoring and hypothesis-based research is needed to address a growing concern of national and international importance.

■ Acknowledgements

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WebTable 1. Regional comparison of monitoring studies and factors influencing estimates of bat fatalities at 11 wind energy facilities in the US, modified from Arnett *et al.* (in press)

Region	Facility	Landscape[1]	Estimated fatalities (MW^{-1} yr^{-1})[2]	Search Interval (d)	Percent search efficiency[3]	Carcass removal (bats d^{-1})[4]	Reference
Pacific Northwest	Klondike, OR	CROP, GR	0.8	28	75*	32* / 14.2	Johnson *et al.* 2003a
	Stateline, OR/WA	SH, CROP	1.7	14	42*	171* + 7 / 16.5	Erickson *et al.* 2003a
	Vansycle, OR	CROP, GR	1.1	28	50*	40* / 23.3	Erickson *et al.* 2000
	Nine Canyon, WA	GR, SH, CROP	2.5	14	44*	32* / 11	Erickson *et al.* 2003b
	High Winds, CA	GR, CROP	2.0	14	50*	8 / [5]	Kerlinger *et al.* 2006
Rocky Mountains	Foote Creek Rim, WY	SGP	2.0	14	63	10 / 20	Young *et al.* 2003 Gruver 2002
South–Central	Oklahoma Wind Energy Center, OK	CROP, SH, GR	0.8	8 surveys[6]	67	[7]	Piorkowski 2006
Upper Midwest	Buffalo Ridge, MN I	CROP, CRP, GR	0.8	14	29*	40 / 10.4	Osborn *et al.* 1996
	Buffalo Ridge, MN II (1996–1999)	CROP, CRP, GR	2.5	14	29*	40 / 10.4	Johnson *et al.* 2003b
	Buffalo Ridge, MN II (2001–2002)	CROP, CRP, GR	2.9	14	53.4	48 / 10.4	Johnson *et al.* 2004
	Lincoln, WI	CROP	6.5	1–4	70*	50* / ~10	Howe *et al.* 2002
	Top of Iowa, IA	CROP	8.6	2	72*	156* 8	Jain 2005
East	Meyersdale, PA[9]	DFR	15.3	1	25	153 / 18	Kerns *et al.* 2005
	Mountaineer, WV (2003)	DFR	32.0	7–27	28*	30* / 6.7	Kerns & Kerlinger 2004
	Mountaineer, WV (2004)[9]	DFR	25.3	1	42	228 / 2.8	Kerns *et al.* 2005
	Buffalo Mountain, TN I	DFR	31.5	3	37	42 / 6.3	Fiedler 2004
	Buffalo Mountain, TN II	DFR	41.1[10]	7	41	48 / 5.3	Fiedler *et al.* 2007

[1]CROP = agricultural cropland; CRP = conservation reserve program grassland; DFR = deciduous forested ridge; GR = grazed pasture or grassland; SGP = short grass prairie; SH = shrubland. [2]Estimated number of fatalities, corrected for searcher efficiency and carcass removal, per turbine, divided by the number of megawatts (MW) of installed capacity. [3]Overall estimated percent searcher efficiency using bat or bird carcasses in bias correction trials. Bird carcasses were sometimes used as surrogates of bats in search efficiency trials, and instances in which this is the case are denoted with *. [4]Number of birds + number of bats used in bias correction trials / mean number of days that carcasses lasted during trials. Bird carcasses were sometimes used as surrogates of bats in search efficiency trials, and instances in which this is the case are denoted with *. [5]For this facility, the proportion of the 8 trial bats not scavenged after seven days was used to adjust fatality estimates. [6]Two searches (one in late May and one in late June) conducted at each turbine in 2004, and four searches every 14 days conducted at each turbine between 15 May and 15 July in 2005. [7]Authors used a hypothetical range of carcass removal rates derived from other studies (0–79%) to adjust fatality estimates. [8]Number of birds used during six trials; the mean number of days that carcasses lasted was not available; on average 88% of bird carcasses remained two days after placement. [9]Six-week study period from 1 August to 13 September 2004. [10]Weighted mean number of bat fatalities per MW with weights equal to the proportion of 0.66 MW (n = 3 of 18) and 1.8 MW (n = 15 of 18) turbines.

WebTable 2. Projected annual number of bat fatalities from wind turbines expected in 2020 in the Mid-Atlantic Highlands, based on projections of installed capacity for this region and current proportional fatality rates available from the eastern US (Table 1). Numbers in parentheses are projected bat fatalities rounded to the nearest 500.

		NREL WinDS Model[1]		*PJM Grid Operator Interconnection Queue*[2]	
Species[3]	*Fatality rate*[4]	*Minimum*[5]	*Maximum*[6]	*Minimum*[7]	*Maximum*[8]
Hoary bat	0.289	9542 (9500)	17899 (18000)	17050 (17000)	31983 (32000)
Eastern red bat	0.344	11358 (11500)	21306 (22000)	20294 (20500)	38069 (38000)
Silver-haired bat	0.052	1717 (1500)	3221 (3000)	3068 (3000)	5755 (6000)
Eastern pipistrelle	0.185	6108 (6000)	11458 (11500)	10914 (11000)	20473 (20500)
Little brown myotis	0.087	2873 (3000)	5388 (5500)	5132 (5000)	9628 (9500)
Northern long-eared myotis	0.006	198 (nil)	372 (500)	354 (500)	664 (500)
Big brown bat	0.025	825 (1000)	1548 (1500)	1475 (1500)	2767 (3000)
Unknown	0.012	396 (500)	743 (500)	849 (500)	1328 (1000)
Total		33017 (33000)	61935 (62000)	58997 (59000)	110667 (111000)

[1]Estimated installed capacity of 2158 MW based on National Renewable Energy Laboratory (NREL) WinDS Model for the Mid-Atlantic Highlands for the year 2020 (www.nrel.gov/analysis/winds/)

[2]Estimated installed capacity of 3856 MW based on PJM (electricity grid operator interconnection queue) for the Mid-Atlantic Highlands for the year 2020 (http://vawind.org/assets/docs/PJM_windplant_queue_summary_073106.pdf)

[3]Eastern red bats, hoary bats, and silver-haired bats are the only species in the eastern US known to undertake long-distance migrations (Barbour and Davis 1969).

[4]Estimated species-specific fatality rates are based on data collected in the eastern US (Table 1)

[5]Minimum projected number of fatalities in 2020 is based on the product of 15.3 bat fatalities MW^{-1} yr^{-1} reported from the Meyersdale Wind Energy Center, PA (WebTable 1) and the projected installed capacity (2158 MW) = 33 017. The species-specific annual minimum number of projected bat fatalities is the product of the species-specific fatality rates (Column 2) and the minimum total number of fatalities (eg for the hoary bat, 0.289*33 017 = 9542).

[6]Maximum projected number of fatalities in 2020 is based on the product of 28.7 bat fatalities MW^{-1} yr^{-1} (average for 2003 and 2004) reported from the Mountaineer Wind Energy Center, WV (WebTable 1) and the projected installed capacity (2158 MW) = 61 935. The species-specific annual maximum number of projected bat fatalities is the product of the species-specific fatality rates (column 2) and the total maximum number of fatalities.

[7]Minimum projected number of fatalities in 2020 is based on the product of 15.3 bat fatalities MW^{-1} yr^{-1} reported from the Meyersdale Wind Energy Center, PA (Table 2) and the projected installed capacity (3856 MW) = 58 997. The species-specific annual minimum number of projected bat fatalities is the product of the species-specific fatality rates (column 2) and the total minimum projected number of fatalities.

[8]Maximum projected number of bat fatalities in 2020 is based on the product of 28.7 bat fatalities MW^{-1} yr^{-1} (average for 2003 and 2004) reported from the Mountaineer Wind Energy Center, WV (WebTable 1) and the projected installed capacity (3856 MW) = 110 667. The species-specific annual maximum number of projected bat fatalities is the product of the species-specific fatality rates (column 2) and the total maximum projected number of fatalities.

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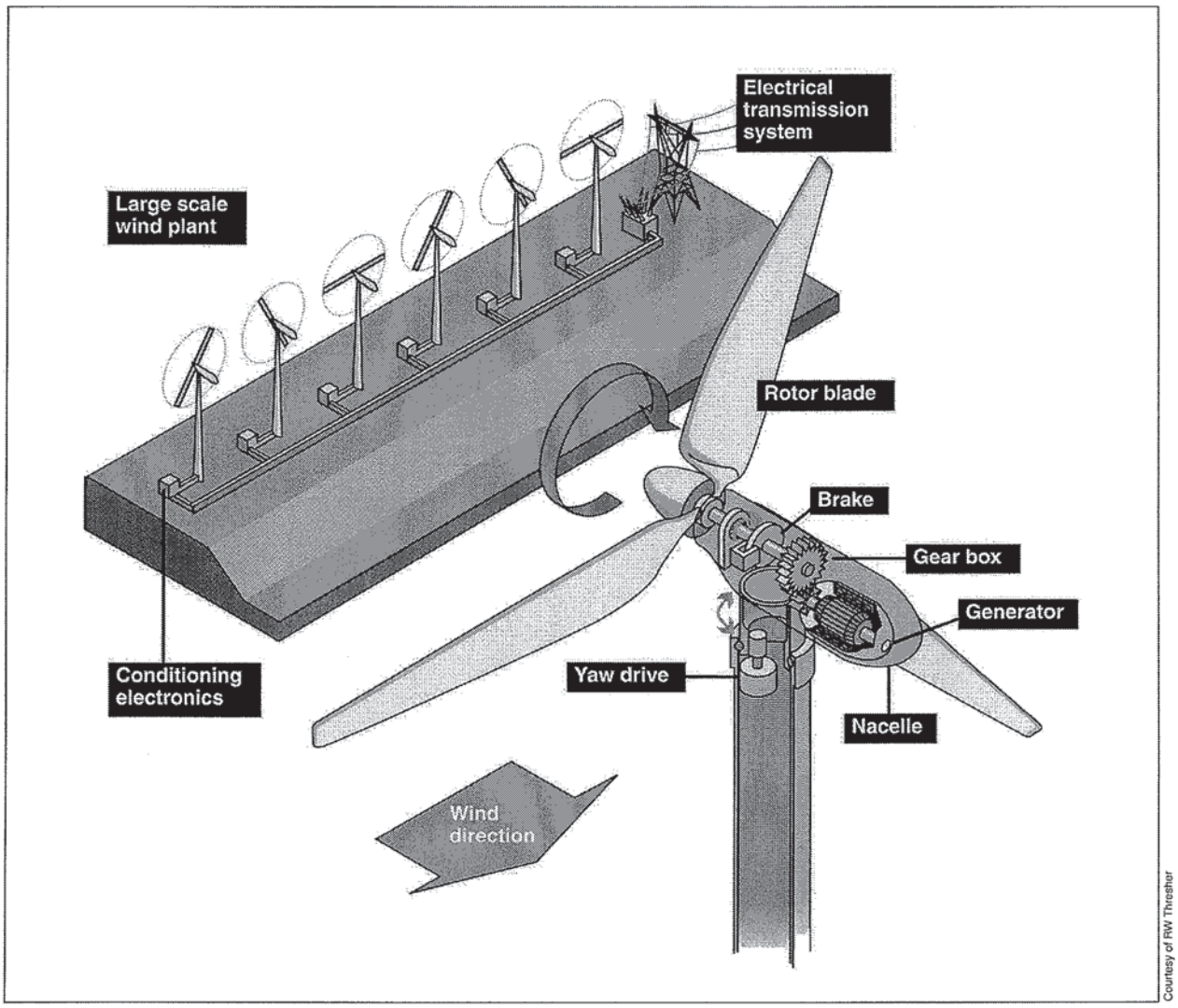

WebFigure 1. *Model of a modern utility-scale wind turbine and wind-energy facility, showing an array of turbines with underground power lines, connected to a local grid by overhead power lines. When rotor blades are pitched into the wind, they rotate a shaft connected to a power generator, which in turn produces electricity. The nacelle is located on top of the monopole and contains the gear box, brake, and electronic control systems used to regulate the pitch of the blades, yaw of the nacelle, rpms of the rotor, and cut-in speed.*

WebPanel 1. Additional acknowledgements

This paper evolved as an outgrowth of several state, regional, and national wind-energy and wildlife workshops, including:

- Bats and wind power generation technical workshop (Juno Beach, FL; 19–20 February 2004; sponsored by the US Fish and Wildlife Service [USFWS], Bat Conservation International, National Renewable Energy Laboratory, and American Wind Energy Association)

- Wind energy and birds/bats workshop: understanding and resolving bird and bat impacts (Washington, DC; 18–19 May 2004; sponsored by the National Wind Coordinating Committee [NWCC])

- Research meeting V: onshore wildlife interactions with wind development (Lansdowne, VA; 3–4 Nov 2004; sponsored by NWCC)

- Wind power and wildlife in Colorado (Fort Collins, CO; 23–25 Jan 2006; sponsored by the Colorado Department of Natural Resources)

- Toward wildlife friendly wind power: a focus on the Great Lakes (Toledo, OH; 27–29 Jun 2006; sponsored by US Environmental Protection Agency, USFWS Great Lakes Basin Ecosystem Team, Illinois Natural History Survey, and US Geological Survey)

- New York wind/wildlife technical workshop (Albany, NY; 2–3 Aug 2006; sponsored by the New York State Energy Research and Development Authority, and New York Department of Environmental Conservation)

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January 18, 2008

Mr. Andrew Golembeski
Everpower Renewables
75 9th Ave. #3G
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Dear Mr. Golembeski:

This is in response to the recent in-person meetings, e-mail exchanges, and discussions between yourself, staff from this office, the Ohio Department of Natural Resources (ODNR), and project representatives, regarding the proposed Buckeye Wind Project, Champaign and Logan Counties, Ohio. We would like to thank you for your willingness to meet with us and discuss this project, and for providing additional information to us in a timely manner to facilitate our review of the project. The current proposal involves the installation of approximately 300 MW of wind power, including wind turbines, pads, transmission lines and access roads. Champaign and Logan Counties are located in west-central Ohio, and are typically rural and agricultural, with scattered blocks of wildlife habitat often comprised of privately-held woodlots, small streams, and wetland areas.

These comments are being provided pursuant to the Endangered Species Act (ESA), Migratory Bird Treaty Act, Bald and Golden Eagle Protection Act, and Fish and Wildlife Act of 1956. This information is being provided to assist you in making an informed decision regarding wildlife issues, site selection, project design, and compliance with applicable laws. The Service has been working closely with ODNR Division of Wildlife to develop recommended survey protocols and site evaluations that will satisfy both state and federal wildlife statutes, and this letter describes these measures, in part. For additional information, please reference ODNR's forthcoming letter on this project.

The Fish and Wildlife Service (Service) supports the development of wind power as an alternative energy source, however, wind farms can have negative impacts on wildlife and their habitats if not sited and designed with potential wildlife and habitat impacts in mind. Selection of the best sites for turbine placement is enhanced by ruling out sites with known, high concentrations of birds and/or bats passing within the rotoswept area of the turbines or where the effects of habitat fragmentation will be detrimental. In support of wind power generation as a wildlife-friendly, renewable source of power, development sites with comparatively low bird, bat and other wildlife values, would be preferable and would have relatively lower impacts on wildlife.

WATER RESOURCE COMMENTS:

The Service recommends that impacts to streams and wetlands be avoided, and buffers surrounding these systems be preserved. Streams and wetlands provide valuable habitat for fish and wildlife resources, and the filtering capacity of wetlands helps to improve water quality. Naturally vegetated buffers surrounding

these systems are also important in preserving their wildlife-habitat and water quality-enhancement properties. Furthermore, forested riparian systems (wooded areas adjacent to streams) provide important stopover habitat for birds migrating through the region. The proposed activities do not constitute a water-dependent activity, as described in the Section 404(b)(1) guidelines, 40 CFR 230.10. Therefore, practicable alternatives that do not impact aquatic sites are presumed to be available, unless clearly demonstrated otherwise. Therefore, before applying for a Section 404 permit, the client should closely evaluate all project alternatives that do not affect streams or wetlands, and if possible, select an alternative that avoids impacts to the aquatic resource. If water resources will be impacted, the Huntington District of the Corps of Engineers should be contacted for possible need of a Section 404 permit.

ENDANGERED SPECIES COMMENTS:

Because of the potential for wind power projects to impact endangered bird, bat, or other listed species, they are subject to the Endangered Species Act (16 U.S.C. 1531-1544) section 9 provisions governing "take", similar to any other development project. Take incidental to a lawful activity may be authorized through the initiation of formal consultation, if a Federal agency, is involved; or if a Federal agency, Federal funding, or a Federal permit are not involved in the project, an incidental take permit pursuant to section 10(a)(1)(B) of the ESA may be obtained upon completion of a satisfactory habitat conservation plan for the listed species. However, there is no mechanism for authorizing incidental take "after-the-fact."

The proposed project lies within the range of the **Indiana bat** (*Myotis sodalis*), a Federally-listed endangered species. Since first listed as endangered in 1967, their population has declined by nearly 60%. Several factors have contributed to the decline of the Indiana bat, including the loss and degradation of suitable hibernacula, human disturbance during hibernation, pesticides, and the loss and degradation of forested habitat, particularly stands of large, mature trees. Fragmentation of forest habitat may also contribute to declines. Summer habitat requirements for the species are not well defined but the following are considered important:

1. Dead or live trees and snags with peeling or exfoliating bark, split tree trunk and/or branches, or cavities, which may be used as maternity roost areas.

2. Live trees (such as shagbark hickory and oaks) which have exfoliating bark.

3. Stream corridors, riparian areas, and upland woodlots which provide forage sites.

The Service currently has no records for Indiana bats within Champaign or Logan Counties, however this is due to an absence of survey data for this area. Suitable summer and hibernation habitat exists within the project area. Additionally, wind power developments within Pennsylvania and West Virginia are known to cause take of relatively large numbers of bats (no Indiana bats to date). Therefore further assessment of the bat community within the project area is warranted to determine if take of Indiana bats (or other bat species) is likely to occur.

Potential hibernacula: Two caves were identified within the project area, as was one documented karst location, and thirteen indicated karst locations (as identified on the map "Caves & Karst Features" provided by Everpower). One cave, Ohio Caverns, is a park and tourism area that has been significantly modified and does not support suitable hibernation habitat. The other cave (Sanborn's Cave/Streng Cave) may be suitable for hibernating bats. We recommend that Sanborn's/Streng Cave, the documented karst location, the indicated karst locations, and any other caves/fissures/openings discovered during project planning activities be examined to determine if the features of the area indicate that they are potential

hibernation sites for bats. The attached document, "Criteria for Determining if Caves or Abandoned Underground Mines are Potential Hibernacula for the Indiana Bat," provides a bulleted list of the criteria necessary for an area to qualify as a potential hibernaculum, and Service biologists would appreciate the opportunity to visit and evaluate one or more of the caves/karst areas within the project area as discussed in previous meetings. If any area(s) is determined to be a potential hibernaculum, it should be surveyed in one of two ways: 1) if the potential hibernaculum is safely accessible by human beings, it should be surveyed during the winter to document the presence/absence of hibernating bats of any species, as well as species composition; or 2) if human access is not possible or safe, any area determined to be a potential hibernaculum should be subject to a fall swarming survey between August 1 and September 30 to determine if bats of any species are using the area for swarming or hibernation.

Mist Net Surveys: Based on maps provided by Everpower ("Woods supporting water features"), there are 4,052 acres (16.3 square km) of suitable habitat for Indiana bats within the project area. The Service's Indiana bat Mist Netting Guidelines (attached) call for two net sites per square km of forested habitat, which equates to a minimum of 33 net sites within the project boundary. Within the identified woodlots greater than 100 acres in size that support water features, 15 woodlots appear to be located within proximity to proposed wind turbines, and these should be sampled to determine bat species composition and use. These woodlots are identified on a map to be provided by the Ohio Department of Natural Resources, Division of Wildlife. We recommend 2 net sites per woodlot. Further, the three highest quality woodlots should be subject to an additional 2 net sites, to maximize opportunities to detect Indiana bats and to determine bat species composition. Service biologists would appreciate the opportunity to visit the project area and to aid in selection of suitable mist net survey locations, as we have discussed in previous meetings. Mist net surveys should follow standard Service protocol, as described in the attached document. Mist net surveys should occur between June 15 and July 31 to detect maternity colonies inhabiting the area, as well as to maximize opportunities to detect species diversity. Bat detectors should also be used in conjunction with mist net surveys to maximize detection of species diversity. If an Indiana bat is captured, this office shall be notified within 24 hours, or by the next business day.

Radio Transmitters: Up to four Indiana bats should be fitted with radio transmitters and tracked to roost site(s) and foraging areas until daily activity patterns are fairly well established, or as long as the transmitter remains attached and activated. Preference shall be given to tracking female bats, though one male Indiana bat may be tracked if captured prior to capturing four female Indiana bats. Additionally, we recommend that up to six additional colonial roosting female bats of other species be tracked to identify maternity sites and habitat use. Please see ODNR's recommended survey protocol for additional information on radiotracking non-Indiana bats.

Acoustic Surveys: Acoustic surveys using bat detectors should be completed in conjunction with all mist net and fall swarming surveys. Additionally, we understand that Everpower has already begun acoustic surveys at several locations within the project area. We recommend the use of Anabat II detectors, digital storage of detection data, and interpretation of the data with appropriate software that incorporates regional differences in bat call structure to filter and differentiate bat echolocation calls to genus, and species where possible.

Coordination of Survey Results: Please submit survey results to this office for review. If an Indiana bat is captured, this office must be notified within 24 hours, or by the next business day. Survey results will be interpreted to determine areas with relatively low bat activity/diversity as opposed to areas with relatively high bat activity/diversity. Based on the survey results, we may make recommendations as to turbine placement and operation, additional consultation under Section 7 or 10 of the Endangered Species Act of 1973, as amended, or pre- or post-construction monitoring.

The proposed project lies within the range of the **rayed bean mussel** (*Villosa fabalis*), a Federal Candidate species. The rayed bean is generally known from smaller, headwater creeks, but records exist in larger rivers. They are usually found in or near shoal or riffle areas, and in the shallow, wave-washed areas of lakes. Substrates typically include gravel and sand, and they are often associated with, and buried under the roots of, vegetation, including water willow (*Justicia americana*) and water milfoil (*Myriophyllum* sp.). The rayed bean has been recorded in Little Darby Creek, and is potentially present in its tributaries. Should the proposed project directly or indirectly impact any of the habitat types described above, we recommend that a survey be conducted to determine the presence or probable absence of rayed bean mussels in the vicinity of the proposed site.

The proposed project lies within the range of the **eastern massasauga** *(Sistrurus catenatus catenatus)*, a federally-listed candidate species. Due to the project type, size, and location, the project, as proposed, should not impact this species or its habitat. Should, during the term of this action, additional information on listed or proposed species or their critical habitat become available, or if new information reveals effects of the action that were not previously considered, consultation with the Service should be initiated to assess any potential impacts.

MIGRATORY BIRD COMMENTS:

The Migratory Bird Treaty Act (16 U.S.C. 703-712; MBTA) implements four treaties that provide for international protection of migratory birds. The MBTA prohibits taking, killing, possession, transportation, and importation of migratory birds, their eggs, parts, and nests, except when specifically authorized by the Department of the Interior. Bald and golden eagles are afforded additional legal protection under the Bald and Golden Eagle Protection Act (16 U.S.C. 668-668d). Unlike the Endangered Species Act, neither the MBTA nor its implementing regulations at 50 CFR Part 21, provide for permitting of "incidental take" of migratory birds.

The Service's Office of Law Enforcement serves its mission to protect Federal trust wildlife species, in part, by actively monitoring industries known to negatively impact wildlife, and assessing their compliance with Federal law. These industries include oil/gas productions sites, cyanide heap/leach mining operations, industrial waste water sites, and wind power sites. There is no threshold as to the number of birds incidentally killed by wind power sites, or other industry, past which the Service will seek to initiate enforcement action. However, the Service is less likely to prioritize enforcement action against a site operator that is cooperative in seeking and implementing measures to mitigate takes of protected wildlife.

The Service and ODNR Division of Wildlife have worked together to develop a recommended bird survey protocol for the project area. Please refer to ODNR's forthcoming letter for a detailed description of the recommended survey protocol. Similar to the bat survey results, bird survey results will be interpreted to determine if potential risk to birds is relatively high or low in various portions of the project area. Based on survey results we may make recommendations as to turbine placement and operation, or pre- or post-construction monitoring.

Thank you for the opportunity to provide comments on the proposed Buckeye Wind Project. Please contact biologist Megan Seymour at extension 16 in this office if we can be of further assistance.

Sincerely,

Mary Knapp

Mary Knapp, Ph.D.
Supervisor

Attachments: (1) Indiana bat mist netting guidelines
(2) Criteria for Determining if Caves or Abandoned Underground Mines are Potential Hibernacula for the Indiana Bat

Cc: Ms. Vicki Deisner, ODNR Bldg. D, Columbus, OH
Mr. Dave Scott, ODNR Div. of Wildlife, Bldg. G, Columbus, OH
Ms. Cara Meinke, Stantec, 30 Park Dr., Topsham, ME 04086

MIST NETTING GUIDELINES

RATIONALE

A typical mist net survey is an attempt to determine presence or probable absence of the species; it does not provide sufficient data to determine population size or structure. Following these guidelines will standardize procedures for mist netting. It will help maximize the potential for capture of Indiana bats at a minimum acceptable level of effort. Although the capture of bats confirms their presence, failure to catch bats does not absolutely confirm their absence. Netting effort as extensive as outlined below usually is sufficient to capture Indiana bats. However, there have been instances in which additional effort was necessary to detect the presence of the species.

NETTING SEASON

May 15 - August 15

These dates define acceptable limits for documenting the presence of summer populations of Indiana bats, especially maternity colonies. Several captures, including adult females and young of the year, indicate that a nursery colony is active in the area. Outside these dates, even when Indiana bats are caught, data should be carefully interpreted: If only a single bat is captured, it may be a transient or migratory individual.

EQUIPMENT

Mist nets - Use the finest, lowest visibility mesh commercially available:

1. In the past, this was 1 ply, 40 denier monofilament - denoted 40/1
2. Currently, monofilament is not available and the finest on the market is 2 ply, 50 denier nylon denoted 50/2
3. Mesh of approximately 1 ½ (1 ¼ - 1 ¾) in (~38 mm)

Hardware - No specific hardware is required. There are many suitable systems of ropes and/or poles to hold the nets. See NET PLACEMENT below for minimum net heights, habitats, and other netting requirements that affect the choice of hardware. The system of Gardner et al. (1989) has met the test of time.

NET PLACEMENT

Potential travel corridors such as streams or logging trails typically are the most effective places to net. Place the nets approximately perpendicular across the corridor. Nets should fill the corridor from side to side and from stream (or ground) level up to the overhanging canopy. A typical set is seven meters high consisting of three or more nets "stacked" on top one another and up to 20 meters wide. (Different width nets may be purchased and used as the situation dictates.)

Occasionally it may be desirable to net where there is no good corridor. Take caution to get the nets up into the canopy. The typical equipment described in the section above may be inadequate for these situations, requiring innovation on the part of the observers.

RECOMMENDED NET SITE SPACING

Stream corridors - one net site per km of stream.
Non-corridor land tracts - two net sites per square km of forested habitat.

MINIMUM LEVEL OF EFFORT

Netting at each site should consist of:

- At least four net nights (unless bats are caught sooner) (one net set up for one night = one net night)
- A minimum of two net locations at each site (at least 30 m apart, especially in linear habitat such as a stream corridor)
- A minimum of two nights of netting
- Sample Period: begin at sunset; net for at least 5 hr
- Each net should be checked approximately every 20 min
- No disturbance near the nets, other than to check nets and remove bats

WEATHER CONDITIONS

Severe weather adversely affects capture of bats. If Indiana bats are caught during weather extremes, it is probably because they are at the site and active despite inclement weather. On the other hand, if bats are not caught, it may be that there are bats at the site but they may be inactive due to the weather. Negative results combined with any of the following weather conditions throughout all or most of a sampling period are likely to require additional netting:

- Precipitation
- Temperatures below 10°C
- Strong winds (Use good judgment: moving nets are more likely to be detected by bats.)

MOONLIGHT

There is some evidence that small myotine bats avoid brightly lit areas, perhaps as predator avoidance. It is typically best to set nets under the canopy where they are out of the moonlight, particularly when the moon is ½-full or greater.

Gardner, J.E., J.D. Garner, and J.E. Hofmann. 1989. A portable mist netting system for capturing bats with emphasis on *Myotis sodalis* (Indiana bat). Bat Research News 30(1):1-8.

Criteria for Determining if Caves or Abandoned Underground Mines Are Potential Hibernacula for the Indiana Bat

- Mine/cave entrances should not be flooded or prone to flooding (debris on ceiling).

- Mine/cave entrances should be accessible to bats (not collapsed).
    - Foliage and other vegetation in front of mine openings do not stop use by bats. The animals can navigate through foliage.
    - Bats can access mines via old open buildings such as fan houses.

- Openings should be at least 2 years old.

- Openings should be at least one foot in diameter or larger.

- Passage should be evident for some distance into mine workings (never enter a mine opening to verify distance).

- There should be some amount of airflow in or out of entrance.

- Bats will use vertical shafts. Vertical passage should be at least two feet in diameter with some airflow.