The Possible Effects of Wind Energy on Illinois Birds and Bats

Report of the Illinois Department of Natural Resources to
Governor Rod Blagojevich and the 95th Illinois General Assembly

June 2007

Cover Photo**:** Wind turbines at Mendota Hills, Lee County, Illinois.
Photo by Penny L. Shank

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Illinois Department of Natural Resources
One Natural Resources Way
Springfield, Illinois 62702

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Executive Summary

Utility-scale wind-powered electrical generation facilities are rapidly expanding in Illinois, with feasibility studies underway for installations in no fewer than 37 of the State's 102 counties; construction completed for approximately 300 MW of capacity; and construction for an additional 900 MW or more pending in the next two years. The wind-generation industry estimates Illinois can provide up to 9,000 MW from up to 6,000 turbines.

Adequate scientific data does not yet exist to affirm or refute the potential biological significance of mortality directly caused by utility-scale wind turbines. While birds are killed through collisions with wind turbines, it is rare that such losses may be significant to particular species. Bats may be in greater jeopardy from wind turbines because two to three times as many bats are killed. Losses of both animals are higher during migration periods.

Only one mortality study has been performed at an Illinois wind energy installation. In that case, it is estimated that only one bird per turbine is killed per year. While other avian species were killed, only one raptor (a red-tailed hawk) was killed. However, three times as many bats were killed through collisions. No remains of threatened or endangered avian or mammal species were found. It remains unclear how significant this level of attrition may be.

While public attention centers on the apparent threat to birds from collisions with wind turbines, collision mortality is only one of many potential adverse effects to wildlife posed by wind energy installations. Habitat displacement and fragmentation are of potentially greater significance to a wide array of wildlife, including mammals, reptiles, amphibians, fish, and invertebrates. Similarly, natural areas could be adversely affected by erosion, sedimentation, water quality degradation, and shadowing associated with wind turbine construction and operation.

One area of concern for Illinois is Lake LaSalle, a cooling lake for a nuclear reactor that is located in an area that has high potential for wind projects. The lake has become an important wintering area for migratory waterfowl because the lake rarely freezes, and surrounding lands provide sufficient food resources if snow cover is not too deep. Impacts to foraging birds could prove significant if a wind project is sited in the area. Although no turbines have been suggested for the Lake Michigan area, this could be another location of concern because it is a known flyway for birds and bats.

To better understand the impact of wind farms on Illinois birds, the state could:

- Develop a map of areas of concern to highlight protected natural resources and wildlife areas where developers should take extra precautions when developing wind farms,
- Fund a major study of bird abundance and richness before and after turbines are constructed at representative sites in the state, and
- Fund a comprehensive study of bat mortality around existing wind farms.

Until the impacts are better understood, regulatory action for wildlife protection is not recommended.

Introduction

The Possible Effects of Wind Energy on Illinois Birds and Bats was requested by House Resolution 943 to assess the danger of wind turbines to birds, including threatened and endangered species, in Illinois. While a small post-construction mortality study was just completed in Bureau County (see below), no major on-the-ground study has been conducted in Illinois. To complete this report, staff of the Illinois Department of Natural Resources (IDNR) consulted the scientific literature to try to determine what impact the proliferation of wind turbines could have on birds and bats in Illinois.

Figure 1. A lone turbine generates 1.5 MW northwest of Pittsfield, Pike County. Photo: Penny L. Shank

The wind industry estimates that, on average, two birds are killed by each modern wind turbine in a year's time. This estimate is based on studies at widely-spaced projects around the country. The IDNR does not have the statutory authority to order wind developers to conduct mortality studies after a project is constructed, but it can recommend such studies under the consultation requirements of the Illinois Endangered Species Protection Act and the Illinois Natural Areas Preservation Act. These laws require units of state and local government to consult with IDNR to determine if proposed actions could adversely affect listed species or natural areas. If impact is likely, IDNR recommends steps to minimize or avoid such effects.

During consultation with Bureau County for the 33-turbine Crescent Ridge wind project, IDNR recommended that a post-construction mortality study be undertaken. The county board adopted the recommendation and added the study as a condition for obtaining a permit to construct the facility.

The developer hired a private consultant to collect data at the Crescent Ridge facility between August 2005 and July 2006, covering a complete avian migration cycle. The final report estimates that about 31 birds (including one raptor, a red-tailed hawk) and 93 bats were killed during the study period, or an average of one bird and three bats killed per turbine. No carcasses of endangered or threatened species were found.

Wind Power in Illinois

Electricity derived from alternative sources is a subject of rapidly increasing interest and investment on an economically significant scale. Consequently, converting the kinetic energy of wind to electricity has become a major growth industry.

The first requirement for this technology is wind of sufficient intensity and duration to sustain electricity production on an industrial scale. The U. S. Department of Energy has mapped the United States according to five levels of wind resources. Generally, regions experiencing Class Three to Class Five winds are deemed suitable for large wind energy systems. While Illinois has no Class Five winds, it does have a small area with Class Four winds (0.4% of IL with the potential

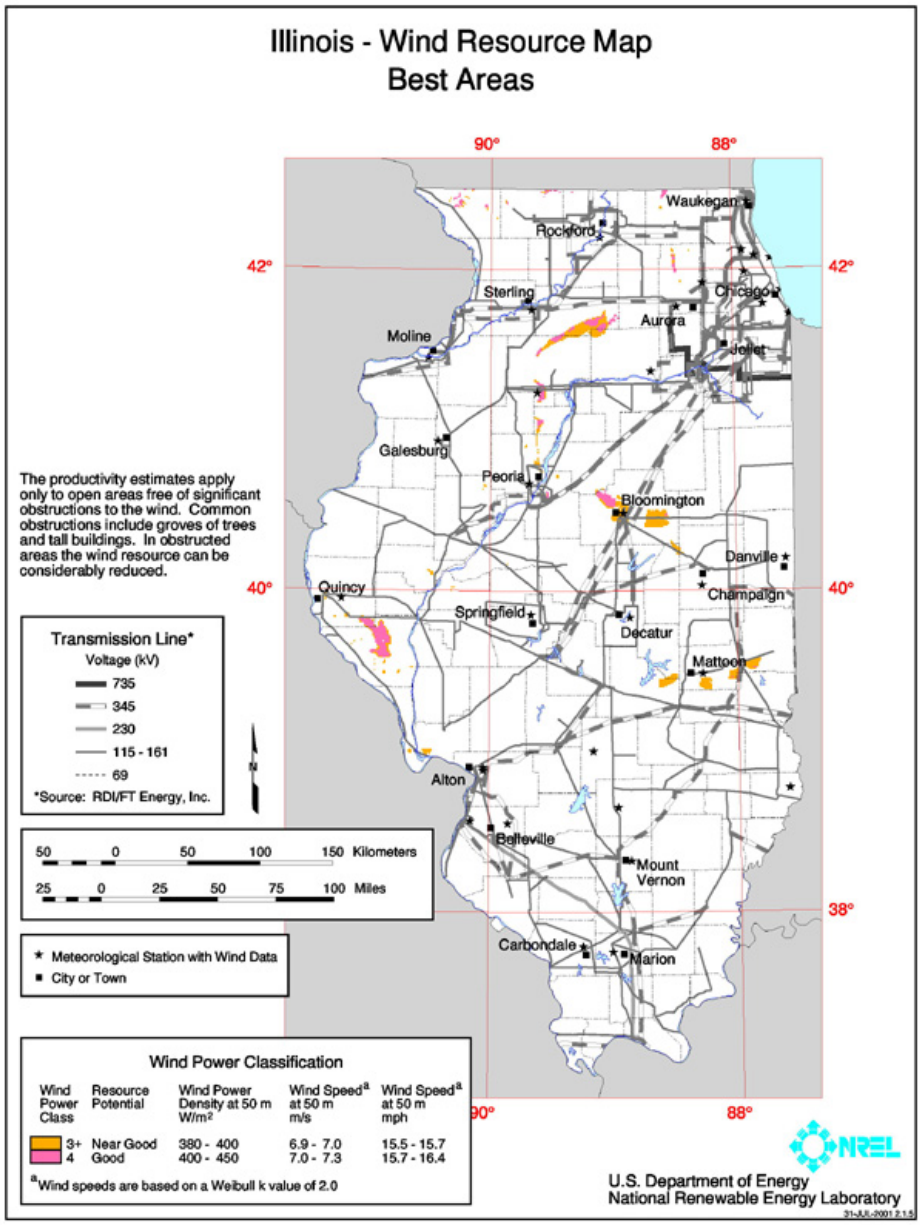

Figure 2.

for 3,000 MW of power), in largely rural agricultural areas southeast of Quincy, the Bloomington area, an area north of Peoria, the Mattoon area, and between Sterling and Aurora (Figure 2). Illinois also has a number of areas with Class Three+ winds (0.8% of IL with the potential for 6,000 MW of power). All of these areas occur in the central and northern parts of the State.[1] Figure 3 shows that most of the rest of the state has either fair or marginal wind resources.

It might be thought that Class Five and Class Four wind areas in other states would be developed before the Illinois potential was tapped, but Illinois meets the two other requirements for a viable installation: a market, and the means to convey the electricity to it. Most Class Five and Four wind areas are located in areas remote from markets and lack the infrastructure to transport the electricity. Illinois, however, has both the existing power grid infrastructure and nearby markets, as

[1] The US DOE wind maps excluded urban lands and environmentally sensitive lands such as state parks and wildlife refuges

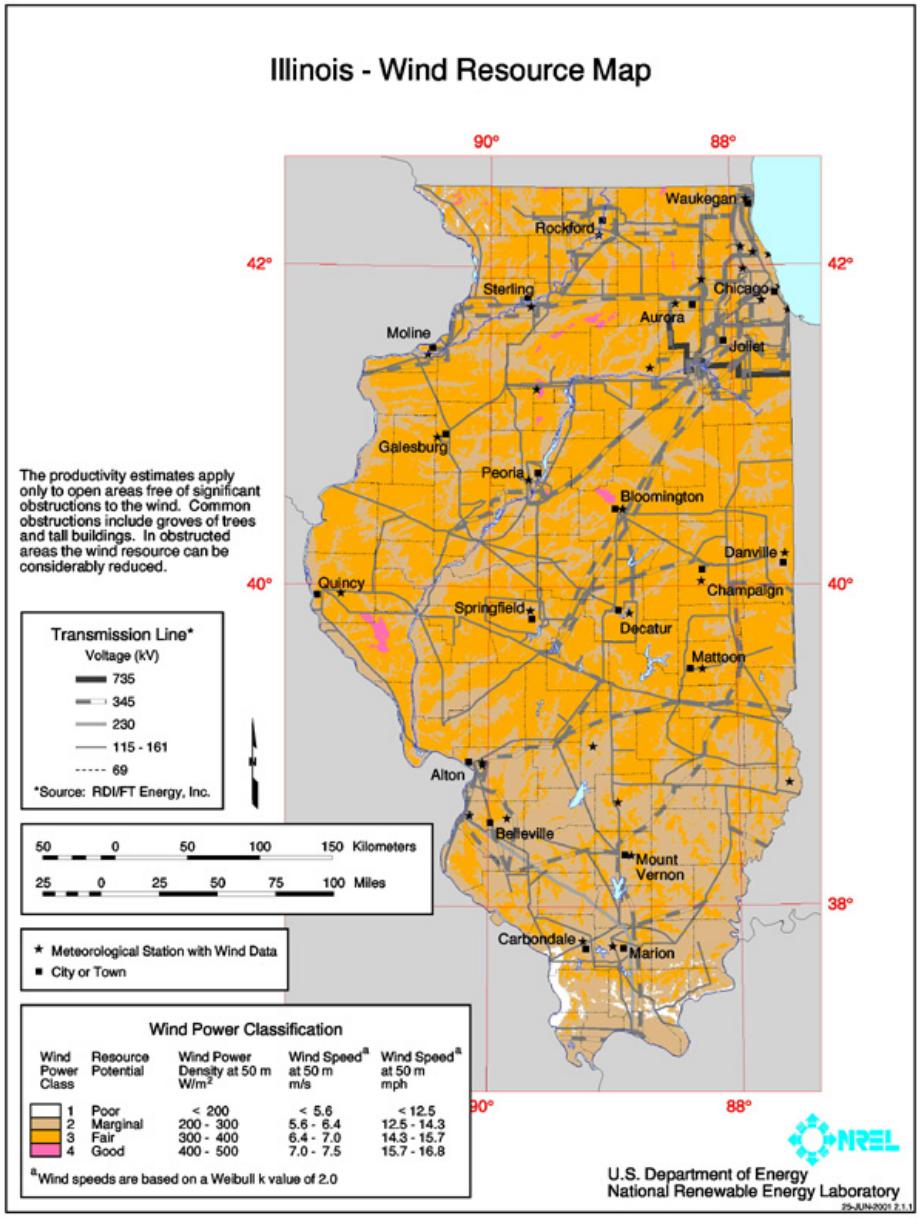

Figure 3.

well as public policies promoting alternative energy sources, making it a regional focus of activity in this emerging industry.

With an estimated capacity of 9,000 MW, assuming 1.5 MW machines, Illinois eventually could support roughly 6,000 utility-scale wind turbines on 1,800 square kilometers (about 695 square miles, or 445,000 acres). Each square kilometer could support about 5MW in installed wind capacity.

Illinois' Existing Wind Energy Projects

Since wind power is not regulated at the state level, the following numbers have been obtained from personal communication with the subject counties. At present, Illinois' utility-scale wind-power capacity is approaching 300 MW. Facilities range from a single 1.5 MW turbine operated by a rural electrical co-op near Pittsfield (Pike Co.) to the recently completed 110-turbine 150 MW

Phase I High-Trails facility east of Bloomington. Smaller arrays such as the 33-turbine 50 MW Crescent Ridge project (Bureau Co.) and the 62-turbine 50 MW Mendota Hills facility (Lee Co.) are also in operation.

Construction permits have also been issued for the following:

- 110-turbine 150 MW Big Sky project in Lee County,
- 110-turbine 150 MW White Oak project in McLean County,
- 100-turbine 200MW Camp Grove project in Marshall and Stark Counties,
- 110-turbine 150 MW Phase I Bishop Hill project in Henry County,
- 160 turbine >200 MW High Trails Phase II in McLean County.

When completed in 2007 and 2008, Illinois turbine arrays will be producing about 1,200 MW of wind-generated electricity.

Projects vary in ownership from fairly small local corporations to consortiums of large multinational energy and investment firms. Typically, a wind-power developer will execute long-term leases with existing landowners rather than purchase land outright. The developer will then pursue zoning and permitting with local governments (usually counties). Once a project is built, it is not unusual for it to be sold or transferred to another corporation that specializes in operations.

Typically turbines must be spaced about one-quarter mile apart to avoid turbulence from adjacent machines. Each turbine is mounted on a deep foundation and is serviced by a gravel access road. This requires about one-quarter acre per machine. Turbines are linked to each other through land-lines that run underground and feed electricity to a step-up transformer at a substation, which boosts the voltage to be compatible with the receiving electrical grid.

Most turbines in use today are mounted on tubular steel towers without external supports, usually about 260 feet high to the nacelle containing the generator. Each turbine mounts three blades, or vanes, up to 120 feet long, the pitch of which can be varied to control the generator's speed. The maximum height for any turbine proposed in Illinois is about 465 feet when a vane is in the vertical position, and the blade sweep is usually more than 100 feet off the ground. Turbines can begin operating in winds as light as 8-10 mph, but the blades must be "feathered" in winds higher than 48-50 mph to avoid damage to the generator. Most are designed to withstand wind speeds up to 100 mph and have an expected life-span of up to 30 years.

Three distinct markets exist for wind energy technology: residential, small business, and commercial utility. Residential systems typically produce power sufficient to supply all or some of the needs for a single-family home and are scaled accordingly. Their environmental effects are highly-localized, but could be significant if such turbines become common or highly concentrated. Small business systems supply the energy needs of individual farms and small businesses, ranging from a few kilowatts up to one megawatt in capacity. Usually, such installations consist of single turbines which create little apprehension about their adverse environmental effects. Utility-scale wind generation systems employ large turbines, usually with a capacity of one megawatt or greater, in tandem arrays covering many square miles. They produce electrical power for wholesale distribution to consumers via the national power grid. It is concern about the individual and cumulative environmental effects of commercial utility systems that prompted this report.

Potential Projects

The Illinois Endangered Species Protection Act and the Illinois Natural Areas Preservation Act require local governments to evaluate, by consulting with the IDNR, whether actions they authorize, fund or perform will jeopardize threatened or endangered species or adversely modify their habitat, or adversely modify a natural area on the Illinois Natural Areas Inventory. If an impact is likely, IDNR recommends steps to minimize or avoid the impact. Developers also

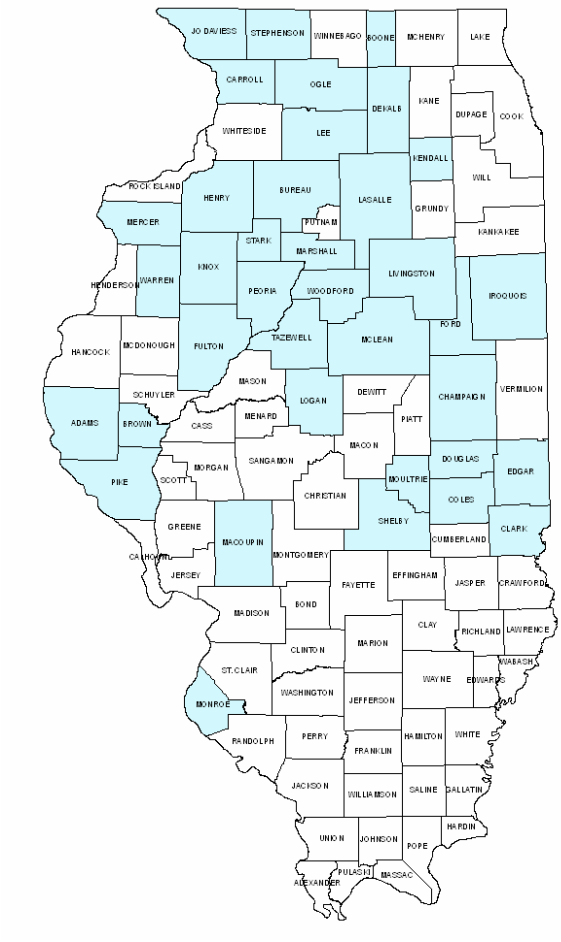

Figure 4. Blue counties have confirmed or potential wind projects.

frequently submit 'Information Requests' during facility planning to determine what protected natural resources might be in a proposed project location.

Over the past several years, requests for either information or consultation have been submitted to IDNR for portions of 37 counties (Figure 4). Through personal communication with county officials, the IDNR is aware that zoning has been approved or is being sought for a number of significant projects in Henry, Lee, Ogle, Stephenson, and Woodford Counties. Feasibility and environmental studies are underway for projects in Adams, Champaign, Logan, DeKalb, Iroquois, LaSalle, Livingston, Ford, Knox, Mercer, Warren, Jo Daviess, Bureau, and Coles Counties. Henry County expects to issue construction permits for up to 700 turbines within the next year.

Some areas, however, are setting limitations on wind energy development. The Boone County Board denied a 15-turbine project, citing concerns about impacts to adjacent agricultural operations. Ogle and Stephenson Counties are defending lawsuits against zoning decisions in favor of wind facilities which have created uncertainty about several projects. The Town of Chatsworth in Livingston County has banned wind turbines within 1.5 miles of the city limits, while the Town of Normal formally opposes any turbines within seven miles of the city.

Potential Effects on Wildlife

The following summary is based on recent authoritative review articles (see Bibliography) available to Illinois Natural History Survey staff. Much of it is based on findings in other states and countries because no scientific studies on flying bats and birds near wind turbines have been conducted in Illinois. The only study available is the mortality monitoring study at the 33-turbine Crescent Ridge Wind Power project in Bureau County. It should also be noted that because limited research is available about the behavior and ecology of many of the species in question, most of the studies do not provide conclusive information.

Direct impacts

Both the wind turbines and the power lines associated with them are possible hazards for flying wildlife. Collisions, probably with the moving turbine blades, are evidenced by finding dead or injured bats and birds on the ground in the vicinity of turbines. Other bats and birds could be injured and die later some distance away, but these remain undocumented. The following information is organized by groups of species that could be most impacted by wind energy in Illinois.

Bats

Bats are probably the creatures most affected by wind turbines in areas like Illinois. They appear to be especially subject to harm during migration to hibernation sites or to southern regions in August and September. Although migratory bats are many fewer in number than night-migrating birds, perhaps 10 times as many bats as birds are killed at wind turbines at upland sites. Substantial bat fatalities are documented in Europe; on mountain ridges in the eastern USA; in agricultural areas in Minnesota, Iowa, and Alberta, Canada; and in Oklahoma. According to the latest summaries, bat fatalities in open areas (such as the Midwest) are somewhere between the low values in the West (1-2 bats/turbine/year) and the high values in the Appalachians and Alleghenies (46 or more bats/turbine/year), and are concentrated around the month of August.

Data from Alberta and Oklahoma suggest that the presence of nearby trees does not add to the hazard for bat kills at wind power facilities; wind turbines in open areas kill bats. Indications are that bats are killed or injured as they actively approach or remain near the turbines in some undefined fashion. The migrating bats fly close—and may actually be attracted—to the rotating blades and perish close to the turbine support structure, particularly in the first part of the night. Sometimes, but not always, they show evidence of injury caused by impact.

Very recent scientific studies have used special equipment to film bats flying very near turbine blades and being knocked out of the sky.

Bat kills also do not appear to be influenced by FAA-mandated flashing or pulsing lights on wind turbines. Limited information suggests that the rotating blades harm the bats rather than the stationary support structure (monopole). No specific studies have been completed, but there is some evidence of lower mortality when blades were feathered. Recent reports of bats "deterred" from radar facilities are questionable and do not represent a potentially feasible way to repel bats from wind turbines.

The conservation implications of wind turbines on populations of migratory bats are unknown. However, most species of bats are especially vulnerable to additional mortality because of their low reproductive rates. Appendix 1 provides more detailed observations on bat mortality.

Hawks and eagles

Locally-breeding raptors are attracted to prey species that are in turn drawn to the base of the turbines for certain kinds of shelter and food. The birds are killed while flying near the turbines, looking downward for prey and failing to avoid the turbine blades. Carcasses of these large birds, which are protected by statute, attract attention when they fall in open areas.

Daytime-migrating birds

Daytime migrants are most at risk where they concentrate on a narrow migration path, such as at Altamont Pass in California. Such sensitive migration routes are not numerous in Illinois, but they do exist. For instance, the western shore of Lake Michigan funnels migrating raptorial birds into and past the Chicago area every year, as documented by visual counts and by Illinois Natural History Survey scientists using radio tracking. Some species of birds, notably Blue Jays, follow restricted, traditional routes in their migration (documented by Richard Graber of the INHS). Offshore Lake Michigan may be another such location of higher concern for both daytime birds and nighttime migrants.

Night-migrating birds

While the numbers of night-migrating birds that are killed by one turbine in a year are not expected to be large, the overall impact of a large number of turbines could be cause for concern. These kills are prohibited under the Federal Migratory Bird Treaty Act, but few serious measures to reduce the danger have been suggested. Reports in the last few years indicate that the great preponderance of mortality in at least some populations of songbirds occurs away from the breeding and wintering

areas, presumably during migration. This has resulted in a greatly increased appreciation of migratory hazards in bird conservation.

Like kills of bats, most of the evidence on kills of nocturnally-migrating birds comes from searching for carcasses at dawn. This provides a crude estimate of the numbers of birds killed but little indication of the circumstances and cause of the kills. Based on sparse evidence, it is thought that such mortality is primarily due to chance encounters with a turbine's revolving blades 100-450 feet above the ground. The number of birds that migrate at these heights is not as well understood as one might expect, but during cruising flight many or most birds fly higher than the maximum blade height of current wind turbines. Important exceptions include takeoff (usually at dusk), descent, and landing (usually in the second half of the night), and perhaps nights with a low cloud ceiling. Cloud height may induce birds to fly lower and FAA-mandated lighting on wind turbines may prove to be a factor on some cloudy nights, as it is with tall broadcast towers. Unfortunately, few studies of bird or bat fatalities at wind turbines have been intensive enough to come to firm, useful conclusions about the interaction of low clouds, migrating vertebrates, and wind turbines. Certainly no mass kills in a single night, such as can occur at tall guyed broadcast towers, have been documented at terrestrial wind turbines in North America.

Local birds in flight

Some studies have documented that local water birds may avoid feeding in areas near wind turbines. On the other hand, other studies have indicated that wind turbines near wetlands, or other areas of waterfowl concentration, may pose hazards for arriving or departing birds. On one November evening, more than 50,000 ducks were observed returning to Lake LaSalle after feeding. R. Diehl from the Illinois Natural History Survey had to stop counting the ducks when darkness fell. Figure 5, an image from the National Weather Service radar at Romeoville overlaying the Illinois Land Cover map, illustrates the masses of ducks at Lake LaSalle. The triangular mass in the

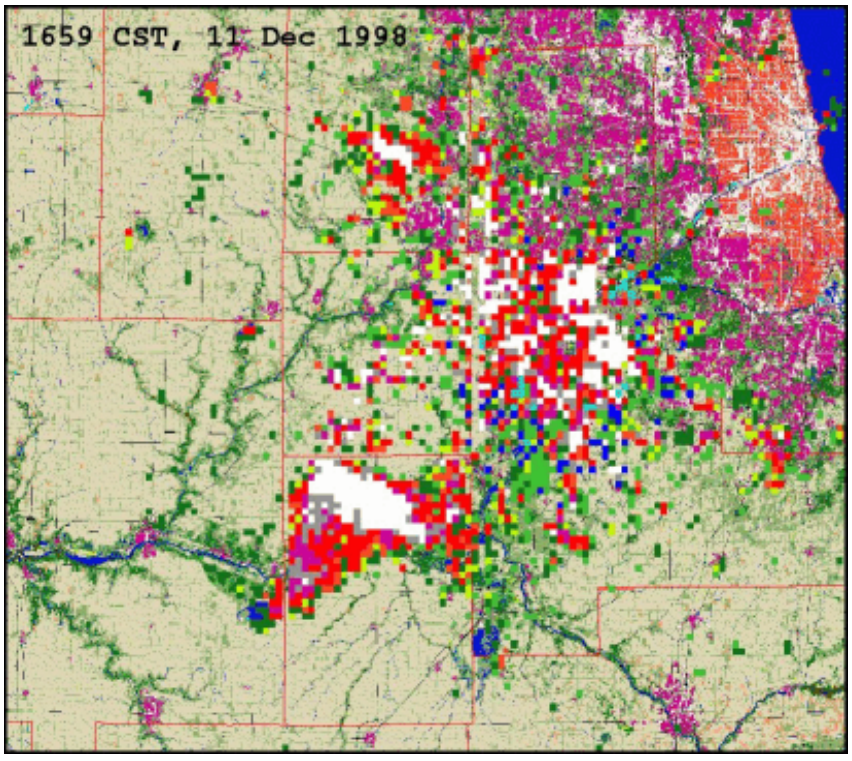

Figure 5. Radar image from Weathertap, Inc.

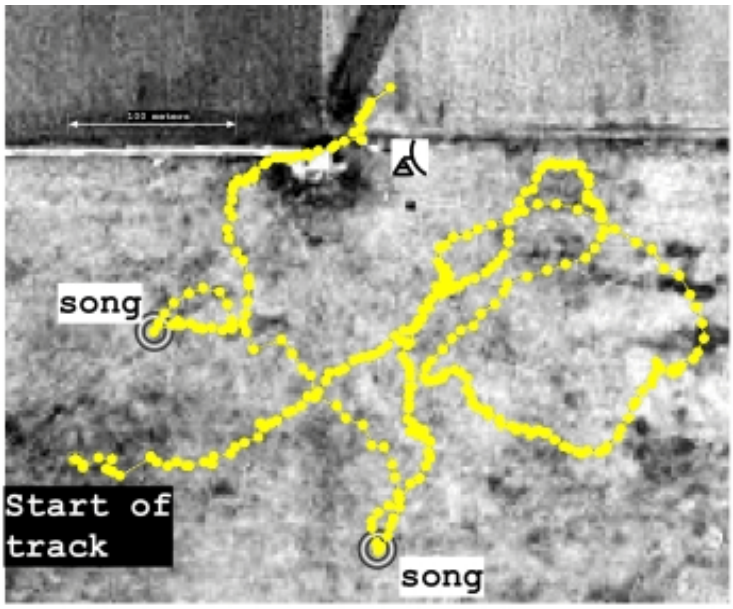

Figure 6. Radar track of part of a display flight of a male Upland Sandpiper in east-central Illinois.

lower part of the image shows the mass of ducks (white area at the top of the triangle) beginning to arrive at Lake LaSalle, at the bottom of the triangle. Other red and white areas are probably concentrations of other unidentified flying birds.

Other grassland birds

During a courtship display, birds such as the Upland Sandpiper, a state endangered species, and the Prairie Horned Lark fly at the height of a rotating turbine. If a male's territory or display ground (lek) exists near a turbine, the bird will be at risk. Figure 6 is a radar track of part of a display flight of a male Upland Sandpiper in east-central Illinois. On an evening in mid-June, the bird was engaged in typical courtship. It sang while flying and hovering aloft, a behavior that occurs frequently during breeding season, both day and night. Like most Upland Sandpiper display flights over eastern Illinois grasslands, this entire track took place within or slightly above the height range of modern wind turbine vanes.

Habitat disturbance, removal, and fragmentation

In Europe, impacts on bird habitat from turbine construction are generally of greater concern than direct collision-caused mortality of flying birds, and this is also true in Illinois. In the Midwestern USA, however, such impacts have not been well studied; the brief bird counts and habitat surveys that have been conducted do not provide data on subtle but lasting effects.

Forest

In forest, about four acres or more are cleared for each wind turbine, not including access roads and power lines. This fundamentally changes the nature of the land cover and creates habitat fragments and edge, which can be deleterious for some important species. For instance, extensive work in southern Illinois shows that forest-breeding birds exhibit decreased nesting success because of disturbance by the Brown-headed Cowbird when forest is broken up. Many of these forest-loving birds are members of species in decline and thus of special concern in the whole region.

Some of the bat species killed by direct collisions with turbines are also adversely affected when sites for roosting and raising young are destroyed. Currently, no proposed or likely turbine sites in Illinois are located near large blocks of forested area.

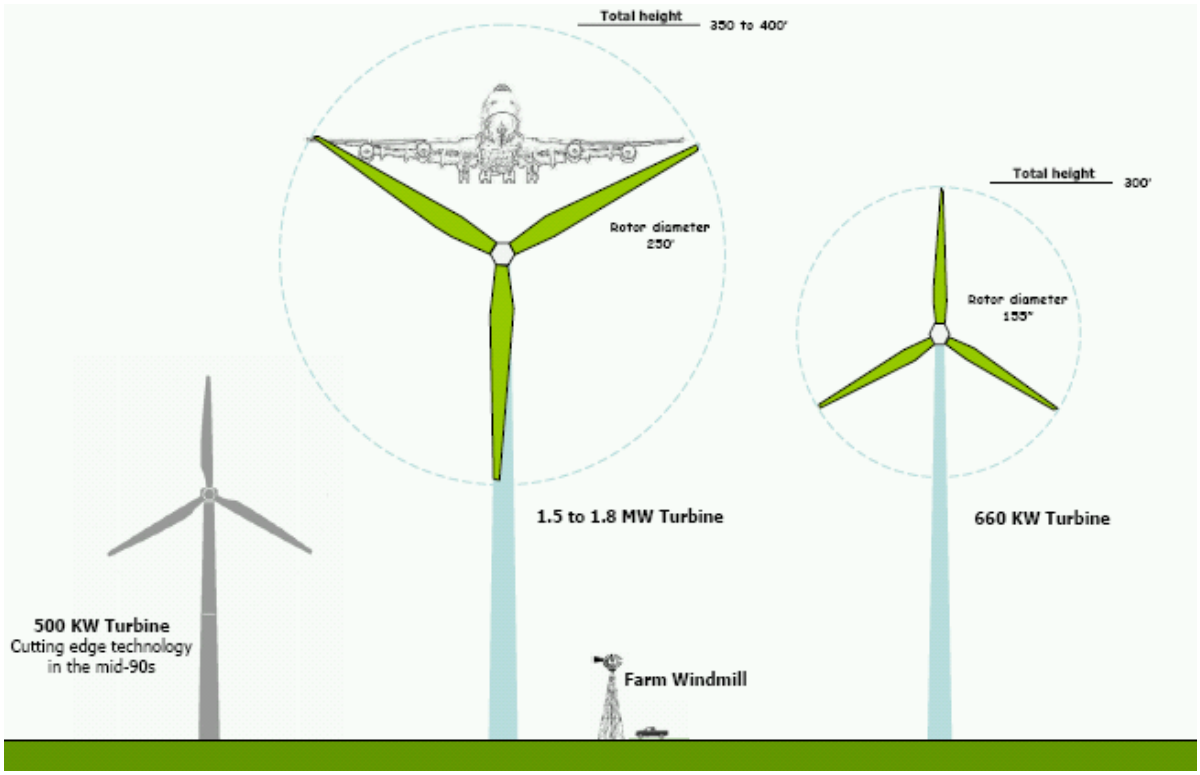

Figure 7. Modern wind turbines (center) are visible from a long distance.
Illustration by Rob Manes, The Nature Conservancy, Kansas

Grassland

On grassland, prairie grouse and their relatives, specifically the state endangered Greater Prairie Chicken, would be at risk in a small area of south-central Illinois. Grouse and their relatives, including prairie chickens, breed communally on traditional "leks" or booming grounds. In other states, when large structures have been constructed, the females ceased visiting the breeding grounds, turning off reproduction for the population. The radius within which this happens has been estimated at about one mile from the structure for Sage Grouse but is not known for Greater Prairie Chicken. In addition, prairie chicken mortality from direct collision with obstacles such as fences and power lines has been a problem in other states.

However, all of the Illinois Greater Prairie Chicken populations exist on lands owned by IDNR and various conservation organizations that are managed as refuges for the species. The lands are also dedicated as Illinois Nature Preserves or registered as Land and Water Reserves. It is unlikely that IDNR or the other steward organizations would allow wind turbines on such land.

Studies in Minnesota indicate that densities of other grassland birds are reduced several-fold near turbines, but the distance of such effects is poorly understood and little research has been published in the US. If wind energy facilities were to be built between populations of grassland birds, they have the potential to isolate populations from each other, thereby creating barriers to genetic interchange. It is unknown if the noise of wind turbines has any effect on grassland birds. In general, grassland is relatively rare in Illinois.

Other wildlife besides flying species can be affected by the construction and operation of wind turbine arrays. No direct information is available on how the state-threatened Franklin's Ground Squirrel, a grassland mammal, would react to wind turbines. In the western USA, ground squirrels in the same genus have displayed altered behavior near wind turbines, perhaps because of the noise generated by the machines.

Agricultural land

Agricultural land continues to be attractive to the wind energy industry in Illinois and wildlife habitat effects on farmland should be minimal. However, they may not be absent. Wind turbines generate turbulent wakes that alter local air flow, temperature, and humidity. These alter soil properties and forest structure downwind and probably have direct effects on plants as well as both flying and ground-dwelling animals.

Flicker

Sunlight passing through the rotating vanes of a wind turbine creates a periodic shadow, a strobe effect which has become popularly known as "flicker." If a three-vane turbine were rotating at 20 rpm, an observer in its shadow could count a passing shadow every second. This rate is low enough that the alternation between light and shadow is easily perceived by both people and wildlife.

Like other shadows, flicker is experienced for only a few hours (or minutes, very early or very late in the day) at any given location as the sun traces its arc across the sky. The intensity of its effect is moderated by atmospheric conditions (e.g., clouds, haze), and refraction and diffusion caused by air molecules decrease the contrast between light and shadow with distance. In theory, a shadow from a utility-scale turbine could reach half a mile at sunrise or sunset, but in practical terms perceptible shadows may extend only half that distance. Because the "path" of the shadow can be reliably predicted, the flicker effect can be a factor in determining turbine placement.

Flicker's effect on people is addressed by nearly every local ordinance governing wind turbine siting. Most ordinances (which also consider noise) require turbines to be sited no nearer than 500 feet from the occupied residence of a participating land owner (who presumably has more tolerance for any irritation it may cause), and usually require turbines to be sited more than 1,000 feet from a non-participating land owner. These requirements may require a turbine to be sited in a less-than-ideal position relative to topography and wind. If equal consideration were to be given to potential effects on wildlife habitat, turbine siting could become more difficult. Many species tend to avoid human structures, and are more likely to be present in those areas where turbines are sited.

Flicker is one factor which may affect wildlife and its use of available habitat. Those few studies which have been conducted generally observe changes in wildlife behavior in response to wind turbines without attempting to distinguish the effects of verticality, noise, motion, or flicker.

Species of birds and small mammals which require open grasslands and are often preyed upon by raptors may be most affected by flicker. In such an environment, a rapidly moving shadow can indicate the presence of a bird of prey. Whether a constantly repeated shadow is tolerated, or elevates levels of stress in prey species, or even potentially results in habitat exclusion, is unknown.

Verticality

Verticality is not tolerated by some species, probably because vertical objects, be they natural or man-made, are perceived to offer perches for predators. Prairie Chickens and Henslow's Sparrows offer two examples of species which are intolerant of any vertical structure.

Cumulative impacts

Unfortunately, no published projections of cumulative impacts are available for Midwestern states like Illinois. In the mountainous eastern USA, however, various wind energy facilities are projected to kill from 6,000 to 25,000 birds (both migratory and resident) each, per year. Total bat fatalities in the four-state mid-Atlantic region are projected to be approximately 30,000 to 100,000 animals per year based on projections of growth of wind energy as a source of electricity. Illinois is only a single state but its projected growth in wind energy is comparable to the vigorous growth on which the mid-Atlantic projections are based. Many authorities have noted that as wind energy continues to expand the cumulative rate of mortality of endangered and threatened species rises steadily.

Figure 8. The 800 kW turbines at Mendota Hills are the smallest size generally used in a utility-scale project. Photo: Penny L. Shank

Endangered Species

In the instances when IDNR has consulted on wind energy projects, potential adverse impacts to state-listed bird species have arisen only once, for Henslow's Sparrow and Loggerhead Shrike at the Bishop Hill project in Henry County. The state-threatened Henslow's Sparrow is an area-sensitive grassland species that requires large open tracts. Henslow's Sparrow may be displaced or excluded from otherwise suitable habitat by vertical structures, such as wind turbines, and by the incursion of roads, which create breaks in the habitat that they will not tolerate. The Loggerhead Shrike, also a threatened grassland bird, requires an interspersion of grassland and trees, which is often provided by fencerows. Shrikes can be affected by the removal of fencerows for construction or the elimination of wind turbulence. At Bishop Hill, the developer decided to seek Incidental Take Authorization for both species.

Terrestrial and aquatic plants and animals can also be impacted by turbine arrays. For example, the Big Sky project in southern Lee County is sited on a long glacial ridge. The original proposed array impinged on the Ryan Wetlands and Sand Prairie Natural Area, known to support two state listed species, the threatened Blanding's Turtle and Regal Fritillary Butterfly. The need for deep excavations for the turbines raised a concern that the confining layer of clay which created these perched wetlands might be penetrated, causing the wetlands to drain. There was also concern that construction could damage or destroy nesting areas, and that construction traffic might kill butterfly larvae on the ground, collide with adult butterflies, or damage the specific host plants on which the Regal Fritillary depends.

Through consultation, the developer created a one-quarter mile buffer area around the Natural Area and relocated several turbines. These measures were sufficient to protect the wetlands from damage and to avoid the likely densest concentrations of turtles and butterflies. The developer also hired

biologists to study the matter further. Based on their findings, the developer sought Incidental Take Authorization for the Blanding's Turtle and Regal Fritillary Butterfly, in case the precautionary measures did not prevent a taking of either species.

Recommendations

The National Research Council, an arm of the National Academy of Sciences, recently concluded that, while data are lacking at many sites, so far there is no evidence that wind turbine fatalities will cause measurable demographic changes to bird populations nationwide.

Even so, in 2003 the US Fish and Wildlife Service issued interim guidelines on avoiding and minimizing wildlife impacts from wind turbines. It was intended to help Service personnel provide technical assistance to the wind energy industry. In addition to site development and turbine design and operation recommendations, the guidelines also recommend:

- Site evaluations at potential development sites to determine risk to wildlife,
- Post-construction monitoring at all developed sites to identify any wildlife impacts,
- Updating bird strike avoidance equipment as it becomes available.

Wind farm regulation is still a developing area, and the costs and benefits of such regulation need to be better understood before they are considered. In the meantime, Illinois could:

- Develop a map of areas of concern to highlight protected natural resources and wildlife areas where developers should take extra precautions when developing wind farms,
- Fund a major study of bird abundance and richness before and after turbines are constructed at representative sites in the state, and
- Fund a comprehensive study of bat mortality around existing wind farms.

Bibliography

Arnett, E.B., K. Brown, W.P. Erickson, J. Fiedler, T.H. Henry, G.D. Johnson, J. Kerns, R.R. Kolford, C.P. Nicholson, T. O'Connell, M. Piorkowski, and R.J. Tankersley. 2007 submitted. Patterns of bat fatalities at wind energy facilities in North America. *Journal of Wildlife Management*.

Arnett, E.B., D.B. Inkley, D.H. Johnson, R.P. Larkin, S. Manes, A.M. Manville, R. Mason, M. Morrison, M.D. Strickland, and R. Thresher. 2007 in review. Impacts of wind energy facilities on wildlife and wildlife habitat. Number, The Wildlife Society, Bethesda, Maryland Report Technical Review 07-01.

Anderson, R, M. Morrison, K. Sinclair, and D. Strickland. 1999. Studying wind energy/bird interactions: A guidance document. Washington, D.C.: National Wind Coordinating Committee.

General Accounting Office. 2005. Wind power: Impacts on wildlife and government responsibilities for regulating development and protecting wildlife. Number, United States Government Accountability Office, Washington, D.C. Report GAO-05-906.

Johnson, G.D. 2005. A review of bat mortality at wind-energy developments in the United States. *Bat Res News* 46:45-49.

Kunz, T.K., E.B. Arnett, W.P. Erickson, R.P. Larkin, M.D. Strickland, R.W. Thresher, and M.D. Tuttle. 2007 in press. Ecological impacts of wind energy installations on bats: Questions, hypotheses, and research needs. *Front Ecol Environ*.

Kunz, T.H, E.B. Arnett, B.M. Cooper, W.P. Erickson, R.P. Larkin, T. Mabee, M.L. Morrison, M.D. Strickland, and J.M. Szewczak. 2007 in review. Methods and metrics for studying impacts of wind energy development on nocturnal birds and bats. National Wind Coordinating Committee, Washington, D.C.

Larkin, R.P. 2004. Wind power issues in Illinois. White paper, 2 pp.
Larkin R.P. 2006. Migrating bats interacting with wind turbines: What birds can tell us. *Bat Research News* 47:23-32.
Larkin, R.P., B. Cooper, W.P. Erickson, J.P. Hayes, J. Horn, G. Jones, T.H. Kunz, D.S. Reynolds, and D. Strickland. 2007 submitted. Ecological impacts of the wind energy industry on bats: Methods and research protocols. *Front Ecol Environ*.
National Academy of Sciences. 2007. Environmental impacts of wind energy projects. National Research Council, Washington, D.C.
United States Department of Energy. 2007. Energy Efficiency and Renewable Energy. http://eere.energy.gov/windandhydro/windpoweringamerica/where_is_wind_Illinois.
United States House of Representatives Natural Resources Committee. 2007. Hearing on Wind Turbine Impacts on Birds & Bats by the Fisheries, Wildlife, and Oceans Subcommittee. Washington, D.C.
Wolfe, D.H., M.A. Patten, E. Shochat, C.L. Pruett, S.K. Sherrod. (In Press) Causes and patterns of mortality in Lesser Prairie-Chickens and implications for management. *Wildlife Biology*.

Appendix. Bats and wind turbines

Many studies indicate that bats are more at risk from wind turbines than are birds, whether resident or migrating. Following are excerpts from some of these studies.

- In the U.S., bat mortality has been documented at wind farms in several states, including Iowa, Wisconsin, Minnesota, Tennessee, Pennsylvania, West Virginia, Wyoming, California, and Oregon.

- At turbines in southwest Minnesota 177 bat carcasses and 40 bird carcasses were found during a two-year period. In north-central Iowa, seven bird carcasses and 75 bat carcasses were found in survey transects during two years. In northeastern Wisconsin, the number of bat carcasses found at two wind farms was nearly three times higher than the number of bird carcasses.

- Most casualties at wind turbines in the U.S. have been members of three highly migratory bat species, the hoary bat (*Lasiurus cinereus*), eastern red bat (*Lasiurus borealis*), and silver-haired bat (*Lasionycteris noctivagans*). However, at least 11 species have been found dead at U.S wind turbines. These include four other species known to occur in Illinois: the little brown bat (*Myotis lucifugus*), northern bat (*Myotis septentrionalis*), big brown bat (*Eptesicus fuscus*), and eastern pipistrelle (*Pipistrellus subflavus*).

- Much of the bat mortality at wind turbines has been documented during late summer and autumn and is thought to coincide with dispersal and migration. Peak bat mortality occurred during August at wind farms in northeastern Wisconsin and north-central Iowa. However, bat mortality at those two wind farms also was relatively high during July, presumably prior to migration. Dead bats were found at Iowa and Minnesota wind farms during June as well.

- Few studies have compared bat mortality or activity at different types or arrays of turbines. In northeastern Wisconsin, bat mortality was higher at a facility where 14 turbines were arranged in three rows within 1.5 km of each other than at a second facility where 17 turbines were arranged in two irregular clusters approximately 3.5 km apart. At wind farms in Pennsylvania and West Virginia, higher than average numbers of dead bats were typically found at turbines near the end or center of a line. The only turbine (out of 64) at the Pennsylvania and West Virginia facilities where no dead bats were found was not operational during the study period. In southwest Minnesota, there was no significant difference in the number of bat fatalities per turbine at lighted (FAA non-pulsating red lights) and unlighted towers. At Pennsylvania and West Virginia wind farms there was no significant difference in the number of bat fatalities or activity at lighted (FAA pulsating red lights) and unlighted towers. In north-central Iowa, bat mortality and activity did not differ significantly between turbines with pulsating and non-pulsating red lights.

- In Pennsylvania and West Virginia, the majority of bats died during nights when wind speeds were low, but turbines remained operational. Turbines at one facility in northeastern Wisconsin were turned off during periods of low wind in 2000. The number of bat carcasses found that year was one-third of the number found in 1999. The number of bat carcasses at a second wind farm, where turbines remained on when winds were low, was essentially identical during both years. Inclement weather did not seem to have an effect on bat mortality at Minnesota wind farms, but the number of fatalities increased just before and after storm fronts in Pennsylvania and West Virginia.

  A 2004-2009 study coordinated by Bat Conservation International, Inc. determined that bats are more active on low-wind nights. Activity decreases by 11 to 39 percent for each meter-per-second increase in wind speed. These results were replicated in Pennsylvania, Wisconsin, and New York. Using this information, it has been suggested that "feathering" turbine blades

(turning them parallel to wind so they remain essentially immobile) on low-wind nights can save a great many bats. This strategy needs further testing to determine its true effectiveness and economic viability.

- The highest levels of bat mortality have been documented at wind farms in Tennessee, Pennsylvania, and West Virginia, where the turbines are situated on forested mountain ridges. High mortality could be the result of forest fragmentation or of bats using linear landscape features as migration corridors. Intermediate levels of bat mortality were found at Midwestern wind farms in southwestern Minnesota, north-central Iowa, and northeastern Wisconsin, which are located in agricultural areas. In Minnesota, bat activity was higher in nearby woodlands and wetlands than at turbines. However, activity was detected at 47% of 135 turbines in 2001 and 38% of 81 turbines surveyed in 2002. Wind farms surveyed in the western United States were located in open habitats (e.g. short-grass prairie, cropland, desert shrubland) and had relatively low levels of bat mortality.

  As part of an in-depth field study conducted by Bat Conservation International, Inc., the Mountaineer Wind Energy Center in West Virginia concluded that its 44 turbines on a forested ridge-top killed between 1,364 and 1,980 bats in just one (1) six-week period in 2004. While mounting evidence suggests that forested ridges in the eastern United States are "high-risk" sites, a recent report of high bat kills at a wind farm in Alberta, Canada is especially disturbing because it is located on open prairie habitat, which, until this point, has been considered safe for bats.

- Several hypotheses about the cause of bat collisions with wind turbines have been advanced. For example, bats may fail to detect turbines acoustically or visually. Alternatively, bats may actually be attracted to wind turbines. Thermal imaging at a wind farm in West Virginia has shown bats flying close to both moving and stationary blades. Bats also were observed landing, or attempting to land, on non-moving blades and turbine masts.

  Some researchers found decreased levels of bat activity at radar installations in Britain and suggested that electromagnetic fields might deter bats from collisions with wind turbines. Others have explored the possibility of acoustic deterrence—could an artificially produced ultrasound signal act as a "no trespassing" sign to keep bats away from turbines? The principle objective is to produce high-amplitude "jamming" sounds. Initial field tests suggest that the device does impact bat behavior and that some version of this "jamming" device might help prevent bat kills at wind turbines.

Appendix Bibliography

Arnett, E.B. (technical editor). 2005. Relationships between bats and wind turbines in Pennsylvania and West Virginia: an assessment of bat fatality search protocols, patterns of fatality, and behavioral interactions with wind turbines. Final report submitted to Bats and Wind Energy Cooperative. Bat Conservation International, Austin, TX. 167 pp.

Crawford, R.L. and W.W. Baker. 1981. Bats killed at a north Florida television tower: a 25-year record. *Journal of Mammalogy* 62:651-652.

Erickson, W.P., G.D. Johnson, M.D. Strickland, and K. Kronner. 2000. Avian and bat mortality associated with the Vansycle Wind Project, Umatilla County, Oregon: 1999 study year. Technical report prepared for Umatilla County Department of Resource Services and Development, Pendleton, OR. WEST, Inc., Cheyenne, WY. 21 pp.

Erickson, W.P., G.D. Johnson, M.D. Strickland, D.P. Young, Jr., K.J. Sernka, and R.E. Good. 2001. Avian collisions with wind turbines: a summary of existing studies and comparisons to other sources of collision mortality in the United States. National Wind Coordinating Committee Resource Document. National Wind Coordinating Committee, Washington, D.C.

Erickson, W.P., G.D. Johnson, D.P. Young, M.D. Strickland, R.E. Good, M. Bourassa, K. Bay, and K.J. Sernka. 2002. Synthesis and comparison of baseline avian and bat use, raptor nesting and mortality information from proposed and existing wind developments. Final report prepared for Bonneville Power Administration, Portland, OR. WEST, Inc., Cheyenne, WY. 124 pp.

Fiedler, J.K. 2004. Assessment of bat mortality and activity at Buffalo Mountain Windfarm, eastern Tennessee. M.S. thesis, University of Tennessee, Knoxville.

Howe, R.W., W. Evans, and A.T. Wolf. 2002. Effects of wind turbines on birds and bats in northeastern Wisconsin. Report submitted to Wisconsin Public Service Corporation and Madison Gas and Electric Company. University of Wisconsin-Green Bay. 113 pp.

Howell, J.A. 1997. Bird mortality at rotor swept area equivalents, Altamont Pass and Montezuma Hills, California. Transactions of the Western Section of the Wildlife Society 33:2-29.

Jain, A.A. 2005. Bird and bat behavior and mortality at a northern Iowa windfarm. MS thesis, Iowa State University, Ames. 113 pp.

Johnson, G. 2004. A review of bat impacts at wind farms in the US. Pages 46-50 in Proceedings of the wind energy and birds/bats workshop: understanding and resolving bird and bat impacts. S.S. Schwartz, ed. Washington, D.C.

Johnson, G.D., M.K. Perlik, W.P. Erickson, and M.D. Strickland. 2004. Bat activity, composition, and collision mortality at a large wind plant in Minnesota. *Wildlife Society Bulletin* 32:1278-1288.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, D.A. Shepherd, and S.A. Sarappo. 2002a. Collision mortality of local and migrant birds at a large-scale wind power development at Buffalo Ridge, Minnesota. *Wildlife Society Bulletin* 30:879-887.

Johnson, G.D., W.P. Erickson, D.A. Shepherd, M. Perlik, M.D. Strickland, and C. Nations. 2002b. Bat interactions with wind turbines at the Buffalo Ridge, Minnesota wind resource area: 2001 field season. Electric Power Research Institute, Palo Alto, CA.

Johnson, G.D., W.P. Erickson, M.D. Strickland, M.F. Shepherd, D.A. Shepherd, and S.A. Sarappo. 2003. Mortality of bats at a large-scale wind power development at Buffalo Ridge, Minnesota. *American Midland Naturalist* 150:332-342.

Kunz, T.H. 2004. Wind power: bats and wind turbines. Pages 50-55 in Proceedings of the wind energy and birds/bats workshop: understanding and resolving bird and bat impacts. S.S. Schwartz, ed. Washington, D.C.

Nicholls, B. and P.A. Racey. 2007. Bats avoid radar installations; could electromagnetic fields deter bats from colliding with wind turbines? PLoS ONE 2(3):e297. dol:10.1371/journal.pone.0000297

Timm, R.M. 1989. Migration and molt patterns of red bats, *Lasiurus borealis* (Chiroptera: Vespertilionidae) in Illinois. *Bulletin of the Chicago Academy of Sciences* 14:1-7.

Tuttle, M.D. 2005. America's neighborhood bats: understanding and learning to live in harmony with them. University of Texas Press, Austin. 106 p.

Young, D.P., Jr., W.P. Erickson, R.E. Good, M.D. Strickland, and G.D. Johnson. 2003. Avian and bat mortality associated with the initial phase of the Foote Creek Rim wind power project, Carbon County, Wyoming: November 1998 – June 2002. Technical report prepared for SeaWest Energy Corporation and Bureau of Land Management.

Zinn, T.L. and W.W. Baker. 1979. Seasonal migration of the hoary bat, *Lasiurus cinereus*, through Florida. *Journal of Mammalogy* 60:634-635.