Proceedings of the Fourth International
Partners in Flight Conference: Tundra to Tropics
262–272

TOWERS, TURBINES, POWER LINES, AND BUILDINGS—STEPS BEING TAKEN BY THE U.S. FISH AND WILDLIFE SERVICE TO AVOID OR MINIMIZE TAKE OF MIGRATORY BIRDS AT THESE STRUCTURES

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Abstract. As imperiled bird populations continue to increase, new challenges arise from the effects of growing numbers of communication towers, power lines, commercial wind facilities, and buildings. This paper briefly reviews steps the USFWS is taking to seriously address structural impacts to migratory birds. New findings will be briefly reviewed that address lighting impacts, new challenges facing birds from tower radiation, and collision and habitat fragmentation effects on avifauna. See the paper in this volume by Klem on his ongoing research with building glass, lighting and windows for details in trying to resolve those challenges.

TORRES, TURBINAS, LÍNEAS ELÉCTRICAS Y EDIFICIOS—MEDIDAS QUE SE ESTÁN TOMANDO POR EL SERVICIO DE PESCA Y VIDA SILVESTRE (USFWS) DE ESTADOS UNIDOS, PARA EVITAR O MINIMIZAR EL EFECTO DE ESTAS ESTRUCTURAS EN LAS AVES MIGRATORIAS

Resumen. En la medida que el número de poblaciones de aves en peligro continúa aumentando, nuevos retos surgen derivados de los efectos de la también creciente cifra de torres de comunicación, líneas eléctricas, instalaciones eólicas comerciales y edificios. Este documento examina brevemente los pasos que el USFWS está tomando para abordar con seriedad los impactos estructurales en las aves migratorias. Se examinarán brevemente nuevas conclusiones que abordan los impactos del alumbrado eléctrico, los nuevos desafíos que enfrentan las aves a partir de la radiación de las torres y los efectos de las colisiones y la fragmentación del hábitat sobre la avifauna. Ver la ponencia de Klem en este volumen, sobre sus investigaciones en curso, relacionadas con cristales de construcción, alumbrado y ventanales, con detalles de cómo tratar de resolver esos problemas.

INTRODUCTION

This paper focuses on research initiatives, scientific breakthroughs, promising applications, policy efforts, and voluntary guidance discussed since the 3rd International Partners in Flight Conference held in Asilomar, CA (Manville 2005). Since the release of bird status reports at the Asilomar Conference, bird populations have continued to slump, and the list of North American birds with declining populations or otherwise at risk at the regional and continental levels has increased since 2002 where 131 species were then designated (USFWS 2002). Today, these include 147 species on the 2008 Birds of Conservation Concern list (USFWS 2008), 92 birds Federally listed as Threatened or Endangered on the Endangered Species Act (ESA), State-listed species, and species listed as high priorities on the U.S. Shorebird Conservation Plan, among others. The growing documented and suspected impacts of structures on birds—from direct collision mortality, barotrauma, electrocutions, cumulative effects, and from habitat fragmentation, disturbance and site avoidance—bode poorly for our avifauna.

Migratory birds—of which there are currently 836 designated species—are a Federal trust resource managed and protected by the U.S. Fish and Wildlife Service (USFWS or Service). The published list of the 836 species is found at 50 CFR Ch. 1, 10.13, List of Migratory Birds. As an agency, our regulatory goal is to “avoid or minimize unpermitted take”—i.e., impacts—essentially to ensure that we do no harm to these species. Unfortunately, with the growing current challenges, we have not done a very good job reaching that goal.

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From what we know or suspect about impacts from structures, the combined effects of direct annual mortality from communication towers, wind turbines, power lines and buildings (both single story and tall structures) may for some species be causing impacts at the population level. This is very troubling. However, the estimates of structurally-caused mortality are at best, "guesstimates" of what actually may be happening in the wild, usually based on extrapolations from individual studies or small-scale surveys. Very few communication towers, commercial wind turbines, power transmission and distribution lines, and buildings are being studied on a full-season, let alone a year-round, basis, in a robust and scientifically rigorous manner, and in any level of detail that would help us better understand cumulative impacts caused by these structures.

Tens of millions of kilometers of power distribution lines are probably present in the U.S. today, but we lack any concrete accounting for their lengths (Williams 2000). However, data from the Electric Power Research Institute (EPRI) on the power transmission line lengths in the U.S. indicate the presence of at least 862 207 km (535 865 mi) of line (J.W. Goodrich-Mahoney, Senior Project Manager, Environment, EPRI, 2008 pers. comm.)—both transmission and distribution lengths growing as demands for power increase. Transmission lines are characterized as those carrying ≥69kV of electricity.

Unfortunately, very few communication towers and few kilometers of distribution and transmission lines are ever searched for dead or injured birds primarily due to lack of personnel, funding, and a perceived lack of importance. Virtually no systematic mortality studies are presently being conducted at buildings. Exceptions include (1) migration seasonal surveys being conducted by the staff of the Fatal Light Awareness Program in Toronto, Ontario, Canada (M. Mesure, Director, FLAP, 2007 pers. comm.), (2) efforts by staff and volunteers of the New York City Audubon Society (R. Creshkoff, volunteer, NYCA, 2007 pers. comm.), and (3) research being conducted by D. Klem (2009 pers. comm.) at Muhlenberg College, Allentown, PA. Although mortality studies are increasing at commercial wind turbine facilities, no full-season studies have yet been conducted in the East, and little research made available to the public is being conducted at Texas wind facilities—the State currently leading the nation in installed wind capacity (e.g, 8361 megawatts [MW] with 1061 MW under construction; AWEA 2009).

Direct mortality from collisions and electrocutions is, however, only part of the overall impact. The effects and impacts from fragmentation, site avoidance and disturbance—be they from communication towers, wind turbines, power lines, or commercial and residential buildings—are often difficult to quantify and are only now beginning to be understood. For example, the footprint from a hypothetical 600-turbine, 1200 MW (i.e., 2-MW per turbine) industrial wind project, the power grid and related infrastructure servicing it, and the road system connecting it, can hugely impact the habitat, especially for species sensitive to development such as "prairie grouse" and sage-steppe-obligate songbirds. Species such as the Federally endangered Whooping Crane (*Grus americana*) can also be put at direct risk from turbines, power lines and communication towers, both at their overwintering grounds and during migration. With 2008–2009 near-record winter Crane mortality from apparent starvation at n = 22 bird deaths, structural concerns raise further apprehension among biologists (T. Stehn, National Whooping Crane Coordinator, USFWS 2009 pers. comm.). With the current push to rapidly develop renewable energy, and as energy demands increase and as new power grids are constructed, more issues involving fragmentation, site avoidance, disturbance, and cumulative effects will result. While, with funding and staffing constraints, we may not see detailed cumulative analysis surveys conducted on tall structures during our lifetime, there is some good news. For all the aforementioned structures, some "corrective tools" and "conservation measures" are available to significantly reduce (in some cases, scientifically validated, while in others, based on anecdotal reviews) structural impacts on protected bird species. This paper focuses on some of these promising "tools."

COMMUNICATION TOWERS

While difficult to track the actual number of communication towers constructed nationwide, the evidence clearly shows a continuing exponential expansion of cellular telephone, emergency broadcast, national defense, microwave, paging, and related tower growth. Based on current evidence (Federal Communications Commission [FCC] 2006), more than 100 000 lighted communication towers >61 m above ground level (>199 ft AGL) are sited in the U.S. today. The website www.towerkill.com is an excellent source of information to compare tower growth in each of the 50 states. By clicking on each state, tower expansion based on FCC statistics from 1998 and 2004 (i.e., towers in the 61–91 m [200–299 ft], 92–153 m [300–499 ft], 153–244 m [500–799 ft], and 245+ m [800+ ft] ranges) can easily be compared (W. Evans 2008 pers. comm.).

The expansion of digital television towers (DTV) appears to be relatively small, even with the requirement to convert to DTV by June 2009 under mandates of the 1996 Telecommunications Act, as amended, perhaps diminishing its impact on birds to less than what had been anticipated. However, since some radio and television towers commonly reach 611 m AGL (2000 ft), they are situated in direct conflict especially with neotropical migratory songbirds, particularly during night migrations when weather conditions are deteriorating and visibility is poor to negligible. Because songbirds tend to migrate in massive, "broad fronts," birds will almost certainly be put at risk irrespective of the tower's location (Gauthreaux and Belser 2006). Add tower lights to the scenario, and the potential for significant conflict and mass mortality is great.

TOWER COLLISION MORTALITY

Direct impacts of communication towers to migratory birds come from two sources, collisions and possibly from radiation exposure. Collisions represent a primary source of mortality and have been well documented since the late 1940s in the U.S. (Aronoff 1949, Kemper 1996, Manville 2005 and 2007a). From a collision perspective alone, 4–5 million birds are conservatively estimated to die each year in tower and guy-wire collisions—with high-end estimates at 40–50 million birds (Manville 2005). These figures are admittedly "guesstimates," but still based on the best available scientific evidence. Like all structural mortality estimates, not until scientifically valid, cumulative impact analyses are conducted will we clearly understand the level of impact each structure is having on bird populations.

However, until impacts are better understood—including the likelihood of additive mortality effects to some populations—the Service will continue to address impacts using the precautionary approach (UNEP 2002). The precautionary approach—also known as the precautionary principle—has its origin in European law. However, the precautionary approach was refined, based on the development and application of international law in light of scientific uncertainty, at the 1992 Earth Summit in Rio de Janeiro, most notably through Rio Principle 15. It states that, "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." Simply put, where sound scientific evidence is not yet available and where uncertainty remains a concern, the Service will proceed with caution. For example, the voluntary tower guidelines developed and released by the Service (USFWS 2000) to properly site, construct, operate, and decommission communication towers are fundamentally based on proceeding with caution where uncertainty and risk are prevalent. As new scientific findings are discovered (e.g., eliminating steady-burning red tower side lights that were shown to reduce avian tower collisions at some towers in Michigan by up to 71%—see beyond), recommendations such as these are passed on to the FCC for rulemaking and Service guidelines will be updated. Therefore, realizing that cumulative impact assessments may not be performed in the short term, due especially to budget constraints and staffing limitations, the Service will take whatever actions it can, working in concert with the FCC, the Federal Aviation Administration (FAA), the communication tower industry, researchers, and the conservation community.

Documented bird collisions continue to be a problem. While C. Kemper documented the record for a one-night avian-tower collision of more than 12 000 birds retrieved and identified in 1963 at a Wisconsin television tower (Kemper 1996), spikes in tower collision numbers have recently been noted. For example, in continuing studies conducted by A. Clark over 29 years at three television towers in Buffalo, NY (Morris et al. 2003), Clark noted a gradual decrease in the number of birds killed at the towers he studied—ranging from a high of 4787 in 1982 to a low of 6 in 1992. The authors hypothesized the decline in the rate of mortality was due to 4 possible factors: (1) an overall decrease in migratory bird populations, (2) change in weather and wind patterns, (3) increases in predation and scavenging around tower bases, and (4) changes in migration patterns.

However, during the fall 2005 migration season, Clark (2006 pers. comm.) documented the largest annual kill at his study towers since 1982. In 2005, he retrieved 1223 birds at the bases of those same three New York towers (878 whole carcasses and 345 "parts thereof" representing 55 species). This included more than 200 Golden-crowned (*Regulus satrapa*) and Ruby-crowned Kinglets (*R. calendula*).

Also during the fall 2005 migration season, additional troubling reports of large bird kills at both tall and short communication towers also surfaced, particularly kills that occurred during a week-long inclement weather event that coincided in the East with the songbird migration in October. W. Evans (2005 pers. comm.)

estimated more than 500 songbirds killed in a three-night period in mid-October at a 336-m AGL (1100-ft) tall tower near West Monroe, NY. Evans also reported several intact, but decaying warbler carcasses including a Hooded Warbler (*Wilsonia citrina*) at a 61-m AGL (200-ft) cellular telephone tower near Alfred, NY. During the same weather event, Evans also reported 147 salvaged birds, mostly Blackpoll Warblers (*Dendroica striata*), at an unlit cellular telephone tower in northern PA that appeared to be less than 46 m (150 ft) AGL. In the case of two cellular telephone tower morality events, nearby solid/steady-burning bright light sources appeared to result in the bird congregations that led to the kills (Manville 2007a). Also during the fall 2005, on 7–8 September and again on 13–14 September, an estimated 400 birds were killed each night at the 336-m AGL (1100 ft) WMTV tower near Madison, WI. In the second kill, 172 carcasses of 23 species were retrieved, including 5 Golden-winged Warblers (*Vermivora chrysoptera*)—of particular concern to USFWS since these are birds of conservation concern.

To begin to better understand the dynamics and the relationships between tower lighting, height, guy-wire supports, location, and impacts to birds, Gehring et al. (2006, 2009) performed a peer-reviewed study on n = 24 towers in various, mostly random locations throughout Michigan. Begun in the fall 2003 and completed in the fall 2005, this study was the first to compare bird collision rates at communication towers equipped with different types of FAA obstruction lighting. Due to variances allowed in 2005 by the FAA on n = 18 towers, steady-burning, non-flashing lights were extinguished. These included on, (1) all white strobe-lit towers (these towers were unaffected since no red lights are required by FAA on them), (2) all red strobe-lit towers, and (3) all red blinking, incandescent-lit towers. Lighting regimes for the aforementioned towers were compared to (4) three guyed towers with a combination of red strobes at the top and mid levels, and steady-burning red lights at the three-quarters and one-third height levels. This lighting regime represents the current lighting system for many communication towers nationwide (Gehring et al. 2009).

Based on the 2005 data, results strongly suggest that by extinguishing the red, steady-burning L-810 lights, but leaving on the strobe or incandescent blinking lights, avian collision mortality can be reduced by as much as 50–71%. Not surprisingly, the most birds killed were found under the tallest, guyed towers, consistent with many other reported studies (Manville 2007a, Gehring et al. 2009 manuscript in review). Gehring et al. (2009) recommended the extinguishing of L-810 lights, provided that the lighting system continues to remain safe for aviators. The FAA will begin pilot conspicuity studies in Michigan during spring and fall 2009 to assess pilot visibility of the towers without steady-burning red lights. If deemed safe, they will likely revise their Obstruction Marking and Lighting Advisory Circular (FAA 2007), giving tower operators the option of extinguishing the steady-burning lights, saving electricity, and significantly reducing bird mortality. No statistical differences were found in avian mortality rates among towers lit only with the different types of flashing lights—i.e., white strobe vs. red strobe vs. red flashing incandescent lighting. The results suggest that the flashing of a light is more important in reducing avian collisions than is the color of the light.

At this writing, J. Gehring has completed the fall 2008 season of a 3-year study of n = 6 tall towers (>277 m AGL [>906 ft]) in Michigan, a 107 m AGL (350 ft) U.S. Coast Guard (USCG) Rescue 21 unguyed tower in Cape May, NJ, and will begin the study of a 138 m (450 ft) USCG Rescue 21 tower that is being built in the vicinity of Cape Hatteras, NC, where bird deterrent devices will be tested on guy support wires. Preliminary results suggest that, similar to the Michigan study of towers 116–146 m AGL, avian fatalities can be significantly reduced at taller communication towers by using only flashing lighting systems. Like the larger Michigan study (Gehring et al. 2009), preliminary data suggest that the unguyed tower in Cape May, NJ, is not involved in large numbers of avian fatalities. Further data collection and analysis are ongoing. The purpose of this study, in part, is to replicate the study in Michigan (Gehring et al. 2009), and if the FAA is willing to allow temporary light change-outs on several of these tall towers, we can test the effects of those changes on bird attraction and mortality.

Evans et al. (2007) subjected night-migrating birds in 100% cloud-cover conditions at ground level to alternating short periods of different artificial light, including various intensities, wavelengths, and flash rates from a ground-based lighting device. This study in October 2005 in Ithaca, NY, represented the first direct investigation of these variables causing bird aggregation in inclement weather. An acoustic transducer and directional microphone, positioned 5 m (16 ft) from the light source, were used to identify a strong or weak presence of birds near the light source. Evans et al. (2007) performed spectrographic analysis on loud calls, basing species identification on the flight call reference guide produced by Evans and

O'Brien (2002), and they visually documented bird presence on site. Birds were induced to congregate at all wattage levels of white steady-burning light tested. However, no aggregation was noted at the 1500 W white flashing halogen lights. The study results further reinforce conclusions reached by Gehring et al. (2006, 2009), Gauthreaux and Belser (2006), and J. Johnson (2005 pers. comm.).

However, Evans et al. (2007) did not find either steady-burning red (L-810) or red flashing (L-864) beacons induced bird aggregation when tested separately at ground level in 100% cloud cover. As one possible explanation, they suggested that the disorientation to red light only occurs if birds are actively using magnetoreception and the red light creates an imbalance in the magnetoreception mechanism. On clear nights, for example, some avifauna use star and moon light as sources for navigation, especially stellar arrays around the North Star (Sauer 1957, Emlen 1967). On cloudy nights, however, evidence suggests that birds may orient by sensing the axial inclination of the earth's magnetic field through a light-dependent mechanism, probably located in the avian eye (Wiltschko et al. 1993, Ritz et al. 2004, Thalau et al. 2005, Wiltschko et al. 2005).

Gauthreaux and Belser (2006) first published this hypothesis that aggregation around communication towers with red lights may be due to disruption of magnetoreception caused by the red light. W. Evans (2008 pers. comm.) has acknowledged the need for further study into bird aggregation, red light disorientation, cloud cover, and magnetoreception, and he hopes to replicate and expand the study to better understand the role of magnetoreception and bird aggregation. Efforts to conduct additional research are presently underway.

Just prior to the apparent "spikes" in tower mortality documented during the fall 2005 as summarized above, evidence was presented at the Research Subcommittee of the Communication Tower Working Group (CTWG) that continued to show increased impacts of lighting, tower height, and guy wire impediments to migratory birds, especially when night migration and inclement weather coincided.

In November 2006, the FCC published a Notice of Proposed Rulemaking (NPRM; FCC 2006) requesting suggestions and recommendations from the public and the agencies on how to address the effects of communication towers on migratory birds. Through the Service's Deputy Director, this author submitted detailed Service comments in February 2007 suggesting the following rulemaking changes. (1) Based on the study results from Gehring et al. (2006), the Service recommended removal of steady-burning L-810 lights where retrofits were being conducted, and the elimination of steady burning lights on all new tower construction where lighting is required (i.e., towers >61 m [199 ft]), within 6.1 km [3.8 statute mile] of airport approach and departure controlled runways, and along interstate highways). (2) Based on a preponderance of information about impacts from tall, guyed towers, the Service suggested a "gold standard" for towers. Keep them unguyed, unlit, and <61 m AGL (200 ft) wherever possible—ideally collocating new towers on existing structures. And (3), we recommended that migratory birds should become part of the FCC's National Environmental Policy Act (NEPA) review process for tower licensing. The rulemaking document and the comments provided above (Manville 2007a) are available in their entirety on the FCC's website under WT Docket 03-187, FCC 06-164, "Effects of Communication Towers on Migratory Birds" (most easily accessed by searching under FCC Docket 03-187, Effects of Communication Towers on Migratory Birds [Service comments included in docket file 2301-2400]).

A lawsuit was won on appeal by the American Bird Conservancy et al. against the FCC in the Court of Appeals for the District of Columbia in February 2008. ABC Inc. v. FCC, 516 F.3d 1027 (2008) requires the FCC to evaluate the effects of communication towers on migratory birds in the Gulf Coast region, including through MBTA, NEPA, and ESA. While at this point the FCC has not yet finalized any rulemaking, currently responding to obligations set by the Court, it is hoped that the recommendations made above will be implemented very shortly. Each migration season delay means more needless bird deaths.

POSSIBLE TOWER RADIATION ISSUES

The radiation issue has only become a recent development with field studies on birds begun around 2000 in Europe (Balmori 2003, 2005, Balmori and Hallberg 2007, Everaert and Bauwens 2007) and laboratory studies conducted in the U.S. during the late 1990s (T. Litovitz 2002 pers. comm., DiCarlo et al. 2002). Virtually unknown, however, are the potential effects of non-ionizing, non-thermal tower radiation on avifauna, including at extremely low radiation levels, far below the safe exposure level previously determined for humans. These "safe" levels were based on thermal heating standards, now inapplicable. The standards are now more than 25 years out of date, and the U.S.

Environmental Protection Agency (EPA) office tasked to direct human safety issues was eliminated due to budget cuts in the early 1980s. No government agency currently monitors the rising background levels of electromagnetic radiation (EMF). Current safety standards assume that non-ionizing radiation is safe if the power is too weak to heat living tissue. However, since the 1980s, growing amounts of published research are showing adverse effects far below a thermal threshold—usually referred to as "non-thermal effects," especially under conditions of long-term, low-level exposure (DiCarlo et al. 2002, Levitt and Morrow 2007).

In 2002 in the U.S., T. Litovitz (2002 pers. comm., DeCarlo et al. 2002) raised troubling concerns about the impacts of low-level, non-thermal radiation from the standard 915 MHz cell phone frequency on domestic chicken embroyos (*Gallus domesticus*) under laboratory conditions (DeCarlo et al. 2002). Litovitz noted deformities, including some deaths of the embryos subjected to hypoxic conditions under extremely low radiation doses. These included doses as low as 1/10 000 below the allowable EPA "safe" level of radiation. Meanwhile, preliminary research on wild birds at cellular telephone tower sites in Valladolid, Spain, showed strong negative correlations between levels of tower-emitted microwave radiation and bird breeding, nesting, and roosting in the vicinity of the electromagnetic fields (Balmori 2003). Birds had historically been documented to roost and nest in these areas. House Sparrows (*Passer domesticus*), White Storks (*Ciconia ciconia*), Rock Doves (*Columba livia*), Magpies (*Pica pica*), Collared Doves (*Streptopelia decaocto*), and other species exhibited nest and site abandonment, plumage deterioration, locomotion problems, and even death among some birds found close to cellular phone antennas. Balmori did not observe these symptoms prior to construction of the cell phone towers. Balmori (2005) noted that the White Stork appeared most heavily impacted by the tower radiation during the 2002–2004 nesting seasons in Spain. Manville (2005) reported Balmori's (2003) preliminary results, and raised concerns of possible similar events in the U.S.

In continuing European studies, Everaert and Bauwens (2007) found strong negative correlations between the amount of radiation presence—both in the 900 and 1800 MHz frequency bands—and the presence of male House Sparrows. In areas with high electric field strength values, fewer House Sparrow males were observed. Everaert and Bauwens preliminarily concluded that long-term exposure to higher radiation levels was affecting bird abundance or bird behavior in this species. Balmori and Hallberg (2007) reported similar declines in House Sparrows directly correlated with levels of EMF in Valladolid, Spain.

Manville (2007b) raised this concern on behalf of the USFWS at an invited Congressional staff briefing. Although Beason and Semm (2002) tested the natural responses of Zebra Finches (*Taeniopygia guttata*) to 900 MHz radiation under laboratory conditions and showed that 76% of the neurons responded by 3.5-times more firings, no studies have yet been conducted in the U.S. on potential radiation impacts to wild bird populations. Magnetite, a mineral highly sensitive to EMFs has been discovered in human, bird, and fish brains. It has been suggested that the radio frequency radiation (RF) may be acting as an attractant to birds since their eye, beak and brain tissues are loaded with magnetite, a mineral highly sensitive to magnetic fields that birds use for navigation (Ritz et al. 2004, R. Beason cited in Levitt and Morrow 2007).

Based on research conducted in Europe, communication tower radiation may already be impacting breeding and migrating bird populations, as well as other wildlife. Manville (2007b) has thus suggested the need to replicate research conducted in Europe on apparent radiation impacts to birds from short, cellular telephone towers, replicating and perhaps modifying studies performed by Balmori (2005), Balmori and Hallberg (2007) and Everaert and Bauwens (2007)—attempting to tease out and better understand the dynamics of what may be taking place. Unfortunately, funding for such studies is as yet unavailable and the priority of such wildlife research remains low compared to other anthropocentric impacts.

COMMERCIAL WIND TURBINES

Commercial wind development in the U.S. continues to grow at an exponential rate. In 2007, the industry noted a >45% growth in turbine development (AWEA 2008), and in 2008, records were further broken with 50% growth (AWEA 2009) Operating turbines are referred to as "installed capacity," generally measured in MW rather than in turbine numbers or turbine height and rotor swept area. By mid 2009, the U.S. had >29 440 MW of installed capacity (with 5866 under construction), lead by TX, IO, CA, MN, WA, OR, and NY in decreasing order of capacity (AWEA 2009). With slightly more than 23 000 turbines installed and operating on the landscape today, and more than 155 000 turbines projected to be operating by 2020 (AWEA 2008, M. Tuttle 2007 pers. comm., National Renewable Energy Laboratory 2007 estimate), the Service has serious concerns about current and potential impacts which continue to grow exponentially. From a wildlife perspective, however, there is some good news. With the exception of the continued high collision mortality of raptors, such as Golden Eagles (*Aquila chrysaetos*), Red-tailed Hawks (*Buteo jamaicensis*) and others—including passerines—at Altamont Pass Wind Resource Area, CA, and the death of *Birds of Conservation Concern* and Breeding Bird Survey declining species elsewhere, avian mortality is not particularly high, at least at the present time. While the wind industry currently estimates that turbines kill 58 000 birds per year in the U.S. (National Wind Coordinating Collaborative Wildlife Workgroup 2009 statistic), the Service estimates annual mortality at 440 000 birds (Manville 2005). This is based, in part, on inconsistencies in the duration and intensity of searches resulting in biases between search areas, the size of the search areas, failure to estimate mortality during peak periods of migration, impacts from wind wake turbulence and blade tip vortices, and biases from unaccounted crippling losses (after Huso 2008). Until a robust, scientifically rigorous cumulative impacts analysis is performed, we will not know with a high degree of certainly the true level of mortality. Admittedly, it still is relatively small. However, with high risk, wildlife-unfriendly sites being selected by wind proponents next to, for example, nesting Golden and Bald Eagles (*Haliaeetus leucocephlus*), and turbines placed on ridge lines where Golden Eagles and Peregrine Falcons (*Falco peregrinus*) migrate, Service concerns are elevated. Bats, unfortunately, represent a completely different situation based on the high documented take of bats in WV, PA, NY, OK, western Alberta, and elsewhere, and the apparent attraction of some tree roosting bats to tall structures such as hoary (*Lasiurus cinereus*) and eastern red bats (*L. borealis*) including turbines (P. Cryan, USGS bat specialist, 2009 pers. comm.). Add to this the impacts from white-nosed syndrome, a likely fungal disease hugely impacting hibernating bats in the East and Northeast, and turbine mortality could become additive (P. Cryan 2009 pers. comm.). However, mortality represents only one of three concerns regarding wind development—and all other anthropocentric impacts, for that matter. Indirect impacts from fragmentation, disturbance and site avoidance are also a huge concern for wildlife. With the exponential growth of industrial wind development, the issue has also become one of cumulative impacts and additive mortality.

To begin addressing risk, the Service developed a Potential Impact Index (PII) to rank and score potential wind development sites in 2002. However, the PII lacked a component for assessing temporal and spatial use of airspace. To correct this shortcoming, DMBM submitted a research proposal for a Rapid Assessment Methodology (RAM) to the Service's Science Support Program (SSP) for funding in 2008. Approved as one of the three SSP proposals to be funded and implemented in 2009, the Service is working with USGS scientist D. Johnson at the Northern Prairie Wildlife Research Center to develop, field-test, validate, and perform workshops in using this tool. The RAM is intended to be a first-cut analysis of a site's suitability, ultimately allowing a potential wind development site to be ranked and scored based on its known or perceived level of risk to wildlife and their habitats. More information on the RAM can be found at www.nationalwind.org, then clicking on the presentations given at the Research VII meeting, October 29, 2008, Milwaukee, WI.

By asking the operative question, which "straw" (*i.e.*, impact) will eventually break the "camel's back," will wind energy become that anthropocentric source, will it be something else that impacts a population, or will it be the result of all cumulative effects? We simply do not know. Thus, as previously mentioned, USFWS prefers to take the "precautionary approach" when addressing issues such as wind development—especially in light of such a poor understanding about wind energy's impacts on wildlife and their habitats.

The Department of Interior strongly supports renewable energy, including wind development, but the Service wants to ensure that it is bird-, bat- and habitat-friendly. We strongly encourage wind proponents to work at the get-go with the nearest USFWS Ecological Services Field Office in the proposed development area where they hope to build, prior to the completion of a land-owner agreement, approval of a power-purchase contract, and the application or receipt of a bank loan. Very few companies approach the Service early on to address potential impacts from wind development. This is further exacerbated by the fact that the Service lacks a strong Federal nexus on private land. The exception regarding a Federal nexus on private land is Section 404 of the Clean Water Act. However, unless there is a Federal permit, Federal funding, or the project is on Federal property, ESA Section 7 does not apply and ESA Section 10 (i.e., development of a Service-approved Habitat Conservation Plan through the NEPA public review process to acquire a "takings permit") is voluntary on the part of the proponent. MBTA is a strict liability statute, there is no consultation process, and the Act is only applicable after a "take" has occurred. The

Bald and Golden Eagle Protection Act is also a strict liability statute, but a permit for "take" under otherwise legal activities is being finalized by the Service, but not yet implemented. From a proactive perspective, the Service's legal options are limited. To avoid or minimize impacts to trust wildlife resources, the Service released interim, voluntary guidelines for land-based commercial wind turbines in July 2003, open to two years of public comment and review. While the voluntary guidelines remain in place, and we encourage the industry to use them, the Interior Department convened an advisory committee to review and make recommendations regarding updates and changes to the Service's guidelines under the auspices of the Federal Advisory Committee Act (FACA). The FAC first met in February 2008, and will continue to meet through the summer 2009 at which point it will provide a recommendation to the Service likely by October 2009 on what the FAC thinks the guidelines should contain.

Once a recommendation is received from the FAC, the Service will designate a committee to review the FAC document to ensure it meets trust responsibilities, statutory muster, and is practical and applicable. The committee will revise the document, as necessary, before it undergoes Service final review. Next, all affected programs from the Service's regions, Washington Office, and the Department of Interior will review and approve the document. Finally, a notice of availability will be published in the *Federal Register* soliciting public review and comment on the Service's "final" draft guidelines. Once public comments are reviewed, final guidelines will be published—possibly more than a year after USFWS receives the FAC recommendations. D. Stout is the Designated Federal Official on the Committee representing the Service and questions should be addressed to him (Dave_Stout@fws.gov) that cannot be answered from information posted on the Service's website.

Direct Impacts. – Birds, including species from raptors, passerines, to waterbirds, have been documented killed during flight by rotating turbine blades (Stone 2007, Arnett et al. 2007, Kuvlesky et al. 2007, Kunz et al. 2007, Nicholson et al. 2005). New evidence is showing that birds and bats can also die from barotrauma—an apparent effect of sudden changes in air pressure from wind wake turbulence and blade tip vortices—that result in collapsed lungs, often with no sign of blunt force trauma (E. Arnett, Bat Conservation Internatl., 2008 pers. comm., P. Cryan 2009 pers. comm.). In addition, birds can collide with towers, nacelles, meteorological tower guy wires, power lines, the associated infrastructures, and "bird unfriendly" wiring can electrocute them. The Service has special concerns about project development on avifauna. (1) No full-season studies have yet been conducted in the East on avian-wind impacts. (2) The "take" of State and Federally-listed birds, Birds of Conservation Concern, Breeding Bird Survey declining species, "watchlist" species, imperiled waterbirds, and raptors that migrate along or below ridge lines are of growing concern. (3) Raptors and other species that nest in close proximity to wind facilities is another concern. (4) Known or suspected impacts of turbines on grassland songbirds (Leddy et al. 1999) and "prairie grouse" species such as Greater Prairie-chickens (*Tympanuchus cupido*), Gunnison's Sage Grouse (*Centrocercus minimus*), and Greater Sage-grouse (*C. urophasianus*; Manville 2004) raise further concerns. (5) The increasing height of land-based turbines now exceeding 130 m AGL (425 ft) and the increasing rotor swept areas exceeding 1.2 ha (3 ac) but projected to reach 1.6 ha (4 ac) by 2010 (B. Ram, wind consultant, 2007 pers. comm.) are putting turbines well within the zone of risk for migrating birds, not to mention impacts to birds during take-offs and landings and birds exhibiting breeding behaviors within the zone of risk. (6) The potential for a single-night, mass mortality event grows, especially when turbine numbers increase, mass migrations and inclement weather coincide, where wind facilities are placed in wildlife-unfriendly habitats, and where weather ceilings force birds down through a "migratory fall out" to well within rotor swept areas.

The major challenge facing the commercial wind industry is not only to make wind generation "clean" but also insure that it is "green." Importantly, that means not creating new problems for migratory birds while still trying to address challenges with our "carbon footprint" and greenhouse gas emissions. There are some preliminary but promising "tools" that are being assessed, some perhaps more pleasing to the industry than others. These include blade "feathering" (aka, idling) when bird and/or bat risk is high, changes in blade "cut-in" speed based on increased wind speed that blades begin to operate (benefitting both birds and bats), turbine setbacks from ridges, end-of-row turbine replacement with pylons, turbine pylon replacement in ridge dips, and other "tools." Research is still preliminary. Proper site selection continues to be critical.

Indirect Impacts.—Habitats can be fragmented, disturbed, and disrupted, forcing out birds and bats, preventing breeding, altering behaviors, and possibly impacting populations—with recent evidence raised in Europe (Stewart *et al.* 2007). Indirect effects, although frequently difficult to quantify, can include (1) reduced nesting/breeding densities; (2) loss of population vigor and overall density; (3) habitat and site abandonment, and increased isolation between patches; (4) loss of refugia; (5) attraction to modified habitats; (6) behavior effects including stress, interruption, and behavioral modification; and (7) disturbance and displacement resulting in habitat unsuitability. As the industry grows, these indirect effects may also become cumulative. Both direct and indirect effects could become additive to normally compensatory mortality—a scenario we wish to avoid.

Habitat fragmentation is of considerable concern for grassland songbirds—the suite of avifauna now in the greatest overall decline—not to mention sage-steppe obligate songbirds and "prairie grouse" species, in addition to other suites of birds and bats. Until very recently, most fragmentation studies had been based on research conducted at "surrogate" structures such as power lines, oil platforms, fences, and roads, with results then compared to possible impacts from commercial wind development (Manville 2004). That is changing with the wind industry funding multi-stakeholder studies of Greater Prairie-grouse-wind turbine effects in the Flint Hills, KS, area, and through other studies elsewhere.

USFWS currently has several concerns regarding the use of sound science in assessing risk to wildlife trust species and their habitats. One is the wind industry's general lack of research independence. Most of the pre- and post-construction monitoring and risk assessment reviews are conducted by consulting firms heavily dependent on wind companies and energy corporations to hire them. While they may be the most qualified to conduct the studies, this becomes the proverbial "double-edged sword" because there presently exists no agreed upon, scientifically validated monitoring protocols that could be used consistently and compared between different projects region- and nationwide. As a condition of site permitting, some states have monitoring requirements, but most states only suggest use of voluntary risk-assessment and monitoring methodologies, if that. Since the vast majority of wind development is currently on private lands, the USFWS lacks any strong federal nexus (e.g., ESA S. 10 is voluntary, MBTA has no consultation provisions and "take" occurs only after-the-fact, NEPA is not required, and CWA S. 404 has limitations) to regulate it. The transparency of research results conducted by wind industry consultants continues to be a recurrent frustration for USFWS—in part because of early-project industry confidentiality issues. It is our hope that the current situation will change. If a project is approved and is soon to be developed, results from pre-construction surveys and any risk assessments should become part of the public record, at the very least shared with the state and federal agencies responsible for protecting species and habitats. The same should hold true for results from post-construction evaluations. We continue to work with the industry and its consultants to develop consistent, robust, scientifically credible, and acceptable pre- and post-construction research protocols—ideally consistent between companies and consultants.

At this writing, positive recommendations are being suggested and discussed between members of the wind Federal Advisory Committee. Iberdrola Renewable Energy-USA worked proactively with the Service to develop a company-wide Avian and Bat Protection Plan (ABPP) modeled after the April 2005 avian protection plan (APP) template developed between the Service and the electric utility industry. Iberdrola's ABPP was publicly released in late 2008. Iberdrola is also working proactively with representatives from the Service's Office of Law Enforcement (OLE) and DMBM to develop a voluntary bird and bat mortality reporting form, much like >33 electric utilities are presently voluntarily providing OLE for birds. This effort is primarily focused on dealing with incident-specific issues. Perhaps overall the wind industry will consider developing an industry-specific template for an ABPP, borrowing from the APP developed by the Avian Power Line Interaction Committee. The Service's goal is to make wind energy truly "green"—i.e., with the goal of avoiding or minimizing take and habitat disturbance—while significantly addressing the challenges avifauna and other wildlife face from the impacts of global climate change. The task is a daunting one but we're moving in the appropriate direction. Whether it's dealing with communication towers, wind turbines, power lines, or building windows, the Service will continue to work proactively with those industries, consultants, entities, conservationists, and stakeholders who collectively can help us resolve the growing impacts from increasing numbers of structures we are placing on the landscape. We strongly encourage all affected "stakeholders" to partner with us.

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