***Status of U.S. Fish and Wildlife Service Developments with Communication Towers with a Focus on Migratory Birds: Updates to Service Staff Involved with Tower Issues* – A Webinar**

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Presented February 20, 2014

Talking Points and Literature Citations, Available to the Public

Released to the public: March 7, 2014 [Communication Tower 2-20-14 Webinar Talking Points-AMM.docx]

INTRODUCTION

Communication towers and communication infrastructure consist of a complex array of single and multiple, collocated antennas and smaller pieces of transmitting and receiving equipment ranging from cellular telephone, mobile phone, DTV, radio, emergency broadcast, national security, Wi-Fi, smart meter, and related technologies. Many of these devices use microwaves, effectively functioning as low-level, constantly emitting, microwave transmitters (Clegg 2014). The placement and operation of these structures in the U.S. continues to grow exponentially. Unfortunately, the cumulative effects – including the cumulative biological effects and the much more detailed effects and reviews under the National Environmental Policy Act (NEPA) – of collisions with these structures, impacts to habitats from degradation and fragmentation, and effects from radiation on migratory birds, bats, and other trust resource species remain poorly understood, generally poorly assessed, and in many cases completely unquantified.

This webinar will attempt to synthesize the overriding issues, discuss intra- and inter-agency coordination, review current research findings and gaps, suggest what U.S. Fish and Wildlife Service (hereafter Service or USFWS) staff involved with towers can do, and briefly suggest next steps. As a postscript to this webinar, a repeat webinar will be presented and recorded by the National Conservation Training Center on Tuesday, May 20 (time yet to be determined), to accommodate those who were not able to link in or hear the webinar on February 20.

BACKGROUND AND BRIEF HISTORY

Tower Collisions

Some will argue that the current estimated annual levels of mortality from avian collisions with communication towers are relatively small (i.e., 6.8 million in the U.S. and Canada; Longcore et al. 2012), compared to collisions with window glass (median 599 million; Loss et al. 2013b, Klem and Saenger 2013), or domestic and feral cats (median 2.4 billion; Loss et al. 2013a). While these comparisons may be interesting and perhaps instructive, they are by far not the end of the story. Impacts to migratory birds must include cumulative effects (cumulative biologically and under the legal mandates of NEPA) from all sources, including the effects of collisions and radiation from cellular towers, the latter which remain unassessed and still poorly understood in North America.

Collisions with communication towers in North America are not a new phenomenon. Since 1948 when Aronoff (1949) described a large bird kill at a radio tower near Baltimore, Maryland, the scientific literature has been replete with references to large bird kills and results of long-term tower mortality monitoring studies. Noteworthy were studies by Kemper (1996) where over 38 years he collected 121,560 bird carcasses representing 123 species from a tall television tower in Eau Clair, Wisconsin – retrieving and identifying more than 12,000 birds killed during a single night in 1963 (still the all-time, single night mortality record).

Light appears to be a key attractant for night-migrating songbirds, especially on nights with poor visibility, low cloud ceilings, heavy fog, or various forms of precipitation associated with passing or stationary cold fronts (Manville 2005; http://www.fs.fed.us/psw/publications/documents/psw_gtr191/Asilomar/pdfs/1051-1064.pdf). The literature is also full of reports of bird-collisions associated with night lighting, beginning with reports in Forest and Stream (1874). Of note are two studies of lighted communication towers that were attracting songbirds. When the lights were extinguished, the birds continued on their migrations, leaving previously lit, cloud enshrouded towers (Cochran and Graber 1958, Avery et al. 1976). In both studies, when the lights were turned back on, within minutes the birds began circling the towers in large numbers. Research has more recently focused on steady burning communication tower lights, especially solid, steady-red lighting.

Early Mortality Estimation and a Call to Action

The USFWS first became involved in estimating tower collision mortality when Banks (1979) assessed avian mortality at some 505 of the then existing 1,010 tall radio and television towers present in the U.S. in 1975, estimating 1.25 million birds killed/yr at these towers. For unknown reasons, tower mortality estimates were not subsequently updated by USFWS. However, in February 1998, a large, single-night mass mortality event of up to 10,000 primarily Lapland Longspurs was recorded in western Kansas at 3 lighted communication towers and a lighted gas pumping facility. Numerous calls from NGOs and other stakeholders captured the undivided attention of the Division of Migratory Bird Management (DMBM) and the Service, resulting in a call to action.

CURRENT DEVELOPMENTS WITH TOWER COLLISIONS

Call to Action and Service Initiatives

By late 1998, the Service developed and publicly released a risk model beginning to address tower collision issues. We also released an annotated bibliography of collision mortality that year (http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/towers.html). We facilitated a meeting of stakeholders in 1999 and co-chaired a tower collision mortality workshop at Cornell University that year (http://www.fws.gov/migratorybirds/currentbirdissues/hazards/towers/agenda.html), which included participation from the Federal Communications Commission (FCC), the Federal Aviation Administration (FAA), U.S. Geological Survey (USGS), State of Wisconsin, tower and cellular industries, consultants, conservationists, researchers and academicians. Also that year, the Communication Tower Working Group (CTWG) was created representing a multi-stakeholder interest group – including multiple Federal agencies and Commissions, State agency representation, leading radar and physiological ornithologists, academicians, consultants, and conservationists – focusing on research

needed to address bird collisions at communication towers. A representative from DMBM was invited to chair the CTWG (A. Manville) which in 2000 developed a nationwide protocol for studying cumulative biological impacts to migratory birds to assess impacts at 250 stratified and subsequently randomly selected towers of different height, lighting and guy wire categories (http://www.fws.gov/migratorybirds/currentbirdissues/Hazards/towers/towers.html). Unfortunately, no funding was acquired to implement the study and none has been garnered to date. The CTWG last met in 2005 when the Research Subcommittee reviewed ongoing developments dealing primarily with lighting and radar studies. No meeting is presently scheduled for the near future. In September 2000, the Service published voluntary communication tower guidance (http://www.fws.gov/migratorybirds/CurrentBirdIssues/Hazards/towers/tower.html) – the current 2013, updated version included below.

At the invitation of the U.S. Forest Service, the Division of Migratory Bird Management developed and helped implement a peer-reviewed research monitoring protocol to assess the impacts of cell towers on migratory birds in the Coconino, Prescott and Kaibab National Forests, Arizona (Manville 2002). With some modifications, that protocol could be used for independent, 3rd party field radiation studies yet to be performed in North America – discussed beyond.

Current Mortality Estimation

To update Banks' 1975 mortality estimate, Evans (1998), working collaboratively with DMBM, reassessed mortality based on the considerably increasing number of tall communication towers, estimating 2-4 million birds killed/yr. The Service reassessed that number in 2000 and more recently, conservatively estimating 4-5 million bird deaths/yr (Manville 2001, 2005). Based on a meta-review of all the published studies in the U.S. and Canada, Longcore et al. (2012) estimated annual mortality at 6.8 million, the vast majority of which appeared to be occurring in the U.S.

Impacts to Bird Populations

Arnold and Zink (2011) asserted that communication towers have no population impacts to migratory birds based against 30-year population trends calculated from Breeding Bird Survey data, literature that at the time was not exhaustively assessed, tabulation errors, and other problems. Longcore et al. (2013) challenged that assertion based on their more detailed and thorough meta-review and regression analysis of the North American avian research data, estimating that at least 13 species of Birds of Conservation Concern (USFWS 2008) and species of concern from Canada are being impacted at the population level based solely on collisions with communication towers; 97.4% of these birds were passerines. Most notable were projected impacts to the Yellow Rail, Swainson's Warbler, Pied-billed Grebe, Bay-breasted Warbler, Golden-winged Warbler, Worm-eating Warbler, Prairie Warbler, and Ovenbird. Their estimates were based on data that included 259,393 documented deaths of 239 species at 107 locations in the U.S. and Canada. Longcore et al.'s (2013) recent findings raise new concerns regarding impacts especially to imperiled migratory birds from communication towers.

Tower Height, Lighting, and Guy Wires

It has been well documented that tall, guy-wire-supported towers kill significant numbers of migratory birds. Documentation was begun in 1955 with the first long-term study at the Tall Timbers Research

Station, Northern Florida (Crawford and Engstrom 2001). Kemper (1996) began his 38 year study in 1957. Numerous other tall tower studies have since been conducted and results published. Cutting edge research by J. Gehring on Michigan State Police and several tall Michigan television towers (Gehring et al. 2009, 2011, 2013a and 2013b), and more recently on tall towers in Michigan and New Jersey (Gehring and Walker 2012), have clearly illustrated the relationship between communication towers, bird collisions, tower structural lighting, tower height, and the presence of guy wires (Gehring 2013, Gehring and Manville 2013, Gehring et al. 2009, 2011), best summarized as follows:

- The majority of fatalities are night migrating songbirds.
- Towers with guy-support wires result in higher levels of avian mortality than towers without guy wires (16 times more in the Michigan study by Gehring et al. 2009, Gehring 2013).
- Taller towers result in higher levels of avian mortality than shorter towers. In the Michigan study (Gehring et al. 2011 and Gehring 2013), tall towers >1,000 ft above ground level (AGL) were involved in 5 times more collisions than towers ± 470 ft AGL.
- Steady-burning lights on towers result in higher levels of avian mortality than flashing lights. In the Michigan study (Gehring et al. 2009, Gehring 2013), tower lighting systems that included non-blinking red lights were involved in 3.5 times more bird collisions than any other lighting system present.
- The elimination (through retrofit, relicensing, or new construction) of steady red (L-810) non-flashing lights could collectively reduce avian mortality by 50-70% nationwide based on current assessments. In the Michigan study (Gehring et al. 2009, Gehring 2013), this level of reduction was attained at the $P < 0.01$ level (using the simple Student t-test).

Changes in Tower Lighting Systems

We wish to express a special thanks to the FAA for allowing lighting variances (i.e., turning off L-810 lights) during the Michigan State Police (Gehring et al. 2009) and U.S. Coast Guard-funded tall tower studies (Gehring and Walker 2012). We also thank the FAA for their willingness to fly several pilot lighting conspicuity studies to assess pilot visibility of towers at night without L-810 steady lights "on." In part as a result of these efforts, the following recommendations are currently available to tower owners and operators for nighttime lighting. We also highlight these issues here for the benefit of any Service staff and personnel who work on communication tower issues since they represent very recent changes. To summarize current lighting standards:

- To clarify, systems with white lights (e.g., white strobes or white strobe-like) do not include non-flashing lights, including non-flashing red lights.
- Nighttime red light systems do currently include non-flashing red (L-810) lights except for the changes referenced in these talking points, beyond. FAA is currently evaluating flashing L-810 lights (and other lighting systems) that will use LED lighting systems that flash synchronously with the existing flashing red lights (e.g., L-864s). The LEDs will be used in place of incandescent or xenon lights, but these LED systems are currently under development and will only become available once FAA releases their specifications. LED lights are considerably more energy efficient than incandescent and xenon lights. Whether LEDs are any more or less attractant to night-migrating songbirds especially during inclement weather events remains a yet untested hypothesis with indeterminate results.

- For towers > 350 ft AGL, FAA has approved a new Style A lighting option which allows L-810 lights to be extinguished on existing towers, and not installed on new construction.
- Recapping, the new FAA standards (Patterson 2012) for towers > 350 ft AGL pertain to all new and existing towers.
- For towers < 350 ft AGL, FAA is currently evaluating flashing L-810 lights using synchronously lighted LED lights. These LEDs are being developed to replace existing incandescent and xenon light systems. The goal is to allow for an easier transition to a flashing L-810 lighting system once FAA releases their specifications.
- The FAA (Patterson 2012) published a cover letter and detailed memo authorizing these and other changes, but the final changes have yet to be incorporated into the new FAA Obstruction and Marking Lighting Circular which will update FAA's (2007) existing guidance. We anticipate the updated Lighting Circular to be publicly available in the near future. The changes, however, have been authorized by the FAA (Patterson 2012).
- These changes, in addition to the benefits to migratory birds, will reduce the costs of tower lighting. For example, by turning off the non-flashing lights on 1 tower, between $216 and $2,505/yr in energy costs will be saved based on tower height and number of lights involved, as well as between $3,002 and $4,200/yr in maintenance costs. Additionally, between 3,940 to 9,849 pounds of CO_2/yr will be reduced from atmospheric release due to the changes in just 1 tower, or for 91 changed towers, between 358,540 to 896,259 pounds of CO_2/yr (Gehring and Manville 2013).
- The FCC, having acknowledged the FAA's conspicuity study results and 2012 determination, now requires that all new towers ≥ 450 ft AGL have no steady red lights.
- The FCC is currently recommending that new towers 350-450 ft AGL contain no steady red lights but has yet to make that a requirement.
- The FCC will eventually address new towers < 350 ft AGL, recommending that existing non-flashing lights flash with the other flashing beacons. These new flashing side-marker lights are currently under development and LED lighting will be suggested for all new construction and for retrofits. Synchronization of flashes will be required.

What can and should Service staff do?

In addition to recommending use of the Service's updated 2013 communication tower guidance – presented below – there are additional tasks Service staff who work on communication towers can implement. These include the following:

- Where Service biologists are reviewing new towers, it is important to integrate the new lighting options and standards into our reviews, especially for towers 350 – 450 ft AGL and above.
- It is important to encourage – or possibly require owners where "take" continues – to implement these new lighting standards on existing operating towers, saving money and protecting birds. These new lighting standards represent scientifically validated "conservation measures" that have reduced collisions at some towers in Michigan by 72% (Gehring et al. 2009).
- We have an additional opportunity to educate the tower industry, regulatory agencies, scientific and conservation communities, the general public and other stakeholders about these positive changes. There are existing websites (e.g., Michigan State University's "Fewer Lights Safer

Flights" at http://fewerlights.anr.msu.edu, and the FCC website at www.FCC.gov) that already contain explanations regarding how to use these changes and what they mean. Agencies and partners should link through their websites to the existing sites.

- Webinars such as this one should help to get the word out.
- Public relations and outreach can help get out the message.
- Tower owners who work with USFWS and collaborate with FCC, especially where changes are not yet required regarding lighting but significantly benefit birds, should be positively recognized for their efforts. This might include awards, features in newsletters, and blogs in the social media.

Concerns Over Radiation Emitted from Towers and Equipment

The effects of radiation from communication towers on nesting and roosting wild birds are yet unstudied in U.S. and Canada, although in Europe, Balmori (2005) found strong negative correlations between levels of tower-emitted microwave radiation and bird breeding, nesting, and roosting in the vicinity of electromagnetic fields in Spain. He documented nest and site abandonment, plumage deterioration, locomotion problems, and death in House Sparrows, White Storks, Rock Doves, Magpies, Collared Doves, and other species. While these species had historically been documented to roost and nest in these areas, Balmori (2005) did not observe these symptoms prior to construction and operation of the cellular phone towers. Balmori and Hallberg (2007) and Everaert and Bauwens (2007) found similar strong negative correlations among male House Sparrows. Research in Europe on radiation effects to wild birds continues. It is important to note that this research, and the troubling findings, are not coming from the U.S., but they need to be made available to USFWS personnel involved with communication tower issues.

Under laboratory conditions in the U.S., T. Litovitz (pers. comm.) and DiCarlo et al. (2002) raised troubling concerns about impacts of low-level, non-thermal radiation from the standard 915 MHz cell phone frequency on domestic chicken embryos – with some lethal results (Manville 2009; www.healthandenvironment.org/wg_emf_news/6143). It is important to note that radiation levels in this laboratory study were far below current FCC-approved and permissible human health radiation standards (i.e., 1.6 W/kg of whole body tissue). The FCC, and most other agencies for that matter, currently lack any wildlife health radiation standards. DiCarlo et al. (2002) found that with embryo exposures of $\geq$ 30 minutes of radiation per day under hypoxic conditions, embryos developed deformities including induced DNA damage at 0.0024 W/kg the current permissible level, and induced heart failure based on affected levels of calcium in the heart at 0.00015W/kg the permissible level. The controls also tested under hypoxic conditions were unaffected (Manville 2005, 2013a).

In Greece, Magras and Xenos (1997) tested laboratory mice treated with radiation to replicate conditions found close to an "antenna park." After 5 generations of newborns, irreversible infertility occurred.

A more recent and detailed laboratory and field study and extensive meta-review of the data by Panagopoulos and Margaritis (2008) have raised serious, non-thermal biological effects from radiation to birds, insects (important food sources for many species of avifauna) and mammals. Findings included rate or gene expression changes, cell death, decrease in melatonin production, population declines in birds and insects, and small but statistically significant increases in certain types of cancer. The study focused on the radiation from mobile telephone antennas, including handsets and base stations.

Extended low doses of microwave cell-phone and mobile phone radiation are being shown to be a distinct risk to human health through enhanced probabilities of cancer (e.g., Hardell and Mild 2001, Panagopoulos and Margaritis 2008), Alzheimer's disease (e.g., Sobel et al. 1996), and an alert 3 years ago by the World Health Organization as a "possible carcinogen" (Clegg 2014). However, their effects primarily on wild birds have only recently been studied, and only in Europe. A compendium of most of the published papers in the peer-reviewed scientific literature that show possible electromagnetic radiation (EMR) effects to wildlife is currently available. It can be found at www.livingplanet.be/ then click on EM Radiation.

Given the findings of the European field studies mentioned above, similar studies should be conducted in the U.S. to validate potential impacts of communication tower radiation – including both direct and indirect effects – to birds, bats and other wildlife in North America. Such studies need to be performed by independent, third-party researchers with no vested interest in the outcomes. Research study protocols based on designs by Balmori (2005), Balmori and Bauwens (2007), Everaert and Bauwens (2007), and others should be reviewed, with attempts made to better assess causality and further tease out the dynamics of impacts (e.g., Manville 2002).

The electromagnetic radiation standards developed by the FCC in the 1980s were based on standards of thermal heating from microwave radiation, maintained by an office in the Environmental Protection Agency. That office was ultimately zero-budgeted and no longer exists. Unfortunately, FCC radiation standards continue to be based on thermal heating, a criterion now nearly 30 years out of date and inapplicable today. This is due to the development of analogue and more recent digital cellular phone technologies, and lower levels of radiation output from microwave-powered communication devices such as cellular and mobile telephones, and other sources of point-to-point communications – levels generally lower than from microwave ovens. Given the U.S. laboratory and European field study findings (e.g., www.livingplanet.be/), radiation must be included as part of a cumulative effects analysis both biologically and under NEPA review, and probably should be performed through an environmental impact statement as a part of NEPA review. It is important to note that the FCC standards are only for human exposures and that there literally are no standards to protect wildlife at virtually any agency, despite exponentially increasing exposures and disturbing research findings.

UPDATED COMMUNICATION TOWER GUIDANCE

The Service published voluntary communication tower guidelines in September 2000, but more recent and cutting-edged findings regarding steady-burning lights, tower height and guy supports (e.g., Gehring et al. 2009, 2011); changes in pilot lighting standards by the FAA (Patterson 2012); and recent developments by the FCC (e.g., new requirements regarding their Antenna Structure Registration Database) have obligated the Service to update the 2000 guidance to align them with the current science and suggested collaboration between USFWS and the FCC. Issues dealing with radiation are not incorporated as a part of this revised guidance although they have been provided on the record to FCC in comments we submitted to the Wireless Telecommunications Bureau regarding the environmental effects of the FCC's Antenna Structure Registration Program (Manville 2011). The revised guidance will be published on the Service's website once FAA updates its 2007 Lighting Circular; FCC finalizes rulemaking regarding "Effects of Communication Towers on Migratory Birds," Docket No. 08-61 (2007) – a process begun in 2003; and any changes in our Eagle Conservation Plan Guidance, Module 1

(USFWS 2013), suggest better ways to address "disturbance take" and "take resulting in mortality" to Bald and Golden Eagles at communication towers and their infrastructure through publication of a new module. The revised guidance also incorporates issues dealing with the Antenna Structure Registration Program. Our guidance was last revised in September 2013.

It is recommended that the following guidance be used by Service personnel who review tower projects and work in various capacities with consultants and developers in the siting, placement, design, and assessment of potential impacts to migratory birds from communication towers. Use of these guidelines also suggests better coordination between the Service and FCC, most especially with Dr. Joelle Gehring, FCC's staff wildlife biologist (Joelle.Gehring@fcc.gov). She is an extremely helpful resource and the first, full-time wildlife biologist hired by FCC. Our specific guidance follows:

September 2013 U.S. Fish and Wildlife Service (USFWS) Revised Voluntary Guidelines for Communication Tower Design, Siting, Construction, Operation, Retrofitting, and Decommissioning

1. Collocation of the communications equipment on an existing communication tower or other structure (e.g., billboard, water and transmission tower, distribution pole, or building mount) is strongly recommended. Depending on tower load factors and communication needs, from 6 to 10 providers should collocate on an existing tower or structure provided that frequencies do not overlap/"bleed" or where frequency length or broadcast distance requires higher towers. New towers should be designed structurally and electronically to accommodate the applicant's antenna, and antennas of at least 2 additional users – ideally 6 to 10 additional users, if possible – unless the design would require the addition of lights and/or guy wires to an otherwise unlit and/or unguyed tower. This recommendation is intended to reduce the number of towers needed in the future.

2. If collocation is not feasible and a new tower or towers are to be constructed, it is strongly recommended that the new tower(s) should be not more than 199 feet above ground level (AGL), and that construction techniques should not require guy wires. Such towers should be unlighted if Federal Aviation Administration (FAA) regulations and lighting standards (FAA 2007, Patterson 2012) permit. Additionally, the Federal Communications Commission (FCC) through recent rulemaking now requires that new towers $\geq$ 450 ft AGL contain no red-steady lights. FCC also recommends that new towers 350-450 ft AGL also contain no red-steady lights, and they will eventually recommend that new towers < 350 ft AGL convert non-flashing lights to flash with existing flashing lights. LED lights are being suggested as replacements for all new construction and for retrofits, with the intent of future synchronizing the flashes. Given these dynamics, the Service recommends using lattice tower or monopole structures for all towers < 200 ft AGL and for taller towers where feasible. The Service considers the less than 200 ft AGL option the "gold standard" and suggests that this is the environmentally preferred industry standard for tower placement, construction and operation – i.e., towers that are unlit, unguyed, monopole or lattice, and < 200 ft AGL.

3. If constructing multiple towers, the cumulative impacts of all the towers to migratory birds – especially to Birds of Conservation Concern (FWS 2008) and threatened and endangered species, as well as the impacts of each individual tower, should be considered during the development of a project.

4. The topography of the proposed tower site and surrounding habitat should be clearly noted, especially in regard to surrounding hills, mountains, mountain passes, ridge lines, rivers, lakes, wetlands, and other habitat types used by raptors, Birds of Conservation Concern, and state and federally listed species, and other birds of concern. Active raptor nests, especially those of Bald and Golden Eagles, should be noted,

including known or suspected distances from proposed tower sites to nest locations. Nest site locations for Golden Eagles may vary between years, and unoccupied, inactive nests and nest sites may be re-occupied over multiple years. The Service's 2013 Eagle Conservation Plan Guidance, Module 1, Land-based Wind Energy, Version 2, available on our website, is a useful document (USFWS 2013).

5. If at all possible, new towers should be sited within existing "antenna farms" (i.e., clusters of towers), in degraded areas (e.g., strip mines or other heavily industrialized areas), in commercial agricultural lands, in Superfund sites, or other areas where bird habitat is poor or marginal. Towers should not be sited in or near wetlands, other known bird concentration areas (e.g., state of federal refuges, staging areas, rookeries, and Important Bird Areas), in known migratory, daily movement flyways, areas of breeding concentration, in habitat of threatened or endangered species, or key habitats for Birds of Conservation Concern (FWS 2008). Disturbance can result in effects to bird populations which may cumulatively affect their survival. The Service has recommended some disturbance-free buffers, e.g., 0.5 mi around raptor nests during the nesting season, and 1-mi disturbance free buffers for Ferruginous Hawks and Bald Eagles during nesting season in Wyoming (FWS WY Ecological Services Field Office, referenced in Manville 2007:23). The effects of towers on "prairie grouse," "sage grouse," and grassland and shrub-steppe bird species should also be considered since tall structures have been shown to result in abandonment of nest site areas and leks, especially for "prairie grouse" (Manville 2004). The issue of buffers is currently under review, especially for Bald and Golden Eagles. Additionally, towers should not be sited in areas with a high incidence of fog, mist, and low cloud ceilings.

6. If taller (> 199 ft AGL) towers requiring lights for aviation safety must be constructed, the minimum amount of pilot warning and obstruction avoidance lighting required by the FAA should be used. Unless otherwise required by the FAA, only white strobe or red strobe lights (red preferable since it is generally less displeasing to the human eye at night), or red flashing incandescent lights should be used at night, and these should be the minimum number, minimum intensity (< 2,000 candela), and minimum number of flashes per minute (i.e., longest duration between flashes/"dark phase") allowable by the FAA. The use of solid (non-flashing) warning lights at night should be avoided (Patterson 2012, Gehring et al. 2009) – see recommendation #2 above. Current research indicates that solid red lights attract night-migrating birds at a much higher rate than flashing lights (Gehring et al. 2009, Manville 2007, 2009). Recent research indicates that use of white strobe, red strobe, or red flashing lights alone provides significant reductions in bird fatalities (Patterson 2012, Gehring et al. 2009).

7. Tower designs using guy wires for support, which are proposed to be located in known raptor or waterbird concentrations areas, daily movement routes, major diurnal migratory bird movement routes, staging areas, or stopover sites, should have daytime visual markers or bird deterrent devices installed on the wires to prevent collisions by these diurnally moving species. The efficacy of bird deterrents on guy wires to alert night migrating species has yet to be scientifically validated. For guidance on markers, see Avian Power Line Interaction Committee (APLIC). 2006. *Suggested Practices for Avian Protection on Power Lines -- State of the Art in 2006.* Edison Electric Institute, APLIC, and the California Energy Commission. Washington, DC, and Sacramento, CA. 207 pp. Also see APLIC. 2012. *Reducing Avian Collisions with Power Lines -- the State of the Art in 2012.* Edison Electric Institute and APLIC. Washington, DC. 159 pp. Also see www.aplic.org, www.energy.ca.gov, or call 202-508-5000.

8. Towers and appendant facilities should be designed, sited, and constructed so as to avoid or minimize habitat loss within and adjacent to the tower "footprint." However, a larger tower footprint is preferable to the use of guy wires in construction. Several shorter, un-guyed towers are preferable to one, tall guyed, lighted tower. Road access and fencing should be minimized to reduce or prevent habitat fragmentation, disturbance, and the creation of barriers, and to reduce above ground obstacles to birds in flight.

9. If, prior to tower design, siting and construction, if it has been determined that a significant number of breeding, feeding and roosting birds, especially of Birds of Conservation Concern (USFWS 2008), state or federally-listed bird species, and eagles are known to habitually use the proposed tower construction area, relocation to an alternate site is highly recommended. If this is not an option, seasonal restrictions on construction are advised in order to avoid disturbance, site and nest abandonment, especially during breeding, rearing and other periods of high bird activity.

10. Security lighting for on-ground facilities, equipment and infrastructure should be motion- or heat-sensitive, down-shielded, and of a minimum intensity to reduce nighttime bird attraction and eliminate constant nighttime illumination, but still allow safe nighttime access to the site (USFWS 2012, Manville 2011).

11. Representatives from the USFWS or researchers from the Research Subcommittee of the Communication Tower Working Group should be allowed access to the site to evaluate bird use; conduct dead-bird searches; place above ground net catchments below the towers (Manville 2002); and to perform studies using radar, Global Position System, infrared, thermal imagery, and acoustical monitoring, as necessary. This will allow for assessment and verification of bird movements, site use, avoidance, and mortality. The goal is to acquire information on the impacts of various tower types, sizes, configurations and lighting protocols.

12. Towers no longer in use, not re-licensed by the FCC for use, or determined to be obsolete should be removed from the site within 12 months of cessation of use, preferably sooner.

13. In order to obtain information on the usefulness of these guidelines in preventing bird strikes and better understanding impacts from habitat fragmentation, please advise USFWS personnel of the final location and specifications of the proposed tower, and which measures recommended in these guidelines were implemented. If any of these recommended measures cannot be implemented, please explain why they are not feasible. This will further advise USFWS in identifying any recurring problems with the implementation of the guidelines, which may necessitate future modifications (Manville 2013b).

ACKNOWLEDGEMENT

These talking points were critically reviewed by the following individuals whose assessment and suggestions are much appreciated. A special thank you is due to:

- B. Blake Levitt, former award-winning medical reporter for *The New York Times,* and author of *Electromagnetic Fields, a Consumer's Guide to the Issues and How to Protect Ourselves* (Harcourt Brace).
- Joelle Gehring, Ph.D., principal investigator for the Michigan State Police communication tower study and the U.S. Coast Guard-funded tall communication tower study, and the first wildlife biologist to be hired by the Federal Communications Commission.
- Diana Whittington, our Division of Migratory Bird Management NEPA specialist and Division NEPA lead. Thanks to the 3 of you.

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