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Division of Migratory Bird Management
U.S. Fish and Wildlife Service
4401 N. Fairfax Drive – MBSP-4107
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January 14, 2011

Mr. Aaron Goldschmidt, Esq.
Wireless Telecommunications Bureau
Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Re: Comments of the U.S. Fish and Wildlife Service's Division of Migratory Bird Management filed electronically, on WT Docket No. 08-61 and WT Docket No. 03-187, Regarding the Environmental Effects of the Federal Communication Commission's Antenna Structure Registration Program

Dear Mr. Goldschmidt:

The Division of Migratory Bird Management (DMBM), U.S. Fish and Wildlife Service (FWS or Service) is pleased to provide the following comments on the Federal Communication Commission's (FCC or Commission) Antenna Structure Registration Program (ASRP). We had planned to present oral comments before the Commission on December 6, 2010, but at the last minute were unable to attend.

Introductory Comments

The Service appreciates the opportunity to continue working with the FCC, a relationship that was spurred by a large single-night kill of up to 10,000 Lapland Longspurs and other birds at 4 adjacent communication towers and a nearby, lighted outbuilding near Syracuse, Kansas, in February 1998. The relationship with FCC more formally began in 1999 at an avian-communication tower workshop at Cornell University at which the FCC was a presenter, and with the 1999 formation of the Communication Tower Working Group that we currently chair and which the FCC has been an active participant. We look forward to maintaining this collaborative relationship into the future while significantly reducing the "take" (defined as, "to pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect" without a permit; 50 CFR 10.12) of migratory birds at communication towers.

Statutory and Regulatory Issues Affecting Migratory Birds

The Service now protects and manages 1,007 migratory birds (50 CFR 10.13, March 1, 2010). Each time a protected bird strikes a communication tower and is killed or injured, the collision represents an unpermitted "take" under the Migratory Bird Treaty Act (MBTA; 16 U.S.C. 703-712), a strict liability statute. While yet to be validated in wild breeding birds in North America, radiation from cellular communication towers in Europe is being documented as a problem for nesting birds, resulting in reduced recruitment, poor chick survivorship and mortality around cellular communication towers where nesting is occurring (Balmori 2005, Balmori and Hallberg 2007, and Everaert and Bauwens 2007). Radiation at the same frequency and intensity as that used in cellular telephones in the U.S. has been validated in the laboratory as a problem for domestic chicken embryos, resulting in deaths (DeCarlo et al. 2002, Manville 2009). If radiation is injuring or killing wild migratory birds, this represents yet another unpermitted "take" of protected species in the U.S.

Bald and Golden Eagles are additionally protected under the Bald and Golden Eagle Protection Act (BGEPA; 16 U.S.C. 668-668d), also a strict liability statute. The Service updated the definition of "disturb" under BGEPA (50 CFR 22.3) to include:

> "to agitate or bother a Bald or Golden Eagle to a degree that causes, or is likely to cause, based on the best scientific information available, (1) injury to an eagle, (2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or (3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior."

To implement this definition, in late 2009 the Service promulgated 2 new regulations that would allow "take" including "disturbance" and limited "take resulting in mortality" (50 CFR 22.26) and "take" of eagle nests for health and safety reasons (50 CFR 22.27). Where communication towers "take" Bald Eagles – either through "disturbance" or by lethal means – an individual "take" permit would be required to be in compliance with the law. The exception is for the Sonoran Desert population of Bald Eagles still listed under ESA.

For Golden Eagles, we will likely only consider programmatic "take" permits (defined under 50 CFR 22.3 as "take that is recurring, is not caused solely by indirect effects, and that occurs over the long term or in a location or locations that cannot be specifically identified"). For both species, permits will only be issued where the breeding population of the raptor is stable or increasing. Thus provisions regarding "disturbance" and "take" under BGEPA now need to be evaluated both by the FCC and by tower developers, owners and lessees. We suggest tower owners and/or operators contact the nearest FWS Ecological Services Field Office for guidance on eagle issues and permitting. Guidance for implementing individual and programmatic take permits is presently being developed. Additional details can be found on the Service's Migratory Bird website (www.fws.gov/migratorybirds/) as this information becomes available to the public.

Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds; January 10, 2001) states that "...each Federal agency taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations is directed to develop and implement...a Memorandum of Understanding with the Fish and Wildlife Service that shall promote the conservation of migratory bird populations" (*Federal Register* 66(11):3854). The Service strongly encourages the FCC to develop, sign and implement an MOU with us under the auspices of E.O. 13186. While FCC is an independent Commission, the Service is about to sign an MOU under the EO with the Federal Energy Regulatory Commission, yet another independent Commission. We encourage development of a similar MOU with the FCC which could include the ASRP as well as other communication tower-migratory bird issues raised by the Service during proposed rulemaking in 2007 (Manville 2007).

FCC National Environmental Policy Act (NEPA) Regulations

Section 1.1306 of the FCC's NEPA regulations (47 CFR 1.1301-1.1319) categorically excludes from environmental processing all Commission actions except where communication towers are to be built in wilderness, designated wildlife refuges, on flood plains, where significant surface features are affected, or where Federally listed species are affected, and for other reasons not related to migratory birds. Unless listed, migratory birds have been excluded from this review. However, the Court of Appeals in *ABC v. FCC* held that registered communication towers (i.e., those > 200 ft above ground level [AGL] in height or within 3.8 statute miles of airport approach and departure runways) may have significant adverse environmental effects on migratory birds, thus necessitating this programmatic environmental assessment (PEA). As the Service previously stated in our 2007 comments to the FCC regarding proposed rulemaking (Manville 2007), migratory birds need to be included in the FCC's NEPA review for *all* communication towers.

Based on the court's determination, this PEA is intended to determine if the ASRP has significant environmental impacts, focusing on migratory birds and listed species. The PEA will consider direct, indirect, and cumulative effects, focusing on impacts from tower location, height, guy wire support, and lighting.

Validated and Estimated Impacts from Communication Towers

Early U.S. Estimates

The impacts of communication towers on migratory birds have been reported in the U.S. scientific literature for more than half a century. Aronoff (1949) first reported several hundred migratory birds that were retrieved from a Baltimore, Maryland, radio tower in 1948. Later, Mayfield (1967) attempted to estimate nationwide bird-tower-collision mortality. During the 1970s, the Service's Bureau of Sports Fisheries and Wildlife raised upward the previous mortality estimates of Mayfield (1967) where Banks (1979) then estimated average annual mortality at 1.25 million birds/yr. This represented the best and most scientifically valid estimate of tower mortality at the time. To update Banks' FWS mortality figure, Evans (1998) and the Service (Manville 2001a, 2001b, 2005) adjusted the Banks estimate to account for increasing numbers of towers since 1979, resulting in the Service's current estimate of 4- 5 million birds killed/yr. at all U.S. towers. A nationwide cumulative impacts analysis will help to determine the most reliable estimate of bird mortality.

A Meta-analysis

An effort by some of the most respected avian-communication tower experts in Canada and the U.S. has produced 2 nearly final manuscripts for submission to a leading scientific journal. The publications will address impacts of tall communication towers to various species of migratory birds (Longcore et al. 2011a , 2011b). The scientists have performed a meta-analysis of bird-tower collisions from published and unpublished records in Canada and the U.S. These include information from 292,925 bird specimens, of 238 different species, collected at 72 North American locations, and they calculated the mean proportion of each species killed at towers within each Bird Conservation Region (BCR) in North America. The mean proportion depends on the correlation between tower height and estimated annual avian mortality. It is already known that taller towers kill more birds than do shorter towers (Gehring and Kerlinger 2007a, 2007b, Gehring et al. in press, Manville 2007, Karlsson 1977). In the Longcore et al. (2011a) study, the authors found that more than 50% of the avian mortality was caused by towers > 984 ft AGL tall, of which only 1,021 were in their study database comprising only 1.6% of all towers examined. Based on data analysis, shorter towers, even those < 490 ft AGL contributed to approximately 25% of all mortality simply because of their sheer numbers. Towers < 600 ft AGL have for the most part been previously left out of estimates of avian mortality. The authors are now able to construct an estimate of total bird mortality that considers towers < 600 ft AGL, with help from Gehring et al. (2009) and other sources.

By geographically stratifying the estimates of avian mortality with estimates of the proportion of each bird species killed within different BCRs, Longcore et al. (2011a, 2011b) have developed geographically explicit estimates of avian mortality at communication towers by species. They compare per-species mortality estimates with population estimates of those species to evaluate the biological significance of this form of collision mortality. In the Longcore et al. (2011a, 2011b) meta-analysis, it is clear that some species are killed disproportionately to other species, contrary to Mayfield's (1967) assertion that tower kill mortality does not affect bird populations because birds are killed at towers in proportion to their abundance. Quite to the contrary, the results show that some species experience tower collision mortality far out of proportion to their population size, as illustrated by Graber (1968). While some of these new estimates should be viewed with caution, especially those with fewer specimens contributing to the mortality profile, the new estimates are especially troubling.

Longcore et al. (2011b) found that many *Birds of Conservation Concern* (BCC; USFWS 2008) suffer mortality equivalent to several percent of their total population size. These conditions may be causing a population effect to some species. Specifically, 42 BCCs, 2 Federally endangered, and 1 State rare and endangered bird were found to be killed at communication towers in Canada and the U.S. based on this meta-analysis. Of these, 15 BCCs have annual mortality estimated to exceed 0.5% of their estimated population size, and 8 BCCs have mortality estimated to exceed 1.0% of their estimated population size. Mortality is estimated to approach 5% in some species, and nearly 13% for the Yellow Rail. Ten of the 20 bird species killed most frequently by percentage of their population are either BCCs or Federally or State endangered birds (i.e., the Federally endangered Bermuda Petrel [6.1%] and the State rare and endangered Pied-billed Grebe [6.2%]). The Federally threatened Red-cockaded Woodpecker was reported infrequently killed at towers (0.1%). The list of birds of concern that may be suffering impacts to their populations includes the Bay-breasted Warbler, Swainson's Warbler, Harris' Sparrow, Black-throated Blue Warbler, Golden-winged Warbler, Yellow-throated Warbler, and the Kentucky Warbler.

Overall, Longcore et al. (2011a) estimated total annual avian mortality at 3.9- 5.9 million birds in the U.S. and Canada. The 3.9-million estimate was calculated from the un-weighted regression with the new shorter towers included, while the 5.9-million estimate was calculated using the regression weighted by study length. Approximately 94% of the annual mortality was estimated east of the Rocky Mountain Front. This meta-analysis clearly raises concerns for some species at their population levels and it helps validate the Service's current tower mortality estimate.

Lighting Studies and Conservation Measures

The Michigan State Police tower lighting study of 21 towers by Gehring et al. (2009) has now clearly demonstrated – in a scientifically valid way – the existence of a proven "conservation measure" that should reduce tower mortality by a highly significant degree where L-810 steady-burning red lights can be extinguished on existing towers or not installed on new towers. The Federal Aviation Administration (FAA) has already successfully conducted several pilot conspicuity studies where L-810 lights were extinguished, FAA appears to be satisfied with the results of these studies regarding continued pilot safety, and will publish an amended lighting circular in the near future that will *not* contain L-810 lighting where it currently is required. We also understand that the FAA is considering increasing the minimum height of towers requiring lighting to 305 ft AGL to better align with tower-height lighting minimums in Canada and Europe.

Ongoing research from a 3-year, U.S. Coast Guard-funded study being conducted by J. Gehring at 6 tall towers in Michigan and 1 in New Jersey continues to validate results from the Gehring et al. (2009) research. The preliminary findings show that avian fatalities can be significantly reduced at taller communication towers by using only flashing (i.e., strobed or blinking) lighting systems without L-810 lights. Preliminary data from the New Jersey component of this study suggest that the 350 ft AGL unguyed tower in Cape May is not involved in large numbers of avian fatalities. Elimination of L-810 lighting, replaced with blinking or strobed red lighting (white strobe-lit-towers do not require L-810 lights), was shown at some towers in Michigan to reduce avian mortality by up to 72% (Gehring et al. 2009, Manville 2007). Based in major part on the study results from Gehring et al. (2009), the Service is now recommending as one of its primary conservation measures extinguishing all L-810 lighting to significantly reduce collisions of migratory birds at communication towers where this lighting regime is presently required. We strongly recommend that the FCC include a review of all towers lit with L-810 lights as a major part of their proposed PEA and work with the Service to see that L-810 lights are extinguished on all applicable towers.

While tall towers have been documented to kill birds even under perfectly clear night skies, as Crawford and Engstrom (2001) reported moderate numbers were killed, inclement night weather events that coincide with songbird migration have been documented to be especially deadly (e.g., Manville 2007). This was well documented during fall 2005 at both tall and very short towers when heavy fog in the East and Midwest coincided with nighttime migration reported by the Service to the FCC in our comments regarding proposed rulemaking (Manville 2007:6-7). This included single-night, mass mortality events in Wisconsin, at several documented locations in New York, and at several ~ 150-ft AGL, unlit cellular telephone towers in North-central Pennsylvania. W. Evans (Executive Director, Old Bird, Inc., pers. com.) reported at least 147 salvaged birds at one of these cellular towers, mostly Blackpoll Warblers. Biologists from the Pennsylvania Game Commission verified these findings when they reported the retrieval and necropsy of at least 140 birds from one of the locations (October 19, 2005 PA Game Comm. Release # 119-05, "Bird deaths in Quehanna due to collisions"). Both Evans and the Game Commission reported that nearby, steady-burning bright light sources appeared to result in the bird congregations at the cell towers that led to the kills. This is a situation that can easily be remedied. Steady-burning lighting at out-buildings, related communication tower infrastructure (e.g., radio/television buildings or power substations), and nearby, lighted power poles, for example, should be extinguished as recommended in the Service's 2000 voluntary communication tower guidelines, 2006 recommendations to the electric utility industry (APLIC 2006), 2007 comments to the FCC, and recommendations to the Service from the 2010 Wind Energy Federal Advisory Committee. Steady-burning lights should be replaced with down-shielded, heat- or motion-sensitive security lighting that only comes "on" when it is needed. Steady-burning lights have been well documented especially in inclement weather to be major attractants for birds, resulting in numerous, well-documented mass mortality events (Manville 2007, 2009).

Concerns with Radiation Issues

Radiation impacts have only recently become a conservation issue with field studies on nesting birds initiated around 2000 in Europe (Balmori 2005, Balmori and Hallberg 2007, Everaert and Bauwens 2007) and laboratory studies conducted in the U.S. during the late 1990s on chicken embryos (T. Litovitz pers. comm., DiCarlo et al. 2002). Virtually unknown, however, are the potential effects of non-ionizing, non-thermal tower radiation on wild nesting avifauna in North

America, including at extremely low radiation levels, far below the safe exposure level previously determined for humans. Unfortunately, these "safe" levels continue to be based on thermal heating standards, now inapplicable. Based on studies in Europe, communication towers appear to be the cause of radiation impacts to breeding migratory birds. We, therefore, suggest FCC include a provision in their NEPA review to assess this aspect of the cumulative impacts of these structures in the United States. The Service is very interested in conducting radiation research on breeding birds in the United States, and would be glad to work with the FCC to make that happen as part of this NEPA review.

Service Recommendations for FCC NEPA Review

We provide the following recommendations to be incorporated into the FCC's NEPA review of the ASRP, including those suggestions below previously provided to FCC in 2007 regarding proposed rulemaking. We suggest that FCC's NEPA review of the ASRP be as inclusive as possible.

- As early as 1999, the Service's then Director Jamie Clark urged the FCC to coordinate with the Service in the development of a Programmatic Environmental Impact Statement (PEIS) regarding communication towers. Given the documented, estimated, and predicted levels of "take" at communication towers nationwide (e.g., Longcore et al. 2011a, 2011b) – including the potential but yet un-validated impacts from radiation on breeding birds in North-American – and the "take" of migratory birds at short towers, including those unlit but guyed and < 200 ft AGL (Manville 2007), we recommend that FCC develop a PEIS rather than a PEA. The Service can work cooperatively with staff from the FCC to flesh out the components – recommended below – of a PEIS. 40 CFR 1501.6 of NEPA gives the Service authority to function as a cooperating agency and Section 1503.2 provides us the authority to comment on federally-licensed activities for agencies with jurisdiction by law, including under MBTA. Additionally, the Service is required by the ESA to assist other Federal agencies – including the Commission – to ensure that any action authorized, implemented or funded by that agency will not jeopardize the continued existence of any Federally listed species. We specifically recommend the following:

- Avoid use of any L-810 steady-burning red lights on new towers being constructed, towers whose broadcast licenses expire and must be re-issued, towers being replaced, and where L-810 side lights burn out (replace with strobe or blinking lights). Pending FAA's update to their current (2007) lighting circular – which we are advised will occur in the near future – all L-810 lights should be extinguished and all L-810 lights should be removed as part of any retrofit (Gehring et al. 2009, Manville 2009).

- Use minimum intensity, maximum "off"-phased red strobe (or strobe-like), white strobe or red blinking incandescent lights with no L-810 sidelights. Use of red or white color and use of strobe versus blinking lights were not statistically different in several previously conducted studies (Gauthreaux and Belser 2006, Gehring et al. 2009).

- Where new towers are to be constructed, or where repair or upgrade of towers will result in increased tower height, where practical attempt to keep towers under 200 ft. AGL in height, be of monopole or lattice design, and contain no guy wires and lights. This represents the Service's recommended "gold standard" and the environmentally preferred alternative for tower placement.

- On May 4, 2010, the "Infrastructure Coalition" (CTIA, NAB, PCIA, and NATE) and the "Groups" (American Bird Conservancy, National Audubon Society, and Defender of Wildlife) submitted an MOU to FCC with interim recommendations for tower height and lighting categories under the ASRP. While we generally agree with the height risk categories (i.e., new towers > 450 ft AGL be placed in Category #1 [always requiring an Environmental Assessment and always placed on public notice], those 351- 450 ft AGL in Category #2 [may not initially require an EA but will always be placed on public notice], and those ≤ 350 ft AGL in Category #3 [does not require an EA and is not placed on public notice]), we disagree with the industry's recommendation that Category #3 towers not require an EA based on avian concerns and that no public notice be required. The latter concern was a dissenting issue for the "Groups." Given the Service's desire to include all towers in a cumulative impacts analysis, ongoing evidence of tower kills at "short" towers (including some that are unlit), new concerns about radiation impacts to breeding birds – especially from cell towers – and the need to better track where towers are being situated, we recommend public notice for this category of towers. This will allow stakeholders an opportunity to raise avian concerns to which the FCC and the Service may be unaware. If the evidence in the public record becomes compelling, an EA would be required upon filing with the FCC once the Commission makes that determination. Additional recommendations include:

- Remove a tower within 12 months after it becomes inoperative.

- Where tower height and guy wires become an issue, more, shorter, unguyed and unlit towers are recommended over fewer but taller, guyed and lit towers.

- Avoid constructing towers in or adjacent to wetlands and other areas where birds concentrate in large numbers or where listed, imperiled, or disturbance- sensitive birds are present.

- Avoid use of any lighting on tower infrastructure (e.g., outbuildings and power stations) that remains lit during the night. Instead, use motion or heat-sensitive lights that operate only for short periods, and down-shield all such lighting.

- FCC should require development and use of a Tower Site Evaluation Form, similar to the one created by the Service that accompanied the 2000 voluntary tower guidance. The FCC should require that the industry complete and submit this form to the appropriate Ecological Services Field Office for review, allowing the Service to make a "study or no-study" determination for tower placement at a proposed site. We provided suggested language to the FCC in our 2007 comments (Manville 2007:25).

- Under FCC's NEPA review, we recommend the Commission consider including voluntary bird mortality reporting to the Service by tower owners, operators, or their lessees once a tower is sited and constructed. The Service already maintains a password-protected, voluntary reporting system administered by the Office of Law Enforcement which dozens of electric utilities are presently using, a wind generation company is field-testing, and which could be modified for use by communication tower owners and operators (https://birdreport.fws.gov/). Such reporting could help better understand when and where mass mortality events occur, and begin to better determine cumulative effects. However, if a tower operator or consultant wishes to "possess" a bird carcass, a Scientific Collecting (50 CFR 21.23) or Special Purpose permit (50 CFR 21.27) is required, which includes mandatory reporting as a condition of both permits.

- FCC should require a post-construction monitoring process that assesses and evaluates mortality and/or habitat fragmentation and disturbance at a statistically significant sample of communication towers of different height classes (i.e., unlit, lit, unguyed, guyed, cellular, radio, television, DTV, emergency broadcast, and others). This will help to begin addressing the cumulative impacts assessment.

- FCC and the tower owners and operators it regulates need to coordinate with DMBM, the appropriate Ecological Services Field Office, and the pertinent Regional eagle biologist regarding the possibility of eagle "take" at a communication tower or its infrastructure resulting in "disturbance" or "take resulting in mortality" for both Bald and Golden Eagles under 50 CFR 22.26, and for "take" of eagle nests for health and safety reasons for eagles and humans under 50 CFR 22.27. Where "take" occurs, a permit under these regulations is required under BGEPA. The Service's eagle and migratory bird experts would be glad to coordinate with the tower owners and operators in avoiding unpermitted eagle "take."

- The FCC must consult with the Service, as required by Section 7 of the ESA, where any listed species and/or their critical habitats are impacted by the ASRP.

- Under auspices of FCC's NEPA review, the FCC should develop and implement an MOU with the Service under E.O. 13186 – incorporating the ASRP as part of this suggested MOU.

This concludes our recommendations to the FCC on the Antenna Structure Registration Program. We appreciate the opportunity to comment on this important program and look forward to making communication towers much more bird-friendly. Should you have any specific questions about these comments, please contact Dr. Albert Manville of our Division (703/358-1963; albert_manville@fws.gov). Respectfully submitted,

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/s/

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NOTICE OF INQUIRY COMMENT REVIEW
AVIAN / COMMUNICATION TOWER COLLISIONS

FINAL

Prepared for

FEDERAL COMMUNICATIONS COMMISSION

Federal Communications Commission

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AVATAR ENVIRONMENTAL

PANDION SYSTEMS

- *We seek comment on the impact on migratory birds, if any, of locating towers in areas with a high incidence of fog, low clouds, or similar obscuration, in proximity to coastlines and major bird movement corridors, or either clustered near or dispersed from other towers. Comments on the role of any of these factors should consider the extent of any such impact during migration seasons.*
- *We also seek comment on any other factors that may influence the impact of communications towers on migratory birds.*
- *24. Consistent with that commitment, we specifically seek comments from the Tribes and other parties on whether any of the questions raised in this inquiry will significantly impact Tribal governments, their land, and resources.*

3.3.5.4 General Responses and Summaries

The effect of the siting of communication towers was not explicitly addressed by the respondents but was frequently referenced in the discussions of location towers in migration flyways and proximity to certain specific habitats. The respondents did not address differential mortality associated with tower siting, including topographical features, regional weather patterns, land ownership, or land use.

No specific studies on communication tower siting were cited by the respondents. As stated above, siting criteria are mentioned in tower studies in combination with other factors, such as tower lighting and height, which are addressed specifically for those study aspects. Tower siting is important in some areas to reduce the collision risk to birds, although insufficient information is available to draw conclusions as to the specific factors associated with siting towers.

3.3.5.5 Specific Respondent Comments

NAB stated that the USFWS' (2000) voluntary guidelines recommending against siting towers in areas that historically exhibit conditions with storm events or frontal systems, especially during spring and fall migrations, is unworkable because this suggested criteria could characterize a vast majority of territory. No specific information was provided.

The USFWS observed that because of their extensive use by avian populations, wetlands are some of the least desirable locations to site towers; however, they stated that information is still needed to support a minimum distance from wetlands to construct towers. The agency indicated that ongoing studies on Michigan State Police towers (see Section 3.4.1), as well as U.S. Coast Guard's (USCG) proposed "Rescue 21" project (see Section 3.4.6) next to the Great Lakes and along the U.S. coastline hopefully will provide the additional information needed to support guidance on where to site towers in, around, or near water or wetlands. They also acknowledged that impacts from communication towers situated on ridges, mountains, and other high ground are not well known. The USFWS stated that studies on cell towers in the National Forests in Arizona (see Section 3.4.3) also should begin to provide some useful data regarding this issue.

3.3.6 Tower Lighting

3.3.6.1 Current State of Knowledge – General

For aviation safety, tower lighting is required for towers exceeding 199 feet in height. Lighting specified by the FAA has traditionally included steady red lights, pulsating/flashing red lights, and/or white strobe lights. Historically, both lights and radio signals were implicated as potential factors for disorienting birds and thus contributing to the increased mortality rates reported for communication tower sites. However, the behavioral effects of radio signals on birds are poorly understood and are not usually identified as the major cause of tower kills. Limited studies suggest that bird behavior around communication towers is similar whether or not the tower is transmitting.

More compelling is the growing body of evidence that birds may be attracted to tower lights, and certain colors and flash patterns may have disorienting effects, especially during inclement weather conditions where the tower illumination bounces and refracts off a myriad of water droplets suspended in the air to create an aura of light and a greater illuminated space around the tower (Avery et al. 1976). Historically, birds have appeared to be "attracted" to artificial light sources from lighthouses and buildings (Ogden 1996). However, it is unclear whether birds are actually attracted to a light source and move toward it or whether the birds are "trapped" by the light during their nocturnal flights (Ogden 1996).

IW 61

Briefing Paper on the Need for Research into the Cumulative Impacts of Communication Towers on Migratory Birds and Other Wildlife in the United States

Division of Migratory Bird Management (DMBM), U.S. Fish & Wildlife Service – for Public Release

LAST UPDATED: January 23, 2009 [Comm Tower Research Needs Public Briefing-2-109.doc]

ISSUE: The number of communication towers including radio, television, cellular, microwave, emergency broadcast, national defense, and paging towers has grown exponentially in the U.S. over the past decade. These towers present health and safety challenges for humans, but they are also a growing impact to populations of migratory birds, 4-5 million of which are conservatively estimated to die each year in tower and guy-wire collisions (Manville 2005). Virtually unknown, however, are the potential effects of non-ionizing, non-thermal tower radiation on avifauna, including at extremely low radiation levels, far below maximum safe[1] exposure levels previously determined for humans.

This briefing paper addresses the need to cumulatively assess the impacts of communication towers on migratory birds both from collisions and radiation, especially neotropical migratory songbirds that are most impacted (Shire *et al.* 2000). The paper discusses some suggested research protocols needed to conduct a nationwide cumulative impacts analysis that would assess effects of tower collisions and radiation on avifauna and on other wildlife pollinators including bats and bees.

BACKGROUND

Light Attraction to Birds in Inclement Weather

Beginning with the earliest reported bird-tower kill in the U.S. (in September 1948 at a 137-m [450-ft] radio tower in Baltimore, MD [Aronoff 1949]), the nighttime attraction of lighting during inclement weather has proved to be a key liability for birds. However, much of the past research focused on carcass collections that were not necessarily correlated to nighttime lighting or to weather events. For example, the first long-term study of the impact of a television tower on birds began in 1955 by the Tall Timbers Research Station in FL. After the first 25 years of the study, 42,384 birds representing 189 species were tallied (Crawford and Engstrom 2001). Kemper (1996) reported collecting more than 12,000 birds killed in inclement weather on one night at a television tower in Eau Clair, WI. Manville (2005, 2007) provided additional details of documented bird-tower collision studies in the U.S., especially in regard to lighting and weather events.

Recently, Gehring *et al.* (2006, 2009) reported where red, steady-burning lights were extinguished allowing only flashing or strobe lights to persist on towers, the lighting change-out resulted in up to a 71% reduction in avian collision mortality at towers in MI. In a short-term

[1] "Safe" levels were based on thermal heating standards, now inapplicable. The standards are nearly 25 years out of date, and the EPA office tasked to direct the human safety issues was eliminated due to budget cuts in the early 1980s. Furthermore, the standards in place do not address the potential effects of radiation on wildlife. 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 on both humans and wildlife 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).

study, Evans *et al.* (2007) looked at lighting attraction at ground level in complete cloud cover, but found that neither red, steady-burning nor red flashing lights induced bird aggregation. They hypothesized 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. Additional studies are underway to better understand the mechanisms of lighting attraction.

Published research protocols developed to count and estimate bird-tower kills have been developed (*e.g.,* Avery *et al.* 1978, Manville 2002, Derby *et al.* 2002, and Gehring *et al.* 2009) and will be briefly reviewed below for use in future cumulative effects assessments for both collision and radiation studies.

Potential Radiation Impacts to Birds

In 2002, T. Litovitz (Catholic University, pers. comm.; DiCarlo *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 embryos under laboratory conditions. Litovitz noted deformities, including some deaths of the embryos subjected to hypoxic conditions under extremely low radiation doses[2].

Preliminary research on wild birds at cellular phone 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, White Storks, Rock Doves, Magpies, Collared Doves, 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 (2004, 2005) noted that the White Stork appeared most heavily impacted by the tower radiation during the 2002-2004 nesting season in Spain. Manville (2005) reported Balmori's (2003) preliminary results, and raised concerns of similar events in the U.S.

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' preliminary conclusion, 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 electromagnetic radiation in Valladolid, Spain.

Of concern to DMBM are the potential impacts of radiation on bird populations. Beason and Semm (2002) tested neural responses of Zebra Finches 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 radiation impacts to wild bird populations. Magnetite, a mineral highly sensitive to electromagnetic frequencies (EMFs), has been discovered in human, bird, and fish brains. It has been suggested that 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). Communication tower radiation in the U.S. may already be impacting breeding and migrating populations of birds, bees, and other wildlife, based on research conducted in Europe. It is therefore important to gain a far better understanding of the

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[2] *i.e.,* doses as low as 1/10,000 below the allowable "safe" level of radiation (T. Litovitz 2002 pers comm.; DiCarlo *et al.* 2002).

suspected impacts of radiation on birds and other wildlife, particularly if those suspected impacts are having effects on species at the population level.

Potential Radiation Effects on Other Pollinators

Radiation has also been implicated in effects on domestic honeybees, pollinators whose numbers have recently been declining due to "colony collapse disorder" (CCD) by 60% at U.S. West Coast apiaries and 70% along the East Coast (Cane and Tepedino 2001). CCD is being documented in Greece, Italy, Germany, Portugal, Spain, and Switzerland. One theory regarding bee declines proposes that radiation from mobile phone antennas is interfering with bee navigational systems. Studies performed in Europe have documented navigational disorientation, lower honey production, and decreased bee survivorship (Harst *et al.* 2006, Kimmel *et al.* 2006, Bowling 2007). This research needs further replication and scientific review, including in North America. Because pollinators, including birds, bees, and bats, play a fundamental role in food security (33% of our fruits and vegetables would not exist without pollinators visiting flowers [Kevan and Phillips 2001]), as pollinator numbers decline, the price of groceries goes up.

Harst *et al.* (2006) performed a pilot study on honeybees testing the effects of non-thermal, high frequency electromagnetic radiation on beehive weight and flight return behavior. They found that of 28 unexposed bees released 800 m (2,616 ft) from each of 2 hives, 16 and 17 bees returned in 28 and 32 minutes, respectively, to hives. At the 1900 MHz continuously-exposed hives, 6 bees returned to 1 hive in 38 minutes while no bees returned to the other hive. In exposed hives, bees constructed 21% fewer cells in the hive frames after 9 days than those unexposed. Harst *et al.* selected honeybees for study since they are good bio-indicators of environmental health and possibly of "electrosmog." Because of some concerns raised regarding the methods used to conduct the Harst *et al.*(2006) study, specifically the placement of the antenna where bees could contact it (*i.e.,* potentially a bias), the experimental methods need to be redesigned and the studies retested to better elucidate and fine tune the impacts of radiation. The results, while preliminary however, are troubling. Kimmel *et al.* (2006) performed field experiments on honeybees under conditions nearly identical to the Harst *et al.* (2006) protocol except that bees were stunned with CO_2 and released simultaneously 500 m (1,635 ft) from the hives. However, in one of their experimental groups, they shielded the radiation source and antenna in a reed and clay box to address potential biases raised in the Harst *et al.* study. Sixteen total hives were tested, 8 of which were irradiated. After 45 minutes when the observations were terminated, 39.7% of the non-irradiated bees had returned to their hives while only 7.3% of the irradiated bees had.

RESEARCH DISCUSSION

If communication tower collisions are killing 4-5 million or more birds per year in the U.S. due to collisions, what impact – if any – might radiation have on avifauna? Bees? Other wildlife? We simply do not know. In 2000, the Communication Tower Working Group (chaired by DMBM/Manville) developed a nationwide tower research protocol that would assess cumulative impacts from tower collisions nationwide, suggesting the use of some 250 towers of different height, lighting, and support categories. The preliminary cost estimate for a 3-year study was $15 million. No funding was ever acquired and the collision study has not yet been conducted.

The proposed 2000 study was to focus on the collision impacts of communication towers to birds during spring and fall migrations, but the same types of mortality monitoring could be conducted during the late spring/summer breeding seasons, looking particularly for evidence of injury and death to breeding birds in close proximity to communication towers. Radiation levels would need to be measured at the tower sites and nests adjacent to the towers during nesting activity, and bird behavior would also need to be monitored throughout the breeding season. Laboratory necropsies would need to be performed on birds and other wildlife suspected of impacts from radiation to better understand what caused their deaths and to verify that they did not die from blunt force trauma from tower or wire collisions. Pre-construction studies should be performed to assess habitat use by breeding and resident avifauna. Post-construction studies should assess site abandonment, development of deformities, injuries, and deaths. A careful review of the protocols developed by Balmori (2004, 2005), Balmori and Hallberg (2007), Everaert and Bauwens (2007), and others is critical because similar studies should be performed in the U.S.

METHODS FOR ASSESSING AVIAN COLLISION MORTALITY

Methods for Assessing Tall Tower Mortality

Bird strike mortality studies at "tall"[3] communication towers conducted previous to research performed by Avery *et al.* (1978) indicated that most dead birds were found within 60 m (197 ft) of the central communication tower structure. Avery *et al.* assessed songbird mortality at a 369-m (1,210-ft) Omega Loran U.S. Coast Guard tower in ND. Based on daily monitoring during 3 fall and 2 spring migration seasons, 63% of the birds they found dead or injured at this tower were within 92 m (300 ft) of the tower. Avery *et al.* placed tagged bird carcasses (*e.g.*, House Sparrows and European Starlings) in catchment nets and on non-netted habitats (*e.g.*, gravel pads, roads, and marshy plots) to assess persistence and scavenging/predation loss. They completely examined the inner 46-m (150-ft) radius of the tower (concentric circle designated "A") for bird carcasses, including both the areas covered with catchment nets and the non-netted areas. Placing tagged carcasses in random search plots, which are then found or not found and/or removed or not removed, helps determine biases (Erickson *et al.* 1999). However, there are inherent problems associated with using tagged bird carcasses, including the attraction of predators, cost, availability, and adequate sample size (D. Strickland, WEST Inc., pers. comm.).

In addition to the total area assessed during this study (168 ha [415 ac]), for the remainder of the search area, Avery *et al.*(1978) divided the habitat into concentric circles of radii 92 m (designated "B"; 303 ft) , 183 m (C; 600 ft), and 731 m (D; 2,398 ft), respectively. Two compass lines (north-south and east-west) divided B, C, and D into 12 substrata beyond the inner core. In each of the substratum, 2 net catchment sampling plots, 12.4 m (41 ft) on a side, were randomly selected. Nylon netting suspended on steel frames 1.5 m (5 ft) high, with the net's center anchored to the ground, was utilized. See Manville (2002) beyond for additional net details.

Sampling nets were demonstrated by Avery *et al.*(1978) to be highly effective in preventing losses to scavengers and predators; none of 33 of the test birds placed in nets during the Avery *et al.* study were taken during the first night, but 12 of 69 test birds placed on non-netted gravel sampling plots were taken during the same period. During the Avery *et al.* study, dead bird searches were made daily at dawn during the peak of songbird migration. In a study at a Tallahassee, FL, television tower – where sampling nets were not used – scavenging was considerably higher; only 10 of 157 birds were left undisturbed after one night (*i.e.*, 93.6% scavenging; Crawford 1971).

Homan *et al.* (2001) placed carcasses of House Sparrows in dense vegetation, comparing searcher efficiencies of humans and canines. The dogs received no special training in carcass searching.

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3 hereafter, towers greater than 61 m (199 ft) above ground level (AGL), generally guyed, and always lit at night.

Thirty-six trials were conducted in 5 x 40–m (16 x 131-ft) study plots. Humans found 45% of the carcasses while dogs found 92%. The ratio of recovered to missed carcasses was approximately 12:1 for dogs and 1:1 for humans, making dogs much more efficient in finding carcasses. Searcher efficiencies were not improved but remained similar when testing residual cover (April searches) versus new growth cover (August searches). Because the protocol in the Homan *et al.* study improved quantitative and qualitative assessments, it provides considerable promise for the research initiatives being proposed in this briefing paper.

Arnett (2006) further tested the dog-search protocols of Homan *et al.* (2001) and others, assessing the abilities of dog-handler teams to recover dead bats at 2 commercial wind turbine facilities. Dogs found 71% of the bats placed during searcher-efficiency trials at Mountaineer, WV, and 81% of those at Meyersdale, PA, while human searchers found only 42% and 14% of the carcasses, respectively. Both dogs and humans found a high proportion of the trial bats within 10 m (33 ft) of the turbine tower, usually in open ground (88% and 75%, respectively). During a 6-day fatality search trial at 5 Mountaineer turbines, dog-handler teams found 45 carcasses while human searchers during the same period found only 19 (42%). As vegetation height and density increased, humans found fewer carcasses while dog-handler team searcher efficiencies remained high. Arnett's (2006) study further reinforces the hypothesis that use of dogs greatly improves efficiencies in finding dead bats very similar to what Homan *et al.* (2001) found for locating passerines. Dog use should be given serious consideration in conducting bird and bat mortality studies at telecommunications towers.

From 2003 through 2005, Gehring *et al.* (2006, 2009) studied 24 tall communication towers in MI. They used flagged, straight-line transects, each technician walking at a rate of 45-60 m (147-196 ft) per minute and searching for carcasses within 5 m (16 ft) on either side of each transect, as suggested by Erickson *et al.* (2003). The transects covered a circular area under each tower with a radius equal to 90% the height of the tower. The straight line transects were much easier to navigate than were circular transects (J. Gehring, Michigan Natural Features Inventory, pers. comm.). Due to dense vegetation, observer fatigue, human error, scavenging by predators, and crippling loss of birds and bats that may have escaped the detection area, Gehring *et al.* tested each technician's observer detection rate and rate of carcass removal. Ten bird carcasses of predominately Brown-headed Cowbirds, with painted plumage to simulate fall song bird migration plumage, were placed once each field season within each study plot to assess observer efficiencies. Likewise, 10-15 predominately Brown-headed Cowbirds were placed by each technician at the edge of designated tower search area to monitor the daily removal of carcasses by scavengers. These carcasses were not painted to avoid placing any foreign scent on them. No catchment nets were used in this study.

Methods for Assessing Short Tower Mortality

Manville (2002) developed a protocol for the U.S. Forest Service (USFS) to study the effects of cellular telecommunications towers on birds and bats, recommending use of elevated catchment nets for a Coconino, Kaibab, and Prescott National Forest study in AZ. Modifying the Avery *et al.* (1978) search protocol, Manville suggested use of 1.9-cm (0.75-in) mesh knitted polyethylene nets, 15 x 15 m (50 x 50 ft) in size, suspended 1.5 m (5 ft) above ground, with 8 gauge monofilament nylon line attached around the periphery of the entire net, supported with 2-m-long (6.5-ft) steel angle posts driven into the ground and spaced every 2-3 m (7-10 ft) apart. He recommended pulling the center of each net close to the ground, securing with monofilament to a cinder block, thus creating a downslope gradient from the edge of the net to its center so a carcass landing in the net would tend not to be blown from the netting edge to the ground by a strong wind. He did not recommend using a wooden lip on the net's edges as Avery *et al.* (1978) had suggested. Materials for each net were estimated to cost $320 (Avery and Beason 2000).

Manville (2002) postulated that use of elevated catchment nets would make finding dead birds killed by tower strikes more reliable, especially under variable habitat conditions (*e.g.*, unsuitable substrate for searching, tall grass, shrubs, roots, boulders, or trees). Manville recommended breaking down the tower's circumference into 3, 120° arcs, then breaking the study plot into 2 concentric circles. The radius of the first circle from the tower's center was 30 m (100 ft) and nets were to be randomly deployed to cover 24% of the total area of that concentric circle, 1 net randomly placed in each 120° arc. For the second concentric circle (30-60 m in radius from the center [100-197 ft]), nets were placed randomly in 8% of the total area, 1 net randomly placed in each of the 3 arcs.

Manville (2002) did not recommend using tagged bird carcasses in the AZ study because he believed that double sampling would address sampling efficiency biases. Double sampling involves (1) net sampling, allowing for an estimate of the number of carcasses that fall beneath each tower and are relatively unbiased for searcher efficiency and carcass removal, and (2) ground sampling where biases are inherent. For short towers, he recommended the entire area the radius of the tower height be completely searched (including under the nets) at dawn each day during the migration season and once weekly during the breeding season. Net sampling allows for adjustment of the ground sampling estimates that would correct for carcass removal and searcher efficiency bias based on the relative difference of the number of carcasses found using the 2 sampling methods at each communication tower studied.

Manville (2002) indicated that the probability of catching a bird in a net would change with increased distance from the tower (*i.e.,* birds my fly or be carried by the wind for a distance before dying). He suggested that if there is a bias because birds tend to die greater than 30 m (100 ft) from a short tower, probabilities can be determined by searching strip transects that radiate from a tower. He recommended using a transect 1.5- 2 times the height of the tower, 15 m (50 ft) wide, placed on a randomly selected compass line. Carcass searches within the transect should help to estimate the area that should be sampled by nets, develop a correction factor outside the radius of the area sampled by the nets, and improve the correction factor for ground surveys conducted exclusive of the net surveys. Manville suggested this transect survey be conducted at least once per week, preferably in the early morning hours, during both migration and breeding seasons. With the recent use of trained dogs to detect and locate dead and injured birds and bats, where dogs have been shown to be at least 50% more effective in finding carcasses, dog use should be considered a viable monitoring alternative (E. Arnett, Bat Conservation International, pers. comm., Homan *et al.* 2001, Arnett 2006).

Derby *et al.* (2002) modified the Manville (2002) protocol to conduct the cellular telecommunications tower study in AZ for the USFS. There, 6 of the 7 cell towers were surrounded by 3-m (10 ft) walls, 29 m (95-ft) long on each side. The walled square was divided into 4 equal blocks, and within 1 of these blocks a 12 x 12-m (40 x 40-ft) nylon mesh net was randomly placed based on net specifications recommended by Manville (2002) but placed > 3 m (10 ft) above the ground to allow company personnel to perform maintenance on the sites. Outside the walled compounds, Derby *et al.* used 4, 6 x 6-m (20 x 20-ft) nets, 3 of the nets randomly set outside the wall to a distance of 30.5 m (100 ft) from the tower, and the 4th net randomly placed in the band from 31 to 61 m (100-200 ft) from the tower. Inside the walled compound the entire area was searched by walking transects 6 m (20 ft) apart (3 m [10 ft] search width). The surveys were performed at dawn 4 times per week during peak songbird migration.

Derby *et al.* (2002) also recommended using straight line transects, 4 oriented perpendicular to the walls, and 4 diagonal from the corners of the wall – representing the "spokes of a wheel."

Each transect was 61 m (200 ft) long, and 6-m (20 ft) wide. Because the Derby *et al.* protocol also used double sampling, no tagged carcasses were used in their study.

Both Manville (2002) and Derby *et al.* (2002) recommended daily searches of all electrical wiring to assess for electrocution and wire collision mortality.

Homan *et al.* (2001) used Labrador retrievers and a Chesapeake Bay retriever to search 6 plots, 5 x 40 m (16 x 131 ft) in size, delineated by flagging, to detect 8 thawed House Sparrow carcasses randomly thrown in each of the plots from 1 m (3 ft) outside the plot, allowing the human or human-dog team to search each plot for 10 minutes. Dogs were kept on 5-m (16-ft) leashes during searches. Humans were active searchers when using the dogs. Searches were not conducted during steady rain or when winds were ≥ 32 km/hr (20 mph). The technique with leashed dogs could easily be used to survey both tall and short tower plots, based on the protocols previously recommended. With the dogs confined to leashes, additional training would be unnecessary.

Arnett (2006) used 2 trained chocolate Labrador retrievers to locate test bat carcasses of different species and in different stages of decomposition at commercial wind turbine facilities on the Appalachian Mountain front in PA and WV. His dogs were trained in basic obedience, "quartering" (*i.e.,* systematically searching back and forth in a 10-m-wide [33 ft] transect), and blind retrieval handling skills. The dogs were trained with dead bats 7 days prior to field trials. When a dog found a test bat, the dog was rewarded with a food treat if it performed the task of finding the bat, sitting or stopping movement when given a whistle command to do so, and leaving the carcass undisturbed. Arnett walked the transect lines at a rate similar to that of humans (*i.e.,* approximately 13-25 m/min [43-82 ft/min]) while the dogs were allowed to quarter the entire width of the transect (5 m [16 ft] on either side of the center line). While this technique was tested on bats, it also shows great promise for use on birds. Dogs would require additional training, but unlike the Homan *et al.* (2001) technique, they would not need to be leashed. The Arnette technique also shows great promise for use at both tall and short communication towers to locate dead birds and bats.

METHODS FOR ASSESSING RADIATION IMPACTS TO BIRDS

Methods for Assessing Radiation Impacts at Tall Towers

At present, radiation studies at tall towers in Europe have not yet been conducted since the impacts to birds and other wildlife have been documented at short, cellular communication towers. The methods suggested below for short tower radiation studies should also be applicable to future tall tower radiation studies.

Methods for Assessing Radiation Impacts at Short Towers

Balmori (2005) selected 60 nests of White Storks in Valladolid, Spain, to monitor breeding success, visiting each nest from May to June 2003, taking care to select nests with similar characteristics located on rooftops. Tree nests were not studied. Nests were selected based on very high (N=30) or very low (N=30) exposure levels of electromagnetic radiation, depending on the distances nests were located from the cell towers. Thirty nests were within 200 m (656 ft) of the towers, while the remaining 30 were located > 300 m (981 ft) beyond any tower. Chick productivity was closely observed. Electric field intensities (radiofrequencies and microwave radiation) were measured using a unidirectional antenna and portable broadband electric field meter set at 10% sensitivity. Between February 2003 and June 2004, 25 visits were made to nests located within 100 m (327 ft) of 1 or several cell phone towers to observe bird behavior. The visits were made during all phases of breeding, from nest construction until Stork fledging. RFs and EMFs were also measured at all nest sites using a unidirectional antenna and field meter.

Balmori and Hallberg (2007) studied the urban decline of House Sparrows in Valladolid, Spain, since this species is in significant decline in the United Kingdom and western Europe, and because it usually lives in urban environments, where electromagnetic contamination is higher. They felt it would be a good biological indicator for detecting the effects of radiation. Forty visits, approximately 1 per month were made between October 2002 and May 2006, and were performed at each of 30 point transect locations (*i.e.*, point counts, the protocol recommended by Bibby *et al.* 2000) between 7 a.m. and 10:00 a.m. by the same ornithologist following the same protocol. At each transect site, all sparrows heard and seen were counted, without differentiating birds by sex and age, and radio frequencies and levels of microwave radiation were recorded using a unidirectional antenna and a portable broadband electric field meter set at 10% sensitivity. Bird densities from each point were calculated based on the number of sparrows per hectare.

Everaert and Bauwens (2007) counted male House Sparrows during the breeding season at 150 point locations (Bibby *et al.* 2000) in 6 residential districts in Belgium, each point location situated at variable distances (mean= 352 m [1,151 ft]; range= 91- 903 m [298- 2,953 ft]) from nearby cell phone antenna towers. Point counts were conducted for 5 minutes, all male House Sparrows heard singing or visible within 30 m (98 ft) were counted, counts occurred between 7 a.m. and 11:00 a.m. when males were most active, and counts were conducted only during favorable weather conditions. Electric field strengths at 900 MHz and 1800 MHz were measured for 2 minutes at each frequency using a portable calibrated high-frequency spectrum analyzer with a calibrated EMC directional antenna. To measure maximum radiation values, the EMC antenna was rotated in all directions.

METHODS FOR ASSESSING RADIATION IMPACTS TO BEES

Methods for Assessing Radiation Impacts to Bees

Harst *et al.* (2006) exposed 4 beehives to 1900 MHz radiation from an antenna placed at the bottom of each hive immediately under the honeycombs, while they left 4 hives unexposed. Each of the 8 colonies contained approximately 8,000 bees. They were set up in a row, with a block of 4 hives equipped with DECT (Digital European Cordless Telecommunications) stations on the bottom of each hive. Metal lattices were installed between the exposed hives to avoid possible effects to the non-exposed control group. The average transmitting power per station was 10 mW, with peak power at 250 mW. The sending signal was frequency modulated and pulsed with a pulsing frequency of 100 Hz. A transparent 10 cm (4 in) plastic tube with a diameter of 4 cm (1.6 in) was mounted at the entrance of each hive to collect single bees and watch them return later to the hives. Twenty-five bees from each hive were randomly selected, stunned in a cooling box, marked with a marker dot on the thorax, and released 800 m (2,616 ft) away from the hives. All marked bees were released simultaneously and were timed from the moment of their release. Return times were noted as the bees each entered the plastic tubes, with the observation lasting 45 minutes. Any bees returning after 45 minutes were disregarded. Bees were able to touch the radiation sending antenna within the hive. Some have asserted that the antenna placement may have resulted in a behavioral bias in regard to bee response, raising a legitimate concern about the methods used to test bee response to radiation in this experiment.

Harst *et al.* (2006) also studied the effects of radiation on bee building behavior using the protocol discussed above. They photographically documented change in honeycomb area, and measured development of honeycomb weight for each hive. Sixteen colonies were selected for this experiment, 8 of which were irradiated, all aligned in a row. At the beginning of the experiment, the empty honeycomb frames were weighed, the hives were filled with bees (400 g [14 ounces]), and provided 250 ml (0.26 quart) food. Bees were fed 2 more times during the 9-day experiment. The honeycombs were photographed each day. The placement of the sending antenna, as previously suggested, may have altered bee behavior and hive productivity.

Kimmel *et al.* (2006) tested 16 bee colonies, 8 of which were irradiated. The experiment was nearly identical to that utilized by Harst *et al.* (2006) except that the sending antenna in 1 experimental group was shielded in a reed and clay box to address concerns about behavioral biases raised in the Harst *et al.* study. Bees were paralyzed using CO_2 instead of cold and were simultaneously released 500 m (1,635 ft) from the hives instead of 800 m (2,616 ft).

RESEARCH RECOMMENDATIONS FOR ASSESSING AVIAN COLLISION IMPACTS

Tall Tower Collision Research Recommendations

We recommend using either the Avery *et al.* (1978) or the Gehring *et al.* (2006, 2009) protocol for tall tower collision studies, depending on the feasibility and availability of catchment nets and dead bird carcasses. Avery *et al.* provided the opportunity to use catchment nets, testing searcher efficiency and carcass removal by placing test carcasses on site (in nets and on the ground). The protocol presumes that the majority of carcasses will be found within a certain distance of the tower's base. The protocol has particular utility for studying very tall towers, especially where terrain around the structures is highly variable and difficult to traverse. It can be used as a standing protocol, or modified as a hybrid based on combining other techniques suggested within this paper such as the use of dogs (Homan *et al.* 2001, Arnett 2006). Dogs have tremendous promise for both tall and short tower studies. If trained hunting dogs are used, then the Arnett (2006) protocol is an excellent tool since the dogs can be used off-leash. However, if untrained hunting dogs are available, then the Homan *et al.* (2001) protocol using leashed dogs is an excellent option.

Gehring *et al.* (2006, 2009) also successfully assessed mortality at tall towers, but catchment nets were not deployed in this study. Due in part to timing, budget constraints, and number of towers studied, this protocol has significant utility where many towers need to be studied. It could also be modified by using trained dogs or incorporating catchment nets.

The statistical designs for both short and tall tower studies – both for assessing collisions and radiation impacts, should be worked out with qualified biometricians. Both the USFWS and the USGS/Biological Resources Discipline (BRD) have well qualified statistical expertise. They should be consulted early in the development of a proposed study.

In both short and tall tower studies, data collection must include all of the following: time of day each tower is examined, time spent searching each site, time since the last search, and weather conditions, particularly inclement weather. Weather data should include the previous night's temperature, wind, cloud cover (clear if < 10% cover, partly cloudy 10-90% cover, or overcast > 90% cover), barometric pressure, rainfall, fog, obscuration, and other relevant weather conditions (Derby *et al.* 2002).

When bird and bat carcasses, and injured vertebrates are found, regardless of the sampling method, data must include tower identification number, name of species (if known), date of collection, closest transect, distance from the tower, azimuth to the tower, exact mapped location (GPS coordinates are very helpful), estimated number of days since death/injury, body condition, probable cause of death, and evidence of scavenging. The carcass is to be collected, numbered, and saved to be used in other investigations (Gehring *et al.* 2009) for which a Federal and possibly state salvage permit will be required (Manville 2002).

Short Tower Collision Research Recommendations

Depending on the availability and utility of catchment nets and the layout of the tower site, we recommend using either the Manville (2002), the Derby *et al.* (2002), Homan *et al.* (2001), or the Arnett (2006) protocols – the latter 2 with greatly improved searcher efficiency, or a hybrid of these methodologies. Manville (2002) suggested using elevated catchment nets, but due to double sampling, he did not recommend using tagged bird carcasses. He also recommended using random transects to adjust for biases.

Derby *et al.* (2002) modified the Manville (2002) protocol, specifically in regard to challenges created by the tower study site in AZ. A randomly-placed catchment net was used within the walled enclosure of each of the sites, and the entire area within the walled compound (ground and net) was searched. Four randomly placed catchment nets were also utilized beyond the walls. Due to double sampling, no tagged bird carcasses were utilized. The protocol could be used as a free-standing technique but should be searched daily during the entire peak of bird migration.

RESEARCH RECOMMENDATIONS FOR ASSESSING RADIATION IMPACTS TO BIRDS

Tall Tower Radiation Research Recommendations

For both short and tall tower studies, any nests close to a tower should be noted, with its GPS coordinates recorded. Breeding, nest success, and survivorship should be monitored, where possible. How birds use their habitats for breeding and residence should be noted, including any issues of site abandonment, egg and clutch failure, development of deformities, injuries, and deaths.

For both short and tall tower studies, where birds appear to be injured or killed by radiation, proximity of the bird/carcass to known nest or roost sites and towers should be noted. Radiation levels at the tower, carcass site, and the nest site should be recorded. Any abnormal behaviors should also be described. Laboratory necropsies should be performed on birds and other wildlife suspected of impacts from radiation to better understand what caused their deaths and to verify that they did not die from blunt force trauma due to collisions. Tower and ambient radiation should be measured using equipment and techniques suggested by Harst *et al.* (2006) and Kimmel *et al.* (2006), or variations of equipment and methods available in the U.S. See the methods section of this paper for specifics.

Where carcass counts need to be assessed at specific tall towers, we suggest using the tall tower collision mortality protocols, discussed above in the methods section of this paper.

Short Tower Radiation Research Recommendations

Depending on the avian species being studied, we recommend using the Balmori (2005) protocol for assessing potential impacts to colonial nesting species such as herons and egrets. Where passerines are to be studied, we suggest the use of the Everaert and Bauwens (2007) and Balmori and Hallberg (2007) protocols for assessing potential impacts. Refer to the methods section above for specific details.

Where carcass counts need to be made at specific short towers, we recommend using the short tower collision mortality protocols, discussed above in the methods section.

RESEARCH RECOMMENDATIONS FOR ASSESSING RADIATION IMPACTS TO BEES

Bees and other pollinators also deserve close scrutiny from the potential impacts of radiation, and their study should be included as part of the overall research effort suggested in this paper. In addition to testing and validating the protocol and results from the Kimmel *et al.* (2006) study (see background and methods sections above), which we recommend be performed at multiple locations in the U.S., bee behavior, hive productivity, and bee survivorship need to be field-tested at both tall and short towers in the U.S. Variations on the protocols used by Harst *et al.* (2006) and Kimmel *et al.* (2006) could easily be developed to field-test potential radiation impacts on bee navigation, flight behaviors, hive productivity, and bee survivorship around both short and tall towers. However, any research protocol developed to assess potential insect impacts – and for that matter, impacts to birds, bats, and other wildlife, must attempt to eliminate extraneous variables that may bias study results. These include everything from antenna placement in the Harst *et al.* (2006) study, to the impacts of diseases, parasites, weather and climatic events, pesticides, contaminants, and other mortality factors on insects and other wildlife. Fine-turning a research protocol must include the combined efforts of trained entomologists, research radiation specialists, ornithologists, wildlife biologists, and biometricians.

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