Species Composition of Birds Killed at Communication Towers in North America

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ABSTRACT

Birds migrating to and from North American breeding grounds are attracted to the lights of communication towers and associated infrastructures and are killed in the millions in collisions with the structures and their guy wires. Avian mortality at towers is not even across species, and the relative importance to populations depends on the status of the species and their vulnerability. Building on our previous estimate of avian mortality at communication towers we, for the first time, estimate mortality by bird species and by geographic regions. To do this, we constructed a database of mortality by species at towers from available records and calculated the mean proportion of each species killed at towers within aggregated Bird Conservation Regions. These proportions were then combined with mortality estimates that we previously calculated for those regions. We compared our estimated bird mortality rates to the estimated North American populations of affected species. Neotropical migrants suffer the greatest mortality; 95% of birds killed are passerines, mostly warblers (Parulidae, 57%), vireos (Vireonidae, 11%), sparrows (Emberizidae, 7%), and thrushes (Turdidae, 6%). Many U.S.-designated Birds of Conservation Concern suffer mortality equivalent to several percent of their estimated total population size, including Bay-breasted Warbler, Swainson's Warbler, Harris's Sparrow, Black-throated Blue Warbler, Golden-winged Warbler, Yellow-throated Warbler, and Kentucky Warbler. Mitigation measures for these impacts are available, particularly changing the lighting scheme on towers, discouraging the use of guy wires, and careful review of proposed tower locations.

KEY WORDS

Communication towers, mortality, night lighting, neotropical migrants, collisions, impact assessment

INTRODUCTION

The deaths of birds from collision with human-made structures is an issue of ongoing conservation concern (Manville 2005; Drewitt and Langston 2008; Longcore et al. 2008; Manville 2009). Mortality at communication towers has generated long-term studies at single sites (e.g., Kemper 1996; Crawford and Engstrom 2001), many incidental observations (Weir 1976; Avery et al. 1980; Trapp 1998; Kerlinger 2000), and comparative studies across towers in several regions (Johnston and Haines 1957; Seets and Bohlen 1977; Morris et al. 2003; Gehring et al. 2009). The U.S. Fish and Wildlife Service (USFWS) has estimated avian mortality from communication towers at 4–5 million birds per year and released guidelines designed to minimize such mortality (U.S. Fish and Wildlife Service 2000) and we have recently updated that estimate and independently derived an estimate of 3.9 million birds per year (Longcore et al. in review). The USFWS has also made recommendations to the Federal Communications Commission (FCC) on how to further reduce "take" (Manville 2007) and Environment Canada is currently undertaking assessments of incidental mortality at towers as part of a comprehensive effort to address incidental mortality in general.

An assessment of the biological significance of avian mortality at communication towers would be greatly aided by estimates of mortality for individual species (Longcore et al. 2005). Biological significance is not a term in widespread usage within conservation biology, but a logical definition might be that a biologically significant impact would adversely affect a species or its habitat and could be expected to affect the population growth or stability of the species and influence the population's long-term viability. Where a stable population is designated as having a lambda of 1.0, anything < 1.0 would indicate a declining population, ultimately resulting in a "biologically significant effect" on the population in question, threatening its stability and

persistence.

This is not an entirely obvious answer, however, and others have concluded that what constitutes a biologically significant population change is not easy to define (Reed and Blaustein 1997). Any change in a population has some biological consequence to other species, and consequently any population decline (or change) is important to some species and the decision of whether it is significant or not may be an arbitrary one (Reed and Blaustein 1997). Biological significance in this context should not be confused with a statistically significant trend in a biological variable. Although statistical significance may influence the judgment of whether an impact is biologically significant, it is not a prerequisite.

For evaluation of the biological significance of mortality, species or populations should be the unit of analysis in most instances. For example, barbed wire fences kill a relatively small proportion of birds compared with such hazards as windows and feral and free-roaming cats, but barbed wire fences are a biologically significant source of mortality for whooping cranes, an endangered species (Allen and Ramirez 1990). Higher taxonomic groups, such as families, or even guilds that cut across taxonomic groups may be appropriate if something is known about the conservation status of these units as a whole. For example, oil pits where slurry is disposed of at energy facilities kill an estimated 500,000–1,000,000 birds per year (Trail 2006). Interpretation of this number is made possible by documenting mortality at oil pits of 162 species, of which 63% were ground-feeding birds, including species of conservation concern (Trail 2006). Mortality at communication towers, up to this point, has been interpreted as being of conservation concern because of the general knowledge that the species predominantly killed at towers are neotropical migrants, especially warblers, which are of conservation concern as a group. Beyond this general observation, no estimates have been made of the species

96 composition of the roughly 4 million birds killed annually at communication towers.

97 In this paper, we combine our previous geographically stratified estimate of avian mortality
98 (Longcore et al. in review) with estimates of the proportion of each bird species killed within
99 different regions to develop geographically explicit tallies of avian mortality at communication
100 towers by species. We chose geographically specific estimates because patterns of avian
101 mortality and tower height vary regionally, and should be incorporated into any estimates. We
102 compare these per-species mortality estimates with population estimates for these species to
103 evaluate the magnitude of this form of mortality.

104 METHODS

105 An estimate of the number of each avian species killed at towers annually can be obtained by
106 multiplying an estimate of total avian mortality for a region by the average proportion of each
107 species found in kills at towers in that region. In a companion manuscript (Longcore et al. in
108 review), we developed an estimate of avian mortality at communication towers in the United
109 States and Canada by Bird Conservation Region. This estimate was built from a regression
110 relating tower height to annual mortality first developed by Longcore et al. (2005, 2008) that
111 used existing studies as raw data and then adjusted annual mortality for search efficiency,
112 scavenging, and sampling scheme of the study. Lower mortality at towers without guy wires and
113 without steady burning lights was incorporated following the results of Gehring et al. (2009).
114 This relationship was then applied to the towers in each Bird Conservation Region (BCR), which
115 had been extracted from digital geographic records for each country. BCRs are divisions defined
116 by habitat and topography that have been delineated for the purpose of bird conservation by the
117 North American Bird Conservation Initiative and are endorsed by a range of bird conservation
118 organizations. They are based on the North American ecoregions developed to promote

119 international conservation efforts (Commission for Environmental Cooperation 1997). The
120 resulting estimate of total annual avian mortality, calculated by BCR, was 3.9 million birds per
121 year (Longcore et al. in review).

122 *Development of per species mortality estimates*

123 We used the approach described by Longcore et al. (2005) to assign the estimated overall
124 mortality to individual species. We conducted an extensive literature search to identify
125 published reports of avian mortality at towers that included complete lists of birds killed. We
126 located these studies from other reviews (Weir 1976; Avery et al. 1980; Trapp 1998; Kerlinger
127 2000; Shire et al. 2000) and directly from other researchers. We recorded these data in a
128 spreadsheet and assigned each tower location to its BCR. For multiple studies of the same or
129 adjacent towers we summed all observations of each species.

130 To develop profiles of birds killed within each BCR we calculated the proportion of each bird
131 species killed at each location within the region and took the mean of these proportions weighted
132 by the number of species documented at that location. We weighted by species number because
133 species number increases rapidly with study length (measured in number of nights sampled) but
134 quickly reaches an asymptote. By using species number as a weight, we emphasize those studies
135 with greater sampling but do not overemphasize the exceptionally long studies or completely
136 discard short studies that may have obtained large samples with many species.

137 We multiplied the proportion of each species killed within each BCR for which there were
138 records by the estimated annual mortality (derived from the tower data and associated
139 regressions by Longcore et al. in review) to produce estimates of the numbers of birds killed of
140 each species within those BCRs.

We combined BCRs where avian mortality at towers has been documented but the records are sparse. Specifically, we combined Shortgrass Prairie with Central Mixed-grass Prairie, Badlands and Prairies with Prairie Potholes, New England/Mid-Atlantic Coast with Atlantic Northern Forest, and Mississippi Alluvial Valley with West Gulf Coastal Plain/Ouachitas and Gulf Coast Prairie, Boreal Hardwood Transition with Prairie Hardwood Transition, and Appalachian Mountains with Piedmont. For the Gulf Coastal Prairie we included a record of mortality at streetlights (James 1956) to develop the species profile because no searches of towers had been reported in the literature from this region. The streetlight kill illustrated the ability of lighted structures to kill migratory birds in this region by attracting and drawing them down to near ground level. We did not assign the bird mortality to species in BCRs in the western United States and Canada where no studies or only single very short studies were found (Dickerman et al. 1998; Ginter and Desmond 2004).

Assessment of biological significance

Ideally, we would have compared mortality to individual populations of species within Bird Conservation Regions. This is not possible because mortality occurs during migrations and mortality cannot be connected to local populations. We instead compared mortality estimates with estimates of total North American population size that are available for conservation planning purposes (Brown et al. 2001; Kushlan et al. 2002; Rich et al. 2004). To assess the status of species killed at towers, we cross referenced them with the most recent list of Birds of Conservation Concern issued by the U.S. Fish and Wildlife Service (2008).

RESULTS

Taxonomic composition of species killed

We assigned mortality to species for the regions east of the Rocky Mountains with sufficient records to describe mortality profiles (Figure 1). The studies contributing to these regional profiles documented 262,925 deaths of 239 species at 73 locations (multiple locations from Gehring et al. 2009 were pooled and used as seasonal summaries using average heights because raw data were not available). We estimated that these regions accounted for 3.65 million annual fatalities, or 94% of all mortality at towers continentwide. Within these regions, 95% of estimated mortality consisted of passerines, with the greatest proportion being warblers (Parulidae, 52.1% of all mortality), vireos (Vireonidae, 11.1%), and sparrows (Emberizidae, 9.5%) (Table 2). For the regions where mortality was estimated by species, 239 species were recorded from tower sites (Table 3). Other studies have documented additional species killed at towers, including Swainson's Hawk and Hammond's Flycatcher in New Mexico (Ginter and Desmond 2004), and additional species in Alaska: Short-tailed Shearwater, Fork-tailed Storm-Petrel, Black-legged Kittiwake, Short-eared Owl (Dickerman et al. 1998) and threatened Spectacled Eider and Steller's Eider (E. Lance, U.S. Fish and Wildlife Service, pers. comm.).

Comparison of per species tower mortality to population size

Avian mortality at towers is estimated to be > 1% of total population size per year for 12 species (Table 3). Annual mortality was estimated to exceed 0.5% of population size annually for an additional 19 species. Fifty-four species identified as Birds of Conservation Concern (U.S. Fish and Wildlife Service 2008) and two federally endangered species have been killed at towers. Thirteen of the 20 bird species killed most frequently by percentage of population are identified as either Birds of Conservation Concern or endangered.

184 Warblers (Parulidae) make up 14 of the 20 species most frequently killed and 12 of the 20
185 species with highest proportions killed. Some species from other groups show surprisingly high
186 mortality as a proportion of population size. For example, 5.5% of the population of Yellow
187 Rails and 3.9% of Pied-billed Grebes are estimated to be killed at towers each year.

188 Regional mortality profiles do show marked differences, which are evident in the top species
189 killed in each region (**Table 1**). This provides evidence in support of a regional approach to
190 estimate mortality so that not the same species composition is assumed to be killed at towers
191 regardless of location.

192 ## DISCUSSION

193 These results show that some species are killed disproportionately to their abundance. Tower
194 mortality is not a random sample of all migrating birds. Mayfield (1967) argued that mortality at
195 towers did not affect bird populations in part because birds are killed at towers in proportion to
196 their abundance. To the contrary, our results show that some species experience mortality far out
197 of proportion with their population size (Figure 2), as was also shown by Graber (1968).
198 Although a linear regression of estimated annual mortality by estimated population is significant,
199 the variation explained approaches nil (r^2=0.08).

200 Our estimates suggest that some species of birds experience mortality from towers up to several
201 percent of their total population size each year. To illustrate the potential significance of such
202 levels of mortality, consider the population dynamics of Neotropical migrants, which are most
203 affected by collisions with communication towers. The migratory period has been suspected to
204 be "the critical period contributing to long-term declines in some species" (Hutto 2000). Sillett
205 and Holmes (2002) presented a long-term study of Black-throated Blue Warbler, one of many

species killed at communications towers (our estimate is ~55,000 per year). Their work was based on observations at breeding grounds in New Hampshire and wintering grounds in Jamaica (Sillett and Holmes 2002). They found that survival of individuals was high during the summer (0.99 ± 0.01) and winter (0.93 ± 0.05), while survival during both spring and fall migration was only 0.67–0.73. This was the first quantification of migration mortality for a Neotropical migrant, and the results reinforced concern about the migratory period as playing an important role in species declines. Sillett and Holmes (2002) concluded that both habitat quality before migration as well as conditions during migration, including the number of communication towers along the migratory route, affect mortality. For short-lived species where a large proportion of the individuals may only expect to have a single breeding season, spring mortality is biologically far more important and much less likely to be compensatory. Although tower mortality is typically higher in the fall (both because of the presence of juvenile birds and higher probability of weather patterns conducive to kills), it is estimated that 25% is spring mortality (Crawford and Engstrom 2001). Within this context, loss of 0.5% and upwards to 2–3% of the total population of a species each year to tower mortality may indeed influence population trajectories, especially for species already in decline (Robbins et al. 1989).

Uncertainty

Estimates of regional species profiles that were documented as part of long-term records from multiple sites are more reliable that those from shorter records encompassing fewer locations but it is not possible to provide confidence estimates for our quantification of these. Some regions have not reached asymptotes in species accumulation with the addition of new tower mortality locations and further data would result in spreading the calculated mortality for those regions over more species, potentially decreasing the apparent impact on those species identified here.

These regions, especially the shortgrass prairie regions, have profiles based on far fewer specimens and have reported far fewer species than other regions (**Table 1**).

The accuracy of the total population estimates also influences the per species assessments. The method of calculating these estimates from breeding bird surveys (Rosenberg and Blancher 2005) has been well received, but has acknowledged limitations (Thogmartin et al. 2006). These population estimates have associated measures of accuracy and precision. For the 20 species ranked as highest annual percent mortality, nearly all estimates of accuracy for landbirds are described as either "likely to be well within correct order of magnitude, often within 50% of true number" or "in correct order of magnitude" (Rich et al. 2004). Obviously, higher or lower estimates by an order of magnitude could increase or decrease the estimated population impact dramatically. For example, incorporating a 50% range around the population estimate for Golden-winged Warbler gives a range of annual mortality from 1.0% to 2.9% for our annual estimated mortality of ~3,000 birds.

The results of the mortality assessment illustrate the potential complications of extrapolated species mortality from historical records. Yellow Rails winter along the Gulf Coast and breed in Canada (Bookhout 1995). They have been recorded dead at towers across six different Bird Conservation Regions and consequently are estimated to experience losses of around 3,230 individuals per year. However, towers can no longer kill as many Yellow Rails as they once did because of the dramatic decline of this species (Bookhout 1995), and the same is certainly also true of Bermuda Petrel Because we have assumed that the proportion of each species of bird killed today is consistent with the past, estimates of mortality for some species that have declined dramatically may reflect historical rather than current patterns. In this instance, our analysis

suggests that mortality at towers may have been a factor contributing to the decline of these species (see Bookhout 1995).

We have not provided statistical estimates of uncertainty, but rather present the estimates as our best judgment based on the evidence available, with an explicit and transparent methodology that will allow improvement in these estimates as additional data are collected.

Biological significance

Advocates for the tower industry frequently compare the mortality at towers to other sources of mortality for birds and argue, implicitly or explicitly, that those sources that kill more total birds are more important for this reason alone (Woodlot Alternatives 2005). Our analysis shows that this approach is flawed because it lumps all birds together without regard for their status as rare or common. Our approach shows that it matters which species are killed and numbers that may appear low when compared with total human-caused avian mortality can indeed be significant for the affected species. This same approach should be used for other sources of avian mortality, such as wind power, where aggregate mortality numbers appear to be insignificant compared with other sources, but analysis of impacts on individual species can indicate significant impacts (Carrete et al. 2009).

Other sources of human-caused avian mortality should be considered in an analysis of the biological significance of avian mortality at towers when those other sources are additive and can contribute to an assessment of cumulative impacts. For example, Klem (1989) estimated that glass windows kill on the order of 97.6 million to 976 million birds per year. Based on inquiries to 125 museum curators for information from their collections, Klem (1989) identified 20 avian species killed most frequently at windows. Comparison of this list with our estimates of

mortality at towers suggests that for some species, such as Ovenbird, Swainson's Thrush, Common Yellowthroat, and Tennessee Warbler, each of these two sources of mortality is important. This approach helps to identify species for which cumulative impacts are likely to occur. For species at risk in such situations, addressing both tower and window mortality would be advised. However, although the 20 avian species killed most frequently at windows do not contain any federal Birds of Conservation Concern (U.S. Fish and Wildlife Service 2008), the 20 avian species killed most frequently at towers contain two such species (Bay-breasted Warbler and Blackpoll Warbler) and those species killed in greatest proportion to their populations at towers are predominantly Birds of Conservation Concern.

The example of mortality at windows illustrates how mortality estimates from several human-caused sources can be used to weigh alternative policy options to protect migratory birds. First, per species estimates (or at least ranks) are needed. Then one can identify whether for any particular species of concern, a conservation action should be concentrated on a single source of mortality or should address the cumulative impacts of multiple sources. This judgment cannot be made without some quantification of which bird species are killed by which causes. The undifferentiated proportions of all birds killed by different sources are less useful to an analysis of the biological significance of the losses.

Finally, our approach illustrates that it is feasible to at least develop per-species estimates of mortality for environmental impact analysis, even if the data are imperfect and assumptions are many. Notwithstanding these limitations, the analysis of impacts is improved by our method over the current methods used in environmental impact studies, especially those surrounding energy development, where comparisons of the number of "birds" killed without consideration of species are made and unfortunately promulgated in the public policy debate (e.g., Gore 2009).

296 In all areas of the assessment of biological impacts, the reliance of aggregate mortality numbers
297 at low taxonomic resolution should be avoided because conservation and impact analysis is not
298 undertaken at higher taxonomic levels. Per species estimates involve many assumptions, but the
299 process of producing them refines understanding of the environmental stressor and may, as it has
300 in this instance, provide substantial additional information upon which to base policies to
301 minimize and avoid ecological harm.

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583

584 **Table 1. Bird Conservation Regions and combinations thereof for which per species**
585 **estimates of mortality were calculated with number of species and specimens in collections**
586 **used to describe the regional mortality profile. The top ten species killed in each region, as**
587 **calculated by weighted averages of proportions killed at each location, are listed (see**
588 **methods).**

Bird Conservation Regions (References)	*# Species*	*# Specimens*	*# Locations*	*Est Mortality*
Southeastern Coastal Plain/ Mississippi Alluvial Valley, W Gulf/Gulf Prairie	192	64,554	4	1,102,356
(Johnston 1955; James 1956; Johnston 1957; Johnston and Haines 1957; Teulings 1972; Carter and Parnell 1976; Crawford 1976; Carter and Parnell 1978; Crawford and Engstrom 2001)				
Top ten species: Red-eyed Vireo, Common Yellowthroat, Ovenbird, Yellow-rumped Warbler, American Redstart, Magnolia Warbler, Palm Warbler, Black-and-white Warbler, Gray Catbird, Chestnut-sided Warbler				
Eastern Tallgrass Prairie	120	14,171	18	430,334
(Brewer and Ellis 1958; Cochran and Graber 1958; Parmalee and Parmalee 1959; Petersen 1959; Parmalee and Thompson 1963; Boso 1965; Kleen and Bush 1973; Gregory 1975; Mosman 1975; Norman 1975, 1976, 1977; Seets and Bohlen 1977; Norman 1982; Robbins et al. 2000; Young and Robbins 2001)				
Top ten species: Ovenbird, Red-eyed Vireo, Nashville Warbler, Tennessee Warbler, Yellow-rumped Warbler, Common Yellowthroat, Gray Catbird, Bay-breasted Warbler, Swainson's Thrush				
Appalachian Mountains/Piedmont	91	7,123	8	407,572
(Trott 1957; Norwood 1960; Bierly 1968; Alsop and Wallace 1969; Bierly 1969; Rosche 1971; Herndon 1973; Remy 1974, 1975; Welles 1978; Turner and Davis 1980; Nicholson 1984; Ellis 1997; Herron 1997)				
Top ten species: Red-eyed Vireo, Bay-breasted Warbler, Swainson's Thrush, Ovenbird, Tennessee Warbler, Common Yellowthroat, Magnolia Warbler, Wood Thrush, Gray Catbird, American Redstart				
Shortgrass Prairie/Central Mixed Grass/Edwards Plateau/Oaks and Prairies	65	611	3	628,109
(Barkley et al. 1977; Blasky 1993; Young 1993; Nielsen and Wilson 2006)				
Top ten species: Wilson's Warbler, Mourning Dove, Yellow-headed Blackbird, Clay-colored Sparrow, Vesper Sparrow, Chipping Sparrow, Yellow Warbler, Swainson's Thrush, Red-winged Blackbird, Common Yellowthroat				
Prairie Hardwood Transition/Boreal Hardwood Transition	135	128,796	16	268,714
(Strnad 1962; Caldwell and Cuthbert 1963; Feehan 1963; Green 1963; Manuwal 1963;				

	Caldwell and Wallace 1966; Kemper et al. 1966; Sharp 1971; Strnad 1975; Kemper 1996; Gehring et al. 2009; Travis 2009) Top ten species: Ovenbird, Swainson's Thrush, Red-eyed Vireo, Blackpoll Warbler, Tennessee Warbler, Gray-cheeked Thrush, Magnolia Warbler, Bay-breasted Warbler, American Redstart, Black-and-white Warbler			
Central Hardwoods	113	15,202	5	198,996
	(Anonymous 1961; Barbour 1961; Ganier 1962; Laskey 1962; George 1963; Laskey 1963, 1964; Able 1966; Elder and Hansen 1967; Laskey 1967, 1968, 1969a, b, 1971; Bierly 1973; Goodpasture 1974b, a, 1975, 1976, 1984, 1986, 1987; Palmer-Ball and Rauth 1990; Nehring and Bivens 1999) Top ten species: Ovenbird, Common Yellowthroat, Red-eyed Vireo, Tennessee Warbler, Magnolia Warbler, Gray Catbird, Bay-breasted Warbler, Swainson's Thrush, Chestnut-sided Warbler, Black-and-white Warbler			
Peninsular Florida	98	15,261	4	187,621
	(Case et al. 1965; Kale 1971; Taylor and Anderson 1973, 1974) Top ten species: Common Yellowthroat, Ovenbird, Black-throated Blue Warbler, Blackpoll Warbler, American Redstart, Black-and-white Warbler, Northern Parula, Palm Warbler, Cape May Warbler, Northern Waterthrush			
Prairie Potholes/Badlands and Prairies	125	2,520	8	224,694
	(Lahrman 1959; Nero 1961; Lahrman 1962; Nero 1962; Janssen 1963; Kemper 1964; Lahrman 1965; Pierce 1969; Avery and Clement 1972; Houston and Houston 1975; Avery et al. 1978; Ball et al. 1995; Young and Robbins 2001) Top ten species: Red-eyed Vireo, Ovenbird, Yellow Warbler, American Tree Sparrow, Dark-eyed Junco, Common Yellowthroat, Swainson's Thrush, Gray Catbird, Lincoln's Sparrow, Sora			
New England/Mid-Atlantic Coast/North Atlantic/ Lower Great Lakes/St. Lawrence Plain	71	7,821	5	201,988
	(Sawyer 1961; Devitt 1967; Baird 1970, 1971; Goodwin 1975) Top ten species: Ovenbird, Ruby-crowned Kinglet, Blackpoll Warbler, Red-eyed Vireo, Common Yellowthroat, Bay-breasted Warbler, Swainson's Thrush, Chestnut-sided Warbler, Magnolia Warbler, American Redstart			

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589

590 **Table 2. Annual avian mortality at communication towers in Canada and the continental**

591 **United States by order, with families for Passeriformes. Only includes BCRs for which**

592 **mortality profiles could be developed.**

Order	*Number of Species*	*Percent of Total Mortality*	*Total Mortality Estimate*
Passeriformes	151	94.75%	3,458,891
Parulidae	*39*	*52.27%*	*1,907,989*
Vireonidae	*8*	*11.18%*	*407,972*
Emberizidae	*31*	*9.58%*	*349,686*
Turdidae	*7*	*7.07%*	*257,947*
Icteridae	*10*	*4.23%*	*154,582*
Mimidae	*4*	*2.48%*	*90,535*
Cardinalidae	*8*	*2.42%*	*88,334*
Regulidae	*2*	*1.78%*	*64,885*
Troglodytidae	*7*	*1.55%*	*56,543*
Thraupidae	*3*	*0.69%*	*25,144*
Alaudidae	*1*	*0.48%*	*17,681*
Tyrannidae	*9*	*0.46%*	*16,685*
Corvidae	*2*	*0.25%*	*9,232*
Certhiidae	*1*	*0.12%*	*4,289*
Fringillidae	*6*	*0.07%*	*2,519*
Bombycillidae	*1*	*0.04%*	*1,614*
Sittidae	*2*	*0.03%*	*946*
Sturnidae	*1*	*0.02%*	*869*
Hirundinidae	*5*	*0.02%*	*696*
Passeridae	*1*	*0.02%*	*553*
Laniidae	*1*	*0.00%*	*142*
Motacillidae	*1*	*0.00%*	*36*
Sylviidae	*1*	*0.00%*	*12*
Columbiformes	3	2.21%	80,611
Gruiformes	9	1.27%	46,193
Anseriformes	15	0.48%	17,557
Cuculiformes	2	0.40%	14,540
Piciformes	7	0.30%	10,883
Ciconiiformes	14	0.20%	7,343
Charadriiformes	17	0.18%	6,559
Podicipediformes	4	0.11%	4,190
Caprimulgiformes	3	0.04%	1,303
Apodiformes	1	0.03%	1,125
Galliformes	5	0.02%	884
Coraciiformes	1	0.00%	128
Falconiformes	2	0.00%	85
Strigiformes	2	0.00%	36
Pelecaniformes	1	0.00%	33

Gaviiformes	1	0.00%	12
Procellariiformes	1	0.00%	12

593

594 **Table 3. Per species avian annual mortality at communication towers in eastern North**
595 **America. Older names or lumped species groups are used to accommodate taxonomic**
596 **changes. E federally endangered in United States, BCC Birds of Conservation Concern in**
597 **United States. SARA1 Endangered under Canada's Species at Risk Act, SARA2**
598 **Threatened, and SARA3 Special Concern.**

Species	*Family*	*North Am. Population Estimate*	*Est. Annual Mortality*	*Percent of Population*	*Status*
Bermuda Petrel *Pterodroma cahow*	Procellariidae	150	12	7.972%	E
Yellow Rail *Coturnicops noveboracensis*	Rallidae	25000	1,373	5.493%	BCC/SARA3
Harris's Sparrow *Zonotrichia querula*	Emberizidae	40000	2,126	5.315%	BCC
Swainson's Warbler *Limnothlypis swainsonii*	Parulidae	84000	4,152	4.943%	BCC
Pied-billed Grebe *Podilymbus podiceps*	Podicipedidae	100000	3,910	3.910%	BCC
Bay-breasted Warbler *Dendroica castanea*	Parulidae	3000000	96,241	3.208%	BCC
Black-throated Blue Warbler *Dendroica caerulescens*	Parulidae	2000000	55,071	2.754%	
Golden-winged Warbler *Vermivora chrysoptera*	Parulidae	210000	3,050	1.452%	BCC/SARA2
Kentucky Warbler *Oporornis formosus*	Parulidae	1100000	15,319	1.393%	
Worm-eating Warbler *Helmitheros vermivorum*	Parulidae	700000	9,013	1.288%	BCC
Ovenbird *Seiurus aurocapilla*	Parulidae	24000000	297,612	1.240%	
Prairie Warbler *Dendroica discolor*	Parulidae	1400000	16,897	1.207%	BCC
Scarlet Tanager *Piranga olivacea*	Thraupidae	2200000	19,942	0.906%	
Canada Warbler *Wilsonia canadensis*	Parulidae	1400000	12,511	0.894%	BCC/SARA2
Henslow's Sparrow *Ammodramus henslowii*	Emberizidae	80000	699	0.874%	BCC/SARA1
Gray Catbird *Dumetella carolinensis*	Mimidae	10000000	82,938	0.829%	
Louisiana Waterthrush *Seiurus motacilla*	Parulidae	260000	2,012	0.774%	BCC/SARA3
Seaside Sparrow *Ammodramus maritimus*	Emberizidae	110000	839	0.762%	BCC
Common Yellowthroat *Geothlypis trichas*	Parulidae	32000000	236,793	0.740%	
Yellow-throated Vireo *Vireo flavifrons*	Vireonidae	1400000	9,776	0.698%	
Connecticut Warbler *Oporornis agilis*	Parulidae	1200000	8,318	0.693%	
Chestnut-sided Warbler *Dendroica pensylvanica*	Parulidae	9400000	61,934	0.659%	
Trumpeter Swan *Cygnus buccinator*	Anatidae	23647	155	0.657%	
Black-and-white Warbler *Mniotilta varia*	Parulidae	14000000	85,248	0.609%	
Blackburnian Warbler *Dendroica fusca*	Parulidae	5900000	35,114	0.595%	
Hooded Warbler *Wilsonia citrina*	Parulidae	4000000	23,186	0.580%	
Philadelphia Vireo *Vireo philadelphicus*	Vireonidae	4000000	22,263	0.557%	
Blue-winged Warbler *Vermivora pinus*	Parulidae	390000	2,149	0.551%	BCC
Prothonotary Warbler *Protonotaria citrea*	Parulidae	1800000	9,813	0.545%	BCC/SARA1
Cape May Warbler *Dendroica tigrina*	Parulidae	3000000	16,185	0.539%	

Northern Parula *Parula americana*	Parulidae	7300000	37,059	0.508%	BCC
Rose-breasted Grosbeak *Pheucticus ludovicianus*	Cardinalidae	4600000	22,484	0.489%	
Killdeer *Charadrius vociferus*	Charadriidae	1000000	4,551	0.455%	
American Redstart *Setophaga ruticilla*	Parulidae	25000000	104,154	0.417%	
Cerulean Warbler *Dendroica cerulea*	Parulidae	560000	2,327	0.416%	BCC/SARA3
Least Bittern *Ixobrychus exilis*	Ardeidae	128000	512	0.400%	SARA2
Blackpoll Warbler *Dendroica striata*	Parulidae	20000000	76,458	0.382%	BCC
Smith's Longspur *Calcarius pictus*	Emberizidae	75000	283	0.377%	
Turkey Vulture *Cathartes aura*	Cathartidae	1300000	4,682	0.360%	
Magnolia Warbler *Dendroica magnolia*	Parulidae	30000000	102,715	0.342%	
Gray-cheeked Thrush *Catharus minimus*	Turdidae	11000000	36,959	0.336%	
Yellow-headed Blackbird *Xanthocephalus xanthocephalus*	Icteridae	20000000	65,915	0.330%	
Ring-necked Duck *Aythya collaris*	Anatidae	200000	647	0.323%	
American Coot *Fulica americana*	Rallidae	6000000	19,014	0.317%	
Bachman's Sparrow *Aimophila aestivalis*	Emberizidae	300000	940	0.313%	BCC
Yellow-throated Warbler *Dendroica dominica*	Parulidae	1600000	4,975	0.311%	
Baird's Sparrow *Ammodramus bairdii*	Emberizidae	1200000	3,590	0.299%	
Northern Waterthrush (Small-billed Waterthrush) *Seiurus noveboracensis*	Parulidae	13000000	38,162	0.294%	
Palm Warbler *Dendroica palmarum*	Parulidae	20000000	58,283	0.291%	
Black-throated Green Warbler *Dendroica virens*	Parulidae	10000000	28,585	0.286%	BCC
Swamp Sparrow *Melospiza georgiana*	Emberizidae	9000000	23,593	0.262%	
Green-winged Teal *Anas crecca*	Anatidae	3900000	9,627	0.247%	
Veery *Catharus fuscescens*	Turdidae	14000000	34,535	0.247%	
Red-eyed Vireo *Vireo olivaceus*	Vireonidae	140000000	331,756	0.237%	
Sooty Tern *Onychoprion fuscatus*	Laridae	4690	10	0.222%	
Marsh Wren *Cistothorus palustris*	Troglodytidae	8000000	17,621	0.220%	BCC
Wilson's Warbler (Black-capped Warbler) *Wilsonia pusilla*	Parulidae	40000000	87,557	0.219%	
Tennessee Warbler *Vermivora peregrina*	Parulidae	60000000	125,475	0.209%	
Wood Thrush *Hylocichla mustelina*	Turdidae	14000000	28,483	0.203%	
Bobolink *Dolichonyx oryzivorus*	Icteridae	11000000	22,177	0.202%	BCC
Grasshopper Sparrow *Ammodramus savannarum*	Emberizidae	14000000	27,966	0.200%	BCC
Black Rail *Laterallus jamaicensis*	Rallidae	110000	215	0.195%	BCC
Northern Oriole (Baltimore & Bullock's Orioles) *Icterus galbula, Icterus bullockii*	Icteridae	8800000	16,652	0.189%	
Sharp-tailed Sparrow (Nelson's & Saltmarsh) *Ammodramus nelson, Ammodramus caudacutus*	Emberizidae	750000	1,341	0.179%	BCC
Great Blue Heron *Ardea herodias*	Ardeidae	124500	220	0.177%	
Chestnut-collared Longspur *Calcarius ornatus*	Emberizidae	5600000	9,016	0.161%	BCC
Clay-colored Sparrow *Spizella pallida*	Emberizidae	23000000	37,090	0.161%	
Yellow-billed Cuckoo *Coccyzus americanus*	Cuculidae	8000000	12,901	0.161%	BCC
Yellow-breasted Chat *Icteria virens*	Parulidae	11000000	17,748	0.161%	SARA3
Yellow Warbler *Dendroica petechia*	Parulidae	30000000	48,068	0.160%	BCC
Mourning Warbler *Oporornis philadelphia*	Parulidae	7000000	10,855	0.155%	
Summer Tanager *Piranga rubra*	Thraupidae	3300000	5,020	0.152%	
Black-billed Cuckoo *Coccyzus erythropthalmus*	Cuculidae	1100000	1,635	0.149%	
Nashville Warbler *Vermivora ruficapilla*	Parulidae	34000000	50,212	0.148%	

Swainson's Thrush (Olive-backed Thrush) *Catharus ustulatus*	Turdidae	100000000	144,574	0.145%	
Le Conte's Sparrow *Ammodramus leconteii*	Emberizidae	3000000	4,178	0.139%	BCC
Pectoral Sandpiper *Calidris melanotos*	Scolopacidae	65000	90	0.139%	
White-eyed Vireo *Vireo griseus*	Vireonidae	16000000	21,905	0.137%	
Rock Wren *Salpinctes obsoletus*	Troglodytidae	3300000	4,420	0.134%	
Indigo Bunting *Passerina cyanea*	Cardinalidae	28000000	37,298	0.133%	
Sedge Wren *Cistothorus platensi*	Troglodytidae	6500000	8,242	0.127%	BCC
Orchard Oriole *Icterus spurius*	Icteridae	3700000	4,530	0.122%	
Red-cockaded Woodpecker *Picoides borealis*	Picidae	20000	24	0.120%	E
Vesper Sparrow *Pooecetes gramineus*	Emberizidae	30000000	34,143	0.114%	
Green-tailed Towhee *Pipilo chlorurus*	Emberizidae	4100000	4,420	0.108%	BCC
Dickcissel *Spiza americana*	Cardinalidae	22000000	23,574	0.107%	BCC
House Wren *Troglodytes aedon*	Troglodytidae	19000000	19,239	0.101%	
Black-whiskered Vireo *Vireo altiloquus*	Vireonidae	80000	76	0.095%	BCC
Brown Thrasher *Toxostoma rufum*	Mimidae	7300000	6,545	0.090%	
Solitary Vireo (Blue-headed Vireo, Cassin's Vireo & Plumbeous Vireo) *Vireo solitaries, Vireo cassinii, Vireo plumbeus*	Vireonidae	13700000	12,315	0.090%	
Western Grebe *Aechmophorus occidentalis*	Podicipedidae	165000	141	0.086%	BCC
Brown Creeper *Certhia americana*	Certhiidae	5000000	4,119	0.082%	
Blue-Winged Teal *Anas discors*	Anatidae	7240000	5,431	0.075%	
Mourning Dove *Zenaida macroura*	Columbidae	110000000	80,479	0.073%	
Pine Warbler *Dendroica pinus*	Parulidae	11000000	8,011	0.073%	
Acadian Flycatcher *Empidonax virescens*	Tyrannidae	4700000	2,915	0.062%	BCC/SARA1
Ruby-crowned Kinglet *Regulus calendula*	Regulidae	70000000	43,158	0.062%	
Eastern Wood-Pewee *Contopus virens*	Tyrannidae	6000000	3,666	0.061%	
Golden-crowned Kinglet *Regulus satrapa*	Regulidae	30000000	18,381	0.061%	
Lazuli Bunting *Passerina amoena*	Cardinalidae	2300000	1,375	0.060%	
Yellow-bellied Sapsucker *Sphyrapicus varius*	Picidae	9000000	5,395	0.060%	
Yellow-rumped Warbler (Myrtle Warbler) *Dendroica coronata*	Parulidae	130000000	78,555	0.060%	
Lincoln's Sparrow *Melospiza lincolnii*	Emberizidae	40000000	23,045	0.058%	
Gray Partridge *Perdix perdix*	Phasianidae	400000	211	0.053%	
Whip-poor-will *Caprimulgus vociferus*	Caprimulgidae	1600000	853	0.053%	
Brewer's Sparrow *Spizella breweri*	Emberizidae	16000000	8,122	0.051%	BCC
Common Snipe *Gallinago gallinago*	Scolopacidae	2000000	925	0.046%	
Yellow-bellied Flycatcher *Empidonax flaviventris*	Tyrannidae	6000000	2,750	0.046%	
Savannah Sparrow *Passerculus sandwichensis*	Emberizidae	80000000	35,806	0.045%	SARA3
Bell's Vireo *Vireo bellii*	Vireonidae	1100000	473	0.043%	BCC
Blue Jay *Cyanocitta cristata*	Corvidae	22000000	9,220	0.042%	
Chipping Sparrow *Spizella passerina*	Emberizidae	89000000	36,727	0.041%	
American Tree Sparrow *Spizella arborea*	Emberizidae	30000000	10,725	0.036%	
Field Sparrow *Spizella pusilla*	Emberizidae	8200000	2,761	0.034%	BCC
Spotted Sandpiper *Actitis macularius*	Scolopacidae	250000	82	0.033%	
Warbling Vireo *Vireo gilvus*	Vireonidae	18000000	5,865	0.033%	
Cattle Egret *Bubulcus ibis*	Ardeidae	750000	237	0.032%	
Carolina Wren *Thryothorus ludovicianus*	Troglodytidae	15000000	4,577	0.031%	
Northern Flicker (Yellow-shafted Flicker) *Colaptes auratus*	Picidae	15000000	4,544	0.030%	
Purple Finch *Carpodacus purpureus*	Fringillidae	3000000	885	0.030%	

Purple Gallinule *Porphyrio martinica*	Rallidae	550000	167	0.030%	
Eastern Meadowlark *Sturnella magna*	Icteridae	8100000	2,017	0.025%	
Wild Turkey *Meleagris gallopavo*	Phasianidae	1200000	280	0.023%	
American Bittern *Botaurus lentiginosus*	Ardeidae	2976000	659	0.022%	BCC
Black Vulture *Coragyps atratus*	Cathartidae	250000	53	0.021%	
Blue Grosbeak *Passerina caerulea*	Cardinalidae	6100000	1,268	0.021%	
Orange-crowned Warbler *Vermivora celata*	Parulidae	80000000	16,669	0.021%	
Fox Sparrow *Passerella iliaca*	Emberizidae	16000000	3,253	0.020%	
Black-headed Grosbeak *Pheucticus melanocephalus*	Cardinalidae	3900000	688	0.018%	
Horned Lark *Eremophila alpestris*	Alaudidae	99000000	17,681	0.018%	
Marsh Hawk (Northern Harrier) *Circus cyaneus*	Accipitridae	400000	71	0.018%	BCC
Red-headed Woodpecker *Melanerpes erythrocephalus*	Picidae	2500000	451	0.018%	SARA2
Rusty Blackbird *Euphagus carolinus*	Icteridae	2000000	367	0.018%	BCC
Hooded Merganser *Lophodytes cucullatus*	Anatidae	350000	60	0.017%	
Lark Bunting *Calamospiza melanocorys*	Emberizidae	27000000	4,562	0.017%	BCC
Painted Bunting *Passerina ciris*	Cardinalidae	3600000	600	0.017%	BCC
Song Sparrow *Melospiza melodia*	Emberizidae	53000000	9,124	0.017%	BCC
American Avocet *Recurvirostra americana*	Recurvirostridae	450000	71	0.016%	
Red-winged Blackbird *Agelaius phoeniceus*	Icteridae	190000000	30,177	0.016%	
Solitary Sandpiper *Tringa solitaria*	Scolopacidae	154000	24	0.016%	BCC
MacGillivray's Warbler *Oporornis tolmiei*	Parulidae	5400000	793	0.015%	
Hermit Thrush *Catharus guttatus*	Turdidae	60000000	8,693	0.014%	
Least Flycatcher *Empidonax minimus*	Tyrannidae	14000000	1,999	0.014%	
Lesser Scaup *Aythya affinis*	Anatidae	4400000	602	0.014%	
Dark-eyed Junco (Slate-colored Junco or Northern Junco) *Junco hyemalis*	Emberizidae	260000000	34,151	0.013%	
Herring Gull *Larus argentatus*	Laridae	370000	48	0.013%	
Little Blue Heron *Egretta caerulea*	Ardeidae	375000	48	0.013%	BCC
Rufous-sided Towhee (Spotted Towhee and Eastern Towhee) *Pipilo maculatus, Pipilo erythrophthalmus*	Emberizidae	23000000	2,990	0.013%	
McCown's Longspur *Calcarius mccownii*	Emberizidae	1100000	131	0.012%	BCC/SARA3
Winter Wren *Troglodytes troglodytes*	Troglodytidae	18000000	2,218	0.012%	
Cedar Waxwing *Bombycilla cedrorum*	Bombycillidae	15000000	1,608	0.011%	
Lark Sparrow *Chondestes grammacus*	Emberizidae	8800000	981	0.011%	
White-throated Sparrow *Zonotrichia albicollis*	Emberizidae	140000000	15,702	0.011%	
American Woodcock *Scolopax minor*	Scolopacidae	5000000	502	0.010%	
Great Crested Flycatcher *Myiarchus crinitus*	Tyrannidae	7500000	725	0.010%	
Lapland Longspur *Calcarius lapponicus*	Emberizidae	70000000	7,174	0.010%	
Red-breasted Merganser *Mergus serrator*	Anatidae	250000	24	0.010%	
Common Grackle *Quiscalus quiscula*	Icteridae	97000000	8,250	0.009%	
Great Egret *Ardea alba*	Ardeidae	270000	24	0.009%	
Chimney Swift *Chaetura pelagica*	Apodidae	15000000	1,125	0.008%	SARA2
Common Ground-Dove *Columbina passerina*	Columbidae	1100000	*91*	0.008%	
Ruddy Duck *Oxyura jamaicensis*	Anatidae	1100000	83	0.008%	
Tricolored Heron *Egretta tricolor*	Ardeidae	293000	24	0.008%	
White Ibis *Eudocimus albus*	Threskiornithidae	150000	12	0.008%	BCC
Brown-headed Cowbird *Molothrus ater*	Icteridae	51000000	3,770	0.007%	
Northern Pintail *Anas acuta*	Anatidae	3600000	247	0.007%	

Upland Sandpiper *Bartramia longicauda*	Scolopacidae	350000	24	0.007%	BCC
Belted Kingfisher *Megaceryle alcyon*	Alcedinidae	2000000	128	0.006%	
Eastern Kingbird *Tyrannus tyrannus*	Tyrannidae	13000000	745	0.006%	
Traill's Flycatcher (Alder Flycatcher or Willow Flycatcher) *Empidonax alnorum, Empidonax traillii*	Tyrannidae	53300000	3,038	0.006%	
Common Tern *Sterna hirundo*	Laridae	406500	20	0.005%	BCC
Red-breasted Nuthatch *Sitta canadensis*	Sittidae	18000000	813	0.005%	
Common Nighthawk *Chordeiles minor*	Caprimulgidae	10000000	359	0.004%	SARA2
Eastern Phoebe *Sayornis phoebe*	Tyrannidae	16000000	656	0.004%	
Horned Grebe *Podiceps auritus*	Podicipedidae	550000	24	0.004%	BCC
Loggerhead Shrike *Lanius ludovicianus*	Laniidae	3700000	142	0.004%	BCC/SARA1
Common Redpoll *Acanthis flammea*	Fringillidae	30000000	786	0.003%	
Gadwall *Anas strepera*	Anatidae	3900000	107	0.003%	
Mallard *Anas platyrhynchos*	Anatidae	13056000	341	0.003%	
Red-necked (Northern) Phalarope *Phalaropus lobatus*	Scolopacidae	2500000	71	0.003%	
Ruffed Grouse *Bonasa umbellus*	Phasianidae	8000000	280	0.003%	
Barred Owl *Strix varia*	Strigidae	600000	12	0.002%	
Common Loon *Gavia immer*	Gaviidae	580000	12	0.002%	
Double-crested Cormorant *Phalacrocorax auritus*	Phalacrocoracidae	1621800	33	0.002%	
Eared Grebe *Podiceps nigricollis*	Podicipedidae	3700000	71	0.002%	BCC
Least Sandpiper *Calidris minutilla*	Scolopacidae	600000	12	0.002%	
Northern Mockingbird *Mimus polyglottos*	Mimidae	37000000	634	0.002%	
Northern Shoveler *Anas clypeata*	Anatidae	3800000	71	0.002%	
Pine Siskin *Spinus pinus*	Fringillidae	20000000	406	0.002%	
Red Phalarope *Phalaropus fulicarius*	Scolopacidae	1020000	24	0.002%	
Red-bellied Woodpecker *Melanerpes carolinus*	Picidae	10000000	192	0.002%	
Tree Swallow *Tachycineta bicolor*	Hirundinidae	20000000	313	0.002%	
White-crowned Sparrow *Zonotrichia leucophrys*	Emberizidae	70000000	1,202	0.002%	
American Black Duck *Anas rubripes*	Anatidae	910000	12	0.001%	
American Goldfinch (Eastern Goldfinch) *Spinus tristis*	Fringillidae	24000000	212	0.001%	
American Robin *Turdus migratorius*	Turdidae	310000000	2,583	0.001%	
Bank Swallow *Riparia riparia*	Hirundinidae	14000000	83	0.001%	
Bewick's Wren *Thryomanes bewickii*	Troglodytidae	4600000	36	0.001%	
Black-throated Gray Warbler *Dendroica nigrescens*	Parulidae	2900000	33	0.001%	BCC
Chuck-will's-widow *Caprimulgus carolinensis*	Caprimulgidae	15000000	91	0.001%	
Dunlin *Calidris alpina*	Scolopacidae	1525000	12	0.001%	
Eastern Bluebird *Sialia sialis*	Turdidae	8200000	41	0.001%	
European Starling *Sturnus vulgaris*	Sturnidae	120000000	864	0.001%	
Franklin's Gull *Leucophaeus pipixcan*	Laridae	980000	11	0.001%	
Great Horned Owl *Bubo virginianus*	Strigidae	2000000	24	0.001%	
Hairy Woodpecker *Picoides villosus*	Picidae	7500000	71	0.001%	
House Sparrow *Passer domesticus*	Passeridae	82000000	546	0.001%	
Northern Cardinal *Cardinalis cardinalis*	Cardinalidae	86000000	840	0.001%	
Purple Martin *Progne subis*	Hirundinidae	10000000	60	0.001%	
Red-tailed Hawk *Buteo jamaicensis*	Accipitridae	2000000	12	0.001%	
Ring-necked Pheasant *Phasianus colchicus*	Phasianidae	7600000	70	0.001%	
Sage Thrasher *Oreoscoptes montanus*	Mimidae	7900000	71	0.001%	BCC
Semipalmated Sandpiper *Calidris pusilla*	Scolopacidae	3500000	28	0.001%	BCC

Snowy Egret *Egretta thula*	Ardeidae	1365000	12	0.001%	
Western Meadowlark *Sturnella neglecta*	Icteridae	30000000	356	0.001%	
White-breasted Nuthatch *Sitta carolinensis*	Sittidae	9100000	114	0.001%	
Wood Duck *Aix sponsa*	Anatidae	4600000	65	0.001%	
American Crow *Corvus brachyrhynchos*	Corvidae	31000000	12	0.000%	
American Pipit *Anthus rubescens*	Motacillidae	20000000	36	0.000%	SARA2
American Wigeon *Anas americana*	Anatidae	3100000	12	0.000%	
Barn Swallow *Hirundo rustica*	Hirundinidae	51000000	201	0.000%	
Blue-gray Gnatcatcher *Polioptila caerulea*	Sylviidae	42000000	12	0.000%	
Downy Woodpecker *Picoides pubescens*	Picidae	13000000	5	0.000%	
Evening Grosbeak *Coccothraustes vespertinus*	Fringillidae	5700000	24	0.000%	
House Finch *Carpodacus mexicanus*	Fringillidae	16000000	70	0.000%	
Northern Bobwhite *Colinus virginianus*	Odontophoridae	7600000	36	0.000%	SARA1
Northern Rough-winged Swallow *Stelgidopteryx serripennis*	Hirundinidae	15000000	23	0.000%	
Olive-sided Flycatcher *Contopus cooperi*	Tyrannidae	1200000	1	0.000%	SARA2
Rock Pigeon (Rock Dove) *Columba livia*	Columbidae	26000000	12	0.000%	
Snow Bunting *Plectrophenax nivalis*	Emberizidae	19000000	40	0.000%	
Western Tanager *Piranga ludoviciana*	Thraupidae	8800000	12	0.000%	
Black-crowned Night-Heron *Nycticorax nycticorax*	Ardeidae	none available	31	n/a	
Clapper Rail *Rallus longirostris*	Rallidae	none available	656	n/a	
Common Gallinule (Common Moorhen) *Gallinula chloropus*	Rallidae	none available	441	n/a	
Green-backed Heron (Green Heron or Striated Heron) *Butorides virescens, Butorides striata*	Ardeidae	none available	747	n/a	
King Rail *Rallus elegans*	Rallidae	none available	303	n/a	SARA1
Sora *Porzana carolina*	Rallidae	none available	20,236	n/a	
Virginia Rail *Rallus limicola*	Rallidae	none available	3,447	n/a	
Yellow-crowned Night-Heron *Nyctanassa violacea*	Ardeidae	none available	69	n/a	

599

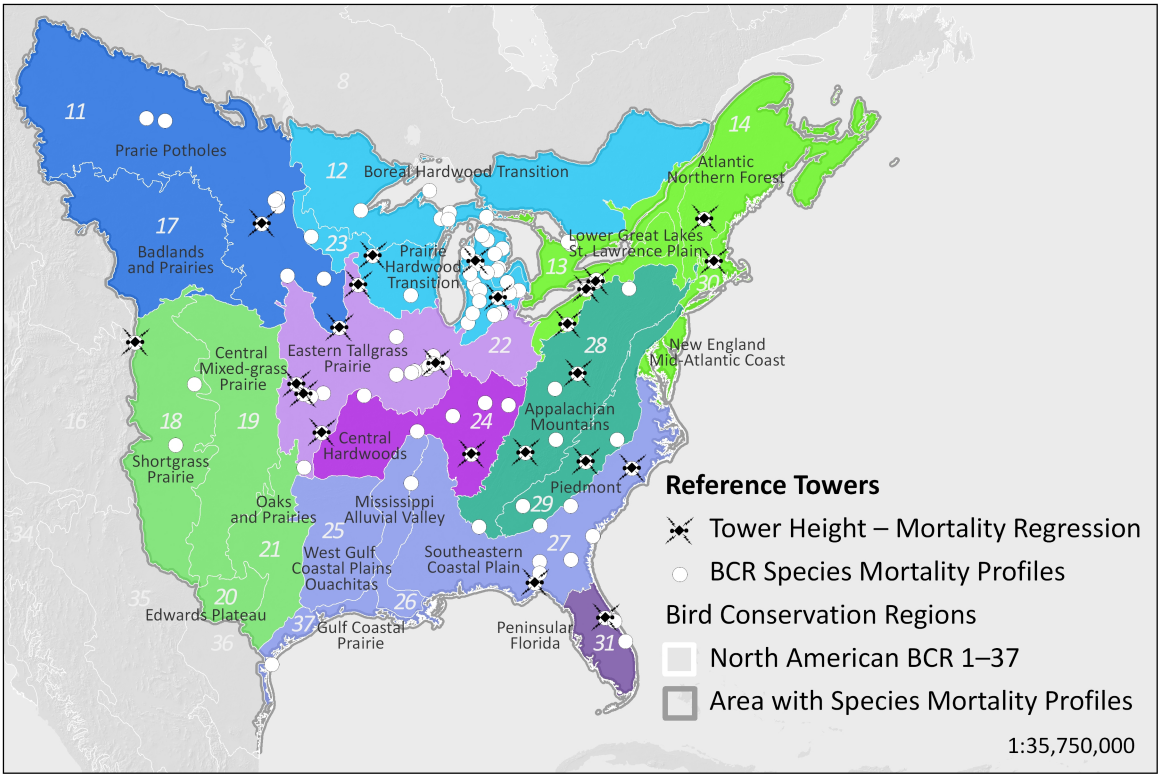

Figure 1. Bird Conservation Regions in North America with locations of studies used to develop mortality profiles for aggregated regions indicated. Locations of towers used for height–mortality regression are also shown (Longcore et al. in review).

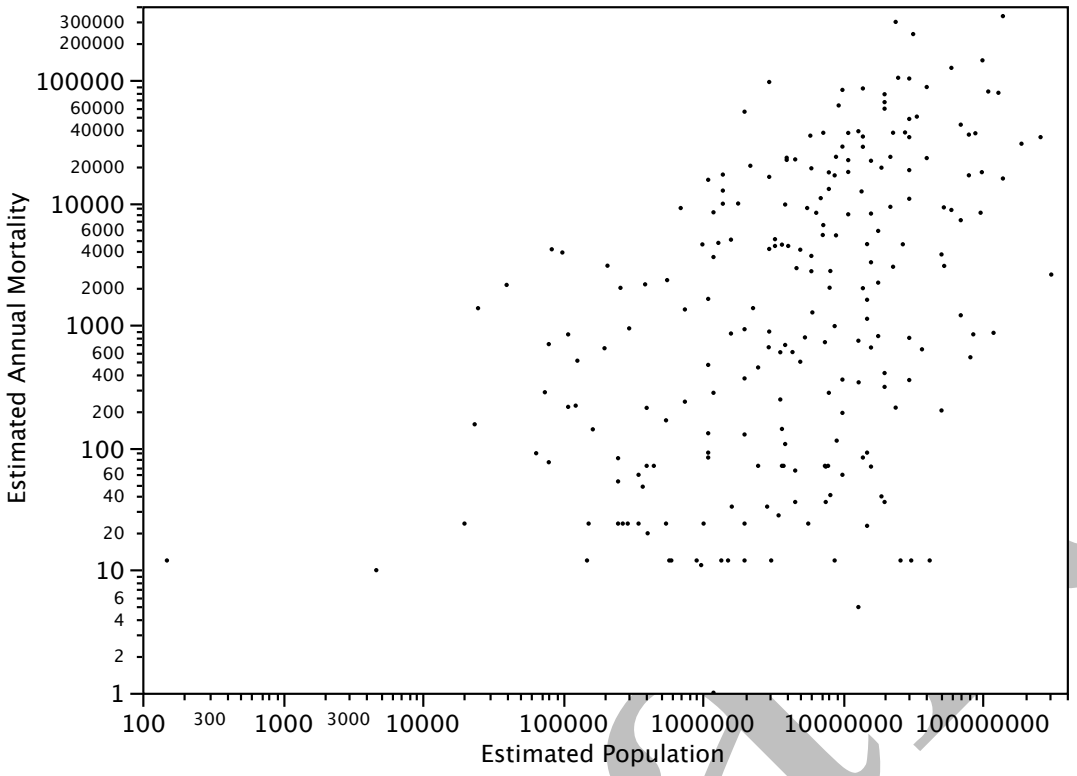

Figure 2. Relation of estimated population size of bird species killed at communication towers to estimated annual mortality at communication towers.