Studies of avian collisions with communication towers: a quantification of fatalities at a self-supported Rescue 21 tower and a test of different tall tower lighting systems

Prepared By:
Joelle Gehring, Ph.D.
Senior Conservation Scientist-Zoology Section Leader
Michigan State University, Michigan Natural Features Inventory
P.O. Box 30444 Lansing, MI 48909-7944

Prepared For:
Rescue 21 Project Office, United States Coast Guard,
2100 Second St. SW, Washington, D.C. 20593

and

Division of Migratory Bird Management, United States Fish and Wildlife Service,
4401 N. Fairfax Dr., MBSP-4107, Arlington, VA 22203

30 November 2007
Report Number 2007-22

Summary

Since the late 1960s researchers have documented avian collisions with communication towers. Their findings suggest that birds, primarily night migrating, neotropical songbirds, are attracted to communication tower lights during inclement weather and then collide with the tower structure or the guy wires supporting the tower. The United States Fish and Wildlife Service (USFWS) conservatively estimates that 4-50 million birds collide with communication towers every year in the United States (Manville 2005). It is likely that the siting or location of a communication tower in relation to avian migratory pathways is related to the frequency of avian collisions. In addition, past research suggests that tower lighting systems are also related to the frequency of avian collisions. My objectives were to quantify the frequency of avian collisions at a tower constructed in an area believed to have high intensities of songbird migration and to compare the frequency of avian fatalities at tall towers > 277 m Above Ground Level (AGL) which are lit with different lighting systems. In the spring and fall of 2007 this study determined that that the self-supported, United States Coast Guard (USCG) Rescue 21 tower studied was not involved in frequent avian collisions despite its' location in coastal Cape May, NJ, an area documented to have large and frequent influxes of migratory songbirds. This is likely due to its self-supporting design compared to a guy wire supported design. Future research at this site would benefit from inclusion of radar ornithology techniques to document the presence of songbirds in the area and their response to the lit tower during their migration. In the spring and fall of 2007 I also compared the numbers of avian fatalities at 6 Michigan communication towers > 277 m AGL lit at night with 3 different lighting systems. Technicians and I found significantly more avian fatalities at the towers lit with both red blinking lights and red non-blinking than at towers lit with white strobe lights or with only red blinking lights. Although it is not possible to reduce avian collisions by changing the location or the support system of an existing tower, this research documents that changing a tower's lighting system can reduce avian fatalities by 60-68 %. In future field seasons I plan to include an additional tower in the Michigan study and pursue Federal Aviation Administration (FAA) marking and lighting variances to change the lighting systems on existing towers; thereby, strengthening the comparisons. This research is an important step in the process of reducing avian collisions at communication towers.

Introduction

For decades researchers have documented avian fatalities at lit towers. Their findings suggest that birds, primarily night migrating, neotropical songbirds, are either attracted to or disoriented by communication tower lights, especially when night skies are overcast, foggy, or when there is precipitation (e.g., Avery et al. 1976, Caldwell and Wallace 1966, Cochran and Graber 1958). Upon flying in close proximity to the structure, birds are vulnerable to collisions with the tower structure or the guy wires supporting the tower. Previous research has demonstrated higher frequencies of avian fatalities at towers supported by guy wires than at self-supported towers and higher frequencies of collisions at towers > 277 m AGL compared to shorter towers (Gehring et al. in prep).

Researchers have also documented that the type of tower lighting system can be related to the numbers of avian collisions. Specifically, Gehring et al. (2007) found significantly more avian fatalities under towers 116-146-m AGL that were lit at night with systems that included non-blinking, red lights than at towers lit with only blinking lights. Gauthreaux and Belser (2006) used a marine radar to demonstrate that more night migrants flew in circular flight patterns near a guyed communication tower (>305 m AGL) with red blinking lights combined with red non-blinking lights than near a guyed tower of similar height equipped only with white strobe lights. Similarly, a study by Kerlinger et al. (in review) at several wind power installations showed that there was no detectable difference in avian fatality rates between wind turbines marked with red blinking lights and turbines with no lights. Although we have documented the relationship between tower lights and avian collisions, researchers have not had the opportunity to test the importance of light systems on tall towers (> 277 m) to the frequency of avian collisions. Considering that taller towers are closer to the migration altitude of songbirds and inherently involved in more collisions, it is possible that light system changes may not be as effective in preventing collisions when compared to towers 116-146 m AGL (Gehring et al in prep).

The location or siting of a communication tower is also believed to be related to the frequency of avian collisions. Towers located near areas of intense bird migration, such as coastal areas or peninsulas of land adjacent to large water bodies, are thought to cause more avian fatalities than towers in areas with lower bird migration intensities. Very few data exist regarding the relationship between bird migration intensities and collisions with communication towers.

The objectives of the study are:

1. quantify the frequency of avian collisions at a tower constructed in an area believed to have high intensities of songbird migration. (Part I)

2. compare the frequency of avian fatalities at towers > 277 m AGL which are lit with different lighting systems. Specifically, towers lit with red blinking lights combined with non-blinking lights will be compared to towers lit with blinking white strobe lights compared to towers lit with only blinking red lights (Part II).

The study of these issues will allow us to site new communications towers more appropriately to avoid avian collisions. In addition, we can better understand the relationship between tower lighting systems and avian collisions and potentially alter existing communication towers to reduce those collisions. This report summarizes the results of the 2007 field seasons. Two additional years of data collection are planned for these studies.

Part I. The quantification of avian collisions with a self-supported Rescue 21 tower located in an area of high migratory bird densities

Study Area and Methods

Research was conducted at an unguyed USCG Rescue 21 communication tower 107 m (350 ft) AGL located on the Training Center Cape May (TRACEN), in Cape May, New Jersey (Fig.1). This area has been documented as a concentration area for night migrating, neotropical songbirds (www.birdcapemay.org/morningflight.shtml). The

Rescue 21 tower system provides contemporary and reliable command, control, and communication abilities to further enhance the USCG abilities to accomplish their mission of search and rescue, as well as Maritime Homeland Security. The tower was lit at night with blinking red strobe lights at the top level and mid level and also with non-blinking, red lights at the midpoints between the top-level and mid-level strobes and between the mid-level strobe and the ground (Fig. 2).

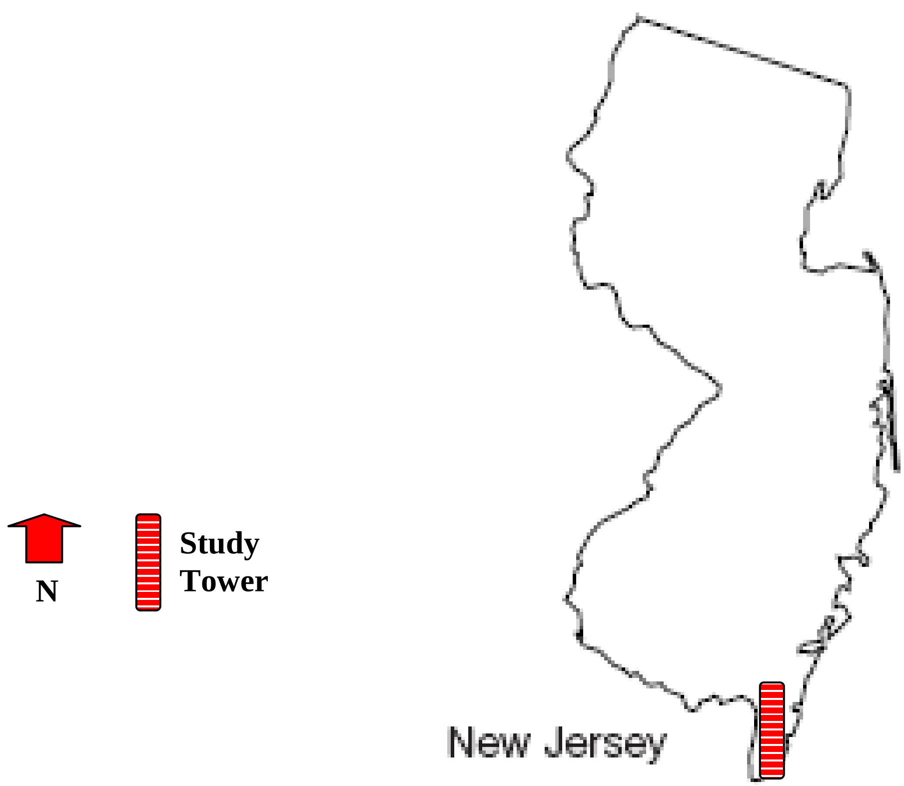


Figure 1. A Cape May, NJ United States Coast Guard Rescue-21 tower was the focus of a study on avian collisions in May and September 2007. The coastal location of the tower likely increases its potential for avian collisions.

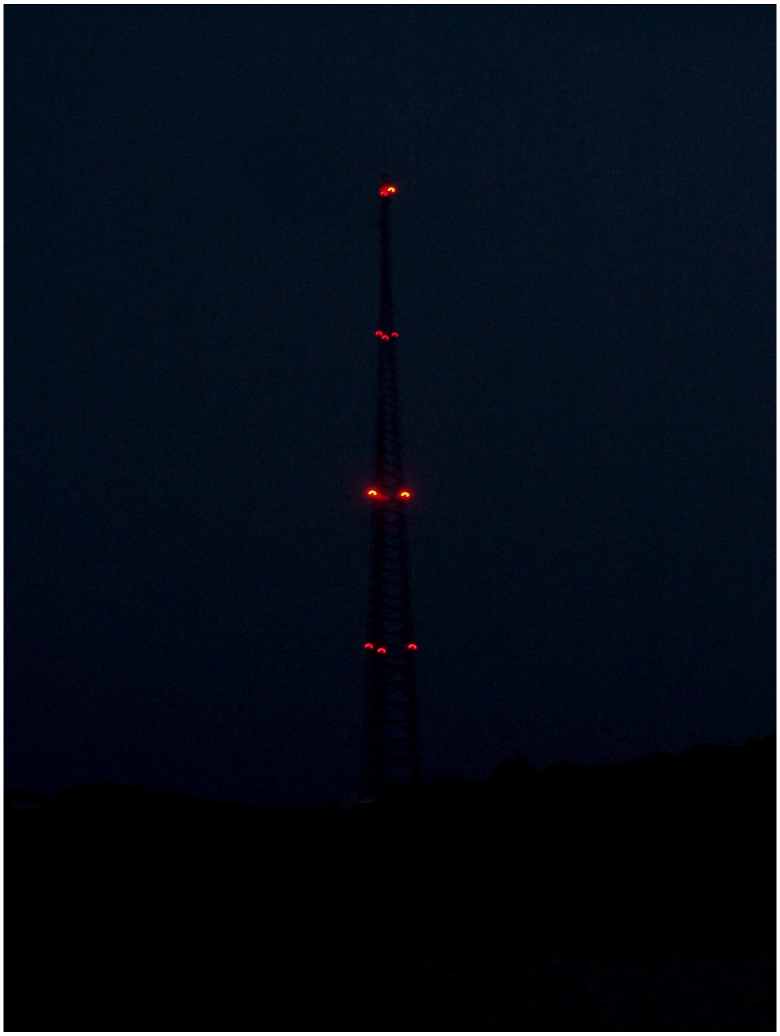


Figure 2. A Cape May, NJ United States Coast Guard Rescue-21 tower was the focus of a study on avian collisions in May and September 2007. The nighttime lighting system was blinking red strobe lights at the top level and mid level (appear bright); with non-blinking, red, incandescent lights at the midpoints between the top-level and mid-level strobes and also at the midpoints between the mid-level strobe and the ground (appear dim).

Carcass searches

The tower was searched 15-31 May and 10-30 September, 2007. After onsite training, the technicians arrived at the towers as early in the day as possible in an effort to prevent diurnal and crepuscular scavengers from removing carcasses. Using flagged, straight-line transects, technicians walked at a rate of 45-60 m per min and searched for carcasses within 5 m on either side of each transect (Fig. 3, Gehring et al. 2007, Erickson et al. 2003). Transects covered a circular area under each tower with a radius of 90% of the height of the tower. Bird carcasses were placed in plastic bags, and the following data were recorded: tower identification number, date, closest transect, distance from tower, azimuth to the tower, estimated number of days since death, and observer's name.

Once bagged and labeled, carcasses were frozen for later identification and verification of species. I maintained the appropriate USFWS and New Jersey Department of Environmental Protection- Division of Fish and Wildlife permits.

Figure 3. A Cape May, NJ United States Coast Guard Rescue-21 tower was the focus of a study on avian collisions in May and September 2007. Flags were systematically placed within the search area to facilitate methodical searches for avian carcasses.

Observer detection and carcass removal trials

It is unlikely that technicians observe all bird carcasses under communication towers. This is in part due to dense vegetation, observer fatigue, human error, and scavenging by predators. Therefore, each technician's observer detection rate and the rate at which carcasses were removed were quantified at each site (Erickson et al. 2003). Observer detection trials were conducted on technicians at their designated tower each field season. Technicians were not notified when the observer detection trial would occur, or how many and what species of bird carcasses would be placed at their tower site. Mr. Christopher Hajduk, Chief of the Environmental Protection and Safety Section at TRACEN, assisted with observer detection trials by placing 10 Brown-headed Cowbird (*Molothrus ater*) carcasses within the tower search area. I was then able to quantify the proportion of bird carcasses detected by each technician. For these detection trials I painted the Brown-headed Cowbirds to simulate the fall plumage of migrating songbirds. Bird carcasses used for observer detection trials were also painted with an "invisible" paint that glowed fluorescent colors when viewed under a black light. When analyzing the study data, the "invisible" paint prevented any confusion between birds that had collided with the towers and birds placed in the plots for observer detection trials.

Similarly, technicians placed 15 bird Brown-headed Cowbird carcasses immediately adjacent to the edges of their designated communication tower's search area and monitored the removal (e.g., scavenging) of carcasses daily during the study period. Using these data I calculated a scavenging or removal rate (Erickson et al. 2003). Bird carcasses used in the removal trials were not painted, as this foreign scent might have prevented scavengers from removing carcasses. Both observer detection trial birds and removal trial birds were placed in a range of habitats characteristic of the individual tower search area.

Statistical analyses

Using methods developed by W. Erickson (WEST, Inc.), I used the observer detection rate and the carcass removal rate specific for each field season to calculate adjustment multipliers by which to correct the observed number of birds at the tower per season. This adjustment method considered the probability that carcasses not found on one day could be found on the following days, depending on the rate of carcass removal (W. Erickson pers. comm.). These two interacting variables were used to determine an average carcass detection probability and the related adjustment multiplier specific to each tower.

Results

During the two study seasons of 2007 technicians found 0 birds determined to be killed during the study (Table 1). One technician detected a bird carcass, likely that of a gull, however the level of decomposition highly suggested that it had died well before the study period and the cause of death was undetermined. Because 50% of the search area was inaccessible due to impenetrable Poison Ivy (Fig. 4), it would have been necessary to make appropriate adjustments to the estimates of carcasses detected by multiplying the number of carcasses by two.

Table 1. The numbers of bird carcasses found at the Rescue 21 communication tower during the spring and fall of 2007.

Migration season	Number of carcasses found	Multiplier
Spring	0	1.37
Fall	0	2.66
Total	**0**	**—**

Figure 4. A Cape May, NJ United States Coast Guard Rescue-21 tower was the focus of a study on avian collisions in May and September 2007. Systematic searches for avian carcasses were not possible in 50% of the tower search area due to 4-6-m tall Poison Ivy.

The observer detection rates for the spring and fall were 0.2 and 0.4, respectively. The carcasses removal rate was 34.4 days and 10.73 for spring and fall respectively. I used the observer detection rate and the carcass removal rate specific for each survey season to calculate adjustment multipliers by which to correct the observed number of birds. This adjustment method considered the probability that carcasses not found on 1 day could be found on the following days, depending on the rate of carcass removal (W. Erickson pers. comm.). These 2 interacting variables were used to determine a carcass detection probability specific to each tower including 1.37 for the spring and 2.66 for the fall.

Discussion and objectives for the Rescue 21 tower study in 2008

The low levels of avian fatalities documented at this communication tower are supported by past research in Michigan where we found a mean of 0.5 bird carcasses per self-supported tower of similar height each migration season, independent of the tower lighting system (Gehring et al. in prep). It is likely that migratory songbirds are attracted to the site, however, are not colliding in detectable numbers due to the lack of guy wires. Based on past research, significantly more avian fatalities would occur had the USCG constructed a guyed tower instead of an unguyed structure (Gehring et al. 2007). These data are very valuable for future tower construction and development, especially in areas with large concentrations of night migrating songbirds.

While self-supported towers do not appear to be involved in high levels of avian fatalities it is possible that night-migrating songbirds are diverting from their migration path as they are attracted to the tower lights. The energy used in this behavior could potentially be detrimental to the ultimate success of an individual bird's migration. For example, it is necessary for some songbirds to fly for 3-4 days at a time without refueling while traversing large bodies of water, depending only on body fat for survival. If their available body fat has been reduced unnecessarily while attracted to lit structures it could potentially decrease their likelihood of surviving later during critical periods of migration. Considering that there are >100,000 communication towers in the United States alone, there is potential for an individual bird to spend considerable time and energy on behaviors not useful for migration and this behavior could ultimately result in indirect mortality. Alternate methods of research would be necessary to document the attraction of night-migrating songbirds to a lit self-supported communication tower.

I am currently investigating options to conduct radar ornithology at the TRACEN USCG Rescue 21 communication tower site in future migration seasons. Radar ornithology would serve multiple purposes. First, we could document the presence or absence of night-migrating songbirds at the site, despite the lack of fatalities; thereby, potentially adding additional insight into the use of self-supported towers to prevent avian collisions. Second, we could examine the prediction that birds are diverted from a direct migration path in response to the communication tower lights.

The data collected in 2007 suggest that by investing in a more expensive, self-supported communication tower at this site, the USCG Rescue 21 system has successfully avoided significantly contributing to the 4-50 million birds estimated to collide with communication towers each year in the United States (Manville 2005). Additional data collection will not only provide study replication to ensure that the study's findings are consistent from year to year but will also further our knowledge of the issue of avian interactions with communication towers and possibly contribute to creative methods whereby to reduce the frequency of fatalities at a national scale.

Part II. The frequency of avian collisions with tall communication towers: a comparison of tower light systems

Study Area and Methods

Research was conducted at 6 communication towers distributed throughout the lower peninsula of Michigan, USA. Towers > 277 m AGL were selected based on granted access by tower owners, existing tower lighting systems, and their dispersion throughout the study area (Fig. 5). Towers located within 1.6 km of an extensively-lit area (e.g., large urban area) or within a tower farm (additional communication tower(s) within 0.81 km) were not included in the study. This procedure prevented a situation where communication tower lights might be less visible to birds or "washed-out" due to sky glow in the surrounding areas (Caldwell and Wallace 1966). I was granted access to two towers lit at night with red blinking lights (L-864) combined with red non-blinking lights (L-810), three towers lit at night only with white strobes (L-865) and no non-blinking lights, and one unique tower with red blinking lights (L-864) combined with L-810 lights reprogrammed to blink simultaneously with the L-864 lights (Fig. 6). The first two lighting systems described meet the recommendations of the FAA (FAA 2000). The last lighting system described does not currently meet the recommendations of the FAA but was provided a lighting variance by the FAA as part of a Special Use Permit on United States Forest Service land. Mr. Christopher Schumacher of the Manistee Ranger Station requested this light change in an effort to possibly reduce bird collisions.

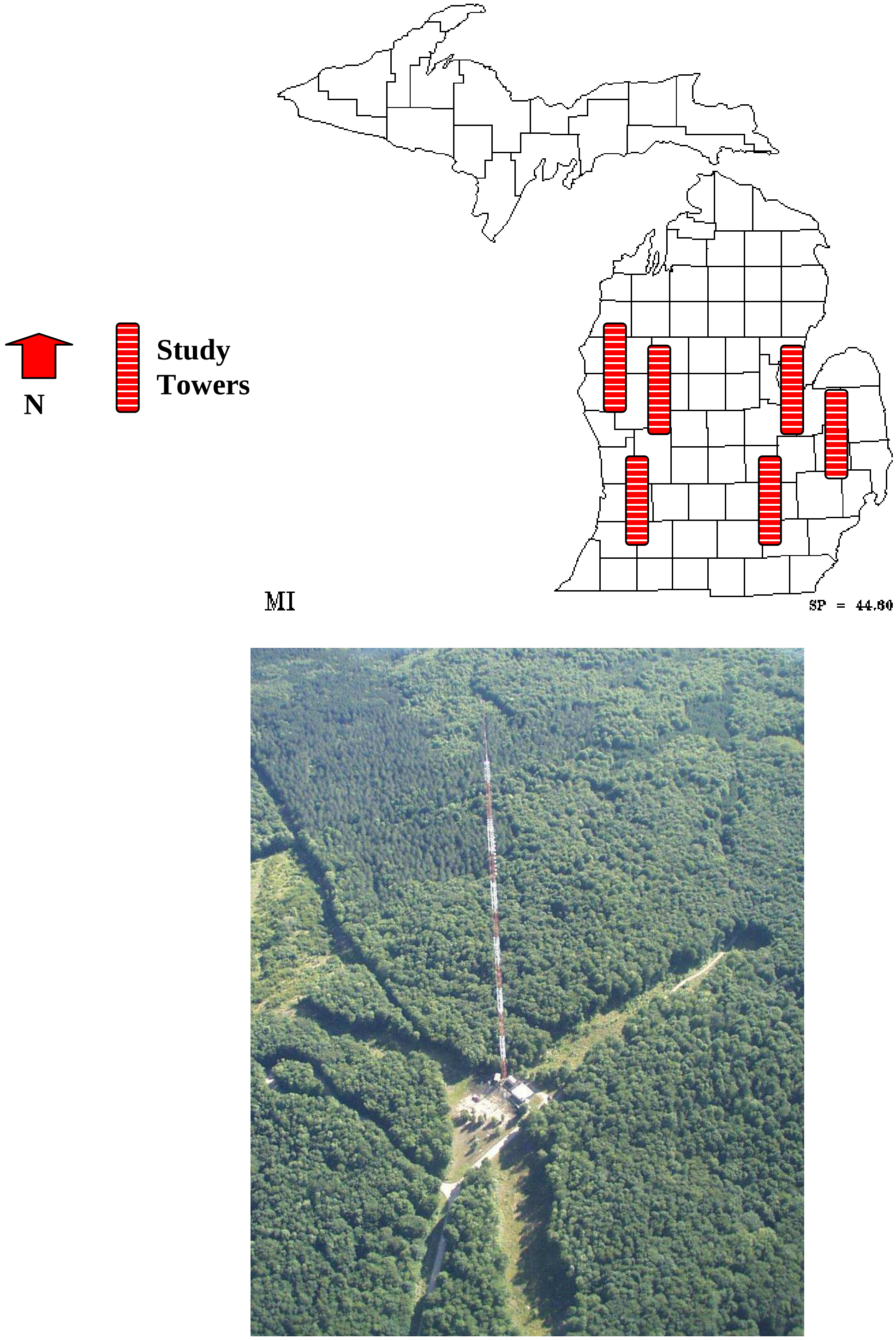
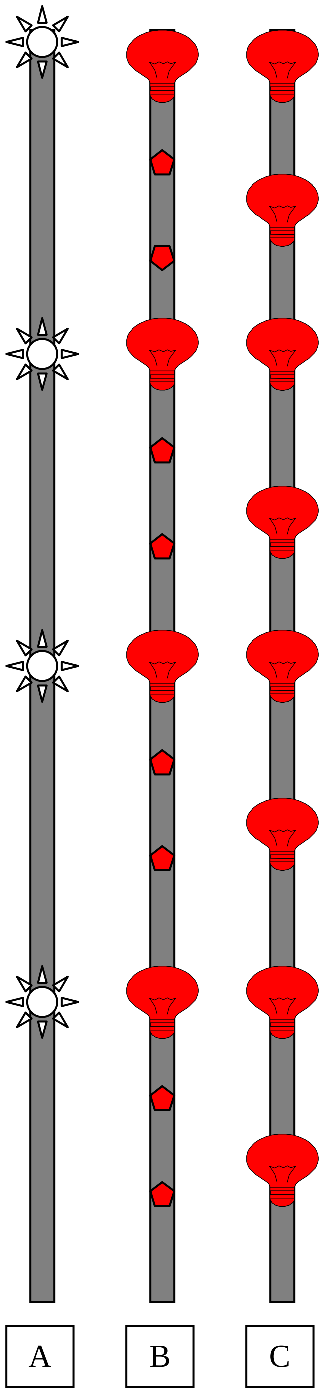


Figure 5. Six communication towers located throughout Michigan were included in a study of avian collisions. The areas under these towers were simultaneously and systematically searched for bird carcasses during 20 consecutive mornings surrounding the peak of songbird migration in the spring and fall 2007 to compare the relationships between avian fatalities and tower lighting systems.



A. 3 guyed towers > 277 m AGL with white blinking strobe lights (L-865) at multiple levels; no non-blinking lights

B. 2 guyed towers > 277 m AGL with red blinking incandescent lights (L-864) at multiple levels alternating with non-blinking incandescent lights (L-810)

C. 1 guyed tower > 277 m AGL with red blinking incandescent lights (L-864) multiple levels and no non-blinking incandescent lights (L-810)

Figure 6. Three communication tower lighting systems were compared on 6 towers > 277 m Above Ground Level. The areas under these towers were simultaneously and systematically searched for bird carcasses during 20 consecutive mornings surrounding the peak of songbird migration in the spring and fall 2007 to compare the relationships between avian fatalities and tower lighting systems.

Carcass searches

Towers were searched 10-29 May and 7-26 September, 2007. Searching the same tower every day, technicians arrived at the towers as early in the day as possible in an effort to prevent diurnal and crepuscular scavengers from removing carcasses. Using flagged, straight-line transects, technicians walked at a rate of 45-60 m per min and searched for carcasses within 5 m on either side of each transect (Gehring 2004, Erickson et al. 2003). Transects covered a circular area under each tower with a radius of 100 m from the base of the tower. Where portions of the search area were inaccessible due to private property, etc. appropriate adjustments were made in calculations. Bird carcasses were placed in plastic bags, and the following data were recorded: tower identification number, date, closest transect, distance from tower, azimuth to the tower, estimated number of days since death, and observer's name. Once bagged and labeled, carcasses were frozen for later identification and verification of species. Gehring maintained the appropriate USFWS and Michigan Department of Natural Resources (MDNR) permits.

Observer detection and carcass removal trials

It is unlikely that technicians observe all bird carcasses under communication towers. This is in part due to dense vegetation, observer fatigue, human error, and scavenging by predators. Therefore, each technician's observer detection rate and the rate at which carcasses were removed were quantified at each site (Erickson et al. 2003). Observer detection trials were conducted on technicians at their designated tower once each field season. Technicians were not notified when the observer detection trial would occur, or how many and what species of bird carcasses would be placed at their tower site. By placing 10 bird carcasses within the tower search area, I was able to quantify the proportion of bird carcasses detected by each technician. For observer detection trials I used Brown-headed Cowbirds (*Molothrus ater*) painted to simulate the fall plumage of migrating songbirds. Bird carcasses used for observer detection trials were also painted with an "invisible" paint that glowed fluorescent colors when viewed under a black light. When analyzing the study data, the "invisible" paint prevented any confusion between birds that had collided with the towers and birds placed in the plots for observer detection trials.

Similarly, technicians placed 15 bird Brown-headed Cowbird carcasses immediately adjacent to the edges of their designated communication tower's search area and monitored the removal (e.g., scavenging) of carcasses daily during the study period. Using these data we calculated a scavenging or removal rate (Erickson et al. 2003). Bird carcasses used in the removal trials were not painted, as this foreign scent might have prevented scavengers from removing carcasses. Both observer detection trial birds and removal trial birds were placed in a range of habitats characteristic of the individual tower search area.

Statistical analyses

The Kruskal-Wallis test combined with Tukey's Honestly Significant Difference (HSD) multiple comparison procedures were used to test for differences in avian fatalities among the tower lighting systems from the spring and fall 2007 combined (Zar 1998). Using methods developed by W. Erickson (WEST, Inc.), we used the observer detection rate and the carcass removal rate specific for each individual tower to calculate adjustment multipliers by which to correct the observed number of birds per tower. This adjustment method considered the probability that carcasses not found on one day could be found on the following days, depending on the rate of carcass removal (W. Erickson pers. comm.). These two interacting variables were used to determine an average carcass detection probability and the related adjustment multiplier specific to each tower. Both raw data and data adjusted for scavenging and observer detection were used when testing for significant differences among tower types. I used the statistical software Minitab (2007) for Kruskal-Wallis and related multiple comparisons with an $\alpha = 0.10$.

Results

Over 20 days in the spring and fall of 2007 technicians and I found a total of 78 birds determined to be killed during the study periods (Table 2). During this study the maximum number of birds found in 1 morning at 1 tower was 8. One of the towers lit with white strobe lights was in an agricultural field which was bare dirt in the spring field season. The technician working at this tower in the spring had a very high observer detection rate and found 15 tower killed birds, while technicians at other white strobe lit towers found a mean of 4 birds that season. This potential outlier is included in the presentation of these data unless otherwise stated.

Table 2. The numbers of bird carcasses found at 6 Michigan communication towers during 20 days in the spring 2007 and 20 days in the fall of 2007.

Tower light system	**Number of towers searched**	**Number of carcasses found**		
		Spring	**Fall**	**Total**
White strobe	3	23 (mean = 7.67, SE = 3.71)	4 (mean = 1.33, SE = 0.67)	27 (mean = 4.5, SE = 2.2)
Red blinking incandescent with non-blinking	2	18 (mean = 9.00, SE = 2.00)	26 (mean = 13.00, SE = 1.00)	44 (mean = 11.00, SE = 1.47)
Red blinking incandescent without non-blinking	1	5	2	7 (mean = 3.500, SE = 1.5)
Total	**6**	**46**	**32**	**78**

I identified each specimen to taxonomic species when possible (Table 3). Twenty species of birds were collected and identified to have collided with the towers during the spring 2007 study period. The Red-eyed Vireo (*Vireo olivaceus*) was the most common species observed in the spring field season, with the Common Yellowthroat (*Geothlypis trichas*) as the second most common species detected (Table 3). The fall 2007 searches detected 14 species of birds with the Ovenbird (*Seiurus aurocapillus*) as the most common and the Blackpoll Warbler (*Dendroica striata*) only slightly more common than the remaining individuals. During the fall field season, technician C. DeLong detected a Blackpoll Warbler that had been banded with an aluminum USFWS band (Fig. 7). Via the Bird Banding Lab, I was able to make contact with the individual (J. Pattison) who banded the bird in October 2006 at the Allegheny Front Migration Observatory in Grant County, West Virginia. This rare band recovery allows us to infer that the individual, which likely hatched in northern Canada, successfully migrated to South America and back to Canada, at least once in its lifetime. However, its final fall 2007 migration was not successful.

Table 3. Avian fatalities (by species) at 6 Michigan communication towers during 20 days in the spring and fall of 2007.

Bird Species[a]	**Numbers of carcasses found**	
	Spring	**Fall**
Wild Turkey (*Meleagris gallopavo*)	1 (2%)	1 (3%)
American Kestrel (*Falco sparverius*)	1 (2%)	
Mourning Dove (*Zenaida macroura*)	1 (2%)	
Blue Jay (*Cyanocitta cristata*)		1 (3%)
Red-breasted Nuthatch (*Sitta canadensis*)		1 (3%)
American Robin (*Turdus migratorius*)	1 (2%)	
Swainson's Thrush (*Catharus ustulatus*)	3 (6%)	
Wood Thrush (*Hylocichla mustelina*)		1 (3%)
Gray Catbird (*Dumetella carolinensis*)	2 (4%)	
Yellow-billed Cuckoo (*Coccyzus americanus*)	1 (2%)	1 (3%)
Blue-headed Vireo (*Vireo solitarius*)		1 (3%)
Red-eyed Vireo (*Vireo olivaceus*)	8 (17%)	1 (3%)
House Wren (*Troglodytes aedon*)		1 (3%)
Northern Parula (*Parula americana*)	1 (2%)	1 (3%)
Ovenbird (*Seiurus aurocapillus*)	1 (2%)	7 (22%)
Black-and-white Warbler (*Mniotilta varia*)	1 (2%)	
Tennessee Warbler (*Vermivora peregrina*)	2 (4%)	
Blackburnian Warbler (*Dendroica fusca*)	1 (2%)	
Common Yellowthroat (*Geothlypis trichas*)	4 (7%)	
Blackpoll Warbler (*Dendroica striata*)		2 (6%)
American Redstart (*Setophaga ruticilla*)	1 (2%)	1 (3%)
Pine Warbler (*Dendroica pinus*)		1 (3%)
Mourning Warbler (*Oporornis philadelphia*)		1 (3%)
Scarlet Tanager (*Piranga olivacea*)	1 (2%)	
Brown-headed Cowbird (*Molothrus ater*)	1 (2%)	
White-throated Sparrow (*Zonotrichia albicollis*)	2 (4%)	
Swamp Sparrow (*Melospiza georgiana*)	1 (2%)	
Unknown duck[b]	1 (2%)	
Unknown -thrush size[b]	4 (7%)	2 (6%)
Unknown –warbler/vireo size[b]	7 (15%)	9 (28%)
Total	**46**	**32**

[a] all names of birds follow the *AOU Check-list of North American Birds*
[b] bird carcass heavily scavenged preventing identification of species

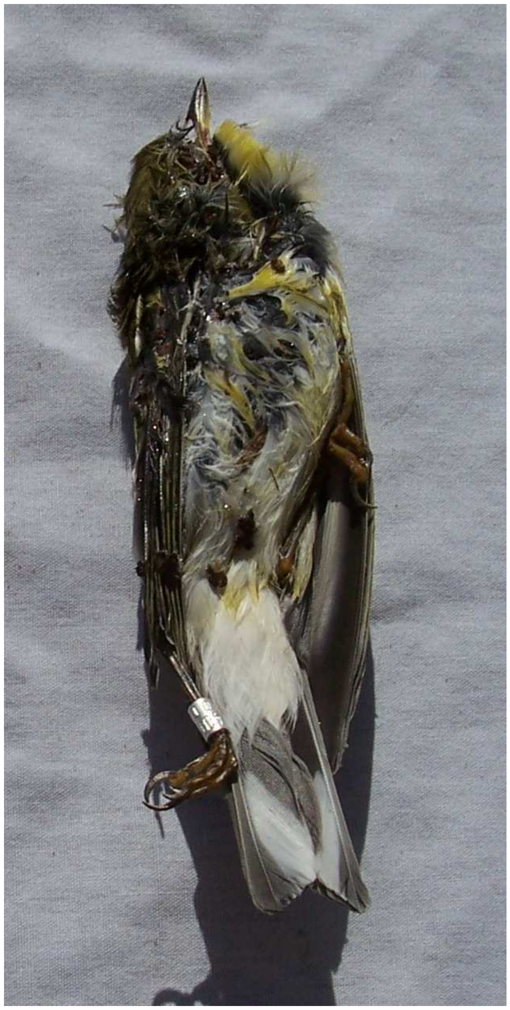


Figure 7. A banded Blackpoll Warbler was detected in September 2007 after a collision with a Michigan communication tower. The bird had been banded in West Virginia in October 2006.

The mean observer detection rates for the spring and fall were 0.18 (SD =0.25) and 0.10 (SD =0.25), respectively. The mean carcasses removal rate was 7.98 days (SD = 0.84) and 5.22 (SD =3.38) for spring and fall, respectively. I used the observer detection rate and the carcass removal rate specific to each individual tower to calculate adjustment multipliers by which to correct the observed number of birds. This adjustment method considered the probability that carcasses not found on 1 day could be found on the following days, depending on the rate of carcass removal (W. Erickson pers. comm.). These 2 interacting variables were used to determine an average carcass detection probability specific to each tower ranging between 1.43 and 4.44 (mean = 2.81, SD = 1.28) for the spring and 2.57 and 5.01 (mean = 3.57, SD = 0.93) for the fall.

Before adjusting for carcass removal and observer detection rates, Kruskal-Wallis ANOVA for ranks suggested that there were no significant differences in avian fatalities among towers with different lighting systems ($\chi^2_2 = 4.24$, $P = 0.120$). However, this was likely due to the extremely high observer detection rate for the technician with bare dirt under a tower lit with white strobe lights and subsequently the large number of birds that he detected. Subsequent Kruskal-Wallis comparisons with that specific outlier tower removed from analysis detected significant differences among the tower lighting types ($\chi^2_2 = 7.31$, $P = 0.026$). Similarly, when all towers were included in the analysis but adjustments made for carcass removal and observer detection rates significant differences were found among the tower lighting types ($\chi^2_2 = 7.59$, $P \leq 0.022$). Tukey's multiple comparisons found that towers with non-blinking lights were involved in significantly more avian fatalities than towers with only white blinking lights ($P \leq 0.05$) or only red blinking lights ($P \leq 0.05$). There was no significant difference in the numbers of avian fatalities between towers lit with red blinking lights and towers lit with white blinking lights.

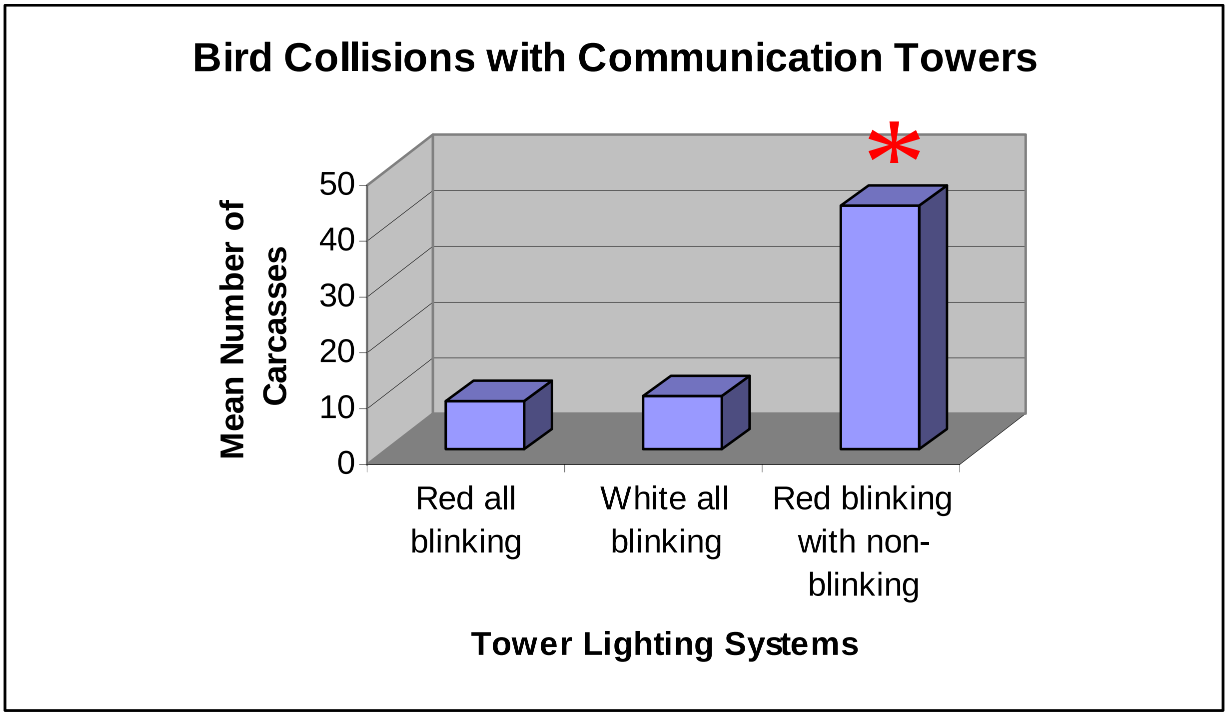


Figure 8. Bird carcass count data adjusted for observer detection and carcass removal were compared at 6 Michigan communication towers > 277 m Above Ground Level (AGL), during the spring and fall of 2007. Three different lighting systems were used on the towers. The areas under towers were systematically searched for bird carcasses during 20 consecutive mornings surrounding the peak of songbird migration.

Discussion and objectives for the tall Michigan tower study in 2008

These results suggest that avian fatalities at communication towers can be significantly reduced by using white strobe lights or blinking red lights instead of the more common lighting system of red blinking lights combined with non-blinking red lights (Fig. 6). Similar to previous research on the effects of lighting systems on avian collisions, which was conducted at 116-146-m AGL towers, fatalities were 60-68 % less frequent at > 277 m AGL towers lacking non-blinking, red lights (Gehring et al. 2007). These results are also supported by research conducted by Gauthreaux and Belser (2006) who used radar ornithology to observe night-migrating songbirds' flight behavior responses when encountering tall communication towers lit at night with either white strobe lights or red blinking lights combined with red non-blinking lights. They found that when birds were near the red, non-blinking lights that they deviated from a straight, direct azimuth of migration and instead flew in a more circular pattern toward the tower; whereas birds flying near a tower with only white strobe lights did not deviate as commonly.

Extinguishing non-blinking, red lights would not only benefit avian conservation but would also be financially and logistically beneficial to tower owners, as it would reduce maintenance and utility costs. However, tower owners and operators are required by the Federal Communications Commission (FCC) to follow the recommendations of the FAA. Currently, the FAA allows only the white strobe system to be used at night without non-blinking lights (FAA 2000). Although white strobe systems provide an FAA approved option to significantly reduce avian collisions, the general public generally finds them aesthetically disturbing compared to red blinking lights. In addition, converting communication towers with traditional lighting systems to white strobe systems can be prohibitively costly for tower companies. Fortunately, the FAA is currently exploring the possibility of changing their recommendations to allow the non-blinking, red lights to be extinguished on towers lit with standard red light systems. Given their mandate for air safety, the FAA will need to conduct proper tests of tower visibility or conspicuity to pilots before such recommendations are changed in order to allow this cost efficient and effective option for tower companies.

This study provides a highly unique opportunity to detect consistent differences in bird fatalities among tower light systems. Additional field seasons in 2008 and 2009 will strengthen the quality of the study. I also plan to equalize the sample sizes of study tower light systems by adding another tower with red blinking lights combined with red non-blinking lights. I will also further pursue acquiring FAA lighting variances that would allow the non-blinking lights to be temporarily extinguished on study towers for the purpose of this research

Acknowledgments

This study could not be completed without the dedication, enthusiasm, and hard work of the technicians who conducted the early morning searches under communication towers -regardless of rainy and cold conditions. The USCG is commended and thanked for granting access to their Rescue 21 tower and for making this important and unique study possible with their funding and support. This study is made possible by the inclusion of towers greater than > 277 m AGL. I owe a large amount of thanks to the private tower owners and engineers who, by allowing us access to their sites, are taking important steps towards learning more about the issue of bird collisions with communication towers and cost-effective methods to reduce the collisions. W. Erickson (WEST, Inc.) generously provided assistance and formats for calculating average detection probabilities considering both removal and observer detection rates. The interpretation and applicability of this study is greatly enhanced by his shared expertise. C. Mensing (USFWS), and his technicians generously provided Brown-headed Cowbird carcasses. Many individuals provided ideas, suggestions, and support for this project and similar previous projects, including but not limited to: A. Manville (USFWS), T. Tansey (USCG), C. Hajduk (USCG), C. Czarnecki (USFWS), S. Lewis (USFWS), P. Kerlinger (Curry & Kerlinger, LLC), B. Noel (Arkansas State University ASU)), E. Macchia (ASU), and J. Bednarz (ASU). Several agencies and organizations provided support and collaboration: Michigan Department of Natural Resources (MDNR), New Jersey Department of Environmental Protection- Division of Fish and Wildlife, Federal Aviation Administration, FCC, and the American Bird Conservancy. I am particularly grateful for the foresight of C. Schumacher (USFS) who initially collaborated with the FAA and a tower owner requesting that one of the current study towers be altered to only blink (without non-blinking lights). This unique tower lighting system holds promise for significantly reducing avian collisions if the FAA deems it safe for aviators. I would like to express my gratitude to the USCG, USFWS, and the National Fish and Wildlife Foundation (NFWF) for granting funds to improve this project. The views and conclusions contained in this document are those of the author and should not be interpreted as representing the opinions or policies of the U.S. Government or the National Fish and Wildlife Foundation. Mention of trade names or commercial products does not constitute their endorsement by the U.S. Government or the National Fish and Wildlife Foundation. Michigan Natural Features Inventory, Michigan State University, and Central Michigan University provided greatly appreciated logistical support for this research. My colleagues at the Michigan Natural Features Inventory provide both logistical and technical support; especially, Y. Lee, S. Ridge, N. Toben, R. Rogers, and H. Enander.

Literature Cited

Avery, M., P. Springer, and J. Cassel. 1976. The effects of a tall tower on nocturnal bird migration- a portable ceilometer study. Auk 93:281-291.

Caldwell, L. and G. Wallace. 1966. Collections of migrating birds at Michigan television towers. The Jack-Pine Warbler 44:117-123.

Cochran, W. and R. Graber. 1958. Attraction of nocturnal migrants by lights on a television tower. Wilson Bulletin 70:378-380.

Erickson, W., J. Jeffery, K. Kronner, and K. Bay. 2003. Stateline Wind Project Wildlife Monitoring Annual Report, Results for the Period July 2001 - December 2002. Technical report submitted to FPL Energy, the Oregon Office of Energy, and the Stateline Technical Advisory Committee.

Federal Aviation Administration (FAA). 2000. Obstruction Marking and Lighting. AC 70/7460-1K.

Gauthreaux, Jr., S. and C. Belser. 2006. Effects of artificial night lighting on migrating birds. Pp. 67- 93 in C. Rich and T. Longcore (editors), Ecological Consequences of Artificial Night Lighting, Island Press, Washington.

Gehring, J. L., P. Kerlinger, and A. Manville. 2007. In review. Communication towers, lights, and birds: successful methods of reducing the frequency of avian collisions. Ecological Applications.

Gehring, J. L., P. Kerlinger, and A. Manville. In prep. Avian collisions at communication towers: The role of tower height and guy wires. Journal of Wildlife Management.

Kerlinger, P., J. Gehring, W.P. Erickson, and R. Curry. In Review. Federal Aviation Administration obstruction lighting and night migrant fatalities at wind turbines in North America: A review of data from existing studies.

Manville, A.M., II. 2005. Bird strikes and electrocutions at power lines, communication towers, and wind turbines: state of the art and state of the science – next steps toward mitigation. Bird Conservation Implementation in the Americas: Proceedings 3rd International Partners in Flight Conference 2002, C.J. Ralph and T.D. Rich (eds.). U.S.D.A. Forest Service General Technical Report PSW-GTR-191, Pacific Southwest Research Station, Albany, CA: 1051-1064.

Minitab. 2007. Minitab®.15.1.1.0. Minitab, State College, PA

Zar, J. 1998. Biostatistical Analysis. Prentice Hall, Englewood Cliffs, NJ.