Risk Assessment for Night Migrating Birds at the Canton Mountain Wind Power Project, Maine

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Patriot Renewables, LLC has proposed to construct the 22-MW, eight-turbine Canton Mountain wind energy project near Canton, Oxford County, Maine. The turbines would be about 448 feet (137 meters) above ground level when the rotor blades are in the 12 o'clock position. The turbines would be located at about 1,400 feet above sea level on wooded hilltops, with the closest turbine being greater than 1.5 miles from the Androscoggin River.

In this report, the radar information and data gathered by Tetra Tech to evaluate risk to night migrants at Patriot Renewables' project site in Canton will be compared to radar data collected as part of more than 70 other studies at more than 60 project sites in the eastern United States. The purpose of this comparison is to contextualize the radar data gathered for the Canton Mountain site with respect to the results of radar studies conducted at other wind power projects in the eastern United States.

In addition to radar comparisons, a risk assessment of night migrating birds is conducted for the Canton project site based on empirically determined fatalities of birds at 26 previously studied wind power sites in eastern North America. These datasets are used to conduct a risk assessment (predict approximate collision fatalities) for the Canton Mountain project. With millions of dollars being spent to date on post-construction fatality studies recommended by state and federal wildlife agencies, as well as non-profit environmental organizations, it is important to examine these data to determine if fatalities are consistent from site to site and whether a newly proposed wind power facility is likely to experience significant impacts, based on what has been found elsewhere.[1]

Analysis and Comparison of Radar Studies in the Eastern United States

There are two basic types of marine radar used for detecting and measuring flying biological target activity at wind project sites: Merlin and non-Merlin based systems. Both systems are based on the same underlying technology; however the Merlin-type system uses a continuous vertical beam to identify and count the number of targets flying over a potential wind project site. This system likely allows for the identification of more targets because monitoring is continuous and since the number of targets is calculated from the vertical radar data instead of the horizontal radar data, which is the case with non-Merlin-type equipment. Differences in the setup and processing of radar data can affect reported results and data quality. Merlin type radars count target heights and numbers in real time, using the vertical beam (VSR) to count both

[1] The New York State Energy Research and Development Authority, working with New Jersey Audubon (radar), Curry & Kerlinger, LLC (fatality study), and the State University of New York College of Environmental Sciences and Forestry, have completed what is likely the first comparative study of radar and avian and bat fatalities at a wind power project in North America. A report is being prepared.

target flight heights and numbers and use an additional horizontal beam (HSR) to report target flight directions. While the Merlin uses two marine radars simultaneously to gather both VSR and HSR data in real time, some other radar systems use one radar beam for both the HSR and VSR and alternate between them when sampling the airspace over the radar unit. The samples are then analyzed in various ways, depending on the operator, and extrapolated to determine target flight heights, targets per km/h, and direction. Different software is also used to analyze the raw data, as well as to estimate the number of targets observed passing a given location.

For the purpose of comparing the Merlin type radar with non-Merlin type radars, three independent measures were selected: 1) mean targets per kilometer per hour; 2) percentage of targets observed within or below the rotor swept zone; and, 3) mean altitude of targets observed. A peer-reviewed or proven analytical tool for using radar data to predict or assess risk is not available. However, these three variables were chosen because they are the three metrics that are likeliest to inform assessing or predicting risk to birds or other biota at a given site, and these are sometimes cited by agency biologists as metrics that may provide insight into the number of fatalities that will likely occur at a prospective wind plant.

A list of spring and fall radar study results (Table 1) provides the raw summary data from which subsequent statistical analyses were conducted. A total of about 80 studies were available that were conducted at more than 60 sites by radar operators using both the Merlin and non-Merlin systems (a Merlin system was used for Canton Mountain). Table 1 provides the spring and fall data for mean rate of target passage per kilometer per hour for spring and fall, the percentage of targets observed flying at altitudes less than 130 m - the height of the rotor when blades are in the 12 o'clock position, and mean altitude of flight. Not all studies include spring and fall observations, so sample sizes are unequal between these groups. In addition, not all studies reported mean altitude of migration. Finally, a few of the studies were somewhat redundant in that they were conducted in different years at the same site for pre- and post-construction.

Analysis of Merlin vs. non-Merlin radar data

Six Merlin-type radar studies were available from five different sites. Two additional studies are underway, and results are not currently available. A comparison of the summary data in Table 1 is summarized in Table 2, along with statistical analyses to determine whether the mean values from the Merlin-type radar and non-Merlin-type radar studies differ statistically according to a randomized t-test. The Merlin-type radar consistently detected a greater number of targets in both spring and fall. In fact, the passage rate for spring Merlin studies averaged twice that of spring non-Merlin studies (622 vs. 295 targets per kilometer per hour). For autumn studies, there was also a two-fold greater passage rate among the Merlin studies (681 vs. 344 targets per

kilometer per hour). Thus, sites where Merlin was used had a much greater average target passage rate than did the 70+ studies where non-Merlin-type radar was used. In other words, use of Merlin-type radar has resulted in higher target counts, on average, than non-Merlin-type radar, which site differences alone cannot explain. The t-test statistic revealed a non-significant difference for spring ($P = 0.161$) and fall ($P = 0.197$) migration between Merlin and non-Merlin recorded passage rates. However, there was still nearly a two-fold difference in average target passage rate between Merlin and non-Merlin for spring and fall, with the Merlin radar showing much greater passage rates. These results, even though not significant at the $P<0.05$ level, strongly suggest that there are differences between the Merlin and non-Merlin data sets that are real. With such a small sample size, it is a surprise that the means are so different.

With respect to the mean altitude of flight, Merlin-type radar studies reported lower flight for both spring and fall studies. For spring studies, there was a 108 m difference and for fall studies there was a 167 m difference, both of which reflect lower flight as measured by the Merlin radar. The mean altitude of targets was 27.6% lower for the Merlin measurements in spring and 39.5% lower in fall. Both spring and fall altitudes for the Merlin were significantly different from non-Merlin data, with spring data being significant at the $P<0.05$ level and fall being significant at the $P<0.01$ level. Again, even with the small sample size, there is a strong indication that the Merlin radar detects more targets, most likely at lower altitudes, than do other radars.

The Merlin radar also detected greater percentages of targets flying at altitudes lower than the tip of the turbine rotors (130 m) than do non-Merlin radars. The average percentage observed flying below 130 m was 9% higher for Merlin as opposed to non-Merlin radars (23% vs. 14%) during spring migration. During fall migration, the percentage difference was even greater (23% difference), with fall studies for Merlin radars averaging one-third of all targets flying within this low altitude band (33% vs. 10%). This is a very large difference. Both spring and fall t-tests revealed differences at the $P<0.05$ level.

These results strongly suggest that the Merlin radar may be more sensitive at detecting targets than are the other types of radars used at the 60+ other sites that have been studied with non-Merlin-type radars. Alternatively, the Merlin software may be confusing ground clutter or insects with vertebrate targets, which would inflate the number of targets counted at lower altitudes.

The difference between Merlin and non-Merlin radars may be a result of differences in hardware or software used, or of some other difference between the study methods (operator experience, radar settings [attenuation, orientation in relation to the axis of migration, etc.]). These differences also suggest that the Merlin radar may be more sensitive or more adept at identifying small targets than other radars. The fact that more targets are seen and more are seen within the rotor swept zone by Merlin radars than are seen by other radars is what would be expected from

a more sensitive radar system. The fact that Merlin radars have consistently reported significantly different passage rates and altitudes, not to mention vastly greater variation than other radars, strongly suggests that the high percentage of targets recorded at Canton (and Colonel Holman Mountain to a lesser degree), is related more to the radar than to differences in migration behavior among project sites. This is reinforced by the possibility that ground clutter and insect contamination may also affect the radar data, particularly at Canton where the radar was located on a side-slope. These factors increase the uncertainty of the database, thereby making predictions regarding fatality rates based on radar data alone tenuous.

There are other explanations for differences among the various types of radars used for studying birds and bats at prospective wind energy project sites. A study by Schmaljohann et al. (Ibis 150: 342-355) demonstrated that density estimations using radar can be as much as 400% different among different radar systems or operators. The reason is because the radars were not calibrated, so it is impossible to determine if one radar type consistently detects more targets than another type of radar. Schmoljohann et al. empirical results suggested that the large differences were due to different detection probabilities related to calibration of the radars' density setting. Schmaljohann et al. conclude, "We fear that quantification of bird migration and predicted bird numbers affected by collisions with artificial structures are in many cases based on unreliable estimates." In addition, it is known that the magnetrons of marine radars degrade over time and become less sensitive, so a new system will likely be more sensitive and pick up more targets than an older one. Radar operators in the U.S. who study prospective wind energy sites simply have never compared their data or tested whether their radars are seeing the same targets. The statistical tests reported above are the first to compare radar results, although the Merlin and non-Merlin radar data are from different sites, so they do not conclusively answer the key question.

The last, and perhaps most important issue regarding the higher passage rate and lower altitude of targets "seen" by Merlin radars, is the possibility that some of the targets observed by Merlin radar are insects, as opposed to birds and/or bats. This has been suggested previously by Kerlinger (Paul Kerlinger rebuttal testimony for the East Haven Wind project, Vermont – Vermont Public Service Board, February 11, 2005) and insect contamination is an issue with whatever type of radar is used. Kerlinger contended that the reason the Merlin radar system detected 1,700+ targets per kilometer per hour for fall migration at a site in northeastern Vermont was related to insect contamination of the radar data. The reported 1,700+ targets per kilometer per hour was roughly four to five times the average rate per kilometer per hour reported by most radar studies in eastern North America at that time. Support for Kerlinger's contention comes from some of the most respected radar ornithologists in the world. Schmoljohann et al. demonstrate how difficult it is to discriminate between insects and birds when using marine radars like the Merlin or non-Merlin systems. What is interesting about this insect issue is the fact that different radar operators screen or filter out insects using different methods and there is no general consensus as to how insects should be screened out. The Merlin system uses apparent

size of echoes to separate insects from birds and bats, whereas others often use the speed of targets. Because insects move at slower airspeeds, they can be screened by speed. However, there is overlap among both size and airspeed, so neither method is exact and how each method is implemented may also account for some of the differences between these two radar systems. It is interesting also that some non-Merlin radar operators who use the same basic hardware report so many insects that they must shut down their radar on some nights (S.A. Gauthreaux personal communication and presentation to New Jersey Department of Environmental Protection).

Review of Bird Fatalities at Wind Plants in Eastern North America

In this section we examine empirical studies of empirically determined fatalities at existing wind projects. Reviews of post-construction methodology are almost always done by the U.S. Fish and Wildlife Service and/or state wildlife agencies prior to initiation of those studies. Following completion of field studies, these agencies also review the reports written and submitted by consultants and researchers who conducted the studies. Such reviews ensure transparency and research that is of sufficient quality that results are credible and useful to the agencies, as well as environmental organizations. States in which federal, and or state wildlife agencies have reviewed post-construction methodology and final reports include Maine, Vermont, New Hampshire, New York, Pennsylvania, West Virginia, Maryland, as well as Midwest and western states. Most of the studies listed in Table 3 have had some level of state and, or federal fish and wildlife review.

In addition to agency review, some papers/reports on these post-construction studies have been published in peer-reviewed scientific journals. The latter include methodological studies that focus on sampling protocols, ways of testing hypotheses, mitigating impacts, conducting searcher efficiency and carcass removal trials, estimation of fatality rates per turbine or per megawatt, and species composition. In addition to simply looking at fatality rates reported from the sites around the country that have been studied, we must look at the variability of fatality rates and species composition. Today, more is known about the quantitative and qualitative impacts to birds at wind energy facilities than almost any other industry, a result of an investment of more than $30 million in post-construction fatality studies conducted at more than 50 wind energy sites in the United States and Canada.

Post-construction studies have been conducted by various consultants, with input and review from state and federal wildlife agencies. The results of all of these studies are available and have been filed with state and/or federal agencies.

To date, at least 26 different wind power projects have been studied in the eastern U.S and Canada (Table 3) as of 2011, and studies are continuing at these and other sites. Studies have been conducted in Maine, New Hampshire (currently being done), Vermont, New York, New

Jersey, Massachusetts (completed, but a report has not been completed), Pennsylvania, Maryland (completed but results have not yet been made public), West Virginia, Tennessee, and Ontario, Canada. A peer-reviewed study of 30 sites from across the United States and Canada has also been published by Kerlinger et al. (2010) in a peer-reviewed ornithological journal.[2]

Study methods for the 26 studies listed in Table 3 have been quite similar. However, there is some variation in methodology, as development of field methods continues, along with newer methodology for analyzing data, as well as conducting searcher efficiency and carcass removal studies. The data in Table 3 include data from one, two, or three years of study at each of the sites. The three or four studies conducted before 2006 were not done as consistently as those after that date because there was little input by the states or federal agencies before that time. Studies done from 2006 to the present have been conducted more consistently and in line with methods approved by various state and federal wildlife agencies.

A total of roughly 42,000 individual turbine searches (defined as one turbine searched one time) have been conducted at the sites listed in Table 3. During these searches 910 bird carcasses were detected. An additional 246 carcasses, sometimes called incidental finds, were reported during these studies by searchers or wind plant staff at times that were not during scheduled turbine searches or in locations outside of the delineated turbine search areas. Thus, to find a single bird carcass, an average of 46 turbine searches during all the studies was required. With each turbine search requiring at least one hour of search time, the search time for finding a carcass is about 46 hours. This also means that for all the turbines searched, less than one carcass per turbine per year was located. Compare this statistic with that for communication towers (~116-146 meter towers owned by the Michigan State Public Safety Communication System and >305 meter towers owned by television stations, with guy wires and two types of FAA obstruction lights), for which about 2 tower searches were required to find a carcass (data from Gehring, Kerlinger, and Manville 2009, Ecological Applications 19:505-514; Gehring, Kerlinger, and Manville 2011, Journal of Wildlife Management 75(4):848-855).

Fatalities on a per-turbine basis ranged from less than one bird per turbine per year to 13.4 per turbine per year. All but two of the studies found less than six fatalities per turbine per year and all but three found below five fatalities per turbine per year. Roughly two-thirds of all the birds killed at all sites combined were songbirds. Roughly two-thirds of all birds found dead at eastern wind turbines were night migrants. This means that the sites ranged mostly between one and four night migrant fatalities per turbine per year at eastern North American turbines. Raptors,

[2] Note. Additional fatality studies have been completed in eastern North America that are not yet public. In Maryland at Criterion Wind, the first year of post-construction study was completed but has only been made available to the U.S. Fish and Wildlife Service and Maryland Department of Natural Resources. In Massachusetts a study has been completed recently at Mount Wachusett Community College, but results are not yet available. In addition, other studies have been completed in Pennsylvania, but are not being made publicly available by the Pennsylvania Game Commission. A study is currently being conducted at the Granite Reliable Power Wind Park in New Hampshire.

shorebirds, waterfowl, rails, and a few other species accounted for the remaining third of carcasses found. No eagles have been found dead at eastern wind turbines.

The site of the highest bird fatality rates reported (13.4 birds per turbine per year) was Wolfe Island at the eastern end of Lake Ontario. These birds consisted of a variety of species, and a large percentage were Tree Swallows and Purple Martins (38%) and Turkey Vultures (6%), species that nested locally on that island and species with large North American populations. For example, Tree Swallows have a North American population of about 20 million individuals, Purple Martins have a population of about 11 million, and Turkey Vultures have a population of about 4.5 million. At that site, night migrants did not account for a much larger number of bird fatalities than the other 25 sites studied. It is possible that these results were different because the turbines were on an island, or that the site was simply an outlier. The fatality rate at Wolfe Island may be the highest reported in North America. Even with this high rate of fatalities of the species found at Wolfe Island, it is highly improbable that the impacts will lead to declines in the populations of the species involved.

What is most striking about the results of the 26 studies summarized in Table 3 is the fact that the fatality rates and other findings are remarkably consistent. Fatality rates did not vary greatly among sites. Sites on ridge-tops and mountains in Appalachia did not have higher fatality rates than did sites on rolling farm hills in New York or wooded hills and mountains in New England. These findings apply to migrating raptors, waterfowl, shorebirds, and night migrating songbirds, as well as resident songbirds and other species. Thus, there is no evidence that topography or geography influence fatality rates at wind power plants in a consistent or statistically significant way.

These data strongly suggest that the impacts, even cumulatively, from existing wind turbines in eastern North America are not biologically significant and in no cases were populations of individual species jeopardized by the fatality rates reported. To date, there has been no suggestion by any agency that the impacts are leading to declines of any species.

Androscoggin River and Risk to Night Migrants at the Canton Mountain Wind Power Project.

In environmental project review comments, the Maine Department of Inland Fisheries and Wildlife noted that the Canton Mountain Wind Project was in close proximity to the Androscoggin River corridor and suggested, therefore, that it was near a migration concentration area. They state that "Large river corridors are known to be utilized by migrating passerines, often in greater concentrations of individuals than other landscape features." This statement, while sounding logical, has little foundation in biological fact. Rivers have only been found to concentrate migrants on perhaps one or two occasions and those studies did not suggest that concentrations were large. There are very few studies that demonstrate highly concentrated numbers of migrants at rivers. The few studies that have been conducted (Bingman, Able, and Kerlinger. 1982. Anim. Behav., 30:49-53) demonstrated only that some birds turned when they reached long, large, and linear water bodies such as the Hudson River. No study has demonstrated that night migrants follow rivers for more than short distances. Most importantly, for a river to be a corridor for migrants, it would have to provide a fairly linear track that is in the preferred axis of migration. A river like the Androscoggin has a corridor that is serpentine and winds to the east and west as it moves southward from central Maine. A bird that followed the river would not migrate efficiently, which is why there is no reason to suggest that the Androscoggin is an important migration corridor.

In addition to the non-linearity of the Androscoggin, it is important to emphasize that the closest turbine to the river at the Canton Mountain project would be more than 1.5 miles from the river. No studies have demonstrated that concentrations of night migrant or other types of migrating birds extend out to more than a mile from a river, or even the Atlantic Coastline, which is a major migration corridor.

Finally, the fact that night migrants have never been found to die in significant numbers or even more than about 5 birds per turbine per year at any wind energy site in North America strongly indicates that there is little likelihood of elevated risk at the Canton site that would result from its relative proximity (>1.5 miles) to the Androscoggin River. Wind power projects are now located near coastlines, ridgelines, and large rivers where there are important migration corridors, yet at none of these sites has there been a statistically higher rate of fatalities of night migrants.

Risk to Night Migrants at the Canton Mountain Wind Power Project.

While there is no universally accepted method for predicting collision rates from radar data, we can make assumptions based on historical data to characterize potential risk and estimate potential collision fatality rates for the Canton Mountain Wind Power Project. Two general approaches may be used. In the first, radar data provided by Tetra Tech for the Canton Mountain site is used to estimate potential risk and fatalities of night migrants via comparisons with passage rate data and, or, percentage of targets below turbine tip height to data from other sites where actual fatalities have been measured. In the second method, empirical data from fatality studies at wind power plants in eastern North America is used to estimate fatalities of night migrants.

1. Mortality projections based on radar data:

Using radar data to estimate fatality rates at prospective wind plants, the number of targets observed per kilometer per hour and the percentage of birds flying below the top of the rotor swept zone (130 m) would be used as indicators of risk and fatalities of night migrants. In other words, the numbers of bird fatalities should simply be proportional to or correlated with the passage rate and/or the percentage of targets flying below the height of the rotors. To date, there has yet to be an empirical confirmation of this methodology, nor has there been a means of analytically using radar to determine risk at wind power or other facilities. However, for the purpose of this section we will assume that radar data can be used to predict or assess fatality risk at wind plants and use the data to estimate a range of potential fatality rates of night migrating birds for the Canton project.

For the analyses that follow, radar results from both Canton Mountain and nearby Colonel Holman Mountain in Dixfield (Timberwinds project) are used. Colonel Holman Mountain is about 3 miles west of the Canton project. Radar studies at Colonel Holman were conducted during spring 2012 using the same radar and methodological approach, with some differences based on differences in topography at the two sites. The same company, Tetra Tech, conducted both studies. Canton passage rates of 304 targets per kilometer per hour for spring and 181 per kilometer per hour for fall, and Dixfield passage rates of 65.6 targets per kilometer per hour for spring are used to estimate fatalities per turbine per year for night migrants based on the relation to passage rates at facilities with known fatality rates. Non-Merlin data (Table 1 and 2) for passage rate averaged 295 targets per km per hour in spring and 344 in fall for all sites studied. Thus, if we assume that Canton's passage rates are within the range of passage rates at other sites, without consideration of target altitude, the fatality rates at Canton would also, in all likelihood, be in the range of other studies in eastern North America, which would be in the range of 1-5 night migrants per turbine per year. The maximum number of night migrant fatalities would, therefore, be 40 birds per year, based on eight turbines that each kill five birds per year. It is also quite possible that the fatality rates at Canton and Colonel Holman would be lower than average because spring passage rates were lower than average for eastern North

America during this season. Thus, less than 4-5 night migrants would likely be killed per year per turbine by the turbines at Canton. That would mean less than 40 night migrants, total, would be killed per year for the whole project.

An alternate estimate based on radar would be made using the Canton estimates of 35.3% and 40.7% of targets below turbine tip height in spring and fall, respectively, and the Colonel Holman estimate of 18.9% below turbine tip height for spring. The Canton rates for targets below turbine tip height are both roughly three to four times the rates reported by non-Merlin radars at many other sites in eastern North America (from Table 1 – 14% for spring and 10% for fall). For Colonel Holman, the rate is roughly twice the rate for other sites in eastern North America. Ignoring the low overall passage rate measured by Tetra Tech at both Canton and Colonel Holman, one could assume, as a worst-case scenario, that the higher percentage of birds in the rotor swept zone at Canton would translate by simple multiplication into fatality rates at Canton Mountain of about three to four times the rates given in Table 3, which range from about two to five fatalities per turbine per year[3]. Thus, with eight turbines times five fatalities (a high, but conservative number) times three (radar factor for three times higher percentage of targets below rotor tip height), the estimated fatalities per turbine would be 15 and for all turbines combined would be 120 birds per year. This could be viewed as a worst case scenario and it is likely that fatality rates would be much lower.

If the percentage of targets below the tip of the turbine for spring 2012 measurements from Colonel Holman were used to estimate overall fatalities, fatality rates for night migrants at Canton would be about eight turbines times five fatalities times two (radar factor for two times higher percentage of targets below rotor tip height) or 7.5 birds per turbine per year and only about 60 total birds killed per year. Again, this does not take into account the fact that the overall passage rates at Colonel Holman are much lower than those found at almost any of the other radar studies in eastern North America.

Thus, using only radar data combined with known numbers of night migrant fatalities at existing eastern North American wind turbines, the likely number of fatalities of night migrants per turbine and per year would range conservatively between 7.5 and 15 birds per turbine per year and between 60 and 120 night migrating birds per year for the entire wind power facility. Because the rate of 15 night migrating birds killed per turbine per year is highly unlikely and exceeds findings at all wind power facilities in North America by a factor of two or three, it is more likely that the fatalities resulting from the Canton project will be much lower than the estimates given above that were based only on the percentage of targets flying below the rotor tip height.

[3] This is based on the assumption that overall passage rate is similar to passage rates at other sites in eastern North America, even though the measured passage rate is actually lower than measured passage rates at other sites in eastern North America.

2. Mortality estimate based solely on empirical studies:

Another approach, which is based on a large body of peer reviewed science, relies strictly on the weight of evidence from previous empirical studies of fatalities at eastern wind power facilities. At those sites, about one to five night migrants per turbine would be killed. Using this approach, the maximum for all eight turbines proposed at the Canton site would be about 40 birds per year, but it is more likely that fatalities would be in the range of eight to 32 birds per year. The latter estimate is based on fatality rates found at Mars Hill and Stetson wind power facilities in Maine (see Table 3 for empirical rates of all fatalities at these sites).

Because the Merlin radar data reported by Tetra Tech for Canton likely overestimated the percentage of targets flying in the rotor height zone (<130 m), there is little doubt that the fatality rates at Canton Mountain would be much lower than the maximum radar-based estimate (15 night migrants per turbine per year) given above. Even if the fatality rates at the Canton turbines were in the 15 birds per turbine per year range (120 total per year), this number would not likely impact populations of any of the species involved. The lower percentage of targets observed below the tip height of the turbine and the lower passage rate found at Colonel Holman, confirms this statement. Therefore, it is highly improbable that the fatality rates would be 15 night migrants per turbine per year, based on the mass of empirical data that is now available regarding fatalities at wind turbines and upon radar data from more than 70 sites in eastern North America.

The estimates provided above for the Canton Mountain project do not reflect impacts that would likely be biologically significant. In fact, the maximum rate of 120 night migrating birds killed per year is less than the fatalities found at thousands of individual public safety communication and mobile telephone-type towers in the United States (Gehring et al. 2009, 2011, Kerlinger, P., J. Guarnaccia, A. Hasch, R. Curry, R. Cutler, L. Tran, J. Stewart, and D. Riser-Espinoza. 2012. Avian mortality at 50- and 60-m guyed towers in central California. Condor 114: 462-469..). These towers are owned and used by state and federal agencies and are subject to review under the NEPA process. The rates of fatalities at these guyed, publicly owned communication safety towers in the 475-foot height class has been found to be roughly 20 times that of individual wind turbines (Gehring et al. 2009 – reference given above, Kerlinger et al. in prep.). Also, in Maine, as of 2010, 111 communication towers in the 300-499 foot tall height category (www.towerkill.com) had been federally permitted without issues relating to significant impacts to birds. Most had guy wires. Those towers likely kill birds in similar numbers to the publicly owned and operated towers. This comparison is made simply to show that fatalities far in excess of those found for wind turbines are permitted regularly by state and federal agencies, and some of those towers are used by the U.S. Fish and Wildlife Service as well as state fish and game departments. Thus, if fatalities at communication towers are permitted and not biologically significant, it is highly improbable that fatalities caused by wind turbines are biologically significant.

Summary and Conclusions

Radar data from the Canton Mountain Wind Power project and more than 70 other studies, as well as empirically determined fatality rates of birds from wind power facilities in eastern North America were reviewed and analyzed to assess risk and determine estimated fatality rates at the Canton Mountain wind power project. The Merlin-type radar that was used for studying night movements of birds, bats and other animals at the Canton Mountain project has been found to systematically yield greater passage rates, lower altitudes, and greater percentages of targets flying at less than 130 m (maximum rotor height) than non-Merlin radars used for preconstruction studies at wind energy facilities in eastern North America. Passage rates determined using Merlin radars were roughly twice as great as those found using non-Merlin radars, while altitudes were 29% and 34% lower in Merlin radar estimates in spring and fall, respectively. The percentage of targets observed flying within and below the height of the rotors was 9% greater in spring and 23% greater in fall for Merlin radars as opposed to non-Merlin radars. From this, it was concluded that Merlin radars are likely more sensitive to various types of targets, including insects, than are non-Merlin radars and comparisons between Merlin and non-Merlin radar results are tenuous.

With respect to fatality rates of birds at wind energy sites in eastern North America, 26 studies (42,000 individual turbine searches) revealed fatality rates roughly between 1 and 6 birds per turbine per year, with two sites reporting rates of roughly eight and 13 birds per turbine per year. Thus, fatality rates of birds at wind energy sites in the eastern United States are well studied and the results of these studies are very consistent. Fatalities have been relatively low, especially when compared to communication towers, and the numbers of fatalities do not vary with respect to topography and geography.

Two ways of estimating fatality rates at the Canton Mountain were explored: one using the results of the Merlin radar from both Canton and Colonel Holman sites and the other using empirical data from fatality studies in eastern North America. Both methods are believed to be conservative estimators and are likely to overestimate fatality rates at Canton Mountain. The rates using the Merlin radar results ranged upwards to 15 birds per turbine, but when both Colonel Holman and Canton radar data were used, the rates were much lower. And, these rates do not include the low passage rates measured at both sites.

Actual mortality data—as opposed to estimated mortality from radar data—from 26 sites at which carcass searches were conducted indicate that only one to five (or six) night migrating birds per turbine were killed. The fact that there are only eight turbines proposed for Canton Mountain combined with the fatality estimates made in this document strongly suggest that the overall number of fatalities at the project will not likely be great, and it is highly improbable that fatalities will be biologically significant – that is, leading to population declines of any species.

Comparisons with rates at communication towers demonstrate that structures that cause orders of magnitude more fatalities than wind turbines are permitted by state and federal agencies on a regular basis. Finally, there is no geographic or topographic reason to suspect that fatality rates at Canton will be higher than found at other wind power facilities, nor is there reason to suspect that the fatality rates will be biologically significant. Therefore, there does not appear to be undue adverse risk, with respect to birds, at the Canton Mountain wind power project.

Table 1. Summary of results of Merlin and non-Merlin type radars from available studies in the eastern United States.

Merlin Radar	T/KM/HR		% at or Below Rotor Swept Zone		Mean Alt Meters	
	Spring	**Fall**	**Spring**	**Fall**	**Spring**	**Fall**
Canton1, ME - original	628	292	28	49	217	158
Canton2, ME	304	181	35.3	40.7	197	178
Dixville, ME	66		18.9		215	
East Haven, VT		1732		49		
Saddleback, ME	708	624	16	24	354	290
Spruce Mtn, ME	409	480	25	21	367	316
Ripley-Westfield, NY	1062	774	12	13	340	332
Mean =	***530***	***681***	***23***	***33***	***282***	***255***
Non-Merlin Radar						
Mars Hill, ME	342	512	14	8	332	424
Kibby, ME		201		12		352
Kibby, ME		585		16		370
Kibby, ME		452		16		391
Sisk, Kibby, ME		458		23		287
Stetson Mt, ME	147	476	22	13	210	378
Stetson Mt, ME - Post		457		2		420
Oakfield/Penobscot City, ME		501		18		309
Bowers, ME	289	344	26	14	315	315
Roxbury, ME		420		14		365
Highland, Somerset C, ME		549		17		348
Rollins Lincoln, ME		368		13		343
Lempster, NH		620		8		387
Tenney, NH		470		13		342
Granite, NH	342	469	14	1	332	310
Errol, VT		366		15		343
Deerfield, VT	404	178	6	4	523	556
Deerfield, VT - YR 2		559		17		395
Sheffield, VT	199	109	6	1	552	566

Milton, VT		326		7		371
Vermont Comm Wind, VT		443		15		330
Kingdom Comm, VT	223	356	22	15	298	350
Clinton Co, NY	110	197	20	12	338	333
Marble River, NY	254	152	11	5	422	438
Howard, NY	440	481	13	5	426	491
Ball Hill, NY	419	189	3	9	493	353
Dutch Hill, NY	535	535	11	11	358	358
Dairy Hills, NY	117	94	15	10	397	466
Prattsburgh1, NY	170	200	18	9	319	365
Prattsburgh2, NY	277	193	16	3	370	516
Chautauqua, NY	395	238	4	5	528	532
Arkwright, NY	175	112	13	10	450	458
Allegheny, NY	268	451	19	14	316	382
Jordanville, NY	409	380	21	6	371	440
Munnsville, NY		732		2		644
Bliss, NY		440		13		411
Clayton, NY	460	418	14	10	443	475
West Hill, NY**	160	732	25	3	291	664
Horse Creek, NY	450	418	14	10	443	475
High Sheldon, NY	112	197	6	3	418	422
Top Notch, NY	509	691	20	4	419	516
Flat Rock, NY (Maple Ridge)		158		8		415
Chrubusco, Clinton, NY		152		5		438
Blenberg, Clinton, NY		197		12		333
Chateaugay, NY	360	843	18	8	409	431
Wethersfield, NY	324	256	19	11	355	344
Perry, NY		64		10		466
Stamford, NY		315		3		494
Alabama, NY	112	67	6	14	413	489
Centerville, NY	290	259	16	12	351	350
Wethersfield, NY	324	256	19	11	355	344
Copenhagen, NY	192	225				
Cape Vincent, NY	166	346	14	8	441	490
Hounsville, NY	624	281	19	17	319	298
Villenova, Chautauqua, NY		189		9		353
Moresville, Del Co, NY	210	315	8	3	431	494
Moresville, Del Co, NY	230		12		314	
Martinsburg, NY		230				
Martindale, PA	271	187	12	8	416	436
Fayette City, PA		297		5		426

Swallow Farm, PA	146	166	12		401	402
Somerset, PA		316		8		374
Casselman, PA		174		7		448
South Chestnut, PA			9	5	382	426
Bedford City, PA		438		10		379
Dans Mtn, MD		188		7		542
Mount Storm/Ned2,WV		241		13		410
Mount Storm/Ned, WV		199		16		410
Liberty Gap, WV	457	229	11	8	492	583
North Briery, WV				10		420
Franklin, WV		229		8		583
Laurel Mtn, WV		321		6		533
New Creek, WV		811		17		360
Preston, WV		379		10		420
Highland Co, VA		385		12		492
Mean =	***295***	***344***	***14***	***9***	***390***	***422***

Table 2. Summary of mean values and T-statistic *P* values from data in Table 1 for Merlin and non-Merlin type radars. Sample sizes for spring are 7 for Merlin and 37 for non-Merlin type radars and for fall are 5 for Merlin and 72 for non-Merlin type radars.

	Merlin	Non-Merlin	Difference (Merlin – non-Merlin)	T-Statistic - *P*
Targets/Km/Hour				
Spring	530	295	235	0.161
Fall	681	344	337	0.197
Percent Below Top of Rotor Swept Zone				
Spring	23%	14%	9%	0.064
Fall	33%	10%	23%	0.014
Mean Altitude				
Spring	282 m	390 m	-108 m	0.018
Fall	255 m	422 m	-167 m	0.008

Table 3. Summary of fatality studies conducted in eastern North America at wind turbine facilities.

Location	Turbine height	Months sampled	Number searches	Number carcasses in searches (incidental)	Searches to find one carcass	Adjusted mortality per turbine/yr	Adjusted mortality per MW/yr
Eastern U.S.							
Mars Hill, ME	119 m	13	1169	20 (23)	58.5	0.44 - 2.04	0.29 - 1.36
Stetson Mountain, ME	119 m	7	506	30 (8)	16.9	4.03	2.68
Atlantic County, NJ	116 m	24	1500	31 (0)	48.4	Not reported	Not reported
Altona, NY	119 m	7	966	14 (5)	69.0	0.54 - 1.01	0.36 - 0.67
Bliss, NY	119 m	16	3703	45 (14)	82.3	0 - 4.45	0 - 2.97
Chateaugay, NY	119 m	7	607	19 (9)	32.0	2.48	1.65
Clinton, NY	119 m	15	2944	30 (17)	98.1	1.43 - 3.26	0.96 - 2.17
Cohocton, NY	119 m	8	1087	15 (3)	72.5	2.90 - 4.70	1.16 - 1.88
Ellenburg, NY	119 m	15	2412	31 (12)	77.8	1.18 - 5.69	0.79 - 3.79
Madison, NY	100 m	7	98	4 (2)	24.2	Not reported	Not reported
Maple Ridge, NY	122 m	22	5671	256 (48)	22.2	3.13 - 9.59	1.90 - 5.81
Munnsville, NY	119 m	8	320	5 (5)	64.0	2.22	1.48
Wethersfield, NY	119 m	7	691	11 (7)	62.8	2.55	1.70
Allegheny Ridge, PA	124 m	10	2395	10 (0)	239.5	2.71 - 8.57	1.36 - 4.29
Bear Creek, PA	124 m	8	2190	6 (3)	365.0	1.03 - 2.00	0.52 - 1.00
Casselman, PA	119 m	8	2040	16 (5)	127.5	0.37 - 4.69	0.25 - 3.13
Garrett, PA	90 m	12	136	0 (0)	0	Not reported	Not reported
Meyersdale,	115 m	3	480	9 (4)	53.3	Not	Not

PA						reported	reported
Buffalo Mountain, TN	88-120 m	37	1329	55 (14)	24.2	1.80 - 7.27	1.00 - 11.02
Searsburg, VT	59 m	5	84	0 (0)	0	Not reported	Not reported
Mountaineer, WV	105 m	10	2002	48 (36)	41.7	4.04	2.69
Mount Storm, WV	118 m	4	978	26 (11)	37.6	2.41 - 3.81	1.21 - 1.91
Canada							
Erie Shores, ON	119 m	12	2391	59 (0)	40.5	2.00 - 2.50	1.33 - 1.67
Exhibition Place, ON	94 m	4	34	2 (0)	17.0	3.00 - 4.00	4.00 - 5.33
Pickering, ON	117 m	12	59	3 (0)	19.7	4.00	2.22
Wolfe Island, ON	117 m	12	6192	165 (0)	37.5	13.40	5.83
Totals			**41 984**	**910** (246)	**46.1**		